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PARTNERS IN RESEARCH

A five year report of the Small Ruminant Collaborative Research Support Program.

Edited by R.D. Blond
Development Design Associates

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A Joint Venture Between
the United States Agency for
International Development
and
Agricultural Research Institutes
in the United States and Overseas

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FOREWORD

The origins of the Small Ruminant Collaborative Research Support Program (SR-CRSP) lie in the passage by Congress in 1975 of the Famine Prevention and Freedom from Hunger Act. The provisions of Title XII in the Act were to:

> "... strengthen the capabilities of US land grant ... universities in program-related agricultural institution development and research ... improve their participation in the US government's international efforts to apply more effective agricultural sciences to the goal of increasing world food production and in general should supply increased and longer term support to the application of science to solving food and nutrition problems of the developing countries."

In this simple but eloquent language, the key elements that have been instrumental in molding the design, goals, and administration of the SR-CRSP were finally established. Specifically:

- To *strengthen the capacities of US universities* as opposed to conducting research exclusively overseas.
- To *conduct institutional development and research* as opposed to direct handouts in the form of commodity transfer.
- To *supply increased and long-term support* as opposed to small, short-term, stop-and-go projects that have characterized so much of the past technical assistance to developing countries.

Implementation of these high ideals could have been attempted in any number of ways. One that was chosen was the *Collaborative Research Support Program* (CRSP) mode, whereby several US institutions representing several disciplines would be engaged in work at several overseas locations. The Small Ruminant CRSP was the first CRSP implemented and has to a degree pioneered this new technical assistance mode. The focus of the work has been limited to research, training, and institution building which are the areas of endeavor in which universities excel. With no precedent to follow or template in place, it is neither surprising that the design, structure, and administration of the SR-CRSP were the subject of considerable debate at its inception, nor that the SR-CRSP continues to be a dynamic program of flexible design. Also, because an inherent aspect of the new program concept was to allow universities and host countries to design their *own* programs collaboratively, the technical work, especially overseas, has actually been in progress for only three and one half years in most cases, and even less in others. The first eighteen months were devoted almost exclusively to program development which involved such tasks as identifying overseas worksites, counterpart institutions, and host country scientists with whom to develop collaborative workplans.

In retrospect, it is likely that one of the hidden accomplishments of the SR-CRSP which has resulted in a continuing spirit of mutual cooperation is the time that was taken in the beginning to develop this program in a collaborative mode, involving USAID, US institutions, and host country agencies as equal partners in this venture.

Currently, there are seven CRSPs in place, all with a superficially different form and structure and yet possessing some common features. All have several US participating institutions and many overseas locations. All have a management entity, technical committee, a board, and an external evaluation panel to provide constant quality control. All are multidisciplinary in their approach and all are joint ventures between USAID (the primary source of funds), US institutions (with their matching contributions), and the overseas host countries.

There is no doubt that for every CRSP, a hundred possible designs could be proffered. None would be perfect, but all might succeed equally well. The essential element in the inter-disciplinary program is a balance between the necessary expression of each scientist's individualism and the collective need for integration. In this respect, CRSPs, like all other social structures, possess the universal characteristics of holarchic order which, as Koestler asserts, "... is possessed of two opposite tendencies or potentials: an *integrative tendency* to function as parts of a larger whole, and a *self-assertive tendency* to preserve individual autonomy." This applies within the CRSP itself and to the CRSP as part of the larger body of researchers worldwide. An example within the SR-CRSP will suffice to illustrate the point. There are a number of principal investigators/scientists at various institutions across the US who work in collaboration with scientists/colleagues overseas. It is imperative that each scientist operate with a degree of "self-assertiveness" or independence so that they may excel in their specialty. However, it is also necessary that the "integrative tendency" be strongly felt so that scientists can function as "part of a larger whole," to solve problems with a wider scope than encompassed by their own subject area. These two forces are opposite, and assertion of too much of one leads to as many problems as an excess of the other. At times, the SR-CRSP has heard strident

voices from within calling for more independence and from without the voices call for more integration. What, in fact, we have strived to achieve is a balance between the two in order to preserve the atmosphere of "creative tension" in which critical inquiry flourishes. The reader may judge whether the accomplishments over such a short span of time represent acceptable progress.

Progress toward what?—the aggrandizement of a handful of US or overseas scientists through the publication of scientific papers? Certainly these are by-products of the quest for knowledge, but they are not the primary product of the SR-CRSP. The primary goals are institutions that will endure, trained scientists capable of solving problems as they arise at the local level, and new knowledge that will lead to improvement in the welfare of those with limited resources.

Research is a very long-term investment. It gives the impression of being costly but experience has shown that the returns on capital invested are very high indeed. Research in the "international" sphere is doubly expensive and requires even more patience before benefits are realized than that required of domestic research programs. But the pay-off, particularly in human terms, is also very high. Not to engage in the adaptive research that allows technological advances to benefit the less-developed countries with their burgeoning populations and unprecedented food supply problems, is to condemn millions to the ranks of the malnourished. Some will argue that research, both basic and applied, is a long way removed from the immediate needs of the smallholders. Not so. Millions of smallholders and their families are now benefiting from basic research that was considered exotic ten and twenty years ago, but is now recognized as the foundation of the "green revolution."

These successes were the outcome of a long period of sustained research that depended on well-established institutions in wealthier nations and on the long-term endeavors of the international research centers overseas. The successes have only highlighted the pressing need for effective agricultural research systems in the developing countries, so that new technology can be adapted for local use. Few would question the view that to build such research capability requires, inherently, a long-term effort. This is a view which is embodied in the language of Title XII and the SR-CRSP Grant and which recognizes the critical importance of the long-term collaborative effort.

The outward manifestations of our efforts to accomplish these program goals have been an enormous emphasis on institution building, especially training of overseas colleagues at all levels, and of continued support on their return. Also, we have made a heavy investment in high calibre scientists placed overseas who have worked with an emphasis on field research in close proximity to the smallholder. It has been a cooperative effort and testimony to the willingness of the Agency, the participating institutions, and the host countries to work in a spirit of close collaboration as equal partners. From every section of USAID, be it the Contracting Office, Science and Technology, the Regional Bureaus, and particularly the Overseas Missions, the SR-CRSP has received outstanding cooperation. From each of the US participating institutions, be it from Board Members, Principal Investigators, or co-workers, the SR-CRSP has received commitment of the highest calibre. And from the host countries and their collaborating institutions, be it from ministerial offices, university departments, research agencies, or the remote experiment station, the program has been sustained by enthusiasm, the provision of facilities, and a dedicated staff.

This volume appears at the end of the first five years of USAID Grant No. AID/DSAN/XII/G-0049 and summarizes work carried out overseas and in the United States under the aegis of the Small Ruminant Collaborative Research Support Program. It represents the report of the University of California, Davis, the Grantee, to USAID. Research aspects of this report closely follow the five year reports of Principal Investigators which have been edited for this publication.

We will not single out any individual or institution for special acknowledgement. Any attempt to do so would fall short of a just recognition of the efforts of so many. The program discussed in this volume is dedicated to the fulfillment of the hopes embodied in Title XII. It is our hope that the SR-CRSP may continue to strive for improvement in the welfare of the poor, and that it may do so in a spirit of mutual cooperation.

David W. Robinson
Program Director
University of California, Davis

Editor's Acknowledgements

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EXECUTIVE SUMMARY

Introduction

The Small Ruminant Collaborative Research Support Program (SR-CRSP) is a joint effort of the US Agency for International Development, US universities, and government agencies in five developing countries. It is supported by a Title XII grant of $15 million dollars over a five-year period and by contributions of over 30% of this amount from participating institutions. The program is administered as a grant to the University of California, Davis, which, through a management entity, provides subgrants to US participants, and maintains fiscal accountability.

Currently the program is engaged in research and training in five countries: Brazil, Indonesia, Kenya, Morocco, and Peru. Supporting research of a more basic or technically complex nature is carried out in the US.

US institutions responsible for the following projects are presently participating in the program:

University of California, Davis	Breeding Animal Health
Texas A&M University	Systems Analysis Breeding
Texas Tech University	Range Management
Utah State University	Reproductive Physiology Range Management
Colorado State University	Animal Health
North Carolina State University	Forages and Nutrition
Montana State University	Breeding
University of Missouri	Rural Sociology
Washington State University	Animal Health
Winrock International	Economics Production and Feed Systems

The range of projects deployed in each overseas site varies from eight in Peru to four in Morocco and is based on the overall research objectives set for each site, the major constraints to improved production, and the needs of host country institutions for support.

The SR-CRSP research programs are all multi-disciplinary; varying degrees of integration between disciplines reflect, in large measure, the demands of the program in each country.

At its inception, the SR-CRSP undertook the planning and development of its own research and training agendas, and selection of overseas worksites and collaborators—a task which took over a year to complete. The longest running country research program has been in place for only three and one half years. Funding is available for an additional program year, through September 1984, and is contemplated for an additional three years. This will enable training and overseas research to generate sufficient progress and momentum such that further research, after the conclusion of the SR-CRSP, can become self-sustaining under the auspices of host country governments.

Brazil

The semi-arid interior of Northeast Brazil, the *sertao,* is an area encompassing about one million square kilometers and inhabited by over 12 million people, most of whom rely on smallholding agriculture for subsistence. The area is plagued by the unreliability of its rainfall, which together with the long hot summer severely restricts plant growth and crop yields. As a survival strategy, farmers practice mixed crop-livestock farming, raising sheep and goats which depend principally on the native bush, the *caatinga,* for forage. Although 90% of the nation's goats and 30% of its sheep are raised in the region, their productivity is extremely low, averaging only one fifth of that found in other areas of Brazil.

The SR-CRSP, in collaboration with EMBRAPA and the National Center for Goat Research (CNPC), initiated a research effort in early 1980 to improve the productivity of small ruminants in the *sertao,* with the prospect of raising the incomes and standards of living of the area's limited resource farmers.

The approach adopted by the SR-CRSP in Brazil has been to field teams of scientists to conduct research with Brazilian collaborators in the major areas constraining small ruminant production while Brazilian scientists undergo training overseas in a wide variety of subject matter areas. Research projects in Animal Breeding and Management, Reproductive Physiology, Animal Health, Forage and Nutrition, Range Management, Economics and Sociology are currently in place. Each project pursues its research objectives independently but cooperates closely where issues necessitate an interdisciplinary approach.

The *Range Management Project,* recognizing the overwhelming constraint of dry-season feed deficits, has focused research on achieving a better balance between wet-season surplus of feed and dry-season shortages, while at the same time trying to minimize the impact of recurrent drought on land and vegetation. Accomplishments include a satellite survey of local range resources, studies of preferred diets of sheep and goats in the *caatinga,* and development of techniques for manipulation of *caatinga* vegetation to prolong the critical availability of green forage into the dry season.

The *Nutrition and Feeding Systems Project* is also tackling the problem of seasonal scarcity of herbage available from the native range. The project is emphasizing research on the use of crop residues and preserved forages as feeds to supplement range resources when these are deficient at the most critical stages of the animal production cycle: post-weaning, breeding, late gestation, and lactation.

The *Animal Health Project* is investigating methods of economically controlling the major diseases that were found to limit small ruminant productivity in the area: intestinal parasitism, caseous lymphadenitis, pneumonia, and mastitis.

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Research is directed at disease control by improved animal management practices rather than by costly vaccination or chemotherapy.

The *Management and Breeding Project* has addressed the question of characterizing existing breeds and types of sheep and goats in the *sertao,* with a view to choosing stock for initiating selection and breeding work. The intention here is to develop a breed or type with a genetic potential appropriate to the biological environment and management practices.

The *Reproduction Project* has oriented its research towards improving the overall productivity of flocks and herds by developing procedures to relax constraints on reproductive performance. Management practices which have been recommended for improving reproductive output include optimal age for weaning, optimal condition of the female for first pregnancy, restriction of the breeding season, reduction of the parturition interval, and a technique for diagnosis of pregnancy to facilitate special arrangements for the gravid female.

The *Economics Project* has developed a whole farm linear programming model based on descriptive surveys of farms in Ceara State. The model provides a means for testing the economic impact of technical interventions in sheep or goat production systems proposed by other SR-CRSP projects, as well as revealing how production responds to market features.

The *Rural Sociology Project* has pursued goals closely related but largely complementary to the Economics Project. Developing a comprehensive view to total agricultural production systems, the project has sought to understand the production decision framework of farmers with special reference to the decision rules governing small ruminant production. In addition, the project is providing a service to the biological projects by evaluating the likely social impact of various new technologies and providing criteria to guide development of new techniques which have the most likelihood of adoption.

Indonesia

SR-CRSP research in Indonesia, developed in collaboration with the government's Agency for Agricultural Research and Development, is directed towards improvements in sheep and goat production in two distinct agroecologies: coastal lowland and interior highlands. In both areas where crop production is intensive, productivity of small ruminants on smallholdings is low. The four SR-CRSP projects and their counterparts have worked cooperatively to alleviate some of these problems where they most matter—at the village level.

The *Breeding Project* has focused on developing from the native thin-tailed sheep, a type whose prolificacy is less erratic and matches its production environment more closely. This will reduce neonatal losses and improve flock performance. A major cause of low reproductive performance has been identified and remedial steps taken to change management practices.

The *Nutrition and Feed Systems Project* in its survey of current small ruminant nutrition in villages, had identified digestible energy, not protein, as the limiting factor. Feeding trials are in progress to determine sheep and goat responses to various feed supplements available to villagers.

The *Economics Project* has participated with the other SR-CRSP projects in the village surveys, to develop a picture of the economic roles and importance of small ruminants. Research has also been carried out to determine mechanisms of price formation and marketing, and on analyzing productivity constraints.

The *Sociology Project,* after completion of the initial survey, has undertaken studies to understand the farmers' decision framework as it affects small ruminants. The nature and extent of farmers' contacts with external institutions such as credit, extension, and markets, has also been studied and will be important in designing an acceptable improvement package for smallholders.

Kenya

The work of the SR-CRSP in Kenya is unique among the Program's five worksites. In the intensive farming region of Western Kenya, an attempt is being made to develop an entire production technology package for meat and milk goats for a situation in which dual-purpose goats are not traditionally raised. Working towards this goal has demanded increasing integration between component projects, and training Kenyan scientists in interdisciplinary approaches as well as in traditional subject areas. This work is conducted in collaboration with the Ministry of Livestock Development (MLD).

Successful development of such an economically viable technology package depends on its ability to fit the existing farming system and cause minimum dislocations. The understanding necessary to achieve this is the outcome of a comprehensive survey of economic aspects, cultural norms, and farm resources, conducted jointly by the *Economics, Sociology,* and *Production Systems Projects.*

The *Economics Project* has completed a linear programming model of the target farm system, which optimizes economic benefits under different patterns of resource use subject to biological and social constraints specified by other component projects.

The *Sociology Project,* after the completion of the survey, has focused on questions of division of labor and labor availability for animal care and management on sociocultural constraints to goat production and on the magnitude and types of external services and supports that would be needed by farmers adopting a dual-purpose goat production system.

The *Production Systems Project* is charged with developing the technology packages from components supplied by the other projects, and conducting farm-trials necessary to validate new production systems. Pending completion of research on package components, the project has focused on the survey and on pursuing research on topics not otherwise covered, such as acceptability of dairy goat products. This project is also responsible for feed production research

focused on identification of feed production strategies to meet the needs of a dual-purpose goat production system.

The *Health Project* completed a survey to identify the most important disease problems likely to face dairy goats in the target area, and is pursuing research on methods to control parasites and contagious caprine pleuropneumonia. The project's work on caprine encephalitis arthritis (CAE) enabled the presence and extent of this important disease to be established and eradicated from Kenya.

The *Breeding Project* is seeking to develop, through genetic selection and cross-breeding, a dual-purpose goat appropriate to the conditions in Western Kenya. The performance of existing cross-breeds in Kenya is being evaluated under target area conditions, and attempts are being made to develop a suitable cross using a hardy local breed and semen from exotic dairy breeds.

The *Systems Analysis Project* has developed a mathematical model which simulates the performance of sheep and goats in Kenya and shows the influence of factors such as nutrition, disease stress, and management on productivity.

Morocco

Small ruminant production has been a traditional activity on the extensive rangelands of the Middle and High Atlas regions of Morocco, and sheep and goat products are in high demand. In recent decades, the equilibrium established through traditional range resource use has been upset by an increased demand for small ruminant products from an expanding human population, and by reduction in the range pasture by encroachment of wheat cultivation. The SR-CRSP is collaborating with the Institut Agronomique et Veterinaire, Hassan II in research to solve the problem of improved small ruminant production and stabilization of range resources and in training Moroccan staff to continue this work.

The *Range Management Project* is investigating two types of range resources, sagebrush-grasslands and oak woodlands, to determine feasible range management practices that will provide for the needs of livestock producers and at the same time protect and develop the productivity of the threatened rangelands.

The *Forage and Nutrition Project* has confronted the problem of seasonal forage deficits and is looking for ways in which crop residues can be used as feed for small ruminants, either to supplement range resources or as a preserved feed for use in winter months.

The *Breeding Project* is investigating the desirability and methods for adjusting the genetic potential of traditional sheep breeds which have outstanding hardiness but low prolificacy. To make full use of feed supplies from irrigated agriculture and the shift from a transhumant to semi-sedentary production system, a different type of sheep needs to be developed with higher reproductive performance.

The *Rural Sociology Project* is pursuing research to advise the biological projects on the social and organizational aspects of production. Of particular interest, in each of the different ecologies, are the producers' decision frameworks and the rules that govern use of communal grazing lands.

Peru

The major research focus of the SR-CRSP in Peru is improvement of sheep and alpaca productivity in Andean peasant communities. With conditions rarely suitable for adequate crop production, more than 350,000 families are dependent on small ruminants for food and income. Unfortunately, productivity is not high and pressure from an expanding population threatens degradation of the range.

The research is conducted in collaboration with INIPA and several universities including La Molina, IVITA, Cuzco, Puno, Arequipa, and Lambayeque.

The *Sociology Project* has devoted its resources to studying the social dimensions of sheep and alpaca production in agro-pastoral communities in the Andes and characterizing the goat production systems in Northwest Peru. These understandings help in guiding the directions of biological research so that proposed interventions are socially acceptable.

The *Economics Project* has focused its efforts on descriptive aspects of small ruminant production systems in Peru, on the mechanisms of price formulation of small ruminant products, and on the models needed to carry out bioeconomic analysis of proposed improvement interventions.

The *Range Management and Forage Project* has investigated ways to mitigate effects of seasonal forage deficits on livestock productivity and to develop grazing systems to optimize animal production and maintenance of range resources. Stocking rate guidelines have been established and research is continuing on improved forages, determination of seasonal nutrient deficiencies, and supplementation schedules.

The *Animal Health Project* research priorities were based on an assessment of the importance of particular diseases and the current lack of effective control methods. Continuing investigations include: developing control measures for chronic respiratory disease in sheep and neonatal enteritis in alpaca; disease-related infertility in sheep; and heavy metal toxicity in sheep living near mining and smelting operations.

The *Breeding Project* has completed preliminary studies directed at identifying native or improved breeds of sheep and alpaca with high genetic potential for improved meat and fiber production under the environmental and management conditions of both smallholder and large cooperative producers in the Andes through progeny and performance testing. Breeding and selection of improved stock is the longer term goal.

The *Reproduction Project* has pursued research on reproductive factors in sheep and goats which limit flock or herd productivity. The project has generated basic data on reproductive performance in local breeds and, based on this, recommended management practices to relieve reproductive constraints.

The *Integrated Goat Project* has been funded out of contingency funds with seed money for two years. This project, under the direct control of the overseas SR-CRSP Site Coordinator, and using resident staff, emphasizes an explicit systems approach to develop improvements to local goat production in the Northwestern desert. Surveys of

existing conditions have now been completed and major constraints identified. Future work on the project is being sponsored by a grant from the Canadian IDRC.

Basic Supporting Research

Nearly all projects have found it necessary to conduct a portion of their SR-CRSP research in the US. Such research is a part of the workplan developed for each overseas site, but is conducted in the US either because it is of a more fundamental nature—and therefore has universal applicability—or because of availability of facilities and equipment not accessible in the host country. Computer facilities are a case in point, and have been used in the US for developing production systems and biological models (Economics and Systems Analysis projects) as well as in data processing (e.g., Breeding Project). Some analytical work has required use of specialized techniques and equipment available in the US (Nutrition and Animal Health projects) and the Breeding projects have made use of specialized flocks and herds established for experimental purposes.

Institution Building

Training

Developed in close collaboration with host country institutions, the Program has devoted a large effort to training host country graduate students and technical staff, as well as US graduate students for work overseas.

The SR-CRSP has provided support for 56 overseas students pursuing advanced degrees at US universities. Twenty of these students are in doctoral programs. Forty students from our host countries are being supported for training to Bachelors and Masters degrees at home universities. The Program has also sponsored 22 US students conducting research on SR-CRSP related topics as part of the requirements for their MS and PhD degrees.

Advanced technical training has been provided for nine overseas professional staff who spent a total of 31 months in the US.

More than a dozen short training courses lasting over 15 weeks in all have been conducted in host countries, with over 350 local staff participating.

On-the-job training is a continuing and important part of the collaborative research effort. Though not quantified, the results are evident in the improved quality of work produced by all staff.

Organization Strengthening

Though never a formally planned part of the program strategy, the SR-CRSP has materially improved the research capabilities of participating institutions in ways other than scientific skills training.

SR-CRSP resources and activities for example have often been the catalyst that has inspired investment from other sources to provide essential long-term research facilities.

Recognition of the importance of sound administration as an ingredient of any research system has led to efforts to provide training and experience for host country administrators. In some cases host country administrative staff have taken over responsibilities previously held by expatriates in residence at overseas sites.

A most important accomplishment has been the linkages that the Program has helped develop between institutions and between subject disciplines. Applied research and problem solving demand contributions from various subject areas which are frequently segregated for historical reasons or administrative convenience. Developing operational linkages within the context of the Program's collaborative research has, in several cases, provided a basis for extending this collaboration to other problems of national importance.

Project Development

Several opportunities have arisen for furthering the principal objectives of the Program in ways apart from the main strategic approach. Three that deserve special mention were funded by the Program to the point when outside funding could take over.

Caprine Arthritis Encephilitis (CAE), introduced into Kenya in the mid 1970's from imported exotic goats, went unnoticed until SR-CRSP scientists spotted its symptoms, launched diagnostic tests, and on confirmation, worked with the Kenyan government to develop measures for its eradication—a feat which has now been accomplished.

The Program provided seed money for an Integrated Goat Production Project in Northwest Peru. With its initial surveys now complete and its future research agenda established, the project was able to successfully apply for funds from the Canadian IDRC to support a further three years work.

The SR-CRSP has taken several initiatives in trying to stimulate research on increasing prolificacy in sheep in developing countries. Two international workshops have been partly sponsored by the Program, and a project proposal commissioned on using prolific sheep research as a vehicle for building livestock research capacity.

Program Background

PROGRAM BACKGROUND

The Role of Agricultural Research in Developing Countries

In most developing countries, sustained economic growth and food security for expanding populations require a steady increase in agricultural production. Increases in agricultural output can no longer rely as they did in the past on expansion of farming into new lands. Instead, new technologies must be applied which can increase the productivity of existing land or bring otherwise marginal land into use.

The view that new technology increases agricultural growth has been demonstrated by the experience in Western Europe and the United States during the last century, but only recently has this been demonstrated for food crops in tropical countries. The increases in yields per unit of land of the improved rice varieties and hybrid corn in developing regions testify to the cost effectiveness of agricultural research. Recognition of this has been a major factor responsible for the substantial increase in the agricultural research effort over the last twenty years, directed towards increasing food supplies in developing countries.

One consequence of this perspective has been the emergence of a global agricultural research network. International agricultural research centers, such as IRRI and CIMMYT, which concentrate on commodities of global importance or on the agriculture of large agro-climatic regions; inter-country and regional research programs in developing countries; and national research organizations in both low and high income countries, are now in place.

The drive towards rapid industrialization, adopted by many low income countries as a means to economic growth, obscured the relatively high rates of return to investment in new agricultural technology. However, "trickle down" theories of economic development and economic development fuelled by industrialization are somewhat discredited. The need to feed growing populations is now seen as paramount, and the efforts of millions of small farmers are vital to achieve it. In this new context, it has been possible recognize and accept the high cost-effectiveness of investment in agricultural research.

Notwithstanding the highly uncertain outcome of research and the often inefficient use of money through inadequate project design and management, it has been suggested that there are few avenues for investment of public funds which can be expected so consistently to yield returns as high as those from investments in agricultural research programs. The increased funding for agricultural research in the last decade is a reflection of these expectations.

The development of the international agricultural research centers (IRRI, CYMMYT, ICRISAT, IITA, etc.) and the establishment, in 1971, of the Consultative Group on International Agricultural Research (CGIAR) provided a vision of hope and incentives for governments to enlarge research expenditures in developing countries.

The international research centers, by their very nature and mandates, are required to devote their main effort to tackling problems of broad applicability and to developing the technological foundation upon which location specific technologies can be established. It is also clear that each country has specific research needs that can best be met by research carried out in the environment in which the new technology is to be used.

Unfortunately, it is a common experience that national research programs in developing countries are often weak in conducting effective research to adapt the new technology that is becoming available. Efforts to remedy the weakness have been gaining momentum over the last decade as the economic importance of their potential contribution has been recognized. International agencies and research centers, as well as the development agencies in high income countries, have collaborated with the governments and research establishments of developing nations to improve local research systems.

Research institutions and universities from the more technically developed countries have become increasingly involved in efforts to improve the research systems of low income nations. It has been suggested that help from these types of institutions has particular merit in that the task they are asked to do overseas is very similar to what they do best at home: research, training, and extension.

In the United States, the special contributions that universities can provide has long been recognized by USAID, which has called upon university expertise extensively over the last three decades.

The Concept of the CRSP

In December 1975, the US Congress approved an amendment to the Foreign Assistance Act of 1961. Included in the amendment was Title XII, "Famine Prevention and Freedom from Hunger." A prime purpose of the new title was to provide the means by which US universities could make their expertise in science and technology more available to low income countries in their search for technical solutions to food and nutrition problems. Title XII provides for a strengthened university capacity and greater participation in overseas development activities. One component of Title XII is "program support for long-term collaborative

university research, in developing countries themselves, to the maximum extent possible, on food production, distribution, storage, marketing and consumption." This provision is being implemented by Collaborative Research Support Programs (CRSPs). The CRSP format has been designed to tackle broadly focused but interrelated multi-disciplinary research needs, and draws upon the capabilities of several institutions rather than any single one.

Funding for the CRSPs was to be provided by the United States Agency for International Development (USAID). A Board of International Food and Agricultural Development (BIFAD) was established to initiate implementation of the Act and to assist in the administration of the Title XII program. A Joint Research Committee (JRC) was appointed by BIFAD to help in conceptualizing, planning, and implementing CRSPs, a task which included help in identifying research priorities as well as in program selection, development, and evaluation.

By mid-1977, BIFAD had conducted an extensive process for identifying research areas, and recommended three to be used in testing the CRSP concept and procedures. Only two of these topics (Small Ruminants and Sorghum/Millet) were approved at the program selection stage, and became the first two CRSPs to be funded. Subsequently, CRSPs in the areas of Beans and Cowpeas, Human Nutrition, Pond Dynamics, and Tropical Soils have been developed.

The Origins of the Small Ruminant CRSP

There are approximately 400 million sheep and over 300 million goats in the developing countries of Asia, the Near East, Africa, and Latin America, representing over half of the total world population of these ruminants. Most of these sheep and goats are owned by small pastoralists and farmers with very limited resources. Generally, the various breeds used and their management are traditional; little effort has been made to upgrade them by incorporating modern technology, and the productivity per animal is low. However, because of their large numbers, small ruminants make a significant contribution to the economy and food supply in these countries. Their importance is often not seen in official statistics on commodities mainly because, being smallholder livestock, they are utilized by the farming family itself, or within the village. But there is little doubt of their widespread importance to the small farmer: they meet his needs and match his resources.

The low initial and maintenance costs of small ruminant livestock places them within reach of the small farmer. Because the investment is low, the risks of loss are acceptable. Feed costs are minimal since the animals are grazed on marginal lands unsuitable for cropping or fed crop residues. The cost of labor for supplying feed or grazing supervision is again minimal, since children can be given these tasks. The products from sheep and goats are convenient for local use and require no infrastructure, markets, or external technologies for their utilization. Their meat and milk outputs come in small quantities which can be readily consumed; their skins and fiber help support cottage industry and local demand.

Improving the performance of sheep and goats under smallholder management offers a direct route to improving the diets and living standards of more than 100 million people living in some of the poorest and least hospitable areas of the world. Much of the technology for improving small ruminant performance is already in existence in the more developed countries, but a major research initiative is required to adapt this technology to farmers' needs and the environments found in developing regions. By far the greatest part of this research has to be conducted in the country where the technology will eventually be used. Rarely, however, do the respective national research systems have the capability or resources for achieving this unaided.

The Goals and Organization of the Small Ruminant CRSP

The long-range goal of the Small Ruminant CRSP is to increase the food supply and incomes of smallholders raising sheep and goats. The major route for accomplishing this goal is by developing new technology to improve animal productivity. Research of this type, aimed at improving production, has to address many components of the production system. There is no single constraint to productivity, but usually several, which interact in a dynamic and complex manner. In the SR-CRSP, this is reflected in the number of scientific disciplines which are addressing the problem simultaneously: breeding and genetics, physiology and nutrition, health, range management, systems analysis, economics, sociology, and farm management. At the beginning of the program, thirteen US institutions were collaborating in seventeen research projects in these disciplines. Those institutions and the areas of research were:

- University of California, Davis
  —Breeding and Genetics
  —Animal Health
- Washington State University
  —Animal Health
- Colorado State University
  —Animal Health
- Montana State University
  —Breeding and Genetics
- California State Polytechnic University, Pomona
  —Male Reproductive Physiology
- Texas A&M University
  —Systems Analysis
  —Breeding and Genetics
- North Carolina State University
  —By-Products and Nutrition
- Ohio State University
  —Forages and Nutrition
- Texas Tech University
  —Range Management
- Utah State University
  —Range Management
  —Female Reproductive Physiology
- Tuskegee Institute
  —Intensive Farm Management
- University of Missouri
  —Rural Sociology
- Winrock International
  —Economics
  —Goat Production Systems

The efforts of each institution are directed by a Principal Investigator (PI) who was initially responsible for drafting the research proposal. Typically, each PI works on the SR-CRSP in a part-time capacity and remains at home base, making working visits to overseas sites. The proportion of a PI's time spent on the SR-CRSP varies considerably, depending on such factors as number of overseas sites and how the research project is organized. On average, PIs contribute about 25% of their time to the program.

Although the Small Ruminant CRSP comprises a number of closely interrelated projects which seek to contribute to a common set of objectives, each project has its own distinct objectives, and has considerable autonomy in designing and implementing its own activities. Apart from the way in which projects are interrelated through overlapping objectives, much of the cohesive strength of the program is provided by its organization and internal management.

Internal Management

The University of California, Davis was selected by the 13 collaborating US institutions to serve as the legal grantee for the program grant and to provide the Management Entity (ME).

The Management Entity, administered by a Program Director, provides leadership in the integration of research and training activities of the component projects, and is responsible for the overall research performance and fiscal management for the program. Within UCD, it is responsible to the Dean of the Graduate Division.

Though the role of the ME is carefully defined in the Grant document and the Board By-laws, practical realities indicate that its major tasks are to:

- Receive on behalf of the SR-CRSP, the funds committed by AID and assume accountability for their use.
- Provide funds to the participating institutions for SR-CRSP activities, and ensure compliance with the Terms of the Grant.
- Provide a focal point for the interaction among the Technical Committee (TC), the Board of Institutional Representatives (BIR), and the External Evaluation Panel (EEP) within the SR-CRSP and AID, JCARD and BIFAD outside the SR-CRSP.
- Execute the decisions of the TC and BIR and seek ways to implement the advice of the EEP.
- Maintain liaison with Regional Sub-Programs through the Directors of the overseas collaborating institutions and Site Coordinators and service them through provision of memoranda of understanding (MOUs).
- Generate the documents of the SR-CRSP including minutes of the TC and Board, reports of the EEP, the Integrated Program Plan, annual reports, the budget and the fiscal reports and provide these to AID and external auditors.

In addition to staffing the program office at UCD, the ME also provides each overseas worksite with a site coordinator, whose principal function is to provide logistical support for PIs and other participating scientists in work conducted at the foreign worksite. Depending on specific needs and opportunities, site coordinators also serve as communication linkages between scientists.

The work of the Management Entity is supported by three committees: the Technical Committee, the Board of Institutional Representatives, and the External Evaluation Panel.

The Technical Committee is comprised of all US Principal Investigators of each component research project, and advises the Program Director on:

- development of plans for the research and training programs and technical services including the addition, modification, or deletion of component projects and program elements;
- evaluation and recommendation of foreign worksites;
- development of staff and facilities at foreign worksites and planning their utilization;
- development of the annual budget plan for allocation of funds for component projects and work in foreign sites;
- development of policies on publication and dissemination of research results, including joint publications; and
- preparation of reports.

The Board of Institutional Representatives comprises one representative from the administration of each participating US institution. The functions of the Board are to:

- provide liaison between institutional administrations and the ME;
- advise the ME on general program policy and objectives, taking into account changing technical requirements of the program and the recommendations of the External Evaluation Panel;
- assess the content and balance of research in the SR-CRSP and the adequacy of funding;
- review cost sharing by the participating institutions and make recommendations as needed;
- review the general expenditure pattern of the SR-CRSP and approve the annual budget plan for allocation of funds to component projects and work in foreign sites;
- approve the addition or deletion of component projects and program elements and changes in program objectives; and
- review the progress and accomplishments of the SR-CRSP including research and training elements and technical services.

The External Evaluation Panel, a five member panel comprised of eminent scientists from non-participating institutions, acts in an advisory capacity and is responsible for periodic review and evaluation of program activities to assess whether particular project goals and program objectives are being accomplished. Specifically, this requires:

- annual reviews of the projects and the program;
- recommendation of changes in program objectives; and
- recommendation of changes in component projects or program elements.

SR-CRSP Overseas Worksites

The research product of the SR-CRSP is ultimately directed toward benefiting the low-resource producers in developing countries, such as smallholder farmers and nomadic herdsmen.

The problems unique to their situation make research overseas not only appropriate, but essential if meaningful progress is to be made in improving small ruminant productivity under these conditions. Because the overseas research component of the SR-CRSP was considered the cornerstone of the project, great care was taken to select appropriate overseas worksites.

Sites were chosen which are representative of the various ecozones and production systems encountered in the tropics so that the applicability of SR-CRSP findings can extend beyond the borders of any nation in which the research is conducted and be useful in other areas of similar climate and topography. Additionally, the countries in which the sites are located have established agricultural institutions staffed by scientists, trained personnel, and students with whom the SR-CRSP investigators have an opportunity to collaborate. These institutions are critical in providing the extension links which are the basis for adopting SR-CRSP findings by farmers.

Identification of overseas worksites, selection of host country collaborating institutions, development of collaborative research programs, and staff selection all took place during the first year of program implementation. There were initial exploratory visits to 21 countries before Brazil, Indonesia, Kenya, Morocco, and Peru were recommended as overseas SR-CRSP worksites.

In May 1979, these recommendations were accepted by the BIR and the Program Director began a series of administrative overseas site visits, the purpose of which was to discuss:

- which institute should collaborate with the SR-CRSP in the selected countries;
- which scientists within each of the selected institutions should collaborate with US counterparts;
- the content and nature of the MOU between the overseas institution and UCD representing the SR-CRSP participants;
- the time schedule for the scientist-to-scientist contacts required for planning and initiating the research program; and
- the preparation of a workplan for each overseas site.

Based on these visits and the discussions between scientists in 1979 and early 1980, an overseas worksite matrix (Table 1) was developed for SR-CRSP participating institutions.

Table 1. Participating US Institutions, Study Areas, and Overseas Locations as Arranged Early 1980

Study	Institution	Peru	Brazil	Indonesia	Morocco	Kenya
Range Management	Texas Tech	X				
	Utah		X		X	
Nutrition & Forages	Ohio	X				X
Nutrition By-Products	North Carolina		X	X		
Health	UC Davis		X	X		
	Colorado	X				
	Washington				X	X
Breeding & Genetics	UC Davis			X		X
	Montana	X			X	
	Texas A&M		X			
Management/ Production Systems	Tuskegee		X			
	Winrock					X
Reproduction	Utah/Cal Poly	X			X	
Economics	Winrock	X	X	X	X	X
Rural Sociology	Missouri	X	X	X	X	X
Systems Analysis	Texas A&M	X	X	X	X	X

Agreement between the University of California, Davis, and each of the overseas institutions participating in the SR-CRSP could not be negotiated in the same manner as the highly complex agreements between UCD and the individual US institutions involved in the Program. Many of the mandatory management responsibilities required by AID in accordance with Federal regulations are defined and transferred by these agreements. The use of such a model with each of the overseas institutions would inevitably take an inordinate amount of time to negotiate and arrangement through Government-to-Government agreement would take even longer. A model recommended by AID, overseas missions, BIFAD staff, JRC, and ME alike which has proven to be a valuable rapid implementation tool has been the development of a relatively simple Memorandum of Understanding between UCD and the official overseas collaborating institution. This broadly defines the scope of work and the anticipated contribution from US and host country institutions. While the same template was used for each of the collaborating institutions, each one was also modified to match local requirements and idiosyncracies. Research activities did not commence until the MOU's with each country were in place.

Table 2 shows the countries and the primary institution with whom the SR-CRSP is collaborating, the dates MOUs were signed, and the type of ecology that is being focused on in each situation.

Table 2. Overseas Research Locations of the SR-CRSP

Country	Ecology of Worksite	Type of Small Ruminant Production System	Institution	MOU Dated	Period of Program Existence at 9/30/83
Brazil	Semi-Arid Lowlands	Extensive	Empresa Brasileira de Pesquisa Agro-pecuaria (EMBRAPA)	March 1980	3 years, 6 months
Peru	Semi-Arid High Altitude	Extensive	Instituto Nacional de Investigacion y Promocion Agro-pecuaria (INIPA)	March 1980	3 years, 6 months
Indonesia	Humid Tropics Lowlands	Intensive	Agency for Agricul-tural Research and Development (AARD)	February 1980	3 years, 7 months
Kenya	Sub-Humid Tropical	Intensive	Ministry of Live-stock Development (MLD)	February 1980	3 years, 7 months
Morocco	Semi-Arid Savannah and Grassland	Extensive	Hassan II University	January 1982	1 year, 8 months

Funding for the Program

Funds for the SR-CRSP have been provided by USAID in the form of a grant, which requires participating US institutions to contribute a matching amount of not less than 25 percent. AID's total commitment up to September 30, 1983, is approximately $15.6 million. The cost sharing contribution by US institutions, taken at 25%, amounts to $3.9 million but in fact, after the first five years, matching has been $5.5 million. The overseas collaborating institutions have shown their own commitment to the program by contributions, mostly in kind, which amount to the equivalent of $1 million per annum.

The Funding Process

UCD places AID grant funds in a master account and establishes separate accounts for each subproject. The amount of the annual budget for each subproject, as approved by the BIR, is transferred to that account and administered under a written agreement between UCD and the participating institution. The institution is authorized to submit expense reports on a monthly basis for reimbursement, and these are approved by the ME before submission to UCD fiscal authorities for payment.

After the first year of funding of subprojects, the ME developed a set of guidelines for subsequent annual budget preparations by PIs. Budget detail is submitted to the ME for the ensuing year along with the annual report of prior year activities and expenditures.

The guidelines issued by the ME include target figures to guide the PI in budget preparation. These figures are based on prior expenditure patterns and the annual subproject plan approved by the TC.

The ME reviews all subproject budgets and makes adjustments found to be necessary. These budgets are made available to the TC for comment. The ME considers any observations made by the TC and submits a final budget proposal to the Board for approval. The Board may make further adjustments within the limits of funding availability.

The ME is responsible for executing the budget as approved by the Board. On occasion, the Board has approved special funds for expenditure through the ME. For example, funds were set aside for site development, for developing a program in Morocco, and for a contingency fund. In the case of the contingency fund, the Program Director is pre-authorized to utilize this fund for items up to $5,000. Larger amounts can be expended only with prior Board approval.

Except for site coordinator support, all host country expenditures flow through subproject budgets.

Research Objectives of the Small Ruminant CRSP

Accomplishment of the long range goal of increasing the efficiency of production of milk, meat and fiber by sheep and goats depends on satisfactory resolution of the constraints that presently limit productivity. The main problem areas that each project is tackling are indicated below, together with the more intermediate range objectives.

Genetic Improvement

The genetic potential of traditional breeds is generally the outcome of a selection process which reflects the impact of environmental, technological, economic and cultural constraints. It represents a strong bias towards survival of the animal under adverse conditions; productivity is only a secondary consideration, and is therefore usually low. With the availability of modern inputs, such as health protection, the genetic base of the stock can be profitably shifted towards greater productivity. Genetic and breeding projects therefore have the following objectives:

- Develop baseline data on the performance of indigenous small ruminants in order to initiate selection procedures for upgrading the genetic potential of native stock. The survival, fertility, and performance of local and local/exotic crosses will be compared in order to identify superior types, well adapted to local conditions.
- Characterize the production norms for indigenous and introduced breeds under local environmental conditions.
- Estimate the inheritance of important production traits, the genetic and phenotypic correlations among them, and genotype x environment interactions influencing them.
- Evaluate the potential for genetic improvement through selection and crossbreeding of native stock.
- Design coordinated large scale selection, breeding, and genetic improvement programs which can be sustained after the SR-CRSP terminates.

Reproduction

The key to improving livestock productivity is to optimize reproductive performance. Commonly in traditional production systems, performance falls well below potential. Factors which may contribute to this include delayed first estrus and parturition, low fertility and prolificacy, high embryo and postnatal losses, short reproductive life of breeding females, and maintenance of non-productive males and females in the flocks. The lack of knowledge of the basic reproductive processes of such indigenous animals as the alpaca, hair sheep, and highland wool sheep further hamper efforts to improve the reproductive performance of these animals. Accordingly, the aims of the reproductive physiology projects are to:

- Determine the male and female reproductive parameters for local goats and sheep, identify the reproductive processes limiting productivity, and establish estimates of reproductive potential for the genotypes studied.
- Establish recommendations for management practices which will optimize reproductive rates.

Nutrition and Feeding

Provision of year-round feed is an important step in improving small ruminant productivity. In most situations, the inadequacy of year-round feed supply is the primary limitation to productivity. When feed supplies fall to the level of maintenance rations and below, feedstuff and labor are non-productive inputs: animals, rather than gaining weight, are more likely losing it. There is little information on the intake, digestibility, and nutritive value of many common tropical forages and crop by-products, which could be utilized for developing a sustained feedbase.

This lack of knowledge about how various levels and combinations of common and exotic feeds influence potential animal productivity leaves unclear what constitutes optimum feeding regimens for animals at different stages of their production cycle. As there is currently no organized system for the efficient incorporation of these feedstuffs into rations, they are fed in combinations which do not necessarily make the best use of the available resources.

Research objectives for these projects are therefore to:

- Characterize the nutritional and economic value of available forage, by-product, and native range feedstuffs.

- Determine the nutritional requirements for indigenous goats and hair sheep in different stages of their productive life-cycle.
- Develop guidelines for formulation of balanced maximum profit rations which use the most advantageous combination of natural and cultivated forages at any given time of the year.
- Establish recommendations for herd and flock grazing practices on the range which will help optimize animal productivity and range conservation.
- Establish recommendations for mineral, protein, vitamin, and energy supplementation practices which will help optimize reproductive rates, disease and parasite resistance, growth rates, feed deficiency, and carcass grade at market age.

Range Management

Traditional grazing practices tend to be based on use of maximum land area, with minimum management of the rangeland itself. Today, with diminished grazing areas and greater populations of man and livestock, this approach leads to overgrazing and permanent damage to rangeland. These projects seek to establish improved grazing practices which provide livestock with more nutritious year-round grazing while at the same time maintaining the quality of the range. In striving towards these goals, the immediate objectives of the range management projects are to:

- Characterize range sites and evaluate existing plant communities in relation to their ecological potential.
- Determine the seasonal variation in availability and nutritive value of range forage plants.
- Evaluate the nutritional requirements, intake, and diet preferences of the grazing livestock at different stages of their productive cycle.
- Determine proper species and numbers of grazing animals to assure optimal long-term productivity and stability of the range.
- Establish recommendations for herd and flock grazing practices which will help optimize animal productivity and range stability.

Animal Health

A wide spectrum of health problems exists among the livestock in developing countries. Ailments which range from poorly characterized endemic parasite burdens to highly specific vector-borne diseases act in concert with other production system constraints and exert a considerable influence on overall animal performance. Poor health depletes the animals' resistance to environmental stress, compounds the debilitating effects of inadequate nutrition, and hampers reproductive performance, all of which cause reduced productive output and profit for small ruminant producers.

Though there are often no cures for many tropical diseases afflicting domestic livestock, their incidence can be reduced enormously by prophylactic measures and improved husbandry. The research objectives of the animal health projects are therefore to:

- Characterize the prevalence and impact of parasitic and infectious diseases in local herds and flocks, including seasonal, nutritional, management, and genetic effects.
- Establish practical guidelines for prevention and control of major diseases using improved diagnostic techniques and treatments for infections and internal parasites, in addition to an improved herd health management program.

Systems Analysis

The many biological parameters that govern the productivity of livestock interact amongst themselves in a very complex manner. This complexity makes it impossible for any one scientific discipline to predict the repercussions of changes introduced into the production systems.

The Systems Analysis Project is therefore seeking to integrate the interaction of the many factors contributing to the function of the production system, through a workplan which has as its objectives:

- Develop a computer simulation model of individual animal and flock performance based on data derived from nutritional, reproductive, and health studies.

- Study the dynamics of traditional and improved production systems, using the simulation technique, identifying the key factors for influencing productivity and productive efficiency, pointing out knowledge gaps, and establishing research priorities.

Rural Sociology

The social environment exerts a pervasive influence in determining overall patterns of sheep and goat husbandry. The decision making process of the farming family is set within this matrix of culture and tradition. If improved husbandry practices are to be adopted by smallholder society, they must offer benefits without concomitant social disruption. To help chart this course, the Rural Sociology Project has developed a research program which aims to:

- Establish, through extensive surveys, the key socio-cultural constraints to small ruminant production.
- Develop an understanding of the process of smallholder decision making, including the role and influence of women and children in sheep and goat production, and the role of livestock in the social fabric of the rural community.
- Evaluate prospective and implemented production system interventions, with a view to understanding the trade-off between increased productivity and social disruption.

Economics

The economic benefits that accrue from livestock rearing must be of major importance in the decision making process of the smallholder farmer. However elegant the solutions to problems of biological and technical constraints to production, they are not likely to have much practical meaning unless they appear economically sound to the smallholder. The gap in our understanding of existing production and marketing practices, the economic rationale underlying these activities, and the economic value of proposed interventions, all present major problems in proposing sound interventions. A further problem is the general lack of data collection and processing facilities which are needed to assess the progress being made at the smallholder level, as new technology is adopted. As such, the general objectives of the Economics Project are to:

- Characterize the existing production systems, including input/output relationships, the role of risk in decision making, and the overall economic rationality and efficiency.
- Study the constraints in transportation, processing, pricing, and storage systems as they relate to producer incentive and market efficiency, and how these may need to be modified to accommodate improved production practices.
- Study the availability of key inputs for the implementation of new recommended practices, including physical inputs, technical assistance, and credit.
- Assess the likely and actual impacts of proposed and implemented new production practices, especially as they concern nutrition, employment, income distribution, and local village economics.

Production Systems

In Kenya, an attempt is being made to develop and put in place a complete goat production system in a situation where small ruminants are almost entirely absent from the smallholder farming regime.

To be acceptable to smallscale farmers, the dual-purpose (meat and milk) goat production system must be based on low cost, low risk technology and be minimally competitive with cropping activities for land, labor, and capital resources. Even in developed temperate countries, relatively little research has been conducted on dairy goat systems, and what is known is generally not suited to production conditions of tropical developing countries.

Potential advantages of small, short gestation, litter bearing dairy ruminants for small-scale farming systems in the humid tropics are readily apparent. However, this apparent potential remains essentially untested. It is necessary to characterize existing farming systems in order to determine if and how this component can be introduced. The research problem, therefore, will be to develop an animal of the appropriate genotype, develop a health-nutrition-management package appropriate to the small farm resource base, and to ensure that this component is economically and sociologically acceptable.

The major research objectives of this project that are needed to meet this challenge are to:

- Characterize existing farming systems in locations selected as having potential for dual-purpose goat production.

- Analyze the farming systems to identify key constraints and propose alternative systems in which these constraints are relaxed.
- Synthesize and evaluate new technology-management packages initially through on-station research and subsequently through on-farm research.
- Assist in extending the new proven technology-management package to farmers in the target areas.

Inter-Relationships Between Subprojects

With the SR-CRSP as the pioneer of this particular program mode, it is not surprising that the grant agreement with USAID specifies the research objectives for the overall program in only the broadest terms. This has allowed a wide latitude of interpretation of the program in designing its operational components, a feature that proved to have particular value when worksites and overseas collaborating institutions were subsequently selected. It meant that each country program could be designed to take account of the specific prevailing circumstances. What emerged, as a consequence of this flexibility, was a series of country programs ranging conceptually from technical assistance to reduce a major production constraint to development of an entire technology production package. Certainly the reason for this spectrum of approaches lies in the different circumstances of each country worksite, such as the state of the existing livestock production system, the institutional setting, and government policies. But there was a further factor. The SR-CRSP, breaking new ground with the collaborative research mode, had little precedent to guide it in choosing implementation strategies that would meet the needs of diverse participants and institutions and targeted beneficiaries. Conceptual considerations offered no real help in providing such guidelines. It is true, for example, that an "integrated approach" has an appealing ring to it, but it is considered a difficult exercise to bring off successfully, and too often is nothing more than window dressing. Equally, the "single factor approach," with its strict focus on tackling a single constraint with little provision for other dimensions of understanding, leaves much to be desired.

The willingness of the SR-CRSP to accept the conceptual spread of the strategies for its overseas projects provides an opportunity for assessing the relative effectiveness of differing program strategies operating under the same management structure. It is convenient here to point out the slightly different approaches of the research activities in the five country worksites.

The objective of the program in Kenya is the development of a "technology package" intended to offer smallholders in intensively cropped areas of Western Kenya the entire technology required for dual-purpose goat production. In a situation where the extent of goat production is minimal and modern inputs almost non-existent, this requires not only new technologies, but ones that are consistent with the social setting and economic realities facing farmers. The development and testing of such a production package clearly demands very close working collaboration of PIs in different disciplines and a significant management effort by all involved has been required to achieve this. It has meant, for example, that research agendas of subprojects have had to be inter-related and research activities coordinated; in the interests of developing an integrated package, it has required surrendering some autonomy of individual research projects. This integrated mode of operation is one which is also in harmony with the needs of the Kenyan collaborating institution, the MLD, who wishes to develop the capability for this type of research approach.

In the four remaining worksites, Brazil, Peru, Indonesia, and Morocco, research is targeted at farming systems in which small ruminants already occupy a position of some importance. In these locations, research is aimed at reducing constraints in existing production systems to improve their poor productivity. The exact definition of the SR-CRSP program in these circumstances depends on a combination of effects that arise principally from specification of the key constraints, and the scope of research already being carried out on related topics by the collaborating institution. In Brazil and Peru, the problems that face small ruminant production are researched best by a SR-CRSP program that fields a broad spectrum of disciplines. However, the inter-disciplinary relationships are considerably less integrated than is the case in Kenya. This is partly in the nature of the problems being tackled, but in part also a result of institutional circumstances. Where the collaborating institutions are either strong and centralized, or operate in a fragmented fashion, a collaborative program with a highly integrated approach is either unnecessary or inadvisable.

Further away from the whole system approach with its full range of disciplines and mutual interdependencies, is the situation found in the Indonesian and Moroccan worksites. In each, the activities of the SR-CRSP serve mainly to complement the continuing work of the collaborating agencies, rather than to spearhead a broad attack on a fresh problem. In Morocco, for example, where the collaborating agency is strong in reproductive physiology and health care and wishes to integrate results as part of its own program, the SR-CRSP has only four projects on site.

Institution Building Objectives

A major goal of the SR-CRSP is to strengthen the capability of participating institutions to conduct research on small ruminant production systems.

Typically, the performance of national research systems in developing countries is hampered by shortages of trained manpower and deficient organizational structures. The latter are frequently manifested as a fragmentation of effort between institutions, weak linkages between research and extension, and the generation of research output that has little practical value to farmers.

Although the program was not planned to make formal improvements in the organizational structures of host country research establishments, it was always foreseen that there would be beneficial spin-offs in this area. The types of strengthening that have arisen in this way have been derived from:

- opportunities to work together with other scientists, which adds to host country scientists' scope of experience and understanding;
- exposures to the team approach to problem solving and the organizational cooperation and coordination essential to this research mode;
- complementarity of resources that strengthens host institutions' abilities to realize their own objectives; and
- availability of improved technology and information.

It is obviously difficult to quantify how these benefits improve a research system; they are generally regarded as important ingredients, but their value must rely on the subjective judgements of the participants themselves.

The program has taken a much more deliberate approach to making investments in the training of young scientists. The goals here have been to:

- give promising students from developing countries the opportunity of training for a degree at a US university in an area related to small ruminant production;
- offer students from the US the chance for post-graduate training in a developing country, within the context of a live problem-oriented program;
- provide host country scientists with the means to upgrade their professional skills, using mainly overseas visits and in-country workshops; and
- provide technical staff with training in specific skills needed for the program's research agenda.

Current Status of the Program

The Small Ruminant CRSP was the first program to be initiated in the CRSP format. Planners and directors did not have the advantages of any model to guide them in their choice of strategies for program implementation. There was little experience to suggest how best to manage and coordinate 13 US and 5 overseas institutions in order to generate effective research results. The existence of 17 semi-autonomous subprojects operating under a management entity, the scope of whose authority was yet to be expressed in operational terms, and the undefined functional relationships between the various management bodies in the program, all left much to be worked out during the initial years of project implementation.

The fact that the program has successfully negotiated these, and many like pitfalls, attests more to the sincerity and commitment of all those involved, than to the quality of the original program design.

Inevitably as the program has evolved, changes have been made to accommodate the many unforeseen circumstances that a long term endeavor faces. Some of these changes have been responses to budget constraints, some to allow more effective management and others to modify research directions to take account of new circumstances.

As it stands today, the overall program retains basically the main characteristics as originally conceived. A few of the major changes and comments on the present status of key issues are given briefly below.

Participating Institutions

Almost inevitably there have been changes in the original pattern of participating institutions and their worksites. Original project proposals were drawn up before worksites had been chosen. When this was completed, the magnitude of the tasks facing projects in various worksites became clearer, and, to make best use of fixed funding, several projects subsequently consolidated their activities to encompass fewer worksites. The Texas A&M Systems Analysis Project, for example, which had originally proposed activities in all five countries, has consolidated, and its major thrust is now in Kenya, with some lesser activities in Peru, and none at all in other sites.

Difficulties in finding suitable host country counterparts have led other projects to shelve their activities at certain sites. The situation of the UCD Health Project in Indonesia is a case in point.

Two institutions, Ohio State University and Tuskegee Institute, withdrew entirely from the program in September 1982. The essential components of their research agendas were incorporated by other participating PIs, and in this report, their accomplishments have been included with the reports of these investigators.

A somewhat different sitution arose in the case of the California State Polytechnic University, Pomona project on reproductive physiology. Given the budgetary constraints that the program was beginning to feel, and given the similarities of the Utah State University project on reproduction, it was decided that one of these institutions should play the lead role, and the other operate as a sub-contractor to it. The continuing research contribution of Cal Poly, Pomona, is now subsumed under the Utah State University Project, and is not reported separately in this volume.

Table 3 summarizes the current position of US participating institutions and the locations of their overseas projects.

Table 3. Participating US Institutions, Study Areas, and Overseas Locations, Mid-1983

Study	Institution	Peru	Brazil	Indonesia	Morocco	Kenya
Range Management	Texas Tech	X				
	Utah		X		X	
Nutrition/ Forages	North Carolina		X	X	X	
	Texas Tech	X				
	Winrock					X
Health	UC Davis		X			
	Colorado	X				
	Washington					X
Breeding & Genetics	UC Davis			X	X	
	Montana	X				
	Texas A&M		X			X
Management/ Production Systems	Winrock					X
	Texas A&M		X			
Reproduction	Utah	X	X			
Economics	Winrock	X	X	X		X
Rural Sociology	Missouri	X	X	X	X	X
Systems Analysis	Texas A&M					X

Although the SR-CRSP has an MOU with only one primary institution in each overseas country, other host country institutions have been drawn into the program. Each subproject, with the concurrence of the primary overseas institution, has made arrangements to work with other national institutions where this best meets the needs of the particular research plan.

A summary of participating host country institutions is given in Appendix IV.

Research and Training

From the outset, the SR-CRSP was envisioned as a long-term program. It was anticipated that, subject to satisfactory performance, the initial 5-year grant would be extended. Part of the rationale for this lies in the inherently long-term nature of research on livestock production systems. It is simply not feasible to complete some major aspects of this research (e.g., breeding) in short-term projects. But the desirability of a long-term program is also due to the extra benefits that technical assistance programs derive from longer term relationships between the people and institutions involved.

Though this report covers the first five year grant period, it is in no sense to be construed as a terminal report. Every project in each of the different worksites is continuing both its research and training activities. The direction of future research and a sense of what still needs to be accomplished, is given more fully in the reports of the Principal Investigators.

A notable trend in the continuing work is the increasing responsibility being undertaken by host country scientists and administrators. Much of this represents the benefits from the program's heavy investment in training of overseas personnel in technical matters as well as in the management of research programs.

In several worksites, research projects pursued initially along disciplinary lines are increasingly finding the need for closer conceptual and working relationships with other SR-CRSP subprojects. This need for greater integration is a natural consequence of convergence towards a common goal. Even so, there is a resulting demand for a planned and orchestrated process for managing integration of functions.

This need has presented a challenge to participating scientists, because for the most part, they are educated in specialized disciplines, rather than in the management and systematic integration of technical, economic, and social sciences towards a common goal. But the challenge has not been limited to the scientists; it is also a matter which confronts institutions. Many research institutions are neither structured nor organized to engage in research that requires the balanced input of a diversity of disciplines. Progress towards this is being made through the activities of the program, but changes of this nature are intrinsically protracted.

Future Funding

The first five year grant from AID for the Small Ruminant CRSP ended on September 30, 1983. An extension of one year has been granted, during the early part of which AID will review the program to determine whether funding for an additional three years would be justified. Research agendas for all projects continue to be planned in anticipation of this extension.

Program Accomplishments

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BRAZIL

Eight states of Northeastern Brazil form a natural ecological region separated by climate and vegetation from the rest of the country. In this region, there are essentially two ecoclimatic zones: a dry inland region called the *sertao* and a narrow coastal strip with a humid climate.

The semi-arid *sertao,* the site of SR-CRSP research, is an area encompassing approximately one million square kilometers, with a population in excess of 12 million people. The climate is characterized by distinct wet and dry periods, each lasting approximately 6 months, and relatively little seasonal variation in temperature. The entire annual precipitation occurs from January to June with a rainfall ranging from 300-900 mm but evaporation is high, frequently as much as 66% of precipitation. Compounding the effects of a water deficit, is the unreliability of rainfall; minor droughts are common, and major droughts periodic—there have already been six catastrophic droughts this century.

Small Ruminant CRSP worksites in the semi-arid region of Northeast Brazil.

The typical vegetation of the *sertao,* known as *caatinga,* is a secondary cover which follows centuries of felling and over-grazing, and consists of a mixture of small trees and bushes with some herbaceous ground cover. In some places the *caatinga* has been cleared for grazing; in others, cotton has been planted. Apart from this and small patches of subsistence crops (maize, pulses, manioc, vegetables, fruit), there is little cultivation outside the areas of irrigation.

Both crop and livestock production provide the rural people of the *sertao* with food and agricultural commodities for home use and cash income. Major agricultural produce includes corn, cotton, beans, rice and cassava; the first three of which are the primary crops of the semi-arid Northeast. Sheep and goats are the predominant livestock species although there are some cattle confined primarily to the wetter regions closer to the coast. The 5 million sheep in the *sertao* are the smooth hair type rather than the traditional wool type commonly found in the more temperate areas of Southern Brazil, and represent about 30% of Brazil's total sheep population.

Over 90% (6 million) of the country's goat population is found in the arid and semi-arid areas of the interior. Their proportion of the total livestock population increases as one moves away from the coast and the rainfall decreases.

Sheep and goats in Northeast Brazil provide a major source of animal protein and cash income. They are raised primarily to produce meat for home consumption, but the animals themselves, and their hides and skins, are also important generators of revenue. Despite the fact that goats appear to be better adapted and more suited to the rigorous semi-arid environment, the farmers in Northeastern Brazil seem to prefer keeping sheep to goats, perhaps because sheep are more easily herded and confined and their meat is more popular than that of goats. Although sheep are apparently never milked, goats are, and most of the milk is used on the farm. Except for the use of goats for dairy production, sheep and goats serve a similar function. It is not known to what extent they are competitive for the same limited resource base and if each species is being raised in the numbers and proportions most advantageous for the optimum management and utilization of the *caatinga.*

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Any program for improving livestock production in the semi-arid interior of Northeast Brazil must address the major constraint to animal productivity: the pronounced seasonal vegetation pattern and the drastic decline of available dry season feed on the range. The prolonged period of nutritional inadequacy causes livestock severe nutritional stress, particularly during the post-weaning, late gestation, and early lactation stages of their productive cycle. They have great difficulty maintaining acceptable rates of growth and reproduction, indeed even surviving during the dry season.

This problem is reflected in their small size, low yield, and depressed offtake, which is estimated at less than 20% of the average in many other areas of the country. There is currently a lack of knowledge of the *caatinga's* ability to support livestock, of the management of this resource, and of the sheep and goats which depend upon it for sustenance. Without more information about factors relating to the *caatinga,* it would be difficult to devise management schemes to mitigate the problem of the dry season feed deficit and enhance animal performance.

A number of long-term programs to raise the standard of living of Northeast Brazil's rural and urban sectors are currently being undertaken by the Brazilian government. A high priority has been placed on improving the performance of small ruminants as a means of improving the nutritional level and earning capacity of the people of the *sertao,* especially the most deprived and impoverished. In addition, improved sheep and goat production is expected to aid the economies of both the rural and urban sectors by increasing the supply of livestock products (hides and skins) upon which Northeast Brazil's regional industries depend. The urban sector is also expected to benefit by the increased meat supply available to city dwellers and the alleviation of migration of rural people into the already overcrowded urban areas.

The government agency, Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), is responsible for coordinating agricultural development and improvement programs throughout Brazil. They have recognized that currently existing technological improvements for sheep and goat husbandry, which for the most part were developed in the temperate regions of Europe, North America, Australia and New Zealand, cannot be transferred directly to Northeast Brazil. Only technologies appropriate for and adapted to semi-arid tropical environments can be effectively implemented and achieve positive results. Research must be conducted to develop these new technologies *in situ* so they are responsive to the actual conditions in which they are intended to function.

At the time of initiation of the SR-CRSP, EMBRAPA was a new organization in the unique position of being able to develop an original research program to meet this challenge. In response to the dynamic and complex manner in which physical, biological, economic, and social factors interact in agricultural systems, EMBRAPA's leadership has emphasized the formation of multi-disciplinary teams to focus on the entire production system and not on isolated components or constraints. This approach was already central to the Small Ruminant CRSP research philosophy.

In September and October 1979, SR-CRSP scientists travelled to Brazil to confer with EMBRAPA administrative and technical personnel at two of EMBRAPA's National Research Centers in Northeast Brazil: Centro Nacional Pesquisa en Caprinos, in Sobral, Ceara (CNPC) and Centro de Pesquisa Agropecuaria no Tropico Semi-Arido, in Petrolina, Pernambuco (CPATSA). Located at these centers are the Brazilian counterpart investigators with whom the SR-CRSP researchers are currently collaborating.

The collaborative research program on the production and socio-economic problems related to goat and hair sheep enterprises in Northeast Brazil consists of projects in seven subject matter areas, each directed jointly by US and Brazilian investigators. Details of institutions collaborating on each project are provided in Appendix IV.

These projects, Animal Breeding and Management, Range Management, Nutrition, Reproduction, Animal Health, Economics and Sociology, have cooperated closely to examine all aspects of the small ruminant production system in the *caatinga* in an integrated and collective manner. The reports of their research and training accomplishments which follow are the outcome of the first three years' endeavors.

Economic Analysis of Small Ruminant Production and Marketing Systems

A.J. De Boer
Winrock International

The major long-term goal of the Economics Project was to set up and institutionalize a research approach that was analytically appropriate to the agro-ecological conditions of this region, flexible enough to incorporate the wide range of production systems found in the *sertao,* and that could be understood and used by biological scientists within the National Goat Research Center (CNPC). The rapid and accurate assessment of technology generated by the cooperating research stations and the training of Brazilian personnel in the various components of this research approach are all key elements in the success of the project.

Other goals which are critical to project success are developing reliable data bases for research and policy purposes, improving design and evaluation of on-farm testing of technology, and answering some important questions about the nature and magnitude of off-farm constraints which limit small ruminant productivity.

The following research agenda was developed to achieve these goals:

- Conduct descriptive (diagnostic) surveys to characterize small ruminant production systems in the *sertao* including farm profiles, farmers' goals and objectives, family consumption requirements, land-use patterns, on-farm levels of animal productivity, grazing patterns, levels of technology applied to cattle and small ruminants, and resource-use patterns.
- Design a long-term farm monitoring survey to obtain production traits of sheep and goats on participating farms under a range of agro-economic conditions using the survey information.
- Design experiments at the CNPC to help overcome production constraints related to nutrition, range management, animal production, health, and breeding.
- Carry out economic analysis of research trials conducted at the CNPC stations, at cooperating research stations and on-farm trials designed to test the suitability of specific technologies under actual farming conditions.
- Study the marketing and price formation procedures for small ruminants and their products in Northeast Brazil and identify policies to improve the performance of the overall marketing system.
- Construct and use a whole-farm linear programming model as a device to synthesize survey information, experimental results, farmer objectives, and alternative management and investment strategies into simple measures of economic costs and benefits.
- Train Brazilian staff in all steps of the research process and in the requirements for interdisciplinary research.

Research Accomplishments

The descriptive and diagnostic stages began in April 1980 and were initially limited to the main small ruminant production areas of Ceara State. The objectives of the survey were to characterize the major farming systems under which sheep and goats are produced, analyze the importance of cattle and cropping enterprises vis a vis small ruminants, describe interactions between enterprises, estimate farm resources and their patterns of use, and describe the production practices applied to small ruminants.

The 1976 crop/livestock Census of Ceara State indicated that seven of the twenty-two micro regions in Ceara contained over 50% of the sheep and goats. Within each of the five micro regions selected, two counties were selected for the economics survey. An average of fifteen questionnaires were filled out per county. One county was subsequently discarded. Studies were conducted on 127 mixed crop/livestock farms with large populations of cattle. Data was analyzed and published in Brazil. Table 1 gives the distribution of agricultural activities by the surveyed farmers. Seven groups of small ruminant owners were distinguished: landowners, manager-sharecroppers, sharecroppers, land settlement scheme farmers (parceiros), cash renters, communal owners, and employees or permanent workers. In general, landowners (64% of the small ruminant owners sampled) have large holdings which are jointly utilized by themselves, sharecroppers, and permanent or temporary wage laborers. The average size of goat herds was 116 head and 142 head for sheep flocks. Most specialization occurred in sheep (39%) rather than goats (3%). Fifty-eight percent had both species (Table 2). Levels of management varied but most producers had corrals, full-time herdsmen, used studs, and castrated; controlled breeding was rare, however.

The baseline data was used to separate farms into large and small categories based on median farm size within the county sample. The sixty-two farms in the small grouping had an average of 172 ha, the 65 large farms averaged 1,165 ha while the sample mean was 680 ha. Linear regression was used to test hypotheses about land-livestock relationships. The major factors hypothesized as influencing total animal units (AU) per farm were farm size, total man equivalents of labor available per farm, and percentage of farm perimeter area fenced. The first two variables were highly significant but total variation in AU's explained by the equation was small (Gutierrez et al., 1981).

A subset of these 127 farms was chosen to participate in the long-term farm monitoring survey. A total of four farms (two large, two small) were selected in each of eight counties. Questionnaire construction started in June 1980, and the first round of surveys started in August-September 1980. A total of eight rounds have thus far been completed. Two studies have been completed using this data: the first examined

Table 1. Distribution of Major Agricultural Activities by Survey Farmers

County	Farms with Crops, Sheep and Goats	Farms with Cattle, Sheep and Goats	Farms with Crops, Cattle, Sheep and Goats
Granja	87	87	80
Sobral	94	88	81
Crateus	93	85	85
Independencia	100	93	93
Taua	94	94	87
Parambu	100	100	100
Quixada	100	100	100
Quixeramobim	100	89	89
Morada Nova	94	94	87
Average %	96	92	88

Source: Gutierrez et al. (1981), p. 14.

capital structure and income generation on the thirty-two sample farms while the second defined general marketing practices and utilization of small ruminants.

Analysis of capital structure concentrated on capital assets, income generation, variable costs, and income/capital ratios between the small farm and large farm groupings. Results were much different between the large and small groups depending upon whether herd/flock size or farm size was used as the delimiter. Small herd/flock holders realized 40% of their net farm income from small ruminants while large herd/flock owners had only 19% of net income from small ruminants and 50% from cattle. Conversely, small landholders had 71% of their net income from cattle and 10% from small ruminants while large landholders had income almost equally divided between cattle, small ruminants and crops (Tables 3 and 4). Overall, there was good corre-

Table 2. Characteristics of Small Ruminant Populations on Sample Farms

County	Average Small Ruminant Population Per Farm (Head)			Producers with only Goats (%)	Producers with only Sheep (%)	Producers with Sheep and Goats (%)
	Goats	Sheep	Sheep and Goats[a]			
Granja	163	149	271	13	13	74
Sobral	60	115	145	0	56	44
Crateus	49	172	194	0	54	46
Independencia	213[b]	173	233	0	71	29
Taua	262	218	448	0	13	87
Parambu	90	49	118	0	14	79
Quixada	94	165	209	0	47	53
Quixeramobim	57	133	161	0	44	56
Morada Nova	58	108	121	6	40	54
Average	116	142	211	3	39	58

[a] The average sheep and goat population does not equal the average of the two preceding columns since not all farms had both species.

[b] A very small number of farms had goats.

Table 3. Average Net Farm Incomes by Activity and by Farm Type in 1980 (US$)*

	All Farms		Small Herd/ Flock Farms		Large Herd/ Flock Farms		Small Land-Holder Farms		Large Land-Holder Farms	
Activity	($)	(%)	($)	(%)	($)	(%)	($)	(%)	($)	(%)
Cattle	880	42	516	28	1110	50	1064	71	823	36
Sheep/goats	544	26	736	40	422	19	150	10	686	30
Crops	663	32	589	32	689	31	284	19	777	34
Total	2,087	100	1,841	100	2,221	100	1,498	100	2,286	100

Small herd/flock farms = 13
Large herd/flock farms = 20
Small landholder farms = 9
Large landholder farms = 24

*Official exchange rate, December 1980 was CR 64 = $1US

Source: Periodical Survey, 1980.

spondence between levels of capital invested in cattle, expenses on cattle and income derived from cattle. This did not hold for small ruminants, however, reflecting their subsistence orientation as a ready source of food and a species on which very low levels of capital investments or current inputs are used. The ratio or income generated to capital invested is thus very favorable for small ruminants in this region (Gutierrez et al., 1982).

Examination of general marketing and consumption practices revealed that sheep and goats are disposed of through home consumption and commercial sales, the latter comprising surplus males (1-1½ years old), cull females, and cull male breeding stock. In Ceara, there are two markets for live animals, rural and urban. The rural market consists of sales to local farmers and farm laborers as well as sales to the small towns scattered throughout the rural areas. Rural markets are the main outlet for sheep and goats because mutton/chevon is less expensive and because of the convenience factor related to small carcass size and regular availability. During the periodical survey, data on sales, home consumption, animal prices and disposition of animals and animal products was collected for three periods covering December 1979 to March 1981. Table 5 gives some summary data from these farms. The results indicate that on-farm consumption of sheep and goats is common, with twenty-eight of the twenty-nine sheep producers consuming an average of sixteen sheep per family over the 16-month period, and eighteen of the nineteen goat producers consuming an average of nine goats over the same period. Sales were about twice the level of home consumption for each species. Offtake over the 16-month period was 43% for sheep flocks (16 consumed + 27 sold) per 99 head and 41% for the goat herds (9 + 17) per 64 head.

On a yearly basis, offtake averaged 24%. About 40% of this offtake was home consumption and 60% was sold off the farm. The offtake for sheep was marginally higher than for goats (25% vs. 21%), but percentages of total herd home/consumed were identical. Therefore, home-consumption is in direct proportion to flock/herd size. This is because larger farms have larger flocks/herds; they also have larger labor forces to feed or to whom home-slaughtered meat can be sold.

Selling strategies favored sales directly at the farm. Farmers cited more flexibility and better bargaining power as well as the cost and convenience of taking animals to market. Of the remainder, 24% were sold to local markets, and 2% cited other outlets. Purchasers were local middlemen (70%), other producers (24%), and urban middlemen (6%). Sales were "by head," not by weight, and an average price for a lot of animals is arrived at. Almost all sales were on a cash basis (Gutierrez and De Boer, 1982).

Work is continuing at Winrock International and in Brazil on statistical analysis of the complex data set on animal performance which is being collected by the periodic survey. In addition, the Animal Health Project has participated in this survey and the Range Management component will collaborate on some research on these farms in 1983/84.

The above information was synthesized into a formal economic model of the whole-farm production unit. The survey results clearly indicated that technology packages aimed specifically at small ruminants could not be analyzed in isolation because of economic and biological interactions with the other important farm enterprises (cropping and cattle). This modeling was carried out at Winrock and Purdue during 1982. Substantial inputs into the model were also made by the Utah State Range Project.

The bioeconomic model was developed using a linear programming approach to analyze sheep and goat production at the whole-farm level. It has four major components: crops, animal feed production, livestock production, and home consumption. The model consists of 690 activities and

Table 4. Components of Gross Income by Activity

A. By total farm income

Component	Activities			
	Cattle	Sheep & Goats	Crops	All
	%			
Sales	46	12	13	71
Farm consumption	—	7	9	16
Seeds	—	—	1	1
Animal feed	—	—	3	3
Payment in kind	—	1	8	9
Total	46	20	34	100

B. By activity gross income

Component	Activities		
	Cattle	Sheep & Goats	Crops
	%		
Sales	100	60	38
Farm consumption	—	35	26
Seeds	—	—	3
Animal feed	—	—	9
Payment in kind	—	5	24
Total	100	100	100

Source: Periodical Survey, 1980.

288 rows. The time unit used was a calendar year divided into four quarters to capture the seasonal effects on productivity. The values for some of the 1,995 parameters were obtained from the baseline and periodical surveys, but many of the biological parameters were derived from experimental data. The objective function of the model maximizes net cash income subject to certain constraints on resource endowment, home consumption requirements, capital and credit limitations. The model determines the inventories of cattle, sheep, and goats by quarter. The model also determines the optimal livestock activities (breeding, growing, fattening) as well as the optimal age for sale and purchase. For crops, it determines planted areas as well as the production system (monoculture or mixed cropping). To illustrate the model performance, an average traditional farm was analyzed, some technical changes tested and, finally, two weather conditions simulated to estimate the influence of weather on production patterns. This study resulted in a PhD thesis submitted to Purdue University (Gutierrez, 1983).

The model generated optimal farm plans which were found to be consistent with actual input and output levels observed on the "typical" farm types modeled. Initial results gave cattle as the only livestock species because it was not possible to segregate vegetation species according to livestock preferences. The higher prices per kg for cattle and poor reproductive levels of traditional sheep and goat flocks/herds resulted in cattle utilizing all available feed nutrients. After consultations with other researchers, available biomass was portioned and sheep and goats entered the optimal model solutions at levels close to those actually observed.

The optimal small ruminant activity shown by the model was purchasing and fattening young stock rather than the breeding activity which is predominant in the *sertao*. When reproductive performance was increased from the net weaning rate of 70% assumed in the model to a 100% rate, the breeding activity entered the optimal solution and net cash income increased by 3%. The model was further used to simulate the impact of good and poor weather conditions on net farm income and levels of sheep and goat production. Under good weather conditions, income increased to 185% (average situation = 100%) while under poor weather, income was 53% of the average level. If the income effects generated with weather variability are compared with the income effects generated by the technological improvement cited above (a 42% increase in weaning percentage leading to a 3% increase in net farm income), this indicates the tremendous influence of weather on feed production and farm income relative to an improvement of small ruminant herd/flock productivity.

The other major area of research complemented the survey work on sheep and goat marketing methods and price formation procedures. In the first study (de Souza, 1981), we hypothesized that weather conditions, prices, a time trend, and inventories all influenced the annual supply of sheep and goats. Statistical supply equations were estimated and the coefficients indicated that producers' annual adjustments of inventories were of a similar magnitude for both sheep and goats. The sales equations are formulated as adjustments of producer inventories which are themselves functions of prices. Again, the estimated coefficients between the sheep and goat supply equations are similar. However, in neither equation is the current (i.e., January 1) stock of animals a statistically significant predictor of sales during the year. The time trend variable is not significant either. By far the most important influence of current year sales is the previous year's inventory of animals, which is a function of the previous year's weather conditions and prices.

In this type of animal supply situation, the highly variable moisture supply conditions lead to major fluctuations in animal inventories and sales. Adjustments of these in response to prices are less important, and a critical economic factor is the ability of producers to adjust their production conditions so they can avoid selling when prices are depressed, such as during drought periods (three consecutive years of much below normal rainfall is a general rule of thumb in this region).

Table 5. Sheep and Goat Populations, Animal Disposals and Product Prices for 33 Sample Farms, Ceara State, 1980-81

	N*	Range	Mean	sd
Total farm area (ha)	33	10-800	265	236
Sheep population, May 1980	29	21-260	99	59
Goat population, May 1980	19	2-129	64	40
Total sheep and goat population, May 1980	33	38-273	124	68
On-farm consumption, Dec. 1979-March 1981:				
Sheep	28	1-45	16	12
Goats	18	1-19	9	6
Number sold, Dec. 1979-March 1981:				
Sheep	28	1-155	27	34
Goats	16	1-44	17	9
Prices of meat sold from farm ($/kg):				
May 1980	16	1.00-2.39	1.68	0.40
Sept. 1980	21	1.20-2.06	1.51	0.27
Dec. 1980	17	1.57-2.19	1.75	0.20
March 1981	21			
Prices of skins sold from farms ($/piece)				
Sheep: May 1980	15	1.00-3.60	2.95	0.40
Sept. 1980	18	1.54-2.57	1.84	0.26
Dec. 1980	13	1.72-2.82	2.22	0.28
March 1981	22			
Goats: May 1980	14	3.00-3.60	3.13	0.30
Sept. 1980	15	1.72-2.57	2.04	0.27
Dec. 1980	10	1.88-2.66	2.21	0.25
March 1981	10	2.66-3.44	3.07	0.17

*n refers to the number of farms in each category of data. For example, 29 farms had sheep, 19 had goats, and 28 farms slaughtered one or more sheep for home consumption during the 16 month period. The means and standard deviations (sd) for each category are computed using the n appropriate to that category, not the n=33 for the entire sample.

The second study examined the international market for Brazilian sheep and goat skins. Increased export of skins, leather and finished leather products is an important objective of the Brazilian government and this study attempted to determine what factors influenced exports. Secondary data from 1969 through 1975 were utilized. The price elasticity of supply for goat skin exports was 0.30 which shows less than a proportional export response to a change in export price. The quantity exported during the current year was highly influenced by quantity produced the preceding year. The price of goat skins in the Brazilian market was not a significant variable influencing exports.

The price elasticity of sheep pelts for export was -2.18 which does not concur with economic theory. Other variables influencing sheepskin exports included sheepskin production during the preceding year and increased domestic incomes which reduced supplies for export (de Moraes, 1982).

Significance of Research Findings

It is important to note that the research results to date are derived exclusively from data collected in Ceara State, much of which is not typical of the extensive small ruminant producing areas in parts of other northeastern states. In general, cattle and cropping were important competing enterprises. Small herd/flock holders gained relatively more income from small ruminants than holders of large numbers of ruminants. Large landholders had income coming about equally from small ruminants, cattle, and crops. This is significant for the research direction in that owners of smaller landholdings and smaller herds/flocks may be more receptive to innovations since their small ruminants are more important economic assets. Goats, in particular, have many characteristics of a subsistence enterprise: the surveys identified low levels of inputs used, almost no supplemental feeding practiced during the dry season, high levels of home consumption, and little selective breeding being practiced. Technical improvement will have to go hand in hand with commercialization of the industry and programs to educate

producers about the potential economic benefits of small ruminants in general and goats in particular.

The whole-farm linear programming model was found to be an adequate representation of existing farm practices and is a flexible analytical tool which can be used to test the economic impact, as measured by net farm cash income, of specific practices (e.g., supplemental feeding, forage crop production, planting improved pastures, worming), or sets of practices (e.g., pasture rotation on different types of pastures, cross-breeding combined with a culling regime). The model also indicated that climatic variation will be a much larger influence on net farm cash income than even substantial improvements in herd/flock productivity. The impact of strategies for better managing drought may help overcome these large fluctuations in animal numbers and farm income.

The research on marketing and price formation identified no obvious constraints within the traditional system given the extensive nature of production, long distances between producers and markets, small numbers marketing per farm and low offtake rates. The price seemed most directly related to animal size. The forthcoming analysis of three years' data from the periodical survey will allow more accurate estimates of factors determining the on-farm prices received for small ruminants.

Implications for Future Research

Economic Analysis of Research Results

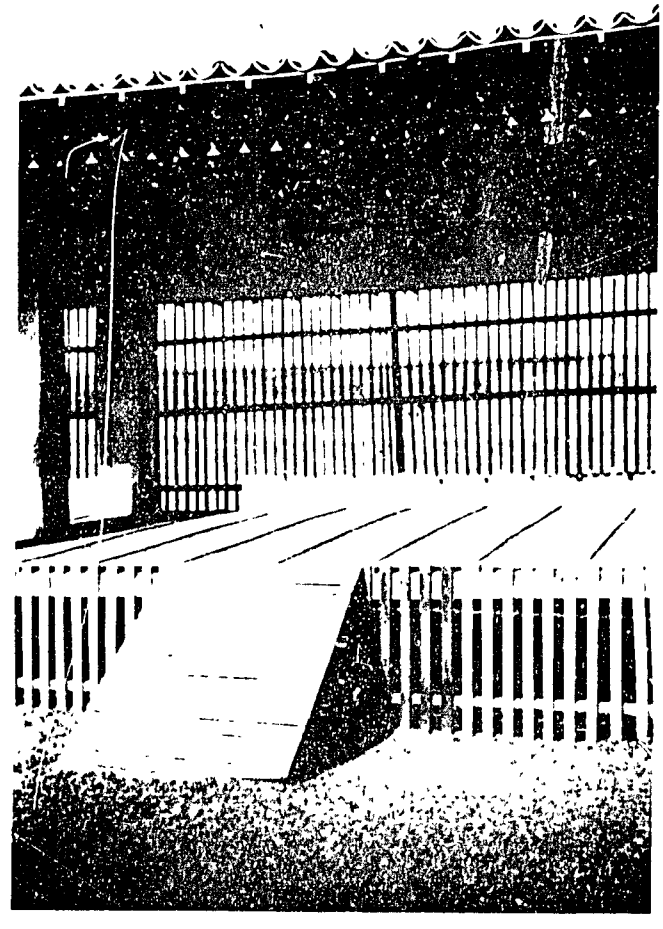
The framework is now in place to train Brazilian researchers in the use of the linear programming model and to use it for the routine analysis of proposed small ruminant interventions. For single experiments, simple budgeting procedures will continue to be used. The focus will now be on forming interdisciplinary teams in the major research areas who can develop specific technology packages which we can then proceed to analyze. A major component of the linear programming model deals with feed utilization and the Range Management Project in particular will work closely with us to improve this aspect of the model and to develop specific range management and feeding regimes that can be subjected to model analysis. An important feature of the model is the ability to trace the impact of a technology over a sequence of weather conditions; the stability of model predictions over a range of possible precipitation regimes can thus be assured.

Field Research

The ongoing operation of the 32-farm periodic survey not only continues to provide data on production characteristics of sheep and goats, but serves also as a field laboratory for the animal health team to assess the farm level incidence of specific animal health problems. It will further be used in a joint project by Range Management and Economics to identify vegetation types and relate these to animal performance, herd/flock numbers, and farm economic status. It is anticipated that these farms will be increasingly used for on-farm experimentation and the economic analysis of these results will be made easier because of the long-term nature of monitoring their performance.

Market Analysis

One constraint to increased production of small ruminants in the Northeast may be lack of favorable prices and market demand for small ruminant meat. Beef is much more expensive in retail markets in the Northeast and if the long-term demand prospects for small ruminant meat are unfavorable, this could have serious implications for small ruminant improvement programs. Therefore, a major study is needed to examine consumer characteristics and the long-term consumption and price prospects for small ruminant meat. Several institutions in the Northeast have an interest in this work and the necessary data so there are good prospects that this research can be carried out before the conclusion of the SR-CRSP.



Goat shelters such as this have been subsidized by the Brazilian government with the hope that they would increase survival and reduce parasitism in the livestock. Photo: W.C. Weir.

Training

The emphasis of the Economics Project has been on developing a network of Brazilian social scientists with experience and expertise in the analysis of small ruminant problems. The project was handicapped during the first 2½ years by not having an EMBRAPA economist assigned as a

Co-PI at CNPC/Sobral, but a significant investment was nevertheless made in training. Two computer software packages were purchased and installed at the Federal University of Ceara's computer center. Training in the use of these packages was provided by Nestor Gutierrez, and these were subsequently used by two graduate students in the Department of Agricultural Economics at that University who were partially supported by SR-CRSP funds. On-the-job training was provided to both students, and they participated in the periodic surveys.

Three advanced degrees have been received under full or partial SR-CRSP support. Titles of theses are indicated in the publication section of this report.

Selected Publications

Gutierrez-Aleman, Nestor. 1983 Characterization and Linear Programming Analysis of Sheep and Goat Production in the *Sertao* Zone of Northeast Brazil. PhD Thesis, Purdue University.

Gutierrez-Aleman, N., A.J. De Boer, and E W. Kehrberg. 1983. Modelo Matematico para Valuar Tecnologias Pecuarias a Nivel do Toda la Finca en el Nordeste de Brazil (Mathematical Model to Evaluate Livestock Technology at Whole-Farm Level in Northeast Brazil). To be Presented at IX ALPA Meetings, Santiago, Chile.

Gutierrez-Aleman, N., A J De Boer, and J. Ubiraci-Alves. 1983. Characteristicas Economicas de los Systemas de Produccion de Pequenos Rumiantes en el *Sertao* de Ceara Brasil (Economic Characteristics of Small Ruminant Production Systems in the *Sertao* Zone of Ceara, Brazil). To be Presented at IX ALPA Meetings, Santiago, Chile.

Gutierrez, N. and A.J. De Boer. 1982 Marketing and Price Formation for Meat Goats, Hair Sheep, and their Products in Ceara State, Northeast Brazil. Proc. III Intl. Conf. on Goat Prod. and Dis. Tucson, AZ. pp. 50-54

Gutierrez, Nestor F, A John De Boer, and Enrique Ospina. 1982. An Econometric Model of the Colombian Beef Sector: 1950-1970. Canadian J. Agr. Econ. 30(1).61-70.

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Gutierrez, N., A.J. De Boer, and V. Vieira. 1982. Capital Structure and Farm Incomes for a Sample of Sheep and Goat Producers in Northeast Brazil. Proc. III Intl Conf. on Goat Prod. and Dis Tucson, AZ. p. 512.

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Gutierrez-A, N., J. De Boer, and Jose Ubiraci. 1981. Some Resource Interactions and Economic Characteristics of Sheep and Goat Producers in the *Sertao* of Ceara State, Northeast Brazil: Preliminary Results. Presented at First National Symposium on Tropical Sheep and Goats. Fortaleza, Brazil

De Moraes Eloy da Costa, Odorico 1982. Oferta de Exportacao de Peles de Caprino e Ovino do Brazil (Export Supply of Sheep and Goat Skins in Brazil). MS Thesis, Federal University of Ceara.

De Souza-Neto, Jose. 1981. Analise Econometrica de Oferta de Caprinos e Ovinos do Estado do Ceara (Econometric Analysis of Sheep and Goat Supply in Ceara State). MS Thesis, Federal University of Ceara.

Improving Reproductive Performance of Small Ruminants

W.C. Foote
Utah State University

The lack of knowledge on reproductive performance of sheep and goats in Northeast Brazil is recognized as a constraint to any program intended to improve small ruminant productivity. A primary objective of the Utah State Reproduction Project has been to help remedy this situation with particular emphasis on researching those aspects with the highest potential payoff. This goal synchronized well with the activities of the newly established National Goat Research Center (CNPC) and also provided support for development of their research agenda in this field.

During this first phase of the SR-CRSP, the Reproduction Project has worked effectively with scientists from the Center to generate basic information on reproduction. More recently, plans have been developed and approved by the CNPC to expand the influence of the Reproduction Project to other units of the EMBRAPA system in Northeast Brazil.

Specific research objectives of the SR-CRSP Reproduction Project have been:

- To determine reproductive potentialities of native and exotic genotypes of goats and sheep in Northeast Brazil.
- To measure the influence of environmental factors on the reproductive performance of relevant genotypes of goats and sheep.
- To develop and apply management practices that are compatible with the resources, objectives and understanding of the producers so as to improve reproductive performance of their flocks.

These objectives have been pursued in close collaboration with the CNPC and other appropriate EMBRAPA units so that the other objective of the project, building research capacity, could be accomplished through formal and informal training and contact between scientists.

Research Accomplishments

Goats

Knowledge of the age at which kids reach sexual maturity is important to herd management because it defines when male and female kids must be separated or the males castrated to avoid unplanned matings. A study was initiated in the first year (1981) with Moxoto kids. It was found that the separation of the penis from the sheath occurred when the

kids were an average of 134.5 days old and 12.2 kg of live body weight, and the first ejaculation via artificial vagina with the presence of sperm cells occurred when they were 139.5 days old and weighed 13.3 kg. The semen characteristics (volume, sperm concentration, and individual motility) were mostly stabilized at 174 days of age. This is the age at which the Moxoto males reach sexual maturity or zootechnical puberty (Figure 1).

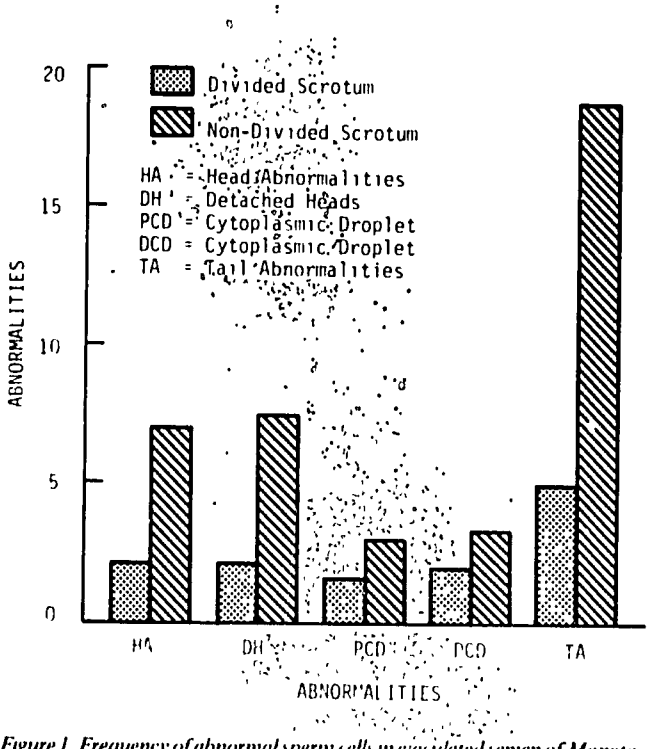


Figure 1. Frequency of abnormal sperm cells in ejaculated semen of Moxoto bucks related to scrotal morphology.

Three breeds of goat (Anglo Nubian, Bhuj and SRD) were studied in the second year. In this study, the separation of the penis from the sheath and the presence of sperm in the semen via electroejaculation occurred at about the same age.

Physical examination of the goats established a morphological difference in the degree of scrotal division (bipartite). To see whether this had influence on semen quality and hence potential significance for breeding management, the following study was conducted. The morphological differences were scored where 0 refers to no division and 5 refers to complete division. Semen from animals with divided and non-divided scrotum was taken to measure the difference due to scrotum morphology. The information obtained showed no difference in ejaculated volume, sperm cells concentration, and individual motility. But the same semen samples tested following thermal stress showed that the animals with divided scrotum have a significantly higher proportion of live sperm after incubation at 30 minutes ($P < 0.05$), 60 minutes ($P < 0.01$), 90 minutes ($P < 0.05$) and 120 minutes ($P < 0.01$) than the semen from animals with non-divided scrotum. The proportion of pathological sperm cells (Figure 1) was greater ($P < 0.01$) in semen from animals with non-divided scrotum (32.9%) compared with semen from animals with divided scrotum (5.4%).

In female goats, the age (363.6 days) and weight (12.6 kg) at puberty were similar between breeds (Caninde, Marota, Moxoto and Repartida) and relationships between the weight at birth and weaning and age at puberty were negative; however, a significant difference occurred ($P < 0.05$) for age and weight at puberty between single and twin born doe kids. The first detected ovulation was one in all breeds studied. Based on estimates from the presence of corpus albicans at laparotomy, ovulation had occurred previously without estrus in approximately 40% of the does.

The estrous cycle and period duration were studied during one complete year with thirty 18-24 month old SRD does. The length of estrous cycle was 21.2 days and of the estrous period 56.8 hours. The estrous cycle duration agrees with information published elsewhere, but the estrous period was longer than the published data indicated for different environmental conditions. These observations need to be reconfirmed. This information is important if there is to be planned management of mating.

Three breeds of female goats (Moxoto, Marota and SRD) were studied during two years in two different nutrition-management conditions (native pasture and confinement), to measure the frequency of estrus and ovulation, ovulation rate, estrous cycle length, and the number of estrous periods per female per month throughout the year and per year. This study will be used as a partial requirement for a PhD thesis of a host country scientist at Utah State. Preliminary results showed that the SRD breed type goats have the highest ovulation rate (1.68) in both management conditions followed by Marota (1.43) and Moxoto (1.36). The ovulation rate of goats on native pasture was higher (1.59) than in confinement (1.45) for all breeds combined. The frequency of estrus was evenly distributed throughout the year, indicating that the goats of Northeast Brazil are continuous breeders. On the average, the goats showed 1.06-1.19 estrous periods/month, 3.50-3.92% of does showing estrus daily and 12.72-14.28 estrous periods/year. The goats failed to adapt well to confinement and consumed inadequate roughage (elephant grass) and concentrate to gain in body weight and demonstrate reproductive levels comparable to those on native pasture. Part of the difference may have been due to the poor quality of elephant grass fed, particularly during the earlier part of the experiment.

A study was conducted with 203 does to measure and demonstrate the usefulness of ultrasound equipment in pregnancy diagnosis. The study in goats was conducted at an average of 109.5 days of pregnancy. The diagnosis was accurate in 93.1% of the cases, 84.3% in case of pregnant, and 100.0% in the case of non-pregnant does, accuracies which are very similar to those experienced in dealing with sheep.

A collaborative study in goat reproduction was undertaken between the CNPC, Universidad Federal Rural de Pernambuco, Recife and the Reproduction Project. In this study, the influence of feeding on reproduction and production performance of producer-owned native SRD goats were measured during two reproductive phases: late pregnancy and early lactation. The results showed that heavier birth and weaning weights were recorded in kids born

from does supplemented with 300 g/day/doe of 16% CP and 75% TDN concentrate 45 days before kidding compared with kids from the non-supplemented control group does and does supplemented 45 days post partum. The kids from a group of does supplemented for 90 days (45 days before and 45 days after kidding) showed better performance than the control group as well as those given 45 days supplementation before kidding. In terms of kid mortality, no difference was found. Higher abortion rates were recorded for the control group (16%) and does supplemented during lactation (12%) than does supplemented 45 days before kidding (8%).

A study is underway to estimate reproduction and production performance and to identify the constraints of goat production systems under traditional conditions. The study uses 4,000 goats in 17 private farms located in five municipalities in Northeast Brazil.

The data being collected are: flock structure (numbers, age, sex, color and breed type), frequency or presence of congenital defects (polledness, prognatism, supplementary teats, intersex, etc.), frequency of kidding throughout the year, kidding percentage, kidding intervals, kidding rate, age at first kidding, sex ratio, mortality rate (by season, sex, type of birth, weight), off-take rate (sales, home consumption), interval between parturitions and first post partum estrus, whole flock body liveweights (at least three per year), body weight of offspring at birth, weaning and one year of age, body weight of dams at parturition and weaning, and growth rate of the kids.

Herd composition at the initiation of the study gave 51.5, 19.0, and 6.5% of adult, yearlings, and kid females, respectively. In males, the proportion was 4.04, 13.3, and 5.66% for adults, yearlings, and kids, respectively. The low proportion of kids shown in this data indicates a high mortality rate or low fertility and/or prolificacy in female goats in the flock. Concerning the frequency of defects, 35.2% out of 2,770 animals have supplementary teats and 12.24% are polled. Sixteen color patterns and combinations were found in goat flocks of this project. The proportions varied from 0.29% for light brown/dark brown and 17.40% for black, followed by 17.30% for light brown, 15.7% for brown, 4.99% for brown/white, etc.

The kiddings in Northeast Brazil occur throughout the year, showing that the goats are continuous breeders. However, a peak of 30.4% of the parturitions occur during July-September and 21.1% occur in May. Seventy-three percent of the kiddings were singles and 26.8% twins or triplets. The month or season of the year seems to have no influence on prolificacy, showing that type of birth is evenly distributed throughout the year. When a limited breeding period was imposed on the goats at a private farm, 100% of the does were bred with 78.2% fertility at kidding, compared to 88.4% fertility in the control farm. No abortion was observed in does in the limited breeding season and 10% abortion was recorded in the control farm. In the farm with a limited breeding period, only 4.2% of kids died to weaning age and in the control farm 27.6% of kids were lost.

Marota, Moxoto, and SRD breed type of female goats are shown confined during a study on reproductive capability in which they are compared with goats grazed in native range pasture. Photo. W.C. Foote

Sheep

During 1980 and 1981, five Brazilian Somali rams were used to study the semen characteristics as they varied seasonally and individually. The data show that ram semen is fertile throughout the year with no significant differences between wet and dry season, except for individual motility, which was shown to be better during the dry season. When the information was classified by quarterly periods, however, the semen characteristics showed statistical differences for ejaculated volume, mass motility, individual motility, concentration, and linear dimensions of the testicle. This observation could be important in planning seasonal mating.

A three year puberty study was conducted using 112 ewe lambs from three breeds (Morada Nova, Santa Ines and Somalis), grazed on native pasture. Breed differences ($P < 0.01$) were found for weight and age at puberty. The Santa Ines breed was heavier (27.7 kg) followed by Morada Nova (22.5 kg) and Somali (18.6 kg). The Santa Ines breed reached puberty at 274.5 days of age, the Morada Nova at 277.5 days, and the Somali at 321.6 days. The ovulation rate was 1.34 for the Morada Nova, 1.31 for the Somalis and 1.24 for the Santa Ines. The ovarian response was determined by laparotomy performed 40 hours after heat was detected. The data available also shows that 77.3% of the ewe lambs ovulated before the first standing estrus at puberty.

The mean estrous cycle and period length for these same ewes was 18.2 days and 31.3 hours, respectively. No difference was found between breeds for estrous duration. The length of the estrous cycle differed for the Morada Nova and Somalis breeds ($P < 0.05$) but neither differed from the Santa Ines. In total, 90.14% of the estrous cycles were from 14 to 19 days in length, 1.8% were less than 14 and 8.1% were greater than 19 days.

The interval between parturition and the first post partum estrus in 279 sheep was studied during 1980-1982, with the same three breeds. The Morada Nova (65.04 days) and Somalis (61.90 days) did not differ statistically ($P < 0.05$) but both were significantly shorter ($P < 0.05$) than the Santa Ines (76.96 days). Overall, post partum interval for sheep was 64.96 days. Ewes producing single lambs had a shorter post partum interval (63.67 days) than those producing multiples (72.26 days; $P < 0.05$).

An experiment, initiated in July 1982, is underway with 72 ewe lambs divided in two nutrition-management groups (fed in confinement and grazed in native pasture) and three breeds (Morada Nova, Santa Ines and Somali). In confinement, the ewe lambs receive elephant grass *ad libitum* plus 1% of their body weight per day in concentrate containing 16% crude protein and 75-80% of TDN. The feed consumption is measured or estimated in both groups to discover the feed availability in native pasture related to the season of the year and to compare it to the feed consumed in confinement. Consumption on native pasture is estimated in cooperation with range scientists at the Center.

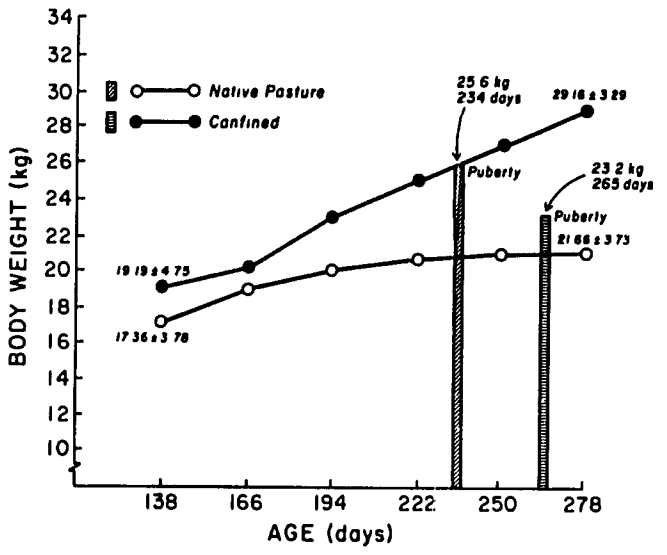


Figure 2. Growth age and weight at puberty of ewe lambs (Morada Nova, Santa Ines, Brazilian Somali) fed in native range pasture and confinement.

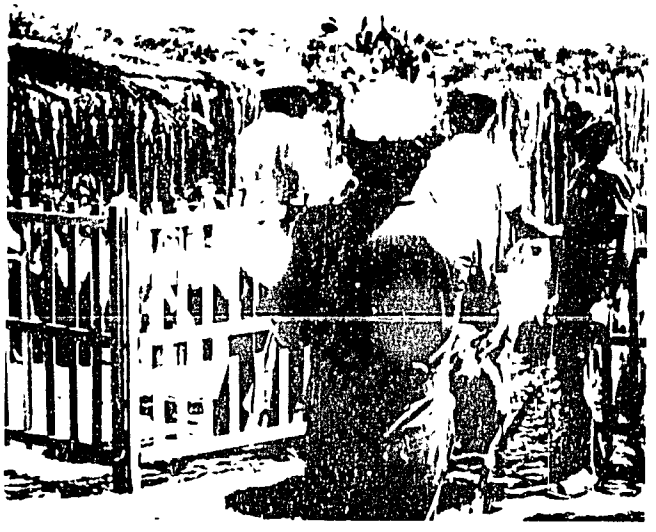
Preliminary results demonstrate a significant effect of nutrition-management on the onset of puberty. Preliminary comparisons were made between the two nutrition-management groups when the lambs were approximately 8.5 months of age. For the three breeds combined, 69% reached puberty at 234 days of age and 25.9 kg body weight in confinement compared to 25% at 265.6 days of age and 23.2 kg of weight for ewes on native pasture (Figure 2). Ewe lambs from the three breeds, fed in confinement, reached puberty at different ages and weights: Santa Ines at 249 days and 32 kg, Morada Nova at 225 days and 23 kg, and Somalis at 229 days and 22 kg. The ovulation rate was 1.14 for confined ewe lambs and 1.04 for lambs fed on native pasture. This experiment will be carried out for 30 more months to find the frequency of estrus and ovulation, ovulation rate, and estrous cycle length throughout the year.

The use of ultrasound equipment for pregnancy diagnosis was evaluated using 112 ewes from the three breeds used in the other study reported. The results showed that at 92 days of pregnancy, 92% of the diagnoses were accurate (100% in the case of ewes that were pregnant and 50.1% for non-pregnant ewes). The use of this method which is easy to perform on the farm is being encouraged in the management of small ruminants, especially for extension technicians in Northeast Brazil. Earlier diagnosis of pregnancy is an important tool in flock management as it allows separation of pregnant ewes for preferential treatment, and for additional matings of ewes not yet pregnant.

Significance of Research Findings

Although the goat and sheep industry in Northeast Brazil provides only a subsistence standard of living, it plays a vital role in the economy of the area. The low level of income is, to a large extent, due to environmental constraints and to lack of resources required for improved production. But efforts to improve production have been hampered by the paucity of information on reproduction, production capabilities and management practices needed to realize potential capabilities. The results obtained from the Reproduction Project demonstrate that reproductive performance could be improved by the use of important management practices:

- Under traditional management, sheep and goats are not weaned, nor do producers know when and how to do so. Our results show that weaning, or at least separation or castration of the male kids must be done by 140 days to avoid undesirable mating.
- Puberty in female goats and sheep takes place around 335 days of age and 16.6 kg of body weight. Pregnancy at this stage should be prevented since this body weight is insufficient to maintain a successful pregnancy to term due to inadequate feeding and growth.
- The ovulation rate at puberty in native breeds of goats is usually low (1.0) and does not permit making selections at this age for higher ovulation rate. In sheep, breed differences appear to be evident at puberty, thus allowing for selection at this age. Our results show that the Morada Nova has a higher ovulation rate than the Somali and Santa Ines, implying that the Morada Nova, with better management, will be more productive than the other two breeds.
- Information on the incidence of estrus and ovulation indicates that in both sheep and goats, reproduction is possible year round if breeding season, nutrition, and health are properly managed. This has been proven in the private flock study where producers have traditionally kidded year round. However, production was significantly improved by restricting the breeding season.
- According to our data, two parturitions per year are not feasible in sheep but with proper management three parturitions in two years could be easily achieved in sheep and is possible in goats. This would significantly reduce the present parturition interval.



Establishing the research project in one of the seventeen privately owned flocks of goats in Northeastern Brazil, near Taua. Photo: W.C. Foote.

- Results on reproduction in the ram and buck indicate that they can be used for breeding throughout the year.
- The accuracy of ultrasonic pregnancy diagnosis in sheep and goats enables producers to introduce this as a management practice to identify non-pregnant animals and avoid their maintenance in the breeding flock.

As a result of our research, reproductive capabilities of sheep and goats are much better understood and some management practices have been introduced at the producer level and information is now available to develop others.

Implications for Future Research

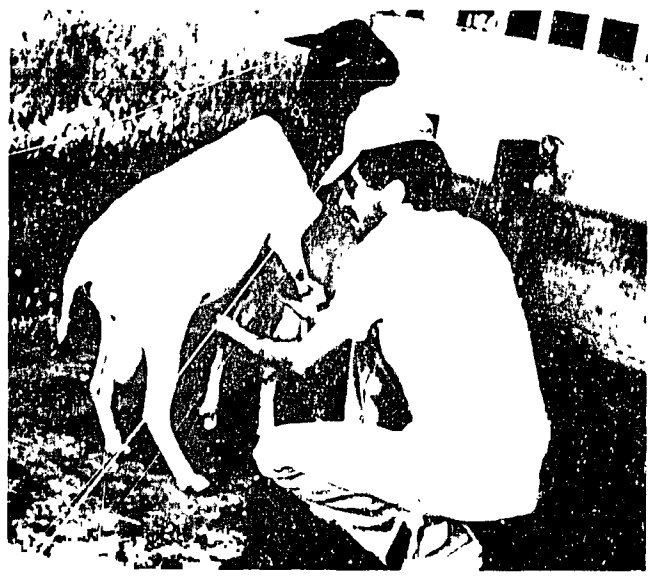
The objective of establishing the most relevant information on reproductive capabilities of sheep and goats has been largely achieved. However, extension of these results to local producers is still in its beginning stages. Major efforts in the future will involve:

- Continuation of programs to develop, apply, and test reproduction-related management practices at the producer level. The program initiated by the Reproduction Project, working directly with producers, is proving to be very successful. Its results have direct application to the low income producer as well as strengthening extension programs and contributing to developing practices with a wider application. It will still be necessary, however, to identify additional basic information that is needed for improved management and reproduction. This will be pursued through continuing research with present CNPC resources.
- Initiation of the Reproduction and Related Management Network Organization in Northeast Brazil will provide a means for research collaboration on constraints related to reproductive performance. Physical and personnel resources are limited and this network organization will provide a way to pool these to solve local and general regional problems in an economical manner. The Reproduction Project has accepted the invitation by the CNPC to participate in the development of the planned dairy goat program and expects to invest the required effort to help make it successful.
- Arrangements have already been made by the Center with support from the Reproduction Project and the SR-CRSP Management Entity to establish a Radioisotope facility and initiate a Radio-Immuno-Assay (RIA) program in reproduction. A new IICA/OAS consultant has been provided to the Center to replace Dr. Simon Riera and will continue the work in reproduction and help establish the RIA program. Other programs for facilities development will be supported by the Reproduction Project as they are identified and as funds permit.

Training

Training, always one of the most important objectives of the SR-CRSP Reproduction Project, has been conducted from the start to provide both degree opportunities and a wide variety of non-degree training for technicians, as well as junior and senior scientists.

In Brazil, a shortcourse entitled "Management of Reproduction" was presented for researchers from the EMBRAPA system units, northeast universities, and extension service personnel. The training covered aspects in experimental design, data collection, organization of data for analysis, analysis and interpretation of results, etc., as they related to reproduction and management for reproduction. Nineteen



Semen collection from Brazilian Somali ram for studies on fertility and seasonal variation in semen quality. Photo: W.C. Foote.

persons completed the shortcourse and received certificates of completion.

Training in specific techniques and procedures required for research have also been provided to scientists and technicians. These include updating techniques for semen research in the male, and laparotomy, laparoscopy and pregnancy diagnosis procedures for research in the female. In addition, training has been provided on data collection, processing and interpretation.

Training has also been undertaken at Utah State to provide graduate degree programs for overseas personnel. Mr. Aurino A. Simplicio from the EMBRAPA/CNPC, started his formal training for a PhD in Reproduction in August 1982 and is expected to complete this by summer 1984. A major part of his research for his dissertation was conducted in Brazil under the direction of the SR-CRSP Reproduction Project and the CNPC. Mr. Jose Ubiraci Alves is now conducting his research with the project at the private farms with goats under a similar arrangement. Information from this study will serve as thesis material for his MS degree. He expects to begin formal training at Utah State in the fall of 1984.

Selected Publications

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Simplicio, A.A., E.A.P. Figueiredo, G.S. Riera, and F.A.M. Lima. 1982. Reproductive and Productive Performance of the Undefined (SRD) Genotype of Goats Under the Traditional Management System of Northeast Brazil. Proc. III Int'l Conf. on Goat Prod. and Dis. Tucson, AZ. p. 349.

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Goat and Sheep Nutrition and Feeding Systems Research

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One of the most serious limiting factors to small ruminant productivity in Northeast Brazil is the seasonality of herbage available from the native *caatinga* vegetation. During the extended 6-8 month dry season, growth and reproduction rates suffer tremendously without supplemental feed. However, if feed supplements must be purchased from off-farm sources, their use is unlikely to prove economical. The challenge therefore is to develop feeding systems from resources available on the farm which can correct the gross nutrient deficiencies of the dry season and contribute to a more profitable production enterprise. The design of improved dry season feeding systems relies on knowledge of:

- Nutrient availability from the *caatinga*, measured in terms of daily animal intake.
- Nutritive value of available feeds such as crop residues and by-products, cultivated forages, and native legumes.
- The production response of animals to increments of supplementary nutrients.

The Nutrition and Feeding Systems Project is directed toward the second and third of these research areas. Our major objectives over the long term are to:

- Determine the nutritional value of local feedstuffs which could be available for dry season supplementation of goats and sheep.
- Develop practical guidelines for dry season supplementation.

Complementary to these two major objectives are three additional areas of activity: forage preservation and storage; correlation of feed composition to animal performance; and verification of the nutrient requirements and relative efficiencies of goats and sheep of the breeds commonly encountered in the target production systems.

Throughout the project, major attention is focused on animals at their most critical stages of the production cycle: post-weaning growth, breeding, late gestation, and during lactation.

Research Accomplishments

After project planning visits by the Principal Investigator in 1979, collaborative research was launched in June 1980. During the 1980 dry season, crop residue samples were collected from farms in three states of the Northeast, and feeding trials were started with weanling lambs and kids at the Sobral station of the National Goat Research Center (CNPC). A set of rustic, but highly serviceable, pens were built at the CNPC for confinement feeding trials. These pens have been used throughout the 1980, 1981, and 1982 dry seasons for growth trials with Northeast Brazil native SRD goats, and Morada Nova and Santa Ines sheep.

Starting in 1981 and continuing through 1982, an animal nutrition analytical laboratory was established at the CNPC. The capacity to conduct fiber, protein, gross energy, organic matter and *in vitro* digestibility (artificial rumen) determinations on a routine basis is now fully developed. The resident senior investigator has organized the laboratory, set up a data recording system, and trained a group of four technicians.

Research activities were extended in 1982 to the EMEPA experimental farm. Fazenda Pendencia, in Soledade, Paraiba. The emphasis there has been on three breeds of dairy goats: SRD, Anglo Nubian, and German Pardo. Sorghum hay, buffel grass hay, and cultivated legumes have been tested for feeding lactating does.

Another major development in 1982 was the establishment of a functional metabolism unit at the CNPC in Sobral. Space was allotted in an unused greenhouse, metabolism crates were constructed by the CNPC carpenter after a first model was perfected, and the first digestibility trial was conducted in October. Several subsequent trials have already been conducted but await sample analysis before results can be reported.

In 1983, nutrition research has been extended to producer goat herds in a trial designed to test the effects of copper and zinc supplementation on the doe's reproductive performance and on the weaning height of her offspring. Plans have been made for the fall of 1983 to initiate energy and protein supplementation trials with SRD does, and to expand the emphasis on semi-confinement systems to growing lambs and kids; and to intensify the work with mature does of the dairy breeds.

Some of the more important information generated during 1980-82 is summarized below.

Chemical Composition of Crop Residues

The main cash crop in the Northeast is cotton. Maize and beans are also planted for home consumption or sale. Certain parts of the residue from these crops were sampled from farmers' fields and analyzed for chemical composition with results as shown in Table 1. Bean and cotton leaves were the highest in crude protein and lowest in total cell wall fiber of the materials sampled. However, the supply of these particular crop residues is not expected to be great. The stem, leaves and husks of the maize plant are similarly poor in nutritive value but could provide some protein and energy as a basal dietary component (Oliveira et al., 1982a).

Table 1. Chemical Composition (as a percent of DM) of Plant Parts From Crop Residues in Northeast Brazil

Residue	No. of Samples	Crude Protein	Total Cell Wall	Cellulose	Lignin
			%		
			Maize		
Stalk	30	6.7	52	32	7.5
Leaf	34	7.8	61	30	5.0
Husk	30	7.8	74	28	4.0
Tassle	30	5.0	65	29	5.7
Cob	25	8.1	66	29	6.0
			Beans		
Stem	13	8.9		35	9.3
Branch	14	9.6	50	34	9.6
Leaf	24	14.3	37	14	5.2
Pod	25	8.5		27	8.0
			Cotton		
Leaf	17	12.8	27	10	6.2
Husk	18	6.1	54	23	9.4

Samples were collected from farms in three states, early in the dry season of 1980.

Source: Oliveira et al., 1982a.

Table 2. Performance of Lambs Consuming Maize Residue Rations During 70 Days in Confinement During the Dry Season in Northeast Brazil

Year and Breed	Ration Description	No. of Lambs	Average Daily Gain	Daily DM Intake	Carcass Yield
			g	$g/W^{.75}$	%
1980	51% maize stover[a]	4	129		52.5
(Santa Ines)	51% maize cobs[a]	4	134		48.7
	25.5% cobs, 25.5% husks[a]	4	164		50.3
	Reference animals[b]	6			44.1
1981	51% maize stover[a]	6	94	90	47.4
(Morada Nova)	5% mata pasto[c]	6	106	90	46.2
	10% mata pasto[c]	6	103	95	46.1
	15% mata pasto[c]	6	93	94	46.8
	Caatinga grazing, no supplement	6	-11		45.8
1982	51% maize stover[a]	10	122	111	
(Santa Ines)	14% mata pasto[a]	10	113	104	
	28% mata pasto[d]	10	55	78	
	14% cunha[d]	10	116	107	
	28% cunha[d]	10	102	91	
	Caatinga grazing, plus 200 g/day maize grain	10	42		

[a] Plus 28% cottonseed cake, 20% maize grain and 1% iodized salt.

[b] Slaughtered at the beginning of the trial.

[c] Plus 51% maize stover, 20% maize grain, 1% iodized salt and 23, 18 or 13% cottonseed cake.

[d] In these rations half or all of the cottonseed cake was replaced by mata pasto *(Cassia sericea)* or cunha *(Clitoria ternatea)*, fed as chopped hay.

Source: Arruda et al., 1981, and Oliveira et al., 1982b.

Acceptability and Digestibility of Maize Crop Residues

Chopped, green napier grass *(Pennisetum purpureum)* and the wholeplant stover, husks, or cobs from maize crop residues were offered *ad libitum* to 18 SRD kids. Relative acceptability of these four materials was measured by pairs of feeds in the six possible combinations. The average palatability index was napier grass 65, stover 56, husks 45 and cobs 34% of the total feed offered. Mean daily dry matter (DM) intakes on the best treatments (napier and husks, and napier plus stover) were about 60 g per kg of metabolic size (body weight$^{0.75}$), which is insufficient to support an adequate growth rate for kids during the stage of weaning to maturity (Johnson et al., 1982).

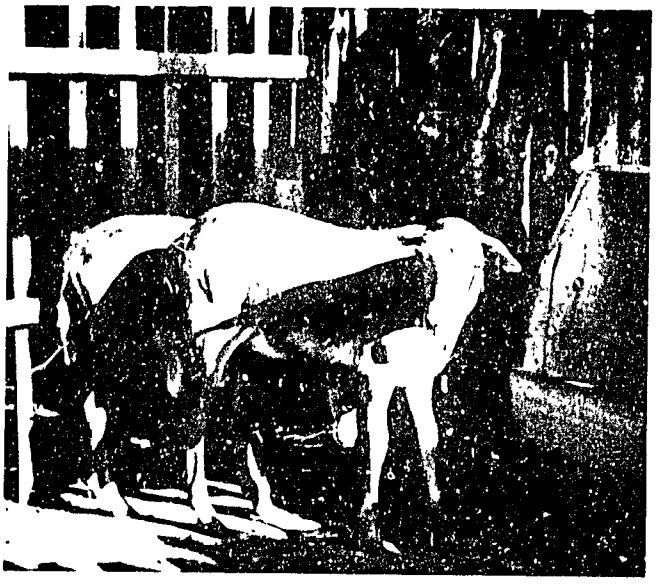
Arruda (1983) conducted a digestibility trial on maize stover rations with Morada Nova wethers. Rations containing 60, 70 and 80% wholeplant maize stover were 59, 56, and 55% in digestibility of total dry matter, at an intake level of 72 g per kg metabolic size, or about 3% of actual body weight. Extrapolating these digestibility coefficients to a 100% maize residue would indicate 47± 5% DM digestibility for the maize residue alone. Digestibility of the crude fiber and non-crude fiber fractions of DM were almost identical, indicating the inappropriateness of the crude fiber determination as an index of indigestibility.

Growth of Lambs on Maize Residue Rations

Results of trials for three years are summarized in Table 2. In the 1980 trial, weight gains and carcass yields were not significantly different when different parts of the maize plant were used as the roughage base. An economic analysis with then-current prices indicated that the dry season confinement feeding of Santa Ines wether lambs was profitable (Arruda et al., 1981). However, it was felt that the use of cottonseed cake, which must be purchased outside the farm, should be minimized. Therefore, in the following year the ground, dried foliage of the native legume, "mata pasto" *(Cassia sericea)*, was introduced as a partial substitute for the cottonseed cake. Average gains were slightly lower (99 g/day) than in the first

year (142 g/day), but were not influenced by the level of mata pasto; carcass yields were also lower. In 1981, six lambs maintained for 70 days under *caatinga* grazing with no supplement lost an average of 11 g/day during the 70 day trial (Oliveira et al., 1982b).

In the third year (Oliveira, 1983), 50 and 100% of the cottonseed cake was replaced by mata pasto or by a second legume hay called "cunha." Again, intakes and rates of gain were quite satisfactory with partial substitution (Table 2). Both daily intake and gains were depressed with total cottonseed cake replacement, only slightly with cunha but severely with mata pasto. This was possibly due to a higher total cell wall fiber content of this ration. Control lambs grazing *caatinga* forage, supplemented with 200 g of maize grain per day, gained an average of 42 g/day.



Morada Nova ewe lambs at the CNPC, Sobral. These lambs made satisfactory growth during the dry season while kept in confinement and fed a ration based on about 50% chopped maize stover, a common crop residue of the region. Photo: W.L. Johnson.

Growth of SRD Kids on Maize Residue Rations

Rations which had given satisfactory gains with lambs in 1980 were repeated in 1981 with SRD kids (Barros et al., 1982a). Results with goats were much less satisfactory than for sheep (Table 3). In the first trial, gains averaged 19 g/day when maize cobs were the only roughage. Gains were 38 g/day when either stover or husks, or maize cobs supplemented with napier grass, were fed. Confinement feeding with such low gains is unlikely to be economical. However, results for goats that grazed the *caatinga* with no supplement were much more catastrophic—three died of starvation and the remaining three lost an average of 25 g/day.

Since low daily intake seemed to be one of the limiting factors, the 1982 trial was designed to test ways of increasing intake, either by reducing the indigestible fiber concentration, by adding molasses to improve palatability, or both (Robb et al., 1983a). Adding molasses to the 50% maize stover ration improved intake over the previous year but did not influence rate of gain or carcass yield (Table 3). A ration with only 30% maize stover and no molasses was equally unsatisfactory. Those diets in which the stover was reduced to 40 or 30% and molasses was added resulted in increased rates of gain (but not DM intake or carcass yield) compared to the 50% stover/5% molasses or 30% stover/0% molasses treatments. The higher rate of gain was a reflection of higher DM digestibility of the total ration (Table 3).

The best results of all were obtained for the group which consumed 30% stover and 5% molasses, and had daily access to *caatinga* grazing. This observation has led to the planning of additional trials to further test semi-confinement systems for young goats during the dry season.

Energy Supplementation Effect on Age and Weight at Puberty, Morada Nova Ewe Lambs

During the 1980 dry season, twenty-four lambs averaging 140 days old and 12.4 kg liveweight were randomly assigned to eight pens; two pens were than assigned to each of four energy levels. All pens were offered 105 g/animal/day of cottonseed meal plus free choice ground maize stover (70%) and cob (30%) mixture. The four energy levels were attained by offering either 50, 200, 350, or 500 g/animal/day of maize grain. Age at first estrus was 326, 290, 305 and 278 days for the four energy groups, indicating a response in precocity at higher energy intake levels. The average weight at first estrus was 20.5 kg and was not influenced by energy intake level. Rates of gain were approximately 39, 52, 56, and 62 g/day. It was concluded that the two highest energy levels could not be economically justified and that dry season supplementation of Morada Nova ewe lambs should be adjusted to attain average gains of about 40-50 g/day (Barros et al., 1982b).

Supplemental Mineral Requirements

Correction of daily intake levels of energy and protein to sustain a respectable rate of gain through the dry season may result in certain mineral elements becoming marginal or deficient. Given the high cost of commercial mineral mixtures, it is desirable to know exactly which minerals are limiting and how much of each is required. Barros and Spears have determined from foliage analysis that the *caatinga* vegetation may provide insufficient zinc and copper. A long term experiment was initiated in 1983 to test this possibility. Barros and Figueiredo (1983) have published preliminary data from twelve female SRD kids grazing in the *caatinga*, indicating no growth response from the addition of bone meal to an iodized salt supplement. Average gains were 66 g/day over an eight-month period which included all of the 1981 dry season. Given the importance of phosphorus to normal animal growth and reproduction, it would be advisable to further test its supplemental response. Barros (1983) has suggested possible species differences in this regard, reporting an average intake of 5 g/day of an iodized salt/bone meal mixture (1:1) by 39 SRD goats, while 119

sheep consumed an average of 31 g/day. No immediate explanation is available for such a large difference in mineral intake.

Feeding Systems for Lactating Dairy Goats

An experiment was conducted at the EMEPA farm in Paraiba with Anglo Nubian and German Pardo lactating goats, in which sorghum hay was shown to be a superior forage to buffel grass hay in terms of total milk yield and yield of milk fat (Table 4). A daily supplement of 400 g/animal of ground maize grain resulted in an average of 325 g/day of additional milk, compared with non-supplemented animals. The German Pardo does yielded more milk (1,232 g/day) than the Anglo Nubians (908 g) but with lower fat (3.0% versus 4.6% for the Anglo Nubians) (Robb et al., 1983b). It was concluded that buffel grass is inferior to sorghum when fed as hays, probably due to a higher content of indigestible cell wall and consequent lower intake by animals. Further trials with dairy goats which are planned to start in Paraiba in 1983 have been designed to test the intake and digestibility of buffel grass under grazing.

Significance of Research Findings

We are learning that instituting major improvements in the feeding system for goats and sheep in the semi-arid Northeast is not a simple task. This should come as no surprise; if easy solutions were available, they would have been applied long ago.

The goats and hair sheep of this region have adapted to hardship. They are survivors. The physiological adaptations that make them survivors are not necessarily compatible with an expectation of high rates of response to improved levels of nutrition. However, hardy as these animals have shown

Table 3. Performance of SRD Kids Consuming Maize Residue Rations in Confinement During the Dry Season in Northeast Brazil

Ration Description	No. of Kids	Average Daily Gain	Daily DM Intake	Carcass Yield	Ration DM Digestibility
		g	$g/W^{.75}$	%	%
1981 (98 days)					
51% maize stover[a]	6	37	56	42.9	
51% maize cobs[a]	6	19	48	41.4	
51% maize husks[a]	6	39	62	45.9	
Napier grass, cobs[b]	6	38	52	44.3	
Caatinga grazing, no supplement	6[f]	-25		40.8	
Reference animals[c]	6			39.3	
1982 (70 days)					
50% stover, 5% molasses[d]	12[g]	37	85	42.3	53
40% stover, 5% molasses[d]	11[h]	48	82	41.6	58
30% stover, 5% molasses[d]	11[h]	61	74	42.4	70
30% stover, no molasses[d]	11[h]	29	65	43.1	66
30% stover, 5% molasses, *caatinga* grazing[d e]	5	72	74	54.4	

[a] Plus 28% cottonseed cake, 20% maize grain and 1% iodized salt.

[b] Chopped green napier grass *ad libitum*; plus cobs 15%, cottonseed cake 49%, maize grain 35%, iodized salt 1%, restricted to 2% of liveweight per day.

[c] Slaughtered at the beginning of the trial.

[d] The 1982 rations contained 1% iodized salt plus cottonseed cake and maize grain at the following levels: 23.5 and 20.5, 21.5 and 32.5, 19 and 45, 18 and 51, and 19 and 45.

[e] 12 hours grazing, 12 hours confinement per day.

[f] Three of the 6 original animals died from starvation; data are means of the remaining 3.

[g] Carcass data are from 6 animals.

[h] Carcass data are from 5 animals.

Source: Barros et al., 1982a, and Robb et al., 1983.

Table 4. Performance of Dairy Goats Fed Two Forages with Two Levels of Energy Supplementation at EMEPA's Pendencia Experiment Station, Soledade, Paraiba (1982)

Treatment[a]	Milk Yield	Milk Fat
	g/day	%
1. Buffel hay, no grain	814	3.7
2. Buffel hay, 400 g maize grain	1099	3.6
3. Sorghum hay, no grain	1000	4.0
4. Sorghum hay, 400 g maize grain	1365	3.7

[a] All animals received 250 g/day of cottonseed cake.

Source: Robb et al., 1983b.

themselves to be, they do suffer from poor, zero, or negative growth rates, reproductive failure, and even death when the dry season reaches its extreme. But they have shown themselves responsive, at least during the growth stage, to supplemental energy, protein and minerals.

The problem is recalcitrant: when supplementation is most needed, the feed materials with which to provide it are the least available. An abnormally poor year in terms of grazing resources will also be poor for the crops, whose residues and by-products might be fed to small ruminants. Also, the farmer may opt to give his limited feed supplies to his cattle and let the goats continue to fend for themselves. If our research findings are to be applied, a new frame of mind must be developed, with the idea that farm profits can be improved if the small ruminant stock can get through the dry season with positive rather than negative productivity.

We have shown some ways to do this. Preserving some type of feed supply for the most severe months of the dry season (October-January) is the first requisite. This can be sorghum hay or a cultivated legume such as cunha, if land can be set aside during the rainy season to grow these crops. Alternatively, it could be the native legume mata pasto, harvested as hay at the beginning of the dry season. Chopped maize stover can also be fed, but this material, more than the others, will require additional high quality energy and protein feeds to accompany it.

It has been conclusively demonstrated that Morada Nova and Santa Ines lambs can reach an acceptable slaughter weight during the dry season, either with total confinement feeding or, perhaps preferably, with judicious supplementation of the *caatinga* resource as it dwindles in supply. For lambs destined to join the reproductive flock, their continued growth toward maturity can be assured by similar but more modest supplementation programs. If both of these practices can be adopted, the flock will be smaller and more productive as the new rainy season commences, greatly enhancing its efficiency. With time, similar strategies for goats will be available.

The evidence is mounting that tropical grasses such as napier and buffel are not high quality feeds for the goats and sheep of Northeast Brazil. These highly lignified grass species require a longer rumen residence time than these small beasts can afford. Therefore, intake levels and rates of digestibility are not sufficient to provide the nutrients for optimum growth, lactation and reproduction.

We are also learning not to expect the native goats and hair sheep to respond similarly to dietary interventions. While they might resemble each other more than either of them resemble their distant cousins, the European breeds, there are still important differences. The ability of Morada Nova and Santa Ines lambs to grow at a rate exceeding 90 g/day when consuming a diet consisting of 50% maize stover, while SRD goats gain barely one-third that rate, is a case in point.

Implications for Future Research

As the evaluation of animal feed resources in Northeast Brazil continues, more attention should be given to those attributes which will assure a contribution to sheep and goat nutrition during the prolonged dry season. Laboratory screening should include crude protein, total cell wall fiber (NDF), and *in vitro* digestibility as a minimum. Promising feeds should then be subjected to *in vivo* digestibility and voluntary intake determinations and incorporated into balanced rations for testing intake and animal performance. In the near future, promising forage legumes, crop by-products, and young lesser-lignified grasses which might be preserved as silage, will be evaluated in the above manner.

As strategies for dry season supplementation continue to be developed and tested, a closer collaboration with the Range Management Project will be established. Simplified techniques are needed for a quick evaluation of nutrient availability from the *caatinga* so that supplementation strategies can be timely, economical, and effective.

We also hope to devote more attention to the adult breeding herd or flock. As soon as land and animal resources allow, we plan to initiate dry season supplementation work with the pregnant doe and ewe.

A final objective for the mid-term future is to catalyze a more intensive outreach effort emphasizing dry season feeding strategies. This, of necessity, will be a multi-disciplinary approach with reproduction, range management, and economic aspects included. One possible model for such a project would be to work through selected EMBRATER agencies to reach clusters of pilot farms in several states of the Northeast. The flow of information in such a project must be continual and two-way, through a network of producers, extension personnel, and state and national research staff. If kept flexible and pursued with energy and diligence, such an effort could have a rapid impact on productivity at the farm level. The alternative is to relegate our research findings to the scientific journals and the occasional seminar or technical bulletin, with only a random chance of affecting rural welfare.

Caatinga which has been cleared by cutting and burning is being compared as a source of nutrients for sheep and goats to brush (in the background) which has not been disturbed for about 25 years. Photo: W.C. Weir.

Training

Training of Brazilians has occurred at four levels: thesis research support for post-graduate degree candidates, in-service training of young scientists, in-service training of technicians, and outreach to personnel of other institutions by conducting workshops. Direct scholarship support for graduate training has not been offered, partly because there have been no identified candidates, but mainly because EMBRAPA normally has had ample scholarship funds of its own.

Thesis research advice and financial support was proferred to Francisco de Assis-Arruda, who has now completed his Master's degree program at the Federal University of Ceara in Fortaleza. Similar support has been arranged for Nelson Barros who intends to apply for admission in 1984 or 1985 to graduate school at North Carolina State University, with Dr. Jerry Spears as his advisor. Barros and Spears have already initiated a collaborative project in Sobral which is expected to yield data for the PhD thesis. English tutoring for Mr. Barros has also been supported.

The in-service training activity is especially important for such a young institute as the CNPC and for its relatively young cadre of scientists. This type of training is continual and depends on the frequency and quality of communication between collaborators. The measurement of success is somewhat subjective, but there is no doubt about its occurrence.

In-service training of technicians is easier to document. Dr. Robb has trained four persons in various aspects of the nutrition laboratory operation; it is now a smoothly operating facility, with greater limitations from physical (electricity and water) than human factors. He has also helped train animal technicians at Sobral and Fazenda Pendencia in conducting feeding and metabolism trials.

A two-part workshop was held in Brazil during July-August 1982. Part I (three days) was devoted to a discussion of new information on goat and sheep nutrition, in seminar format. About 20 persons from the CNPC staff and state research agencies attended. Part II (five days) was a hands-on shortcourse in laboratory analytical procedures, supervised by Dr. Robb and completed by ten persons.

Selected Publications

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Range Research For Increasing Small Ruminant Production

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A large proportion of the world's poor live on lands classified as arid or semi-arid, where scarce or erratic precipitation and marginal soils make crop production a risky venture, or entirely preclude it. These people depend largely on animal agriculture for their sustenance, and the type of husbandry practiced is, almost without exception, extensive grazing of native rangelands. Such is the case for a large region of Northeastern Brazil, known locally as the *sertao*. Characterized by scant and unreliable rainfall, and vegetation patterns which reflect this, the crux of the problem for animal production in the *sertao*, like so many range areas, is providing adequate nutrition. Such concerns as genetic improvement and herd health pale in the light of animals starving on a recurring basis.

Improvement of the forage resource is the obvious short-term rationale for our research in the *sertao*. This includes two directions: achieving a better balance between the wet-season surplus and the dry-season deficit on an annual basis, and on the long-term basis, minimizing the impacts of recurrent drought.

Another dimension to the long-term consequences of land and animal management is the inherent stability and sustained productive capacity of the land. In their attempt to face current demands of growing human populations and withering economics, agriculturists in developing countries often feel compelled to over-graze or over-exploit the land. On a world-wide basis, this has led to an unprecedented degradation of the land resource over the past two decades. The special term "desertification" has been coined to describe the phenomenon.

The *sertao* is not exempt from this problem. However, before steps can be taken to change the trend of events, the ecological characteristics of the system must be understood. This includes not only knowing about the specifics of sheep and goats, but also about the climatic, edaphic, vegetational, and sociological aspects of the region and its people. It is these additional components that separate range science as a discipline from the more traditional animal science disciplines.

Given this perspective, we are approaching the problem of sheep and goat production in the *sertao* region of Northeastern Brazil with four general objectives or problem areas in mind.

- Ecological assessment of the range forage resource: Soils, vegetation, and climate of the *sertao* are highly diverse and climate varies profoundly from season-to-season and year-to-year. To understand how these factors affect forage and animal production and to enable local experiment station results to be extended to the broader region, ecological studies are necessary.
- Plant-animal relationships: Typical of all tropical ecosystems, the vegetation of the *sertao*, the *caatinga*, contains a wide diversity of plant species. These species vary widely in their palatability and nutritional value to sheep and goats, and any particular species may vary markedly over the year. These studies are aimed at understanding the nutritional relationships of animals to their erratic and diverse environment.
- Rangeland improvement and brush management: One of the few so-called "management" alternatives available to smallholders of the *sertao* is manipulation of the woody *caatinga* vegetation. Local wisdom holds that clearing improves forage conditions. While this may be true in the near-term, the long-range consequences of land clearing are not well known and may be highly undesirable, both from the standpoint of animal production and land stability.
- Grazing management: With information in-hand from the first three objectives, we will ideally be able to design and recommend grazing management practices and land treatments that will optimize the relationship between effective animal production and sustained forage production.

Esophageal fistulated goats and sheep are used to determine what the animals eat to survive through the dry season in the caatinga. Photo: W.C. Weir.

Research Accomplishments

Ecological Inventory and Assessment

SR-CRSP research on sheep and goat production is not an end in itself; the program is designed to address the management and production constraints of the smallholder in Northeast Brazil. Therefore, understanding the entire production system is a key element in the SR-CRSP/ EMBRAPA association. To this end, production characteristics of *caatinga* must be known before extrapolation of grazing research results is attempted. How much of the *caatinga* in Northeast Brazil, or even in the Acarau Valley, is similar to the native vegetation at the CNPC fazenda, for which we know details of goat diet preferences and nutritional levels and response to clearing? How many different kinds of *caatinga* are there? Is vegetation response to clearing and burning practices always the same? The present objective is directed toward answering questions such as these. The studies are being undertaken by Utah State researchers Joao Queiroz and B.E. Norton.

The ecological survey of range resources is divided into two phases. The first, now complete, consisted of intensive on-the-ground site descriptions in an area of 1,400 km^2 in the Acarau Valley. Three types of information were collected: soil characteristics, including evidence of erosion; vegetation present on the site, plus evidence of dynamic features such as successional trends, and the way the area is being utilized by the local landowners. A survey of this kind requires expertise in soil taxonomy, ability to recognize plant species, and an appreciation of mechanisms responsible for ecological change. The vegetation currently present on a site may not be a reliable indicator of soil type or site potential. The output from the ground survey is a classification of types of *caatinga*, a thorough description of each type, and a map showing the distribution of the types. Preliminary data analysis indicates approximately ten distinct types of *caatinga* in the area studied; cluster analysis and ordination techniques have yet to be applied in the data to give this classification an objective basis.

It would appear from work completed thus far that there are very different types of native *caatinga* within the relatively small study area, with contrasting vegetation mixtures and productivities. They reinforce the importance of having an accurate picture of the resource base before trying to extrapolate site-specific research data to a general area.

The ecological data indicate an apparent incongruity for a semi-arid region: vegetation characteristics are strongly influenced by the incidence of excessive water in the soil profile during the wet season, which may override differences in soil parent material. Hence, soil drainage features and topographic location are key discriminatory criteria in a range site classification system. The small elevational increase of 15 cm in an otherwise poorly drained site is sufficient to permit the establishment of a patch of Marmeleiro *(Croton hemiargereus)*, where otherwise no perennial would grow.

Different sites produce different kinds of regrowth following clearing and burning, with different subsequent changes in the vegetation as the woody species regain dominance. The intensity of cutting and burning on one site will determine the dominant regrowth species; excessive and indiscriminant treatment, for example, will encourage dominance by Mufumbo *(Combretum leprosum)* which has no forage value for livestock.

An early successional phase which follows cutting and burning consists of a sparse, patchy community of Mufumbo and Catingueira (as shown above) with poor productivity. Photo: J. Malechek.

Brazil does not have the trained manpower to carry out such an intensive ground survey over the entire Northeast region, nor would it be an economically wise enterprise given the capability of existing remote sensing technology. The second phase of the range resource survey will focus on the analysis of radiation from half hectare units or "pixels" recorded by LANDSAT monitoring satellites, relating the radiation data to the ground survey. By integrating ground survey data and the satellite data, each type of *caatinga* can be represented by a unique spectral signature. The advantage of LANDSAT technology is that once the spectral signature has been defined, it is a simple computer step to print a map of all the pixels which match the signature and calculate the total area of the type. A comparison of the computer-generated resource map with ground sites to check for accuracy can provide feedback to refine the signatures. The resulting resource survey, limited to a small area of the Northeast, is intended as a trial of the methodology with the hope that procedures, if successful, will be adopted by a Brazilian agency concerned with resource management in the region.

Diets and Nutrition of Animals on Uncleared Caatinga *Range*

By far, the most common animal management practice in the *sertao* is grazing of mixed flocks of sheep and goats on native, uncleared *caatinga* rangeland. Before changes in such management can be recommended, or before advanced

research can be planned, it is critical to understand this traditional form of grazing management. Responses of animals and forage supplies to the highly erratic wet-season/dry-season precipitation regime are of particular importance. This information is important in explaining nutritional conditions and in management of the range for forage species that are palatable to livestock.

To gain insight into these questions, Utah State researcher Jim Pfister stocked an area of typical *caatinga* rangeland with a mixed flock of sheep and goats and measured forage availability, animal weight responses, forage intake, and nutritive and botanical characteristics of diets on a seasonal basis. Animals with a surgically prepared esophageal fistula provided representative samples of grazed diets, by season, for laboratory analyses.

Green grasses, for example, and the herbaceous annual forb Bamburral were found to be important foods to both sheep and goats during the wet season; sabia', a tree species, was selected by goats but not by sheep. As the dry season began, the vine Jitirana was avidly selected by both sheep and goats and continued to be eaten even into the late dry season. Fallen leaves from woody species became more important as the dry season progressed and herbaceous species were no longer available. These species included Catinguera, Mororo', and Marmeleiro. Interestingly, Pau Branco, the dominant tree of the area, was never an important forage item.

From a nutritional standpoint, diets were of higher quality than expected. Crude protein in diets (Figure 1), an important nutritive index, was observed to remain high throughout the year. Values never fell below about 12%, even near the end of the dry season. The National Academy of Science's recommended level of crude protein for goats in late gestation is about 13 percent. Subsequent lab analysis of some of the species that were highly selected by grazing animals (Table 1), confirmed that even fallen leaves retain relatively high crude protein levels into December, the usual end of the dry season.

These findings, although preliminary, indicate that protein may not be as great a limitation as anticipated on native *caatinga* range where a mixture of herbaceous and tree species are available. They also offer a preliminary guide for further work on selective clearing of trees that are not eaten by small ruminants. Work is in progress on further nutritional analyses.

Related research is being done by Pfister on theoretical aspects of feeding behavior in sheep and goats. This is an attempt to explain the reported greater survivability of goats over sheep during periods of extreme nutritional stress such as that imposed by extended drought. The approach involves measurement of the amount of time spent by sheep and goats at a feeding station (the hypothetical semi-circle of forage within reach of a feeding animal at a particular position). During dry season months when both species were consuming fallen leaves, no species differences existed; however, as the wet season progressed and goats began feeding from the tops of tall (> 2m) annual forbs and from overhead branches, their feeding station times tripled. Foraging time is an important component of ruminant feeding strategies and the bipedal stance often assumed by goats seems to be costly in time. The nutritional pay-off of this behavior will be determined.

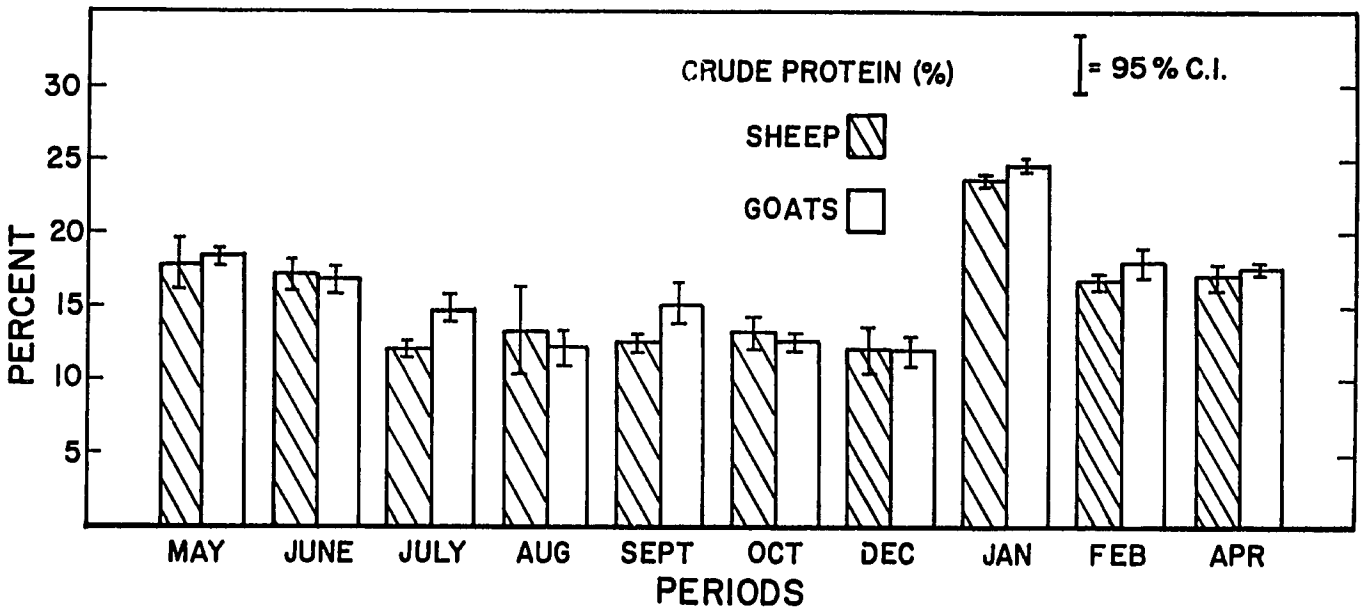

Figure 1. Seasonal trends in dietary crude protein for sheep and goats feeding on native caatinga range.

Table 1. Dry Season Crude Protein Values (%) of Important Forage Species

	Sept.	Oct.	Dec.
Tree foliage			
Mororo	21.2	—	—
Sabia	19.7	—	—
Marmeleiro	19.3	15.9	—
Dried leaves on standing dead Jitirana	15.6	—	—
Leaf litter			
Mororo	5.2	6.1	—
Sabia	—	10.5	11.1
Catingueira	—	11.4	11.1
Marmeleiro	—	12.6	9.5

Range Improvement: Land Clearing and Brush Manipulation

Land clearing serves two apparent purposes: it provides saleable wood products (firewood, fenceposts) and is thought to increase forage production by annual grasses and forbs through removal of competition by trees and shrubs. However, the widespread and common practice raises numerous issues including questions such as:

- What is the extent of the increase in forage yields due to clearing and how many years does the effect last?
- How are animal diets, nutrition, and animal production affected?
- Do different seasons and methods of clearing change the response?
- What are the long-term effects on soil productivity, erosion, and ecosystem stability?

Utah State researchers Robert Kirmse and Fred Provenza began an initial study of these questions in 1981. They have compared forage yields, forage composition, and animal diets and nutrition on paired cleared and uncleared sites. Additionally, rates of forage decomposition are being measured to determine how grazing the flush of herbaceous vegetation produced after clearing might be deferred in order to serve as a standing forage reserve for the late dry season when traditional feed supplies are nearing exhaustion.

In related research, Utah State researcher Linda Hardesty is studying the response of selected important woody species to various times and methods of cutting. This research should indicate how best to control, by cutting, a particular species that presents a noxious brush problem.

We have also observed that some tree species cut at certain seasons tend to retain leaves on the re-sprouted new twigs and branches well into the dry season, whereas the uncut parent trees drop their leaves in the regular dry-season deciduous pattern. This raises the possibility of using selective cutting of certain species to prolong, in effect, the green period of available forage. However, we are only now beginning our investigations into the acceptability and nutritional value on these re-sprouts.

Initial results indicate an unquestionable "release" of herbaceous ground-level annual vegetation from competition by over-story trees during the first growing season after clearing. Figure 2 vividly demonstrates this effect, but it should be pointed out that much of the increase in production is in the form of coarse stemmy material that is

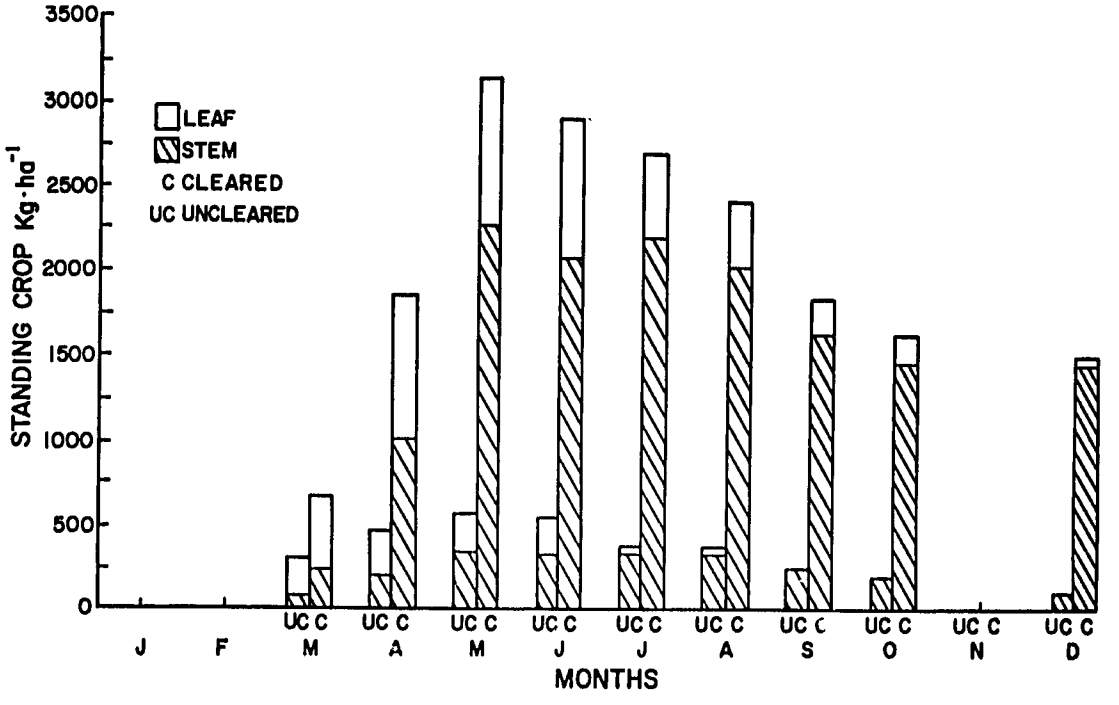

Figure 2. Monthly standing crop of herbaceous annual vegetation on cleared and uncleared caatinga ranges. Much of the yield on cleared land is in the form of plant stems (1982).

not consumed by either sheep or goats. Fallen leaf litter is abundantly available throughout the dry season on uncleared land while the remaining material from herbaceous species on cleared land is in a declining phase throughout the dry season. This raises the prospect of selective clearing or strip clearing to provide a boost for production of annual herbaceous species during the wet season, but would also retain important tree species that yield nutritive and abundant forage for use in the late dry season. Fallen leaves from woody species also provide a valuable ground cover that is presumably important in erosion prevention when the first intense rains occur.

Initial results on decomposition studies show a marked difference between rates for leaves from trees, grasses, and forbs. Forb leaves decay rapidly, tree leaves very slowly, and grass leaves are intermediate. The potential nutritional consequences of this to sheep and goats is still unknown, but is being investigated.

Significance of Research Findings

Initial computer runs of the newly-completed farm-systems model constructed by Nestor Gutierrez of the Winrock Economics Project point to the significance of range related research for the *sertao*. Model output indicated differences in farm income between "average" years and "poor" years amounting to 85%. The major contributor to this difference was corresponding variation in forage supply. To put this in perspective, increasing small ruminant natality rate from 70% to 100% (through model manipulation) increased farm income by only about 3 percent.

Thus, if guiding principles of systems analysis and computer modeling are followed, the importance of the range forage resource must be emphasized, both in practical management terms and in allocation of scarce research resources to high priority problems.

The research of the Range Management Project is highlighting the management activity which has the highest potential for affecting forage supplies of the Northeast: *caatinga* clearing and manipulation. For example, our initial study of forage production and animal nutrition on cleared land indicates a 6-fold increase in yields of herbaceous annual species during the first year after clearing. However, if a major decline occurs 3-5 years after clearing (as we are hypothesizing, based on results from other semi-arid tropical regions), a very close examination of marginal costs and marginal benefits is called for. A less radical type of treatment is already designed for possible research where well planned strip clearing would be substituted for the traditional "clear-cut" approach. This would theoretically give the short-term benefit of increased herbaceous annual forage production while maintaining the nutritionally important and predictable tree and shrub species that apparently modulate the vast swings between wet and dry seasons and normal years and drought years.

The practical appeal of this research approach, aside from being biologically important as revealed by modeling results, is that we are dealing with modification of an existing local technology. As mentioned earlier, land clearing is an integral part of smallholder activities in the *sertao*, and is practiced using local labor during seasons when farmers are not otherwise occupied. It is even subsidized indirectly through certain government incentive programs.

Bearing in mind the considerable current and long-range economical and ecological impact that land clearing can have, it is vitally important to know as much about it as possible, with all of its ramifications for animal nutrition and production before making recommendations to change traditional smallholder sheep and goat production practices.

Researchers emptying feces from the collection bag on a sheep. Forage intake can be determined indirectly by knowing the daily quantity of feces and the digestibility of the diet consumed. Photo: J. Malechek.

Future Research Directions

With only just more than two years of field data and related lab work completed, we do not yet know enough about land productivity capabilities, seasonal and yearly forage supplies, land responses to clearing, and animal nutritional characteristics to make major changes in the overall direction of our research. Range research is slow in yielding definitive results because of the profound effects of yearly climatic variations. For example, we are already seeing a 5-fold difference in forage yields between 1981, a "poor" year (519 mm precipitation), and 1982, an "average" year (715 mm precipitation). With such major differences between two successive years that were not extreme in total precipitation levels but showed contrasting patterns of rainfall distribution, it is obvious that predictions and recommendations would be no more than speculation, unless backed by a run of several years of data that embraced a wider span of variability. Thus, our first priority is to continue research now in progress so that we can witness more of the extremes that are characteristic of the Northeast.

Another major priority will be better integration with the Winrock Economics Project and the North Carolina State Nutrition Project. In the first case, the Winrock production model will be the focus of collaboration. At present, the model does not consider ecological variability in land production characteristics. Although this component can easily be added to give the model greater regional predictive power, additional field work will be required to establish a quantifiable relationship between soil types and vegetation on the one hand and composition and productivity of farm livestock herds on the other hand. We will undertake this work in 1983-1984.

Another relationship to the Winrock Economics Project will be established through joint analysis and evaluation of data from on-going grazing trials being conducted by collaborating Brazilian scientists. These trials are being conducted in two areas in Ceara State; at Taua, under the supervision of Dr. Joao Ambrosio of the Federal University of Ceara, and at Quixada, under the supervision of the state research agency EPACE.

Dr. Ambrosio will be spending a sabbatical year at Utah State in 1984 and will have the opportunity of collaborating with Winrock and Utah State scientists on his research. Plans are also underway to bring one of the EPACE scientists to Utah for graduate training at the PhD level. He would evaluate grazing trial data from the EPACE experiments as part of his thesis research, under the joint supervision of Utah State and Winrock scientists.

Closer relationships will also be pursued with the North Carolina State Nutrition Project investigators, in their efforts to evaluate nutritional characteristics of individual native tree and shrub species and to understand the mineral nutrition of sheep and goats.

Brazilian workers construct goat-proof fences for grazing comparisons between undisturbed vegetation and the regrowth after clearing and burning. Photo: W.C. Weir.

Table 2. Degree-Related Training as a Part of the Utah State University Range Project in Brazil

Name	Nationality	Degree Sought or Obtained	Type of Support	Area of Study	Location and Duration of Study	Present Position
James A. Pfister	USA	PhD	F[1]	Range Animal Nutrition	Brazil (1.5 yrs)	Grad. Research Assistant, USU
Robert Kirmse	USA	PhD	F	Range Ecology	Brazil (3 yrs)	Grad. Research Assistant, USU
Joao S. de Queiroz	Brazil	PhD	F	Range Ecology	Brazil (1 yr)	Grad. Research Assistant, USU
Linda Hardesty	USA	MS PhD	F F	Range Ecology	Utah (1 yr) Brazil (2 yrs)	Research Associate, USU
Roberto Cesar Magalhaes Mesquita	Brazil	MS	P[2]	Range Animal Nutrition	Utah (1 yr)	Grad. Research Assistant, USU

[1] F designates full financial support (assistantship stipend plus research operating costs) from SR-CRSP funds.

[2] P designates only partial support (usually research costs) from SR-CRSP funds.

Table 3. Non-Degree Training as a Part of the Utah State University Range Project

Name or Group Instructed	Number Instructed, if Group	Type of Training	Location	Length of Training
Brazilian scientists from EMBRAPA and affiliated research organizations	25	Shortcourse on methods of measuring *caatinga* vegetation	Brazil	3 days
Brazilian scientists from EMBRAPA and related research organizations	12	Shortcourse on techniques of animal diet analysis	Brazil	2 days
Sandra Mara, graduate student, Federal University of Ceara'	—	Diet analysis; vegetation sampling procedures	Brazil	9 months
Vanceslau Alves Costa, Field worker/animal caretaker	—	Care and husbandry of fistulated animals; sampling procedures	Brazil	18 months
Edith Oliver, BS, Texas A&M Univ.	—	Vegetation sampling methods	Brazil	4 months
Daniel Hardesty	—	Ecological sampling procedures	Brazil	9 months

Training

The range management group has adopted the position that trained scientists are the most valuable and enduring "products" of a research project for developing nations. Thus, we have chosen to invest project dollars in advanced, highly qualified graduate students, rather than in placing PhD-level scientists overseas.

Our emphasis has been on US nationals as well as nationals from Brazil and other developing countries. We anticipate that the US students will find careers at American universities and other institutions engaged in international agriculture and resource management. International experience gained in these graduate programs, including language training, will enable them to step directly into their professional positions with only minimal adjustment. Likewise, we expect our students from developing countries to return to their respective countries to initiate their own research and educational programs, adopting techniques, philosophies, and approaches gained in association with their graduate work.

We have also engaged in shortcourse training for professionals and informal on-the-job training for several Brazilian personnel. Tables 2 and 3 present a summary of our training activities.

Selected Publications

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Kirmse, R.D. and F.D. Provenza. 1982. Herbage Responses to Clearcutting *Caatinga* Vegetation in Northeastern Brazil. First Brazilian Symposium on the Semi-Arid Tropics. Recife, Pernambuco, Brazil.

Malechek, J.C. 1982. Grazing Management of Goats in Extensive Rangeland Production Systems. Proc. III Int'l. Conf. on Goat Prod. and Dis. Tucson, AZ. pp. 404-408.

Malecheck, J.C. and F.D. Provenza. 1983. Nutrition and Feeding Behavior of Goats on Rangelands. World Ani. Rev. 41: (In Press).

Malechek, J.C. and F.D. Provenza. 1981. Feeding Behavior and Nutrition of Goats on Rangelands. Proc. Int'l. Symp. on Nutrition and Systems of Goat Feeding. Tours, France. pp. 411-428.

Pfister, J.A., J.C. Malechek, and E.A. Lopes 1982. Dry Season Diets of Goats and Sheep Grazing Native *Caatinga* Range. First Brazilian Symposium on the Semi-Arid Tropics. Recife, Pernambuco, Brazil.

Pfister, J.A. and J.C. Malechek. 1983. Diet Selection of Goats and Sheep Grazing *Caatinga* Range in Brazil. Abstracts of Papers, 36th Ann. Mtg., Society for Range Mgmt., Albuquerque, NM.

Pfister, J.A., J.S. de Queiroz, R.D. Kirmse, and J.C. Malechek. 1983. Rangelands and Small Ruminant Production in Ceara' State, Northeastern Brazil. Rangelands 5: (In Press).

Sociological Analysis of Small Ruminant Production Systems

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The goals of the Sociology Project in Brazil were twofold: to develop an understanding of the role of small ruminant production within the total production system and identify the likely constraints to increasing production; and, to demonstrate to EMBRAPA the contribution sociologists can make to an integrated multi-disciplinary program designed to increase small ruminant production.

Northeast Brazil has a much more complex agricultural system than one might guess at first glance. Although it is classified as a semi-arid area, crop production is nonetheless important and animal production has to be integrated with it on most farms. In addition, there are substantial year-to-year variations in rainfall which indicates that producers have developed an ability to adapt to changing conditions. The Sociology Project has tried to develop an understanding of the dynamics which influence shifts between crop and animal production, and, within the animal area, the shifts between large and small ruminant production and how climatic variation influences both of these. Superimposed on this is a complicated land tenure situation which is characterized by a considerable amount of absentee land ownership and share cropping arrangements. An additional goal has therefore been to understand how the land tenure situation might influence increased production of sheep or goats.

The first year's activities in Brazil (1981-82) focused on the State of Ceara. The objectives of this effort were to:

- Develop a comprehensive view of the total production system of agriculturists in the *sertao* of Ceara.
- Understand the production decision framework of farmers and in particular the decision rules governing small ruminant production within this total system.
- Develop a sociological analysis which would complement the economic analysis done with the same sample.

The 1982-83 activities had three objectives:

- To study the role of goat production within the total production system of small producers in northern Bahia. This was to be done much in the same manner as was accomplished in Ceara the previous year.
- To evaluate the possibilities and sociological consequences of introducing dairy goats in the *sertao* of Paraiba.
- To examine the biological performance and sociological responses to the introduction of new management techniques of goats among small producers in a micro region of Paraiba.

Given the nature of the Northeastern Brazil agricultural system, the potentials for error in attempting to improve small ruminant production through a uni-dimensional strategy of biological intervention are quite high. Without a thorough understanding of the social organization of production and the role that small ruminants play on "typical" farms, there is a strong possibility that proposed interventions will either not be adopted by farmers, accomplish nothing, or help only the relatively well-off farmers.

In Northeast Brazil, goats are generally able to withstand periods of drought better than cattle. Photo: G. Primov.

Research Accomplishments

From the interviews conducted with the sample of small ruminant producers in Ceara, a technical report was prepared (Primov, 1982) which contained a number of interesting insights. However, overshadowing all else is the observation that the total production system is highly variable and greatly influenced by rainfall. Small ruminant production has not developed as a form of specialized commodity production and therefore it would not be expected that it would respond significantly to market incentives. For most farmers, the relative importance of small ruminants within their total production strategy tends to vary considerably between wet and dry years. During dry years, small ruminant production becomes much more important since animals serve as both a subsistence and cash crop. During wet years, cotton and cattle are seen as much more profitable while small ruminants become more expendable. Marketing small ruminants is largely determined by the financial needs of the household rather than

external market conditions, and increases in price and/or demand are therefore unlikely to stimulate production. Producers, particularly the smaller land owners, cannot increase production without sacrificing the flexibility they need in order to cope with alternating dry and wet years. Since producers are confident that they can market whatever animal they produce, there is little incentive to upgrade animals for marketing purposes. The very poorest sector of the rural population who are principally *landless* producers, raise few animals and do not have many opportunities to increase their livestock production. Of the smallest stratum of *landowners,* 25 hectares or less, many avoid goat production entirely because these animals require either constant supervision or fencing. This is in spite of the fact that the land owners are quite aware that goats survive droughts better than sheep.

On the basis of these findings it is recommended that the SR-CRSP in Brazil should avoid encouraging small ruminant producers to specialize in small ruminant production nor should they be encouraged to significantly increase the size of their herds. Since these animals represent a vital component in the producers' abilities to respond and adapt to changing environmental conditions, specialization in any commodity production, including sheep or goats, is not recommended. The producers perceive their greatest problems as being in the area of improving herd productivity and in health related problems. It is recommended that research efforts be directed toward overcoming these constraints.

The second major activity which was undertaken in the State of Bahia is still incomplete. The objective of this project was to understand the role of goat production within the total production system and to compare small ruminant production in *sertao* Ceara and in northern Bahia. The project also sought to identify for other projects (biological and economics) the most important problem areas of goat production as identified by the producers. This project involved interviewing a random sample of about 50 small producers in four municipios in northern Bahia. Preliminary data indicate that although small ruminant production in northern Bahia is more important to producers than it was in Ceara, it is less important than expected: differences in the production system between Bahia and Ceara are differences of degree rather than of kind. In Bahia, water shortages are by far the most important problem in production. Since shortages of water also lead to shortages of forage, inadequate nutrition is a serious issue as well. Health problems did not appear to be as severe as they were in Ceara.

The third research activity was the study of dairy goat producers in Paraiba. This project sought to develop a general description of the local dairy goat production systems and to identify problem areas which might help direct future research efforts. This project, involving interviews with 54 goat producers in two counties in Paraiba, produced several significant conclusions. First, production systems were characterized by a high degree of interdependence and interaction between livestock and agricultural production. While goats and goat milk were not important staples for home consumption, goats were the most reliable source of cash income. In general, the dominant management techniques for goats involved minimal labor and capital investments. The main constraints to increasing goat milk production in this area were a lack of financial resources on the part of the small producers, a lack of water during most of the year, the deterioration of the *caatinga* during the dry season, animal health problems (particularly endo and ecto parasites), and inadequate extension services.

The data from this study suggested that because most producers cannot depend on a regular cash supply, research priorities should involve the development of technologies which require a minimum amount of cash and fixed capital investments. Moreover, because most producers owned only native breeds of goats, research on these species and the use of the native vegetation seems to be crucial at this time. Because the technology of dairy goat production was not well known and because the small producers lacked very basic knowledge of techniques and the minimum capital necessary to improve goat milk production, a much closer relationship between researchers and extension workers will be necessary in order to achieve any success in this area.

The objective of an additional study, done in cooperation with the Texas A&M Management Project and completed in April 1983, was to monitor the changes in various elements of the small farms where improved dairy goat management techniques, primarily supplemental feeding, were initiated. The sociological portion of the project concentrated on assessing the labor requirements of the recommended practices and their impact on overall labor requirements of the farm. Particular attention was paid to the division of labor within the family, monitoring the dynamics of the production system for alterations after the new practices had been introduced, assessing the actual expenses associated with the new management practices and comparing them with the increased monetary value of milk and cheese output. This study also offered the opportunity for assessing the likelihood that these producers would continue the new practices during the next dry season. The research was designed as a pilot project and involved five producers who were selected on the basis of professed interest in improving goat milk production and who had the necessary infrastructure to implement and continue improved production practices.

Preliminary data indicated that even though the labor requirements for goat production on these farms had doubled after the project started, it had not become an undue burden for the five families involved. All families were able to keep up with all the other farm activities. Livestock production in general, and goat production in particular, were traditionally male tasks. Women were only partly involved in the feeding and caring of the goat kids but were the key actors in processing goat milk into cheese. Only the largest of the five producers indicated that he would be able to feed the concentrate ration during the next dry season. Another producer said he would give the does and kids at least some kind of concentrate. Two producers stated they could not afford the ration during the dry season.

Goat milk can provide a valuable addition to the household diet; it is produced in convenient amounts and children can provide the labor for herding and milking. A young girl is shown milking a doe near Juazeiro, Bahia. Photo: G. Primov.

Significance of Research Findings

All of the studies undertaken in Brazil to date point to one overall conclusion. In spite of the fact that small ruminant production in Northeast Brazil primarily takes place within a grazing system that is range oriented, crop production plays a very important role in the overall farming system. Any attempt to improve small ruminant production without taking into consideration the parallel cropping system and the dynamics of the interchange between animals, crops and climate, is probably doomed to failure. For the small and medium sized land owners, small ruminants provide a source of flexibility and insurance for times when rains and crops fail. Given this system, producers are not going to be willing to make major investments in their small ruminant enterprise nor to specialize in small ruminant production. In the context of the Northeast with its highly variable rainfall, specialization in the production of any one commodity is probably close to committing economic suicide. Thus, it is imperative that the Range and Nutrition projects in particular examine the cropping aspects of the farming system in order to see how their recommendations would fit within that context.

Future Research Directions

By September 1983, the Sociology Project will have provided to the other programs in Brazil a good baseline description of the significant factors involved in farmers' decisions concerning small ruminant production in Northeast Brazil. While a number of the issues mentioned in the research accomplishments section could be studied in considerably more detail and across a considerably broader cross section of the Northeastern population, taken together, the reports that are already published or are planned constitute a good reference for those projects still active in Brazil. It is hoped that future work can be undertaken particularly in terms of monitoring the results of technological/managerial interventions proposed by the biological projects. Future efforts could also profitably look at the effectiveness of the extension service and the access farmers have to credit.

Training

One Brazilian student has received graduate training at the University of Missouri in the Department of Rural Sociology. This student, Marisa C. Neumaier, completed the requirements for her Masters degree in Rural Sociology in September 1983. Ms. Neumaier is a staff member of the soybean center in the EMBRAPA structure. It is hoped that if the appropriate administrative details can be worked out, she will be able to maintain at least minimal contact with the goat research in Northeast Brazil in the future.

Selected Publications

Neumaier, Marisa C. 1983. Sociological Aspects of Goat Production in Paraiba, Brazil. MS Thesis. Department of Rural Sociology, University of Missouri.

Primov, George P. (In Press). Small Ruminant Production in Bahia, Brazil. SR-CRSP Technical Report Series.

Primov, George P. 1982. Small Ruminant Production in the *Sertao* of Ceara, Brazil: A Sociological Analysis. SR-CRSP Technical Report Series No. 15.

Small Ruminant Flock/ Herd Health Program in Smallholder Systems

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It is generally recognized that the major constraint to livestock production in the *sertao,* the desert area of Northeast Brazil, is the uncertain feed supply. The next major constraint in obtaining maximum production is disease. The entire gamut of etiologic agents including bacteria, viruses, parasites, exogenous toxins, and nutritional and metabolic imbalances are known, or more often suspected, to cause disease in the region. While it is generally true that maintenance of a good nutritional plane enhances resistance to disease, it must also be recognized that disease can lessen an animal's competitive vigor and instinct for survival under the stressful conditions associated with limited feed supplies and harsh climates. Maintenance of adequate nutritional levels and reduction of the disease burden are obviously complementary to one another in maximizing animal production.

The major goal of the Animal Health Project in Brazil is to increase the productivity of goat producers by developing the means for controlling diseases that are major problems to the *sertao.* The initial approach was to identify the major disease problems and to set priorities for disease research. In many cases this has involved confirmation of the existence and establishment of incidences and prevalence of conditions reported or suspected to occur largely on the basis of anecdotal information. The selection and pursuit of research projects has been made on the basis of the perceived importance of the disease process and of the feasibility of performing the research needed to reach the eventual goal of disease control. Such work must necessarily include development of a basic understanding of the diseases involved and relating that understanding to conditions in the field. The most obvious need in the pursuit of these objectives at the Brazilian National Center for Goat Research (CNPC) has been the development of laboratory facilities and technical support to carry on such work.

The project has identified intestinal parasitism, caseous lymphadenitis and pneumonia as disease processes in which research projects can be pursued with reasonable expectations of progress at the CNPC. Collaborative projects have been established with animal health scientists at the CNPC within the framework of the Brazilian national agricultural research enterprise (EMBRAPA). In part to service these projects, but more importantly to establish a continuing research resource for the CNPC, the project has provided support for laboratory facilities and training of technical staff.

In addition, veterinary consultation and collaboration have been provided to other SR-CRSP projects at the CNPC. It is the intent, in part accomplished, to integrate the animal health research projects with other SR-CRSP projects by collaborating with SR-CRSP scientists where animal health could have a meaningful effect on the results.

Research Accomplishments

A senior investigator, D.E. Hansen, was stationed in Sobral for two years with the major responsibility of determining the nature of disease problems in the *sertao.* A survey was made to determine the prevalence of various diseases among 31 farms and the incidence of specific diseases of small ruminants on each of these farms in the state of Ceara, Brazil. Prevalence and incidence were recorded during scheduled visits to 21 farms, for which the animal health survey was the primary purpose of the contacts, and to 10 farms on which the veterinary scientist collaborated with SR-CRSP investigators from the Economics, Nutrition and Reproduction projects. The primary purpose was to determine which diseases were major economic constraints in the production of meat and hides. The findings of the survey which ran from July 1981 to June 1982 are presented in Table 1.

Table 1. Prevalence and Incidence of Disease in Sheep and Goats on 31 Survey Farms in the State of Ceara in Northeastern Brazil

	Prevalence		
Disease	No. of Farms Affected	% Affected	Incidence on Farms %
Mortality of Newborn (< 60 days of age)	31	100	8.5-27
Parasitism	19	61	—
Abortion	15	48	8.2-51.3
Photosensitivity	9	29	22-60
Pneumonia	9	29	3-43
Lymphadenitis	8	26	5-18
Mastitis	3	9.7	20-25
Diarrhea	20	65	—

Other diseases were observed but not included because of uncertain diagnoses or too few numbers to be significant. These included contagious ecthyma, foot rot, birth defects, ectoparasites and other skin diseases. Plant intoxications occur in a highly seasonal pattern.

It should be noted that Ceara is on the fringe of the major goat producing area of Brazil. Some of the diseases which are considered to be of little importance by producers in Ceara, such as caseous lymphadenitis, are of major concern to producers in areas of more intensive goat production.

An analysis of the specific management practices was made on the 31 ranches surveyed to determine the possible reasons for the wide variation in incidence of mortality (8.5-27%) in newborn animals. The analysis demonstrated that four practices which in combination had the most beneficial effect in lowering mortality were, 1) treating naval cords at birth, 2) regular cleaning of the corrals and houses throughout the year, 3) separation of the dams and newborns from the rest of the herd, and 4) cleaning and disinfecting the corrals and houses prior to parturition.

Brucellosis, the cause of undulant fever in man, is considered to be prevalent in Brazilian cattle. It was therefore thought to be a likely cause of abortions in sheep and goats and a possible hazard to human health. To determine the likelihood of this danger, a serologic survey for evidence of infection by *Brucella abortus* in sheep and goats was carried out in more than 7,000 animals. Positive titers were found in only 0.21% of the animals tested. This suggests that the health hazard to either animals or humans from this disease in sheep and goats is almost negligible under present conditions.

To determine the type of forage utilized by sheep and goats in the *sertao*, range management specialists required the surgical preparation of an esophageal fistula from which ingesta could be collected. Dr. Hansen provided surgical service and training for the range management technicians and developed a new surgical fistulation technique. This technique greatly improves the feasibility of the collection procedures by reducing the problems of maintaining the fistula and thus prolonging its useful life.

Several long-term projects have been established to study the dynamics of intestinal parasitism in sheep and goats in the *sertao*. A major problem being addressed is determining the chronology of contamination, exposure, infection and onset of clinical disease which is critical in the development of control programs. The severe climatic and nutritional variations in the region tend to mask the effects of parasitism and necessitate the use of indirect methods to ascertain stages and levels of the infection cycle. The general procedure used is to expose groups of susceptible kids, which have been raised free of parasites, to infected premises for 90 days after which they are killed and examined for evidence and levels of parasitism developed during that interval. The findings of multiple consecutive group exposures are then correlated to seasonal and climatic variables.

Using a similar technique, the effects of housing goats on slatted floors during the night on the level of parasitism has been studied. The effect is considered to be negligible. The same procedures will be used to complete a study on suspected breed differences in susceptibility to parasitism.

Bacterial pneumonias have been demonstrated by gross and histopathologic examinations to be the most common cause of death and the major cause of condemnation at slaughter of sheep and goats in the Sobral area. A microbiology laboratory has been established by the Animal Health Project at the CNPC. Dr. Mary Sawyer has been placed in the laboratory as the Senior Investigator with the primary responsibility of organizing a functional laboratory and training her Brazilian replacement, Dr. Cristine Almeida,

Collecting a blood sample from a kid for a serologic test. Photo: H. Olander.

who has been hired by the project for that purpose. This laboratory will enable CNPC scientists to determine the prevalent etiologic agents associated with the common pneumonias.

The laboratory will also assist in a study of the etiology of mastitis in a dairy goat operation which is managed by the SR-CRSP Nutrition Project in the state of Paraiba.

A major project has been established to study caseous lymphadenitis. This disease, which is characterized by abscessed lymph nodes, occurs throughout the world and is prevalent in sheep and goats in the *sertao*. Preliminary clinical and cultural studies have indicated an incidence of abscesses as high as 20% in some herds near Ceara, but organisms other than *Corynebacterium pseudotuberculosis* were isolated in 50% of abscesses cultured. These studies have indicated that lymphadenitis is less prevalent in Ceara than in the rest of the Northeast. Field studies are now underway to determine the level of subclinical infection and the age of natural infection of kids in herds with a high incidence of disease. The general procedure is to determine the age of serologic conversion of kids indigenous to herds with a high incidence of disease and of susceptible kids newly exposed to those herds and to correlate this with pathologic and bacteriologic findings. The microbiology laboratory at the CNPC is providing the necessary laboratory support.

Significance of Research Findings

The research that is in progress is addressing the need for a general understanding of the dynamics of disease processes in tropical desert regions. To the extent that these studies are successful, they will help to reach the overall objective of the Animal Health Project which is to increase small ruminant production through the control of disease. Application of rational control measures requires an understanding of the basic mechanisms by which disease agents thrive or are suppressed in a given environmental situation. The interaction of disease control with other aspects of livestock management in increasing productivity has been stated in the project goals. However, specific interaction between the Animal Health Project and other SR-CRSP projects has occurred with regard to improved health of test animals. Examples are the improved surgical technique used in range management testing and improved sanitation measures associated with the goat mastitis study in Paraiba which should reduce the level of disease and its associated production variables. Further, the studies on the dynamics of parasitic and microbial infections which are in progress should provide the impetus and example for changing management practices to improve animal health and production.

A finding of some import regarding human health has been the very low incidence of *Brucella abortus* infection in sheep and goats in the *sertao*, suggesting the relative safety of these animals as suppliers of meat and milk under present circumstances. It also underlines the need for care in exposing highly susceptible sheep and goat populations to foreign livestock.

Perhaps the most important effect of the project's research will be the establishment of a functional microbiology laboratory to support investigations and research on infectious diseases at the CNPC. Such a facility will provide an important aid for recognizing, monitoring and controlling disease processes which could directly effect the outcome of research in other projects at the Center as well as the productivity of the sheep and goat industry of the *sertao*.

Future Research Directions

The most pressing need of the Animal Health Project in Sobral is the establishment of a permanent microbiology laboratory to support research on infectious diseases. The current work on pneumonia, caseous lymphadenitis and mastitis is providing the impetus for the development of such a capability. In the initial stages, these projects will provide a sufficient workload for the development of facilities and techniques and training of personnel. As the capability of the laboratory matures, research should be pursued in the areas of abortion and neonatal death which previous work has indicated to be major constraints on goat and sheep production.

Training

The project has attempted to provide a means for exchange of graduate level training between the CNPC and UC Davis with the goal of establishing a long term liaison between senior scientists and the developing staffs of both institutions. It has also attempted to support on-the-job training of technical help for Brazilian counterparts. A major endeavor in this direction involves the development of a microbiology facility and the concurrent training of a Brazilian microbiologist as described below. In addition, discussions have been held with CNPC administrators concerning the presentation of an international conference on caseous lymphadenitis to be held in Brazil. This will add impetus to the work on the project and will provide a valuable learning experience for project scientists.

Graduate training programs which are in progress or have been arranged follow.

Terezinha Padilha-Charles, DVM, MS, began her training for a PhD in parasitology at UC Davis under Dr. Norman Baker in 1982. Her work is to be completed in 1985.

Carlos Costa, DVM, MS, is scheduled to come to UCD in the Fall of 1983 to work towards a PhD in parasitology under Dr. Baker.

Janete Santa Rosa, DVM, MS, has been tentatively proposed to begin work toward a PhD in pathology at UC Davis beginning in 1984.

Cristine Almeida, DVM, has been hired to work and train with Mary Sawyer, PhD, UC Davis microbiologist, in developing the microbiology laboratory at the CNPC. The project supported an initial training period for Dr. Almeida in an EMBRAPA laboratory in Rio de Janeiro under Dr. Charlotta Langenegger. She will provide continuing direction for Dr. Almeida in working toward an MS degree in Brazil. It is hoped that a PhD program will ultimately be provided for Dr. Almeida at UC Davis.

Selected Publications

Hansen, D., B. McGowan, and E. da Silva. 1983. The Development of a System for Surveillance of Disease of Sheep and Goats on Small Farms in Northeastern Brazil. SR-CRSP Technical Report Series.

Hansen, D., B. McGowan, N. East, E. da Silva, M. da Silva, J. Santa Rosa, C. Costa, M. Sawyer, J. Sawyer, and H. Olander. 1983. The Prevalence and Incidence of Diseases of Sheep and Goats on Selected Farms in Northeast Brazil. (In Preparation for Publication as an EMBRAPA Bulletin and in the Journal of International Sheep and Goat Research.)

Hansen, D., J.A. Pfister and J.C. Malechek. 1983. Surgical Establishment and Maintenance of Esophageal Fistulae in Small Ruminants. (Proposed for Publication as an EMBRAPA Bulletin and in the Journal of International Sheep and Goat Research.)

Sawyer, M., M. da Silva, and J. Kleber. 1983. Control of Mastitis in Dairy Goats. (In Preparation for an EMBRAPA Bulletin.)

Breeding and Management of Sheep and Goats

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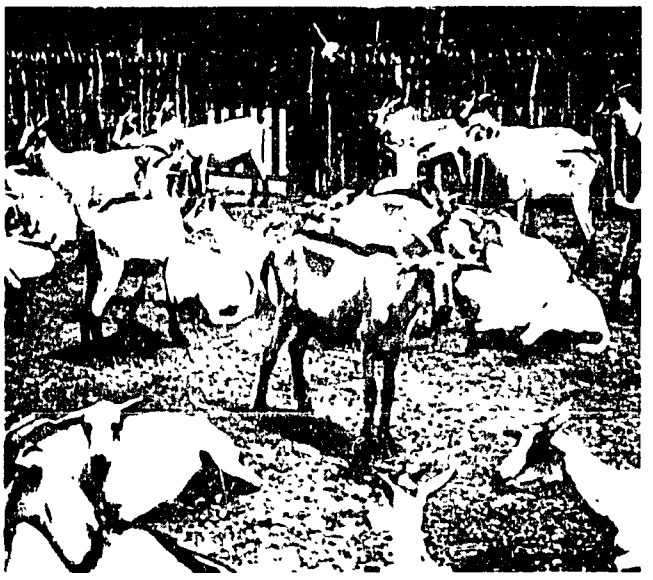
Texas A&M University

The Texas A&M University component of the SR-CRSP in Brazil was initially charged with responsibility for breeding, and much of this report will relate to this activity. However, beginning in the fall of 1982, the project assumed responsibility for the Management component and information on this aspect will be treated briefly.

Given the environmental and socioeconomic constraints which characterize Northeast Brazil, the presence of adapted, productive genotypes is an indispensable requirement for efficient animal production. If these do not already exist, they must either be introduced or created, based on breeding programs within the country. The goals of the SR-CRSP Breeding Project may therefore be stated as follows:

- To describe the existing breeds in order to facilitate communication and reporting.
- To characterize the distinctive genotypes (or breeds) in respect to their performance traits as a guide to determining their utility in an overall breeding and production strategy.
- To identify the environmental constraints to production and the individual animal characteristics which contribute to improved adaptation and productivity, with the view that emphasizing some of these in selection might increase efficiency of selection.
- To collect or obtain the necessary genetic parameters and design and place in motion the indicated long-term improvement programs.
- To evaluate the potential gain which might be realized from introducing selected exotic genotypes.
- To attempt to extract from the work in the US and Brazil the maximum amount of information which may be transferable to other areas or environments.

If each of these goals is pursued consecutively and carried to near completion, many decades and extensive resources would be required. To economize on time, they have been pursued in parallel in this project and some progress on each has been made. However, it must be realized that breeding projects are of long-term duration and therefore expectations of this project should be viewed in light of the short period of time that work has been in place in the field. By contrast, alteration of management practices offer the potential for immediate improvement but require repetition with each season or generation. In the near term, management, in the broadest context, offers the only means of bringing about quick improvement. Even in an adverse environment such as



One of the unique breeds of goats in Northeast Brazil is this research flock of Moxoto goats at the CNPC, Sobral. Photo: M. Shelton.

Northeast Brazil, few problems of a technological nature are encountered in suggesting practices which will bring about improved productivity. However, serious socioeconomic problems are faced when introducing new technology. Thus, the overall goal of the management component of this project is to ferret out those practices based on existing or new technology which can be implemented or recommended for implementation within the socioeconomic constraints existing in Northeast Brazil and other LDC environments, and which have a high probability of making a contribution to improved productivity.

The possibilities for making contributions in this area appear to be very good. However, as of this writing, the Texas A&M University Management component of the SR-CRSP Brazil program has been in place for only six months and accomplishments should be viewed in this light. Also, the state of Paraiba (EMEPA) has an active program to encourage and assist producers in developing the dairy goat. At the request of Brazilian collaborators, the management component has placed a scientist in Paraiba to assist this endeavor. The initial efforts have concentrated on nutrition because this is an obvious limitation and is an area where an early response might be obtained or where useful data may be collected in a short period of time.

Research Accomplishments

Genetic Resources

One of the first accomplishments of the project was to provide descriptive information on the various genotypes of sheep and goats found in the area with some preliminary information on production conditions (Shelton and Figueiredo, 1981). The sheep are generally described as "Ovinos Deslanados," or without wool. However, the most

prevalent type is known as the "Crioula" which often have a vestigal fleece cover that is not exploited commercially. In addition to the "Crioula," the recognizable breed groups include Morada Nova, Santa Ines, and the Brazilian Somali. The first two are largely unique to Brazil, although they resemble hair sheep found in adjacent regions including the Caribbean. The Morada Nova is a small hair sheep which has been in Brazil for many years. The Santa Ines is a larger breed derived from crossing exotic types on the Morada Nova and is distinctive by its size and long, pendulous ears. The Brazilian Somali is descended from the Somali Blackhead or Blackhead Persian which has been altered through a long period in the tropics. In addition to the above types, the Rabo Largo sheep, found in the more arid interior, carries at least some infusion of fat-tail types introduced in earlier years. The only exotic likely to be encountered in the area is the Bergamacia, a wooled sheep of Italian origin.

The majority of the goat population is known as the SRD (without well defined type). At least four recognizable local types exist: the Moxoto, Repartida, Caninde, and Marota. The most prevalent exotics are the Anglo Nubian and Bhuj (of Indian origin), but a few individuals of the Alpine dairy breeds (Alpine, Saanen, Toggenburg, etc.) can be found in some areas or have been introduced on an experimental basis.

Breed Characterization

A detailed study designed to provide comparative information on the different breeds of sheep and goats is being conducted by the CNPC (Sobral). Although preliminary in nature, some of these data have been reported and appear to provide a reasonable basis for conclusions.

In respect to sheep, some distinct breed differences are evident (Figueiredo et al., 1983; Figueiredo et al., 1982b). The Morada Nova is smaller in size with a higher lambing rate. The Santa Ines is larger with a more rapid growth rate but a lower level of multiple births. The Brazilian Somali is both small and has a low-twinning rate but possesses survival advantages under nutritional stress. At this point, it is not clear that any one of these breeds should be selected for exploitation at the expense of the others. Thus all three are being included in improvement programs or plans. Given a choice, producers will usually select the Santa Ines because of their larger size. One project is currently underway in which Crioula are being graded up to breeds chosen by the producer. Most of these choose Santa Ines. This should provide an evaluation of this breed under producer conditions and also contribute to long-term improvement efforts. Another project is concerned with improvement programs for Morada Nova. At present, efforts are underway to introduce new genetic material prior to initiating an improvement program for the Somali breed.

Breed characterization studies of goats have involved the Moxoto, Caninde, Repartida, Marota, Bhuj, and Anglo Nubian. These have been evaluated as pure types at Sobral (CNPC) and as crosses on SRD types at Quixada (EPACE). Although these efforts are still underway, some preliminary results have been reported (Shelton and Figueiredo, 1981; Figueiredo et al., 1982c). Based on studies with the pure breeds at Sobral, it appears that in terms of growth rate, the various indigenous types are similar and the two exotics (Anglo Nubian and Bhuj) support a more rapid growth rate, perhaps reflecting their larger mature size. Reproductive data are somewhat erratic between the breeds, due perhaps to small numbers and to widely variable numbers between breeds. These data do not provide a good basis for a choice between native breeds in terms of reproductive rate. However, there is a good basis for choice between the exotics. The Anglo Nubian breed has been shown to be markedly superior to the Bhuj which has higher death losses. In the crossbreeding studies, the data have been summarized for the growth rate of the kids, but the evaluation of the F1 females is only in the initial phase (first mating). Growth data show no evidence of a real difference between the indigenous or native breeds but the two exotics sire kids with a significantly increased growth rate (Table 1).

At this stage, it appears that the Bhuj has little to offer in Northeast Brazil in pure form, but it may well make a valuable contribution to crossbred populations. The Anglo Nubian appears to be a useful animal in the region and future breeding programs should capitalize on this breed in pure form or in selections derived from crossbred foundations.

The number of breeds or genotypes of goats (native and exotics) exceed the number that can be included in long-term improvement programs with current resources. Fortunately, the Bank of the Northeast (BNB) has provided funding for a program throughout the Northeast designed to preserve and improve native types of sheep and goats. Collectively, this represents an important resource which over time can have an important bearing on animal breeding efforts in the Northeast. It has been a high priority goal of the SR-CRSP Breeding Project to get this effort coordinated to maximize the long-term gain from these regional efforts in terms of animal improvement and generation of research information. Since this is not an SR-CRSP funded effort and a large number of individuals and agencies are involved, coordination cannot be forced. Only time will determine if these efforts are successful. However, since the BNB project places emphasis on native breeds, researchers are able to concentrate on work with SRD and/or mixed breed populations. At present, the latter appears to offer more potential for genetic improvement. This could be done while preserving some distinctive traits of native breeds such as the color of the Moxoto.

The above discussion relates primarily to meat production, the primary product obtained from sheep and goats in Northeast Brazil. However, two other products, milk and skins, are certainly of interest, and skins are of considerable economic significance in Brazil. Two investigations have been undertaken to determine factors contributing to value of skins and these should be considered in animal breeding efforts since Brazil, including the Northeast, has a large industry in trading and tanning of skins. In one effort, a number of tanneries working with sheep or goat skins were interviewed. The finding was that size of the skin obtained at

Table 1. Least-Squares Means of Body Weights (kg) of Native and Exotic Breeds of Goats and their Crosses in Tropical Northeast Brazil (n = 142)

Main Effects	Classification	Mean Body Weights (figures within parentheses indicate one standard error)		
		At Birth	At 6 Months	At 12 Months
Genotypes	SRD x SRD	1.86 (0.064)[a]	13.75 (0.842)[b]	20.44 (0.679)[bc]
	SRD x Caninde	1.96 (0.059)[a]	11.30 (0.026)[a]	18.51 (0.576)[a]
	SRD x Marota	2.01 (0.052)[a]	12.77 (0.009)[ab]	18.63 (0.554)[a]
	SRD x Moxoto	1.99 (0.072)[a]	12.92 (0.897)[ab]	19.23 (0.692)[ab]
	SRD x Repartida	2.01 (0.053)[a]	12.38 (0.815)[ab]	19.66 (0.513)[ab]
	SRD x Anglo-Nubian	2.42 (0.071)[b]	14.35 (1.056)[b]	22.09 (0.811)[c]
	SRD x Bhuj	2.48 (0.065)[b]	12.10 (1.093)[ab]	20.66 (0.805)[bc]
Sexes	Males	2.28 (0.035)[m]	14.62 (1.122)[m]	21.91 (0.381)[m]
	Females	1.94 (0.034)[n]	10.97 (0.295)[n]	17.87 (0.354)[n]
Types of Birth	Singles	2.29 (0.025)[p]	13.54 (0.641)[p]	20.50 (0.340)[p]
	Multiples	1.93 (0.041)[p]	12.06 (0.628)[q]	19.28 (0.413)[q]

Note: Means for any characteristic with the same superscript letter do not differ significantly at the 5 percent level of probability.

slaughter and defects were the primary factors contributing to variation in value of the skins, but there was little evidence that breeding was a major factor except that it might contribute to size. The defects were largely related to environment or care in slaughter, preservation and marketing of the skins. The need for a larger slaughter animal to obtain maximum skin value (at least 28 kg) would require that all animals be maintained to advanced age. The end result would be increased stocking rate, increased death losses and reduced percent of the flock in the breeding age. Since castration is not widely practiced, the surplus carryover males would interfere with a constructive breeding program (Figueiredo et al., 1982a).

In a further study, sheep and goat skins obtained from slaughter of experimental animals at CNPC were processed through a local tannery. Again, the overriding conclusion was that defects were the primary problem and that genetic differences were minor.

Although human food of animal origin is produced more efficiently through milk than through meat, relatively few goats and essentially no sheep are milked in Brazil. However there is interest, centered in Paraiba, in increasing the use of goats for milk production. The apparent requirements are an adapted animal genotype with the genetic potential for a significant level of milk production, a nutritional level adequate to support milk production in line with the genetic potential and a market infra-structure where commercial exploitation is the goal. Anglo Nubian and various Alpine dairy breeds have been imported to the region. In one study (Rodrigues et al., 1982), it was shown that German Alpines maintained on a good ration (Parda Alema) perform satisfactorily as milk producers. Anglo Nubian does were intermediate between these and native types. However, it remains to be determined how these breeds, especially the exotics, perform under less than optimum conditions.

Selection Experiments

In the selection experiment involving Morada Nova sheep, two lambing seasons have been completed and the third is in process. With this short time period, there is no evidence or expectation of a response to selection. In 1981-1982, a total of 222 females were available for breeding. Of these, 96% mated and 90.1% lambed with a lambing rate of 132.8. If these lambs were marketed within the year born, this would lead to offtake values substantially greater than that typical of Northeast Brazil. One analysis has been completed relating a number of characteristics of the ewes to lamb production. Of the several variables recorded including age, condition, weight, color, and presence of external lesions of caseous lymphadenitis, only weight and condition of the ewe were significantly related to lamb production. It may be significant to note that the presence of visible lesions of caseous lymphadenitis did not significantly affect subsequent lamb production in the first season.

Data are currently being analyzed to provide preliminary estimates of genetic parameters for Morada Nova sheep. These data are being utilized for a thesis for a graduate student at TAMU. With both these sheep and for goats, a high priority interest is to determine the net gain from multiple births and if this is a desirable trait under the adverse conditions found in Northeast Brazil.

In the study involving producer flocks, one mating season has been completed. This information provides some descriptive data on the flocks and preliminary mating results. More sheep (52.4%) were described as Crioula, but 43.4% showed some evidence of having an infusion of the Santa Ines breed. Age of the selected groups ranged from milk teeth to four years of age. A high percentage of the sheep were white but several other shades including spotting were observed. This is a questionable observation in view of the

fact that white sheep have been shown to suffer some problems in Brazil. Approximately 40% of the sheep showed some wool cover. Continued observations on the performance of the animals with various colors and degrees of wool cover should provide information on the contribution of these traits to adaptation or productivity. Only 5-6% of the sheep showed identifiable genetic defects (such as prognathism), but this is biased as the data were not collected on a random sample.

Body weights (flock means) ranged from 28 to 42 kg at mating. The percentage of the ewes mated ranged from 60 to 98 for the various flocks involved.

Host country scientist, Aurino Simplicio, performing laparotomy to obtain data on ovarian function throughout the year, and how it is influenced by nutrition and management practices. Photo: W.C. Foote.

Management

Although preliminary in nature, the Management component has obtained some meaningful results. One of the major problems identified as a constraint to goat production is fencing. The styles of fences employed in Brazil are expensive if materials and human effort are included. Costs, even cash costs, can sometimes be reduced by use of a solar powered electric fence if large areas are to be fenced. It must be recognized that electric fencing has limited applications to the smaller producers. However, of 48 properties requesting assistance with animal sanitation practices in the Soledade Region of Paraiba, property sizes ranged from 20 to 2,400 hectares. Of these, 75% maintained goats but only 41% sheep.

It has been shown that goats persisting under dry *caatinga* conditions will respond to non-protein nitrogen (NPN) and energy and that NPN sources can be successfully used in mixed rations under farm conditions (Neumaier et al., 1983). Mixed rations for lactating goats have been successfully tested in which Algaroba pods were used as a replacement for corn.

The low offtake from flocks in the Northeast appears to be due in large measure to the low percentage of breeding females in the total population and to high death losses prior to marketing or breeding age. Reproductive rate is not as low as the low offtake values suggest. Research results in the US indicate a majority of the death losses occur within the first few days following birth. Many of the flocks in Brazil are small and intense management at parturition reduces early deaths. However, mortality at or around weaning and during the dry season is a significant source of loss. In one study (Figueiredo and Pant, 1982), 45.8% of the death losses occurred after 60 days. The same factors that contribute to death losses also reflects slow growth and delayed marketing or sexual maturity. Any management practice which can improve performance and survival in this critical period could markedly improve production. As shown above, supplementation with protein (even NPN) and energy will contribute to improved gain and survival.

Significance of Research Findings

Description and characterization of the genetic resources are reasonably complete and adequate to provide a basis for planning future directions. In the case of sheep, it appears desirable to work with each of the breeds, though the Morada Nova has been identified as the breed with the higher lambing rate. Data being collected in the selection project will be used to determine if in fact a high lambing rate is desirable in an adverse environment or LDC conditions where feed inputs are often not available to capitalize on a high lambing rate. The low offtake rate and high death rate at or near weaning brings into question the desirability of a high rate of multiple births. It is questionable to transfer this US practice, where excess grain production occurs and a favorable feed price ration normally exists, to LDC's where neither of these are in place. For this reason, the SR-CRSP needs to approach the question of multiple births with caution. The Santa Ines has been shown as the breed with increased size and more rapid growth rate, and producers are showing a distinct preference for this breed. However, it is not clear at this point how the breed will perform under farm conditions. Although the Somali is a very hardy breed on a worldwide basis, the genetic sample of this breed in Brazil is small and perhaps not typical of the parent breed. The indicated course of action is to consider the introduction of new genetic material before attempting a major development program with the Somali.

Native goat breeds show a great deal of similarity in performance, but the Anglo Nubian has a potential use for both meat and milk production. Improvement programs should utilize this breed either in pure form, in systematic crossing, or in selections based on crossbred foundations. In respect to the dairy programs, the Alpine (Parda Alema) has shown surprising adaptation to the Northeast when provided with a good nutritional regime. It seems very important to obtain data on this breed or crosses involving it under more typical local conditions.

Implications for Future Research

Breeding

In the near future, long-term selection programs will be established for both sheep and goat species. These will run parallel with collection and refinement of data on genetic parameter estimates.

For the SR-CRSP in Brazil, as well as other sites, a high priority will be placed on delineating the emphasis to be placed on multiple births in adverse environments. Combined data from more than one LDC site should provide a useful consensus.

Unless environmental and socioeconomic constraints can be relaxed in the Northeast, it is extremely important that animal breeding be carefully oriented to existing field conditions. There is always a danger that experimental work will be conducted under improved conditions and thus not be applicable to producer conditions. This involves not only climate and nutrition, but disease and parasite problems as well. There is a disturbing tendency for researchers or extensionists to expect a great deal of expertise on the part of the producer in dealing with the latter problems. In the writer's opinion, such expertise in health management is not likely to occur unless the government provides this service to the producer. There appears to be a need for animal breeders, veterinarians, and animal nutritionists to attempt to estimate likely levels of management and inputs in the future and direct efforts or conduct selection under these conditions.

Management

The Management component of this project has been underway for only a very brief period. During this time, efforts have been concentrated on nutrition because this constituted an obvious serious need and was an area in which early results could be expected. However, over a longer period of time, the Management component needs to expand efforts into more traditional aspects such as alternatives to the large amount of time spent in confinement. There is also a great need to combine studies involving grazing management and supplemental feeding. Possible alternative breeding dates for goats and sheep should be considered. The current effort in management is heavily oriented toward assisting the dairy goat in Paraiba. It seems desirable that SR-CRSP efforts in this area continue to be closely integrated with EMEPA efforts and avoid direct initiatives or responsibility in this area.

A cooperating Brazilian family near Taua proudly display a prolific female goat and her triplet offspring. Photo: W.C. Weir.

Training

The collaborative work mode per se has provided informal but valuable training for all involved. But it would be difficult to express this in quantitative terms.

In terms of formal training, a total of six graduate students associated with the project in Brazil have requested and been encouraged to attend graduate school at Texas A&M. From the outset, funding has been allocated for one graduate student per year on the project. An added factor that has limited the numbers attending is that students are integral participants in the work in progress and careful sequencing is required to schedule their absence from fieldwork assignments. At present, one student, Antonio Amaury Oria Fernandes, is attending Texas A&M as a graduate student in Animal Breeding and is doing his thesis on SR-CRSP project activities. Other students from EMBRAPA, including the CNPC, have been or are presently registered as graduate students at TAMU, but are not directly associated with this project.

The Brazilian Co-Principal Investigator has traveled to the US on project funds for a period of training and orientation including participation in the Third International Conference on Goat Production and Disease.

A one-week training short course was held in Brazil for research personnel at CNPC and collaborating state agencies. Approximately 25 people attended this training course which may be repeated at a future date if the project continues and the need exists.

Dr. C.A. Zometa has provided on-site traineeships, each lasting three months, for two graduate technicians at Fazenda Pendencia. Others are scheduled for the near future.

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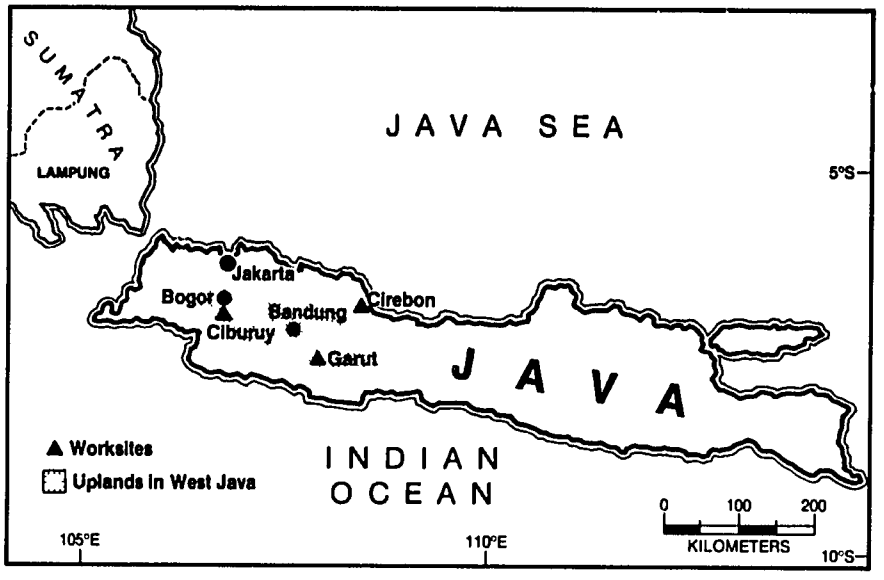

Location of Small Ruminant CRSP worksites in Indonesia.

INDONESIA

The activities of the SR-CRSP in Indonesia are almost exclusively confined to Java, an island with a land area similar to that of California but carrying in excess of 80 million people. Situated in the humid tropics and with highly fertile volcanic soils, it is not surprising that crops form the backbone of the Javanese rural economy, and that livestock contribute less than 10% of the value of agricultural production. Despite this, however, the 3 million sheep and 7.5 million goats fill a vital economic niche for the smallholder.

Farm sizes have been declining precipitously in Java in recent years and the current average size has fallen to 0.3 ha per farm. Because large ruminants are not economical on such small acreages there has been a large increase in the sale of the cattle and water buffalo formerly used for draft power. As farm sizes get smaller, there is little land available for grazing or fodder production and intensive "cut and carry" confinement or semi-confinement husbandry systems for the smaller ruminants have become well developed. Fueling this trend are increased crop intensities and yields which have increased the supply of crop by-products and residue yields available for feed. Tree crops also provide a wide variety of livestock feeds, as do grasses and leaves gleaned from hedgerows. Tree leaves and food crops which serve as livestock feed include: banana, bamboo, cassava, corn, cucumber, hibiscus, jackfruit, and sweet potato. In addition to the widely practiced "zero grazing" confinement system, there is some grazing encountered along roadsides and other unused areas. Concentrates are rarely used, as land is at a premium for growing food or estate crops. Small ruminants are primarily a cash crop on Java, raised for their meat and manure and marketed rather than consumed by the producer. Most sheep and goats are raised by smallholders in highly intensive, crop/livestock production systems with a herd size rarely exceeding 5 head. Increased herd sizes are found in areas where dry farming is practiced.

There are three major cultivation zones on Java, defined primarily by elevation, and each associated with a particular cropping profile: in the lowlands, wet rice farming predominates; in the upper elevation slopelands the revenue producing estate crops, coffee, tea, cocoa, rubber and spices are grown; the highlands are characterized by intensive vegetable production systems. Each zone is characterized by a different livestock production system, with emphasis on different animals and different breeds.

Sheep breed types found on Java display a continuum extending between two main types, the Thin-Tailed hair sheep, prevalent in West Java, and Fat-Tailed wool sheep found mostly in East Java. Both types are known to be highly fertile, but of low mature liveweight. Lamb mortality tends to be high, partly on account of low birth weights and partly because of unpredictable multiple births.

The Kacang goat is the indigenous type and Kacang Etawah crosses are also common. The Etawah is actually a cross between the Jamanapuri imported from India and better local Javanese goat varieties. Though essentially a milking goat, the Etawah is rarely used for milk in Indonesia. Both the Etawah and the Kacang type are valued almost exclusively for their meat.

The relatively poor productive performance of sheep and goats on Java suggests that there is ample room for improvements even within the context of the smallholder system. Feed constraints are probably less a factor in the humid environment of Java, suggesting that with modifications to breeds, health care systems and management, production could be significantly improved by adaptation of existing technology.

More information is needed about the genetic potential, nutrient requirements and health problems of the livestock, the nutritional value of their common feedstuffs, and the socio-economic constraints in the production system. Until these poorly identified and understood factors are investigated, it will be difficult to implement modifications in the system which optimize return.

The SR-CRSP is focusing its research at two locations in Java, Cirebon on the north coast and Garut in central Java. These locations are representative of rainfed and irrigated agricultural areas respectively, and sheep and goat production systems show a shift from highly intensive stall-fed animals in Garut to the more relaxed semi-grazing system of Cirebon. The SR-CRSP is concentrating its efforts on research in improved nutrition, controlled breeding with more advantage taken of prolificacy traits, as well as examining economic and sociological constraints to the adoption of improved technology. Transport, marketing credit, land tenure, and the integration of husbandry with the predominant garden culture all present severe problems in developing more productive systems.

The Agency for Agricultural Research and Development (AARD) is the official Indonesian agency with which the SR-CRSP is collaborating. Subsidiary collaborative organizations and their relationship to each of the four SR-CRSP projects in Indonesia are indicated in Appendix IV.

Genetic Improvement of Sheep and Goats for Smallholder Production

G.E. Bradford
University of California, Davis

At the start of the SR-CRSP program in Indonesia, the Indonesia Animal Husbandry Research Institute (LPP, subsequently renamed BPT) had only a limited program with small ruminants. Two stations (at Cicadas and Cilebut) had recently been established and a small number of animals acquired. No direct work with village livestock owners had been carried out. As a result, performance parameters for Indonesian sheep and goats were not well established, particularly under the production environments characteristic of smallholder operations. There have been reports of exceptional prolificacy in Javanese sheep (e.g., Mason, 1980) but here also, quantitative data are quite limited. Lack of such data precludes assessment of the ways in which productivity is limited by genetic factors.

Improving genetic potential of livestock in production traits is generally an efficient and highly cost-effective method of improving productivity, especially in populations not recently subjected to selection for performance. Genetic improvement can be effected with no new inputs other than some simple records, and in some cases, with no changes or only modest changes in management. While gains per year are relatively small, they are cumulative and permanent. Also, breeding and selection programs require performance records which often prove to be of at least as much value for improved management as for the genetic programs which prompt the initiation of recording.

The initial goals of the Breeding Project were therefore to work with the BPT staff in establishing the capability for research on small ruminant breeding in Indonesia, to identify those traits most in need of genetic improvement, and to assess the merits of selecting within local breeds and types versus introducing new germ plasm through exotic breeds.

The longer term goals are to initiate genetic improvement programs adapted to local needs and capabilities, with a view to producing inherently more productive sheep and goats for Indonesia. Because genetic improvement is a long-term undertaking, it must be continued well beyond the life expectancy of any specific aid program if it is to realize its full potential for increasing productivity. Training of host country personnel to enable them to carry on the work following termination of the SR-CRSP is therefore an integral part of this project plan.

Since its inception, the Breeding Project has directed its attention towards the following specific objectives:

- To characterize performance of Indonesian sheep and goats with regard to reproduction and growth rates under experiment station and village conditions, for purposes of identifying constraints to production and potentials for genetic improvement.
- To investigate in detail the reported prolificacy of Javanese Thin-Tail sheep, assess the desirable and undesirable effects of this prolificacy on management and productivity, and determine its genetic basis vis-a-vis that in other prolific breeds of sheep.
- Based on results of the characterization phase, to develop plans for reducing genetic and management constraints to productivity of small ruminants in Indonesia. These plans should be appropriate to local production systems and infrastructures.
- To train Indonesian personnel in small ruminant management and performance recording, and data analysis and interpretation.
- To collaborate with personnel on other projects in acquiring a more complete information base for use in developing improved small ruminant production practices and systems for Indonesia.

Research Accomplishments

To develop an understanding of the performance variables of Javanese village sheep and goats, identification and recording systems have been developed for use both in villages and on experiment stations.

Forms, printed in Indonesian, which facilitate convenient data recording and computerization, have been developed and personnel trained in their use both on station and in the field.

A senior sheep management specialist has been posted in Bogor for a full year, and is emphasizing identification of constraints to production under village and station conditions, summarization and interpretation of data from both sources, development of improved management plans for research and village production, and training of junior BPT staff for more effective management of research animals and data collection.

Five reports documenting various aspects of performance of the Javanese sheep and goats have been published, and others are forthcoming as more data becomes available and is analyzed.

Data from the project are being used for an MS thesis in Animal Breeding in the US, and animal performance data from this project are also being used by the SR-CRSP Economics and Farming Systems projects in Indonesia.

The majority of the data summarized to date are on the Javanese Thin-Tailed sheep. The data show that these sheep are in fact quite prolific, with litters of 3 and 4 occurring with relatively high frequency, and litters of 5 and 6 occurring on rare occasions (Subandriyo et al., 1981; Inounu et al., 1982; Sitorus and Subandriyo, 1982). However, they also show a much higher incidence of single births than expected for sheep which have 3 or more lambs at the frequencies observed here, i.e., they are unusually variable in litter size. Also, mortality is very high in the larger litters (Inounu et al., 1982) and growth rates are very low (Thomas et al., 1982).

This unusual variability in litter size in Javanese Thin-Tail (JTT) ewes was investigated further in data from 56 ewes in the Cicadas flock. The overall mean number of lambs born in 131 lambings was 1.98, identifying the breed as above average but not exceptional prolificacy. However, 11% of parturitions contained 4 or more lambs, a most unusual result for a group with a mean of 2 or less. The distribution of litter sizes is plotted in Figure 1, along with that for a group of UC Davis Suffolks with a similar mean litter size.

As noted in Figure 1, the standard deviation and therefore coefficient of variation is 50% higher for the JTT ewes than for the Suffolks. Furthermore, our subjective assessment is that plane of nutrition for the JTT ewes was substantially below that which would lead to a maximum litter size. Thus, if they respond to improved nutrition with an increase in litter size similar to that observed in other breeds, one would expect even more large litters. Whether that would increase the variability is not known, it is possible that it would shift ewes from the 1 or 2 class into the 3 class without increasing the proportion of 4's, 5's and 6's. However, the distribution of litter sizes among individual ewes also appeared to be different in the JTT group. The range in total number of lambs born per ewe was 2 to 6, 3 to 10, 5 to 13, and 10 to 25 for ewes with 2, 3, 4, and 6 lambings, respectively.

This extreme variability presents problems in management, since prepartum nutrient requirements are much higher for ewes carrying 3 or more lambs than for those with singles, and post lambing management requirements for acceptable survival rates are much higher for the small lambs resulting from large litter size. Thus, efficient utilization of high prolificacy requires that one have ewes among which a high proportion will reliably produce mostly 2's and 3's, with few singles or litters of more than 3. In this situation, intensive management for all ewes would probably be justified. On the other hand, if intensive management (e.g., supplementing with concentrates during gestation and lactation, artificial rearing of lambs above 2 per litter using milk replacers) is not possible, then one wants ewes which produce no more than twins; 26% of ewes with 3 to 6 lambs, as in this sample of Javanese Thin-Tail ewes, is a definite disadvantage.

Controlling this variability, which is almost certainly genetically determined to some extent, requires that we know the mode of inheritance of litter size in these sheep. Litter size in sheep is generally inherited as a quantitative trait of low heritability, which means that it can be changed by selection, though rather slowly. However, in most sheep, including breeds such as the Finnish Landrace with substantially higher mean litter size than the Javanese Thin-Tail, variability in litter size is less. There are, however, a few with variability similar to that in the JTT sheep, with the most intensively studied of these being the Booroola Merino. In the Booroolas, it has recently been established (Piper and Bindon, 1982) that the extreme variability is due to segregation of a gene with a large effect on ovulation rate. Ovulation rate sets the upper limit to litter size, but prenatal loss can reduce litter size to any number down to one.

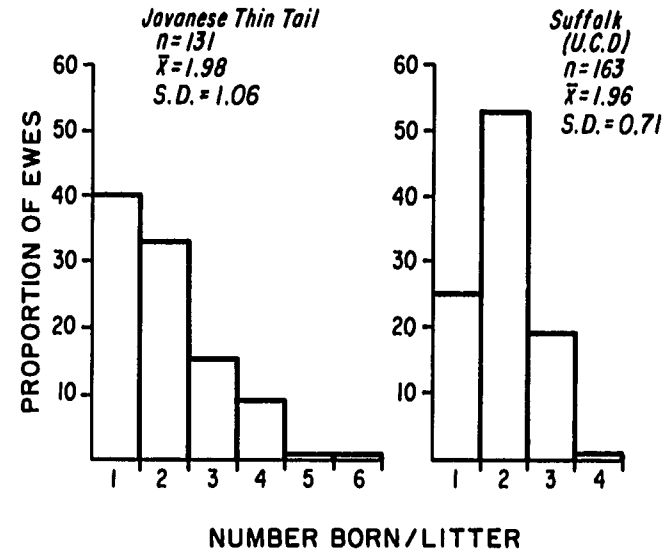

Figure 1. Frequency distribution of numbers of lambs born to Javanese Thin-Tail ewes at the Cicadas research station. Data on UC Davis Suffolk ewes is shown for comparison.

Since the variability in the JTT ewes is similar to that in the Booroola, we are investigating the possibility of a 'Booroola' gene in the JTT breed. Only a relatively few daughter-dam pairs and paternal half sister groups are available for study as yet. These data are shown in Table 1.

While the data in Table 1 are limited, they are at least not inconsistent with the hypothesis of a single gene for prolificacy, which in either heterozygous or homozygous state confers on ewes the ability to produce 3 or more lambs per parturition (though because of prenatal mortality, it by no means assures a large litter each time). Sire 186 is inferred to be heterozygous for the postulated gene, while sire 185 did not carry it.

Further evidence in support of this hypothesis is provided by data on ovulation rate from three groups of ewes at Cicadas. Dr. J.F. Quirke performed endoscopies at two consecutive estrus periods, the first of which was synchronized on all ewes in the flock in April/May 1983. The results are summarized in Table 2.

The repeatability of ovulation rate shown in Table 2 (0.81) is remarkably high; by comparison, the value in the UC Hopland flock of Targhees was 0.27, following the same protocol and measured by the same person. Removal of effects of body weight and birth year in the ovulation rate data in Table 2 changed repeatabilities very little; the four values were 0.76, 0.85, 0.74 and 0.79, respectively. The repeatability was high even when ewes with only one of two ovulations were considered: 87 of 105 such ewes had the same number both times. There was also a remarkably high correlation between ovulation rate and prior litter size. For example, all 15 JTT ewes in the study which had previously given birth to triplets or more had 3 or more ovulations at

Table 1. Litter Sizes of Daughter-Dam Pairs and Paternal Half Sister Groups of Javanese Thin-Tail Ewes in the Cicadas Flock

Dam No.	Dam's Litter Size	Daughter's Litter Size
	A. Daughters Sired by Ram 185	
36	3, 4, 1	1, 1, 4; 1; 1
158	3, 3	2, 2
163	1, 2, 2, 2, 3, 1	2, 3, 2
168	2, 2	1, 2
176	3, 3	1, 1, 1
Unknown		1, 2
Average	15-2.33	17-1.65
	B. Daughters Sired by Ram 186	
37	2, 2, 2	2, 1
41	4, 4, 2	3, 4, 3; 2, 2
117	2, 3, 4, 3	1; 1
158	3, 3	1, 3, 2; 3, 2, 4
164	1, 1	3, 3, 3, 4
165	1, 1	1, 1
175	1, 1, 1, 2	1, 2
701	2, 3	1, 1
704	2	2, 1
Unknown		2; 2, 1; 3, 1; 2, 4
Average	23-2.17	34-2.12

least once, 11 of them both times. The ewe with 6 litters of 3 to 6 lambs had the highest ovulation rate, 5 both times.

These results provide strong evidence for the hypothesis of a major gene affecting ovulation rate, with the similarity in pattern in the three groups lending further support. Data on the limited number of daughter-dam pairs in the ovulation rate data were also consistent with this explanation. Additional data on daughter-dam pairs from known sires are required to prove or disprove the hypothesis, and matings of the ewes in the ovulation rate study have been made with that objective.

The data base established by the Breeding Project has revealed that a major constraint to production under village conditions appears to be the long intervals between parturitions, in spite of the fact that experiment station data and the performance of a few village ewes shows that these sheep are quite capable of lambing at intervals of 8 to 9 months. Analysis of the village management system (Bell and Inounu, 1982) indicates that the infrequent parturition problem is due to failure to mate the ewes. This problem appears to be due to a lack of ram availability and the failure to develop a plan to ensure that the few breeding rams in the villages are rotated in a systematic fashion. A ram rotation scheme has recently been developed by Breeding Project personnel which should remove this constraint. This scheme will be tested in the near future in one or more cooperating villages.

Although less information is available, effective availability of males may be a similar constraint to goat production. This will be investigated further, and programs to correct the problem initiated if appropriate.

Under experiment station conditions, feed supply has been shown to be a further major constraint to production, especially during the dry season. The Breeding Project scientist, Mr. Bell, in consultation with irrigation engineers in Indonesia and California, is developing an improved irrigation plan to correct this problem.

To assist with the longer-term objectives, a general plan for setting goals and implementing a breeding program for multiplication centers was drafted in 1980 by the Breeding Project PI, in consultation with BPT staff and the management staff of the Margawati Station in Garut, West Java. This plan has not yet been fully implemented, and the Margawati flock had to be reduced drastically in 1982 because of the activity of Galunngung volcano. At the request of the Dinas Peternakan in Garut, SR-CRSP Breeding Project staff used performance records collected at Margawati in 1980-82 to calculate indexes on all station sheep, for use of the Margawati staff in determining which animals to keep in these circumstances.

In summary, the work to date has established that the Javanese breeds have an adequate or more than adequate prolificacy potential. Improvements in management to increase lambing frequency and survival, and in genetic potential or nutrition (or, most probably, both) to increase growth rates, have been identified as areas needing attention. A study completed as part of the SR-CRSP Breeding Project in Kenya suggests that a reduction in amount of wool cover, in which there is substantial variability in the Javanese sheep would also improve growth rates. In general, the performance and variability of these sheep suggests high potential for improving performance by selecting within the

local types. Their high prolificacy potential is something that might be difficult to find in other sheep adapted to confinement rearing in the humid tropics. All of these points indicate that improvement within local types is likely to be preferable to introduction of new germ plasm.

Significance of Research Findings

The identification of very long parturition intervals in village flocks, due to failure to mate the females, represents probably the most important finding in terms of potential for effecting an immediate and substantial increase in production of small ruminants in the Indonesian smallholder confinement production system. For example, estimated lamb production per unit of feed fed to each ewe would increase about 58% with a 9-month interval compared to a 15-month interval, the latter representing a conservative estimate from the 53% breeding age ewes lambing within a 12-month period reported by Bell and Inounu (1982).

Documentation of the extreme variability in litter size indicates potential for very high production from the Javanese Thin-Tail ewes, but also major management problems. Inounu et al. (1982) reported mortality rates of 16.7, 18.4, 35.5, 42.9 and 60.0% for lambs born in litters of 1, 2, 3, 4, and 5, respectively. Applying these to the proportions of ewes producing the different litter sizes reported for JTT in Figure 1 gives a mean of 133 lambs weaned per 100 ewes lambing. Applying the same mortality figures to the distribution of litter sizes shown for the Suffolk ewes included in that figure gives a mean of 149 lambs per 100 ewes, a 16% increase simply from reducing variability in litter size, with no change in mortality rates for each litter size. For a population of a million ewes, this would represent an additional 160,000 lambs. The reduced variability in litter size would reduce variation in birth weights and hence in weaning weights, an added advantage. Solution of these problems and utilization of this potential will depend on determination of the mode of inheritance (which may be known from the data on ovulation rate to be collected later this year, or which may take considerably longer).

The finding of unusually high reproduction potential in the Javanese sheep and goats indicates that work should focus on improvement of these animals, rather than going to the expense and risk of importing animals.

A very general finding is that there are areas of management where feasible modifications can make significant improvements in productivity of small ruminants under Indonesian village systems. Although not specifically our responsibility, the Breeding Project specialist currently in residence on-site has the experience to make important contributions in this area. For example, he has identified the long lambing interval problem in the villages and developed a ram rotation plan to correct this problem. Such improvements in management are critically important since productivity increases resulting from genetic improvement may be quite limited until management in Experiment Station, Multiplication Station, and village flocks is improved. Thus, we feel the emphasis on management is well justified from the perspectives of both the Breeding Project and the Program as a whole.

Future Research Directions

Field Studies

An important aspect of the entire SR-CRSP in Indonesia, is monitoring sheep and goat performance in four West Javanese villages. A high priority in the Breeding Project research is the continuation of this work with more detailed analysis of the data in order to indicate production constraints and the means for their relief. Based on results to date, work on systems for distribution and use of rams as a means of increasing frequency of parturition will be emphasized.

Table 2. Ovulation Rate, Body Weight, Cycle Length and Duration of Estrus in Javanese Thin-Tail (Garut Strain), Javanese Fat-Tail and Semarang Ewes

	JTT		Fat-Tail		Semarang		All	
No. of ewes	85		48		22		155	
No. in estrus[1]	77		48		21		146	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Body weight (kg)	24.2	5.4	23.2	4.9	21.3	4.1	23.4	5.1
Ovulation rate:								
First estrus	1.83	1.01	1.83	.93	1.67	.86	1.81	.96
Second estrus	2.05	1.10	1.96	1.05	1.81	.68	1.99	1.03
Repeatability	.79		.88		.74		.81	
Cycle length (days)[2]	16.6	.88	16.3	.71	16.1	.78	16.4	.83
Duration of estrus (hrs)[2]	33.1	6.5	34.2	7.5	35.7	7.2	34.2	7.0

[1]Following synchronization with progestagen impregnated pessaries.
[2]Total numbers of ewes recorded for cycle length and estrus duration were 134 and 76, respectively.

Ismeth Inounu, BPT, Bogor, with Javanese Thin-Tail ewe no. 162, Cicadas flock. Demonstrating its remarkable prolificacy, this ewe gave birth to 25 lambs in 6 parturitions in 4 years (3, 3, 6, 4, 5, 4) and had 5 ovulations in each of 2 consecutive cycles in 1983. Photo: G.E. Bradford.

The Breeding Project will also continue its collaboration with the Margawati Station (and other multiplication stations where there is interest) in developing selection criteria and mating plans for genetic improvement. Results of research on inheritance of prolificacy and growth in the local breeds will be incorporated into these plans as rapidly as feasible.

Inheritance of Prolificacy

Preliminary analysis has suggested the possibility of a major gene for high ovulation rate/litter size segregating in the Javanese Thin-Tail sheep. If this proves to be the case, control of prolificacy may in fact be more difficult than if inheritance of the high prolificacy of these sheep is of the more usual quantitative nature. Confirmation of the presence of a major gene would lead to the following options:

- Development of strains homozygous for the "prolificacy" gene. These animals would be expected to show considerable variability in litter size, but on average to have a high litter size and hence to require and justify continuous intensive management and good nutrition.
- Development of strains which do not carry the "prolificacy" gene. At this point we estimate such ewes might have mostly singles and twins. This might be an adequate level of prolificacy for most management situations, and if not, selection on the quantitative variation which undoubtedly exists in these animals should increase it, though at rates of probably only 1-2% per year as in other sheep.

We believe that following either of these options (or both, for different management levels) would represent a substantial improvement over the present situation, in which there is no basis to predict whether a ewe will have mostly singles and twins, or mostly 2's to 4's. Very different management of the ewes and the lambs is required for good viability and growth of lambs in these two situations. An economic analysis of costs and returns from the two kinds of ewes would be called for.

If the basis of inheritance proves to be quantitative, selection for ewes which do not produce more than two lambs would be of interest to determine if this would reduce the extreme variability in litter size.

Growth

Work on growth will be carried out in close collaboration with the Nutrition Project. Questions to be pursued include:

- Comparisons of the growth rates at different levels of energy intake of lambs born in litters of 1, 2, 3,≥4. This would integrate well with the economic analysis suggested above.
- Growth rates of lambs from ewes of different degrees of wool cover, and of lambs differing themselves in degree of wool cover.
- Comparative growth rates of Thin-Tail and Fat-Tail sheep, and of Etawah and Kacang goats.

Training

Training has been considered an integral part of this project from the beginning. There are two related objectives. One is the training of host country personnel in animal management and animal breeding research activities, so that data collected, now and in the future, will be from appropriately managed animals and collected in a way to maximize its utility for the research objectives of the project. This aspect of training will also increase the ability of the persons involved to assist village livestock owners in solving management problems. Training in this area has been accomplished through participation of UC Davis personnel in shortcourses in Indonesia, short-term training of Indonesian staff in the US, and interaction between UCD staff working in Indonesia and BPT staff.

The second objective is support for graduate training of young Indonesian staff, with the aim of preparing them to take over leadership of breeding research activities in Indonesia when the SR-CRSP terminates.

The following is a summary of training activities under this project in Indonesia to date.

Management Training

- Participation of D.T. Torell in Sheep Management Shortcourse in Bogor, June/July 1980. Mr. Torell was Sheep Management and Research Specialist in charge of the University of California's Sheep Research program at the Hopland Field Station from 1951 through 1981.

- Seven-week training in sheep and goat management, record-keeping, etc., for Mr. Subandriyo at UC Davis and UC Hopland, January/February 1981.
- Work by Mr. Monte Bell with Ismeth Inounu, Bess Tiesnamurti and Mrs. Endang in livestock management and recordkeeping at Cicadas and Cilebut stations which included daily or weekly conferences on ways of maximizing information obtained from an experiment station flock. Mr. Bell has also worked with the BPT staff to perform an important training function for non-degree staff working at both the experiment stations and in the village monitoring program.

Graduate Training

- Mr. Rachmat Setiadi, of the Margawati Station staff (Dinas Peternakan, Garut), was funded for an MS program at Institut Pertanian Bogor (IPB) from July 1981-July 1983.
- Mr. Subandriyo, of the BPT staff, is being funded for an MS program at Montana State University from March 1982-March 1984. He will spend one quarter enrolled at the University of California, Davis.
- Funding for an MS program at IPB is being provided to Mrs. Endang Triwulanningsih of the BPT staff, 1983-1985.

Selected Publications

Bell, Monte and Ismeth Inounu. 1982. Sheep Reproduction Parameters from Sixteen Farms in Sukawargi Village, District of Garut, West Java. Working Paper No. 8, SR-CRSP, Bogor, Indonesia.

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Economic Analysis of Improved Small Ruminant Production Systems

A.J. De Boer
Winrock International

Animals are an important component of the integrated farming systems found in many regions of Indonesia. Although the subsistence needs of farm families are primarily met by food crops, animal production is often the primary means by which farmers accumulate cash, store capital, provide inputs such as traction and manure for crop activities and/or provide high quality food for the household. These functions of livestock in traditional farming systems are further enhanced by the role of animals in social and religious ceremonies such as "Idul Adha" and "Idul Fitri."

In Indonesia, these roles are particularly important for goats and sheep which are easy to raise, prolific, and have a ready market. Their initial and maintenance costs are low and they utilize marginal land and crop residues. Special advantages of small ruminants over large ruminants (cattle, buffalo) include higher reproduction rates, broader adaptability to a range of environments, easier marketability, and lower risk. Despite these apparent advantages, the small ruminant population in Indonesia has been stagnant over at least the past 20 years. In fact, the population of sheep and goats in Java declined at 0.5% per annum over the 1967-1976 period (Sabrani et al., 1982d).

Sheep and goats are typically identified with the smallholder. In Indonesia, there are more sheep and goatkeepers than cattle owners or commercial chicken/pig farmers. For example, in Central Java in 1980, there were 0.97 million households engaged in small ruminant activities compared with 0.62 million in large ruminants and only 9,600 farmers in commercial chicken and pig raising (Dinas Peternakan, Central Java, 1982). Our studies (Knipscheer et al., 1983b) indicate that every fifth farm in Indonesia has small ruminants.

Despite these indications of the importance of sheep and goats for Indonesian smallholders, there has been little information about the physical and economic productivity of the small ruminant enterprise. In cropping systems research, where the farming systems approach has been practiced, it is known that a large gap exists between yields found under controlled experiment station conditions and those found under actual farming conditions. Although there is a growing knowledge about the productivity of small ruminants on Java under research station conditions (Obst et al., 1980) and under controlled conditions in villages (Winantea and Djuniarti, 1981), little is known about the actual biological and economic productivity of sheep and goats under

Indonesian small farm conditions. The question is how much on-farm productivity deviates from productivity rates obtained on research stations (the "yield gap"), the sources of this difference, and the economic implications of closing this gap.

Initial project goals were to establish a "farming systems research" philosophy within the collaborating institution to allow BPT researchers to identify relevant researchable problems and to begin long-term cooperative programs with villages to test the results of the research. At the center of this approach is the development of indigenous research capacity on the economics of small ruminant production and marketing problems.

The long-term goals are thus (a) to establish institutional capacity to carry out a range of studies related to constraints on increasing income from small ruminant farming, (b) to develop a farming systems research methodology appropriate to the needs of BPT and the participating farmers, and (c) to assist with the development of national research and development programs for small ruminants.

To achieve these goals, the following objectives have guided the project:

- Characterize small ruminant production and marketing systems to assist in the identification of productivity levels and resource use.
- Develop appropriate economic methodologies for analysis of traditional and improved production systems.
- Construct agro-economic profiles of selected livestock farming systems to identify the on-farm testing program required.
- Carry out policy-oriented studies to identify pricing, marketing, and investment needs to spur technological change.
- Develop institutional capacity within BPT through formal and on-the-job training, research planning, and professional meetings.
- Carry out studies in other areas (outside Java) of Indonesia to identify potential and needs for small ruminants and build up institutional expertise in BPT sub-stations.

Research Accomplishments

Planning for the research project started in early 1980 with the drafting of questionnaire outlines for review in Indonesia. In the summer of 1980, a training workshop was held to discuss research needs, research approaches data requirements, and collection procedures, the formation of "village programs," distribution of breeding stock, and research responsibilities. During the course, questionnaires were developed for baseline surveys (Sabrani et al., 1982b) and for periodic surveys to monitor husbandry practices and resource use relationships (Thomas et al., 1982). These early surveys were rather general in scope and served to define overall differences between upland and lowland farming systems (Knipscheer and Soedjana, 1983; Sabrani et al., 1983a; Mawi and Sabrani, 1982), relationships between resource base and small ruminant production (Muljadi et al., 1980; Sabrani and Muljadi, 1981), and income generated by small ruminants (Knipscheer and Sabrani, 1982; Knipscheer et al., 1983b). Additional survey work was initiated in a transmigration area in Sumatra to assess research needs and development prospects for small ruminants under a situation of vastly different resource endowments relative to Java (Mink, 1983). The initial surveys helped identify the important constraints to expanding small ruminant numbers and productivity, helped develop a research methodology for solving these problems (Sabrani et al., 1981; Sabrani et al., 1982c; Thomas et al., 1982), and allowed subsequent fieldwork to focus on very specific types of problems such as low reproduction rates (Soedjana and Knipscheer, 1982; Knipscheer and Soedjana, 1983), the impact of animal distribution ("dropping") schemes (Knipscheer et al., 1983b), demand for sheep and goat meat (Sabrani, 1980), seasonal changes in meat prices caused by Islamic festivals (Soedjana, 1982), and the efficiency of traditional marketing systems (Sabrani and Knipscheer, 1982; Sabrani et al., 1983b). The research approach thus changed gradually from large scale data collection efforts to shorter, more focused interdisciplinary surveys which examined specific components of the production system.

Sheep or goat house, West Java. Small ruminants in the intensively farmed areas are confined in such barns close to the homestead and fed with forage cut by hand and carried to them. Note the large overhang of the roof, giving shade and protection from torrential rain, and the large ground clearance, making manure collection an easier task. Photo: M. Nolan.

Three quite distinct locations have served as field research sites. The first, Cirebon, is a lowland, rice-producing area along the north coast. The second, Garut, is a typical highland, mixed-cropping system while a third location, Ciburuy, is intermediate in elevation between the above two and is distinct in that it is located next to a large rubber plantation. Table 1 gives the general characteristics of the sites and Table 2 gives the average farm sizes in the sampling

strata that were selected for the farm surveys. Table 3 gives average herd/flock composition on the survey farms. These data show two major constraints—the very small farm size which limits feed and cash resources for small ruminant production and the high proportion of adult males to breeding females which constrains herd/flock offtake rates. Tables 4 and 5 synthesize much of the survey data from the villages into measures of herd/flock offtake (final column, Table 4) and the relative importance of small ruminants in the household economy of the villages. The final column of Table 5 illustrates that smaller farms (size strata I and II) generate a relatively larger proportion of total income from sheep and goats. These income figures are for small ruminant holders only. As the percentage of farmers that keep sheep and goats is about twice as high in the upland areas as in the lowlands (about 60% vs. 30% based on Van Santen, 1980), the small ruminant share in total agricultural production should be higher in the upland regions than in the lowland regions.

The important implication of this analysis is that small ruminants provide a vehicle to improve the income of poor and destitute farmers. Research in village small ruminant production will have a relatively larger impact on landless and subsistence farmers than on medium and larger farmers. There is therefore a strong social justification for the further allocation of resources for research on small ruminants. Moreover, as meat is generally consumed by higher income groups, the small ruminant enterprise also represents a method of income transfer from urban high-income to rural low-income population groups.

Another important economic component in the villages is the practice of sharing of animals. Sharing ("gadohan") is common in all villages in Java, as well as on Sumatra (Mink, 1982). Animals are lent by owners to neighbors, relatives, or friends in return for a share of the offspring. The specific conditions regarding the number of lamb/kids to be returned and the time of repayment differs by location.

The extent of sharing is difficult to estimate, but without doubt shared animals constitute an important part of the flock of landless and subsistence farmers (Sabrani et al., 1982d). Higher sharing-in rates were found in Garut and Cirebon. This was caused by the "dropping" of adult animals by an external agent (BPT/SR-CRSP). In each location, about 100 animals were dropped. As it is the objective of such schemes to increase the average flock per farmer, it is instructive to examine the result of this dropping scheme.

In Cirebon, sharing-in rates and sharing-out rates are virtually equal, indicating that at least part of the received animals are shared "forward" to other farmers. Furthermore, the high selling rate for female adult goats (35%) indicates that some of these animals are also sold (Knipscheer et al., 1983b). The total village sheep flock, however, has expanded by 35 animals indicating that only the sheep farmers have been able to absorb the dropped animals within their flocks. This is due to the extensive grazing system that allows for greater flexibility in flock sizes.

The number of ewes in Garut increased by only 28 head, while the selling rate for ewes during the recall period was as high as 46%. This selling rate cannot be maintained over the long term and is undoubtedly caused by farmers selling their own stock after having received animals from the dropping scheme. This observation is confirmed by a further analysis of the data which showed farmers selling and sharing-out their animals during the same two months during which they received the animals by the dropping scheme. These observations cast serious doubts on the effectiveness of the distribution of animals by *gadohan* dropping schemes in areas where feed supplies are already fully used. Such schemes are often launched without adequate study and technical backstopping. It is therefore quite likely that the

Table 1. Environment and Land Use Parameter at Three Survey Locations in West Java

	Cirebon	Ciburuy	Garut
Elevation	0-4	450	600-700
Topography (m)	level	undulating	hilly
Soil texture	silt loam	—	sandy
Rainfall (mm/yr)	1,128	4,500	2,000
Temperature (°C)	28	23	25
Cultivated land (ha)	811	—	1,495
Uncultivated land (ha)	269	—	679
Rainfed rice fields (ha)	755	127	259
Dry land (ha)	56	13	1,236
Estate (ha)	0	46	0
Communal pasture (ha)	14	16	0
Forest (ha)	0	0	433

Source: SR-CRSP/BPT Survey, 1981.

Table 2. Average Size of Land Owned and Farmed by Holders of Small Ruminants by Location (ha)

Stratum	Cirebon			Garut		
	Owned	Farmed	N	Owned	Farmed	N
I. Landless	0.01	0.01	19	0.01	0.01	10
II. Subsistence	0.04	0.04	30	0.06	0.11	21
III. Smallholder	0.21	0.21	2	0.16	0.21	37
IV. Medium Holder	0.34	0.55	35	0.38	0.53	71
V. Large Holder	1.12	1.92	14	1.33	1.67	6
Weighted Average	0.29	0.48		0.29	0.40	

increase in livestock numbers resulting from these distribution programs is only temporary. The main cause of the stagnant small ruminant population is the modest productivity of the animals rather than their numbers.

There are good prospects, however, to raise the productivity of the animals. The reproduction rate of small ruminants in Indonesia is still only about one young animal per year per adult female. On specialized (commercial) farms, reproduction rates of two young animals per adult female are often realized (Knipscheer et al., 1983a). The sheep farmers in Ciburuy show that such a reproduction rate is also feasible for smallholders where food supplies are adequate.

The other major area of research has focused on the marketing and price formation process for small ruminants and the role of specialized agents in this process. An initial assumption was that the Islamic holidays led to lucrative prices for small ruminants (particularly intact male sheep) and that a focus of the SR-CRSP should be research on management and feeding systems that would allow producers to meet these market needs. The methodology used has been short, focused interviews on specific market participants with supplemental information provided by the village monitoring surveys. The surveys in West Java (Sabrani et al., 1983b) and Central Java (Sabrani and Knipscheer, 1982) have identified the marketing channels and marketing agents. A particularly critical figure is the village trader who controls many of the assembly and distribution functions. In addition, these individuals often produce or share-out animals and are important for introducing improved technology. Studies will continue on the potential uses of these traders in introducing change. A study of Islamic holiday marketing was conducted by Soedjana (1982). The influence on prices during the 1982 Idul Adha festival was not as pronounced as was hypothesized. Gearing a production system to meet the demands of these movable feasts may be an unduly risky strategy.

Table 3. Flock Composition and Three Locations in West Java (1981)

	Number of Farms Surveyed	Flock composition (Head/Farmer)[a]				
		AM	AF	YM	YF	K/L
Cirebon (sheep)	30	0.18	3.33	0.32	0.62	0.83
(goats)	49	0.20	1.70	0.20	0.40	0.50
Ciburuy (sheep)	33	0.38	2.55	0.64	0.88	1.22
(goats)	30	0.34	2.48	0.36	0.86	1.20
Garut (sheep)	135	0.37	2.07	0.37	0.58	0.74

[a]AM = adult male
AF = adult female
YM = young male
YF = young female
K/L = kid or lamb

Source: SR-CRSP/BPT Survey, 1981.

Table 4. Income per Animal Unit per Location (West Java, 1981)

	AU/Farmer (AU)	Offtake (AU)	Income/Farmer* (Rupiah)	Income/AU	Offtake (%)
Cirebon					
(sheep)	0.1503	0.0798	39,302	261,490	53
(goats)	0.1195	0.0682	36,547	305,833	57
Ciburuy					
(sheep)	0.1781	0.1098	53,238	298,922	62
(goats)	0.1641	0.0805	40,104	244,388	49
Garut					
(sheep)	0.1709	0.0770	41,466	242,633	45

*623 Rupiah = $1US at time of survey.
Source: Derived from SR-CRSP/BPT Survey, 1981.

Significance of Research Findings

Animal Performance

The cooperative village program has identified several phenomena that are of interest to the biological science projects. First, the variability of animal weight gains is much higher than expected (Thomas et al., 1982) given the full confinement system and apparently fairly uniform levels of feeding and management applied. Second, poor offtake rates seem to be caused by long lambing/kidding intervals rather than small litter sizes (Knipscheer et al., 1983b). Breeding strategies are now a focal point of the Breeding Project. Third, internal parasites may be more of a problem than anticipated, particularly in Cirebon where seasonal grazing is practiced. Fourth, production performance achieved by specialized commercial producers with access to protein supplements is far greater than that achieved in the villages (Knipscheer et al., 1983a) and gives an indication of the potential productivity gains by a straightforward transfer of existing technology and management.

Economic Performance

By synthesizing secondary data on sheep and goat holdings with results of the SR-CRSP/BPT survey and other surveys, we now have a much more comprehensive picture of the economic role and the economic importance of small ruminants in Indonesia. These studies indicate that

Table 5. Estimated Share of Small Ruminant (SR) Income of Total Income for Sheep and Goat Keepers at Two Locations in West Java (1981)

Location	No. Farms Surveyed	Estimated Annual Income/Farm (1980)	SR-Income (1980-81)	% SR Income in Total Income
Cirebon (lowland)				
Strata I + II	44	146,693	31,688	21.6
III	2	200,906	26,938	13.4
IV + V	33	318,899	43,038	13.5
Average	(79)	220,000	37,593	17.1
Ciburuy (rubber plantations)[a]				
Strata I - V	66	180,000	46,671	25.9
Garut (upland)				
Strata I + II	30	95,114	21,502	22.6
III	31	158,376	35,207	22.2
IV + V	74	442,391	45,692	10.3
Average	(135)	300,000	41,466	13.8

[a]No estimates for total income per stratum available.

Source: Derived from SR-CRSP/BPT Survey, 1981.

about every fifth farm household in Indonesia has small ruminants which typically provide 15-25% of gross farm income for those households. The sharing system is widespread and additional economic studies are needed to pinpoint resource allocation decisions between different forms of the sharing system since these should have an effect on biological productivity of the system. Possibilities of expanding small ruminant numbers through animal distribution ("dropping") schemes was .amined (Knipscheer et al., 1983b). The impact was uneven and seemed directly related to the elasticity of roughage feed supplies. Further use of these schemes must be directed at areas with adequate feed supplies or where the work being carried out by the Nutrition Project can be implemented. Otherwise, the tendency is to replace village stocks with the dropped animals. Economic studies of commercial systems (Knipscheer et al., 1983a) found considerable variation in economic returns per animal unit but these systems were, in general, highly profitable because of the high rates of compensatory gain made by small ruminants purchased from villages and because of a regular and low cost protein feed supply. Surprisingly, some commercial operations were also engaged in breeding operations.

Studies on marketing have focused on building profiles which describe how the system operates, who the participants are, the general marketing channels, and how prices are formed at each stage in the process. The marketing system is characterized as diffuse (many small producers marketing irregularly), well organized (regular marketing agents with good knowledge of market conditions), with facilitating functions including the holding of animals for further fattening. Given the diffuse nature of the market, marketing costs are relatively high, but there appear to be no major sources of inefficiency and the marketing agents do not appear to be making excess profits relative to the costs and risks involved (Sabrani and Knipscheer, 1982; Sabrani et al., 1983b; Soedjana, 1982). These studies identified a key marketing agent, the village trader, who is found in most villages with significant small ruminant numbers. Given this person's regular contact with producers and his role as holding, fattening, and sharing-out sheep and goats, future work must consider this individual's role as a potential change agent, demonstrator, and provider of inputs.

Finally, the underlying approach in most of the research reported so far has been a farming systems research philosophy. This has allowed teams of researchers to participate in most of these studies and has helped focus the biological research on problems relevant to village conditions. The teams are now meeting regularly with villages and an open exchange of ideas has developed. The approach is becoming institutionalized within both BPT/Bogor and BPT/Ciawi.

Implications for Future Research

Research to date has concentrated on describing and analyzing existing production systems, identifying productivity constraints, and setting in place research to eventually improve the system. Situations have been identified where

Young boys herding sheep, Cirebon, West Java. In contrast to the confinement system found in other areas, small ruminants in this location are grazed on what amounts to communal pastures. Often individual family flocks are combined and put under the care of 1 or 2 children to release adult labor for other tasks. Photo: M. Nolan.

herd/flock expansion may be feasible such as on areas of Java where villagers have access to plantations (Knipscheer et al., 1983b) or in transmigration areas where farm sizes are much larger (Mink, 1983). However, most situations studied have limited opportunities to expand numbers (Knipscheer and Soedjana, 1983; Mawi and Sabrani, 1982) and the research must focus on improving offtake and animal size with existing small herd/flock systems. One thrust in the latter area was to examine productivity levels of efficient commercial producers (Knipscheer et al., 1983a) and the findings of this work will be incorporated into future work. The sources of low reproduction are now being built into the breeding program and the regular village meetings are seeking ways to modify current breeding practices to shorten lambing/kidding intervals.

The studies of traditional feeding systems are also being used to set up village trials at BPT sub-stations.

The future emphasis of the Economics Project will be to evaluate specific technologies that are being developed, the economic consequences of specific practices on different groups of producers, how commercial producers' production practices can be transferred to villages, how the village trader can be used as a change agent, the role of women in specific production and marketing tasks and how we can bring them into the research and development process, and what type of production strategy is needed to achieve the best possible prices.

The end result, we hope, will be a set of specific recommendations that can be utilized by BPT personnel, the Dinas Peternakan officials, and the Government of Indonesia to improve small ruminant production. The capacity is building up within BPT to conduct the type of adaptive

farming system research required for small ruminants which are an integral part of Indonesian small farm systems. Future research must continue along these lines.

Training

The training objectives have been to first develop the general approach to economics research that enables the economist to analyze sheep and goats as part of a larger and very complex farming system. Both formal and informal training has focused on the skills needed for effective field survey work, analysis of data that reflected local producer conditions, use of simple analytical devices such as hand-held calculators, quick turnaround times between surveys and publication of results, and participation in conferences and workshops focused on interdisciplinary research on livestock production.

Specific training activities promoted by the Economics Project in Indonesia are summarized below:

Degree-Related Training

- Agus Muljadi is completing an MS program at Texas A&M University (May 1981-August 1983). The thesis work will use the baseline survey data that Mr. Muljadi helped collect in 1980-81. He has also taken coursework in sheep and goat production at Texas A&M.
- Sugiyanto completed an MS program at the Institut Pertanian Bogor (August 1980-January 1983). His research focused on statistical analysis of factors influencing sheep output in the surveyed villages. Sugiyanto was also responsible for tabulation and analysis of periodical data on labor use by tasks.
- M. Sabrani is undertaking a PhD program at the Department of Agricultural Economics, Gadjah Mada University, Jogjakarta. The SR-CRSP will provide partial support for thesis research.

Non-Degree Technical Training

- On-the-job training has been provided to Tjeppy Soedjana, M. Sabrani, Uka Kusnadi, and S. Mawi on design, analysis, and write up of surveys.
- A shortcourse in data analysis using a hand-held calculator was conducted by Dr. Richard Bernsten in March 1982. Twelve BPT staff participated.
- M. Sabrani and A. Muljadi attended the Third International Conference on Goat Production and Disease in Tucson, AZ, January 1982.
- M. Sabrani attended and presented a paper at the First Asian-Australian Animal Production Congress, Kuala Lumpur, September 1980. He also attended the Second Congress, Manilla, November 1982 and presented two papers on SR-CRSP research.
- M. Sabrani attended and co-authored a paper at the IDRC Conference on "Livestock in Asia: Issues and Policies," Singapore, February 1982.
- M. Sabrani acted as Co-Director and H.C. Knipscheer acted as Lecturer, in "Course on Village Data Gathering," held February 28-March 18, 1983. This course was sponsored by the Australian National University, at BPT/Ciawi. Five staff from BPT/Bogor attended.
- Tjeppy Soedjana was supported in the course, "Technical Writing in English," held in January 1983.
- Support was provided for Uka Kusnadi to participate in an English course.
- Partial support was provided for the SR-CRSP/BPT joint training workshop held July-August 1980.
- Support was provided for Tjeppy Soedjana to attend the joint IDRC/ADC/Winrock Training Workshop in "Socioeconomic Research Techniques for Livestock in Asia," Bangkok, Thailand, April 18-May 18, 1983. Partial support was also provided for H.C. Knipscheer and A.J. De Boer to participate as lecturers.

Selected Publications

Knipscheer, H.C. and T.D. Soedjana. 1983. The Productivity of Small Ruminants in West Javanese Farming Systems. SR-CRSP Technical Report Series No. 13.

Knipscheer, H.C., T.D. Soedjana, and A.J. De Boer. 1983a. New Small Ruminant Technology for Small Farms in Indonesia: The Impact of Flock Size. SR-CRSP/BPT Working Paper No. 6. Bogor.

Knipscheer, H.C., M. Sabrani, A.J De Boer, and T. Soedjana. 1983b. The Economic Role of Sheep and Goats in Indonesia: A Case Study of West Java. Bulletin of Indonesian Economic Studies.

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Mawi, S. and M. Sabrani. 1982. Sheep Management Systems in Two Different Food Cropping Patterns. Ilmu Dan Peternakan 1(1).

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Nutrition and Feed Systems Research

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West Java is characterized by good soils, high year-round rainfall, very high rural population density, and very small, intensively managed farms. Sheep and goats are raised in small flocks, often in total confinement near the villager's home. Their daily ration is harvested by hand by the head-of-household or a member of his family and carried in baskets to the animal pens.

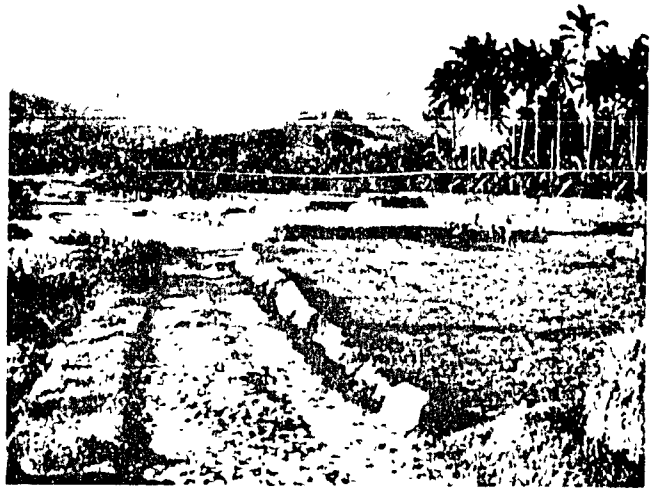
The first task of the Nutrition and Feeding Systems Project has been to find out what kinds of materials are used as feeds in the villages, how much is consumed daily by the animals, the chemical composition of village feedstuffs, and the productivity of the village animals as related to quality and quantity of feed consumed. These objectives have been addressed by means of village survey and monitoring activities. Village workers have been trained to collect feed samples and dry them in ovens specially designed and built to operate under village conditions. Samples properly dried, preserved, and stored have then been transported to Bogor for analysis of crude protein, cell wall fiber constituents, important minerals, and *in vitro* digestibility of the dry matter and fiber.

Simultaneously, feeding trials have been conducted at the BPT experimental farms for the purpose of testing various diet formulations and quantifying animal response. Emphasis has been placed on feedstuffs known to be generally used or thought to have potential application in the villages.

As in other worksites, we are interested in building a data base from which to improve the predictability of animal performance from laboratory analyses. This objective is particularly important for the Indonesia project for two reasons: the wide variety of feeds available and in use makes the attainment of this objective more feasible than in sites where the feed base is more limited; and, the constant fluctuation of feeds employed by villagers makes it more critical to conduct a rapid test of feed quality rather than rely on published composition data. BPT has as one of its objectives the development of a feed composition data bank, to which our project is contributing information. In data banks of this type, however, the standard deviation is of as much interest as the mean, and if the degree of variability is high, it is especially important to analyze each new lot of feed that one encounters.

The issue of animal nutrient requirements and relative efficiencies is of interest, because villagers are faced with choices between widely different breed types—the small native Kacang goat, the large exotic Etawah goat, the native West Java Thin-Tail ("Priangan") sheep, and the Fat-Tail sheep that is more common to East Java. Information about nutrient requirements and relative breed or species efficien-

cies is appropriately generated as part of thesis projects in conjunction with experiments that also have an immediately applicable practical objective.



Use of agricultural land in Java. The high population density combined with the rich volcanic soils has resulted in a highly intensive cropping system. If small ruminant production is to be increased in areas such as this without competing with crops, crop residues will likely comprise a larger proportion of livestock feed. Photo: N. Thomas.

Research Accomplishments

During the three-year period of this report, considerable activity has been undertaken toward the fulfillment of the above-stated objectives. A list of project titles, leaders, and current status follows:

- Baseline survey of small ruminant production systems in villages of West Java. N. Thomas, I.W. Mathius, A. Djajanegara. Completed in 1980.
- Monitoring of small ruminant production in West Javanese villages. I.W. Mathius, N. Thomas, H. Pulungan, J.E. van Eys, M. Rangkuti, A. Prabowo, W.L. Johnson, A. Djajanegara, and village staff. In progress.
- Profile study on feeds and feeding of sheep in Sukawargi village, West Java. I.W. Mathius, J.E. van Eys. Completed in 1982.
- Intake preferences for cassava, sweet potato, banana and napier grass foliages by Priangan sheep and Kacang goats. B. Haryanto, N. Thomas, W.L. Johnson. Completed in 1980.
- Cassava leaves as supplement for napier grass for lambs and kids. I.W. Mathius, A. Djajanegara, M. Rangkuti. Completed in 1981.
- Substitution of cassava meal for commercial concentrate in sheep rations. H. Pulungan, B. Nusa Bakti (Margawati Station, Garut). Completed in 1982.
- Utilization of leucaena leaf meal-molasses mixtures by sheep and goats. A. Djajanegara, M. Rangkuti. Completed in 1981.
- Gliricidia foliage as a protein supplement for growing lambs and kids fed chopped napier grass. M. Rangkuti, I.W. Mathius. First experiment completed in 1982; second experiment in progress.
- Cassava leaf and cassava root meal as supplements to chopped napier grass for growing lambs. H. Pulungan. Completed in 1982.
- Energy and crude protein requirements of local goats. M. Sitorus, T. Sutardi. Completed in 1981.
- Trace mineral status of Javanese Thin-Tail sheep. A. Prabowo, S. Lebdosoekojo, J.E. van Eys. Completed in 1982.
- Effects of mineral supplementation on performance, intake and blood characteristics in Javanese Thin-Tail sheep. A. Prabowo, I.W. Mathius, M. Rangkuti, J.E. van Eys. Completed in 1982.
- Ground nut straw as feed for growing lambs. I.W. Mathius, M. Rangkuti, L.P. Batubara. Completed in 1982.
- Coconut oil cake and rice bran as supplements for lambs fed pelleted napier grass. I.W. Mathius, M. Rangkuti, L.P. Batubara. Completed in 1982.
- Chopped cassava root as an energy supplement for growing lambs fed napier grass. H. Pulungan. In progress.
- Effects of supplementation with corn meal or rice bran on utilization of cassava leaf-napier grass diets by growing sheep and goats. I.W. Mathius, M. Rangkuti, H. Pulungan. In progress.
- Mineral supplementation of sheep fed native grass diets. A. Prabowo, J.E. van Eys, W.L. Johnson, H. Pulungan. In progress.
- Effects of sulfur fertilization and cutting interval on *in vitro* degradation of cell wall constituents of various plant parts from tropical forages. B. Betta, J.E. van Eys, W.L. Johnson. In progress.
- Evaluation of small silos for preservation of tropical forages and nutritive value of ensiled grasses for sheep. J.E. van Eys, I.W. Mathius. In progress.
- Utilization of cassava root meal as an energy supplement for growing lambs. J.E. van Eys, M. Sitorus, H. Pulungan. In progress.
- Laboratory evaluation of forages and data collection on feed composition. P. Mahyuddin (BPT/Ciawi; collaborative activity). In progress.
- Mineral supplementation requirements and development of mineral licks. T. Panggabean (BPT/Ciawi; collaborative activity). In progress.
- Evaluation of soybean curd sludge as a supplement to native grass diets for sheep and goats. H. Pulungan, J.E. van Eys, M. Rangkuti. In progress.

- Mineral status of sheep and goats as affected by level of dietary energy. A. Prabowo, J.E. van Eys, M. Rangkuti, W.L. Johnson. In progress.
- Treatment of fibrous residues with emphasis on rice straw. M. Winugroho (BPT/Ciawi; collaborative activity). In progress.

The paragraphs that follow present a brief summary of the highlights that have emerged from the above experiments, particularly those already completed. The reader who wishes more detail is referred to the publication list at the end of this report.

Village Baseline Surveys

In order to design the detailed Village Monitoring Survey, a preliminary baseline survey was conducted with a larger sample. A total of 374 families were surveyed in three villages. There were important locational differences in type of feeding practiced. In the highland location (Garut) only sheep are kept, and always in confinement. In the lowland location (Cirebon) sheep are usually allowed to graze but goats are always kept in confinement. Across locations, the percent of farms using certain feeds were: native grasses, 95%; banana leaves, 28%; maize tops, 28%; and cassava leaves, 18% (Djajanegara et al., 1982).

Village Monitoring Results

Monitoring sites were selected to be representative of the different climatic and geological strata of West Java. Garut represents the upland site, Cirebon the coastal plains, and Ciburuy an intermediate site with a large estate crop (rubber). Data from the first year of monitoring are still being analyzed. Some preliminary observations are possible, however (Mathius et al., 1983c). Important differences in the management of the small ruminant enterprise were observed among sites. In Garut, animals are maintained under complete confinement. Two-thirds of all activities related to sheep production are carried out by the head of the family. Women (wives) are responsible for 4% and children for 23% of the activities. In Cirebon and Ciburuy, both goats and sheep are found, but each farmer has only one species. Goats are kept in complete confinement while sheep are allowed to graze on the rice stubble (Cirebon) or in the rubber plantation (Ciburuy). In these villages, husbands are responsible for 45% of all activities related to small ruminant production, wives for 15% and children for 40%. The relationship between family size and size of animal enterprise was poor for all three locations.

Although the number of confined animals and the average liveweight per farm is similar among villages, the amount of feed collected per animal or per unit of liveweight differs considerably. This was most pronounced during the wet season. Garut farmers offer the largest amount (277 g/kg BW—wet season) and Cirebon farmers the smallest amount (226 g/kg BW—dry season). Assuming an average of 25% dry matter (DM), these amounts of feed on offer are in excess of the animals' daily requirements (about 50 g DM/kg BW). However, only if the feed were of highest quality would daily intake reach the level of 50 g DM/kg BW. Casual observation, reinforced by animal performance records, would suggest that actual intakes are somewhat lower and that performance is limited by the digestibility of the feed offered, or perhaps by specific nutrient deficiencies.

Sheep and goats in Garut and Ciburuy seemed to have more opportunity for diet selection and higher DM intakes than in Cirebon. Sheep production under grazing in Cirebon was depressed due to high endo-parasite infections (particularly Haemonchus spp., Trichostrongylus spp., and Paramphistomum spp.). Observed death losses were as high as 25%. Endo-parasite infections were of less importance for grazing animals in Ciburuy, and not observed in confined animals in any location.

Comparisons of liveweight gains between locations indicated highest weaning weight and daily gain for animals in Ciburuy, while Cirebon was lowest. Protein and mineral content of diets on offer do not explain the observed differences in gain. Crude protein levels were highest in Cirebon and are higher than NRC requirements for growing sheep and goats in all locations. This is also true for Ca and P. The high levels of total cell fiber, generally above 55% and highest in Cirebon, play a role in reducing intake and animal performance.

Much of the difference in nutritive value of small ruminant diets can be attributed to differences in botanical composition. In Ciburuy, the proportion of native grasses was relatively constant across seasons, ranging from 70 to 85%. In Cirebon and Garut, the contribution of native grasses ranged between 45 and 85% with the lowest proportion occurring during the dry season. In Cirebon, crop by-products were fed at 20 to 35% of the diet and the rest was made up of tree foliage or waste products from home or markets (e.g., jackfruit and pineapple peelings). In Garut and Ciburuy, the remainder of the diet was made up of crop by-products such as cassava leaves, maize tops, sweet potato vines and melon or pumpkin leaves. Tree legumes constituted only a minor proportion of the total ration in Garut and Ciburuy.

The total liveweight of animals carried per farm was only slightly affected by season in spite of the fact that significantly larger amounts of feed were available in the wet season, especially in Garut. Much of the wet season increase in quantity was from native grasses, which may be lower in nutritional value. Feeding of crop by-products decreased proportionally but remained quantitatively constant. Crop by-products enter the feed supply as a result of harvest and are not directly considered to be a feed resource. This attitude may change if adequate methods of crop preservation can be developed and if a nutritional superiority for certain crop by-products can be demonstrated.

Results to date indicate that the most important constraint to flock size is the amount of fodder a farmer and his family can collect daily. If increases in animal performance are important, improvements in feed quality rather than quantity will be necessary.

An effect of season (dry vs. wet) on diet chemical composition could be observed in all locations. Crude protein levels increased during the wet season, probably due

to an increase in the proportion of more immature native grasses. Concentration of total cell wall fiber (NDF), calcium, and phosphorus remained relatively constant.

A major seasonal difference between locations could be observed in growth rates of young stock. In Cirebon, growth rates dropped dramatically at the beginning of the wet season, which could be due to health problems or mineral deficiencies. Micro-mineral analysis of liver samples indicated significantly lower concentrations of copper and zinc in the wet season than in the dry season.

Additional supplementation above the all-forage diet is observed only sporadically. Occasionally, the feeding of soybean curd sludge or rice bran may be encountered. Mineral supplementation is limited to salt at irregular intervals, if at all, and the purchase of any supplement is generally considered too expensive, or farmers are not aware of the benefits.

Intake and Digestibility of Village Feedstuffs

The evaluation of feedstuffs available to villagers is an important line of research at the BPT station in Bogor. In a trial with eight Priangan lambs and eight Kacang kids (Haryanto et al., 1982), both species showed an overwhelming preference for cassava leaves when they were offered free choice and paired with either sweet potato vines, banana leaves, or chopped napier grass. Significant species differences were noted for banana leaves (preferred by goats over sweet potato vines or napier grass, but rejected by sheep) and napier grass (equal preference by sheep to sweet potato vines, but rejected by goats). Half the animals were offered 200 g of concentrate per day in addition to forage. The sheep readily ate the concentrate, reducing their forage DM intake by 112 g/day. The goats, however, ate very little concentrate and actually slightly increased their forage intake.

In another trial, leucaena leaf meal and molasses were fed *ad libitum* to 20 wether lambs and 20 kids in proportions of 100/0, 80/20, 60/40, and 40/60, as a supplement to chopped napier grass which was also offered *ad libitum*. Maximum intake of the total ration (53 g/kg $W^{.75}$) and maximum DM digestibilities (56% for sheep, 65% for goats) were obtained with the 60/40 supplement. Goats tended to prefer the rations with molasses, while sheep tended to prefer those without. Also, the goats consumed a higher proportion of napier grass when the supplement contained molasses, but when it did not, the sheep consumed higher levels of napier grass. Regardless of diet, the digestibility coefficients for DM averaged eleven percentage units higher for goats than sheep.

Growth Trials with Javanese Thin-Tail Sheep and Kacang Goats

A series of trials have been conducted with lambs or kids in which a basic ration of napier grass has been supplemented with fresh or wilted gliricidia foliage, wilted cassava leaves, cassava root meal plus urea, a commercial concentrate mixture, peanut straw, coconut oil cake, or rice bran.

Lambs (initial weight 11.6 kg) and kids (9.9 kg) were fed gliricidia maculata either wilted (six lambs) or fresh (six lambs and six kids), and chopped fresh napier grass. Both forages were offered *ad libitum*. Excellent growth rates were attained over a six-week period for the lambs (107 g/day) and kids (82 g/day). Average voluntary DM intake per kg $W^{.75}$ was 63 g/day of gliricidia by sheep, 53 g of gliricidia by goats, and 31 g of napier grass by both species. Weight gains and DM intakes were higher but DM digestibility was lower ($P < .05$) for the sheep consuming wilted gliricidia, compared to fresh. It would appear that this tree legume has excellent potential as an energy and protein source for small ruminants.

Cassava is a common cash crop throughout West Java; its foliage is high in crude protein content and palatable to ruminants. Cassava root meal is a highly digestible energy source because of its high starch content but contains very little protein. In a series of growth trials, sheep fed wilted cassava leaves as a supplement to *ad libitum* chopped napier grass did not increase total DM intake but did consume more crude protein, with average gains of 50 to 60 g/day. Adding 50 or 100 g/day of cassava root meal did not change the results. Goats reacted differently from sheep in that total intake was higher with cassava leaves but average gains were only 23 g/day. Goats may be more sensitive to marginal levels of hydrocyanic acid in cassava products.

When 20 wether lambs (14 kg average initial weight) and 20 male kids (19 kg) were fed *ad libitum* napier grass alone or with .5, 1.0 or 1.5 kg of cassava leaves per day, the digestibility of DM, protein, and NDF was higher ($P < .05$) by goats than sheep. These levels of cassava leaf did not influence digestibility of the total ration by either species. Trials with cassava root meal have proven inconclusive; this product needs further testing for both goats and sheep.

Mathius et al. (1983b) offered peanut straw at 100, 200 or 400 g/day to 12 lambs (initial weight 18 kg), in addition to *ad libitum* chopped napier grass. Average gains over a 12-week period were 23 g/day for the lowest peanut straw level (actual intake of peanut straw was 91 g/day) and 36 g/day at the highest level (actual intake, 297 g/day). Intake of DM and digestible DM was higher with peanut straw, but the DM digestibility of the total ration was lower.

Coconut oil cake was offered to 15 lambs (initial weight 16 kg) at 100, 200 or 400 g/day in addition to *ad libitum* napier grass pellets. DM intake increased at supplementation levels up to 200 g/day; DM digestibility was highest (62%) on the same treatment. Average gains were influenced very little by coconut oil cake supplementation (Mathius et al., 1983a). In a separate but identically designed growth and digestibility trial, rice bran replaced coconut oil cake with similarly small effects on total DM intake. When 340 g/day of rice bran was consumed, average gains were still only 42 g/day. The quality and form of napier grass undoubtedly influenced the outcome of these trials.

Energy and Protein Requirements for Growth of Kacang Goats

Twenty-seven male Kacang kids, age eight to ten months and with initial weights of 15 ± 2 kg, were assigned to one of nine diets for an 8-week growth study followed by seven days of total fecal collection for digestibility estimates. At the end of the trial, all animals were slaughtered for carcass composition estimates. Diets consisted of chopped napier grass, rice bran, maize meal, coconut oil cake, cassava waste, soybean oil cake, urea and minerals to provide three levels of energy (2.6, 3.0, and 3.2 Mcal DE/kg DM) and three levels of crude protein (10.3, 13.1 and 15.3%), in a factorial design. Increased levels of dietary energy caused faster daily gains and greater protein retention ($P < .01$); DM digestibility also increased. The fat to protein ratio of the carcass increased with the level of dietary energy but decreased with higher dietary crude protein. The intake level of 230 kcal of digestible energy (DE) and 88 g of crude protein per kg of body weight$^{.75}$ resulted in the highest nitrogen retention. Maximum DM digestibility was achieved at an intake of 196 kcal DE/kg BW^{75}. DM intake was relatively constant across treatments, with a mean of 440 ± 15 g/head/day. Daily gains were maximized at 195 kcal DE and 8.2 g CP/kg BW$^{.75}$ (Table 1). Average gains were not affected by the level of protein in the ration but energy intake had a large effect ($P < .01$).

It seems that in diets providing more than 140 kcal DE/kg BW^{75}/day, increasing the level of crude protein above 10% had little effect on the growth of local goats. However, large improvements in daily gain might be expected from an increase in digestible energy content of the diet up to 200 kcal DE/kg BW^{75}/day (Sitorus, 1983).

Concentrations of copper, iron, zinc and manganese were measured in liver samples from 32 sheep slaughtered over an eleven-month period in Garut (upland) and Cirebon (lowland) villages (Prabowo et al., 1983). Iron concentration was 298 ± 26 ppm which was considered normal; no location or seasonal effects were noted. Results for the other minerals are given in Table 2. Copper values are also considered normal, but varied significantly from the wet to dry seasons. Zinc and manganese values are considered below normal. The locational differences for these two elements (lower values for Garut) and the seasonal differences (lower values in the wetter season) may be related to situations of greater availability of feed and consequent higher metabolic activity of the enzymes which incorporate these minerals.

A complete mineral mix was added in graduated levels to 100 g of concentrate mix and fed daily to twelve lambs. Three additional lambs received only the concentrate (no minerals) and three received no supplement. All lambs were offered *ad libitum* chopped napier grass. The group consuming only napier grass gained only 8 g/day. The napier grass/concentrate group gained about 36 g/day, while the supplemented groups gained 69 g/day and experienced a 25% increase in feed DM intake over the napier/concentrate group. Ten grams of mineral supplement per animal per day was considered optimum.

Significance of Research Findings

Although much work remains before we have a complete understanding of present small ruminant feeding practices in West Javanese villages as well as the best strategy for bringing about improvements, several preliminary conclusions are possible.

Crude protein levels of village diets for small ruminants appear adequate, but digestible energy intake appears to be a limiting factor in present village feeding systems. This could be related to a high content of cell-wall fiber in tropical grasses, which means that they will be more slowly digested by goats and sheep, and that a ceiling will be imposed on total DM intake. The addition of wilted cassava leaves has been shown to increase dietary intake for lambs sufficiently to allow average gains of 55 g/day. Gliricidia foliage as a supplement for lambs will result in average gains of 90 g/day.

Deficiencies or impaired metabolism of certain micro-minerals may also be a problem. This is an area that needs further study.

The local Kacang goats respond to supplementation differently from the West Java Thin-Tail sheep. At adequate levels of digestible energy, goats consume more low or medium quality forage than sheep. However, sheep seem to utilize unsupplemented low quality diets better than goats and respond better to protein supplementation in terms of DM utilization and weight gain.

Table 1. Average Daily Liveweight Gains (g/day) of Male Kacang Kids Fed Diets with Different Levels of Digestible Energy and Crude Protein

Energy Intake (kcal DE/kg BW$^{.75}$/day)	Intake of Crude Protein (g CP/kg BW^{75}/day)[a]			
	5.8	7.55	8.8	mean
142	-12	6	4	-1
170	28	30	29	29
195	67	70	73	70

[a]Corresponding dietary crude protein concentrations were 10%, 13% and 15.5%.

Source: Sitorus, 1983.

Table 2. Micro-Mineral Concentration (ppm) in Sheep Liver Samples from Two Locations in West Java, in the Wet and Dry Seasons

	Copper		Zinc		Manganese	
	wet	dry	wet	dry	wet	dry
Cirebon—lowland	236[a]	265[b]	71[a]	84[b]	7.7	8.1
Garut—upland	229[a]	254[b]	38[a]	44[b]	4.8[a]	5.5[b]

[a,b]Values for each element with different superscripts in the same row are significantly different ($P < .05$).

Energy and protein requirements of local goats for maintenance and weight gain are in close agreement with recently published NRC requirements.

Implications for Future Research

In reality, the research program for small ruminant nutrition and feeding systems in Javanese villages has only just begun. Much work remains if the project objectives are to be fulfilled. However, initial results can be of value in bringing to focus the necessary next steps.

In the village monitoring program, a new simplified questionnaire will emphasize practices of immediate nutritional importance. Feed sampling will continue and will be expanded to allow quantitative estimates of nutrients actually consumed by the animals as well as feed nutrients placed on offer. The feed offered and the next day's feed remaining will be weighed on selected farms at regular intervals; samples will also be taken of the feed refused. Techniques will be developed (fecal nitrogen index, or inert external markers such as ytterbium) to provide rapid indirect estimates of intake.

Feed evaluation will continue but with more rapid performance of chemical analyses (crude protein, important minerals, and cell wall fiber constituents including cellulose, hemicellulose, and lignin). Attention needs to be paid to anti-quality factors such as tannins and cyanogenic compounds. Rates of cell wall degradation will be measured in selected important feeds, as this is the main determinant of total dry matter intake.

More emphasis will be placed on native grasses since they are the most abundant feed resource and probably the cheapest in terms of labor and management input. There is, however, likely to be an optimum ceiling beyond which native grasses should not be offered to animals and supplementation with higher quality crop by-products or tree legumes such as leucaena and gliricidia will probably be profitable in most cases. A few commonly available industrial by-products, such as soybean whey ("ampas tahu") need to be evaluated.

Feeding trials at the BPT farms will continue to quantify the growth response to measured levels of energy, protein and mineral intake. This line of work needs to be expanded to mature ewes and does in order to measure their response in terms of reproductive performance.

Feed preservation technology must be adapted to and tested under village conditions. Small scale storage may be important in improving the availability of high quality feeds for the dry season, or for use during temporary periods when labor supply is diverted to meet periodic high demands in rice cultivation or other crop enterprises.

More intensified studies of the rumen physiology of native sheep and goats are called for. Differential indices of selectivity, rumen degradation rates, particle size reduction by mastication, and pass-through rates may indicate that different feeding strategies are required if both species are to perform to their economic optimum.

In all of this work, an expanded level of collaboration outside of BPT/Bogor will be desirable. Collaboration with scientists at BPT/Ciawi has begun and will accelerate. A more intensified involvement with animal nutrition faculty and graduate students at Gadjah Mada University and Bogor Agricultural Institute will also be helpful.

Now that preliminary findings are available, it is time to begin a formalized outreach activity. This should involve a two-way dialog with researchers and teachers at other institutions, with extension program leaders throughout Java and, to a limited extent and on a pilot basis, directly with farmers--as has already begun to take place in the villages of the monitoring program. A proposal for a project along these lines is currently being considered by the USAID Mission in Indonesia.

Training

The first training activity was held in August 1980 for the young men who had been selected as village workers. This involved classroom and field activities. The in-service training of village staff has since been a continuous activity. Agreement in principle has been given to eventually help support these individuals for university training in Indonesia.

In-service training of the young research staff at BPT is a daily activity and one which has had high priority for both Neil Thomas and Jan van Eys, as well as for senior BPT scientists.

Support has been given for English language training to four young scientists who are potential candidates for graduate study abroad.

Training village staff in feed separation and identification, Tenjonegara, near Garut, West Java. Photo: N. Thomas.

Indonesians already studying abroad include Ms. Sorta Silitonga, who was provided a part-time assistantship stipend while studying for her MS degree at the University of Minnesota. Her program was successfully completed in March 1983. Also, Mr. Budi Haryanto is studying at NCSU under a Government of Indonesia/World Bank fellowship. He completed his MS in June 1983 having already started his PhD coursework in the fall of 1982. He plans to undertake his PhD thesis research in Indonesia.

At least three other young scientists are potential candidates for MS study at NCSU or other US universities. A fourth person is now working out arrangements to start a PhD thesis project with the intention of later enrolling for the coursework portion of her program at NCSU; a fifth person has expressed an interest in a PhD program in the United States. Yet another young researcher (Marudin Sitorus) has enrolled at the Bogor Agricultural Institute for his PhD; the Principal Investigator is serving on his committee of advisors and will help in the design of his thesis research. Mr. Sitorus may also spend one semester as a visitor at NCSU for specialized training.

Other BPT nutritionists are being supported for graduate training by the Australian government (Andi Djajanegara from Bogor, Thamrin Panggabean from Ciawi).

Short-term training in the United States was supported for Mr. Andi Djajanegara who spent a week in Dr. Van Soest's laboratory at Cornell University and two weeks at Raleigh looking at nutrition laboratory management procedures.

Several BPT scientists have been supported for international travel to present papers at scientific meetings in Singapore, Malaysia, the United States and Japan.

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Sociological Analysis of Small Ruminant Production Systems

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In February 1980, when the formal memorandum of understanding was signed between the SR-CRSP Management Entity and the Indonesia Ministry of Agriculture, the Indonesian Animal Husbandry Research Institute (subsequently called BPT) had only a limited program in socioeconomics and no trained sociologist on its staff. Yet, to the credit of the Institute's leadership, it was recognized that it was important to have a viable sociology and economics component within the Institute's structure in order to adequately understand the human component of the animal enterprise. Consequently, one of the first goals of the Sociology Project in Indonesia was to strengthen the capacity of BPT to engage in village oriented research on the social aspects of small ruminant production in Java.

The Indonesian farming system is complex and the role that small ruminants play within it varies. While crop production occupies the majority of a family's resources (labor, capital and land), small ruminants are considerably more than a trivial or hobby activity. The over-arching goal for the Sociology Project was to develop an understanding of the social and cultural contexts in which small ruminant production occurred. This is necessary if specific technological interventions are to be evaluated for their social soundness and the likelihood of their acceptance by the population as a whole. It will do little good for the biological projects to propose new methods of management, or some other intervention, if they are either unacceptable to the population by virtue of their conflict with some dominant cultural norm or if they actually harm rather than help the small farmers to whom the program is directing its attention.

As a step toward reaching these goals, the following specific objectives have formed the locus of activity of the Sociology Project since its inception in 1980:

- To describe the framework within which small ruminant producers in West and Central Java allocate resources and make decisions. Among those areas considered important were labor allocation, social status considerations, and division of labor within families.
- Once the initial characterization was completed, to develop more specific studies on issues which emerged from the initial work. As the study developed, significant questions regarding the role of women, the characteristics of nonproducers of small ruminants, the role of the village trader in small ruminant production and marketing, and the implications of animal sharing arrangements were largely unanswered by the baseline survey.

- To increase the ability of BPT to carry out sociological analyses with its own staff resources.

Throughout, the emphasis of research has been to provide the biological projects with social criteria by which they might evaluate the potential value of their research. Ultimately, the Sociology Project will have to "service" the biological projects in the SR-CRSP to the extent of providing them with an understanding of the implications/feasibility/desirability of those interventions they suggest. We are only now entering this phase.

Research Accomplishments

In order to develop an initial characterization and description of the role small ruminants occupy in the Javanese farming system, an interdisciplinary baseline survey was undertaken in two West Java villages. In addition to collecting data on the social, economic, and demographic characteristics of the sample families (in this case the samples were drawn from sheep and/or goat producers in each village), the sociology portion of the data collection effort ascertained the extent and nature of farmers' contact with various institutions (credit, markets, and extension), their attitudes and values, particularly as they would relate to their willingness to adopt new farm practices, and collected information on nutritional intake and migration patterns. These data formed the core of an MS thesis of the BPT staff member who was trained at the University of Missouri. In addition to this activity in West Java, a similar effort was undertaken in Central Java through collaboration with the Faculty of Economics at Satya Wacana University.

In both the West and Central Java locations, the villages chosen for study were selected because they represented different production systems—a coastal, intensive rice production system and an upland, mixed-crop system. In the case of the upland village in West Java, the situation was further complicated by the fact that this particular area was the location of the locally famous fighting sheep which were a highly valued and prestigious animal in that area.

One hundred and forty-five farmers were chosen as a sample from the upland site which was representative of the region of Garut, while a lowland sample of 100 farmers represented the region of Cirebon (see Table 1 for a description of the sample villages). The samples were divided into five groups based on farm size. The two study sites were characterized by intensive farming and animal production activities. Multicropping predominated in the upland communities while wet rice monoculture prevailed in the lowland village. Animal production activities in the upland site were dominated by sheep production while villagers in the lowland site raised both goats and sheep. Sheep were raised confined in pens in the upland site as were goats in the lowland villages (Table 2). While individual ownership was the most common form of animal raising, some sharing arrangements did exist among the lowland farmers. In both sites, there was no significant relationship between farm size and the number of animals owned. Men and women shared the activities in crop production relatively equally in both locations. However, the sexual differentiation of labor was more pronounced for animal raising where male household members participated more than females (Table 3). Male household heads had the greatest role in sheep and/or goat raising whereas women were responsible for most of the decision making in poultry production. In both sites, husbands played the key role in deciding what farm products would be sold, when they would be marketed and how the money would be used. The larger the farm, the greater the frequency in which villagers sold farm products.

Farmers preferred to obtain credit from formal governmental institutions and they were responsive to advice from extension agents. In actual practice, however, most found that they could not get funds from government institutions and they relied instead on the informal money lender system.

Table 1. Descriptive Data on Sample Villages (1980)

	GARUT		CIREBON	
Description	VII.1	VII.2	VII.3	VII.4
1. Altitude, m	600	600	10	10
2. Area, ha	736	1,438	415	665
3. Population	7,550	5,485	4,130	6,288
4. No. of household	1,930	1,556	726	1,392
5. Density/sqkm	1,026	381	995	945
6. Cultivated area, ha:				
—wet rice field	154	105	366	389
—dry field	495	741	—	54
7. Non-cultivated area	87	592	42	—
8. No. of sheep/goats	1,900	2,028	166	443

VII.1: Sindangratu.
VII.2: Tenjonegara.
VII.3: Kertasura.
VII.4: Purwawinangun.

Table 2. Sheep and Goat Management

Raising Methods	GARUT (Sheep)	CIREBON (Sheep)	CIREBON (Goats)
	percentage		
1. Grazed	6	74	57
2. Confinement	85	26	100
3. Combination 1 & 2	9	0	0
Sample Size	145	43	57

Similarly, since extension personnel seldom visited the study sites, villagers were forced to rely on neighbors for advice (Table 4).

In data that were available only from the Garut (upland) site, the main reason given for raising sheep was to acquire an asset which could easily be turned into cash (Table 5). Farm families rarely consumed their owr animals even though they felt it was important to serve meat.

Sheep are the highest status animals in Garut villages and high quality sheep were priced accordingly. In the highland villages, sheep gave status to villagers and 77% of the farmers stated that sheep received special attention whereas only 23% indicated that poultry was the most preferred animal. Most farmers (77%) stated that raising high quality sheep was more important than owning a large number of animals, regardless of quality. There was a predisposition on the part of farmers in the highland villages to improve management techniques for both sheep and poultry and this was especially true for larger farmers. However, when asked about specific changes they had made during the past two years and their management techniques or if they had borrowed money to buy animals, only a handful of responses indicated that they had done anything. One cannot be sure if this represents their true feelings or if they simply did not have access to new and reliable information about improved animal husbandry.

In response to questions addressing more general attitudinal belief systems, there was an interesting intersection of traditional and modern beliefs in the farmers of the Garut villages. The vast majority of respondents felt that traditional crop priorities were not necessarily better and to get ahead one must take chances, yet they felt that success was more dependent on God's will than man's effort and that the sons of businessmen had a better chance of success than the sons of farmers. Eighty-five percent agreed with the statement that success in farming depended more on God than on the efforts of man. Thus, in developing a program to modernize agriculture in this society, efforts should recognize not only technical issues but also the spiritual dimensions that govern farmers' behavior.

Overall, it is important to recognize that there are considerable differences among Javanese farmers. Village location, relative wealth, and farm size all seem to provide some points of differentiation when one talks about devising programs for sheep and goat producers. Interestingly however, differences in herd sizes across categories of farm size were negligible. Sheep and goats appeared to be a commodity which, by the nature of the management system (i.e., a confinement, cut and carry system of feeding for the most part) could be kept by nearly any farmer—even those with little or no land.

Table 3. Division of Labor: Relationship of Sex to Tasks Performed

Description	GARUT Male	GARUT Female	CIREBON Male	CIREBON Female
	percentage			
1. Help with crops	65	62	33	29
2. Help with livestock	70	58	70	34
3. Off-farm work	39	43	42	34
Sample Size	279	281	266	221

Table 4. Extension: Usual Source of Information by Farm Size

Category Label	Farm Size (hectares)+ 1† .02	.02-.15	.15-.30	.30-1.0	over 1.0
	percentage				
Garut:					
1. Neighbor	86	90	82	81	0
2. Other friends	0	0	6	2	0
3. Village leader	0	0	6	10	0
4. P.T.D.††	14	6	6	1	0
5. Extension worker	0	0	0	6	0
Sample Size	7	21	34	77	0
Cirebon:					
1. Neighbor	84	93	0	59	57
2. Other friends	16	0	0	7	7
3. Village leader	0	0	0	0	7
4. P.T.D.††	0	3	0	25	7
5. Extension worker	0	0	0	9	22
Sample Size	19	32	0	34	14

†In Garut only 3 farms were larger than 1 hectare and they were combined with the next smaller category (.30-1.0 ha). In Cirebon, only 2 farms fell in the .15-.30 hectare category. These were combined with the next smaller category. This accounts for the lack of case in the respective cells.

††Village staff in charge for agriculture.

Significance of Research Findings

One of the primary tasks for the Sociology Project is to identify constraints to and consequences of the adoption of new technology. The research conducted to date does not point to any over arching concerns in this area although some points should be noted. One of these would be whether the current extension system can deliver new technology to small ruminant producers in such a way as to significantly affect production over a wide area. In addition, the credit system is perceived as being relatively inaccessible and is not used by most farmers. If new capital is required for the adoption of new technology, this might prove to be a stumbling point. On the positive side, small ruminants appear to be an important component of the farming system, and are raised by a wide variety of farmers—large and small alike. In the current Javanese farming system they do not compete with crops for land, labor or capital resources, and are complementary to

Table 5. Reason for Raising Sheep and Poultry, Garut

Category Label	Farm Size (hectares) 1† .02	.02-.15	.15-.30	over .30	Total
	percentage				
1. Sheep:					
—cash	10	10	16	9	10
—consumption	0	0	0	1	1
—saving money	80	76	57	71	69
—other reason	10	14	27	19	20
2. Poultry:					
—cash	20	10	14	3	8
—consumption	10	0	21	5	7
—saving money	60	48	27	55	11
—inheritance	0	14	8	8	70
—other reason	10	28	30	29	4
Sample Size	10	21	37	76	144

intensive crop production in West and Central Java. It is probably unreasonable to expect great nutritional improvements to occur through the increased production of these animals as most families raised them as a cash crop. However, by providing farm families with additional cash income, one could assume that their overall quality of life would be enhanced.

Future Research Directions

Having established a macro view of the role of small ruminants in the Javanese farming system, the Sociology Project is now prepared to launch a number of more specific studies designed to answer questions which have only tangentially been addressed to date. Studies just begun or planned for the near future include:

- The role of women. To date, all data collected by the SR-CRSP in West and Central Java have been collected by men from men. Yet the indications are that women play more than a minimal role in the typical Javanese farm and especially in the management of sheep and goats. As the SR-CRSP moves into an "outreach" phase, it will be crucial to adequately consider women's roles and responsibilities in planning implementation programs. A study is planned to explore this area in more depth.
- The role of the village trader. Previous research has shown that most farm animals are sold at the farm gate to a trader who deals directly with the farmer. This individual acts as a middle man and in turn sells the animals he purchases to an urban market or slaughterhouse. The role of this individual in setting prices, encouraging farmers to produce small ruminants, perhaps through loans of cash or animals, and his ability to accumulate animals for market during times of peak urban demand (e.g., religious holidays) needs to be better understood.
- A study of non-small ruminant producers. To date, all data has been collected on farmers who raise sheep and/or goats. Most of these farmers are probably operating at their maximum level of animal numbers (although the herds could undoubtedly be made more productive). It seems that for most farms, labor is not available to manage more than four or five animals. However, in a number of villages, the producers of small ruminants do not constitute a majority of the farm families. Developing an understanding of the problems farmers encounter in beginning to produce sheep or goats, and why farmers are not raising them if they have the resources to do so, is important for any program designed to expand production.
- Animal sharing arrangements. This is a very complex area which requires more study. Our limited data suggests that perhaps 20-25% of small ruminants are raised on some kind of "share" basis. In addition, the Breeding Project seems to be moving toward a strategy to increase the genetic potential of village herds by providing improved male animals to villages. Obviously, it is impractical to provide every individual producer with an improved male. Thus, some form of village sharing arrangement level will be necessary. Further research on the nature of current sharing arrangements and the potential for such arrangements for improving the genetic pool within a village is obviously needed.

Fighting rams, Sukawargi Village, Garut. Rams especially raised for fighting are a very prestigious animal in this area, where exhibitions of sheep fighting are a major community event. This illustrates that animals are often kept for reasons other than economic or subsistence. Photo: G.E. Bradford.

Training

The Sociology Project has sponsored two graduate level training programs for BPT staff members.

- Kedi Suradisastra, a member of the BPT staff, was funded for an MS program in Rural Sociology at the University of Missouri, from January 1981-December 1982. Mr. Suradisastra was awarded his degree in May 1983. He has now returned to the BPT staff in the socio-economics working group.
- S. Mawi of the BPT socio-economics working group is being funded for an MS program in Rural Sociology at Institut Pertanian Bogor (IPB). This program was begun in August 1982 and will be completed in June 1984. Mr. Mawi will return to the BPT staff at that time.

In addition to degree training, the SR-CRSP Principal Investigator participated in the village survey methodology shortcourse held at BPT in June 1980. This course was designed to acquaint junior and senior BPT staff and village enumerators with the essentials of social science data collection methods and analysis techniques.

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A Small Ruminant Production Model on a Programmable Calculator

N. Thomas

Initial survey and monitoring activities of small farms in Java carried out by the SR-CPSP have confirmed the small scale of sheep and goat production and the low level of productivity (e.g., Sabrani et al., 1982; Thomas et al., 1982), even though economic studies show the importance of this activity to the farmers engaged in it (Knipscheer and Soedjana, 1982).

The combination of small scale and low productivity creates difficulty in the assignment of priorities to an improvement process. Small scale enterprises may show considerable variation in their major management features, and low productivity implies one or several constraints to realizing the genetic potential of the animal. The need to integrate biological and management aspects of production in the design of an effective improvement program prompted the development of a simple computer model as a research tool. The objective was to provide Indonesian researchers with a means of evaluating different strategies for increasing animal production. A major consideration was to keep the model sufficiently simple so that it could be developed and operated on a programmable calculator which would allow it to be used in the field, and would avoid any potential difficulty in access. This approach was proven successful under other circumstances (Thomas and Farias, 1981).

Methodology

Model development was centered on those parameters of animal production considered important in any initial analysis and being recorded in the village monitoring program. Inclusion of every possible variable would cause a rapid escalation of complexity of such a model and probably render it usable because of data limitations. Simplicity was considered vital to the present purpose. The chosen parameters were grouped according to their relationship with the individual, the breed, the farm, or locality (Table 1).

The model was designed to be iterative, allowing modifications of the values of certain parameters during different time periods. The form of the model is described in the flow chart in Figure 1. While the model operates at the level of the individual animal, input data is formulated for the population being considered, variation in the individual being introduced through probability distributions defined for each parameter.

Animal growth is the basic element of the model, growth rates of study or experimental populations being derived from the equation $Y=a+bx$, where Y is defined by:

Table 1. Animal Production Parameters Included in the Model

Type	Parameter
Individual Animal	Sex Weight Age Litters born (if female) Months pregnant or open (if female)
Breed Characteristics	Prolificacy Birth weight Weight at first estrus
Farm	Liveweight change Birth mortality Pre- and post-weaning mortality (seasonal) Mating management (lambing interval) Market weight Breeding flock size Cull age

$$\frac{\text{LW change during period } t_n\text{-}t_{n+1}}{\text{LW at } t_n}$$

and x is defined by $\log_e$ LW at t_n. This model has fitted well with observed populations, and was adopted because of the need to include LW change of mature animals in order to detect environmental effects on growth during different periods. Under village conditions, there are generally too few young animals to be able to derive satisfactory growth functions for short periods.

The model was designed for, and tested on, a Hewlett Packard 41CV programmable calculator fitted with the extended function and extended memory modules, though it is adaptable to other machines. In its current form, the program requires approximately 5K of memory, with about the same amount reserved for data manipulations and storage.

Application

The model allows the evaluation of animal production over any time period for a given set of input data. Iteration is monthly. For each month of the year, different growth functions of the same basic form can be specified if necessary. Most other parameters are defined as constant over time (for a given run), though some can be modified (e.g., mortality) to take into account dry season/wet season differences. Most parameters are probability-linked. In its present configuration, 20 different farm flocks of up to 20 animals each can be simulated at one time. On the basis of user-defined values, the model will 1) sell market-weight males, 2) maintain a specified size of breeding flock based on the number and age of mature females, 3) cull the oldest females when (2) is exceeded, 4) keep or sell young females based on consideration of (2) and (3) and, 5) provide a monthly summary of offtake and feed requirements.

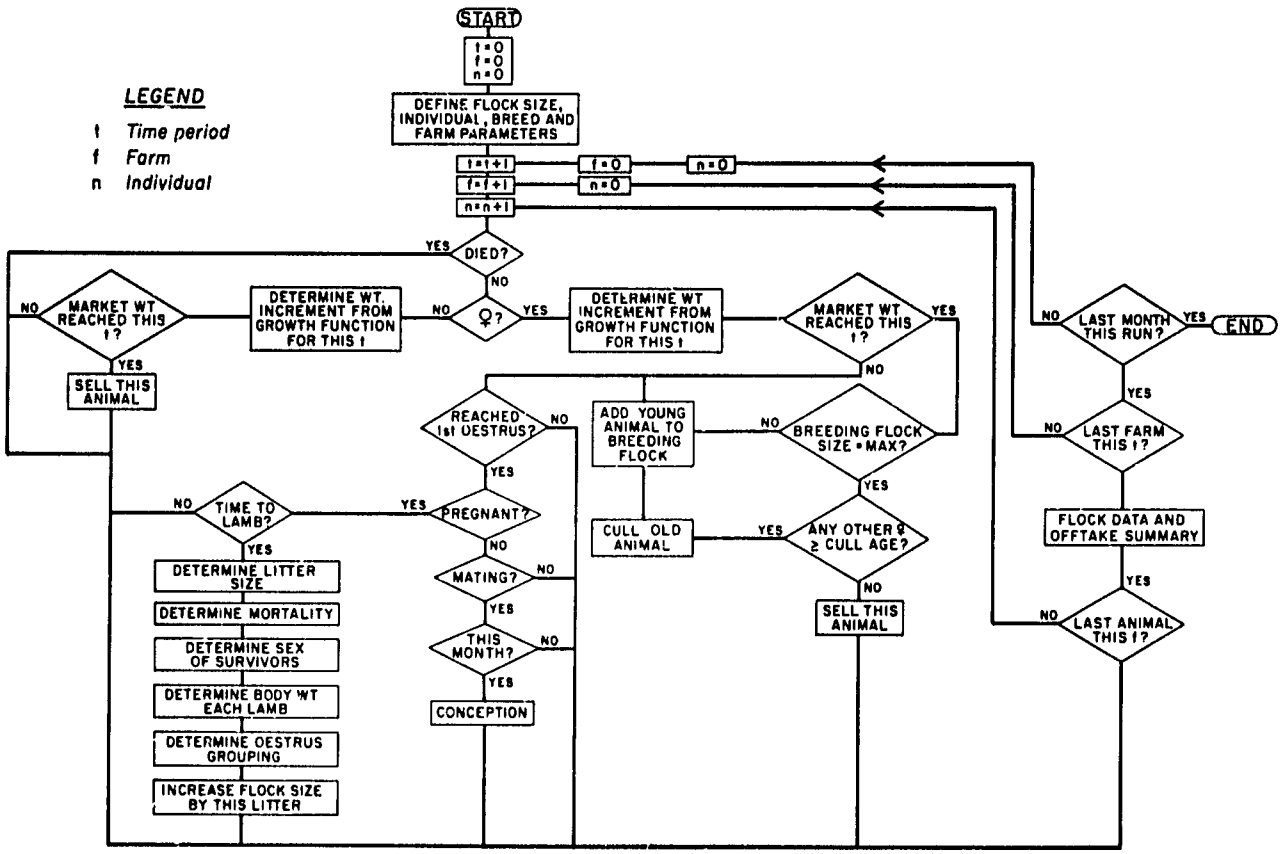

Figure 1. Flowchart of the small farm animal production model for operation on a programmatic calculator.

Significance

The model provides a rapid means of: 1) evaluating the data being collected from village monitoring programs such as those being conducted in Indonesia under the SR-CRSP; 2) examining the impact on animal production of different improvement strategies (these may have been derived from experimental studies or may be imaginary); 3) assigning priorities to strategies tested under (2); and 4) teaching research workers the degree of integration between different aspects of animal production, and allowing them a greater appreciation of the impact of other disciplines upon their own. In this sense, it is self-teaching.

While the model has been developed on the basis of information derived during the Indonesia program, it is applicable to a broader range of production conditions. It allows a quantitative assessment of the impact of different factors on the offtake from, and the longevity of, small-farm breeding flocks. It is a tool that could be used by any research worker, or even a trained extension worker, directly involved in farm production studies.

Funding for the development of the model was provided by the SR-CRSP Nutrition and Breeding projects and it is anticipated that the model will be used by both programs in research development.

Future Research Directions

The model is currently being used to examine differences in productivity at different localities in Indonesia. It has confirmed the low offtake realized by farmers under these conditions, and has highlighted the feed constraint to increased flock size.

While the model is fully operational and the principal objective has been met, the potential of the model to meet some of the more basic interests of the SR-CRSP research scientists would require that it be expanded. The success of the initial development on the HP 41CV, could be positively continued by transferring to a desk-top microcomputer, thus meeting the need for greater memory that increased complexity implies. Equally, the HP 41CV is limited in execution time and output format, and desk-top backup would significantly improve usability. However, the main features of simplicity and portability should not be lost. At this point, more emphasis should be given to applying the model to wider situations rather than to improved sophistication and a narrower set of opportunities. On-going field studies in other SR-CRSP sites provide excellent opportunities for this.

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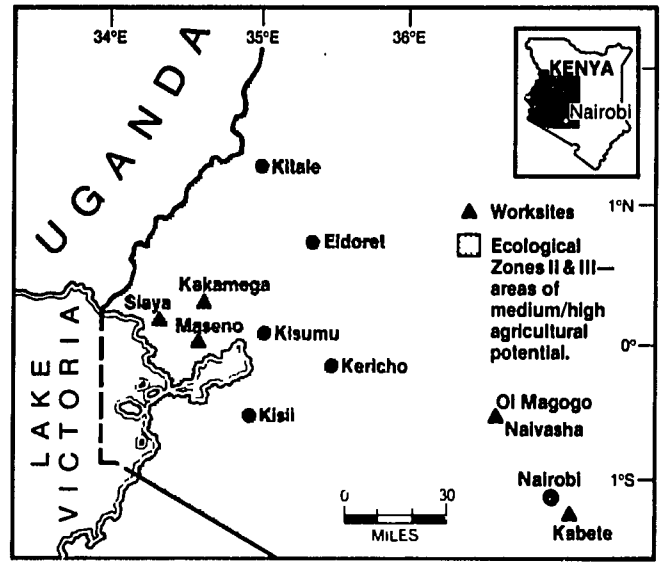
KENYA



Principal Small Ruminant CRSP worksites in Western Kenya.

Kenya has a wide range of environments. With elevations ranging from sea level to 16,000 feet, its ecozones include arid to semi-arid rangelands, a humid equatorial coastline and environs of Lake Victoria, the highland slopes of Mt. Kilimanjaro, and the Abedere Mountains, the moist temperate region of the South Central highlands. Within this ecological diversity, there is also great diversity in the agricultural production systems, which correspond closely with precipitation zones. Annual rainfall ranges from 200-2,000 mm and generally increases with elevation.

Three quarters of Kenya's total land area and most of its rangeland falls into the category of low agricultural potential, with less than 600 mm rainfall per year. In these areas transhumant pastoralism is widespread, with herds of cattle and small ruminants. The remaining quarter of Kenya's land is in the medium and high potential categories for agricultural production.

Over 70% of the Kenyan population relies on smallholder agriculture for its livelihood in these zones. Livestock, although a secondary enterprise, are found on most of these holdings, with cattle on approximately one million farms and sheep and/or goats on .6 million farms. Small ruminants are raised in an intensive "zero grazing" or limited grazing husbandry system and are both consumed by the producer and sold to provide revenue.

The expansion of human population in these already densely populated areas is causing farm size to shrink and diminishing the available resources per capita. Average farm size is now 2.3 hectares and mean household size is 7 persons.

Smallholder, subsistence level farms in the humid tropics often produce inadequate and inconsistent amounts of high quality protein foodstuffs such as milk needed for good health, especially of children and pregnant women. Many farms no longer have the land to provide sufficient feed for a lactating cow, however, they may support several lactating goats. Goats, (3 to 5) in place of a cow, have multiple advantages: loss of an individual animal has less impact on family welfare; initial investment per animal is low; mating does to kid in different seasons allows a small, but consistent daily supply of milk throughout the year; and litters of two or three kids at 7 to 8 month intervals markedly increase offtake of slaughter stock for family consumption or sale to provide needed income.

Realization of these advantages for goats producing both milk and meat within a small-scale integrated farming system requires resolution of many constraints. In the past, little effort has been directed toward the development of a dairy goat adapted to the climatic and health stresses of the humid tropics. Furthermore, the genetic potential of even an adapted dairy goat will not be realized without simultaneous development of appropriate feed production, management, and marketing practices.

The advantages of a small, short gestation, litter-bearing dairy ruminant for small-scale farming systems in the humid tropics are readily apparent. However, this apparent potential remains essentially untested. To be acceptable to small-scale farmers, the dual-purpose goat production system must be based on low cost, low-risk technology and be minimally competitive with cropping activities for land, labor, and capital resources. It is necessary to characterize existing farming systems, including those that do not now incorporate a dual-purpose goat component in order to determine if and how this component can be introduced. The research problem is, therefore, to develop an animal of the appropriate genotype, to develop a feed resource-nutrition-health management package appropriate to the small farm resource base, and to ensure

that this component is economically and sociologically acceptable. Successful resolution of this researchable problem will require the holistic, multidisciplinary approach embodied in the SR-CRSP.

SR-CRSP research activities in Kenya focus on dual-purpose goat production as a component of small farm systems in the medium to high rainfall region of Western Kenya. Currently, seven projects administered by four SR-CRSP institutions are working in Kenya in collaboration with the Ministry of Livestock Development. These institutions and projects include: Breeding, Systems Analysis, Sociology, Health, Economics, Production Systems, and Forages.

An important feature of the SR-CRSP approach is the focus on integrating economic and sociological factors with agricultural data obtained at experiment stations and in the field, both to delineate the current small ruminant production systems and to develop a coherent series of recommendations for improving animal productivity and marketing efficiency.

The initial characterization phase primarily involved surveys of small-farm systems and goat health status in 1981-82; work continues with case studies of small farm families, market surveys, and on-farm evaluation of interventions to improve feed production and goat nutrition, health and management. To date, component research has primarily been conducted on experiment stations: breeding at Ol Magogo Station; health at Kabete Station; and goat nutrition, management and feed production at Maseno. However, a few promising interventions are now undergoing preliminary trials on selected farms.

Genetic Improvement of Sheep and Goats for Smallholder Production Systems

G.E. Bradford
University of California, Davis

The SR-CRSP in Kenya set the specific goal of assessing the potential of dual-purpose goats, i.e., goats kept for milk as well as meat, for improving the diet quality and increasing the income of small farm owners in the higher rainfall farming areas of Kenya.

To achieve this goal, goats with higher milk production potential than the East African and Galla goats commonly kept in Kenya were needed. The tasks set for the UCD Breeding Project were therefore to produce goats with higher milk production potential, and to evaluate reproduction and milk and meat production of such goats as compared to the local breeds. The latter was to be carried out in collaboration with other SR-CRSP projects, particularly the Production Systems and Animal Health projects, and was to include both station and field testing. The Breeding Project was thus a key to the whole program, in that evaluation of dual-purpose goats in Kenyan smallholder production systems depended on a supply of animals with adequate potential for milk production to justify milking them, and a program for breeding them and making them available in sufficient numbers.

A secondary goal of the Breeding Project was to provide consultancy on small ruminant breeding problems in Kenya at the request of the MLD.

Research Accomplishments and their Significance

Breeding Project personnel participated in assembling a flock of 360 East African and Galla does at Ol Magogo Farm and were responsible for planning, funding and supervising construction of facilities for goat research at Ol Magogo. These facilities included breeding pens, sorting and dipping areas, milking stalls, pens for bucks, and an office for the project, since none of these was available when the project was initiated. Construction took place in 1981 and early 1982.

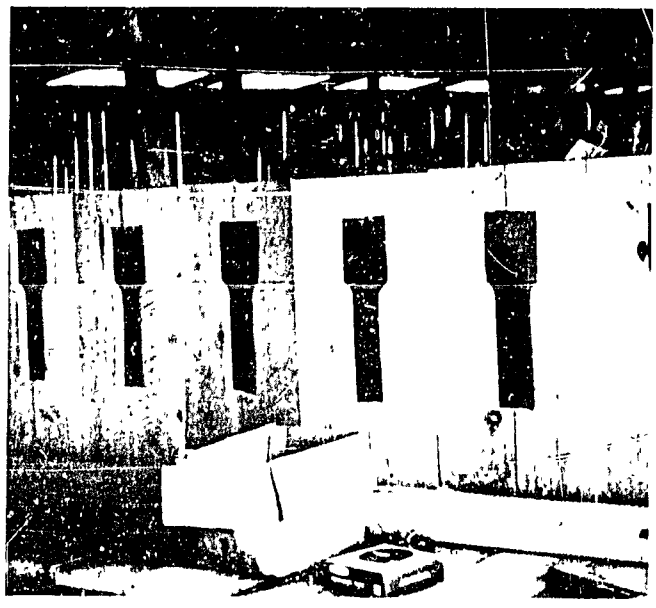
Because of the very limited number of dairy goats in Kenya, it was decided, in consultation with personnel from the MLD and the SR-CRSP Production Systems Project, to import dairy animals from the US for crossing with local goats. Plans were developed to ship 120 goats from California in September 1981, and half of the animals had been purchased when the restriction that all goats must be serologically negative for CAE (caprine arthritis encephalitis) was imposed. Thirty-five CAE-negative goats were then assembled, an import permit issued by the Kenya Government, and arrangements for shipment completed. Shortly before the shipment was to leave, the import permit was rescinded, and no goats were sent then or subsequently.

A Dorper ewe at Ol Magogo Farm involved in the study of influence of the extent of wool cover on performance. Ewes with limited wool cover, such as this one, generally wean heavier lambs. Photo: G.E. Bradford.

As a supplement to and backup for the shipment of animals, semen had been collected and frozen at UCD, with the assistance of Dr. Nelson of the Cal Poly Pomona SR-CRSP Reproduction Project. One shipment of semen was sent to Kenya and used to inseminate project does in November 1981. These does were in quarantine because of an outbreak of sheep pox followed by a foot and mouth quarantine of the area, and no males could be brought in to check estrus. Set-time insemination of does synchronized with progestagen pessaries was therefore used. Conception rate was very low, possibly due to the fact that the synchronizing treatment was not suited to the Kenyan breed of does.

The balance of the semen was used to inseminate naturally cycling does in May 1982. Eighteen of 36 East African does kidded from these inseminations, but only 4 of 15 Gallas kidded. The 50% conception rate achieved with East African does would make AI a practical means of introducing new germ plasm into the Kenyan goat population. We believe that the rate could be improved with further experience. At this time, it is not known if the lower conception rate with Gallas is due to small number sampling error, or whether there is a breed difference in potential success rates.

When we requested a permit to ship additional semen to Kenya, several conditions relating to health status and age of the bucks were imposed which has precluded any further shipment to date. However, progress is being made in meeting the conditions, and the possibility of providing semen from the UCD Goat Facility for the Kenyan program remains open (see section on supporting research in the US).



Goat milking stalls under construction at Ol Magogo Farm, Naivasha Animal Husbandry Research Station. Photo: G.E. Bradford.

Other accomplishments in connection with the goat project include development of breeding, kidding, growth and milk production record forms, and initiation of training of Ol Magogo personnel in milking and milk recording.

One sheep research project has been carried out. This was a study by Mr. Odenya of the MLD/FAO Sheep and Goat Development Project on the effect of degree of wool cover in Dorper ewes on ewe and lamb performance. Mr. Odenya and the PI devised and tested a scoring system for degree of wool cover in February 1980, and Mr. Odenya scored several hundred Dorper sheep prior to coming to UCD for graduate study, and, on a return trip in 1980, scored the same animals and some additional ones. As part of his MS thesis, Mr. Odenya analyzed these scores plus performance data on the sheep.

The results show a strong negative relationship between amount of wool on the ewe and weaning weight of her lamb. Since the Dorper breed, like other sheep originating from a cross between wool and hair sheep, does not produce a commercially valuable fleece, the results suggest that output from these sheep could be increased 10 to 15% by selecting to produce woolless animals. Mr. Odenya's analysis also showed a heritability for wool score of .25 to .30, indicating that selection would be effective.

These conclusions need to be tested in other tropical sheep originating from wool x hair breed crossing. If they generally hold, the finding has very important implications for improvement of productivity of tropical sheep where the fleece is not an important product.

The UCD Breeding Project in Kenya was transferred to Texas A&M effective October 1, 1982, to permit the UCD PI to initiate an SR-CRSP Breeding Project in Morocco. Future directions are discussed in the TAMU report and workplan.

Training

To date, three MS students from Kenya have come to UCD through this project.

Mr. William Odenya, whose research was discussed above, was sponsored by an FAO Fellowship, with supplementary funding for research provided by the UCD Breeding Project. Mr. Odenya completed his degree and returned to Kenya in September 1982.

Mr. Alfeyo Okeyo-Mwai entered UCD in September 1981 and is expected to complete his MS in summer 1983. His studies have been supported entirely by the SR-CRSP.

Mr. Edward Rege came to UCD from the University of Nairobi on a World Bank Fellowship. Although not officially part of the SR-CRSP, his coming to UCD resulted from contacts between the project PI and Co-PI, Dr. Kimenye of the University of Nairobi.

Other training activities included training in goat semen processing and artificial insemination. The training was done by Dr. Nelson of the Cal Poly Reproduction Project, funded by the UCD Breeding Project. Several Kenyans participated, with Mr. Charles Ngugi of the Central Artificial Insemination Service at Kabete becoming highly proficient.

Selected Publications

Bradford, G.E. 1981. Potential of Dairy Goats as a Source of Milk on Smallholder Farms in Kenya. SR-CRSP Technical Report Series No. 7. 12 pp.

Kimenye, D., C. Ngugi, Y. Berger, C. Ahuya and F. Ruvuna. 1983. AI and its Potential in Goats: Ol Magogo Example. Technical Report (In Preparation).

Odenya, W.O. 1982. Relationship of Coat Cover and Production Traits in Dorper Breed of Sheep. MS Thesis, Univ. of Calif. Davis. 74 pp.

Development and Breeding of Genetically Improved Goats

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One of the constraints to dual-purpose goat production by smallholders in Kenya is a suitable type of goat. A goat is required that has sufficient milk production and growth characteristics to justify being kept by the smallholder yet at the same time possesses sufficient adaptability to the rigors of nutritional, management and health stresses prevalent in smallholder production systems. Adaptability of indigenous strains is usually, in part, accomplished through slow maturing rate and low level of milk production.

Whether goats will become an important source of both milk and meat in Western Kenya for smallholder farms will depend on a number of conditions including whether the Breeding Project can identify a breed or breeds that thrive reasonably well to produce milk and meat in the "target environment" and fit well within the current smallholder farming system. The broad objective of the Breeding Project has therefore been to identify a breed or breeds of dual-purpose goats that meet the needs of the West Kenyan smallholder, and are adapted to that environment.

Several methods are available to attain this objective. One option is to adopt a system of mating that will rapidly displace indigenous stock with stock originating from European dairy goat breeds. A second alternative is to evaluate the dairy potential within indigenous breeds. Selection would then proceed based on high performance individuals from this indigenous stock for propagation and dissemination. The selected indigenous stock may be selected separately or combined with optimal amounts of exotic breeding.

The first method is rapid but the incompatability of upgraded stock and limited smallholder resources has historically led to poor results. The second alternative, though considerably slower, offers higher expectations by providing a highly variable group of goats indigenous to Kenyan environments. The great variability is important for the identification of individuals with large potentials in milk production, survivability and growth. Both groups, those utilizing exotic temperate dairy goat germ plasm and those of selected indigenous breeds, East African (EA) and Galla (G), are being screened for the development of a dual-purpose goat suitable to Kenyan smallholder environments.

In developing a successful dual-purpose goat, it is of primary importance to determine the genetic potential for milk production and growth that is optimal for goats kept by smallholders. The specific objectives of the Breeding Project are therefore:

- To compare indigenous breeds and their crosses with locally available dairy breeds with regard to variability and level of milk and meat production, health status, and their suitability to different environments under Kenya conditions of a smallholder farming system.
- To initiate formation of a new or composite dual-purpose breed derived from dairy and indigenous goat breeds.
- To establish a recording and evaluation program of dairy production (including progeny testing) and initiate selection within the newly formed indigenous and composite dairy breeds.

A secondary phase of our objective is evaluation and multiplication under conditions closely related to those of a smallholder farmer. This phase will involve the release of a "breed-type" or cross suitable for full-scale production by (or for) smallholder farms. This objective will be addressed after a breed-type or cross suitable for Kenya smallholder conditions has been identified or developed.

Research Accomplishments

Assembly of the goat herds, development of facilities and supervision of the 1982 matings were carried out by University of California Breeding Project personnel. Results of matings from the 1982 breeding season are presented in Table 1. Due to lack of semen from temperate dairy breeds, the 1982 breeding season did not produce enough offspring for a comprehensive breed comparison. Thus, only those matings that produced 20 offspring in any one breed group will be discussed.

It is important to note that of those matings utilizing semen of temperate dairy breeds via artificial insemination, 43% of the does conceived. This figure represents results affected by difficulties in matching equipment size to doe size and the use of virgin females, i.e., females of unknown reproductive capacity.

An average litter size of 1.2 kids per doe kidding resulted from the 1982 breeding season. The range of litter size varied from 1.05 to 1.29 kids per doe, with the East African x Galla at the lower end of the range and the East African and Toggenburg x East African at the upper end. Average litter size is a measure of twinning rate. Twinning rates were highest in the East African and Toggenburg x East African at 29 and 28%, respectively. Males in each breed group were heavier than females at birth. Birth weights of single kid births were also higher than birth weights of kids from multiple births across all breed groups.

The combined average birth weight of GxEA and EAxG was 2.5 kg which was 0.2 kg heavier than the average weight of the two parent breeds. Based on these results, there is about 8.7% heterotic effect for birth weight resulting from crossing the two breeds.

Doe weights recorded in 1982 for EA and G does at ages 2 through 5 exhibit large seasonal weight changes. These changes can be attributed to changes in forage quantity and quality. In age groups 2 through 5, the Galla is consistently heavier than the East African. Does 5 years of age were considered as having reached maturity and the observations

Table 1. The 1982 Kid Crop at Ol' Magogo by Breed Group

Breed Group[a] Sire	Dam	Kids Born	Does Kidding	Twinning Rate, %	Birth wt, kg	% Kid Mortality
G	G	49	43	14	2.8	26.5
EA	EA	96	75	29	2.1	15.6
G	EA	66	58	11	2.5	21.2
EA	G	20	19	5	2.5	30.0
T	EA	88	68	28	2.4	30.7
T	G	39	34	15	2.8	35.9
Average		358	297	20	2.5	23

[a] G = Galla, EA = East African, T = Toggenburg

for December 1981 to January 1983 indicate that mature body weight for Galla does at Ol' Magogo was 35.5 kg, while East African does had a mature body weight of 28.4 kg.

Survivability of kids is one of the most important production traits. Average kid mortality was high (23%) and would be expected to be even higher for smallholders and therefore would be a major constraint for smallholder production. The East African had the lowest mortality (16%) and the Toggenburg x Galla had the highest (36%). These preliminary data have very important implications for breed or cross choice both for immediate distribution and for the breeding program. Mortality is also influenced by type of birth, single or multiple. The death rate for kids from multiple births was 29% while the death rate for single births was 24%. Deaths were classified as being caused by pneumonia (65.3%), scours (21.9%) and weak or still births (12.9%).

Development of milking facilities and initiation of milk recording were also carried out by the University of California before TAMU took over the project. Large variability in milk production in the Galla and East African are evident in Figure 1, even though these are only partial lactation records from the 1982 kidding season. Galla does exhibited larger variability and higher average daily milk yield than the East African does. It appears that both breeds reach their peak of lactation during the 5th week. Of the small number of Toggenburg crosses available, the average daily milk yield was approximately twice that of Galla does. Galla does of milk strains thought to have much greater milking potential than the present Gallas have now been introduced into the research project.

The large variability in milk production has implications for the selection of indigenous stock, especially for the Galla. While the importance of survivability exhibited by the East African kids implies a very real selection advantage for this breed group, measurement of other production traits, such as growth rate, age of puberty and worm tolerance, is continuing on the 1982 kid crop. Analysis of this future data will further document the variability present in these production characteristics.

The Breeding Project continues its close association with other SR-CRSP projects: animals from the Breeding Project are being used in the forage and water availability experiments; data being collected at Ol' Magogo are also to be used for model validation by the Systems Analysis Project; experiments in collaboration with the Health Project are seeking answers to the apparent tolerance levels of indigenous stock to internal parasites and trypanosomes; collaborative testing of the efficiency of a new anthelmintic (ivermectin) and breed x treatment interaction using Breeding Project goats is expected to yield results of interest to both projects. Finally, the milking protocol package for smallholders is being developed in part of the dairy goat operation at Ol' Magogo.

Yearling crossbred does produced from mating dairy breeds, Toggenburg and Nubian, to local East African breed in Western Kenya. Photo: H.A. Fitzhugh.

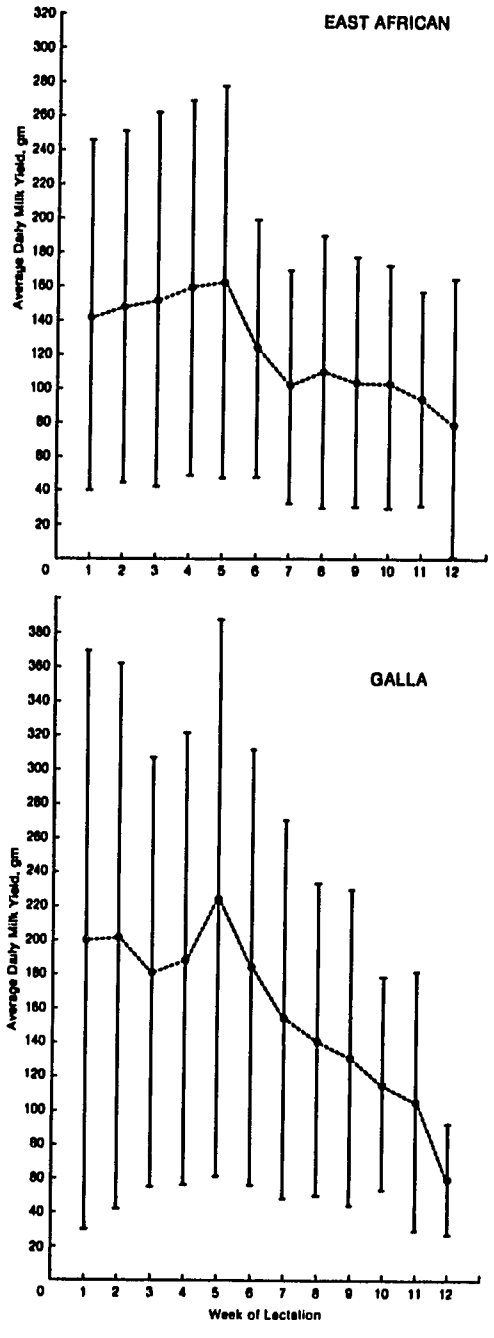

Figure 1. Average milk production and variability (standard deviation) of Galla and East African does at Ol Magogo, 1982-1983.

Future Research Directions

The continued evaluation of productivity and variability of locally available breed types is essential for the development of appropriate types of dual-purpose goats in Kenya. The great variability observed in the indigenous breeds has resulted in a redirection of the original objectives of the Breeding Project. Based on the variability in milk production and the need for adaptability to particular management systems, the classical comparisons of breeds and a dependence on the importation of exotic dairy breeding has been de-emphasized and in its place the establishment of testing programs and selected lines of indigenous stock will be given primary emphasis. Several avenues are opened by this approach, such as the formation of a composite breed designed to incorporate the survivability of the East African, the milk production of the Galla, the milk persistency of the Toggenburg and the growth rate and milk production of the Nubian. The first two breeds are indigenous to Kenya, while the last two breeds are established exotics in Kenya. Utilizing four breeds and possibly a fifth, the Jamnupari, increases the residual heterosis of the composite, and greatly enhances the responsiveness to selection of the base population for the development of a specialized West Kenyan breed. This composite breed, synthesized from locally available stock, is a Kenyan dual-purpose goat. Selection criteria used in the development and improvement of the Kenyan composite breed will be based on the optimal production levels determined from the systems analysis simulations.

Establishing testing programs for indigenous stock is a major opportunity of this program. The screening of large numbers of individuals based on the variability found for milk production and survivability plus other production characters, is an advantage of this approach. Selection of individuals within the large populations of Gallas and East African types vastly increases the selection differential and is expected to lead to the establishment of elite lines within each type.

Training

Training of Kenyan and US personnel is a major objective of both the Systems Analysis and Breeding projects. Training of Kenyan personnel insures the long term goals of the Kenya SR-CRSP program, while training of US personnel adds understanding and professional development in the international field of scientific research.

Training or development of personnel in systems and breeding takes two forms: one, the scholastic training of students; and two, the collaboration of experts, in their respective fields, with these same students and project personnel. Scholastic training of students can be divided into two categories. The first are those students supported by SR-CRSP funds and the second are those students not supported by the SR-CRSP but analyzing SR-CRSP data and/or facilitating data management for the SR-CRSP in Kenya. The first group consists of the following individuals:

- J. Mathenge from Kenya completed an MS in Animal Breeding at TAMU with a thesis entitled "Growth Curve Analysis of Rambouillet Ewes." June 1980-December 1981.
- A. Okeyo from the MLD, Kenya, is enrolled at UCD in an MS Animal Breeding program and has been supported by the TAMU Breeding Project since October 1982.
- S. Tallum from the MLD is enrolled at TAMU for an MS in Animal Science with an emphasis in systems analysis. January 1983-December 1984.
- H. Blackburn is enrolled at TAMU in the PhD Animal Breeding program. Mr. Blackburn spent June to December 1981 in Kenya collecting data on sheep and goat production in the Marsabit district. December 1978-August 1983.

Several other students at TAMU have been involved in systems analysis, data analysis and model development. The following students received funding from other sources but contributed to the overall SR-CRSP Kenya program:

- P. Kiriro completed a BS in Animal Science at TAMU in December 1982. Mr. Kiriro was on an AID fellowship from Egerton College, Kenya.
- Z. Gathuka completed a non-thesis MS in Animal Science at TAMU. He was funded by an FAO fellowship from the MLD, Kenya.

Other types of training are also connected with both the Systems Analysis and Breeding projects. MLD personnel are involved in many of the previously discussed experiments. The MLD staff is involved in training in forage research techniques, goat dairy management, laboratory techniques and minor veterinary surgery techniques, e.g., cannulation.

Selected Publications

Kimenye, D., C. Ngugi, Y. Berger, C. Ahuya, and F. Ruvuna. 1983. Artificial Insemination and its Potential Use on Goats in Kenya. Kenya SR-CRSP Workshop, Naivasha, Kenya.

Ruvuna, F., T.C. Cartwright, G.M. Smith, G.E. Bradford, Y. Berger, C. Ahuya, and J. Muia. 1983. Preliminary Results on Performance of Different Breeds of Goats at Ol' Magogo. Kenya SR-CRSP Workshop, Naivasha, Kenya.

Systems Analysis and Synthesis of Livestock Herds

T.C. Cartwright
Texas A&M University

The broad objective of the Systems Analysis Project is to provide a method for increasing the effectiveness of research by establishing research priorities and by providing a method for evaluating the application of research results. This is achieved by development of a dynamic, comprehensive mathematical model, based on biological functions, for sheep and goat production systems which utilize the individual animal as the modeling unit.

The systems analysis process is an integrated multiple step process utilizing data and knowledge of a team. This team includes components from the SR-CRSP Forage, Breeding, Management, Animal Health, Economics and Sociology projects. Simulating production systems for sheep and goats is a complex process and the analysis of a system requires several simulations. Each simulation is studied to understand the changes that occur to particular segments of interest (e.g., reproduction, weaning weight, death loss, or milk production) within the system as input variables change. Changing one of a few variables of interest in successive simulations serves as a method of successive approximations designed to lead to identification of optimal combinations of inputs.

These simulations provide a method for examining the effect of new practices and determining optimal combinations and sequences for implementing them. With complex input-output animal interactions, it is important to examine the effects of an intervention throughout the entire production system in order to avoid unanticipated effects which could be counterproductive to final biological or economic efficiency.

The project's specific objectives have been as follows:

Model Development and Validation

- To develop comprehensive, interacting, biologically based mathematical models to simulate sheep and goat production systems.
- To validate the general sheep and goat models for basic structure and functions with sets of independent data and then to revalidate for each of the different smallholder locales and conditions.
- To incorporate in the goat model an interacting function for effects of internal parasite load, diseases, and other stresses as the need arises and information becomes available.

Simulations, Analysis and Synthesis of Dual-Purpose Goat Management Systems

- To examine the effect of specific forage production and management practices on goat production and on the carrying capacity of smallholder farms with various characteristics.
- To examine combinations of practices in order to predict optimal inputs to maximize outputs under given constraints and to provide simulated production data for economic analysis.
- To simulate smallholder production of goats of varying genetic potential for maturing rate, size, and milk production for farms with specific resources and management in order to estimate optimal traits of goats for breeding objectives.
- To simulate sheep and goat production for use of the Integrated Project in Arid Lands (IPAL), currently active in desert areas of Northern Kenya.

Research Accomplishments

The TAMU production systems models are designed to simulate individuals and flocks of sheep and goats in a manner similar to that which would occur if an actual individual or flock was placed in an actual specified production environment. The simulation of production systems for a given location requires that feed, environment, management, and animal performance data be available. These data are used to simulate actual known production as a validation; after validation, this simulation is then set as a baseline for comparison of management alternatives. Most of the required baseline data is available from data previously collected by the MLD and other organizations in Kenya or can be obtained from the on-site SR-CRSP projects.

Baseline validations have been completed for a limited number of settings, and simulations of alternative systems have begun. The selection of alternative systems is guided by biological potential, economic feasibility, and social effects and/or constraints. In order to simulate alternative systems, management policies (including supplemental feeding), forage qualities and availabilities and genetic potentials of the breed are specified. Genetic potential is defined as the performance level that would be achieved by animals in good health and with good nutrition throughout their lives.

To establish a baseline simulation that closely mimics current production capabilities, forage data must be available. However, in the early stages of the SR-CRSP, data on forage in Western Kenya was unavailable. To avoid unacceptable delays, we made use of forage data gathered in the Mt. Kulal area of the Marsabit district by IPAL even though the data was not derived from an ecology related to the target area of the SR-CRSP. A number of management interventions were evaluated using this simulation: a flock health program; a controlled breeding season; control of flock structure; and supplemental feeding and grazing management.

A preliminary application of the dual-purpose goat model based on the IPAL data was used to demonstrate some of its capabilities. Goat flocks were monitored beginning in 1979

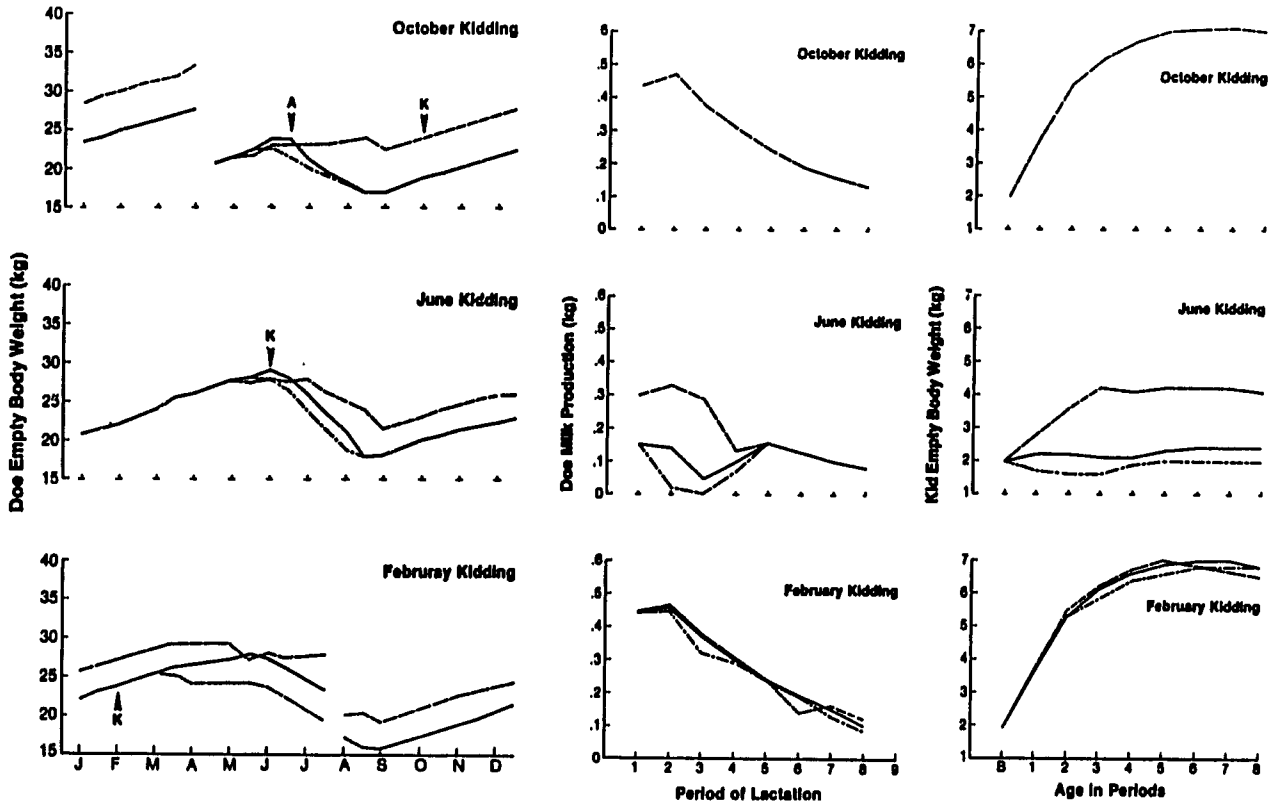

Figure 1—Body weights (Figure 1.A) and milk production (Figure 1.B) for two year old does bred in three different seasons and growth patterns of their kids (Figure 1.C) for three production systems. (K = kidding; A = abortion; ---- migratory; -.- sedentary; ____ base)

for body weight, reproductive performance, milk production, health status, and forage intake. Diet preference was observed and forage samples were hand-plucked to analyze forage quality. The goats were under the care of locally recruited herdsmen who managed them by traditional methods with a minimum of interference.

Three herd management routines were simulated, one representing a traditional system of flock movement from dwarf shrubland to riverine woodlands (base). The second is sedentary representing household and flock settlement around watering facilities in dwarf shrubland. The third management routine is migratory where households and flocks move from shrubland to mountain forests.

A two-year-old East African doe was simulated for one year in each production system for each of three breeding dates (June 1, February 15, and September 15). Each simulation was begun 45 days before breeding with an initial doe weight of 20 kg. These nine simulations illustrate how management decisions (e.g., breeding season) can help synchronize animal requirements with forage availability.

Doe body weights are shown in Figure 1.A for all nine simulations. The severe drop in weight during the dry season resulted in abortions for does breeding in June on the base and sedentary systems. The higher quality forage for the migratory system is reflected in the much smaller drops in body weights. Does kidding in June and lactating during the dry season and does on both the base and sedentary systems mobilize large amounts of body reserves. The rate of this mobilization is highest for the does on the sedentary system.

Milk production for the doe kidding in October (Figure 1.B) reflects the assumed potential of two-year-old East African does. The low milk production of the June kidding

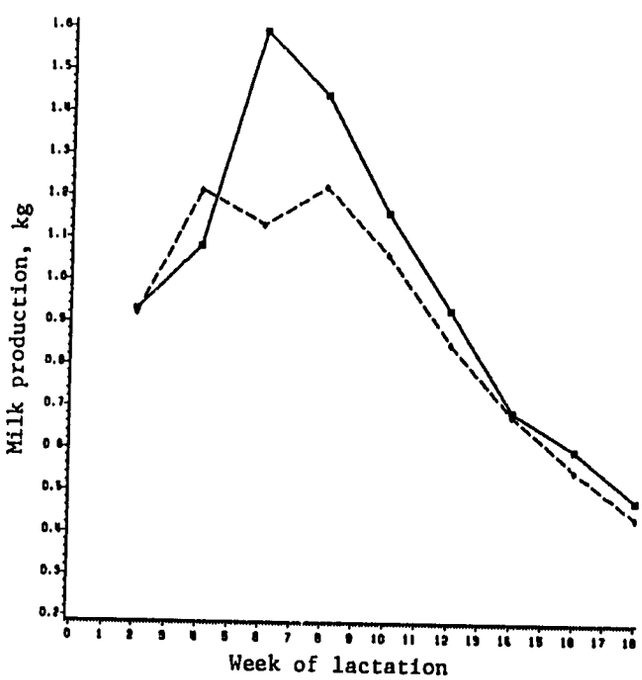

Figure 2. Milk production for two mature does of different genetic potential for size and each with the same genetic potential (3 kg) for milk production. (WMA = 35 kg: ✱—✱; WMA = 45 kg: □—□)

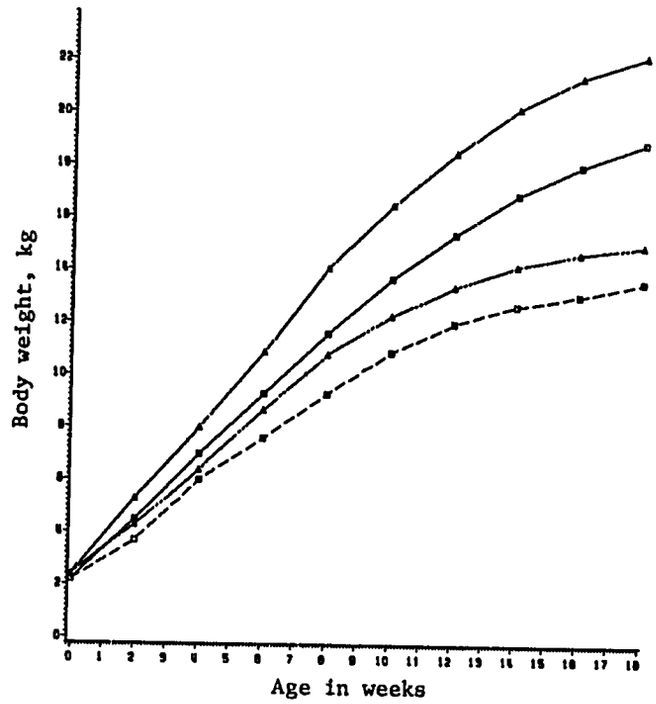

Figure 3. Growth patterns for kids of different genetic potentials for size and two milking routines, i.e., kids receive 100% of the dam's milk or 50% of the dam's milk. (WMA = 35 kg and 100%: △—△; WMA = 35 kg and 50%: △—△; WMA = 45 kg and 100%: □—□; WMA = 45 kg and 50%: □—□)

does reflects their severe nutritional stress. Does kidding in February produced sufficient milk for kid growth but mobilized large amounts of body tissue in the process. Kid growth rate (Figure 1.C) corresponds closely to level of milk production. The June-born kids on the base and sedentary systems would not have survived. These simulations were used to demonstrate and help validate the goat model.

The next set of simulations will examine production alternatives for goats in a region of smallholder farming in Western Kenya. These simulations will utilize parameters that represent a breed of higher genetic potential for milk and growth than the previous simulation.

The Forage Production Project estimated the amount and quality of forage that could be produced for goat feeding by a smallholder farmer in Western Kenya. The does simulated were considered to be representative of Toggenburg x East African or Toggenburg x Galla crosses. The parameters that were used in the model to represent the genetic potential of these does include two mature body weights, 35 kg and 45 kg, and a potential peak milk yield of 3.5 kg or 4.5 kg per day. The simulations determined that six does kidding at two-month intervals is the stocking level that can be supported on the given smallholder farm feed resource. The simulated intake is a function of doe weight, condition (body fat percentage), lactation/gestation status and quality (digestibility and protein percentage), of the forage and, of course, the amount of forage available.

Figures 2 and 3 illustrate the individual potential of dual-purpose goats for two different traits, milk production and kid growth. The heavier mature body weight (45 kg) doe exhibits higher milk yields over the last lactation period due in part to an increased body size (Figure 2).

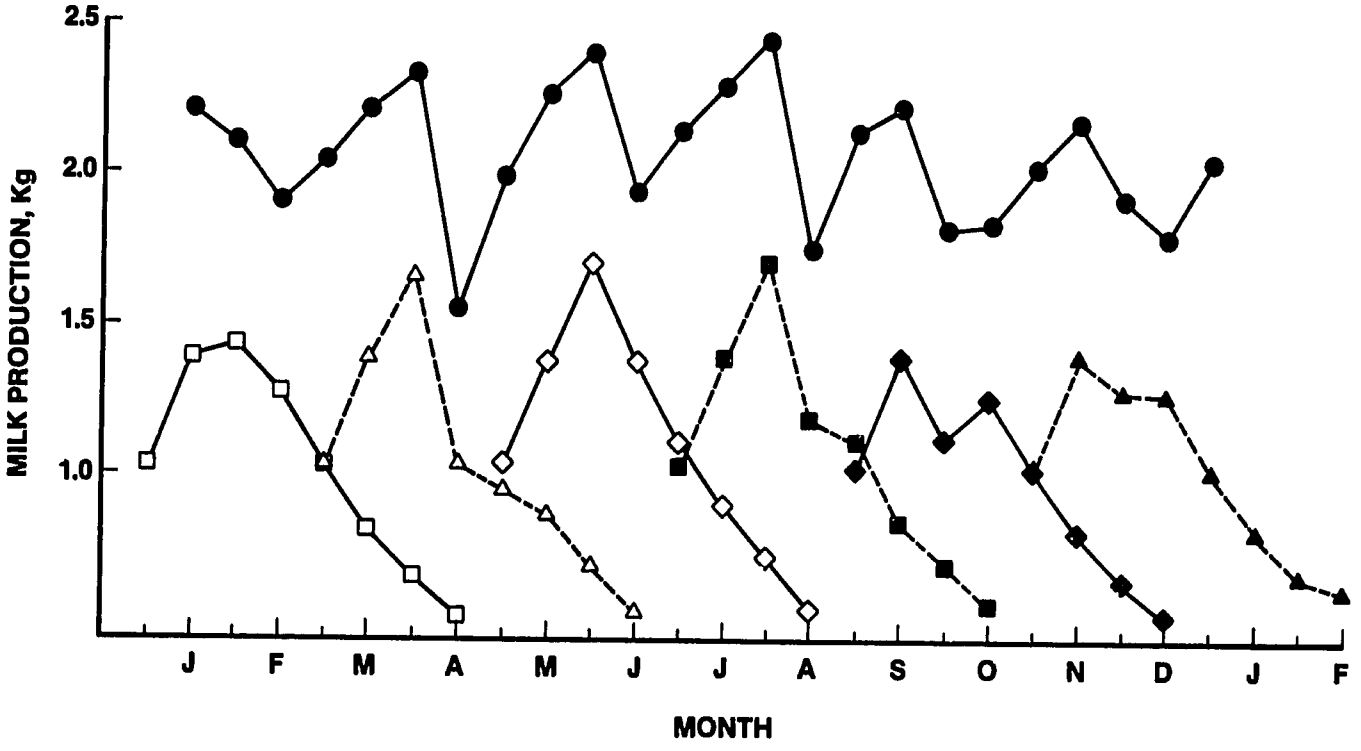

Figure 4. Total milk production available to a smallholder for a 12 month period from lactations of 6 does with genetic potential for mature size of 45 kg and milk production of 4.5 kg. (total milk = ●-●)

Kid growth was simulated under two conditions: where the kid received all of the milk and where the kid received only half of the milk. Again, two different genetic potentials for mature body weight were utilized, 35 kg and 45 kg, respectively. Kid growth, as expected, is the greatest at 45 kg mature size potential and a 100% milk supply followed closely by the kid of 35 kg potential under a similar milk supply. The situation is similar when milk supply is restricted by one half (Figure 3).

Figure 4 depicts a simulation of six lactations over a one-year period. These lactations indicate not only the total milk production available to the smallholder for a six doe operation but also the "milk flow" (used in the same sense as "cash flow"). Smallholder use of one kilogram of milk daily for household purposes leaves sufficient milk for kid growth even during the leanest period in April.

These simulations clearly illustrate some of the future uses of Systems Analysis in the SR-CRSP Kenya projects. Once sufficient data from experiments have been collected and analyzed, simulations along these lines can indicate possible interventions in small ruminant production and synthesis of optimal combinations of breeding, nutrition, management, marketing, and other practices.

Factors having major effects on small ruminant producing systems in Kenya include disease and parasite stresses interacting with nutrition and breeding which further interact with management, marketing, and other socio-economic effects. Specific production system components and alternative practices to be examined in future activities include:

- Selective supplemental feeding
- Grazing practices
- Use of crop by-product forage
- Disease control programs
- Breeds, crossbreds and composites
- Milk for family/kids
- Breeding season and weaning age
- Culling and marketing practices
- Supplemental feeding of stored or purchased feeds
- Sociological constraints/incentives

Simulation of these specific alternatives are planned to provide feedback to the SR-CRSP Nutrition, Forage Production, Health and Breeding projects and feed forward to the Economics and Sociology projects, and to extend data interpretation.

An application of the model that is of particular interest to the dual-purpose goat program is the prediction of an optimal goat genotype for the given physical environment and socio-economic context. As appropriate, hair sheep and dual-purpose goat production systems for Western Kenya and other ecozones will be evaluated with primary emphasis on integration of secondary livestock enterprises into pre-existing smallholder agronomic production units.

Training

Many of the training activities undertaken by the Systems Analysis Project have been very closely related to the activities of the Breeding Project, also conducted by TAMU. To avoid trying to allocate training to one project or the other, both are artificially reported together under the TAMU Breeding Project.

Selected Publications

Cartwright, T.C., F. Ruvuna, B. Hart, H. Blackburn, G. Smith, and A. Carles. 1983. Simulated Dual-Purpose Performance of Goats Utilizing Forage Production Potential of a Smallholder. Kenya SR-CRSP Workshop, Naivasha, Kenya.

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Smith, G. M., A. Charles, J. Schwartz, H. Blackburn, F. Ruvuna, and T.C. Cartwright. 1982. Analysis and Synthesis of Small Ruminant Production Systems. Kenya SR-CRSP Workshop, Kabete, Kenya.

Economic Issues in a Dual-Purpose Goat Production System

A.J. De Boer
Winrock International

The goals of the Economics Project in Kenya are structured to be highly complementary to the dual-purpose goat Production Systems Project. In addition, the goals are limited to a specific problem and a specific production environment: to analyze the potential economic benefits to small Western Kenyan farms from introducing dual-purpose goats as a farming activity.

The rationale for this approach hinges on the precarious state of small farm agriculture in Western Kenya and the need to introduce new activities into the system to improve farm family incomes and nutritional status. Development of this long-term research program must first focus on determining what essential components are needed to increase the probability of dual-purpose goats being adopted, carrying out research on these components to determine performance levels, testing these components on farms, and then modifying the research in light of these results. This type of research presents a particularly difficult set of problems since on-farm constraints cannot be accurately specified prior to the commencement of the research program. Potential problems in marketing the products (goat milk, breeding stock) are not known since little, if any, market existed at the time of project initiation, and existing livestock production practices are usually quite different from that required for successful production of goat milk. The major project goal must therefore center around the development of a cadre of experienced Kenyan staff with the research skills to conduct the program and adapt the essential research programs to a variety of farming situations.

Specific project goals are to:

- Provide a well-trained group of professional agricultural economists with the analytical skills, research experience, and professional motivation to contribute to the conduct of multidisciplinary research on small ruminants and their producers.
- Strengthen the overall research capacity of selected host country research institutions by providing leadership in conducting interdisciplinary research, conducting training programs and publishing research results.
- Develop general purpose analytical models to allow researchers to examine the impact on farm income, farm self-sufficiency, and farm resources from introducing a wide range of dual-purpose goat activities.
- Examine off-farm constraints most likely to jeopardize the successful production and sale of goat milk and breeding stock.

- Conduct supplementary policy analysis essential to identify required support from both the public and private sector for large scale implementation of a dual-purpose goat program.

These goals can be conveniently broken down into procedures which look at on-farm constraints, those which examine current and potential off-farm constraints, and research where the various constraints are synthesized into whole-farm models. Specific research tasks have therefore been to:

- Conduct basic research on farms-household resource allocation processes including farmers' goals, objectives, resources, and production activities. The focus is on-farm constraints.
- Provide support for biological research programs through economic analysis of experimental results. The focus is on constraints identified on the research station. The productivity gap between the research station and farmers is identified and analyzed.
- Identify and research the off-farm constraints such as market access, market demand, price formation and credit access which will impact upon adoption of dual-purpose goat production technology and also affect development programs based upon this technology.
- Pursue integrative research where results from several disciplines are synthesized into economic models of the whole-farm system or into economic models of components of that system. This model building requires a substantial descriptive phase. The model objective is to depict the economic costs and benefits of adopting various combinations of dual-purpose goat technology.
- Monitor the economic impact of the SR-CRSP on farms by using economic models which assist in the analysis of the costs and benefits derived from alleviating both individual constraints and sets of constraints.

Research Accomplishments

The major initial activity of the Economics Project was participation with the Sociology and Production Systems projects in the Small Farm Systems Survey. The Economics component focused on the labor, prices, and marketing aspects, and key results are reported in the survey section of the Production Systems report. Four important findings resulted from this survey:

- The small size of the farms and the observed lack of other sources of grazing in all likelihood preclude the possibility of adopting dual-purpose goat technology which requires extensive foraging on good-quality pastures.
- The lack of a money inflow may pose a barrier to investing in dual-purpose goats due to capital shortages.
- The attitude toward livestock is not a high priority whereas subsistence is a high priority. Thus, any tradeoffs between livestock and subsistence may be biased against livestock.
- A high proportion of household food supplies are purchased, with much of the cash so used coming from off-farm earnings (an active market exists for milk in these villages).

The survey data was synthesized into economic models of traditional small farms. When these models were well-validated against actual survey results, the dual-purpose goat enterprises of interest could be introduced and the changes in optimal farm plans examined.

Whole-Farm Modeling

The first step was constructing model budgets of dual-purpose goats and checking for consistency with budgets for other species and other parts of Kenya (De Boer et al., 1983). A linear program model was then formulated to simulate farmer behavior in the face of dairy goat technology availability and government policy. The model maximizes net revenue from specific farms subject to various constraints and attempts to capture the more important elements of the farm's decision environment. The basic structure includes production, consumption, purchasing, and sale of crops; production, input requirements, and sale of livestock; and animal nutrient requirements. The model is constrained by monthly labor supplies, land, livestock feed supplies, human nutritional requirements, goat nutritional requirements, and cash. Most of the model is typical of many linear programs; thus, the livestock, crop, and diet components will be the only ones discussed. As mentioned earlier, each of these components still contains simplifying assumptions that are reflected in the results.

The livestock subcomponent has activities for producing dairy goats and native cattle, goats, and sheep. The model focuses on the mechanisms by which metabolizable energy and digestible protein from crop by-products, fodder production, fallow land, and purchased feed affect the prospects for developing various livestock enterprises on the farm.

The dairy goat alternatives are modeled in the most detail. The major decisions allowed for in the dairy goat portion of the model are number of dual-purpose goats held, breed, kidding season, management system, feeding method, time of kid sales, and disposition of milk. The dual-purpose goats are assumed to be crosses between an exotic breed (such as Toggenburg or Anglo-Nubian) and native East African goats. Three types of animals are defined: three-fourths, one-half, and one-quarter exotic. Does are assumed to kid in April or November when weather conditions favor lactation. Two confinement options are present. In the full confinement system, the animals are confined in specially built houses and all feed must be brought to the animals. The only forage options considered are on-farm produced crop wastes and napier grass. Does are fed purchased dairy concentrate at the rate of one kilogram of feed to two kilograms of milk produced. The partial confinement system differs in that (a) housing is cheaper, (b) kids can be fed on cut napier grass or in fallow areas, and (c) since goats do some grazing, labor increases are avoided. Weaner kids from dairy goat

production can be sold at any time between four and fourteen months of age.

The base model of the traditional farm gave an optimal farm plan with the total farm area in maize/beans intercrop. An additional 122 kg of maize is purchased. Net returns are generated from both the sale of maize immediately after harvest and the sale of some beans. Total net returns are Ksh 930. Native livestock (cattle, sheep, goats) do not enter the optimal farm plan, probably because of the assumptions regarding grazing availability off the farm.

Next, dual-purpose goats are introduced into the set of allowable farm activities, and farm size was varied from 0.6 to 1.6 ha. At the smaller farm sizes, net returns are negative. This concurs with the Small Farm Systems Survey results that small landholders are unable to produce adequate food crops and must rely on outside remittances to purchase the additional foodstuffs. The results at the 1.0 ha farm size assumption are identical to the base model run, since dairy goats do not enter the optimal farm plan.

A number of situations are found where dual-purpose goats enter the optimal farm plan. These are discussed in turn. As farm size expands to 1.6 ha, the farmer eventually has adequate forage for his goats. A total of Ksh 468 of milk is sold as well as Ksh 660 of kids. Net farm returns are Ksh 3,195 as opposed to the one ha base model figure of Ksh 930. However, the major source of net returns is still sale of maize and beans. With a 50% subsidy on capital costs, the optimal farm plan strongly favors dual-purpose goats, milk sales rise to Ksh 3,160, kid sales are Ksh 5,355 and net returns are doubled over the traditional base model levels on a 0.8 ha farm. Next, the impact of allowing a low cost silage making technique to enter as a possibility was modeled. The family nutrition constraint is also dropped. This allows maize to be produced for silage. A single 1 ha farm is assumed. The effect is to allow three dual-purpose does plus followers to be held, reduce purchases of concentrate feeds, produce 1 ha of maize-beans intercropped, and a net farm return of Ksh 3,780. For this, food purchases are required, but the potential economic impact of this technology or related technologies which make dry season feed available appears favorable. Research is continuing on these technologies and experimental results will be incorporated into the linear programming model as they develop (De Boer et al., 1983).

Traditional Animal Health Practices

To assist in the planning of an effective animal health program which complements the other research efforts, a socioeconomic assessment was carried out on the factors influencing current types and severity of animal health problems, and current animal health measures. In addition, animal management and socioeconomic factors which influence herd/flock health were investigated (De Boer et al., 1983).

This survey was conducted jointly with the SR-CRSP Animal Health Project in Western and Nyanza provinces in mid-October 1980 and in late January 1981. Two sets of information were simultaneously collected from randomly selected farms in six sublocations. The two data sets were subsequently merged. Variables covering animal management, crop management, socioeconomic status and farm location are used to try and explain some simple measures of sheep and goat flock/herd health status.

The influence of measured tick loads, fresh fecal egg counts, and weight changes in farmers' sheep and goat herds/flocks are hypothesized to result from seasonal (not measured) and locational differences, the socioeconomic status of farmers and the animal husbandry practices used. Data on fecal sample strongyle/strongloides egg counts, tick populations, and average animal weight differences were collected for each sheep and goat during surveys carried out in October 1980 and January 1981. These data were subsequently averaged per herd/flock per farm and are the basic input into the multiple regression equations. These equations are used in an attempt to explain variation in the above dependent variables by using sets of independent variables through stepwise regression procedures using ordinary least squares. A large number of regression equations were estimated using combined data from each district and data delineated by district. Independent variables included many livestock management, crop management, socioeconomic, and location variables (Mortimer, 1982).

In general, the results were disappointing. Many of the relationships between variables which we hypothesized to be important (e.g., fecal egg counts and deworming incidence, tick counts and dipping) are not statistically significant. Conversely, a number of regression relationships are found to be significant although there are no *a priori* reasons for them being related. Also, some significant variables have the wrong sign from that hypothesized; K-TICKS 2 for example, positively related to the presence of farmers who dipped sheep and goats. Many reasons can be hypothesized including inadequate numbers of observations, problems in preservation of fecal samples, problems with adjusting animal weight gains to account for stages of animal growth, and sampling of animals for tick counts.

The results point to a limited number of factors which we found to be logically related to the health status of sheep and goat flocks/herds in Western Kenya. One of the dependent variables, herd/flock weight changes, is probably much more a function of nutritional conditions than health status. A few relationships between fecal egg counts and tick counts are useful for the formulation of further hypotheses that can be tested during field surveys. It should be noted that measurement problems are a major constraint to this type of work unless a very effective mobile lab is available, large numbers of fairly uniform animals are available for sampling, and farmer responses are accurate (De Boer and Mortimer, 1983).

Food Consumption Surveys

The gathering of data concerning household consumption patterns is of great importance. This data can help identify, characterize, and define consumption patterns and constraints that may be present in a segment of the population or region within a country that may be of interest to researchers,

government, and other agencies. These kinds of data may also assist in delineating certain household nutrition relationships that are needed for planning policy interventions.

The long rains data were collected in April and June 1981 while the short rains survey was conducted in October 1982. April marks the beginning of the long rains. Seasonal food shortages should begin occurring at this time. Unless the farmer planted a short rains crop the previous year to ensure sufficient food through the long rains harvest, increasing amounts of food purchases should continue until harvest time.

The household consumption survey questionnaire was administered by the enumerators in conjunction with the monthly monitoring by the Small Farm Systems Survey for the particular month involved. The respondents were asked to recall types and quantities of food consumed over the previous 7 days. They were also asked how much the food cost or, if it was their own food, to place a value on it. Selected major markets in each cluster were visited to collect a range of prices faced by farmers. From this we were able to compare the value put on certain crops by farmers with that at the markets and shopping centers. The value put on food consumed by farmers from their shambas is very close to actual market prices. This is not surprising, however, since it is these same farmers who sell produce at the markets surveyed and therefore know what prices are charged for the different commodities.

The major findings can be summarized as follows:

- A very significant amount was purchased in every cluster in every sampling. For total food, the lowest percentage was 46% in Ngiya location, Siaya district in October 1982.
- Contrary to our initial hypothesis that farmers produce most of their staple energy foods (maize, sorghum, millet, cassava) and purchase a relatively large proportion of protein foods, our figures show that proportional purchases of energy foods are similar to or higher than for protein foods. Undoubtedly, the inclusion of beverages in the total food category pushes that proportion higher.
- The Siaya district clusters consistently purchase a smaller proportion of their total food needs; generally about 20% less than those of the Kakamega households. For protein foods, the pattern is not so clear, with Siaya cluster farmers purchasing a higher proportion of protein foods during the short rains and a lower proportion during the long rains. In general, Siaya farmers produce a higher proportion of starchy staple crops (maize, sorghum, millet, cassava, bananas) than Kakamega farmers and are thus able to consume a higher proportion of total food needs from farm-produced food.
- Seasonal effects are not so pronounced as hypothesized for all foods with only 3-4% reductions in the proportion between the long rains and short rains periods. In Kakamega, there was little difference in protein food proportions between the periods but in Siaya there was a difference of almost 30 percent. This was probably due to the fact that long rains beans are harvested earlier in Siaya and were available during the June survey period in Siaya but not in Kakamega, where beans are harvested later. By October, however, the beans would have been eaten and the proportion between Kakamega and Siaya districts were similar.

These preliminary results indicate that farmers in the Small Farm Systems Survey clusters:

- do not produce all their household food requirements;
- participate regularly and actively in the market;
- regularly purchase (often on credit) milk from a variety of sources at, or close to, controlled prices; and
- purchase large proportions of staple energy foods.

Significance of Research Findings

Research to date has identified the major economic and biological constraints that small farmers will face in Kenya when they attempt to produce dual-purpose goats at economically viable levels. First, the existing cropping system provides only sporadic quantities of low-quality feed following harvest. Possibilities for introducing forage crops in direct competition with food crops do not appear bright. Farmers have a strong orientation towards self-sufficiency in food crops (Job, 1982) and preliminary model results indicated that cropping was more profitable than growing forage for goats on most of the farm size groups found in the survey areas. Simulations with silage-making showed potential promise and highlights the need to use crop residues more efficiently and to introduce forage crops in conjunction with food crops.

Model results were also highly sensitive to capital costs. Given the substantial family cash requirements and the limited cash generated from farming, the large scale introduction of an economically viable dual-purpose goat production package may face a local capital constraint (De Boer et al., 1983). The survey results pointed out that formal financial institutions were neither available nor used by the respondents and the major sources of cash were off-farm labor.

Food consumption survey results refuted the notion of the farmers being subsistence producers. Farmers entered the market for purchased food regularly, even for staple items such as maize and beans. Milk purchases were frequent enough to indicate that a potentially good local market would exist for goat milk and perhaps for goat milk products. The high demand for cash also augers well for farmers who can get established producing and selling goat milk as a source of regular cash income.

The animal health assessment was less successful in terms of being able to draw definite conclusions about the socioeconomic status of producers and its effect on the incidence of small ruminant health problems. Perhaps the hypothesized relationships simply do not exist. Health problems may be more intimately related to management factors such as daily feeding and watering practices that were not measured during the survey. Further work on tick control is underway (Reynolds et al., 1983) and an accurate

assessment of the potential benefits is now needed to complete the study.

All of the studies highlighted the strong interactions between biological and social science research which are needed to successfully develop appropriate technology for the target populations. The major thrust in the future will be cooperative research with on-farm trials, monitoring farmer reactions to dual-purpose goats, and incorporating more and better biological information into the economic models. Use of the goat simulation model will also assist in these efforts to predict more accurately the outcome of specific technologies and policies.

Implications for Future Research

Survey Research

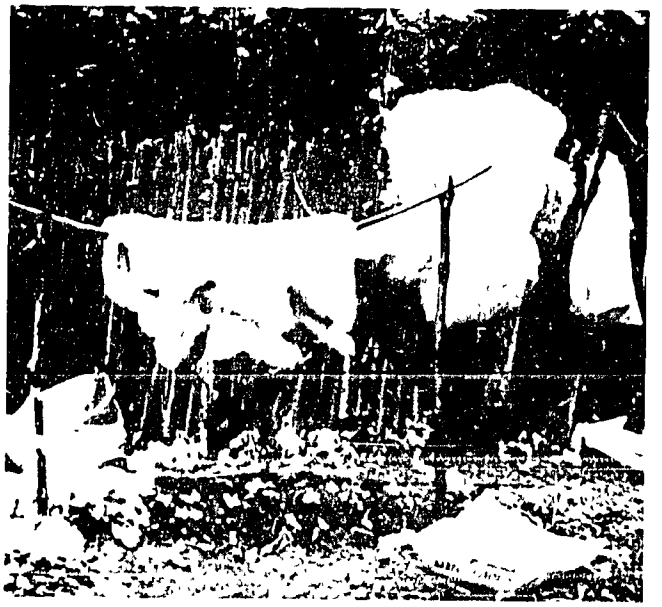
The original 80 farms included in the Small Farm Systems Survey are now being used for the on-farm trials. Regular survey work on all the farms is no longer needed. Future survey work will focus on constructing agroeconomic profiles of small-farm production systems which will allow quick and low cost identification of farms, groups of farms, or regions where the elements needed for a successful dual-purpose goat project are in place. This work, of course, requires multidisciplinary survey teams which can cover the physical, biological, and social aspects as well as the economic factors identified as critical to the profitable adoption of dual-purpose goats.

A further area of survey research will focus on prospects for marketing and sale of goat milk, goat milk products and breeding stock. While past research supports the prospect of selling small amounts of goat milk locally, any large scale adoption and multiplication of dairy goats could lead to disposal problems, particularly since Kenya Cooperative Creameries has few depots in Western Kenya and are not presently obliged to pick up goat milk.

The prices assumed for surplus crossbred kids are a weak link in the economic analysis. No regular market exists for dairy goat kids and the eventual development of a market and firm price structure will be largely dependent upon the success of the research project and the anticipated capitalized value of a lactating doe. Most small farms in Western Kenya are not familiar with dairy goats, at least not to the extent necessary to judge levels of anticipated costs, revenues and capitalized value. The initial model results have shown that prices received for surplus animals have a large impact on enterprise profits and trying to establish a potential market value for these animals will be an important research objective in the future.

An important finding of the food consumption surveys was that relatively large amounts of cash were being spent on food purchases on a regular basis.

The next step is to determine where the cash is coming from which allows these large food purchases and to assess more carefully whether goat milk can replace cow's milk within the farmer's milk purchasing patterns. Also, studies are needed on the influence of increased local goat milk availability on milk consumption patterns and the possibilities of substitution of local goat milk for other protein sources. These studies will be initiated in the near future.



Sheepskins are often processed alongside the highway in Kenya. The full wool pelt is carded to obtain the white fluffy appearance. Smaller pieces are made into hats and muffs for sale to tourists. Photo: W.C. Weir.

Whole-Farm Economic Modeling

Future research must incorporate improved sub-models for animal feed requirements, potential feed supplying activities, a biological response module, more accurate prices, and better representation of farmers' goals and objectives. With these improvements, the linear programming model will be useful in predicting farmers' likely responses to dual-purpose goat production packages. The feed component is being improved in conjunction with the Feed Resource Project experiments while goat nutritional requirements under conditions likely to prevail on these farms is being researched by the Production Systems Project. In the near future, the goat model, developed by the Systems Analysis Project, will be used to provide improved input-output coefficients for the linear programming model. This will be of particular value in forecasting the seasonal outputs of milk and kids in response to alternative feeding and management regimes. Improved information on prices and farmer objectives will be provided by the Economics and Sociology projects.

Animal Health Economics

The approach has shifted from large scale surveys to analysis of specific health practices. During 1981-1982, small scale dipping experiments were carried out and limited economic analysis conducted on the data. For 1983-1984, economic analysis of alternative internal parasite treatments will be conducted. The current approach will focus on

specific health problems encountered by dual-purpose goats at Maseno and on the cooperating farms and joint research projects will focus on low-cost management and therapeutic control measures.

Training

A major project goal is training Kenyan staff in the economic analysis of animal production systems and in research procedures being used in the dual-purpose goat project. This goal has not yet been attained because of a shortage of qualified Kenyan staff who could have been assigned to the project. A promising candidate, Mr. James Njukia, was identified at Texas A&M University but when he failed to complete PhD preliminary exams, withdrew from consideration as a Co-PI. In October 1983, a fully qualified Co-PI was hired by the MLD and assigned to Maseno. If the program continues beyond October 1984, this individual would receive further advanced training in addition to the on-the-job training now being received.

Two advanced degrees were received by Morgan Job and Dana Mortimer from research work in Western Kenya. Non-degree training included Mr. James Njukia at Texas A&M University from January-June 1981, participation by De Boer and Matthewman in the 1982 Workshop at Kabete, De Boer and Nyaribo at the 1983 Workshop in Naivasha and on-the-job training by De Boer during May-July 1983.

Selected Publications

De Boer, A.J. and D.L. Mortimer. 1983. Some Relationships Between Farm Characteristics and Herd/Flock Indicators on a Sample of Farms in Western Kenya. Paper Presented to Small Ruminant Technical Mtg., National Animal Husbandry Research Station, Naivasha, Kenya.

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Sands, M.W., H.A. Fitzhugh, R.E. McDowell, and S. Chema. 1982. Mixed Crop-Animal Systems on Small Farms in Western Kenya. SR-CRSP Technical Report Series No. 17.

Dual-Purpose Goat Production Systems For Smallholder Agriculturalists

H.A. Fitzhugh
Winrock International

The overall goal of the Production Systems Project in Kenya is to develop and adapt goat production systems to the needs of smallholder agriculturalists in the humid/sub-humid tropics, emphasizing dual-purpose utilization of goats for milk and meat production.

SR-CRSP activities in Kenya follow the approach generally known as farming systems research (FSR). FSR includes three successive phases:

- Characterize target farming systems, including identification of resources and constraints.
- Design interventions and alternative systems based on analysis of traditional systems, results of component research, and experience of researchers and farmers.
- Test interventions and alternative technology packages, involving both on-station and on-farm research as dictated by requirements of experimental protocol.

Even though these phases are separate activities, they may overlap in time; e.g., designing and testing start before characterization is fully accomplished. This overlap is generally time and cost effective in terms of accomplishing research goals. Some types of research require the controlled experimental environment of the research station; but, acceptability of alternative systems can only be evaluated in the real world production environment by using actual farm resources including labor and management.

The Production Systems Project fills a central role in this FSR approach. First, the Project was responsible for coordinating the Small Farm Systems Survey, a joint activity of the Economics, Sociology, and Production Systems projects designed to accomplish the "characterization" phase. The survey also identified three areas of priority research not addressed by other SR-CRSP projects in Kenya. These were:

- Nutrition and management of dual-purpose goats
- Utilization and acceptability of goat milk products
- Production of adequate feed from a limited resource base on small farms

Research in these areas, essential to the development of dual-purpose goat production systems, was undertaken by the Production Systems Project.

Notwithstanding the research on component or disciplinary type problems, the major responsibility of the Production Systems Project is integration of research results

from the SR-CRSP and other sources in the design of interventions and alternative technology packages and the careful testing of these packages to ensure they meet farmers' needs. Because the critical test of new technologies must be on-farm under the management of farmers, on-farm research has priority for Production Systems activities in the final stage of SR-CRSP activity in Kenya. In the interim, research on goat nutrition-management and feed production problems is being conducted both under the relatively controlled environment of an experiment station and on cooperator farms.

An example of current on-farm research is the case studies of crossbred lactating does placed on small farms in Nyanza and Western Provinces. These studies have identified major researchable problems and provided benchmark data for evaluating the impact of future interventions. Experiment station activities include evaluation of feed and food yields from traditional and modified cropping systems; nutritional and management requirements of dual-purpose goats; comparison of dual-purpose ruminants under zero-grazing utilizing typical small farm feed resources; evaluation of management practices and facilities for feed preservation and storage; construction of animal housing; processing, preservation, hygiene and handling of milk.

As results from this and other SR-CRSP projects become available (e.g., adapted dairy goats, herd health programs, feed resources, management strategies), they are integrated into production systems and tested on small farms in the region. Testing is coordinated with other SR-CRSP biological and socioeconomic projects.

Research is planned and conducted in close collaboration with SR-CRSP personnel, scientists from the Ministry of Livestock Development (MLD) and other participating institutions. Emphasis is placed on training students through their participation in the research program and through financial support for advanced study in Kenya or elsewhere.

Principal output will be technically and economically feasible dual-purpose goat production systems suitable for small-scale farms in high-potential tropics. An additional output will be trained personnel capable of improving and extending these systems.

Research Accomplishments

Research activities began in Kenya in mid-1980 with the Small Farm Systems Survey designed to characterize prevailing small farm systems and identify research priorities for establishing a dual-purpose goat component in these systems. In 1981, research activities on goat nutrition-management began and the Production Systems Project was assigned responsibility for research on feed production under small farm conditions. In 1982, research was initiated on the processing of goat milk products and evaluating consumer acceptability to these products. Results from these research activities are summarized in the following sections.

An SR-CRSP scientist supervising planting of experimental feed crops at Maseno Station, Western Kenya. Photo: H.A. Fitzhugh.

Characterization of Small Farm Systems

The Small Farm Systems Survey was a collaborative research activity of the Sociology, Economics, and Production Systems projects. Coordination of the survey was the responsibility of the Production Systems Project as was the evaluation of the biological components of the farming system. Analysis of the sociology and economic components was performed by the Sociology and Economic projects, respectively. Results from this survey have been instrumental in the design of research activities by all projects collaborating in the Kenya program.

The problem of increasing income, food production, and risk minimization on small farms can best be approached by understanding the existing farming system. This implies knowledge of the farm resource base, interactions among components of systems, constraints to production, and farmers' objectives. This understanding can then be used to design interventions to the system that can be carefully tested on farms to ensure suitability to farmers' needs. The Small Farm Systems Survey was designed to provide this understanding of farming systems and to influence design of interventions.

The farming systems of interest are located in the Lake Victoria Basin of Western Kenya. As these systems share general characteristics in common with other crop-animal systems in the humid tropics of Central Africa, this research has potential for broader application.

The survey was conducted from October 1980 to December 1982 on 40 farms in Kakamega district of Western Province and 40 farms in Siaya district of Nyanza Province. Farms were visited at least once monthly by enumerators native to the local area and fluent in the local language.

Details of survey procedure were presented by Sands et al. (1982e) and Job (1982).

As an aid to grasping the various interactions among components of the farming systems, schematic models are used. Figures 1 and 2 are schematic representations of "typical" small farms in Western Kenya. Boxes labeled "Market" represent off-farm activities involving purchased inputs (except land), such as supplies, animals, and household items, and products and labor sold off the farm. Commodities stored on the farm are represented by tank symbols. Crop and livestock subsystems are represented by rectangles. The "Household" is the core of the family farm. Labor use, human food, and animal feed are identified as are interactions between the crop and livestock subsystems. Solid lines (——) depict strong flows while broken lines (.....) indicate intermittent or weak interchanges.

Typical Kakamega Farm. The "typical" small farm in Kakamega district (Figure 1) had 0.98 ha of land worked by 2.05 workers and supported 5.90 dependents. The female was head of household on 58% of the farms because the male had left to work in the urban areas.

The major crop was maize/beans intercropped on 0.41 ha during the long rains (March-August). Minor crops included maize, sorghum, bananas, sweet potatoes and vegetables planted on 0.3 ha. Improved maize seed was purchased for the long rains. Improved seed as well as native varieties, was used during the short rains (September-December). Native varieties were used for planting materials for other crops. Most labor for the maize/beans intercrop (71 days) came from the available household supply (642 days) which was also used for tending minor crops and household activities such as fetching water, collecting firewood and cooking.

The majority of harvested maize (843 kg) was consumed on the farm as ugali, a maize meal mush. Relishes included: sukuma wiki (kale), wild vegetables, and fish or meat. Harvested beans (382 kg) were eaten and sold in the market. Half of the families had one or two cows and one sheep, and most had 7 to 10 chickens. When cows were milked, a small

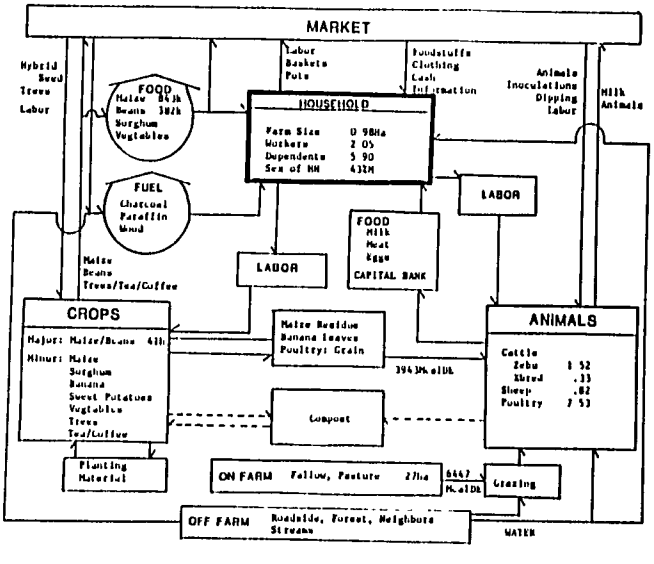


Figure 1. Model of a Kakamega small farm (long rains 81).

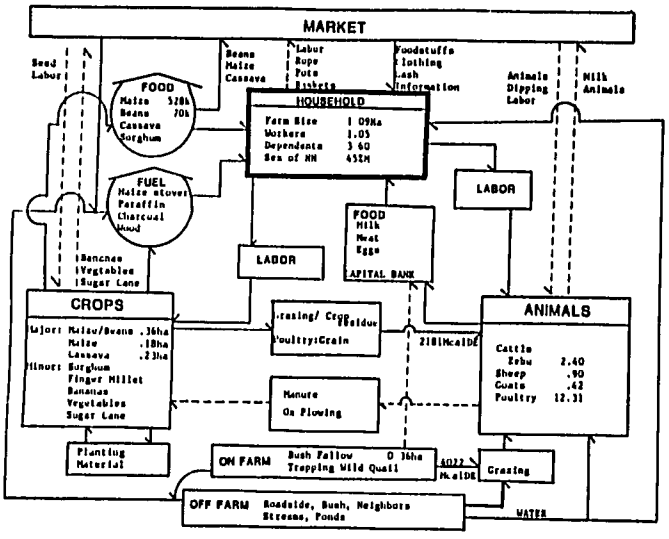


Figure 2. Model of a Siaya small farm (long rains 81).

proportion (20-30%) of milk was sold and the rest consumed on the farm, primarily with tea. No milk was processed as cheese; some was soured. Calves and lambs were usually sold and served as a major source of income to pay school fees, purchase clothing, and other items. Most eggs were allowed to hatch, though two to three were sold or eaten per week. Chickens were sold when cash was required. The visit of a relative or important neighbor usually warranted slaughter of a chicken.

Interactions between crop and animal components were not particularly strong. The most important direct interaction was feeding crop residue to livestock. Maize stover and thinnings provided about 3,943 Mcal of DE available for livestock consumption. Banana leaves were also fed. Spoiled maize grain was occasionally fed to poultry.

Grazing on unimproved land provided the majority of energy and protein for the ruminants. On-farm noncropped land provided approximately 6,447 Mcal DE annually. Off-farm grazing along roadsides and other common land was used extensively. Forage quality could be quite high at certain times of the year. Grasses such as *Cynodon dactylon* and *Digitaria scalarum* retained high levels of protein and digestibility when grazed frequently. In addition, local legumes (*Glycine weightii, Trifolium* ssp.) were found in many heavily grazed areas.

Manure was not utilized in a systematic fashion, but composted household scraps, manure, and crop residues were used by some farmers on their long-rains hybrid maize. Oxen plowing was usually not utilized in this area of Kakamega district because of small plot sizes. Most cultivation was thus accomplished by human labor.

The principal constraints to crop production are water availability and soil fertility. Though total rainfall is generally adequate, yields would probably benefit from improved timeliness of planting and weeding. Also, hybrid maize would respond to nutrient additions (manure, purchased fertilizers) to the humic nitosols in the area. Anthracnose was an important constraint to crop production in Kakamega.

The principal constraint to livestock productivity was inadequate and inconsistent nutrition. Because of small farm size, devoting crop land to forage crops is not a viable option, and increased forage production will depend on changing the cropping system. Residue yields should increase with crop productivity. Cover crops or relay planting a forage source after harvest of beans and maize are options.

Typical Siaya Farm. The Siaya small farm, modeled in Figure 2, has 1.09 ha; the family has 1.05 workers and 3.60 dependents. Because of outmigration of males in search of wage employment, 55% of the farms were managed by a female head of household. The main crops were maize/beans intercropped (0.36 ha), maize alone (0.18 ha) and cassava (0.23 ha). Minor crops include sorghum, finger millet, sweet potatoes, bananas and vegetables. Local varieties were used for all crops. Labor required for the maize/beans intercrop (86 days) and other crops was drawn from the pool of family labor (328 days), which is divided between farming and household activities such as fetching water from streams, collecting firewood and cooking.

The maize harvested (528 kg) was primarily consumed on the farm, and supplemented by purchased maize, cassava, and sorghum. Harvested beans (70 kg) were consumed and sold in the local market.

The typical farm had 2 to 3 cows, and several sheep and goats. Milk was consumed on the farm primarily in tea. Calves, kids, and lambs were usually sold to meet major cash needs. Family labor, usually a male child or older male, was used to herd the livestock 7 to 8 hours per day. Livestock require little labor because feed is rarely cut and carried to them. Poultry included native chickens (10-15 birds) and ducks. Eggs were usually hatched and rarely eaten or sold. Birds were sold when cash was required. An important visitor was often occasion for slaughter of a chicken. Poultry meat was supplemented by trapping wild quail on fallow bush land.

Interactions between crop and livestock components were limited. Some crop residues were grazed after grain harvest. Although approximately 2,081 Mcal of DE was potentially available from maize residues, the actual amount consumed by livestock was probably much less due to trampling and the use of stalks for fuel. Farmers rarely allowed livestock to graze cassava leaves because of potential toxic effects. Grazing on unimproved land provided the vast majority of feed, with on-farm grazing land providing approximately 4,022 Mcal DE. Off-farm grazing provided a minimum of 15% and probably more than 35% of the maintenance requirements plus nutrient costs for production. The primary grasses are poor quality *Cymbopogon* ssp. and *Brachiaria* ssp. growing under bushes *(Lantana camara, Albizia coriana,* and *Markhamia platycalyx).* Manure was not systematically utilized as fertilizer; however, some manure from the night boma may be used when planting maize.

Potential intensification of the system is primarily dependent on increasing the present low yields of maize per hectare (900-1,050 kg). Water availability is probably the major limiting factor. More timely planting and weeding are important in order to take advantage of the water that is available. More use of manure and purchased fertilizer would increase nutrient availability. The parasitic weed, *Striga hermontheca,* is a major problem in maize and sorghum, and is best controlled by rotation of maize and sorghum with resistant crops (e.g. cassava, millet, or forages). Ox plowing (usually hired teams of 6 oxen) is sometimes used to prepare larger plots.

Improving crop productivity should increase residue yields. These increases should make feasible the collection and storage of residues for later use. Increased use of higher quality forages would require additional management to discourage poor quality forages such as Lantana and Cymbopogon. Relay cropping of forages into old cassava stands or fallow maize fields may provide animal feed.

Economic Factors

Farm Labor. Tables 1 and 2 show the disposition of labor to tasks according to age and sex. Except for the higher participation rates of those over 40 in Siaya, the profiles are similar. The following comments refer to the Siaya sample.

Table 1. Labor Input Profiles, Siaya District (% Participation by Tasks)

	Age Group and Sex[a]								
	Under 15		15-40		Over 40		Adult Female	Adult Male	Female All Ages
Operation	M	F	M	F	M	F	%	%	%
Digging	7.9	0.7	20.9	24.4	14.3	32.3	56.7	34.3	57.4
Planting	7.4	3.7	12.1	35.5	14.0	27.0	62.5	26.1	66.2
Weeding	7.9	3.6	7.3	32.3	16.4	32.3	64.6	23.7	68.2
Harvest Maize	10.6	4.2	3.1	42.5	12.7	26.5	69.0	15.8	71.2
Harvest Beans	0	0	3.2	41.9	12.9	14.9	83.8	16.1	83.8

[a]M = Male
F = Female

Table 2. Labor Input Profiles, Kakamega District, Hamisi Area (% Participation by Tasks)

	Age Group and Sex[a]								
	Under 15		15-40		Over 40		Adult Female	Adult Male	Female All Ages
Operation	M	F	M	F	M	F	%	%	%
Digging	2	4	27	25	7	33	58	34	62
Planting	6	6	23	27	8	27	54	31	60
Weeding	6.7	5.5	27	28.3	6	25.9	54.2	33	59.7
Harvest Maize	8.9	6.7	24.7	25.2	5.6	28.6	53.8	30.3	60.5
Harvest Beans	3.5	8.3	15.4	38	3.5	30.9	68.9	18.9	77.2

[a]M = Male
F = Female

There is no appreciable difference between the participation of adult males and females in land preparation operations. Twenty percent of all workers doing land preparation were adult males. The corresponding number for females is 24%. Children comprised only 14% of the labor doing this operation, a substantially larger proportion than the 6% figure recorded for Kakamega. In the oldest age group, which supplied as much labor as those aged 16-40 years, there were twice as many females as males engaged in land preparation. This predominance of labor from women over 40 is observed for other tasks in the crop cycle. The labor allocation for planting maize and beans is similar to that for land preparation in both areas. There was, however, slightly less adult male participation in this operation in both areas. Weeding in Siaya is very much a woman's job. Only 7% of the weeding was done by adult males between the ages of 16 and 40. In Kakamega, 6% of the work force weeding comes from males over 40 years old. Few males take part in crop harvesting in the Siaya area. In the Kakamega area, males are involved in harvesting in about the same proportion as for other operations in the production cycle.

Farm Finances. The survey indicated that off-farm income is a very important source of revenue for many farms. In Kakamega, 18 persons from 13 households were reported as working more than 30 days off the farm. Six of these were migrant husbands who were long-time Nairobi residents. In Siaya, 19 persons on 11 farms were working more than 30 days off the farm. About the same number in Kakamega were involved in trading.

Cash expenditures included food, clothing, school fees, school building funds, Harambee projects (community fundraising activities), and other services. As approximate figures, annual cash expenditures on survey farms for a household with two children in primary school would be:

Food Purchases	48
Clothing	75
Primary School Fees	14
School Building Fund	12
Harambee Projects	5
Other Services	6
	US $160

Few, if any purchased inputs were used in agriculture. Agricultural assets are small, consisting of hand tools and other implements with total values of $10-$20.

Sociological Factors

The sociological portion of the survey showed that a considerable number of husbands, especially in Kakamega (17.5%), were employed off-farm and the families had a heavy dependence on females for farm labor (60-70%). The attitudes of the head of households varied considerably from one sample area to the other. The farmers in both areas were skeptical about planning for the future expecially those in Siaya who were also more kinship-oriented and distrustful of outsiders. Kakamegians, in contrast, were more trusting of strangers and willing to work with nonrelatives.

Slightly less than one-half of the farmers in both communities were willing to change their farming practices. More saw changes as benefiting large farmers rather than small ones. The farmers liked new crop varieties. They trusted government extension agents. Kakamega farmers were more likely to take risks by using credit. In both areas, the preferred way of increasing income was through increased crop production. The least preferred of listed options was to increase efforts in goat production. The farmers in the survey had little contact with mass media of any type.

Conclusions

The comprehensive description provided by this study of the farming systems of Boro Division in Siaya district and Hamisi Division in Kakamega district led to several broad conclusions:

- The overall productivity of the smallholder farming system was low. Maize yields ranged from 900-2,300 kg/ha while bean yields were between 200-1,000 kg/ha. Similarly, livestock productivity—milk production, reproductive rates and growth rates—were low.
- The principal constraints to increased crop productivity are:

  Water availability at critical periods in maize growth, and timeliness of planting and weeding.

  The parasitic weed, *Striga hermontheca,* and termite damage, which reduce grain yields.

  Cost and restricted availability of inputs (fertilizer and pesticides).

  Lack of readily available improved genotypes for crops other than maize and sorghum.

  Government restrictions on marketing of maize and beans which act as disincentives to purchase inputs needed to increase production much above subsistence requirements.
- Principal constraints to increasing animal production on smallholder farms in Western Kenya include:

  Insufficient amounts of adequate quality feed on a year-round basis. On small farms the demand for food crops takes priority over production of feed for livestock. Strategies are needed to meet nutrient requirements from food crop residue and forages without decreasing food production. Preservation of seasonal surpluses for use in subsequent dry seasons is also needed.

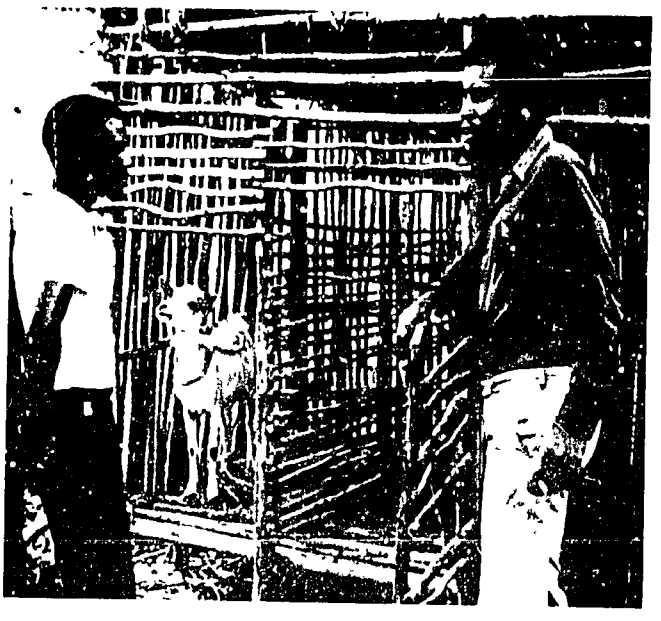
  Health problems primarily caused from tick-borne diseases (*Theileria* spp., *Babesia* spp., *Rickettsia,* anaplasmosis and Nairobi sheep disease) and internal parasites. At lower altitudes near surveyed locations, trypanosomiasis is a problem. Tick control (dipping or spraying) and selective drenching are not commonly practiced because of cost and lack of assistance or instruction in procedures.

  Insufficient milk production of most cattle or goats to meet needs of young stock with a surplus for human consumption. Improved cattle genotypes are available in limited numbers but improved goat genotypes are essentially unavailable to the smallholder.

  Management constraints that include the need for practices allowing animals longer daily access to grazing or harvested feeds, particularly at cooler times of the day (i.e., dawn and dusk). Dairy animals require more frequent access to water.

  Socioeconomic constraints principally related to the role of livestock. Livestock function primarily as a means of capital storage and only secondarily as units of production. Producer priorities are therefore geared towards keeping more animals rather than increasing productivity. Interventions to increase productivity must not appreciably increase the risk of the animal dying or being stolen. Acceptance of small ruminants may be constrained by traditional preference for owning cattle.

  Lack of status associated with keeping goats. In order to remain healthy and produce to potential, dual-purpose goats definitely require better management than the native meat goats, which largely serve as scavengers. Living conditions on small farms are generally poor for people and animals alike, and health care is rudimentary. Water often must be carried long distances. Improving production and health management will entail changing farmers' attitudes toward goats and convincing them that returns of milk and income will justify their labor investments. Management interventions must necessarily be low cost and suited to farmers' capabilities.



Enumerator Peter Amuhinda and Research Officer Salim discussing the goat loan program at a farm in the Kakamega district of Western Kenya. The goat is the offspring of a "loaner" goat in last year's trial. Photo: W.C. Weir.

In comparing all of the favorable factors and constraints toward expanding goat production, the report concluded that the constraints were greater than the favorable factors in the surveyed areas. This does not imply that the task of introducing new farming practices concerning goats is impossible. It does suggest that it will be much more difficult to introduce a dual-purpose goat than to introduce a new maize variety. It also suggests some areas will more readily accept new technology than others. The introduction of a dual-purpose goat will require the introduction of several innovations at the same time: feeding and breeding practices, care of milk, animal health practices, etc. Since this package

is much more complex than simply changing a variety or any other single practice, great care should be taken in developing the innovation program including both research and extension. Any new practice must be carefully tested and adjusted to the many microecological conditions in the area.

Implications for Future Research

The characterization of small farm systems has been instrumental in the design of research to be conducted by the SR-CRSP in Kenya. Results will also provide a baseline against which future interventions will be measured.

Future research will include evaluation of the extent to which the 80 farms which have been closely monitored are representative of farms in Western Kenya. This work will involve rapid appraisal of key indicator data for a broader cross section of farms.

The on-farm evaluation of specific interventions and technology packages will build on the experience gained working with farmers during the survey. Some of the farms in the survey are already involved in the early phases of the on-farm research.

Goat Nutrition-Management Research

Research has been limited by availability of suitable goats, experimental facilities and technicians. Efforts to relieve these limitations have included: accumulation of a herd of crossbred does, (predominantly Toggenburg x East African but generally of uncertain percentage Toggenburg) which have been mated to Toggenburg bucks; construction of a barn with provision for individual feeding and digestion trials; rehabilitation of an existing MLD laboratory for analysis of feed and milk samples; and training MLD counterpart staff in conducting research. By April 1983, these efforts had been largely accomplished.

Rather than delay all research during this development period, experiments suitable to the available resources were conducted. These included:

- Feeding trials with preweaning kids and lactating does using rations based on locally available foodstuffs.
- Control of external parasites (primarily ticks) on small farms.
- Comparison of techniques for ensiling and drying small batches of forage.
- Evaluation of performance of crossbred goats placed on small farms.

The design of these experiments left much to be desired. Because most of this work was conducted on "live" farms, clear-cut tests of hypotheses were often not possible. However, the information garnered from these experiences has been invaluable in defining future research needs and developing an understanding of the nutrition-management problems and potential for dual-purpose goats on small farms. Two examples of experimental results illustrate the value of these efforts.

On-Farm Evaluation of Dual-Purpose Goats. Survey results indicated that goats are generally not milked in this region of Kenya. In order to identify the problems, constraints and resource requirements of a dual-purpose goat component, crossbred (Toggenburg x East African) does have been placed on small farms. The cooperating farmers have been instructed in goat management and hygenic milk processing. Lactation traits, labor requirements, health problems, weight change, feed offered and offals, and use of milk were observed (Table 3).

Numbers of goats available for distribution were limited. Ten does, each with one male kid, were placed in April 1982. The intent was to manage these arrivals in a zero grazing regime; however, 6 of the 10 goats were actually tethered or herded for grazing during part of the production year. An additional fifty goats were placed on farms in March-May 1983.

The most common feeds offered goats were maize thinnings, leaves and stover (100% of farms); sweet potato vines (90%); napier grass (80%); native grasses, legumes, weeds (80%); and banana leaves (40%). Estimates of daily energy and protein intakes were approximately 24% below calculated requirements for lactating does and growing kids.

Three does died: two from severe mastitis infection and one was poisoned by neighbors. Another doe would have probably died from severe internal parasitism if it had not been removed from the farm and treated. Four kids died; all suffered from internal parasites and apparent malnutrition. The need for veterinary backup, vividly demonstrated by these results, has since been addressed.

Table 3. Observations on Ten Does Placed on Small Farms in 1982

Item	Range	$\bar{X}$	SD
Milk yield, kg	62 to 292	140	67
Days lactating	87 to 242	145	46
Doe weight after parturition, kg	25 to 44	32	5
Weight change in 150 days after parturition	-10.5 to 3.5	-3.2	4.6
Kidding date	5 March to 9 April	28 March	—
Rebreeding date[a]	28 Sept. to 2 Dec.	1 Nov.	—

[a]Does were continually exposed to bucks after 16 September, 1982.

Reported daily labor inputs to management of goats ranged from .6 to 4 hours per head, primarily by male family members. These estimates were probably biased upwards by the inability to distinguish between labor required for goats vs. total labor for all livestock. Nevertheless, the additional labor for cutting and carrying feed was the probable reason for most farmers abandoning the zero grazing system, especially after milk yields began to decline. There was a tendency for farmers to insist that goats eat all or most of feed carried to them before more feed was brought. Because zero grazing was not popular and also failed to utilize the inherent selectivity of free grazing goats, this management system is not being recommended for the second placement.

The five most common uses of milk reported by farmers were boiling with tea (100%), cooking with vegetables (60%), consumed fresh by children (50%), cooking with maize meal (20%), and soured before consumption (20%).

Milk Requirements for Rearing Kids. While milk is needed for human use, kids also need milk for adequate development. Kids which die and those which get a poor start in life reduce potential income from sale of slaughter stock and reduce value of herd replacements. Milk replacers and high concentrate rations for kids are not feasible. Thus, the challenge in dual-purpose systems is to wean healthy kids on minimal milk.

Milk requirements to weaning were measured in two trials (Table 4). In the first trial, all kids were weaned at 60 days, in the second, kids were weaned when they weighed 10 kg. Sweet potato vines, cut grass and maize leaves were available free choice. Kids weaned at 10 kg were approximately 3 weeks older and consumed 44% more milk but also had a lower incidence of morbidity (8% vs. 56%) and mortality (0% vs. 18%) than kids weaned at 2 months.

Table 4. Means and Standard Errors for Milk Consumption, Weight and Age of Kids Weaned at Constant Age or Constant Weight

Item	Trial 1	Trial 2
Number[a]	16	12
Milk, kg	39.4 ± 5.3	56.5 ± 3.6
Weight, kg	8.0 ± .6	10.0
Age, days	60	80 ± 5.0

[a]Equal number of male and female kids in each trial.

Given the average lactation yield of 145 kg from the ten crossbred does, milk requirements for rearing twins (50 to 60 kg each) would leave little milk for human consumption. Also, does would have to average nearly 2 kg of milk per day during the first 2 to 3 months of lactation to provide the preweaning requirements of twins. Thus, the slope of lactation curve and persistency must be considered in research to improve the genetic potential for lactation and to develop nutrition-management practices to attain this potential for dual-purpose goat production systems.

A principal thrust of future research in this topic will be to develop nutritional strategies to supply the requirements of growing kids, replacements and lactating does. These strategies will involve supplementation of forages (primarily crop residues, thinnings, and ratooned crops) with energy-protein concentrates during critical stages of the production cycle, such as kids to improve postweaning growth rate, and lactating does to improve postparturient fertility. The particular need is to match available feed resources through the year with the requirements of goats to provide for year-round breeding, and lactation so that at least small amounts of milk will be continuously available for family use.

Research to develop herd health management strategies will be conducted with the Health Project to reduce the drain of parasites and disease. The often prohibitive cost of prophylaxis and therapy and the shortage of health specialists to serve farmers requires that these strategies be low cost and simple. Brucellosis and tuberculosis are particular concerns because of the potential human health hazard; continuing monitoring for these diseases is therefore indicated. If they should become a problem, research with vaccinations and herd management will be needed. Research is planned in collaboration with the Health and Breeding projects to evaluate the relative importance of acquired and/or genetic immunity to local diseases and parasites of indigenous breeds vs. introduced dairy goats or crosses.

Processing and Acceptance of Goat Milk Products

Although goat milk is consumed by pastoralists in other parts of Kenya, the survey revealed no consumption of goat milk by families in the survey region and some hesitancy to try the milk. Reasons for this hesitancy were only vaguely stated. However, there have been taboos in the region against consumption of goat meat and milk by women, previous disease outbreaks such as brucellosis may have been linked with goat milk consumption, and goat milk can have a distinctive smell and flavor. Fresh milk has excellent nutritional value for humans but also serves as an excellent medium for disease organisms.

Poor acceptance, disease risk and failure to preserve goat milk products posed major constraints to achieving project goals. Research on these aspects of the system included determining current sources of milk (primarily bovine), evaluating processing and preserving methodologies, applying these methodologies to goat milk, and conducting taste tests to compare acceptability of cow and goat milk products.

Summarizing the results of this research:

- Goat milk—fresh or soured—was readily accepted in a series of tests using school children and members of farm families of different age and sex. These tests involved over 390 persons. Comparisons between goat and cow milk products showed no difference in average acceptance.
- Milk is commonly boiled in tea, cooked with food and/or soured; thereby minimizing health hazards to consumers.

- Quantities of milk currently or potentially available from dual-purpose goats are limited and generally consumed on the day of milking so longer-term preservation (e.g., cheese) or larger quantities for later use is not an immediate priority for research.

Feed Production Research

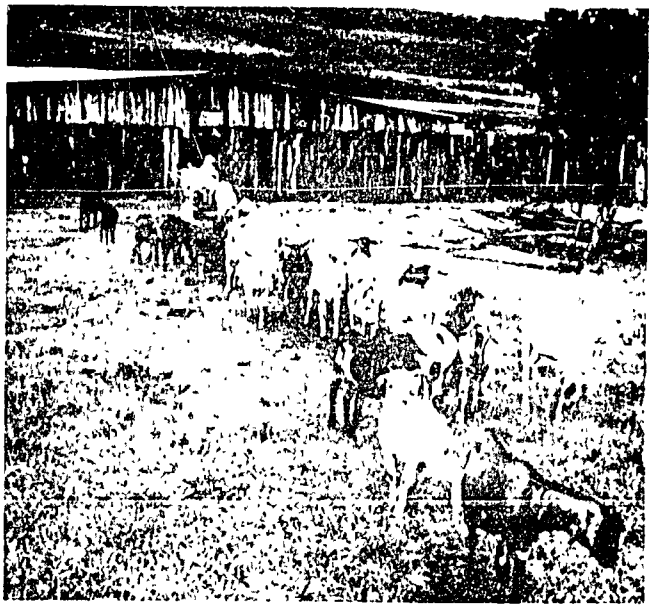
A principal constraint to improved livestock performance is the amount of feed produced from the limited land area available on small-scale farms which emphasize food and cash crop production. Arable land is in such short supply that very little, if any, can be devoted to continuous pasture for livestock. At present, farmers are providing feed for their livestock from crop residues, small fallow areas or uncropped areas on the farm, and off-farm grazing.

The goal of the feed production research is to identify feed production options that can be integrated into a dual-purpose goat production system. These feed resource options must provide sufficient quantity and quality of feed at the appropriate times during the production cycle so that the dual-purpose goat component can efficiently produce meat and milk with the least change to existing farm systems and at minimal opportunity cost.

Interventions to increase feed from existing cropping systems which have been evaluated include planting at higher than optimum densities to allow thinning; stripping, topping and ratooning; and intercropping and relay cropping forage crops in the food cropping system. Interventions to increase feed from existing noncropped areas include traditional cut-and-carry forage grasses such as Napier *(Penisetum purpureum),* and grazing legumes, such as leucaena; and nontraditional cut-and-carry crops, such as pigeon pea. Interventions to increase feed from off-farm grazing areas include evaluation of native legumes found in communal grazing areas and testing of introduced legumes such as stylosanthes.

The most important research results have been identification of feed production strategies with highest potential for meeting needs of an integrated dual-purpose goat production system. As these strategies have been identified, research has focused on testing specific feed-increasing interventions.

Preliminary results from the analysis of different strategies to increase feed from existing cropping systems suggest that intercropping sorghum at planting of maize, cutting the sorghum 4-6 weeks later and allowing sorghum to ratoon is a feed increasing strategy with high potential. High quality feed is produced at the first cutting (up to 1.0 MT/ha) and the stover from the regrowth can be combined with maize stover. Maize grain yields are not reduced. Intercropping and relay cropping pigeon pea within maize-based cropping patterns has also been identified as a strategy with potential to produce high quality feed (up to 28% crude protein) and help meet the feed requirements of goats during the dry season. Figure 3 summarizes the process followed in the analysis of cropping systems as a feed resource.



Galla, East African and Toggenburg cross does leaving the dairy barn after the morning milking at Ol Magogo for grazing in hill pastures. Photo: T.C. Cartwright.

Preliminary results from the analysis of cut-and-carry crops suggest that the future research emphasis should be on high quality legumes rather than on grasses. Experimental results using pigeon pea as a fence-row crop show that it can be pruned at different intervals and continue to produce a high quantity of feed. The facts that farmers can produce their own seed and that complicated seed treatment or seedling establishment is not required (as in the case of leucaena), suggest that pigeon pea has good potential as a cut-and-carry forage crop for small farms in Western Kenya.

Only limited research progress has been made in identifying feed increasing strategies for communal grazing areas. Biological questions such as identifying forage legumes are less difficult than social questions related to community management of these areas. With future emphasis on on-farm trials and farmer participation in the research process, these questions will be addressed and better guidelines for biological research in this area will become available.

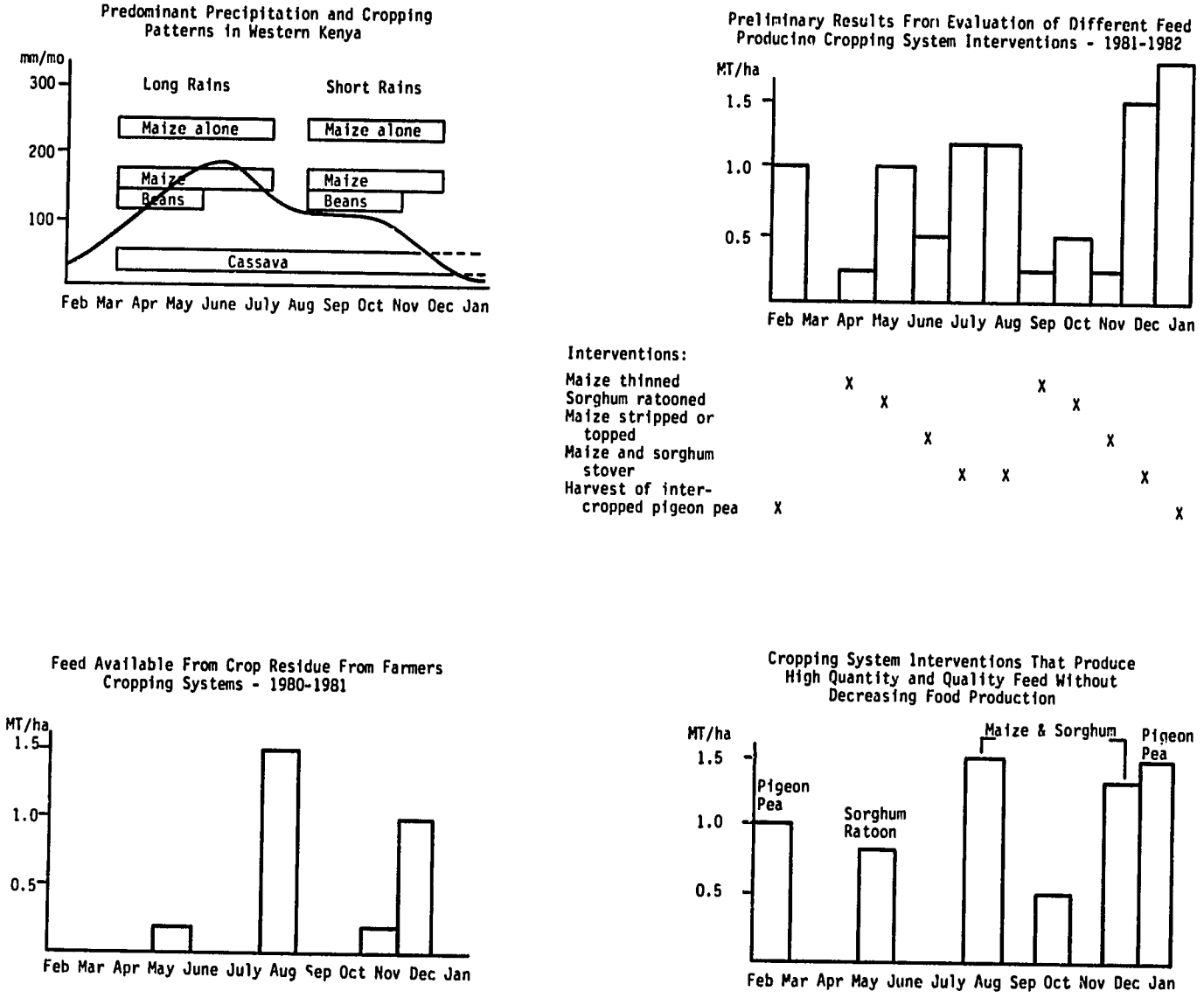


Figure 3. General research strategy followed by Feed Resources Project in the analysis and identification of feed resource interventions to increase feed from cropped areas.

Significance of Research Findings

The survey identified major biological and socioeconomic constraints to the successful introduction of dual-purpose goats to small farms in Western Kenya and, thereby, established priorities for research.

Observations on crossbred goats placed on small farms and experience with rearing kids and lactating does on station have helped in the development of a phenotypic profile of a successful dual-purpose goat. This profile is important to the Breeding and Health projects as well as the Feed Production and Nutrition-Management projects. Important characteristics include:

- Adaptation to disease-parasite and poor nutrition conditions. Farmers are not likely to purchase health products or nutritional supplements, so hardy goats which are productive under prevailing conditions are needed.
- Available feed resources will not support high daily milk yields common for dairy genotypes under temperate conditions. However, does should have genotypes to produce at least 3 kg/day during the first 2.5 months of lactation in order to provide milk for rearing twins, as well as human consumption. Optimizing daily milk yields and length of lactation may be expedited by using computer simulation models from the Systems Analysis Project.
- Does which tend to become anestrous or abort under nutritional stress will have markedly reduced productivity. The degree to which these tendencies are genetically controlled is not well-known but these traits should be considered when developing dual-purpose lines.

The true significance of the early results from production systems research will become apparent only through evaluation of proposed technologies and management interventions on small farms. Acceptance by farmers will

depend on the benefits their perceive relative to costs in terms of additional capital, labor, risk or just general aggravation of dealing with goats. Socioeconomic, perhaps more so than biological factors, will ultimately determine if dual-purpose goat systems are generally accepted by farmers in Western Kenya. However, even if the dual-purpose goat production systems prove unsuccessful, research will provide important new knowledge and the basis for strategies as well as improved genotypes. The need for a low cost source of protein supplement in the diet of poor farm families in the tropics is a very general one, as is the need for a high value, readily marketed source of income like the slaughter goat. Thus, the research in Western Kenya has value wherever people are trying to produce both income and a balanced diet from the limited resources of small farms in tropical developing countries.

Training

The goals of the training program comprise development of technical and scientific personnel qualified in multidisciplinary research relevant to developing countries, and successful extension of dual-purpose goat production systems through training producers. The goals have been pursued through degree training, specialized shortcourses and on-the-job training.

Graduate Training

- James Kibuchi was supported for his MS program in Animal Science at Tuskegee Institute (1981-1982). His thesis research involved feeding sweet potato meal to lactating goats. Mr. Kibuchi returned to Kenya to enter the employment of the MLD.
- Ephraim Mukisira, an MLD employee, is being supported for his MS in Ruminant Nutrition at Louisiana State University (September 1982-August 1984). His research will emphasize analysis of nutrient value of forages for ruminants.
- Moses Mathuva, an MLD employee, is being supported for his MSc in Tropical Animal Production at the University of Reading (September 1982-December 1983). His research will involve nutrient requirements of small ruminants.
- Michael Sands was supported to conduct research in Kenya towards his PhD in Animal Science at Cornell University. Dr. Sands coordinated activities of the Small Farm Systems Survey, a major SR-CRSP research activity in Kenya. He is currently employed by Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE) on a small ruminants research project in Panama.

Training Courses in Kenya

- Dr. Sands conducted a training course on field survey techniques for enumerators and extension personnel, October 1980.
- Ms. Boor conducted courses on cheesemaking and hygenic processing of milk for Peace Corps volunteers and for Maseno Veterinary Farm staff in October 1982.
- Drs. Brown and Russo conducted training courses in goat management and feed production for recipients of dual-purpose goats in March 1983.

On-the-Job Training in Kenya

Kenyan counterpart staff (Mathuva, Salim, Otieno and Nderito) assigned to work with Production Systems scientists are recent graduates of the University of Nairobi or Egerton College. They had little training and no prior experience in the design, conduct, and analysis of experiments. Considerable time and effort was devoted by Production Systems scientists to promoting and supervising their experience. Each of the Kenya counterparts was given principal responsibility for one or more experiments, including analysis and reporting results at the SR-CRSP scientific meetings held annually in Kenya.

Members of this counterpart staff who have displayed initiative and aptitude for research have been nominated for graduate studies. Many Kenyan students do not score well on GRE tests, often because of lack of familiarity with the testing process (multiple choice, limited time) and American culture which are reflected in the questions. Production Systems scientists have conducted 6 to 8 week testing sessions for those Kenyan counterparts before they take GRE exams.

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Animal Health Constraints on Small Ruminant Performance

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The role of the Animal Health Project in achieving the goals of the SR-CRSP in Kenya is to identify disease problems that are important production constraints and to propose economic measures for control. Some disease problems have well-known solutions that can be readily applied, while others, especially some that occur in Kenya, require specific research to help solve the problem. If a dual-purpose goat is to find a place in the farming system of Western Kenya, it is likely that the dairy performance of locally adapted goats will have to be improved. To achieve this, it may be necessary for the program to introduce exotic dairy breeds for crossing. Imported stock however lacks immunity to diseases that native goats have developed. Therefore, in addition to solving well-known problems of intestinal parasites in exotics, it will be necessary to develop strategies to protect them from diseases indigenous to Western Kenya and to have effective control measures before the overall program objectives can be achieved.

To accomplish these objectives, it is clear that research and training must be done in close collaboration with the Ministry of Livestock Development (MLD). This approach will allow the work to continue after the SR-CRSP is terminated and will provide the necessary collaboration during the presence of the SR-CRSP in Kenya.

The specific project goals are:

- To assess the prevalence and economic significance of major small ruminant diseases and ectoparasites in Western Kenya.
- To adapt and modify successful control and prevention measures where possible.
- Where solutions to major disease problems are unknown, to develop research projects which will provide answers to such problems.
- To expand the animal health research capabilities within Kenya through interaction with MLD scientists and by providing graduate education for selected Kenyan students.

Research Accomplishments

Health Survey

In order to provide basic information necessary for determining the direction of the Animal Health Project, an initial survey of herd health in Western Kenya was conducted. For the survey, Dr. Abinanti worked closely with personnel from the MLD, the FAO Sheep and Goat Development Project (FAO/SGDP), and other SR-CRSP projects, particularly the Winrock Economics Project. The Washington State Field Director, Dr. Paul Sayer, supervised the initiation of the survey in December 1980. The primary emphasis of this survey was to assess the incidence and prevalence of infectious and non-infectious diseases in goats and sheep on small farms in Kenya and to prioritize those of most importance.

A total of 495 goats and sheep on 69 small farms in the Siaya and Kakamega districts were examined and 344 of them followed for the entire period of the survey, December 1980 through October 1981. Each of the farms received three visits. The farms were selected on the basis of local recommendations, with the consultation and advice of personnel from the MLD and other SR-CRSP projects. Care was taken to choose representative farms within a wide range of ecological characteristics and to provide for maximum cooperation and minimum interference, with other studies by other groups.

All of the animals examined were tagged for identification, aged by number and condition of teeth, sexed, and assessed for general health. The team noted and enumerated external parasites and took samples of blood and feces for later analysis.

The survey revealed that the general condition of both sheep and goats was quite good throughout the entire observation period. Relatively few animals appeared emaciated, with more sheep than goats exhibiting this characteristic. The condition of the majority of the animals was listed as "normal" or "moderate" with a slight increase in the numbers in the normal category during the rainy seasons, February through April. The generally good condition of the animals was unexpected in view of the opportunities for infection with a variety of agents and the extent of the demonstrated internal parasite loads.

In regard to specific health concerns, cutaneous streptothricosis was observed in a few of the sheep and goats during the rainy seasons, but not in the dry season. Enlarged lymph nodes in several of the animals in one area under study might have been an indication of heartwater disease or caseous lymphadenitis. Watery feces in large numbers of animals and diarrhea in fewer of them were indications of internal parasites. Ticks were more predominant in animals kept in herds than in animals kept tethered.

The survey findings led the Animal Health component to focus its specific disease research on five areas: Caprine arthritis-encephalitis (CAE), ticks and their effects on goats, contagious caprine pleuropneumonia, internal parasites, and the role of selenium in small ruminant health.

Caprine Arthritis-Encephalitis Virus

In 1980, SR-CRSP scientists, while examining herds of goats imported into Kenya by another program, first noticed symptoms of CAE. This was subsequently confirmed and SR-CRSP personnel alerted government authorities of the threat to native stocks posed by introduction of the virus with exotic goats. This timely alert allowed steps to be taken to ensure that the CAE threat was neutralized.

The improvement of milk production from goats has been a long-time goal in Kenya which resulted in importation of both does and bucks from dairy breeds in the United States in 1978. The animals were kept at Ol Joro Orok except for the bucks who were moved to two other locations for breeding purposes. In 1980 when the SR-CRSP became active in Kenya, it was noticed that imported animals showed symptoms that, by June of 1981, were diagnosed as possibly indicating the presence of CAE infections. The situation was made particularly serious by the fact that until introduction of the exotic animals, CAE was unknown in Kenya.

Once it was established that CAE infection was a definite possibility among the imported goats, reagents for the agar gel immunodiffusion test for antibody against CAE were obtained from WSU. An initial screening test was conducted on all goats imported from the US, their offspring, goats that had been in contact with those imported, and indigenous goats that had never had contact with the imported goats. The imported goats and their progeny at Ol Joro Orok had a high prevalence of antibody (79.6%) and four other positive animals were discovered in another region. Of the four outside Ol Joro Orok, three were imported bucks and one was an East African male weaner that had been penned with the imported bucks for approximately five months.

The MLD took immediate action to quarantine those stations with serologic reactors and to order the immediate slaughter of animals testing positive. By this time, more than half of the imported goats were showing clinical signs of CAE and gross pathologic findings of affected joints in the slaughtered goats were typical of animals with the disease. It was decided that more extensive testing of goats in Kenya should be initiated.

In December 1981, Dr. Scott Adams, Veterinary Medical Officer of the Animal Disease Research Unit, USDA, and a faculty member of the Department of Veterinary Microbiology and Pathology at WSU, provided technical research assistance to the government of Kenya in this matter. Dr. Adams, whose activities were supported in part by SR-CRSP funds, worked closely with MLD scientists at the Veterinary Research Laboratory, Kabete, and WSU's SR-CRSP on-site resident scientist.

A survey of antibodies to CAE was conducted on the sera of 936 goats from Kenya, 100 from the Sudan, and 103 from Somalia. The work clearly demonstrated that transmission of CAEV from goats imported from the US was appreciably nil and had been well contained. In addition, the results indicated that horizontal transmission was not a problem because the virus apparently did not pass from buck to doe during breeding. The study also revealed no evidence for vertical transmission via sperm to kids. Indications exist that African goats are susceptible to CAE, but the optimal condition for transmission of the virus contact between infected does and neonatal kids - was not present in Kenya.

The researchers concluded that CAE in Kenya had been contained and eliminated. Dr. Adams' work resulted in benefits to both the US and Kenya. This study has been instrumental in establishing lasting improvements and increased vigilance in small ruminant importation procedures. It is apparent that continued monitoring is essential, particularly with regard to the possibility of exotic animals introducing CAE into Kenya and sheep transmitting progressive pneumonia (PP) to goats in the same herd. The work that has been done indicates that PP could be transmitted from sheep to goats in close contact. Findings conclusively show that CAE is most commonly transmitted in the colostrum and in the milk, information that is crucial in preventing introduction of the disease to native goats when exotic goats are placed in herds to improve milk production.

Ticks and Their Effects on Goats

E. Mwangi, an MLD employee working closely with the SR-CRSP herd health project on-site resident, Dr. J.F. Bell, is involved in a project investigating parasitism of ticks on goats native to the area. Tick-borne diseases cause serious losses in animal herds in tropical and sub-tropical parts of the world, including Kenya. The continuation of goat husbandry is often attributed to the inherent resistance of indigenous animals to tick-borne diseases and the widespread use of dips or other control measures. It may be true, however, that resistance apparently inherent in native goats is not simply genetic and that chemicals have only limited application, especially if the parasites develop resistance to the chemicals. This study was undertaken to provide basic information about the tick population on goats as a starting point in the control of both the parasites and the diseases they transmit.

The research plan was to compare the effects of ticks on East African goats introduced into a new area of Kenya and on tick-free indigenous animals of the same breed. However, this comparison proved prohibitively difficult for two reasons. First, the introduced goats experienced a high mortality—probably from heartwater—and second, finding native goats known to be tick-free from birth proved impossible. The ticks on the goats were, nonetheless, collected, counted, and preserved.

The data from the study indicate that goats do not acquire resistance to tick infestation. It is possible, however, that failure to do so is a result of continuous rather than intermittent exposure, a phenomenon discussed in the literature on fleas.

Contagious Caprine Pleuropneumonia

SR-CRSP work on contagious caprine pleuropneumonia (CCPP) is critical. CCPP is the most serious disease of goats in Kenya, occurring in epidemics in all areas of the country, and causing high mortality as well as great economic loss. Disease control programs have not been successful, in part because of the lack of a good diagnostic test.

This study dealt with an enzyme-linked immunoabsorbent assay (ELISA) test used to diagnose CCPP in goats infected with mycoplasm strain F38. Work was conducted by J.K. Bari, a WSU graduate student from Kenya and forms part of his Master's thesis. All the vaccinated goats in the test were ELISA positive, an observation that conforms with the results of experiments conducted on animals other than goats. This study indicates that it is fairly safe to assume that the finding of antibody in the sera of goats means that they

have been previously vaccinated or infected, although it may not indicate that they are currently infected or are immune. The ELISA test for mycoplasm strain F38 was significantly more sensitive than the component fixation test. Additional studies will evaluate whether the test is specific to mycoplasm strain F38 and it will be useful in field situations. The acuteness of CCPP is made apparent by the fact that the in-contact goats in this study contracted the disease and died before they had developed antibodies detectable by the ELISA. The ELISA was effective for detection of antibody to mycoplasm strain F38 and was significantly more sensitive than the complement fixation test.

Internal Parasites

J. Njanja recently completed his coursework for a Master's degree and has returned to Kenya to study the efficacy of ivomectin against mixed nematode infections (predominantly *Haemonchus contortus*) in goats. He is comparing use of the drug with the current routine treatment (TBZ drench) to formulate guidelines for use of anthelmintics in goats in Kenya.

The animals used in the study come from a herd of approximately 450 does and 150 male kids among animals maintained by the SR-CRSP Breeding Project. These animals were previously treated with TBZ once a month. The study divides the animals into groups and treats one with ivomectin, one with TBZ, and leaves one group, male kids, untreated as controls. Animals are being monitored for internal parasites using fecal examinations, necropsy of animals that die during the trial, and euthanasia and necropsy of selected male kids during the trial. It is anticipated that this work will lead to a recommendation for anthelmintic therapy to be used in dual-purpose goats.

Role of Selenium in Small Ruminant Health

S. Mbwiria, who completed his graduate coursework at WSU, has studied the role of selenium in ruminant nutrition. Various diseases have been associated with selenium deficiency in sheep and in East African domestic and wild animals. The element has been effective in inducing weight gain when fed to cattle and it might be associated with nutritional muscular dystrophy in goat kids. The purpose of Mbwiria's study is to examine selenium in selected areas in Kenya, including the Maseno area, and to compare its levels in soil, plants, and blood from goats and sheep.

The results of the study indicate that animals in some areas of Kenya have selenium deficiency in blood samples. The preliminary findings, however, indicate that most of the areas covered in the survey had adequate selenium levels, using previously reported findings of disease based on mineral deficiency as an indication of what constitutes adequate levels of selenium. The findings also show that blood selenium levels of sheep are generally lower than for goats, a condition that might be attributed to the two animals grazing different plants or the goat's inherent ability to accumulate more selenium than sheep.

SR-CRSP field technicians examining an East African goat on cooperator's farm in Western Kenya. Photo: H.A. Fitzhugh.

Implications for Future Research

For the immediate future, work is planned for five areas: Haemonchosis and other intestinal parasites, contagious caprine pleuropneumonia, introducing exotic crossbred goats into trypanosomiasis areas, caprine arthritis encephalitis virus, and determining the cause of any diseases and deaths of the exotic crossbred goats introduced into Western Kenya.

Work on *Haemonchus contortus* and other parasites focuses on the possibility of ivomectin (oral formulation) as an effective anthelmintic. It will be compared with TBZ drench, which is now the routine treatment. The bulk of this work is being conducted by Dr. J. Njanja, an MLD employee currently working towards a Master's at WSU under the auspices of the SR-CRSP project. Most farmers in Kenya rely on TBZ for parasite control but since resistance to this this drug occurs, the establishment of a more effective anthelmintic would be of particular importance. Following this work, Dr. Njanja will assist in developing an internal parasite control program for dual-purpose goats in Western Kenya.

Dr. J.K. Bari's research on CCPP diagnosis has been closely coordinated with efforts at the MLD to prepare a vaccine for this disease. Our new coordinator in Kenya, Dr. Fred Rurangirwa, will have as a major research responsibility, the development of a CCPP vaccine suitable for field use.

Trypanosomiasis, which can be devastating to goats, is common in some parts of Western Kenya, and making a study of the disease as it affects goats is vital if exotic stock are to be introduced. Since trypanotolerance in indigenous goats has been noted, the focus of the study is on the mechanism of

this tolerance. If it is acquired and if the mechanism can be determined, it should be possible to protect exotic animals from trypanosomiasis when they are introduced into parts of Kenya where the disease is prevalent. The question of trypanotolerance forms the basis of Dr. D. Mwamachi's Master's thesis work, which should begin in February 1984. He has recently begun his coursework at WSU.

No new infections of CAE were found among goats in Kenya this year, but the animals should still be monitored for the disease. Goats that have been exposed to sheep with antibodies to progressive pneumonia virus need to be tested to determine whether they have been infected, as research has shown that PP virus can be transmitted from sheep to goats when the animals are in close contact. SR-CRSP personnel in the US and Kenya will continue to monitor goats in Kenya for these viruses

As exotic crossbred dairy goats are introduced onto small farms, some of the animals will become diseased and perhaps die. If the SR-CRSP is to keep abreast of herd health, it is imperative that causes of mortality and morbidity among exotic crossbred animals be determined with as much accuracy and specificity as possible. Working with MLD personnel, SR-CRSP scientists will maintain careful records on newly introduced goats, take serum samples at regular intervals, match each new goat with an animal of the same age from the local area, diagnose clinical diseases and keep records of treatments and signs, take regular fecal samples, and perform a complete and thorough necropsy of any goat that dies.

Training

The major aspect of training in the SR-CRSP program at Washington State has been the education of Kenyan students at the MS degree level. WSU has an agreement with the MLD outlining the nature of this program. The agreement and the program are designed to ensure that students receive the best training available in the US that can be directly and meaningfully applied to field problems existing in Kenya's small ruminant herds. Since the trainees are veterinarians working for the MLD, they already have significant field experience before they enter the program.

Each graduate trainee does some preliminary field work in Kenya in order to become acquainted with a particular research problem. During this time, the student also forms an advisory committee comprised of scientists at the MLD and faculty members at WSU. With the research topic in mind, the trainee completes coursework towards an MS at WSU during the first year of training and in the second year the student performs field work related to the thesis topic in Kenya. The result of the research is a Master's thesis and, upon successful completion of the entire program, each student is awarded an MS from WSU.

Three students, Dr. Johnson Bari, Dr. Stanley Mbwiria, and Dr. James Njanja, completed their coursework and have performed field research. An additional student, Dr. Derrick Mwamachi, is currently doing coursework at WSU and plans to return to Kenya in January 1984. His thesis research will involve trypanosomiasis control in goats.

The SR-CRSP will also provide funds to support the studies at WSU for Suryakant Waghela, DVM. He is currently Assistant Director of Livestock Development (Research) at the MLD and in February 1984 will begin studies leading to a PhD.

Elizabeth Olouch is on leave from the University of Nairobi faculty working toward a PhD at WSU. Most of her financial support comes from other sources, but she is working on SR-CRSP objectives involving trypanosomiasis diagnosis.

Drs. Raul Rosadio and Antonio Garmendia are Peruvians supported by money from other sources but working on SR-CRSP activities. Dr. Rosadio is working toward an MS at WSU and he intends to work toward a PhD in conjunction with the SR-CRSP Peru Animal Health Project at Colorado State (CSU). Dr. Garmendia is a PhD student and will do his thesis in Peru in collaboration with SR-CRSP components at WSU and at CSU.

Dana L. Mortimer completed an MS in Agricultural Economics at WSU in 1982 using data produced by the SR-CRSP herd health survey to prepare her thesis. She worked, in part, with people involved with the SR-CRSP at WSU and with Dr. John De Boer from the Winrock Economics Project.

The WSU's Animal Health Project performed non-degree technical training in June and July 1981 when two technicians from the University's College of Veterinary Medicine traveled to Kenya to assist scientists and technicians at the Veterinary Research Laboratory in Nairobi in the establishment of specific research techniques.

Steve Schmidt, a veterinary physiology technician and a specialist in spectrophotometry, examined the equipment available at the Veterinary Research Laboratory to assess its suitability for use in selenium, molybdenum, and copper analysis. He found, unfortunately, that the unit was inoperative and needed major and expensive repair and alteration. After extensive inquiries in the local area, Mr. Schmidt located some useable equipment that was available, made repair cost estimates and arrangements, and performed some minor repairs on equipment. He then offered instruction in the care and operation of spectrophotometry equipment and provided details on sample collection and tissue preparation.

Karen Farnsworth, a veterinary parasitology technician, traveled with Steve Schmidt to the Veterinary Research Laboratory and delivered a Titertek Multiscan ELISA Reader and accessories. She instructed the staff in the ELISA procedure, including sample preparation. She also visited the parasitology laboratories and offered suggestions for updating and improving some of the routine methodologies.

Selected Publications

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Adams, D.S., B.M. Mugenya, E.W. Allonby, J.F. Bell, S. Waghela, and R. Heinonen. 1983. Observations on Caprine Arthritis-Encephalitis in Kenya. Veterinary Record. 112:227 and 228.

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Mortimer, D.L. 1982. A Socioeconomic Assessment of Small Ruminant Disease in Kenya. MA Thesis, Department of Agricultural Economics, Washington State University, Pullman, Washington.

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Sociological Analysis of Small Ruminant Production Systems

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The SR-CRSP research program in Kenya is unique among the five sites in which the SR-CRSP is working. It is the only site where the potential for small ruminant production is being explored in an area where these animals, particularly as raised intensively, are not commonly found. In all other SR-CRSP sites, small ruminants are a well accepted part of the agricultural production system and their viability is not an issue. That is not the case in Western Kenya. Here, one has to seriously ask whether small ruminants belong in the system and if they do, what are the likely problems to be overcome in order to successfully incorporate them into the farming system. This goal presents a most difficult challenge for sociology as one is forced to try to anticipate issues and problems rather than observe how the animals are actually cared for as we were able to do in the other four sites.

Initial activities in Kenya were designed to obtain a broad assessment of the social organization and characteristics of the Western Kenya small farming system. Data were collected through both baseline survey techniques and intensive field observations. It was hoped these two efforts would allow for an assessment of the division of labor within families regarding animal care and management, the labor availability on farms, possible cultural or social constraints to raising or consuming goats and goat products, farmers' contacts with governmental support services, markets and credit systems, and farmers' willingness to adopt new farm practices.

Throughout, the goal was to develop a body of information which would allow for the assessment of technological interventions and management strategies regarding their likelihood of acceptance within the West Kenya small farm population and whether the existing infrastructure could adequately support the dual-purpose goat package being proposed.

Research Accomplishments

The first two studies undertaken in Kenya are nearly completed. The first, a field project in the Samia area conducted by Amanda Noble, focused on a women's dairy goat cooperative and gathered information on women's participation in agricultural work, particularly as it involved animal management. Women are an extremely important component of West Kenya agriculture as over one-third of the households are headed by women. However, we had some reason to believe that women did not traditionally care for livestock.

Farm houses in the Siaya district of Western Kenya. Trial dual-purpose goats have been loaned to farmers in this region by the Production Systems Project to help determine the nature and extent of problems which need to be overcome if incorporation of these animals in the farming system is to be achieved. Photo: W.C. Weir.

This study showed that goats and other large animals were traditionally under the care of men. This practice had been relatively enduring up to the time of the study in spite of significant male out-migration. Out of necessity, women have assumed many of the daily labor tasks associated with livestock. However, the study revealed that this new responsibility had not yet been incorporated into the socialization of young women and thus the assistance of sons was still frequently sought. Even with a high incidence of absent males, women rarely had economic control of animals in terms of decision-making regarding animal sale or slaughter.

The study of the women's dairy goat cooperative pointed out some potential problems for goat production in general. Although the dairy goat group was functioning relatively well, it was heavily dependent on outside technical support and advice. For complex commodities such as a dairy goat, this support may well be essential if the animals are to survive and produce milk in significant quantities.

A second major effort of the Sociology Project was participation in the interdisciplinary small farm baseline survey. The details of this are given in the Production Systems report.

Both the survey and observational data indicated that ruminant production in the study areas of Western Kenya was not high and goat production was particularly low. Knowledge about milking goats was essentially nonexistent. Compared to cows, goats were considered a lower status animal and the use of intensive livestock management systems was relatively unknown. Traditionally, individuals who raised goats did not do so for personal consumption. Instead, the animals were primarily maintained as a source of liquid capital to be sold as needed for cash, although they were occasionally slaughtered and consumed for ceremonial purposes.

Interestingly, although the size of farms in the West had been declining, there did not appear to be a surplus of on-farm labor available for initiating new enterprises. This was a result of the substantial out-migration of men seeking wage labor elsewhere and a significant rise in the number of children attending schools. Given the large number of farm households which are headed by females, perhaps as many as 50% in the study areas, it is important for a small ruminant project to consider what norms, if any, exist for women regarding livestock care. Considerable evidence indicated that livestock production, with the exception of poultry, was not considered to be a part of the woman's domain. Traditionally women did not care for livestock and to the extent that they did, all major management decisions such as buying and selling were reserved for the male head of household even in the case where he was absent. While some of these traditions may be eroding in the wake of male out-migration, changes in norms and role definitions frequently lag far behind other changes which have more immediate impacts on the structure of the family. Thus, West Kenya exhibits many residual norms which inveigh against women caring for livestock. Yet if livestock are to be cared for, they will have to be tended, in many cases, by women. This paradox is not easily resolved and requires more study.

More recently, the Sociology Program has focused on exploring in more detail, some of the issues uncovered in the baseline and preliminary observational studies. In addition, monitoring activities of animal management interventions have also been undertaken. One of these involved a study of the feasibility of low cost small ruminant tick control through the use of local dips. This study was undertaken at four sites and produced somewhat mixed results. Four local groups were charged with organizing the dipping schemes with the technical assistance of the MLD and the SR-CRSP. One group showed reasonably good prospects for self-management and the ability to continue the project with minimal technical support. Major problems, however, were noted with the other three groups who were judged to have relatively poor prospects for being able to continue the activity. Some of the key issues for these groups were: questions about the necessity of tick control; inadequate or inconvenient water supply; inadequate participation and cooperation between neighbors; limited financial resources among local people to sustain self-management; inadequate understanding in dipping techniques and some reluctance to learn; apprehension among local people about the objectives of the technical support groups and poor performance by technical support personnel. A number of recommendations for dealing with these problems have been formulated and are reported in Reynolds et al. (1983).

Significance of Research Findings

Overall, complete knowledge of all the sociocultural aspects of agricultural production in Western Kenya is lacking and it cannot be definitely stated whether the dual-purpose goat scheme will succeed. Introduction of a new technology such as this will necessitate confronting a number of issues, not least of which is the inherent distrust of innovation. When the commodity has the additional disadvantage of being labor intensive, it may exclude farms where sufficient labor does not exist or where available labor is only present with women who do not traditionally care for animals such as goats. In addition, the observations of the Samia goat project demonstrated that a complex intervention, such as a dairy goat, will require a considerable amount of technical backstopping. Yet, the survey data indicated that farmers in the sample had little or no contact with extension agents on a regular basis. The SR-CRSP will need to carefully consider whether a dual-purpose goat package can be made to work within the context of the existing technical support infrastructure.

In addition, the survey data and more recent observations indicated that there is a considerable degree of heterogeniety in the West Kenya region. The two districts chosen for intensive study, Siaya and Kakamega, are in many respects markedly different from one another and the strategy for implementing a dual-purpose goat in one region may not work in another. While it may be possible to develop a dual-purpose goat package that is technologically sound, economically viable, and socially acceptable for some segment of the West Kenya farm population, it remains to be seen whether this group will constitute a significant proportion of that population. The goal for the Sociology Project in the future will be to evaluate alternative packages with the intent of identifying potential beneficiaries and to determine the degree to which these classes of individuals are represented in the population as a whole.

Future Research Directions

Future research plans in Kenya are designed to build on two things: the work already undertaken and the transition of the program from purely on-station research to on-farm evaluation and trials. The Sociology Project will focus on six primary areas in its future research efforts in Western Kenya. They are:

- To continue documenting the prevailing cultural themes associated with livestock production. This would include the importance of livestock at ceremonies and for bride price. The project will also document roles in livestock management and decision making by gender and age.
- To ascertain the importance of the non-agricultural economy. If agriculture is only a "sideline" for farm families, they may not be predisposed to investing in a new commodity.
- To determine the relative importance of livestock and crops in the small farming system.

Udder capacity of Galla does (left) is generally larger than that of East African does (right). Small teat size of East African does is a problem when hand milking. Notice the typical difference in body size between the East African and Galla doe. Photo: T.C. Cartwright.

- In collaboration with other projects, to determine the labor requirements for the dual-purpose goat and the labor availability on small farms.
- To determine the degree of access to infrastructure support systems including extension, credit, and markets.
- To monitor the social consequences of animal loans to farmers ("dropping") and forage intervention schemes being planned by the Production Systems Project.

Training

One of the goals of the MLD is to add a social science component to its staff structure in the research division. The Sociology Project has been working with the Ministry to identify potential candidates and has committed itself to supporting advanced degree training at the University of Missouri for a qualified individual. It is expected that this training program will be initiated in 1984.

To date, the Sociology Project's primary training activity consisted of funding the research conducted by Abdillahi Aboud for his Master's in Rural Sociology. Mr. Aboud's primary source of support for his Master's program was USAID and the Sociology Project's contribution was to fund the direct costs of the research in Kenya and a living allowance during the period of the research. Mr. Aboud completed all requirements for his degree in the Spring of 1982 and is now a provincial range management officer in the MLD.

In addition, one US student has been trained in Kenya through funds provided by the Sociology Project. Amanda Noble's thesis research, begun in 1980 and completed in 1982, was supported by the SR-CRSP. Ms. Noble completed all requirements for her MS in Rural Sociology in the Summer of 1982.

Selected Publications

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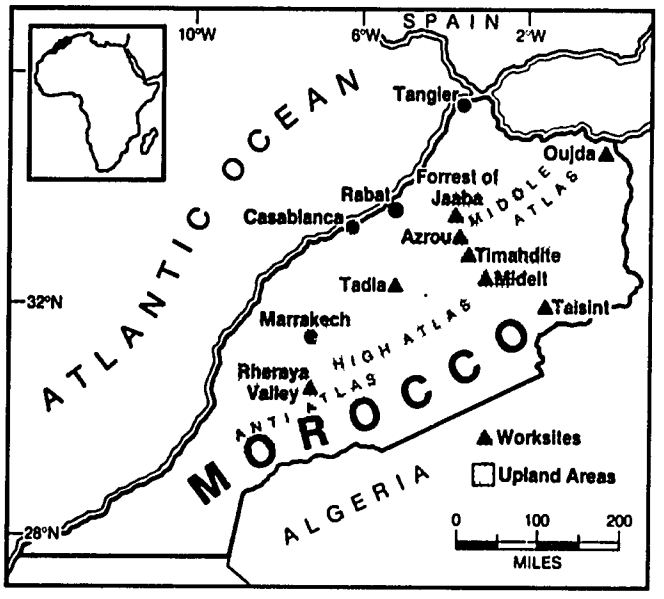
MOROCCO

Morocco has three distinct geographical regions: The coastal belt, the High Atlas mountains with the semi-arid plateaux adjoining them, and the Sahara desert. The coastal region is highly fertile and intensively cultivated in vegetables and cereals. One hundred miles inland, the middle Atlas mountains rise sharply, and are succeeded by the High Atlas rising to 13,000 feet.



Small Ruminant CRSP worksites in Morocco.

The ten million rural inhabitants dependent upon agriculture in Morocco derive their livelihoods from only 7.9 million hectares, or 11% of the country's total land area. A further 12 million hectares of marginal arid rangeland provides most of the feed for the country's small ruminant livestock, and another 5 million hectares consists of forest of variable quality used mainly for fuelwood and grazing.

Moroccan small ruminant production is noteworthy for having the world's highest per capita numbers of sheep and goats, which rely on a large number of different production systems with characteristics that are highly dependent on their location. Whether in the irrigated Gharb region, the cereal plains near Khemisset and Meknes, the dryland farming of the Tadla region, the highland rangelands of the Moyen and High Atlas mountains, the low rainfall Eastern desert plains, or the irrigated oases of the Errachidia or Quarzazate regions, there are different sets of resources, different predominant breeds, and different traditional solutions to the problem of integrated resource use.

Irrespective of the detailed nature of their production systems, about half the rural population that raise livestock are the farmers engaged in rainfed agriculture. Those that rely on irrigated cultivation are also dependent on some livestock to supplement their incomes, and these make up about one quarter of the livestock producing population. The smallest proportion are the migratory herders who are dependent solely on livestock husbandry.

Today, small ruminant production in Morocco is encouraged by ever increasing consumer demand from a population growing at an annual rate of nearly 3%. In contrast, the land resources devoted to small ruminant production dwindle as the area of land planted to cereal crops expands. Because of this, the traditional transhumant sheep and goat production system is deprived of its crucial dry season forage, and increasing pressure is placed on the remaining grazing land. As a consequence, overgrazing has already reached serious proportions in a number of areas suggesting that the livestock economy has already passed the limit of sustained yield under traditional practices. If grazing land resources are to be protected so that they remain productive and if producer interests are to be respected, balance must be restored to the system.

The SR-CRSP is pursuing approaches that offer hope for establishing a new equilibrium in the small ruminant production system. These include: to increase the efficiency of feed utilization by using improved breeds of livestock and improved management practices; to establish alternative feed resources linked to the new cropping practices; and to develop improved grazing practices that will protect range productivity in the long term.

Morocco has several strong research programs underway that relate closely to the SR-CRSP objectives, but much of this research is of a more basic nature rather than applied to problems of production. Efforts to conduct research that has direct application to the producer of small ruminants have also been very limited, in spite of the enormous importance of sheep to the domestic economy. Nevertheless, the activities of the SR-CRSP complement the research emphasis of Moroccan livestock research institutions, and may encourage a long-term interest in improving small ruminant production systems.

The principal collaborating institution for the SR-CRSP in Morocco is the Institute Agronomique et Veterinaire (IAV), Hassan II. The Institution grants the only advanced agricultural degree in Morocco and is the administrative center for Morocco's other agricultural training institutions. Principal locations of research facilities used by the SR-CRSP are IAV itself, the National Agricultural School of Meknes, and the research farm at Tadla.

Prolificacy and Productivity of Moroccan Breeds of Sheep and Their Crosses

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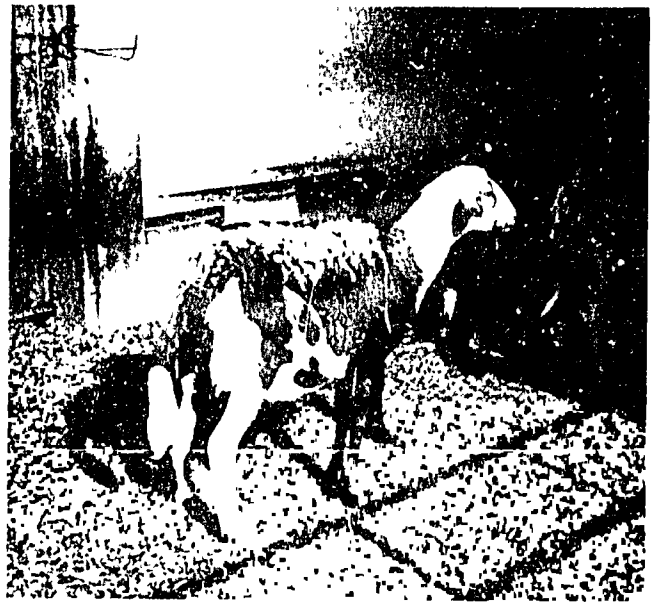
The goals of the Morocco Breeding Project are to determine the mode of inheritance of prolificacy in the D'Man breed of sheep and to evaluate the potential for using this prolificacy to increase productivity of sheep for use in the irrigated agriculture areas of Morocco.

The rationale for this is that while sheep are one of the most important components of food production systems in Morocco, improvement programs to modify the sheep for a changing agriculture have not yet been identified. The development of irrigated agriculture in Morocco has taken over substantial amounts of the better traditional sheep grazing land, but at the same time, produced many crop residues and by-products suitable for use as sheep feed. This has resulted in a shift of a considerable part of the sheep population from extensive grazing, including transhumance, to semi-sedentary and sedentary production systems. To date, the breeds used in the latter systems are almost exclusively the range breeds, with excellent hardiness and good size but very low prolificacy. However, to fully utilize the feed supplies from an irrigated agriculture system and to pay for the higher production costs of such systems, compared to range, more prolific breeds of sheep are needed. Lambing rates of 1.5 to 1.7 lambs born per ewe per lambing are generally much more productive under the feed conditions of mixed crop/livestock systems than rates of 1.0 to 1.1, characteristic of the range breeds. Higher flock productivity associated with higher prolificacy is much more likely to result in retention of the livestock component in such systems. While even lambing rates higher than 1.5 to 1.7 are possible, because a much greater management and labor input is required for lamb survival, they are probably not desirable under any production conditions in Morocco at present.

Achievement of higher twinning than that characteristic of the Moroccan range breeds requires both an improved genetic potential for ovulation rate and improved nutrition before and at the time of mating. Raising the extra lambs born to satisfactory weights requires increased nutrition for a month or so before lambing and at least 2-3 months after lambing. Crop residues and by-products from irrigated crop production provide potential feed sources for these critical periods. Due to their shorter gestation and lactation periods, sheep are much better suited than cattle to the short rainfall season and short period of feed abundance.



D'man ewe at Tadla Farm, showing evidence of hair sheep ancestry common in this breed. The breed is notable for its high prolificacy and is being used by the Breeding Project to develop a crossbreed adapted to changing conditions in Morocco. Photo: G.E. Bradford.

The higher genetic potential needed for animals to respond to improved feed can come through selection, which is a relatively slow method (0.5 to 1.5% increase in twinning rate per year) or from crossing with prolific breeds. The latter offers a means of effecting rapid change in prolificacy, and the mean level can be set close to any desired point by varying the proportions of the prolific and non-prolific breed inheritance in the cross. The disadvantage of this method is that the prolific breeds generally are not adapted to extensive or semi-extensive conditions, and tend to transmit this lack of adaptability in proportion to their percentage contribution to the cross.

Morocco is fortunate in having a prolific breed of its own, the D'Man, kept primarily in the oases of the Ziz and Draa valleys south of the Atlas Mountains. The D'Man has a much higher incidence of multiple births than other Moroccan breeds, with litters of 3 or more surprisingly frequent. These sheep are relatively small in size, and probably not well adapted to extensive management. However, they are much more likely to be adapted to a hot dry environment than prolific breeds from temperate countries, such as the Finnish Landrace and Romanov. The SR-CRSP Breeding Project in Morocco is therefore focusing initially on the D'Man as a gene source to increase prolificacy for Moroccan irrigated agriculture sheep production.

A characteristic of the D'Man breed is its exceptionally high variability in litter size. A pattern of much greater than expected variability in litter size is also characteristic of the Javanese Thin-Tail breed in Indonesia, and the implications

of this pattern with regard to mode of inheritance is discussed in the Indonesia report. Briefly, the pattern in temperate country sheep breeds with an average litter size of 2 is mostly twins, with a few singles and triplets, for example 70% twins and 15% each singles and triples. Litters of more than three are very rare. The genes influencing variation in these breeds are known to have individually small effects. In the D'Man (and the Javanese Thin-Tail), a mean value of 2 may be made up of 40% singles, 35% twins, and 25% 3's, 4's and 5's. This suggests the possibility of genes with large effects on prolificacy, e.g., an animal with a gene for high ovulation rate may have 3 or 4 lambs, while another in the same flock lacking this one gene may have only one lamb. Such a gene is known to exist in a strain of Australian Merinos (Piper and Bindon, 1982). If there are such genes in the D'Man, the method of utilizing the prolificacy through crossing will be quite different than if the genetic determination is of the more common quantitative nature. The experimental plan therefore involves assessment of the mode of inheritance of number of lambs born and ovulation rate in the D'Man.

As nutrition is of great importance to the realization of genetic potential for prolificacy, the project is being carried out at the same farm as major parts of the SR-CRSP Nutrition Project and in collaboration with it.

Research Accomplishments

The project was initiated in the spring of 1982, with the first lambs born early 1983. Therefore we have only limited results to date.

Design of pens and handling facilities for a research flock of sheep at Tadla Farm was the first step taken in May 1982. An existing building was modified to house the first sheep which arrived in July 1982. Construction of the permanent pens began in December 1982, with sheep moved into the first of these March 1, 1983. Eighteen general use or breeding pens should be completed this year. Construction of working facilities and conversion of an existing building as a facility for endoscopies and other more intensive work will follow as funding permits.

The first lamb crop, produced by mating Sardi rams to Sardi ewes and D'Man rams to D'Man and Sardi ewes showed the following:

- Prolificacy of the Sardi ewes was higher than previously reported for this breed; 1.48 on a small group (21) of mature ewes, and 1.12 on 117 yearling ewes. Previous reports had indicated a twinning rate of less than 5% for the breed. We attribute this result to feeding the ewes on a ration of alfalfa hay prior to breeding. The results indicate a need for further assessment of prolificacy potential of the Sardi and other Moroccan range breeds at different levels of nutrition.
- The D'Man ewes apparently did not stand up well to the stress of being moved to a new environment and had both a disappointing litter size (1.53) and very high lamb mortality. However, these ewes were moved twice pre-breeding and once during pregnancy, and do not appear to compete well when fed with other sheep. Management is being modified accordingly.

Perhaps the most important finding from the first lambing season is that Tadla Farm is in a selenium deficiency area. Several lambs died with well-defined white muscle disease lesions; mortality from this cause was apparently stopped by injections of selenium/Vitamin E.

At this early stage of the project, two results of particular significance stand out.

The finding of an apparently serious selenium deficiency indicates a need for selenium supplementation as a routine practice for sheep raised in confinement in the area and the possibility of a significant improvement in performance as a result. Work needs to be done on selenium levels of soils, forages and livestock in the region before the magnitude of the problem is known. Selenium deficiency has several negative effects on livestock productivity including a reduction in fertility in addition to causing white muscle disease. The severity of the problem in the Tadla sheep suggests the possibility of subclinical deficiency, even if clinical symptoms are not shown by animals which graze over a wider area, as do most of the local sheep. This problem is being pursued by the SR-CRSP, with collaboration from Dr. Johnson of the University of Minnesota.

Taking a blood sample from a Sardi ewe at Tadla Farm, for assay of progesterone to determine duration of postpartum anestrus. Photo: G.E. Bradford.

The poor performance of the D'Man ewes during the first year of the project indicates a need for special management of these animals, and suggests that for reasons apart from their smaller size, they may not be useful as a pure breed in the area. The D'Man x Sardi crossbred lambs in the first crop are of good size and vigor and with the known early puberty of the D'Man, may have advantages over the Sardi. However, it is still too early to draw conclusions on this point.

Implications for Future Research

The goals of the Breeding Project are by nature long-term, and since the project has just begun, it is too early for results that would indicate a change in direction. However, as anticipated when the project was initiated at Tadla Farm where no livestock had previously been raised, development of feeding and management practices suited to the production system of the area will occupy a good deal of attention during the early stages of the project. It appears we will be able to achieve the breeding goals simultaneously with solving some other problems. Establishing a breeding flock under semi-intensive management will be an effective means of identifying and working on many aspects of the technology of sheep production of the area. At this stage, the project is collaborating with the SR-CRSP Nutrition Project and with an animal health specialist from the Minnesota Project. The project should provide valuable data for economic analyses, and potential interaction with the SR-CRSP Range and Sociology components at later stages.

Training

As in our other locations, the goal of training activities is to assist where needed in developing the expertise among host country personnel to carry on all aspects of the work when direct UC involvement in the project terminates.

Two IAV staff members have been nominated by IAV for doctorate training at the University of California. Ismael Boujenane of the Department of Animal Production and Lahsen Derqaoui of the Department of Reproduction, have applied for admission to PhD programs at UCD in Genetics and Endocrinology, respectively. They expect to enter UC in September 1983 and are scheduled to work in complementary areas of the general field of genetics of reproduction as well as use data from the Tadla project for their dissertations.

Technical training during the first year of the project has consisted of work with Tadla Farm personnel in sheep feeding and management, facilities development, estrus checking, recordkeeping, and health care. This activity will continue through interaction of the project resident scientist, Mr. Berger, with IAV scientific and support staff.

Sardi ewes with Sardi and Sardi x D'Man lambs from the first SR-CRSP experimental matings, Tadla Farm. Photo: G.E. Bradford.

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Nutrition and Feeding Systems Research

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Small ruminants have been a traditional part of Moroccan agriculture for many centuries, particularly in the upland areas where extensive transhumant systems are the most prevalent types of husbandry. However, in a few irrigated valleys, raising sheep in total confinement is also a traditional practice. Improvement of animal productivity in any of these situations requires overcoming the constraints of inadequate year-round forage. This in turn demands a better qualitative and quantitative understanding of the feed resources and of the animals' requirements, particularly during the critical stages of post-weaning, conception, late gestation, and lactation.

To address the need for this information, a project workplan was jointly developed with the Moroccan Scientific Panel in October 1982 and had the following long-term objectives:

- To characterize the nutritional value of by-products, crop residues, and cultivated forages potentially available for feeding sheep or goats in partial or total confinement. As needed, studies will be made of storage and/or treatment methods for preserving or enhancing the nutritive value of fibrous feeds.
- To quantify the productivity of sheep or goats in relation to levels of energy, protein, and mineral intake.
- To participate in the training of Moroccan students and junior research workers.

Primary emphasis has been given to sheep in the dryland farming and irrigated areas north and west of the Atlas range, in an area approximately bounded by Rabat, Meknes, Marrakesh, and Casablanca. Wheat is the most important dryland crop in this region, and large numbers of sheep scavenge the fields of wheat stubble after the June harvest and up to the start of the rains in November. Wherever irrigation is available within the region, other crops and, therefore, crop residues abound. In irrigated areas, the possibility of planting forage crops also exists, but more likely as feed for dairy cattle than for sheep.

A project on the evaluation of potential feeds for small ruminants was already underway when our project started, but we participated in this and supported its continuation. Early results are reported below. It is still premature to report, even tentatively, on three additional lines of research initiated early in 1983 which were as follows:

- Survey of small ruminant production practices in the rain-fed areas near the Tadla irrigation perimeter.

Moroccan women collecting wheat stubble from fields several months after harvest. It will be fed to their sheep which are kept near the homestead during lambing season. Photo: W.L. Johnson.

- Effect of grazing pressure of pregnant Sardi ewes in wheat stubble fields, on animal weight change, reproductive performance, and length of the grazing period.
- Energy utilization by Timahdit lambs fed oat hay and sugar beet pulp.

Research Accomplishments

Considerable support from the SR-CRSP has gone into the development of facilities for applied research, including animal pens at the IAV farm at Tadla and at the National School of Agriculture at Meknes, and into equipment for drying samples at Tadla and for laboratory analyses both at IAV (Rabat) and Meknes.

Although the collaborative project did not officially start until 1982, support was given to research already in progress since the fall of 1981. Three projects from this phase were completed as theses and are reported below.

Utilization of Waste Palm Dates for Sheep Production in the Draa Valley

This study was conducted in two stages: a survey of farm practices in the Draa valley, and an intake and digestibility trial with sheep (Khal, 1982).

Forty-eight farms chosen at random were surveyed in March 1982, in two valleys of the Draa. Average farm size was 3.6 hectares, of which about 60% were planted to cereal grains and 20 to 25% to alfalfa. Each farm had from 30 to 400 date palm trees. Sheep were the most important animal in one of the valleys, but they were slightly outnumbered by cattle in the second.

About 25% of the palm dates produced are of inferior quality and are used as livestock feed, although the exact proportion used in this way depends on the variety. All of the 48 farms reported using waste palm dates and pits in their feeding program from November to February. Use of these products was reported to continue throughout the year, with the lowest usage in April and May.

The animal trial was conducted at the IAV campus in Rabat. Eight Timahdit rams were offered 1.3 kg of chopped alfalfa hay per day plus 0, 300, 600 or 900 g of crushed whole dates and 5 g/day of a mineral mix. Total dry matter (DM) intake was highest when 600 g of dates were fed (Table 1). It was found that digestibilities of organic matter and fiber fractions in the whole ration were improved by the addition of palm dates; digestibility of the protein fraction, however, declined. The palm dates contained very little protein (3.7% of DM) and it is possible that the animals were deficient in total protein intake when offered ration 4. A feeding trial with weanling lambs, begun in May 1983, is further investigating the optimum combination of alfalfa and palm dates for confinement feeding. On the basis of research conducted to date, it is clear that strategic use of waste palm dates in limited amounts (300-600 g/animal/day) can help in year-round utilization of alfalfa. The latter can be used as greenfeed for 8-9 months of the year, and as hay in winter.

Nutritive Value and Utilization of Alfalfa in the Ziz Valley

This study was also conducted in two parts, the first being a farm survey and the second a systematic year-round sampling of alfalfa production plots.

Fifty-four farms in five zones of the Ziz valley were surveyed in February 1982. These farms averaged 6.5 ha in size, of which 15 to 60% were planted to alfalfa; the greater proportion of land planted to alfalfa was generally found on larger farms. Most farms could not harvest green alfalfa during the coldest months (November-January); but all farmers surveyed professed to using alfalfa hay during this period (Igmoullan, 1982).

Twenty-five hay samples were taken from these farms. They were found to contain 17±2% crude protein and 27±3% crude fiber, which is indicative of very good quality. Considering that 60% of the lambing in the Ziz valley occurs between November and February and that twins and triplets are very common (the prolific D'Man breed is the most common of the region), it is critical that forage quality remain high.

A long-term study underway at the Tafilalet Regional Experiment Station in Errachidia is designed to determine how alfalfa varies in productivity and nutritive value throughout its growing season. This study will help in formulating recommendations for making hay for the colder months. The sampling is being continued through 1983, though results of the 1982 sampling should be available by mid-1983.

Alfalfa is an outstanding forage for any ruminant, and its presence as a cultivated crop in the irrigated Ziz and Draa valleys has undoubtedly contributed to the success of the prolific strain of D'Man sheep in these regions. For the rest of the country such an intensive feeding system for sheep needs to be approached carefully. The prolificacy of the D'Man is not found in other breeds. When the D'Man is moved, other problems may develop such as the manifestation of an apparent selenium deficiency which was observed during the 1983 lambing season at the IAV Tadla Farm. In irrigated regions close to large cities, dairy cattle may be a more

Table 1. Intake and Digestibility of Alfalfa/Palm Date Rations by Timahdit Rams (Means of Eight Animals)

	Ration			
Parameter	1	2	3	4
Feed offered (g/animal/day)				
Chopped alfalfa hay	1,300	1,300	1,300	1,300
Crushed whole dates	0	300	600	900
DM intake (g/kg $BW^{.75}$)				
Alfalfa hay	61	56	52	39
Dates	—	15	28	33
Total	61	71	80	72
Ration digestibility (%)				
Organic matter	64	68	68	70
Crude protein	76	69	63	55
Cell wall fiber (NDF)	44	50	50	56

Source: Khal, 1982.

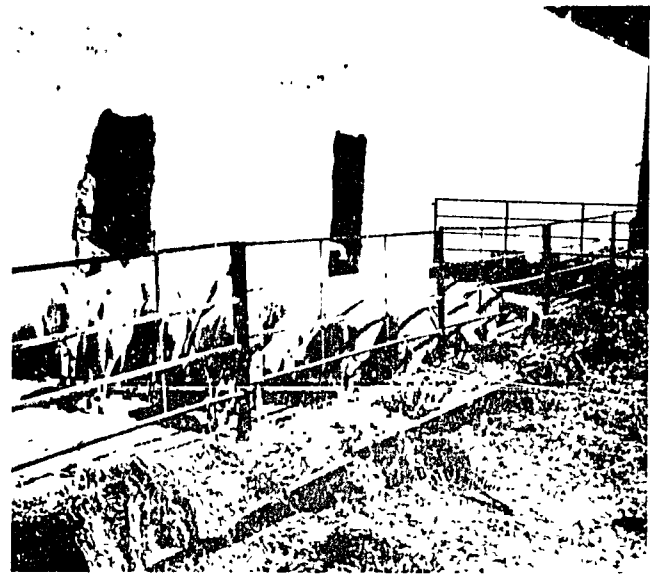
economical enterprise than sheep breeding. However, there may be a place for specialized feedlots in the finishing of range-reared lambs. This would represent a new economic activity for Moroccan farmers.

Nutritional Characteristics of Persian Clover

Persian clover of the variety INRA 6209 Maroc D was planted in August, September, October or November, 1981. The earliest seedings resulted in premature flowering and subsequent slow growth rates. The later seeding dates were more successful in that the first harvest had a much higher leaf/stem ratio. However, by April 1982 all plots died out, probably due to the combination of very hot weather and no irrigation.

Chemical analysis of the whole plant (28 samples) gave very low DM values (8 to 12%), high ash (13 to 20% of DM), excellent protein content (16 to 28%), low cell wall fiber or NDF (14 to 35%), and very low lignin content (less than 4%). Average daily intake by six rams was 65 g/kg $BW^{.75}$ (Sahnoun, 1982).

Persian clover seems to have some promise as a winter feed in the region. However, as a first step, a wider range of varieties should be tested and then the agronomic practices need to be worked out before more detailed nutritive evaluation is undertaken.



In the irrigated valleys of Morocco, excellent quality alfalfa can be produced. The Nutrition and Animal Breeding projects are working at the Tadla Experimental Farm to improve the utilization of this alfalfa by using improved sheep breeds and feeding practices. The temporary facilities above were used for the initial studies. Photo: W.C. Weir.

Implications for Future Research

Having made the decision to concentrate on the wheat stubble regions, the surveys and experiments underway in 1983 will help determine specific research emphases for the next few years. Strategic supplementation with energy, protein and/or certain minerals may well be indicated for the dry season wheat-stubble grazing period.

As our work on native range utilization in the Atlas mountains progresses, a need may be seen for strategic supplementation on the range or for removal of lambs to feedlots or semi-confinement at a certain weight, age or season of the year. The Nutrition and Feeding Systems Project will be responsive to these needs as they are identified.

The Breeding Project is looking at the effect of crossing D'Man sheep with the less prolific but larger range breeds. Undoubtedly the offspring of these crosses will have special nutritional requirements if they are to make a positive economic contribution. Feeding trials with F_1 D'Man x Sardi lambs will be conducted in collaboration with the Breeding Project to help evaluate the growth responses of these animals. One such trial is scheduled to begin in May 1983. Later, feeding trials with the F_1 ewes may be needed to evaluate the nutritional requirements for gestation in the event of multiple fetuses.

Training

Each year the IAV, Hassan II selects a group of "third-cycle" students for training to the equivalent of an MS degree. These students travel abroad, usually to France or the United States, for a year of coursework and then return to Morocco for thesis research. One of the main training avenues of the NCSU project will be the support of research projects for these students whenever they can fit in with the objectives of our collaborative workplan. Three such students (A. Igmoullan, M. Khal, and A. Sahnoun) were supported in 1981-82. One additional student is receiving support in 1983 for his participation in the farm survey in the Tadla region. This type of support will continue and hopefully expand.

Candidates for the PhD from IAV, Hassan II or from NCSU will likewise be supported for thesis research. Mr. Jean-Marie Luginbuhl, a native of Switzerland and an international development career specialist, will be the first candidate thus supported. Mr. Luginbuhl participated in program evaluation and planning during the summer of 1982, and will return to Morocco early in 1984 for long-term residence in the Animal Production Department of IAV. His activities with the project will include research for the PhD dissertation at NCSU.

When appropriate, we hope to expand the training activity to extension personnel in Morocco who will be involved in the adaptation of improved feeding systems to the local conditions of the extension districts.

Selected Publications

Igmoullan, A. 1982. Caracteristiques Nutritionelles de la Luzerne Poussant dans la Vallee du Ziz (Nutritional Characteristics of Alfalfa Grown in the Ziz Valley). 3rd eme Cycle, IAV, Hassan II. Rabat, Morocco.

Khal, M. 1982. Les Dattes dans l'Alimentation Animale: Valeur Nutritive et Conditions d'Utilisation dans la Vallee du Draa (Dates for Animal Feeding: Nutritive Value and Conditions of Utilization in the Draa Valley). 3rd eme Cycle, IAV, Hassan II. Rabat, Morocco.

Sahnoun, A. 1982. Valeur Alimentaire du Trefle de Perse (*Trifolium resupinatum* L.) Produit en Errigue dans le Gharb. 3rd eme Cycle, IAV, Hassan II. Rabat, Morocco.

Sociological Analysis of Small Ruminant Production Systems

M.F. Nolan
University of Missouri, Columbia

Sheep and goat production have been important to Morocco's agriculture for centuries but in recent years, population growth and the extension of cultivated lands have de-stabilized traditional production systems. As a result, Morocco's forests and rangelands are threatened by overgrazing. The goal of the Sociology Project is to identify the socio-economic factors leading to overgrazing in highland areas of Morocco. Identification of these factors should permit the formulation by range and animal scientists of improved strategies for livestock production and resource use which are culturally acceptable.

In general, small ruminant production in mountain areas of Morocco is conducted by agro-pastoralists, that is, by people who raise both crops and animals. Two general groups can be identified in Morocco's mountain regions, traditional agro-pastoralists and former pastoralists. The traditional agro-pastoralists are groups, such as those found in the High Atlas mountains, who practice intensive crop production on narrow terraces but who also have substantial numbers of animals. The second are those people for whom crop production was relatively unimportant until the coming of the French in 1912 and who are the descendents of transhumant or nomadic pastoralists. Though most members of this second group presently engage in crop production, a few still have a nomadic lifestyle. To date, project efforts have been concentrated in a traditional agro-pastoral area—the Rheraya and Azzaden valleys of the Eastern High Atlas mountains near Marrakech. The production systems in these areas are being intensively studied before beginning work in areas occupied by former pastoralists. Dr. Gilles has, however, given advisory support to Neal Artz, a Utah State University student working near Azrou among former transhumants.

The following activities have guided the Sociology Project in Morocco since 1981:

- To describe the context in which small ruminant producers make decisions about animal production. Priority in Morocco has been given to decisions concerning pasture and forage utilization.
- To identify the social and economic factors that lead to overuse of Moroccan ranges in order to understand what must be taken into account when developing range improvement programs.
- To evaluate the effectiveness of traditional Moroccan resource management systems, particularly the *agdal* pasture reserve systems, as range management tools.

In the Atlas Mountains area of Morocco, villages are situated on the hillsides which saves more fertile valley soils for cultivation. Photo: W.C. Weir.

Research Accomplishments

Collaboration between sociologists at the University of Missouri and Morocco's National Agronomic Institute began in autumn of 1981 when Abdellah Hammoudi, the Moroccan Co-PI, began visiting the Rheraya Valley to obtain a basic understanding of the animal production system practiced there. He was assisted in these efforts by two 3rd cycle students from the Institute, El Mostapha Darfaoui and Mohammed Chami. Both students prepared MS theses based on their efforts.

Mr. Darfaoui prepared a map of vegetation in the high part of the valley which identified 23 types of vegetation, nine "vegetation formations," and four patterns of vegetative change due either to climatic or grazing factors. In addition to mapping work, Mr. Darfaoui studied goat diets in March, April, May and herd movements. In the winter, animals stay near the village but in summer some herds move to camps (azibs) at altitudes of 2,300-3,100 meters.

Mr. Chami, estimating the productivity of herds in the Rheraya Valley, found that lambing and kidding rates were relatively low (83% and 103%, respectively) and liveweight gains per annum were 7.9 kg per sheep unit and 5.5 kg for goats. Mr. Chami also gathered preliminary estimates of reproduction parameters, milk production, growth curves of monthly energy needs, and of existing feed resources.

This work in the Rheraya Valley provided general information about animal production and laid the groundwork for a more detailed study in the future. Using their data and other information gathered by A. Hammoudi, a detailed questionnaire was designed and 800 households were surveyed from a sample group of villages, stratified by ecological zone. Items in the questionnaire were similar to those included in Kenyan and Indonesian baseline studies but contained more questions on pasture movements. This data is presently being analyzed at the IAV computer center. Preliminary results from the survey have been used by T'hami Ait M'hand to design a sampling frame for a study of the economic contribution of livestock to households in the Rheraya Valley. Mr. Darfaoui's mapping work indicated the existence of a large *agdal* at Oukaimeden. *Agdals* are areas where season of grazing has been traditionally regulated. In April 1983, a study of the operation of this *agdal* was begun by M. Mahdi under the supervision of A. Hammoudi and J. Gilles.

Implications for Future Research

The Rheraya Valley

Completion of the Rheraya Valley study is the first priority of the sociology group in Morocco. After the analysis of survey results, a number of topics need to be considered in more detail, including:

- The process by which pasture use decisions are made. What factors are taken into account in deciding when and where to pasture animals?
- Perceptions of overgrazing and understanding of range management principles. How do local herders evaluate vegetation and what are the alternative management strategies currently available to them?
- How do agricultural production and non-farm employment constrain/enhance small ruminant production in the region?

Successful completion of these tasks will involve tighter integration with other SR-CRSP disciplines.

Gathering firewood for household fuel places an additional burden on the productivity of dry lands and on efforts to control erosion. A corn plot which has been cleared from among the rocks into the Rheraya Valley is shown above. Photo: W.C. Weir.

Moyen Atlas

This is an area where the SR-CRSP range scientists have done considerable work. It represents an area whose economy has recently been transformed from one based on pastoralism to one based on agro-pastoralism. While producing large numbers of small ruminants, it is quite distinct from the High Atlas region. Since this region is an important SR-CRSP range research site, work similar to that presently being done in the Rheraya Valley needs to be conducted in support of other SR-CRSP research.

Agdal Studies

An old, traditional system of pasture management in Morocco, the *agdal* system, may provide the basis for the implementation of modern range management programs. Numerous *agdals* still exist in Morocco but they are little understood and seem to be deteriorating. In the future, the Sociology Project will try to identify different types of *agdals* still in existence, study their operation, and the reasons for their decline. Such studies can reveal important culturally-based management practices which can suggest dimensions or orientations which should be included in proposed new practices. Ways that the *agdals* might be revitalized in order to protect Morocco's rangeland resource could also emerge from this research.

Training

The Sociology Project has supported the thesis research of three MS students at IAV; T. Ait M'hand (to be completed in 1983); M. Chami (1982); and M. Darfaoui (1982).

Selected Publications

Chami, Mohamed. 1982. Productions Animales et Systems Alimentaires du Haut Atlas Occidental (Valley de Rheraya). 3rd eme Cycle, IAV, Hassan II. Rabat, Morocco.

Darfaoui, El Mostafa. 1982. Etude des Resources de L'Activite Pastorales et du Comportement Alimentaire des Caprins Dans la Vallee Rheraya (Haut Atlas Occidental). 3rd eme Cycle, IAV, Hassan II. Rabat, Morocco.

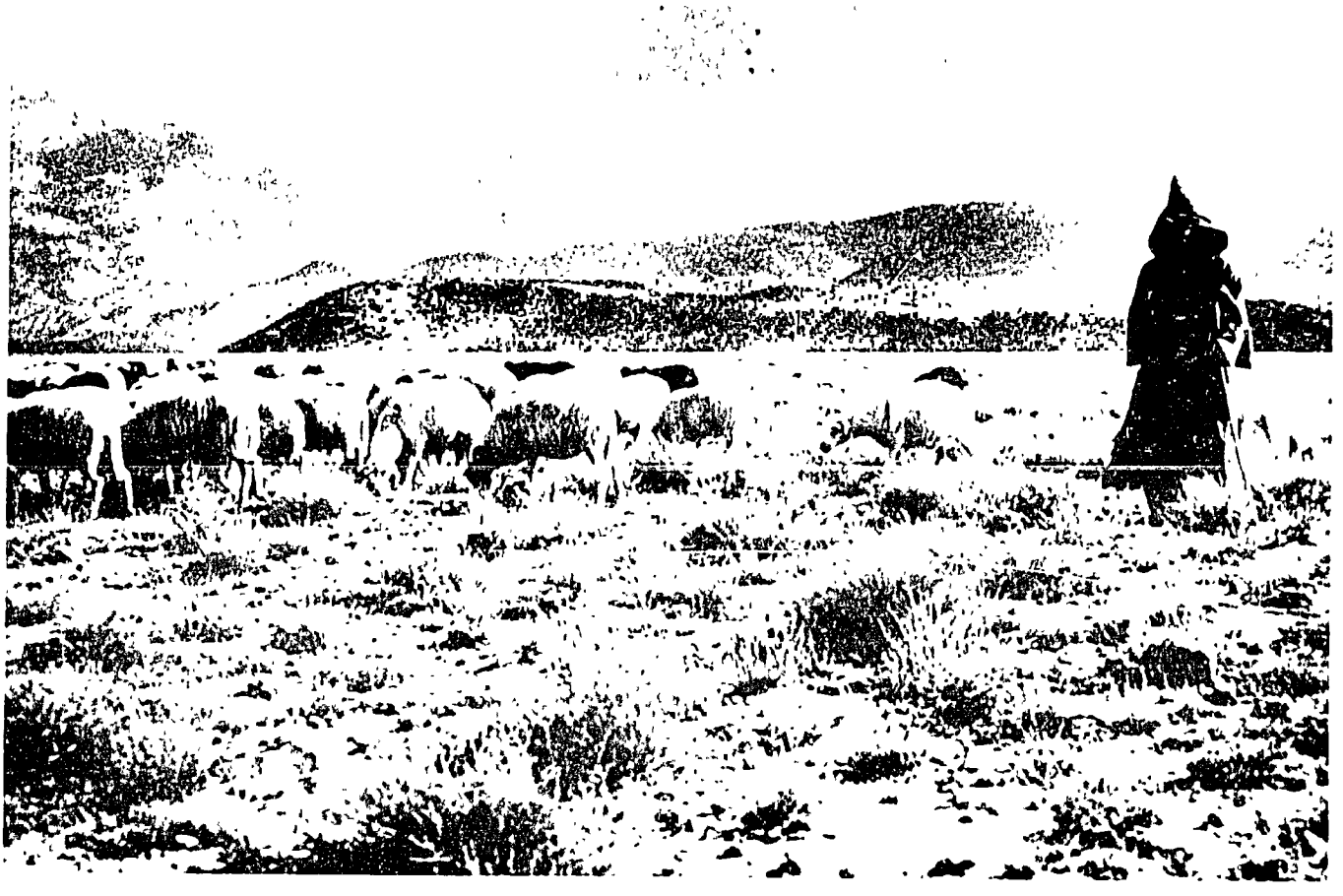
Rangeland Research for Increasing Small Ruminant Production

J.T. O'Rourke
Utah State University

Increasing production of domesticated small ruminants has been recognized as a means of improving the economic and social welfare of less developed countries. However, no animal improvement program can proceed without primary attention to the forage resource. In Morocco, as in many LDC's, the main source of forage is from rangelands, most of which have been overgrazed and are presently producing at levels far below their potential. In order to ascertain the specific ecological limitations to range improvement and increased production in Morocco, SR-CRSP research has focused on two major range types, the oak woodlands and the sagebrush-grasslands. The major work has centered on research stations at Talsinnt (sagebrush-grasslands) and Sidi Aissa (oak woodland) but studies of these vegetative communities have been pursued under different environmental conditions at Plaine de l'Aarid and Ain Beni Matha within the sagebrush grasslands. Mountain grassland, found adjacent to the oak woodland types, has also been studied to provide information on these adjacent areas which are used for grazing in conjunction with the oak woodland. Mountain grasslands have been studied at the Timahdite Station in the Moyen Atlas mountains, an area close to the Sidi Aissa oak woodland. Both mountain grasslands and oak woodland types have been studied in the High Atlas mountains in the Rheraya Valley.

Technical objectives within the Range Management Project in Morocco have been carefully developed not only to provide answers to rangeland resource problems but to coordinate with other fields of study involved in the Morocco SR-CRSP, thus addressing problems of sheep and goat production as a system. The research emphasis of the project has focused on providing:

- An ecological assessment of range forage resources, in which the successional status, productivity, and ecological potential for important range sites are being determined, in addition to monitoring plant community changes in relation to climate and grazing.
- A more complete understanding of plant-animal relationships, which includes determination of animal diets, feeding behavior, and animal performance, a description of the annual forage cycle, and examination of forage intake in relation to nutritive requirements.
- Information leading to range improvement, such as the effect of grazing rates on plant species composition in the field and on sheep diets.



Native plants such as white sage have been replaced in the headwaters of the Moulouya River with introduced grasses such as tall wheatgrass. The effectiveness of such treatments on plant productivity and animal nutrition is being studied to recommend improved management options. Photo: J. O'Rourke.

- Information on sociological aspects of range management including the rationale behind decisions made by pastoralists as it affects range management.

Research Accomplishments

Ecological Assessments of Range Forage Resources

Research has been carried out in the sagebrush grassland (Guermai and Bouksim, 1982), in the oak woodland (Belarbi and Othmani, 1982), and in the Rheraya Valley of the High Atlas mountains (Darfaoui, 1982).

A study of the vegetation in the Plaine de l'Aarid covers an area of sagebrush grassland which has largely been replaced by introduced wheatgrasses (*Agropyron* spp.). The potential productivity of seeded sites was found to be 1.75 tons of dry matter per hectare. In studying the effect of protecting native sagebrush *(Artemisia herba-alba)* from grazing for up to twelve years with seeded wheatgrass stands, it was determined that range improvement, as measured by dry matter production, was similar when these protected areas were compared with seeded areas. This study also indicated that the method of stock raising practiced in the region is not adapted to a judicious use of the seeded areas. The needs of the animals are at a maximum in December and January, a period during which a large proportion of lambs are born and at a time in which the seeded wheatgrasses are dormant and low in quality.

In the oak woodland, a study was conducted to evaluate the potential forage productivity of the herbaceous layer and to characterize the system of utilization of the riparian zones in the forest. Plant frequency, plant cover, seasonal variation in aerial biomass, and chemical composition of the forage were analyzed on four sites characterized by soil type and stocking rate. The results obtained show that forage production of the herbaceous layer is low. However, protein levels are, in general, satisfactory. With regard to the current utilization of the forest, results from questionnaires indicate that the forest contributes to the shelter needs of herds during the whole year, particularly in winter and during periods of heat. In addition, significant quantities of wood, estimated roughly at 360 kg per ha per year, are taken from the forest.

These studies indicated that both forage and wood products are important commodities to be derived by local livestock grazers from oak woodlands and that research is needed to determine the optimal balance of forage and wood products and how that balance can be achieved and maintained. This research forms part of the basis for the proposed study of oak thinning and how it approaches an optimal balance of forage and wood products.

Twenty-three vegetation types were defined and classified in nine vegetation formations in the Rheraya Valley. This vegetation map enabled us to define four stages of vegetation change depending on climate and grazing pressure.

Plant-Animal Relationships

Studies have been conducted on animal production and feeding systems in the Rheraya Valley (Darfaoui, 1982 and Chami, 1982), in the western part of Quarzazate at Tassrirt (Boudiab, 1981), in the sagebrush grasslands (Lamtaibi and Khettabi, 1982), and in the oak woodland (Doukkar, 1982).

In the Rheraya Valley it was evident that there is a low reproductive efficiency in cattle (66%) and a low average daily gain up to 6 months of age (82 g). The annual production per unit of cattle is about 85.4 kg of liveweight. Cattle feeding systems are based on feeds produced locally on the farm. For small ruminants the performance is again average to low, the fertility percentage being 83 and 102%, respectively for sheep and goats. Average daily gain (ADG) of young animals (between 10 and 30 days) are 51 and 40 g/day for sheep and goats, respectively, while between 30 and 90 days, the ADG is 52 g/day for sheep and 36 g/day for goats. Annual meat production per unit of sheep is 7.9 kg, whereas that for goats is 5.5 kg. The feeding system for small ruminants is essentially based on native rangeland. A study of goat behavior in the Rheraya Valley found that their diet is mainly constituted of browse species (85.9% of the diet). However, when calculating selectivity indices it was concluded that, when available, herbaceous species, particularly grass, are preferred to shrubs.

At Tassrirt the problems of sheep and goat production and management were analyzed. Rangeland forage production was found to meet only 80% of the small ruminant needs and overall animal performance was not satisfactory. Sheep and goat fecundity rate was 82% and 81%, respectively. The ADG in a period ranging from 10 to 30 days was 55 g for sheep and 48 g for goats. Growth between the age of 30 days and 90 days was 51 g/day for sheep and 32 g/day for goats. The annual average meat production for sheep and goat unit was 6.8 and 6.6 kg, respectively. The low productivity of the herd in this region is closely related to improper land use, particularly the conversion of rangeland to submarginal cropland, lack of technical answers to problems, and inadequate extension facilities.

At Ain Beni Mathar on both sagebrush and sagebrush/alfa *(Stipa tenacissima)* sites, sheep diet (using the bite count method), plant frequency, aerial biomass, and chemical composition of the forage were measured during March, April, and May. The results obtained show that white sage is the most frequent and productive species in the area and that its contribution to the total above ground biomass increases from March to May. It is not only the most favorable plant in terms of chemical composition but is also preferred by sheep.

In the oak woodland, the seasonal variation of the nutritive value of leaves from the green oak *(Quercus ilex)* and from deciduous oak *(Q. faginea)* has been investigated. Dry matter, crude fiber, and total nitrogen of the past year's green oak leaves were constant from March through June, but new leaves were higher in total nitrogen (17.55%) and in phosphorus (1.71%). Within the leaf there was no significant difference in chemical composition between the stem, leaf base, and leaf tip. Deciduous oak leaves were richer in total nitrogen, mineral matter and phosphorus than leaves of the green oak, and provide a more valuable feed source. When the diet was constituted exclusively of green oak leaves, a sharp drop in the consumption level occurred, probably a result of intoxication by tannins.

Range Improvement

The projects' efforts to determine the effects of grazing rates on plant species composition and on sheep diets on native rangelands in the Moyen Atlas mountains on the Timahdite Range Research Station is a continuation of work begun at the station in 1979.

From March through June 1980, data were collected to investigate the effects of three stocking rates on vegetation dynamics and sheep diets (Chergaoui, 1982a). The three stocking rates used were: light (2.78 sheep/ha), moderate (4.17 sheep/ha), and heavy (6.67 sheep/ha). Plant species frequency, aerial biomass, and diets of esophageally fistulated animals were determined at monthly intervals. No changes in the species' frequency were observed over the study period. However, aerial biomass varied from March to June and under the three stocking rates; 819.9 kg dry matter/ha (heavy stocking), 950.5 kg dry matter/ha (moderate stocking) and 1,300.2 kg dry matter/ha (light stocking) with utilization levels of 49%, 30% and 26%, respectively. Diets selected on the three grazing treatments did not differ greatly in their proportions of grass, sedge, forbs, and browse. Grass and sedge were an especially important food item on all pastures from March through June. However, forbs were slightly more abundant in the diet under the light stocking rate. In general, plant part selection was influenced to a certain extent by plant phenology. Leaves were the major plant part constituent in diets throughout the study period for all stocking treatments.

From March through November, 1981 (except for September) and again from March through June of 1982, the effects of these same three stocking rates on the frequency and the aerial biomass of the same pastures and on sheep nutrition continued to be studied by Chryaa (1982) and Harkousse (1982). The lowest forage production under the three stocking rates was observed in August. In summer, for light, moderate, and heavy stocking rates, the contribution of grasses to aerial biomass was 36, 28 and 20.5%, respectively, that of forbs was 25, 28 and 32% while browse species contributed by 38.5, 43.5 and 47%, respectively. In fall (November), the contribution to aerial biomass was 30, 25 and 51% for grasses and 60, 47.5 and 36% for shrubs for light, moderate and heavy stocking rates, respectively. In spring (April and May), the contribution of grasses significantly increased to 50, 58 and 62% for the light, moderate and heavy stocking rates, respectively. A decrease to 23, 26 and 18.5% was observed for shrubs under the same respective stocking rates.

Total fecal collection was accomplished using one-year old rams equipped with canvas fecal bags. The chemical composition of the diet was significantly affected by the season, but not stocking rate. The crude protein content of the diet varied from 5% in August 1981 to about 20% in March 1982. The crude fiber varied from a minimum of 21% in March 1981 to a maximum of 38% in November 1981. The

acid detergent fiber and acid detergent lignin varied respectively from 31 and 2.6% in March 1982 to 43 and 4.5% in May 1982. Though generally the plant parts in the diet varied with the phenology of the plants, the leaves were the most frequent plant part in the diet throughout the study period. The dry matter intake and digestibility were estimated using the lignin ratio technique and total fecal collection. They were significantly affected by time and level of stocking rate. This effect was shown by a decrease in dry matter intake and digestibility of the diet. The intake varied from 68 to 95 g/mean body weight for the light stocking rate, from 65 to 94 g/mean body weight for the moderate and from 59 to 65 g/mean body weight for the heavy stocking rate. The dry matter digestibility estimates varied from a minimum of 62% with the heavy stocking rate to a maximum of 72% with the light stocking rate.

These three years of studying Moyen Atlas mountain rangelands at various stocking rates has yet to show any changes in terms of plant composition or in diet selection. However, as in other studies of this type, more time is needed to determine the optimal stocking rate. These studies have, however, begun to describe the seasonal nutritive value of these rangelands and the species that compose them.

Sheep flocks heavily graze on congregating areas in the High Atlas Mountains. The Rural Sociology and Range Management projects are investigating traditional protection of such areas through the "agdal" system. Photo: W.C. Weir.

Sociological Aspects of Range Management

In order to understand the rationale behind decisions made by pastoralists as they affect range management, studies have been initiated in the Rheraya Valley of the High Atlas mountains (Darfaoui, 1982) and in the Timahdite area of the Moyen Atlas mountains.

The Rheraya Valley study, which focused on the distances travelled by sheep and goat herds from the village to the pastures, concluded that vegetative degradation in the Valley is mainly due to mismanagement and over utilization, rather than the so-called destructive behavior of the goat, and points to studies needed to determine proper stocking rates and season of use.

Range management research is being closely coordinated with the Sociology Project through the work of Neal Artz in the Moyen Atlas mountains. This work has indicated that past efforts to improve range management practices in Morocco have been successful only to the extent that they were accepted by the recipient pastoralists and capable of incorporation into their management schemes. Experience and logic testify that this integration is more probable when the innovations are in accord with the pastoralists' own perception of the range resource and its management. The Timahdite study is establishing a framework for selecting the most feasible means of achieving an improvement in the stocking rates and seasonal use of collective rangelands. It is based on how the pastoralist understands the notion of stocking rates and seasonal grazing, and how that understanding influences their current range management practices.

The study has centered on the Ait Ben Yacoub, one of four fractions composing the Ait Arfa du Guigou tribe which inhabits the Rural Commune of Timahdite. The fraction comprises about 350 households, most of which engage in agro-pastoral activities. They own about 25,000 sheep which graze 8,000 ha of collective land to which the fraction holds exclusive grazing rights, another approximately 8,000 ha of collective land shared with the other three fractions of the tribe and about 6,000 ha of forest. Residues of cereal crops and fallowed fields on approximately 2,000 ha of cultivated land constitute their principal off-range forage resources. The combination of collective rangeland, cultivated land and forest is the base of the agro-pastoral exploitation upon which the fraction subsists. An important dimension that must be recognized is the collective status of most of the rangelands in the study area. It is not uncommon in the exploitation of common range resources to find that a specific, closed group that is more or less homogenous has exclusive grazing rights, and that all individuals composing the group have access to all the resource.

Our preliminary investigation indicated a marked contrast with this model of common resource exploitation: herdsmen external to the tribal group holding grazing rights to the collective have established themselves in the community and assumed de facto rights to the rangeland; herd sizes in the collective vary from several to several thousand sheep; and herders regularly use specific areas of the collective regardless of the quality or amount of forage available, indicating limited access to the whole. It is still too early to make conclusions on the key elements in the pastoralist's perception which could lead to recommendations on how best to plan development schemes for implementation.

Significance of Research Findings

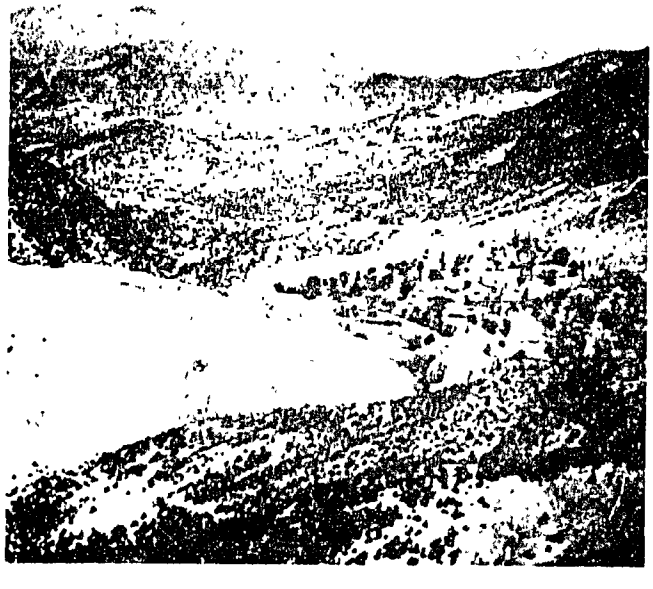
Our knowledge of the effect that stocking rate of rangelands has on plant composition and sheep nutrition and our understanding of sheep diet preferences on mountain rangelands in Morocco has grown steadily since 1979 when studies were initiated on the Timahdite Range Research Station. The dominant plant species have been identified and their nutritional status determined by season of the year. The preferences that sheep have for native range plants has been analyzed seasonally on areas that have been severely grazed for many years, on areas that have been protected for one to two years, and on pastures grazed at various rates for up to four years. Sheep performance under these grazing rates has also been addressed. Many of the plant species found to be both dominant in the pastures and preferred by sheep are species native to Morocco which have been brought to the US and genetically improved over time. As the need arises for seeding of localized disturbances in the native plant cover, information now exists to guide the choice of species that might be selected which will be both adaptable and preferable. Though these studies will be continued to better understand how grazing rate affects plant composition and thus animal performance, considerable information now exists to guide managers of Moyen Atlas mountain grasslands.

Baseline data collected to date in the sagebrush grassland is beginning to provide solutions to technical problems and is already entering into management decisions, particularly on seeded rangelands of Plaine de l'Aarid. Studies in the oak woodland are in the initial stages and have primarily provided a basis upon which to determine direction of future research.

Future Research Directions

The research program in the oak woodland will be continued to complete baseline information on the forest forage resources and the nutrition of grazing animals. This information will permit the establishment of a management plan for these forested areas. Specific research that is proposed includes: a determination of the dietary botanical composition made in February, April and June by the bite count method; measurements of forage availability and nutritional characteristics of the forage made on the same seasonal basis; the effects of defoliation intensity on oak seedling survival; a comparison of the *in vivo* digestibility by sheep and goats of three diets containing different proportions of ground oak leaves and oat hay; investigation of the potential tannin toxicity for sheep and goats; *in vitro* evaluation of dry matter disappearance of alfalfa hay substrate after 24 hour incubation. Nitrogen retention will also be compared in two groups of sheep and goats infused with tannin solution and with solvent alone. Blood will be analyzed for blood urea nitrogen and an attempt will be made to correlate this parameter to dietary digestible nitrogen. These studies will be undertaken by Fourth Year Meknes students and Third Cycle students from Rabat. A study to be initiated in 1983 by Walt Schacht involves the response of the herbaceous layer to the thinning of dense oak tree stands and the significance of the resulting food availability to foraging livestock. A secondary interest is to investigate how well relative foraging efficiencies and relative times spent feeding on certain food items reflect nutrient intakes of these items. Does the amount of time spent feeding on one food item as opposed to other food items indicate its position along a relative scale of preferability and its nutrient intake? Ability to interpret the movement patterns of grazing animals in response to nutrient intake would greatly facilitate a livestock grower's attempt to maximize animal production.

Work within the sagebrush grassland will include work at two locations. At Ain Beni Mathar baseline information on vegetation and grazing animals existing under present management practices will continue to be collected. The effect of three stocking rates of ewes and lambs will be evaluated beginning in 1983. Measurements of forage utilization, animal selectivity and productivity will be made on a monthly basis during the March to June period. The potential for range improvement through planting shrubs will also be explored. At Plaine de l'Aarid an attempt will be made to improve our understanding of responses of *Artemisia herba-alba* to environmental factors and to management, which will help in selecting better management schemes for areas of *Artemisia* range and will be of value in determining the possibility of using *Artemisia herba-alba* in reclamation of deteriorated arid rangelands. Specific studies will include germination and seedling development under different conditions of temperature and water stress in a controlled environment, defoliation effects on survival of the seedlings and on the mature plants, plant and animal responses to two grazing systems and four levels of stocking,



The High Atlas Mountains of Morocco have little vegetation other than brush. Villagers living in areas seen in the center of the picture rely on sheep and goat production to supplement their meager diets and incomes. Photo: W.C. Weir.

and the comparison of *Artemisia herba-alba* plant population characteristics under different histories of use, i.e., continuous grazing with a high stocking rate, protection for five years, protection for 15 years, and cultivation.

Laboratory research to be conducted in Rabat which has implications for many areas in Morocco, is to identify the establishment characteristics of selected range plant species to assess their possible use in range seeding programs. Plant species selected will be two grasses potentially important for arid rangelands (*Digitaria commutata* Shult and *Cymbopogon schoenanthus* (L.) Spreng), a shrub *(Cistus laurifolius)* of possible value in more humid areas.

Training

No Moroccan students will be funded in the US due to the fact that the Minnesota Higher Agricultural Education Project is funding all available qualified students. US graduate students are supported by other funding sources while in the US due to limited funds allocated to this project.

Training support has therefore been provided to US graduate students who are gathering data overseas for their research and Moroccan students enrolled in Moroccan institutions who are actively engaged in SR-CRSP activities. US students supported by the Range Management Project while in residence in Morocco are: Neil Artz, Val Jo Anderson, and Walter Schacht. Eight Third Cycle students from IAV, Rabat, have received (or are receiving) project support for their theses work. They are: A. Chergaoui, A. Boudiab, El. M. Darfaoui, M. Harkousse, M. Chami, A. Chryaa, M. El Honsali, and T. Ait M'hand. Fourteen fourth year (BA equivalent) Meknes students have also received partial support for their degree work. They are: A. Doukkar, Mr. Othmani, Mr. Belarbi, Mr. Bouksim, Mr. Guermai, Mr. Khettabi, Mr. Lamtaibi, B. El Bare, S. Ben Omar, Mr. Hansal, Mrs. Traore, Mr. Dembek, F. El Assri, and A. Kabak.

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Cheragoui, A. 1982b. Literature Review of the Effect of Stocking Rates on the Vegetative Dynamics: (1) Dietary Preferences of Animals on Pasture; (2) Nutritive Value of the Diet on Pasture; (3) Animal Performance on Pasture. 3rd eme Cycle, IAV, Hassan II. Rabat, Morocco.

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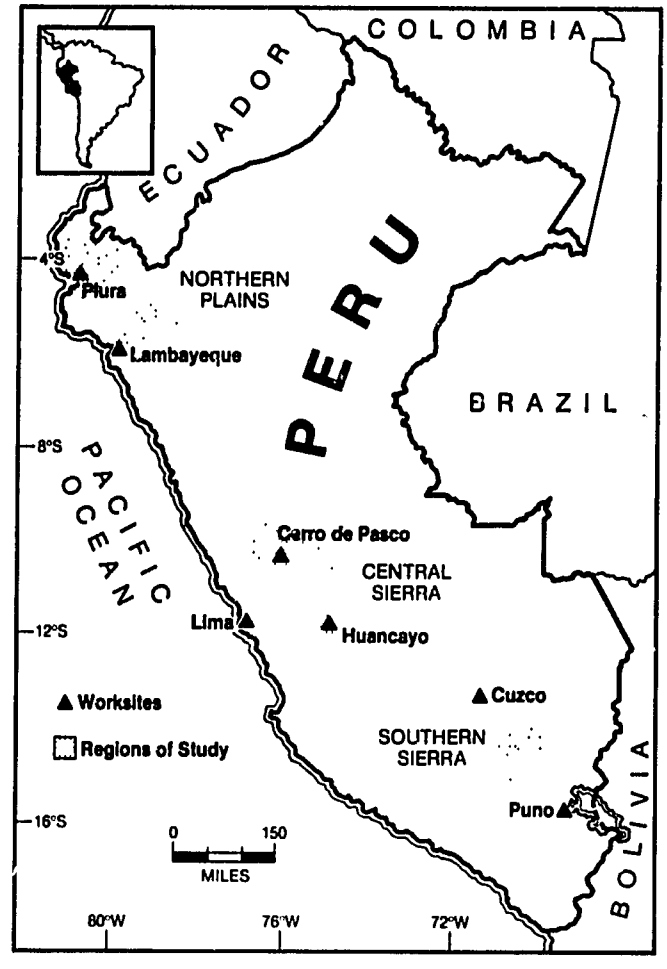


Location of Small Ruminant CRSP research sites in Peru.

More than 2,000 indigenous Indian communities, totalling nearly 350,000 families, live in the semi-arid Sierra highlands of the Peruvian Andes. Most of these communities are autonomous villages, but some are associated with large cooperative agricultural units, Sociodad Agricola Interes Social (SAIS), which were created by the Agrarian Reform Movement a decade ago. The SAIS generally comprise one or more former haciendas and a number of the surrounding indigenous communities organized into coordinated production units. They own 75% of all the agricultural land in the Sierra with holdings commonly found at elevations between 12,000 and 18,000 feet. Only about 2% of this land is arable. Frost, hail, and snow threaten crops grown at all but the lowest elevations. Where planting is possible, the Indians primarily cultivate corn, quinua, and potatoes. With 98% of their land suitable only for pasture, if it is indeed usable at all, the Highland Indians are very dependent on their livestock, particularly small ruminants, for food and cash.

The *puna*, the natural grazing land of the high Sierra, has an estimated area of about 24 million hectares. The largest areas of this pastoral land are found in Junin, Huancavelica, and Puno, with important areas also in Cajamarca, La Libertad, Ancash, Apurimac and Cuzco. In Puno, the highlands level out to true *altiplano* around Lake Titicaca where it supports a mixed crop-livestock system of agriculture. From Cuzco northward, however, the *puna* is suitable only for grazing, with crops limited to the lower elevations. Although soil quality is generally good and the average total annual precipitation is normally adequate (800 mm), the extended dry season (May-October) coincides with the coldest months and causes serious reduction of pasture growth. Winter temperatures range from -5° to 14°C and summer temperatures from 5° to 17°C.

Despite these constraints, there is potential for forage improvement in the nearly level valleys at the lower elevations around 13,000 feet. Irrigation is possible in these areas, white clover and other legumes can be introduced with little liming, and perennial and annual ryegrasses grow well with adequate water and fertilizer. Evidence that this type of pasture improvement is feasible can be witnessed on the SAIS Tupac Amaru. This unit, comprised of 16 surrounding communities and an internal cooperative, demonstrates the successful use of irrigated pasture in a high intensity, low frequency, rotational grazing system.

The small ruminant population in Peru comprises approximately 15 million sheep, 2 million alpaca, 2 million goats, and .5 million llama. These animals are at least dual-purpose and more usually multi-purpose. Goats, found primarily along the coast, provide meat and cheese; fiber and meat are provided by llama, alpaca and sheep. In addition, alpaca provide hides and llama are used as pack animals at high altitudes. The expanding market demand for lamb in Peru has caused sheep to become increasingly important as meat suppliers in addition to their traditional role as export wool suppliers. The alpaca, despite its contribution to the economy, has not been nearly as well researched as the sheep, and as the world demand for alpaca wool grows, it will become increasingly more important to acquire the knowledge necessary to improve the productivity of this small ruminant, so uniquely adapted to the high Andes.

The primary animal husbandry system encountered in the high, semi-arid areas of Peru is extensive range production of sheep and alpaca. The increasing human population adds pressure to an already overburdened production system which may result in permanent damage to this delicate ecosystem. Small ruminant production in the high Andes has not been extensively researched and knowledge about those components of the system which critically affect animal productivity and product distribution is lacking. It has been common experience in the past that interventions designed to solve agricultural problems have frequently resulted in a negative rather than positive impact on the small farmer. Part of the reason for this lies in an inadequate understanding of the complex balances of the existing production system. A specific objective of the Small Ruminant CRSP is to focus research on the potential impact of improved technology in order to achieve the intended goal of improving the living standards of smallholders.

The scope of the biological constraints to production that the SR-CRSP is tackling in the Peruvian Andes is necessarily broad if the problem of low productivity is to be solved. For example, research on constraints spans such diverse topics as: describing the individual animal's performance to assess genetic potential of indigenous breeds; developing an understanding of the reasons for poor reproductive rates in native flocks; establishing a profile of the disease incidence ranked in order of economic importance and measures to control major disease; and improving cultivated forages to maintain livestock in the deficit periods on the natural range.

An important component of the small ruminant collaborative effort will focus on integrating economic and sociological factors with biological data obtained in the field, both to delineate the current small ruminant production systems and to develop coherent recommendations for improving animal productivity and marketing efficiency. These recommendations will consider how the elements which comprise the various production systems operate in relation to each other to influence the functioning of the overall small ruminant production system in Peru. Towards this end, all project participants have cooperated on a baseline study to characterize the entire small ruminant production system in the Andean highlands, the data from which will be useful to each project in designing its research agenda and making recommendations for improvements to the system.

This collective approach to confronting the severe constraints upon animal productivity in this harsh and isolated environment has facilitated the development of an integrated research endeavor which views the various agricultural problems of the region from a comprehensive, rather than isolated perspective.

Although the official collaborating institution for these research endeavors has been the Instituto Nacional de Investigacion y Promocion Agropecuaria (INIPA), the program has worked closely with two universities on most of its projects: the National Agrarian University (UNA) at La Molina and the Institute for Tropical High Altitude Research (IVITA), a subsidiary of the Veterinary Department of San Marcos University in Lima. A complete listing of projects and collaborating institutions is given in Appendix IV.

Evaluation and Genetic Improvement of Sheep and Goats in Extensive Management Systems

R.L. Blackwell
Montana State University

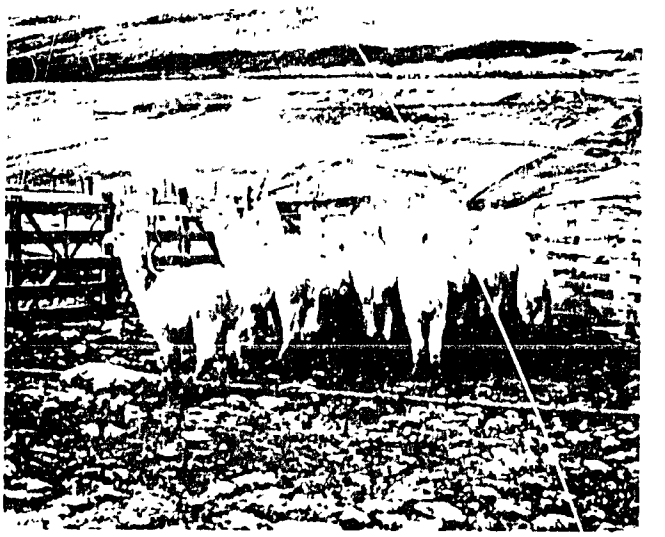
Historically, wool production has received major attention in most sheep improvement programs in Peru, but in recent years incorporating higher genetic capability for meat production from sheep has increased in priority, a reflection of the increased relative value of meat. However, productivity of sheep in Peru still remains low principally because growth rates and reproductive rates are low. Improved sheep are produced primarily by large enterprises and make up about 20% of the 15 million Peruvian sheep population, and breeding programs that utilize modern breeding technology are found at a number of these enterprises. The remaining 12 million sheep of native or criollo type are in the hands of the small farmer where improvement efforts for meat and fiber production have been very limited.

Alpaca, the most numerous and economically most important of the South American cameloids in Peru, is produced primarily for fiber and secondarily for meat. This species has received limited attention in animal breeding research but its economic value to the region justifies its inclusion in the Breeding Project.

Launching a small ruminant breeding program in Peru, with small producers as target beneficiaries, has been hampered by the paucity of scientific information on the performance of existing breeds or types of livestock. Projects to evaluate existing breeding programs and breeding stocks were required to establish data for future reference and to estimate population parameters needed to sharpen selection methods and breeding procedures appropriate for the Andean conditions. Performance testing programs, progeny tests and breed evaluation projects were needed to provide the necessary experimental data and to make the desired comparisons. Evaluation and identification of breeding stock with high genetic potential and the further improvement of these stocks was considered to have research priorities nearly equal in importance to the procurement of sound experimental data.

The general objectives of the Breeding Project have been:

- to identify breeds or stocks of animals with high genetic potential for increasing meat and fiber production under extensive management conditions in the Andean region;
- to develop appropriate animal breeding methodology for the region and demonstrate its effectiveness in the production of superior breeding stock;



An experimental flock of alpaca at SAIS Pachacutec provides opportunities to study factors that affect productivity of alpaca wool. Photo: W.C. Weir.

- to develop methodology for utilizing superior breeding stocks to improve the productivity of indigenous herds and flocks; and
- to provide the opportunity for training in genetics, animal breeding and livestock husbandry for university students and other professionals.

Research collaboration was established with Universidad Nacional Agraria (UNA), La Molina, and with Universidad Nacional Tecnica del Altiplano (UNTA), Puno. Limited research with IVITA has been undertaken using existing alpaca data from the La Raya Station. UNA has limited physical resources for animal breeding research but through excellent working relations with SAIS Tupac Amaru, SAIS Pachacutec, and Central de Cooperativas in the Central Sierra, large populations of experimental animals were made available to the project. UNTA has an excellent research facility in the *altiplano* region of the Southern Sierra for sheep breeding research, and faculty and students of high capability and interest have contributed greatly to project effectiveness. Managers of the SAIS and Cooperative have contributed ideas and enthusiastic support in land, labor, and experimental animals.

Research Accomplishments

The Project's major accomplishments include: training students and organizing a team of researchers and technicians to carry out the research; establishing experimental populations of sheep and alpaca; developing procedures for routinely obtaining growth, reproduction and wool production data; and setting up a data management system for efficient storage, retrieval, and analysis of large quantities of data using the computer at UNA.

Sheep

The sheep breeding projects are located at three sites: SAIS Tupac Amaru and the Central de Cooperativas in the Central Sierra, and at the Chuquibambilla Station in the *altiplano* of the Southern Sierra. The breeding ewe population totals approximately 8,000 animals, their progeny, and approximately 2,500 rams. All animals are identified with numbered ear tags; the dams are known and in a majority of cases the sire of the offspring will be known. In all projects, progeny performance data include reproduction and lamb producing ability of daughters (maternal ability), growth rates, and wool production of all offspring. Control populations have been established at two locations.

The first project, undertaken at the Central de Cooperativas, was a comparison of the two prominent breeds in Peru, the Corriedale and the Junin, using six rams of each breed mated to approximately 30 ewes each. This breed comparison was repeated a second year. A second breeding comparison, also replicated over two years, evaluated a selection and classification system used by SAIS Tupac Amaru. The objective was to determine whether or not there were real differences between aggregate breeding values of samples of rams from two of the several classifications used, "Super" and "A." Both classes are considered to be well above average in merit for growth and wool production, with the "Super" class being judged superior to the "A" class. This breeding comparison also included a third group of rams from a flock of ewes that had been selected for twin producing ability over a period of about eight years. Twinning in ewes is generally considered to be economically important, and since twinning is rare in the high elevations of Peru, this flock of about 350 ewes might be considered unusual. The important question is whether genetic differences useful for reproduction have accrued as a result of selection in this group compared to other breeding groups of Junin ewes that have not had selection pressure applied for twinning. The results of these studies are found in Table 1.

Table 1. Effect of Ram Source on Lamb Weights and Fleece Production

	Birth Weight (kg)	Weaning Weight (kg)	8-Month Weight (kg)	8-Month Fleece Weight (kg)
Number	986	815	302	400
Super	3.6	24.6	29.4	1.36
"A"	3.5	24.3	29.0	1.38
Twin	3.6	24.6	29.3	1.36
Number	264	232	203	207
Corriedale	4.0	18.0	21.5	1.25
Junin	4.0	17.8	22.9	1.17

The data consisted of growth and wool production records in both experiments. The differences between the progeny of the two breed groups of rams are very small. The tentative conclusion is that the samples of rams tested were not genetically different for those traits. Presumably the breeds they represent (Corriedale and Junin) do not differ greatly. The comparison between the "Super," "A" and "Twin" groups also indicate that no important differences exist between those three breeding groups. The most worthwhile results, still forthcoming, in both comparisons are expected from data on the lamb producing ability of the daughters. These experimental groups of females are being mated for the first time during the 1983 breeding season.

In the course of these breeding comparisons production data have been collected from sizeable samples of sheep in the Central Sierra. These data are summarized in Table 2 and appear to be reasonable norms for the Corriedale and Junin breeds in the Central Sierra of Peru. Similar production data on the native sheep are not yet available on this project. In some cases, location and management differences were involved which were generally substantial, suggesting important management and/or environmental effects. There is significant variation among animals within groups, as indicated by the standard deviations for the various production traits.

Table 2. Production Levels for Junin and Corriedale Sheep in the Central Sierra of Peru.

	Mean and Standard Deviations
Mature ewe weight at breeding (May)	48.0 ± 4.60 kg
Mature ewe weight at shearing (February)	36.0 ± 4.60 kg
Fleece weight, mature ewe (12 months)	3.8 ± 0.50 kg
Staple length, mature ewe (12 months)	9.0 ± 1.34 cm
Birth weight	4.0 ± 0.63 kg
Weaning weight (4-5 months)	22.0 ± 3.47 kg
Lamb weight (8 months)	25.7 ± 3.07 kg
Lamb fleece weight (8 months)	1.3 ± 0.23 kg
Staple length, lamb fleece	9.2 ± 1.05 cm
Ewes lambing of those at mating	82.0 ± — %
Lambs weaned per ewe at mating	71.0 ± — %
Twin births	0.9 ± — %
Weight of lamb weaned per ewe at mating	16.2 ± — kg

Our studies of data previously collected on sheep in Peru indicate that the heritabilities of some growth and wool production traits are similar in published values from other countries. Genetic progress from mass selection should result if selection intensity is great. However, the evidence from the ram selection and classification system (Table 1) suggests that the selection intensities probably are not very great, even in the better managed flocks. Traits other than growth and fleece production are probably given considerable emphasis in selection decisions.

Data collected on breed comparison and ram selection and classification projects were analyzed to obtain estimates of certain non-genetic effects from which to develop correction factors for adjusting records prior to their use in breeding management decisions. Comparisons have been made between the magnitude of the effects of age of dam and sex of lamb found in this study and published results from other regions where growth rates were greater. The effects on birth weight and weaning weights were similar in trend to published results but smaller in absolute magnitude. The effects appear to be somewhat proportional to weight attained. This suggests that correction factors should be multiplicative rather than additive. These relationships are shown in Figures 1 and 2 for weaning weight. Clearly, these results indicate that correction factors should come from records on populations to which they will be applied.

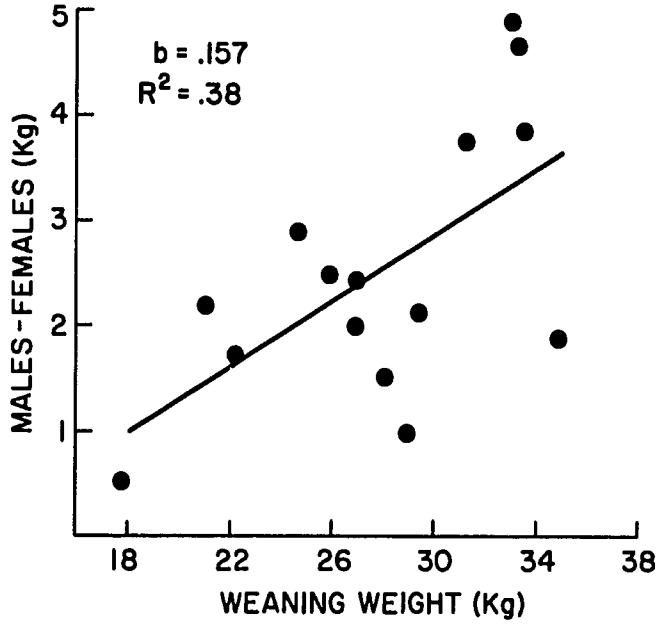


Figure 1. Relation between mean weaning weight in sheep and the difference between weaning weights of males and females. The 15 data points came from published reports and the research in Peru.

Low rates of reproduction and growth are important limiting factors in meat production by Andean sheep. Under better management conditions only about 71 lambs are weaned per 100 ewes mated (Table 2). This is due to the high proportion of ewes that do not lamb at all (18%), to extremely low twinning rates (0.9%), and to death loss from birth to weaning, which is substantial. Growth rates are low and weaning weights at five months are about 22 kg. This low weaning weight and poor reproductive performance results in only 16 kg of lamb weaned per ewe mated. Some of these production parameters may not be greatly different from those found under extensive range conditions elsewhere. A notable exception is the low prolificacy.

Considerable attention is being given to studying the role of heredity in reproduction among Andean sheep. Breed of sire comparisons among groups of Corriedale, Junin,

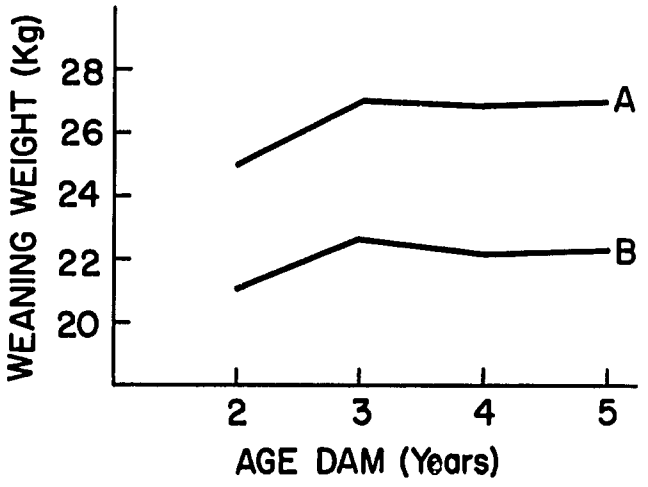


Figure 2. General effect of age of dam on weight of lambs at weaning in Peru (B) is compared to that found in other locations where weaning weights are greater (A).

Targhee, Finn x Targhee and Criollo rams were initiated in 1981. The purposes were to determine if ewes with 25% Finn genes will have higher reproductive performance in the high elevations of Peru than Corriedale, Junin or Criollo ewes and to obtain data to investigate genotype x environmental interactions relative to the environments of Montana and Peru. This mating plan has resulted in the production of experimental populations of females that carry 25% Finn genes and those with no Finn genes. Under conditions in Montana and Idaho, genetic change of this magnitude increases lambing rate by about 30 percent. There is, however, some reduction in wool production. Daughters with Finn genes and their contemporaries with other genotypes will produce their first lambs in 1983.

Research with the "Twin" flock at SAIS Tupac Amaru has resulted in improved data recording for research purposes. Management and nutrition for this flock is probably better than average for the SAIS through the use of cultivated pastures, and twins are being produced in significant numbers. The experiment to investigate whether this flock is genetically different from the Junin breed generally for twin production will continue. The first daughters produced in this experiment will lamb in 1983. Research has just been initiated to further clarify the genetic and environmental (nutritional) components responsible for twin production in this flock.

Experimental Criollo flocks have been assembled at three locations to test their performance in direct comparison with Corriedale and Junin ewes. By evaluating the Criollo ewe under the same management conditions as the improved ewes, we should determine whether or not their low production in community environments is due to adverse production management. Evidence regarding their genetic potential will be obtained, especially lamb production performance.

A progeny testing program was initiated in 1982. Each year, young rams will be selected from large groups of performance tested rams 16-18 months of age and mated to a

large test flock of ewes. About 50 rams are selected each year at SAIS Tupac Amaru from approximately 2,000 rams and mated to approximately 4,000 ewes, using natural mating under controlled management. At the Chuquibambilla Research Station, 15-16 rams are selected from approximately 500 performance tested rams and mated to approximately 2,000 ewes using artificial insemination. In the long term this project will produce large amounts of research data and will also document the effects of simple selection procedures for the improvement of meat and wool.

Alpaca

The alpaca flocks at the La Raya Station contribute data for breeding research and have provided useful information. A replicated, single trait selection experiment initiated in 1981 at SAIS Pachacutec in the Central Sierra uses a herd of 1,200 breeding females. Staple length of wool and growth rate are the individual traits for which selection is practiced, but evidence of correlated responses is being obtained for other traits of economic importance.

Analysis of alpaca data has given results that encourage mass selection for fiber production and growth. The estimated heritability of yearling body weight was 0.55-0.69 and of first fleece weight was 0.22-0.35. The genetic phenotypic correlations between fleece weight and body weight were -0.03 and 0.50, respectively. Estimates of the phenotypic correlation from another data set suggest a value substantially lower (about 0.10). Heritability of birth weight and weaning weight (7-8 months) were 0.53 and 0.39, respectively. Prediction of future fleece weights from first fleece weight should be fairly accurate as indicated by repeatability estimates in the order of 0.60. Body weight data show a steady increase in weight from birth (about 7 kg) to a maximum mature weight at five or six years (about 60-65 kg). Staple length (12 months growth) tends to decline with age as does fleece weight. The phenotypic correlation between fleece weight and staple length, within ages, was estimated to be 0.30. Age of dam had an effect on offspring birth and weaning weights. Offspring from five year old dams were 1.0 kg heavier at birth and 1.5 kg heavier at weaning than were offspring from three year old dams (first parity). Dam's body weight, within an age group, was positively correlated with offspring birth weight ($r = .25$) and weaning weight ($r = .36$).

Significance of Research Findings

Breeding Project research in Peru has been directed largely at seed stock production problems. The application of simple and objective performance testing procedures for meat and wool production have been employed so that results obtained can be adopted directly by others with limited cost. By setting in motion large scale performance testing and improvement programs in some of the large enterprises and research stations, breeders can quickly identify good breeding methods and good breeding stock. Populations can be expanded and improved. Genes from these stocks can subsequently be transferred to less productive native flocks. This organizational approach to improvement programs for the region seems logical, given the existing division of animal resources among the large enterprises and small farmers. Import of breeding stock continues even though the present genetic base is considered broad enough and large enough to make genetic improvement independent of further imports. Experimental needs for exotic stocks continue, of course, but this should be done with care and objectivity. One great need is the development of breeding policy and goals and the organization to accomplish them.

The Project has laid the foundation for assessing the importance of quantitative genetics in the overall production system. Experimental populations have been developed and are yielding useful production data. Data management systems have been established. It is anticipated that this program will be the nucleus for a regional breeding program that can be utilized both by private breeders and government agencies to develop long range programs and policies in livestock improvement.

The experimental populations are available to other projects and disciplines so that research can further identify production constraints and develop and test production and management systems to improve total productivity. The experimental flocks are of sufficient size to accommodate a reasonable number of research variables in addition to those of immediate concern to the breeder.

Research results with sheep reveal the limited selection effectiveness even in well managed flocks. This indicates the need for simple and accurate selection indexes that are highly goal oriented and that emphasize only the economically and biologically important traits. Alpaca research clearly shows that heredity has substantial effect on fiber production and growth. Some aspects of color inheritance in this species have been clarified to a limited extent but the importance of heredity in reproduction in this species has not yet been studied by this project.

Future Research Directions

The research program has been established at three major and two minor sites. It is planned to continue the work at the major sites; one with alpaca and two with sheep. Resource availability and expectations of useful information being derived at each site will be factors in determining the fate of research at the minor sites.

The mass selection research with alpaca is by nature a long-term project. It will be continued as planned with the basic objective to achieve genetic improvement by single trait selection for staple length and growth rate. Data on other traits of economic and biological importance will be recorded so that correlated responses can be determined in those traits for which no deliberate selection was practiced. There are no specific plans to proceed with color inheritance studies since other traits appear to have higher priority for breeding research with this species.

Sheep breeding research will be maintained near the present level, but an increased effort will be made to incorporate the recording of more observations on reproductive traits in particular, and to insure that all important

Targhee ram—one of 14 imported to Peru to provide an experimental link between the Finn evaluation project at Bozeman, Montana, and the breeding evaluation of Corriedale and Junin breeds in Peru. Photo: R. Blackwell.

aspects of growth and wool production are adequately addressed. The ability to accurately identify sires with high genetic merit for lamb production, expressed as daughter productivity, has high priority. If this proves to be successful, then incorporating artificial insemination as a tool in gene dissemination will be needed. Closer integration of the Breeding Program with the Reproductive Physiology and Animal Health projects is considered essential to the development of a viable breeding program with widespread application.

Sheep populations with Finn genes will be maintained and monitored to determine their long-term benefits to sheep production in this harsh Andean environment. It may be that the production of twins in relatively large numbers may not be economically desirable. The added management inputs that may be required, need to be evaluated economically before widespread use is made of Finn genes to increase prolificacy. This and other aspects of the Breeding Program will require close working relationships with the Economics Project to insure that economically sound breeding policy is developed.

The larger problem is that of genetically improving the indigenous sheep of the Andes that make up about 80% of the population. Evaluation of these sheep under good management conditions will continue. Improving the Criollo type sheep by selection or by introducing genes from improved breeds will be given high priority. However, it is obvious that management improvement will be necessary before breeding improvement can have a significant impact on much of this segment of the population. Programs to guide the small farmer in improvement and management of sheep are needed. Though the process and responsibility of developing programs to improve sheep production is logically that of government agencies or the universities, this project is able to assist by methodology, information, and guidance in the development of such programs.

Training

Improvement in Andean animal agriculture will be affected largely through research and education. This will require well trained professionals knowledgeable in local conditions, traditions and language. Therefore, training must be the keystone of the SR-CRSP. In Peru the opportunity for graduate training in animal breeding at the masters level is available at UNA. Several provincial universities and UNA also provide professional training beyond the BS in which the title of Inginiero Zootecnista is awarded upon the completion of research and a thesis. The Animal Breeding Program has given highest priority to professional training in Peruvian institutions for as many students as possible. This approach provides students with an excellent opportunity to participate actively in the research program and gain experience in animal production and management. The shortcourse method has been used as part of the training program and participation in the annual meetings of the Peruvian Association of Animal Production has been encouraged and supported by the project. Most students working in the project have presented results of their research to the scientific community. Updating of senior faculty members has been accomplished by providing the opportunity to attend meetings such as the American Society of Animal Science and the Latin American Association of Animal Production. On-the-job training has been used to provide experience for undergraduate students who work on the project during breeding, lambing, and shearing, and some English language training has been provided for selected students. One advanced student has started a PhD program at Montana State University in genetics and animal breeding.

Degree Related Technical Training

The following students are or have been associated with the project as graduate degree candidates or for post-BS training in pursuit of the title Inginiero Zootecnista.

- Humberto Rodriguez has completed the MS degree and is now teaching at the University of Huancayo.
- Gladys Huapaya expects to complete her MS degree in 1983. She is the principal person in data management. She has received on-the-job computer training as well as formal English language training.
- Prospero Cabrera expects to complete an MS degree in 1983. He is in charge of field work on the sheep research projects in the Central Sierra.

- Juan Roque, MS candidate, is in charge of field work on the alpaca research project.
- Juan Bueno, MS candidate, assists with data collection and field work on the sheep research projects.
- Diana Chavez and Gladys Garay are completing work for the title Inginiero Zootecnista, starting an MS program and assisting with data collection, data management, and analysis.
- Roxana Diaz is starting an MS program jointly in Animal Science and Economics.
- Eugenia Montecinos and Esther Lencinas are working toward the title Inginiero Zootecnista and assisting with all phases of research with sheep, primarily data collection and analysis, in the Southern Sierra.
- Juan F. Chavez is a faculty member at UNA, and has just begun graduate study at Montana State University in genetics and animal breeding.

Non-Degree Technical Training

This type of training included a one-week shortcourse in genetics and animal breeding attended by over 60 participants from the Ministry of Agriculture, University faculty, students and other professionals such as managers of SAIS and Cooperatives. Twelve to 15 students also receive on-the-job training each year serving as field assistants in data collection and animal management during the breeding season, at shearing, and lambing. This provides them with the opportunity to obtain practical experience in several phases of animal production on well-managed livestock enterprises and to gain appreciation for the experimental approach in animal production.

The Breeding Project has supported the compilation and publication of research work completed during the past 10 to 15 years by the Sheep and American Cameloid Program (Programa de Ovinos y Camelidos Americanos) at UNA. Three publications are planned; one each for sheep, alpaca, and vicuna. Approximately 500 copies each will be published in mimeographed form. Volume 1 on vicunas has been published" (1982). The other two are in progress and approaching completion.

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Blackwell, R.L., M. Carpio, D.D. Kress, and P.J. Burfening. 1982. Sources of Variation in Weights of Lambs in the Peruvian Andes. Abstract. ASAS.

Burfening, P.J., M. Carpio, D.D. Kress, and R.L. Blackwell. 1981. Reproductive Performance of Improved Sheep in the Central Highlands of Peru. Abstract. ASAS.

Carpio, M., M. Gamarra, P. Cabrera, G. Huapaya, P.J. Burfening, D.D. Kress, and R.L. Blackwell. 1983. Reproduction, Growth and Wool Production of Junin Sheep in the Peruvian Andes Abstract. ASAS.

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Improving Small Ruminant Nutrition, Management and Production Through Management of Native Range and Improved Forages

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Small ruminant livestock production in Peru is concentrated in the high *puna* grasslands (3,500 m) of the Andean range. Some large sheep and alpaca ranches exist on these slopes and in the high valleys; however most small ruminants are owned by campesino farmers who live in small villages, subsist on cropping irrigated and marginal land, and depend on native rangeland to graze their animals. Livestock production is closely integrated with traditional cropping practices. Common use grazing of several livestock species is usual, with dairy cattle, and beasts of burden such as llama, oxen, and equine stock frequently found grazing together with sheep and alpaca.

Range/forages research in Peru was noticeably limited at the beginning of the SR-CRSP in 1979. Besides lack of funding support from Peruvian institutions for this research, there were only 3 scientists in the entire country with any training in range science beyond the bachelors degree. This finding was remarkable considering that 1) most smallholders are pastoralists who graze animals for their subsistence, 2) an estimated 95% of the millions of small ruminants in the Andes depend on native range for at least part of their daily forage consumption, and 3) overgrazing and mis-use of range has resulted in a plummeting range condition and forage production and a corresponding dramatic rise in loss of fertile topsoil. Furthermore, cultivated improved pastures were also mis-managed and not used in the most effective manner to benefit large numbers of animals.

Reversing this trend, or at the very least maintaining current productivity, was our broad goal as we designed our research objectives. These centered around proper stocking rates of small ruminants, improved grazing management practices in both native range and improved pasture, and enhancing the nutrition of free-ranging animals. Range management schemes are technically feasible which will not only provide more forage than is presently available but could also maintain currently high stocking rates. Complementary grazing systems are also a practical alternative to

manipulate range vegetation to make them more productive for small ruminants. The appropriate use of cultivated forages, especially in irrigated fallows, could open up the nutritional bottlenecks of the dry season, further increasing total livestock production. But in developing these objectives, we have tried never to lose sight of the fact that the intended beneficiaries are the limited resource pastoralists and farmers.

The broad objectives of the Range Project have been translated into the following specific research tasks:

- To inventory the range resources at the research sites.
- To determine the seasonal variation in the range forage quality.
- To determine the diets and forage preferences of sheep and alpaca grazing the rangelands.
- To evaluate the long-term impact of grazing practices on animal performance and the native vegetation.

When Texas Tech was asked in 1982 to absorb the research project on improved forages from Ohio State University, the research tasks facing us were expanded to include:

- Evaluation of the potential of various grasses and legumes based on their establishment, productivity, nutrient quality, and persistence in a cold, harsh environment, with and without the benefit of irrigation.
- Evaluation of cultivated forages as a supplement to the vast hectares of native range at critical times in the life cycle of small ruminants (i.e., breeding, late gestation/early lactation, and their combined stress periods).
- Evaluation of appropriate grazing regimes to more effectively use cultivated forages for the greatest number of animals as a supplement to native range. Examples of trials include the optimum number of hours of grazing/day and optimum number of days of grazing/week.
- Determination of the optimum degree of defoliation and interval of rest from grazing that results in long-term maintenance of extremely expensive pastures of improved forages.

Throughout our research program, we have sought to reach our institution-building goals by working collaboratively with other US institutions involved in the SR-CRSP in Peru; by providing support for training Peruvian scientists and students; and by helping develop small ruminant experimental research centers (ERC) in Peru.

Research Accomplishments

Livestock grazing management research requires strict control of both land and animals to ensure that study pastures are grazed and rested according to predetermined schedules. The opportunity to pursue this approach was provided by our collaborators at the IVITA Camelid Research Center at La Raya (Cuzco), the UNTA livestock research facility at Chuquibambilla (Puno) and the SAIS's "Pachucutec" (Lima) and "Manco Capac" (Puno). At each of these ranches, generous collaboration has been offered in the form of land, labor, and improved livestock. This welcome state of affairs allowed our Peruvian field studies to be larger and better equipped than our budgets would otherwise have supported. We were also able to conduct more small, short-term research projects within this larger framework.

Nutrition Laboratory

In order to accelerate the nutritional evaluation of range and improved forages in the Southern Sierra, a capital investment of over $75,000 was made in 1980 to develop a nutrition laboratory. This decision was questioned at the time, but 1 to 2 years later the lab began to bear fruit when, in early 1983, the first samples were processed. This was accomplished through the diligent work of Dr. A. Schlundt and Luis Carlos Fierro, long-term project residents.

Range

Our first ERC, located at SAIS Pachacutec, Corpracancha, is providing baseline animal and vegetation data on stocking rates of 1) sheep under short duration grazing (an experiment not even duplicated in the US), 2) sheep alone under continuous year-long grazing vs. short-duration grazing, and then compared with sheep and cattle grazing sympatrically under a short-duration system, and 3) sheep grazing fertilized range. Two years of data collection were completed in March of 1983.

Some key research findings during the first year illustrate the effects of stocking rate and management practices on liveweight gains. Lamb birth weights decrease with increased stocking rates. The highest lamb crop at birth (85%) and weaning (85%) was at a stocking rate of 4 ewes/ha, but this same stocking rate had the lowest average daily gain (ADG) (0.128 kg/day) and 150-day adjusted weaning weights (AWW) (22.5 kg/lamb). The highest ADG (0.163 kg/day) and AWW (28.4 kg/lamb) was at the lowest stocking rate. The stocking rate of 4 ewes/ha produced the most kg of lamb/ewe at weaning (19.1 kg of lamb/ewe). In comparing grazing strategies, lamb birth weights were highest in sheep rotation (3.9 kg/lamb), followed by continuous grazing by sheep alone (3.6 kg/lamb), and then complementary (sheep plus cattle) grazing (3.2 kg/lamb). Average daily gain and 105-day adjusted weaning weight was highest on the sheep rotation (0.135 kg/day and 23.8 kg/lamb, respectively). Respective lamb production/ewe was 15.5 kg, 14.4 kg, and 13.8 kg/ewe on the sheep rotation, continuous, and cattle and sheep rotation. The fact that lamb gains were not dramatically suppressed until stocking reached 6 ewes/ha suggests that animal performance can be maintained at stocking rates up to 4 ewes/ha, 33% above what is currently recommended for that particular site. However, if cattle and sheep are grazed together in a complementary grazing scheme, extreme care must be taken to avoid overstocking cattle.

One of the most important aspects of evaluating grazing management is its impact on native vegetation. Ivan Lares, thesis student at UNA, is shown clipping vegetation in experiments to determine the sustained productivity of range plants. Photo: F.C. Bryant.

An intensive study on the description of range sites was completed by Brad Wilcox in December 1982 (MS thesis). This research detailed the important interrelationships between soils and plant communities and resulted in the delineation of sites by their potential to produce range forage. The most productive of the sites were on saturated Histosols and on Argic Pachic Cryoborolls that produced during peak production 2,714 and 2,730 kg of green biomass, respectively. Peak standing crop was highest in March and April and lowest in August. This data indicates that the range will carry only 1/3 as many animals in August compared to March and April. This suggests that marketing strategies need to be developed to remove young animals from the range in June in order to have enough reserve forage for adult animals to carry them through the dry season.

Baseline data on the botanical composition of adult female and young (tui) alpaca diets was determined at La Raya in a study by Ramiro Farfan from June to December 1981. Diets were determined using the micro-histological technique of identifying plant fragments found in fecal material. Adults consumed higher percentages of grass, while tuis foraged more on forbs and grass-like plants. Higher nutritional requirements of tuis for growth may explain this difference in diet selection. Selection of plant parts by adult and tuis was different from research results on other small ruminants in North America. Alpaca consumed leaf material at a fairly constant rate through the dry season. Stem material in their diets declined through the dry season, whereas, most studies on sheep and goats report an increase. The most remarkable finding was the relatively high consumption of seeds (up to 23% of the diet) which could explain how both female and growing alpaca cope energetically during the driest months when high quality forage is in short supply. This information suggests that it may be possible to supplement alpaca in the form of seeds, rather than meal, or blocks traditionally used in North America. Competition for forage between sheep and alpaca grazing in common may be a potential area of concern. Future studies on alpaca diets will require the use of fistulated alpaca to determine the nutrient quality of their diets.

To evaluate use of range vegetation by small ruminants on an important illuvial range site, a study was conducted at La Raya during the winter dry season of 1981. Mature sheep, llama, and two types of alpaca were stocked in small pastures for two separate 2-week intervals during the dry season to ensure heavy use of key forage species. Dominant grasses were *Festuca rigida, Stipa obtusa* and *S. ichu.* About 60% of the standing biomass (estimated at over three metric tons/ha) was an accumulation of previous years' growth. Dominant grasses were hardly used during the trials, and thus, could not be used as key species to compare use by the different livestock species. Differences ($P < 0.05$) in use were found between camelids and sheep while none were recorded between the three types of camelids studied. Lack of grazing of the dominant grasses under heavy stocking indicated that forage manipulation would be required to increase livestock productivity of this important type of range site. Thus, a follow-up study was initiated in May 1983 to evaluate the use of llama as manipulators of the taller bunchgrasses. Twelve llama were stocked in five pastures to simulate five levels of stocking (light, moderate, heavy, very heavy, and extremely heavy) in a rotation system of seven days grazing followed by 28 days of rest. The results of this one-year study will provide a stocking rate recommendation for ranchers to reduce tall grass dominance of sites through short-term intense llama grazing.

A pilot project to determine the optimum alpaca stocking rate of a single range site was initiated at La Raya ERC in 1981. Year-long, continuous grazing by alpaca from production flocks was studied stocked at 0.7, 1.0, 1.5, and 2.0 alpaca per ha per year. Livestock weights indicated that stocking rates should not exceed 1.5 alpaca/ha (Table 1).

Alpacas were also studied at La Raya to determine their activity budgets on pastures stocked at 4 rates (0.7, 1.0, 1.5, and 2.0 alpaca/ha). Observations were recorded during two 2-week periods in the early and late dry season with activities recorded at five minute intervals during daylight hours. Across stocking rates, feeding dominated the activity budgets at 78%, followed by walking (7%), sitting (6%), and standing (5%). The remainder (4%) was spent in miscellaneous activities. The time spent walking was inversely related to stocking rate while feeding time was directly related. Time spent suckling decreased significantly by the end of the dry season but was not affected by stocking rate. The activities of offspring closely matched those of their mothers although less time was spent ruminating.

In Puno, Juan Astorga and Al Schlundt organized four range site studies in grazing exclosures where vegetation productivity was determined. Also, in small pastures on two of the sites, vegetation consumption by sheep and alpaca was estimated. These studies were complemented by soil descrip-

Table 1. Alpaca Mother and Tui Weights (kg) as Affected by Stocking Rate

Stocking rate	1981					
	Early (6/1)		Late (9/4)		Difference	
(Alpacas/ha)	Mothers	Tuis	Mothers	Tuis	Mothers	Tuis
0.7	56.8	18.9	54.0	24.8	-2.8	+5.9
1.0	58.0	20.7	54.3	23.3	-3.7	+2.6
1.5	59.9	21.9	56.0	25.5	-3.9	+3.6
2.0	62.0	23.8	51.4	24.0	-10.6	+9.2

tions and subsequent forage quality analyses. For a long-term range improvement study, an overgrazed site at SAIS "Manco Capac" was selected. The study emphasizes range improvement through grazing management. Main variables of the experiment are grazing period, rest period, and stocking rates. Treatments are, in effect, simulations of individual grazing systems so long-term results will provide range trend information related to the many treatment combinations.

Two doctoral candidates from Texas Tech, Rich Reiner and Carlos Fierro, arrived in the Southern Sierra early in 1983 to begin field studies in small ruminant nutrition in the region. Reiner's project at La Raya will provide detailed information on nutritional factors which limit alpaca production on these ranges. Fierro's study includes a detailed characterization of local community grazing schemes and the seasonal status of sheep and alpaca nutrition under present management. These will provide a basis for recommending modifications of existing management practices.

In mid-1981 when SR-CRSP contingency funds became available for initiating the Northern Goat Project, Al Schlundt participated in the socioeconomic survey of the project and the subsequent data analysis. Three thesis projects were also completed as part of the Northern Goat Project and were supervised by Schlundt through faculty counterpart Villena (UNPRG). First, a range goat study attempted to rank browse species in goat diets by timing the browsing of each species during active feeding periods during the dry season (Table 2). Garcia demonstrated that in Olmos, goats made significant use of dried grasses and forbs even during the driest times of the dry season. Silva and Chafloque studied the range sites of Olmos, formulated a useful classification of them, and estimated their individual contributions to the total browse available for goats. Finally, Soto developed formulae to predict the browse and total shrub biomass available for four important shrub species in Olmos. When integrated, these three projects formed a coherent package of information for use by the Goat Project in formulating improved goat production strategies.

Table 2. Goat Diets (%) for Olmos, Lambayeque, as Estimated by the Proportion of Feeding Time Spent for Each Plant Species

	Month of Study							
Component	1	2	3	4	5	6	7	8
Feeding activity								
Budget (% time)	50	53	42	53	48	52	51	41
Plant species								
Algarrobo	10	10	14	2	0	1	3	1
Charan	2	1	1	0	0	0	1	1
Chicaz	0	0	0	8	11	9	2	3
Faique	33	35	36	8	11	9	11	13
Membrillejo	8	5	0	5	2	2	2	6
Overo	0	0	4	37	36	36	33	29
Pina de overo	3	2	1	0	0	1	1	2
Zapote	3	5	3	0	2	1	2	6
Annual grasses	41	42	42	39	37	41	45	40

Improved Forages

Texas Tech assumed the responsibility for work on cultivated forges in the spring of 1982. New studies that will be initiated in 1983 by long-term resident Luis Carlos Fierro pertain to evaluation of grazing regimes of cultivated forages, and the optimum defoliation and resting intervals of improved pastures.

Variety gardens were established at Corpracancha by Dr. VanKeuren and the Ohio State component in 1981. Data collection on these plantings have been continued by Dr. Arturo Florez and we now have over two years of information on production, height, vigor, resistance to cold, and nutrient quality. Table 3 reports the top three species in each category of evaluation. Based on all these parameters, Dr. Florez has recommended the following association for the environmental conditions (altitude, temperature, precipitation) at Corpracancha: *L. perenne* var. *Rauni* × *L. multiflora* var. *Lena* - *T. pratensis* var. *Redman.*

Using cultivated pasture to supplement ewes at critical times of the year appears to improve lamb crops but seems to have little influence on birth weights of lambs, except under rotational grazing (Table 4). For example, compared with ewes under rotational grazing who received no supplement but grazed native range, lamb crops at birth were improved from 60% to 90% by flushing them at breeding, and from 60% to 105% by adding a 6 week period on cultivated pasture during the last trimester of gestation and the first 8 weeks of lactation. Also, birth weight of lambs improved considerably by supplementing at either stress period. Comparing rotationally grazed ewes vs. continuously grazed ewes, lamb crops, lamb birth weights, and ewe weights were all higher if ewes were grazed under a rotational system and supplemental than continuously grazed ewes similarly treated (Table 4).

In addition to these animal production studies, tame pasture management research is returning useful data which will serve to recommend optimum stocking rates by season and appropriate rotation schemes. Further, Carlos Fierro, who coordinates Texas Tech projects in the Southern Sierra, is working closely with Ramiro Farfan to determine, through clipping studies, the optimum harvest strategy for cultivated pastures at this altitude. They are actively seeking an economic justification for the promotion of cultivated pastures in the *altiplano.* The literature is contradictory on this subject.

Other uses of tame pastures during seasons which are not critical for supplementing range ewes are also under evaluation. Lamb fattening for slaughter and early ewe-lamb maturation and supplementation of bred alpaca are examples of alternative uses under investigation.

Significance of Research Findings

Range science is the single most important resource management science in Peru. There are over 20 million hectares of range in the country which vary from desert plains to high mountain meadows to jungle savannas. Practically all of the nation's livestock is based upon the exploitation of this resource, primarily in the high Sierra and especially on the high *puna* of Puno in the Southern Sierra. What we have done is to give good examples of the way range research needs to be organized and conducted to obtain short-term results and at the same time begin long-term projects which will mature in five to ten years instead of one or two. We also have projects that emphasize the application of cultivated forages technology to the range unit. Results from these projects will have far-reaching management implications when appropriately delivered by Peruvian

Table 3. Rank Order of the Top Three Grasses and Legumes Based on Several Criteria at the Corpracancha Study Site

Species Rank	Green Biomass	Relative Cover	Vigor	Resistance to Cold
Grasses:				
1	*L.*[1] *perenne* var *Ruani*	*P.*[2] *pratensis*	*L. multiflorum* var *Lena*	*P. pratensis*
2	*L. multiflorum* var *Lena*	*L. perenne* var *Ruani*	*L. perenne* var *Ruani*	*L. perenne* var *Diana*
3	*L. perenne* var *NFG*	*L. perenne* var *NFG*	*L. perenne* var *Diana*	*L. multiflorum* var *Lena*
Legumes:				
1	*T.*[3] *pratensis* var *Redman*	*T. pratensis* var *Redman*	*T. pratensis* var *Redman*	*T. pratensis* var *Redman*
2	*T. repens* var *Steinacher*	*T. repens* var *Ladino*	*T. repens* var *Ladino*	*T. repens* var *Ladino*
3	*T. repens* var *Milka*	*T. repens* var *Steinacher*	*T. pratensis* var *Otowa*	*M.*[4] *sativa* var *Fon Perry* 1979

L[1] = *Lolium*

P[2] = *Phleum*

T[3] = *Trifolium*

M[4] = *Medicago*

Table 4. Animal Production Data From Ewes Receiving Cultivated Pasture at Corpracancha as a Supplement at Critical Nutritional Stress Periods.

Treatment	Lamb Crop at Birth (%)	Lamb Crop at Weaning (%)	Lamb Birth Weight (kg)	Ewe Weight at Weaning (kg)
Rotational grazing				
Supplement at breeding	90	90	4.07	31.45
Supplement at late gestation early/lactation	105	95	4.11	34.21
No supplement	60	60	3.73	29.79
Continuous grazing				
Supplement at breeding	85	75	4.00	30.36
Supplement at late gestation early/lactation	90	85	3.74	32.33
No supplement	75	70	3.76	30.14

extension specialists. Moreover, when coupled with results from the other SR-CRSP projects in Peru, we should be able to provide a technological package of animal management that will benefit the smallholder as well as poor people of the cooperatives. In fact, plans are currently being considered to establish a production system or "model" to test our research findings.

Some of the results which will be of lasting benefit include:

- Delineation of range sites as management units.
- Determination of the capabilities of native range to produce forage.
- Establishment of stocking rate guidelines.
- Development of grazing systems to perpetuate the grazing resource.
- Determination of nutrients limiting animal production at various times of the year.
- Recommendations of supplementation schedules for optimizing animal production.
- Recommendations of species and varieties of improved pastures of grasses and legumes.
- Integration of improved forages into the range production system.
- Management of cultivated pasture through control of grazing animals.
- Integration of results from Range/ Forages Management with Breeding, Health, Reproductive Physiology, Economics, and Sociology to support the technological package for producers.
- Strengthen range research in Peru and the Andes of South America.

Future Research Directions

Future research will maintain our present course. Basically, rangelands and cultivated pastures in Peru are overgrazed, abused, and mismanaged. Our focus on stocking rates, grazing management, range improvement, the nutrition of free-ranging animals, and the management of cultivated forages are paramount to any overall improvement in animal production in the highlands of Peru.

The first three years of research thrust by Texas Tech have resulted in the establishment of three primary ERCs at Corpracancha (UNA), La Raya (IVITA) and Puno (UNTA). Success of these ERC's was possible only through strong linkages with Peruvian scientists who have become outstanding Co-Principal Investigators, namely Dr. Arturo Florez (UNA), Ing. Ramiro Farfan (IVITA), and Ing. Juan Astorga (UNTA). By design, our plan from the start was to emphasize the collaborative research portion of the SR-CRSP acronym. Through the technical advice and commitment from several US Senior Investigators and Research Associates—Dr. Al Schlundt, Dr. Frank Craddock, Luis Carlos Fierro, Richard Reiner, Dr. Gerry Matches, Dr. Ron Sosebee, Brad Wilcox, Dr. Donald Burzlaff and others—and the financial support from USAID, we have given the scientists of Peru the foundation to carry out long-term research in range management and improved forages.

The task at hand for the next five years is to become the support program in the SR-CRSP acronym. We will accomplish this in two ways. First, we will continue to provide financial support to our Peruvian Co-PIs to maintain a high level of research activity at the ERC's. This step is fundamental in continuing the research effort. There will be, in future years, less emphasis on expatriate residents as technical advisors and more emphasis on US Senior Investigator participation to fill this need. Second, the Texas

Sheep grazing experimental pastures on native range at the Corpracancha Experimental Research Center Central Peru. Photo: F.C. Bryant.

Tech component of the SR-CRSP will shift more emphasis to graduate level (MS or PhD) training of host country scientists in the US. Our goal in this will be institution building through people trained in range/forages management, rather than investment in equipment, laboratories, and vehicles.

Training

One of the proudest accomplishments of the Texas Tech component of the SR-CRSP has been our efforts to train LDC students in the US, at home universities, and to offer management training to our collaborators.

Postgraduate training of LDC students in the US has included the following:

- Ing. Ramiro Farfan was funded from 1980-1982 and was awarded the MS degree in Range Management at Texas Tech University. Ing. Farfan currently is Program Director of Range/Forages research at the National Camelid Research Station, La Raya, Peru.
- Ing. Enrique Nolte is currently completing his requirements for the PhD degree at Ohio State University. Ing. Nolte was funded through the Ohio component from 1981-1982, and will be funded through Texas Tech from 1983-1984.
- Luis Carlos Fierro, a Mexican national, is being funded at Texas Tech from 1982-1985 pursuant to a PhD degree in Range Science. His previous wealth of research experience as Director of the La Campana Range Experiment Station, Chihuahua, and Director of Range Research for the Mexican Institute of Agricultural Research makes his presence in Peru one of the highlights of the Texas Tech component.
- Lucrecia Aguirre will be funded for an MS degree at Texas Tech in Range Management for the period, 1982-1984.

Eighteen Peruvian students have been funded for one to three years by Texas Tech at Peruvian institutions to support their thesis work for the BS degree and the Ingeniero, a level above the basic undergraduate degree. Drs. Schlundt and Florez and Ing. Astorga have undertaken the responsibilities of thesis directors for all.

While it is a worthy goal to train Peruvian students in the US, it is equally important to have well trained American students conduct their research in Peru. Their exposure to international agricultural research will provide longlasting benefits to their respective US institutions, as well as the benefits from their technical expertise provided while working with Peruvian institutions.

- Brad Wilcox was funded from 1980-1982 and received his MS degree in Range Management at Texas Tech. He spent over one year in Peru conducting his research on soil:plant relationships and is currently working toward a PhD at New Mexico State University.
- Richard Reiner will be funded from 1982-1985 pursuant to the PhD degree at Texas Tech. His research deals with alpaca nutrition, a project which will require him to spend over 15 months in Peru.

Management training supported by the Texas Tech Range Project has included attendance at professional meetings as well as on-site shortcourses. Dr. Arturo Florez has participated in two annual meetings of the International Society for Range Management at Calgary, Alberta, Canada, and Albuquerque, New Mexico. This scientific exchange of information and professional development was a welcome relief after 11 years of minimal contact with other professionals. This interaction is necessary to keep current with developments in range research. Further, a complete volume of the Journal of Range Management was donated to the library at UNA to provide invaluable reference material for students.

Ing. Ramiro Farfan participated in the IVth International Convention on South American Camelids in November 1981 at Punta Arenas, Chile. Again, scientific exchange and professional development and training were the objectives supporting this visit.

Two Range shortcourses were held in Peru. In Lima, a shortcourse, held in August 1982, was attended by over 120 scientists, extension agents, and representatives of at least 6 foreign countries. Lecturers were from the US (6 scientists) and Peru (5 scientists). A 210 page proceedings, in Spanish, resulted from this shortcourse. In Puno, a shortcourse was held in April 1983, to reach professional agriculturists in the Southern Sierra of Peru.

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Economic Aspects to Increased Productivity of Small Ruminants

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The goals of SR-CRSP research in Peru have focused on strengthening institutional capacity for research on small ruminants rather than concentrating on any specific production system.

In Peru, small ruminant production systems and the marketing of small ruminants and their products are characterized by great diversity which arises from ecological differences caused by rainfall and elevation; by organizational differences caused by parastatal operations in some systems and private ownership of assets in others; by land ownership ranging from common property grazing to private plots; by species differences (sheep, goats, and alpaca); and by substantial cultural differences caused by race and language. Different Peruvian institutions are interested in diverse facets of small ruminant research and the SR-CRSP has been flexible enough to respond to a variety of needs in both the biological and social sciences.

Within this operational mode, the goals of the Economics Project have been to:

- Develop a cadre of well-trained Peruvians capable of carrying out a wide variety of research studies dealing with production, marketing, and institutional aspects of small ruminants in Peru.
- Develop close working relationships with range management, animal breeding and rural sociology researchers to complement their focus on specific production systems.
- Strengthen the research and analytical capacity of the Dept. of Economics and Planning at the National Agrarian University (UNA) to develop it into a center of excellence for economic aspects of small ruminant research in Peru.
- Develop analytical models to assist in researching the complex agroecological-cultural conditions which exist among Peruvian small ruminant producers.
- Help develop model or pilot farms in the Peruvian highlands that will serve to transfer SR-CRSP research results to surrounding farms.

The overall project objectives in Peru have taken into account on-going research interests of Peruvian collaborators, the initiation of the Northern Peru Goat Project, the needs of the Dept. of Economics and Planning at UNA, and the research agendas of the other SR-CRSP projects in Peru.

The specific research objectives of the Economics Project in Peru are to:

- Study cooperative forms of grazing units, focusing on the different sets of economic rules and incentives under which these units operate. The objective is to identify sources of inefficiency which can be overcome by research or by changes in operating rules and procedures.
- Analyze the role of small ruminants in mixed crop-livestock systems in the highlands, the rules regarding land use, grazing rights, use of crop by-products and residues, resource use, and economic returns for each type of activity. These studies will assist in designing on-farm technology testing programs designed to benefit these limited-resource producers.
- Conduct benefit-cost analysis of technologies being developed by other projects including fertilization of native pastures, pasture rotation, fencing, use of irrigated pastures, breeding for finewool versus meat, alpaca culling practices, and analysis of fiber pricing differentials.
- Conduct evaluation of on-farm experiments including practices used on demonstration or "model" ranches, small farm trials, and grazing trials.
- Conduct research on wool and alpaca fiber marketing in Peru including analysis of factors involved in price formation, impact of government policy on domestic prices, efficiency of private versus state marketing agents, and economics of alternative grading systems.

Mixed flocks of alpaca, llama, and sheep graze in competition. The Range Management Project is studying the feed sources used by each species, their interactions, and the implications of this for improved grazing management. Photo: W.C. Weir.

Research Accomplishments

Cooperative Enterprises

This research continued and expanded on-going work by D. Martinez and C. Valdivia at the UNA in Lima. The first objective was to provide a broad overview of the history, legal framework, organization, management, and performance of three types of cooperative enterprises that evolved following the 1968 land reforms. Three different enterprises were selected to allow comparisons of the three main organizational forms found in the Pasco Department of the Central Sierra. All three were selected from among the 23 enterprises which are associated with the Central de Cooperatives de Pasco. The first study (Martinez, 1983a) describes the main differences between these enterprises. One unit is owned by the Central de Cooperatives and serves as both a breeding multiplication unit and production unit. The second consists of a communal cooperative comprising two former estates that were allocated to the community of Huayllay. The community members jointly own the property through a stockholding arrangement. The third property is owned by former workers on the estate which was turned over to them during land reform. All enterprises are based on grazing sheep, llama, alpaca, and at lower elevations, cattle. Substantial differences were found between the units in terms of labor productivity, seasonal changes in stocking rates, quality of sheep, and the proportion of private to cooperative animals grazed on the units.

We hypothesized that the different organizational, management, and incentive systems existing between these large scale grazing enterprises would result in differing rates at which they would accumulate investment capital and improve productivity. In the resulting study (Valdivia, 1983), the comparison was between one of the production cooperatives (CAP) studied by Martinez (Production Cooperative "El Diezmo-Palcan" which was given to the former estate workers during land reform) and a Social Interest Agrarian Society (SAIS) which has quite a different organizational and management structure. Capital accumulation, income generation, member participation in the enterprise, and members identification with the enterprise were the variables examined.

The factors affecting capital accumulation were mainly the area of pasture lands allocated per family, the amount of wages paid, and profits distributed. The CAP showed a tendency toward capital accumulation that was not present in the SAIS. In the case of the CAP, the main source of members' income was wages. There was a tendency to reduce the importance of other sources of income, such as members' personal flocks. On the other hand, most families in the SAIS did not rely on the wages paid by the enterprises, but on their own animals and/or cropping plots provided by the SAIS. Participation was low because the government retained control of the cooperatives. However, partial participation did exist in the CAP. A main reason why participation did not exist in the SAIS was that government control was stronger than in the CAP. Identification did exist in the CAP, translating into an emphasis on capital accumulation. The opposite took place in the SAIS. Labor absorption into the unit was an important factor affecting identification (Valdivia, 1983).

In a companion study (Martinez, 1983b), the comparisons of technical and economic performance were extended to the private small farm sector. Two quite different institutions are involved in production of sheep and alpaca: business-oriented cooperatives and traditional *comunidades campesinas* (peasant communities). Economic theory related to each institution was reviewed and applied to the decisions of land and labor use. Special attention was directed to the potential for *comunidades campesinas* to overgraze common pasture areas. Economic models of herd management under each production system were then developed.

Case study data from two *comunidades campesinas* and two cooperatives were used to describe relative production conditions. Herd size, measured in standard sheep units per family, did not vary between the systems; however, wool yields were significantly greater for the cooperatives. Correlation analysis did not reveal strong associations between herd sizes and family size or average age in the peasant communities, thus not supporting the hypothesized existence of informal institutional rules to prevent overgrazing. Finally, marketing data show that the peasant communities sell most of their animal fiber outside the community and therefore are not subsistence units. This result has important implications for designing policies to stimulate small ruminant production.

Fiber Marketing and Price Formation

Two coordinated studies were carried out to determine the relative importance of prices in determining the supply of fiber, the major factors influencing fiber prices, and the impact of government taxation and fiber processing policies on fiber price and supplies. The first study (Llerena, 1981) examined the alpaca fiber market. The alpaca industry is important in Peru with an estimated 10% of the population engaged in production, of which 85% are smallholders. Production is characterized by low cash inputs in areas where, because of ecological limitations, alternative enterprises are not possible. A number of supply response models were estimated using secondary data on production, prices, and climatic variables. The short run elasticity of quantity supplied with respect to price was extremely low (less than 0.05 for all models estimated) indicating that current prices had relatively little effect on current quantities supplied. However, the ratio of alpaca fiber prices to wool prices had a vigorous effect on alpaca fiber supplies. It was hypothesized that this phenomenon is due to producer decisions on which product is kept for home consumption and which is sold, rather than to underlying production shifts. Further examination showed that this ratio by itself could serve as a reliable short-term forecasting tool.

In the companion study (Lotterman and Millones, 1982; Millones, 1983), hypotheses were formulated based on the findings of the alpaca fiber study which indicated that the relative proportions used as home consumption were important in determining domestic supplies of either fiber.

That is, producers can use either alpaca fiber or sheep wool for home production of clothing and vary the proportion according to relative prices (Llerena, 1981). In contrast, on the international market, there is much greater product differentiation where alpaca fiber is classified as a luxury product and Peruvian alpaca fiber accounts for over 85% of total world trade. However, Peru is a relatively small producer and exporter of wool, accounting for about 2% of either category. It thus can be supposed that the demand for Peruvian wool is an exogenous factor not influenced by Peruvian production or policy. In addition, it would seem logical that this external demand would be relatively elastic and thus that the export price of Peruvian wool could also be treated as an exogenous variable.

An important question is the degree to which this export price determines domestic prices, particularly prices to producers. The relationship between international and domestic prices as well as the lag period, if any, in price adjustment, is also a critical variable in wool and fiber market and price analysis.

International price series were used from the USDA, Australia, and Uruguay, but a major problem was encountered in establishing a consistent and reliable Peruvian export price series for wool. Two Peruvian price series were used. Correlations between these various international price series and Peru export prices were not high. One problem concerns the conversion of Peruvian currency (local prices for export are quoted in Soles) into the other currencies. The correlations were calculated between price series deflated in terms of their own currencies. Logically, if two price series were directly related, but measured in two different currencies, their respective deflated prices should move in parallel only if the exchange rate fully reflects the differential between the rates of inflation for the two currencies. This of course is not true for Peru during most of the study period. Policy has typically been to fix the rate of exchange until pressure to devalue becomes overwhelming. This usually results in periods of severe overvaluation of the Sole with resulting depression of the domestic value of export commodities such as wool. The next step will be to translate these studies into policy recommendations for the Peruvian government and private institutions for action with respect to marketing and processing policies.

Economics of Genetic Improvement

Two brief studies were conducted which served merely to set out the issues involved in establishing sheep breeding policies in Peru. In the first study (Lotterman, 1981a), the broad economic factors impacting upon a breeding program were set out. In terms of product prices, (deflated as best as possible in real prices reflecting producer purchasing power for the items sold), wool prices and alpaca fiber prices were approximately constant over the past 20 years while sheep meat prices showed a moderate upward trend over this period. Another factor affecting these trends is Peruvian foreign exchange rate policy which has tended to undervalue exports such as wool and alpaca fiber. Meat, on the other hand, is consumed domestically and the prices received by producers is less dependent on international prices and exchange rates. The net effect was to raise the prices of meat relative to wool and the proportion of gross income realized from small ruminant meat has increased.

Based on these factors, it would seem that genetic selection programs should give serious thought to increasing the weight of meat traits and reducing the weight given to wool traits in their selection criteria.

In the second paper (Lotterman, 1981d), the basic economic framework for selection between meat and wool is set out using an enterprise budgeting model which is then converted into selection indices based on economic weights. The simple traits of wool and meat yields are decomposed into specific traits such as wool yield, wool grade, rate of gain, dressing percentage, and prolificacy, and incorporated into the budgeting process. Finally, techniques for incorporating long-term price trends are reviewed and their use in selection procedures illustrated.

Pasture Improvement

Three collaborative studies with Peruvian graduate students were initiated and initial research results obtained. All three studies will be continued as part of the long-term thrust on developing pasture improvement strategies for both cooperative and smallholder units. The first study (Lotterman et al., 1982) reviewed irrigation costs and water costing policy as a potential constraint to the strategic use of irrigated pastures in the Peruvian highlands. A major effort has been put forward by a New Zealand aid project and over 6,000 ha of improved pastures have been established between 1974 and 1982, slightly under one-half of which were irrigated. Most of the major irrigation projects are being developed in the arid coastal zones and are characterized by long delays, cost overruns, and very high costs per hectare irrigated. The situation is somewhat better in the Sierra. The two major programs are "Plan Menis" and a small/medium scale irrigation program. Based on a review of Plan Menis documents by the Ministry of Agriculture, USAID, and the Interamerican Development Bank, as well as interviews with representatives of these institutions, it appears that most Plan Menis project costs fall between $100 and $1,000 per irrigated hectare. Most schemes in the small and medium scale ("Pequenos y Medianos") program vary from 250 to 2,500 ha and involve new construction. Review of documents for projects in the Sierra shows a range of costs from $500 to $3,000 per new ha.

Based on estimates of animal production per hectare from irrigated versus nonirrigated pastures in the Peruvian Sierra, a simple budgeting model incorporating amortized payments for irrigation was used to calculate the pounds of gain per ha per annum necessary to repay the initial costs of various liveweight prices.

Table 1 presents the initial results of the sensitivity analysis. The interest rate is the "real" rate which is the market weight less annual inflation. This work will be continued using this framework.

Table 1. Pounds of Additional Annual Animal Live Weight Gain Necessary to Amortize Initial Cost of Irrigation Investment for Cultivated Pasture

Initial cost/ha	Live Weight Price								
	$.40/kg			$.90/kg			$1.60/kg		
	6%	12%	18%	6%	12%	18%	6%	12%	18%
$ 200	40.0	625.0	92.5	17.8	27.8	41.1	10.0	15.6	23.0
$ 500	47.5	160.0	227.5	43.3	76.1	101.1	24.4	40.0	56.9
$1,200	235.0	382.5	547.5	104.4	170.0	243.3	58.8	95.6	136.9
$1,800	352.5	572.5	822.5	156.7	254.4	365.6	88.1	143.1	205.6
$2,500	490.0	797.5	1142.5	217.8	354.4	507.8	122.5	199.4	285.6
$8,000	1502.5	2550.0	3657.5	694.4	1133.3	1125.6	390.6	637.5	914.4

The second study focused on setting up a simple analytical model for assessing the economics of fencing (Lotterman and Cruces, 1983). The relationships between the discount rate and type of fencing (Sod "champa" versus wire fences) were illustrated with wire being cheaper at lower discount rates and sod being the lower cost investment at higher discount (interest) rates. Next, the affect of field shape (square versus circular) and field size are illustrated and principles for determining economic optimum field subdivisions are set out. Fence costs under various grazing situations typically found in the Peruvian Sierra are then estimated based upon these principles.

The third study estimated economic returns to fertilizer applied to native rangelands in the Sierra (Lotterman and Diaz, 1983). Data was derived from experiments conducted by UNA over the period 1968-1970. Fertilization was with 120 kg of ammonium nitrate, 400 kg of single superphosphate, and 67 kg of potassium chloride applied biannually with a yearly maintenance application of 107 kg of urea. Sheep and cattle were used in the experiments. The grazing system was complicated, especially from the point of view of the economist, by use of a "put and take" system. The number of both sheep and cattle was not constant throughout the experiment for either treatment. Animals were added or removed in a "put and take" system in accordance with the amount of forage available. Unfortunately, details on criteria used for deciding when to put or take animals are not explained in the published reports nor are the exact dates of additions or removals recorded. All livestock were weighed in and out in addition to regular monthly weighings.

Problems were encountered in assigning costs to the control and treatment herds so the analysis concentrated on partial budgeting of the fertilizer response only. At the interest rates prevailing over the past 15 years when the real rate (market rate less the rate of inflation) has been strongly negative, fertilization of native pastures at the above rates was profitable since borrowing money at negative real rates of interest is highly profitable to those with access to institutional finance at these rates. Again, however, difficulties in analyzing the experimental data, a lack of accurate cost data, and problems in determining the "real" rate of interest charges to the borrower all limit the results of this study. Research collaboration with the Range Management Project will significantly improve the quality of data and the reliability of recommendations for fertilization in the near future.

Significance of Research Findings

Many of the studies raised more questions than they answered, due in part to deficiencies in both secondary and experimental data and to which we had access. Another very real difficulty in working with Peruvian economic data covering product prices, interest rates, inflation rates, and input prices is the presence of substantial distortions caused by overvalued exchange rates, price controls, taxes, and subsidies. Therefore, the studies dealing with aggregate output and price formation must be treated with caution. While these studies have provided useful training for the students involved, their impact on the overall SR-CRSP and on potential recipients of SR-CRSP research results will be so small as to not warrant further efforts in this area.

The research on organizational farms and economic efficiency of the different types of cooperative production units created after land reform will be of more direct relevance to the overall SR-CRSP in Peru when full scale testing-demonstration work commences on one or more of these units. The Economics Project now has the necessary financial and accounting data to assess the economic attractiveness of the research to be carried out on these units. In addition, the baseline surveys of these units have established weaknesses in the current production methods which can help guide SR-CRSP researchers. The return to Peru in January 1983 of the two Peruvian trainees who initiated this work will allow close collaboration with these units.

The research carried out on breeding policies and pasture improvement must be regarded as the most preliminary but also the most promising in terms of the overall needs of the SR-CRSP in Peru. The work so far has been useful in developing a simple yet appropriate analytical framework for the needed economic analysis and in identifying references and sources of data. Now that the Breeding, Range Management and Forages projects are producing results amenable to economic analysis, this cooperative work will assume the main thrust of future research efforts.

Significance for Future Research

Research to date has focused more on descriptive aspects of the various small ruminant production systems found in Peru, on the methods by which small ruminant products are priced, on the problems of data quality, and on the models needed to carry out bioeconomic analysis of specific improvement packages. Relatively little work has been done with the communities although 1980-81 surveys in two communities in Huancavelica Department have not been reported here. Also, only a small amount of work has been carried out in direct collaboration with other SR-CRSP projects in Peru.

Future research will continue with the moderate efforts already initiated with the large scale grazing cooperatives where such research is clearly complementary to other research being planned or executed on these units. However, the major thrust will now be directed towards applying a farming system approach to the identification and solution of problems facing the small farm sector and towards conducting collaborative research with the other SR-CRSP projects in Peru. The initial studies indicated that the prospects for selective pasture improvement through small scale irrigation, fencing, and fertilization may be quite promising and this area will receive major emphasis in the future. Also, our conclusions that sheep production for meat offers good prospects for the future suggests that more research should be focused on meat production systems.

Given the very limited funds that will be available to support research in Peru, the Economics Project will need a sharp focus on a few selected areas and the highest payoff relative to overall SR-CRSP objectives will come from economic research emphasizing problems of the smallholders and problems encountered in devising economically sound pasture and pasture/forage based systems.

Training

The initial plan of the Economics Project was to start two well-qualified Peruvians in degree programs in the US, replace them within the Dept. of Economics and Planning with a qualified expatriate economist who would assume full teaching and thesis advisory duties, and build up a substantial core of junior Peruvian research associates, each of whom could specialize in a specific research area dealing with small ruminants. To carry out this plan would also require a considerable investment in local computing capacity.

A live animal market in the Peruvian Sierra. Photo: J. De Boer.

By November 1980, Mr. Edward Lotterman arrived in Peru to take up an adjunct faculty position. Five promising junior Peruvian staff were assigned to the project to be joined later in 1981 by two "Licenciatura" candidates. In December 1980, Domingo Martinez and Corinne Valdivia left Peru to commence MS degree programs in the Dept. of Agricultural Economics at the University of Missouri. They completed their degrees in January 1983 and returned to Peru. The two "Licenciatura" candidates completed their research projects with partial support by the SR-CRSP and remain on the faculty at UNA. Three research associates continue to be associated with the project and Roxana Diaz will work on a joint project between Economics and Animal Breeding towards an MS degree in Animal Science at UNA.

The emphasis has been to encourage, as appropriate to the levels of skills and experience of the junior researchers, research projects which collaborated with other disciplines and which covered a wide variety of small ruminant economic problems. Several of the research associates have dropped out of the project without receiving degrees but the overall success rate and the increasing ability of the Peruvian collaborators to conduct, write up, and present their research results is most encouraging.

Among specific accomplishments of formal degree training supported by the Economics Project were the following:

- Domingo Martinez-C., MS, University of Missouri, Columbia. January 1981-January 1983.
- Corinne Valdivia, MS, University of Missouri, Columbia. January 1981-January 1983.
- Louis Millones, Licenciatura, National Agrarian University. December 1981-January 1983 (partial support).

- Ghorki Llerena, Licenciatura, National Agrarian University. November 1980-January 1982 (partial SR-CRSP support).
- Roxana Diaz, Ing. Agr., National Agrarian University. November 1980-December 1982.
- Martha Cruces, Ing. Agr., National Agrarian University. November 1981-December 1982 (degree not completed).
- Juan Machuca, Licenciatura, National Agrarian University. September 1980-September 1981 (degree not completed).
- Jesus Ruiton, Licenciatura, National Agrarian University. January 1980-September 1982.
- Ruben Velarde, Licenciatura, National Agrarian University. January 1980-present.
- Isabel Luque, Licenciatura candidate, National Agrarian University. November 1980-August 1981 (degree not completed)

The project has also provided resources geared to nondegree technical training and includes such activities as participation of residents and on-site collaborators in meetings and symposia held in Peru, the US, and other countries.

Selected Publications

Diaz, R., E. Lotterman, A. Carrasco, and A. Florez. 1982. Evaluacion Economica del Pastoreo Rotativo Complementario con y sin Fertilizacion en la SAIS Pachacutec (Economic Evaluation of Complementary Pasture Rotation With and Without Fertilization on SAIS Pachacutec). Paper Presented at Annual Mtg. of Peruvian Association of Animal Production, Cajamarca, Peru.

Llerena, G. 1981. Analysis Economico de la Produccion y Commercializacion de la Fibra de Alpaca (An Economic Analysis of Alpaca Fiber Production). Licenciatura Thesis, National Agrarian University, Lima.

Lotterman, E.D. and M. Cruces 1983. Notes on Economic Aspects of Fences For Grazing Management. Mimeo. Winrock Int'l., Morrilton, AR. 14 pp.

Lotterman, E.D. and Roxana Diaz. 1983. Economic Returns to Fertilization of Native Range in the Peruvian Sierra. Mimeo. Winrock Int'l., Morrilton, AR. 16 pp.

Lotterman, E.D., A.J. De Boer, and J. Ruiton. 1982. Irrigation Costs in Peru, Implications for Livestock Production. Mimeo. Winrock Int'l. Morrilton, AR. 11 pp.

Lotterman, E.D. and L. Millones. 1982. Are Peruvian Wool Prices a Function of International Prices? Mimeo. Winrock Int'l., Morrilton, AR. 9 pp.

Lotterman, E.D. 1981a. Economic Factors Affecting Livestock Breeding Programs in Peru. Paper Presented to SR-CRSP Short Course on Animal Breeding, Lima, Peru. 18 pp.

Lotterman, E.D. 1981b Book Review of "Yo Asumi el Activo y el Pasivo de la Revolucion," by Javier Silva Ruete, for Centro de Documentacion e Information ANINA, Lima, Peru. 4 pp.

Lotterman, E.D. 1981c. Agricultural Policy, Peasant Economics and Livestock Production in Peru. Paper Presented at Meeting of the Association Peruana de Produccion Animal, Ayacuchor, Peru. 15 pp.

Lotterman, E.D. 1981d. Economic-Biological Relationships in Genetic Improvement of Livestock. Paper Presented to SR-CRSP Short Course on Animal Breeding. Lima, Peru. 15 pp.

Lotterman, E.D. 1981e. Sheep Production in the US: Old Problems and New Technology. Paper Presented to National Agrarian University, IDRC Symposium on High Altitude Livestock Production, Lima. 16 pp.

Martinez, D. 1983a. A Comparative Study of the Organization, Management, and Husbandry Practices of Three Sheep Production Units in the Central Sierra of Peru. SR-CRSP Technical Report Series No. 11. 68 pp.

Martinez, D. 1983b. Economics of Small Ruminant Production in the Peruvian Puna: Theoretical Considerations and Some Evidence. MS Thesis, University of Missouri, Columbia. 149 pp.

Millones, L. 1983. Modelos de Comportamiento para la Produccion Nacional de Lama de Ovino en el Peru (Behavioral Model of National Sheep Wool Production in Peru). Licenciatura Thesis, National Agrarian University, Lima.

Ruiton, Jesus. 1982. The Status of Credit for Small Livestock Holders in the High Andean Region of Cajamarca Department. Paper Presented at Annual Mtg. of Peruvian Association of Animal Production, Cajamarca, Peru.

Valdivia, C. 1983. A Comparative Analysis of Capital Accumulation in Two Peruvian Sheep Associative Engerprises: Factors Enhancing and Restricting Their Development. MS Thesis, University of Missouri, Columbia. 234 pp.

An Investigation of Small Ruminant Health Problems

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The economic losses in livestock productivity in Latin America attributable to disease are enormous. It has been estimated that in the 1960's diseases accounted for one-third of the 68% lower livestock productivity in Latin American countries compared to the United States. The herds are constantly at risk to both endemic and exotic diseases. In addition to posing a major obstacle to increased productivity, animal diseases also create a major barrier to international trade in livestock products. The effects of disease are probably greatest in flocks of the small farmer, where they are exacerbated by poor management and malnutrition. For purposes of socioeconomic development, it is imperative to reduce the risks, reverse the disease trends, and maximize the livestock potential of the area.

With its populations of 15 million sheep, 3 million alpaca, and 500,000 goats, Peru is heavily dependent upon small ruminants and camelids for food and fiber production. Approximately 70% of these animals are managed as small family flocks and about 30% are owned by large worker-governed cooperative farms. Efforts to improve livestock production through disease control or prevention must be applicable to smallholder flocks as well as cooperative units.

Disease constraints to small ruminant production in Peru are diverse in their causes and their effects. Determination of the responsible disease entities is dependent upon recognition based on clinical signs, lesions, or specific diagnostic tests. An understanding of disease etiology and pathogenesis is a prerequisite to developing diagnostic tests that will allow determination of occurrence and relative importance of each entity. Strategies for disease control or prevention through immunoprophylaxis or management alterations must be based on a detailed knowledge of the presentation, cause, distribution and occurrence of each disease. To achieve this goal, continuity of the research effort is important, and training of Peruvian investigators to continue the work after termination of the SR-CRSP is essential. Establishment of a working relationship with Peruvian agricultural extension officials is considered necessary in order to optimize prospects for application of research results to the field.

The long range goal for the Animal Health Project in Peru is to decrease disease-related losses of food and fiber products of sheep, goats and alpaca by:

- Determining the causes and prevalence of major infectious and non-infectious diseases in smallholder production units as well as large cooperatives.
- Developing control or prevention strategies for chronic respiratory diseases of sheep based on increased knowledge of the cause, lesions, diagnosis, and transmission of the specific entities that comprise this complex.
- Developing control or prevention strategies for neonatal enteritis in alpaca based on increased knowledge of the cause, pathogenesis, diagnosis, and transmission of microbial agents involved.
- Evaluating the role of infectious agents in losses due to infertility in sheep and developing control strategies for the responsible entities.
- Providing advanced training for veterinarians interested in disease investigation.
- Promoting the exchange of ideas between US and Peruvian scientists.
- Enhancing the dissemination of research findings to Peruvian officials and lay personnel concerned with disease control in small ruminants and camelids.

Research Accomplishments

In May 1980, a collaborative research program on sheep and alpaca diseases was established between this project and scientists from CSU and IVITA, a veterinary research institute of the Peruvian government which is affiliated with San Marcos University (SMU) in Lima. Following reviews of local disease prevalence reports and discussion with Peruvian officials, it was agreed that research should focus on chronic respiratory diseases of adult sheep, neonatal enteritis of alpaca, causes of infertility in sheep, and certain other conditions affecting sheep, goats, and alpaca. Research priorities were based on importance of the problem, lack of effective control procedures, and capabilities and interests of investigators. Selection of worksites was based on location of facilities and personnel and availability of case material. It was determined that the veterinary school facilities of San Marcos University would serve as headquarters for the project and a site for most laboratory research. IVITA field stations at Huancayo in the Central Sierra and La Raya in the Southern Sierra were designated as field research facilities. Case material was known to be available on large cooperative farms, smallholder (community) flocks, or IVITA alpaca herds located near these stations. The North Coast area of Peru was to serve as the site for collection of goat disease data. Field trips to other areas in Peru for sample collection were to be made as needed.

At the start of the project, internal economic problems in Peru resulted in depletion of veterinary and agricultural research facilities at IVITA and San Marcos University. Therefore, one of the first priorities of the Animal Health Project was to restore these facilities to working order. Large sums of money and much time and effort were expended in equipment repair and replacement, facilities renovation, and new equipment purchase for diagnostic and research laboratories in Lima, Huancayo, and La Raya.

Chronic Respiratory Diseases

Research on chronic respiratory diseases of sheep in the Central Sierra region was designed to determine the disease entities that contributed to this complex, improve methods for their diagnosis, and to determine the extent of the problem in smallholder flocks. A detailed pathology and serology study of 80 sheep with clinical evidence of chronic respiratory disease was completed in 1982 (Snyder et al., 1983; Table 1). Thirty one (31%) of these animals had sheep pulmonary adenomatosis, an infectious neoplastic disease that had been reported in the Central Sierra as early as 1945. Four sheep had lesions of ovine progressive pneumonia (OPP) and 26% were serologically positive for this virus-induced disease. This latter disease is a major problem of sheep in North America but had not been previously reported in Latin America. A subsequent serologic study revealed that infection is widespread throughout Peru. A variety of other pulmonary diseases of lesser frequency or consequence were found in the necropsied sheep.

Since sheep pulmonary adenomatosis (SPA) was found to be the most important component of the chronic respiratory disease complex of sheep on a large farm in the Central Sierra, further investigations were carried out to better define the occurrence and cause of this disease. To determine whether SPA was as important in smallholder flocks as in the large cooperatives, 903 carcasses were inspected at 5 slaughterhouses that processed animals originating from small family flocks (Ellis et al., Table 2). Sixteen cases of SPA were found, giving a prevalence rate of 1.8% which is similar to the frequency of the disease on a large cooperative, the SAIS Tupac Amaru. Considering that ill and dying animals are not usually sent to slaughter, it seems probable that the true prevalence of SPA is much greater than those figures would indicate.

Evidence from research laboratories in South Africa, Scotland, and Israel indicates that SPA is probably a virus-induced disease. We therefore examined sections of lung and bone marrow from SPA cases by electron microscopy in search of viral agents. C type virus-like particles compatible with a retrovirus were observed budding from the plasma membrane of leukocytes in lung and bone marrow of all 12 cases of SPA examined. No such particles were observed in the tissues of 4 sheep without SPA. Further studies are in progress to ascertain the role of this virus in SPA. Cells from lung lesions and bone marrow are being cultured in an attempt to isolate and characterize the virus. Ultracentrifuged lung fluid and homogenized lung and bone marrow from SPA and control sheep were injected into neonatal lambs in an attempt to transmit the disease but results of this experiment are not yet available.

Caprine Arthritis Encephalitis

Caprine arthritis encephalitis (CAE) is a retrovirus-induced disease of goats that has been recently described in the US. It is characterized by encephalitis in kids and chronic progressive polyarthritis in adult goats. Most goats in the US are seropositive. To evaluate the risk of introducing this disease to Peru with goat importation from the US, it was important to determine whether the disease was already present in Peru. Serum samples were collected from imported and indigenous (criollo) goats from the North and Central Coast regions of Peru. Nineteen of 198 (9.6%) were seropositive for CAE. Although the seroreactors were predominantly goats that had recently been imported, five of 50 criollo goats from the Lima area were seropositive. Four clinical cases of CAE were observed on a dairy goat farm near Lima that had about 200 goats imported from the US since 1980. Two of these were necropsied and had lesions compatible with CAE, but no virus isolations were

Table 1. Diagnoses of Lung Conditions in Adult Sheep with Clinical Evidence of Chronic Respiratory Disease at SAIS Tupac Amaru, Peru

	No.	Age (Years)	Lung Wt. (Gm)	OPP-AGID (% Positive)
Sheep examined	80	4.3 (2)*		21/77 (26)
Sheep Pulmonary Adenomatosis (SPA)	22	3.6 (2)	1393 (640)	2/22 (9)
Ovine Progressive Pneumonia (OPP)	4	6.0 (2)	1037 (240)	2/3 (75)
SPA + OPP	9	3.0 (1)	1269 (376)	8/9 (89)
Normal	9	6.0 (3)	507 (100)	1/9 (11)
Parasitic disease				
Dictyocaulus sp.	30	4.7 (2)	443 (188)	10/30 (33)
Muellerius sp.	5	6.5 (4)	355 (219)	0/30 (0)
Echinococcus sp.	6	6.4 (2)	405 (182)	2/6 (33)

*Mean (standard deviation)

Table 2. Summary of Pulmonary Disease Conditions Observed in Slaughtered Sheep From Smallholder Flocks

	Location of Slaughterhouse				
	Pachacayo	Huancayo	Ayacucho	Sicuani	Santa Rosa
No. sheep examined	32	82	333	71	385
Sheep pulmonary adenomatosis	0	2	8	1	5
Ovine progressive pneumonia	0	0	0	—	—
Bacterial pneumonia	4	3	5	4	—
Pleuritis	3	1	5	1	—
Verminous pneumonia	23	11	201	31	—
Echinococcosis	3	30	7	3	—

attempted. None of 10 samples collected from a family goat herd in a remote area of the North Coast region was positive for CAE. Obviously, further studies of the occurrence and distribution of CAE in Peru are indicated.

Other Viral Infections

Serologic surveys are a good preliminary method of determining the prevalence and distribution of infectious diseases. With the exception of the data cited above, there is no current information on the prevalence of viral infections in sheep in Peru. A preliminary study of sera taken from sheep in three geographic areas of Peru indicated that 47% were positive for antibodies to respiratory syncytial virus, 82% for parinfluenza-3, 3% for border disease virus, 49% for bluetongue virus, and 13% for progressive pneumonia virus. These studies will be extended with further serologic investigations, necropsy studies, and virus isolation attempts.

Perinatal Lamb Mortality

Perinatal lamb mortality is one of the major factors impairing productivity on sheep raising enterprises around the world. In a study done on one of the largest sheep raising enterprises in Peru, perinatal mortality was measured over a ten year period. Between 1971 and 1980, a total of 603,624 lamb births were recorded. Mortality during the first 4 days of life was 36.94/1,000 births, and for the period from 4 to 30 days, 5.87/1,000.

Noninfectious conditions predominated as causes for mortality. The weak lamb syndrome, accidents and injuries, and the starvation complex appeared to result from a combination of nutritional, environmental, and management factors. Diseases of infectious etiology appeared to be second in importance, but may have been underreported to some extent. Variation in mortality between years did not affect the patterns of mortality by cause.

Infectious Diseases and Infertility

Serologic studies of two important causes of abortion and infertility in sheep, toxoplasmosis and leptospirosis, have been initiated. Sera have been collected from the northern, central and southern parts of the country. Results show that approximately 25% of sheep have experienced infection with toxoplasma and approximately 12% with *Leptospira ballum*, and 9% with *Leptospira bratislava*. The prevalence of chlamydiosis has not been ascertained to date but is planned for in future studies.

Heavy Metal Toxicity

This investigation was designed to determine the degree to which sheep living in proximity to mining and smelting operations are accumulating various toxic substances, and to correlate the body burdens of various pollutants with morbidity and mortality rates for selected diseases.

Collection of liver tissue was initiated in 1982. Preliminary results are extremely interesting, and show 3 to 4 fold differences in liver levels of several heavy metals between different units of SAIS Tupac Amaru (Table 3). The results indicate markedly higher levels of most heavy metals in the two units (Quilla and Pucara) that are located nearest to a smelter.

Control tissues for comparison and establishment of baseline values are being collected from sheep in Colorado as well as from sheep at greater distances from the smelting operations in La Oroya.

Neonatal Enteritis in Alpaca

Research utilizing partially purified *Clostridium perfringens* Type A enterotoxin and alpha toxin have been conducted at San Marcos University and La Raya. Preparation of the toxins and initial testing in laboratory animals have been conducted at SMU, while neonatal alpaca clinical experiments have been conducted at La Raya. Inoculation of neonatal alpaca (crias) with sporulating cultures of *C. perfringens* Type A has also been conducted at La Raya.

Signs similar to naturally occurring enterotoxemia were observed for a short time following inoculation of the alpaca crias with enterotoxin and alpha toxin. No deaths were observed. It was presumed that death did not occur because of the small amount of toxin injected and the short time toxin

Table 3. Liver Content of Heavy Metals in Sheep From SAIS Tupac Amaru, Junin, Peru

		Heavy Metal Concentration (ppm)					
Unit	Number of Samples	Copper	Manganese	Lead	Zinc	Arsenic	Cadmium
Atocsaico	7	19.2	13.2	6.4	143	—	2.3
Cochas	2	29.5	16.5	6.3	175	—	2.3
Casaraca	4	26.8	19.8	8.0	173	—	2.2
Consac	6	39.4	16.2	7.2	160	—	2.8
Qiulla	12	65.6	26.3	28.2	716	.74	1.9
Pucara	25	29.6	29.6	34.1	491	.62	1.5
Pachacayo	40	28.1	10.5	5.7	86.6	.13	—

would be active compared to the natural disease. Crias inoculated intragastrically with sporulating cultures of *C. perfringens* exhibited clinical signs of enterotoxemia for up to 72 hours post inoculation.

During January and February 1982, approximately 100 *Escherichia coli* isolates were obtained from alpaca cria. The majority were obtained from clinically ill neonates with diarrhea or from necropsy tissues. Twenty isolates were chosen for further study using four alpaca crias in ligated intestinal loop studies. Ten *E. coli* isolates were inoculated into individual loops in each animal and each isolate was injected into two different animals. Eight of the 20 isolates were positive, eight were weakly positive, and four were negative. One isolate which was positive, one which was weakly positive, and one which was negative, were inoculated into neonatal alpaca via esophogeal tube. Three crias were inoculated with each strain. Clinical signs of diarrhea were observed only in the group inoculated with the gut loop positive strain.

Further enterotoxin assays were conducted during January and February, 1983 at SMU. Suckling mice were inoculated with enterotoxin preparations from the *E. coli* which were positive in the cria gut ligation test. The porcine *E. coli* enterotoxin which was used as a positive control, was positive. However, none of the alpaca *E. coli* was positive. This indicates that the enterotoxin from the alpaca was not a heat stable enterotoxin which is the common enterotoxin found in enteropathogenic *E. coli* isolated from ruminants. Further studies are underway to define the enterotoxin involved and to serotype the *E. coli* imported to the US.

Alpaca Fever

Alpaca fever is a disease caused by *Streptococcus zooepidemicus*. It occurs in alpaca of all ages but is most prevalent in recently weaned alpaca, during the time of high stress. Frequently, outbreaks occur leading to death of a significant percentage of the herd population.

In an effort to determine where *S. zooepidemicus* is carried by healthy alpaca, a study was conducted on 75 alpaca, 25 adult male, 25 adult female, and 25 crias of weaning ages. Culture samples were taken from the nasal cavity, oral cavity, and rectum, at the time of cria weaning, at shearing, at spraying, and a few days following these activities. Many hemolytic Streptococci were isolated but none were *S. zooepidemicus*. Also, none of the animals was affected with alpaca fever during the course of the study.

Significance of Research Findings

As already indicated, recognition of disease entities responsible for production losses must precede introduction of control or prevention measures. Therefore, the major significance of the present research findings lies in this arena.

Previous data on one cooperative farm in the Central Sierra indicated that sheep pulmonary adenomatosis was responsible for 22% of the total annual death loss, or approximately 2,700 of 150,000 adult sheep. Further studies indicate a similar, if not greater, prevalence in smallholder flocks. Inasmuch as this loss is occurring in prime breeding stock (mean age 3.6 years), this one disease has a major economic impact on the sheep production areas of Peru.

Pathology studies have been useful in further defining SPA and differentiating it from OPP and other components of the chronic respiratory disease complex, many of which can be controlled with currently available technology. Control of SPA, however, will probably be dependent upon a serologic or other test to detect animals infected with the causative virus prior to the onset of the disease. OPP free flocks are being developed in Europe using this technique. In order to develop a useful assay for serum antibody, a viral antigen must be obtained and current work is being directed to this end. Although other control strategies are available, they have proven of limited value (autogenous tumor vaccines) or not feasible in Peru (slaughter of all affected animals and contacts and reintroduction of uninfected animals).

Data on seroprevalence of various viral, bacterial, and protozoan infections are necessary antecedents to developing control programs in these diseases. Specific alternatives are dependent upon characteristics of the agent and the host response, mechanisms of transmission, and prevalence rate of infected animals. Further data on causes of infertility are required before control methods can be developed. Vaccines

for such agents as bluetongue are under development in the US and may be available soon. Present results indicate that CAE may be confined in Peru to herds in contact with imported goats. If this trend holds with more extensive studies, eradication of the disease in Peru by test and slaughter may be feasible.

Neonatal lamb mortality on the well-managed SAIS Tupac Amaru was lower than that reported for similar studies elsewhere in the world. This suggests that the SAIS model of animal production might be useful for other production units within Peru and in other developing countries. However, the major causes of mortality demand additional scientific investigation to further minimize their effects.

The juxtaposition of the mining industry in Peru with agricultural enterprises poses a serious potential health hazard for exposed animal populations. The health effects of low level chronic exposures to heavy metals in the environment are poorly understood. In addition to frank toxicity, i.e., lead poisoning, the possibility exists that these substances may act synergistically with other agents to increase morbidity and mortality rates for a variety of conditions. For example, it is important to determine whether chronic exposure to arsenic might increase the incidence of SPA. While we intend to study this problem at SAIS Tupac Amaru, the intoxication may be more important in sheep living in undernourished or heavily parasitized communities.

Future Research Directions

Chronic Respiratory Diseases

The major effort required in this area is the development of a diagnostic test for early detection of animals infected with the causitive agent of SPA. This will require continued basic applied research: 1) development of a protocol for experimental induction of SPA, 2) isolation of the causitive virus, 3) development and testing of a serologic test for antibody to viral antigens. Early work in this area has been attempted in Peru but lack of modern equipment and adequate facilities have hampered the research. Application has therefore been made to the USDA for permission to undertake SPA research at CSU. If this becomes possible, the basic research will be done in the US and diagnostic tests will be applied in the field in Peru after they are developed.

Seroprevalence of Infectious Disease in Peru

The work to date in this area is only preliminary and much broader based results are required in order to develop control or prevention strategies for causes of infertility, CAE and other diseases such as bluetongue. In the case of causes of infertility, serologic titers will need to be correlated with reproductive outcome to determine the relationship between current and prior infection with each agent and variables including live birth, abortion, perinatal death, infertility, birth weight, twinning and congenital anomalies. Correlation between seroprevalence and disease must be obtained with each entity in order to evaluate these results properly.

Neonatal Enteritis of Alpaca

Research directed at purification of *C. perfringens* enterotoxin will be continued at both SMU and CSU. Purification of the enterotoxin will allow development of improved preventive and diagnostic methods.

Further assessment of the contribution of enteropathogenic *E. coli* to neonatal mortality will be conducted. As the impact of *E. coli* is elucidated, control measures will be implemented. Such measures are currently available for calves, lambs, and pigs, and should be adaptable to alpaca crias.

Along with the above studies, efforts are currently being initiated to define the mechanism(s) by which maternal immunoglobulins are transferred from dam to neonate in the alpaca. An understanding of this transfer of immunity is crucial to the control of infectious diseases of the neonate. Studies will be conducted at La Raya and CSU.

Heavy Metal Toxicity

We plan to conduct analyses to determine whether a relationship exists between heavy metal levels in sheep and the incidence rates for several disease conditions, including pulmonary adenomatosis, infertility and neonatal death. Morbidity and mortality data have been accumulated by SAIS Tupac Amaru for over 10 years. Low levels of toxic heavy metals may be an environmental risk factor for other disease entities.

Neonatal Lamb Mortality and Parasitism in Smallholder Flocks

Work in this area is just beginning and results will be used in developing strategies for intervention to increase production in these flocks. Experience has shown, however, that veterinary medical intervention in undernourished flocks of small farmers must be undertaken with caution as negative consequences may result. For example, rigorous positive control in sheep can interfere with development of immunity to internal parasites. Therefore, our plan is to test such strategies in well-controlled experiments on previously studied flocks and to obtain objective data on the production, economic and social consequences of such intervention. Results of such studies will be analyzed and recommendations made to Peruvian government extension officials.

Alpaca Fever

Future studies are planned to identify reservoirs of *S. zooepidemicus*. These studies will be conducted by culturing tissues collected from alpaca at slaughter near the La Raya Research Station and, in particular, lymph nodes will be sampled to determine if *S. zooepidemicus* resides in clinically normal animals. Culture identification and serologic typing of *S. zooepidemicus* isolates will be conducted at San Marcos University. Typing antisera will be produced at CSU.

The Director of the La Raya Experiment Station, Dr. Julio Sumar, showing a young alpaca. Photo: W.C. Foote.

Training

Degree-Related

The intent of degree-related training is to provide a conceptual foundation and research experience in disease investigation to qualified individuals from Peru or North America.

John A. Ellis, DVM, is completing his PhD in Comparative Pathology (August 1980-December 1983). Upon completion of his PhD, Dr. Ellis will pursue research on diseases of economic importance of livestock in the US and developing countries.

Antonio Ramirez, DVM, is working on his MS in Microbiology at CSU (July 1982-December 1984). Upon completion of his degree, Dr. Ramirez will return to Peru (IVITA) and undertake research and extension in bacterial diseases of alpaca.

Raul Rosadio, DVM, MS, is beginning his PhD studies in Pathology at CSU (August 1983-December 1986). His future plans are to continue his appointment with IVITA. Dr. Rosadio's research will focus on sheep pulmonary adenomatosis.

Advanced Professional Training

The purpose of this type of training for Peruvian professionals is to provide an opportunity for exposure to modern approaches to disease investigation through communication with colleagues in the US, direct observation of experimental methods and literature work.

E. Caletti, DVM, PhD, traveled to CSU and the National Animal Disease Center, Ames, Iowa for a 4 week period in 1980 in order to develop new research plans and approaches and become familiar with techniques of cell-associated virus isolation, and to become acquainted with recent literature in the fields of virology and cell culture.

D. Huaman traveled to CSU for a 4 week period in July 1980 to learn new approaches to isolation and characterization of bacterial toxins.

E. Ameghino, DVM, visited California, Washington State, and Colorado State in March/April 1983 to attend a conference on Food Animal Veterinary Medicine, an SR-CRSP health projects' meeting, and to become familiar with new methodology in diagnostic veterinary medicine and current literature.

Technician Training

Technician training is designed to better prepare Peruvian technicians and others to undertake experimental methods appropriate to research in the SR-CRSP workplan. Such training was conducted by senior US investigators during 1 to 2 month periods in Peru as well as Peruvian investigators in Lima. Seminars and training sessions were provided for 5-25 veterinarians and animal health technicians at San Marcos University in Lima, IVITA Station at La Raya, and SAIS Tupac Amaru in 1980, 1981, 1982, and 1983.

Selected Publications

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Ramirez, A., L.H. Lauerman, D. Huaman, and A. Vargas. 1981. Preliminary Induction of *Clostridium perfringens*, Type A Enterotoxemia in Alpaca *(Lama pacos)*. IV Int'l. Conv. of South American Cameloids. Punta Arenas, Chile.

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Improving Reproductive Performance of Small Ruminants

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The importance of ensuring an adequate reproductive performance in programs directed at improving livestock production hardly needs stressing. Poor reproductive performance imposes a major constraint on all phases of production as well as the rate at which genetic improvement can be achieved in a selection or breeding program. In Peru, the Reproduction Project was faced with a situation in which there were few available research results to indicate actual levels of reproduction in sheep, goats, or alpaca although, in general, these were believed to be low. Good research data which identified the physiological basis for poor reproductive performance was also lacking. Improvement in all these species requires the development of more basic information on the details of their performance and, in the case of the alpaca, fundamental data on their unique endocrine physiological processes.

The goals of the Reproduction Project, developed in collaboration with Peruvian physiologists, have been:

- To measure and evaluate the reproductive capability of sheep, goats, and alpaca in relation to their environment.
- To develop alternative management practices which would increase reproductive performance.
- To characterize levels of production and management systems of smallholder producers and measure the influence of selected management practices.

The University of San Marcos (SMU) and the National Agrarian University (UNA) and SAIS Tupac Amaru, located in the Central Sierra, together with the coordinating efforts of INIPA, provided the infrastructure and major research resources of personnel, pastures, and animals for conducting the reproduction research project.

Research Accomplishments

Reproductive Capability of Sheep

A standardized procedure was established at the La Raya Research Station in the Southern *Altiplano* and at SAIS Tupac Amaru in the Central Sierra to measure reproductive capabilities of the three breeds of sheep in Peru.

The Criollo is the native-type sheep, relatively small in weight (26 kg) and generally expected to be better adapted to the harsh environment of the high Andes. The local Corriedale was developed largely by crossing imported Corriedales with the Criollo until a more or less typical Corriedale type was achieved with an average adult weight of 41 kg. The Junin is found primarily in the Central Sierra. It is the largest in body weight (46 kg) and was developed by crossing the Corriedale with several other imported breeds to improve wool production.

The ewes were bred during May and June at elevations of approximately 4,000 meters. Fertility varied according to age and breed of ewe, but overall averages were 95% or higher for Criollo and approximately 10% less for other breeds. Lamb mortality was also highest in the youngest ewes and in the Corriedale and Junin compared to the Criollo. Birth weights were similar among the three breeds but tended to be less in the Criollo. The prolificacy was very low for all breeds with less than 0.2% twinning. Bearing in mind that the management at these sites is much better than for community or privately owned flocks, this strongly suggests that at least under traditional breeding times and management systems, the lambing rate is the most serious factor limiting reproductive performance.

The incidence of estrus and ovulation and the rate of ovulation measured by laparoscopy throughout the year in the same breed and age categories (Table 1) demonstrated that low lambing rate is brought about by low ovulation rate rather than increased embryo or fetal loss. These lambing rates are much lower than the normal rates for Corriedale and other breeds from which the Junin was developed and suggests a local environmental influence such as nutritional deficiency or high elevation.

A selection program independent of the SR-CRSP, initiated several years earlier at SAIS Tupac Amaru to increase prolificacy, developed ewes reported to have a higher lambing rate in excess of 1.2. However, because these ewes are managed under improved conditions which provide a higher and more consistent level of nutrition, the possible influences of genetic selection and nutrition are confounded. Until the factors which limit prolificacy are identified, steps cannot be taken to develop improvement programs. A project has been suggested by the Reproduction and Breeding projects to conduct an experiment measuring the influence of elevation and nutrition but funding is not available. The Reproduction Project is cooperating with the Breeding Project to measure ovulation rate in crosses between imported prolific and native breeds. In addition, arrangements are being made to measure ovulation rates of ewes selected for prolificacy and also to manage them under conditions which allow for more significant comparisons.

Seasonal variation in the occurrence of estrus and ovulation (Figure 1) exists for all breeds. The variation is less for the Criollo than the Corriedale, especially in the Southern *Altiplano*. The Junin was not measured in this region. Based on data collected to date and expressed as the proportion of the total for each month for ovulation and for 17 day cycle intervals for estrus, the lowest proportions were during October through December-January and the highest from April through August. These locations are only 10-15° south of the equator, and do not appear to offer enough change in photoperiod to cause shifts toward anestrus. However, Cardozo and Foote (1968) indicated some seasonal variation in reproduction in the Criollo and Corriedale sheep in the

Table 1. Incidence (%) of Ewes Ovulating in the Central Sierra—Peru (April 1981-February 1982)

Month	Breeds			Total
	Criollo	Corriedale	Junin	
April	66.7	30.8	60.0	52.5
May	71.4	93.3	66.7	78.0
June	60.0	40.0	50.0	48.1
July	0.0	80.0	76.9	74.2
August	80.0	76.9	76.9	74.4
September	50.0	58.3	64.3	60.0
October	25.0	33.3	0.0	18.8
November	11.1	16.7	16.7	15.2
December, 1981	12.5	0.0	8.3	6.9
January, 1982	14.3	26.7	21.4	20.9
February	0.0	7.1	7.1	4.6

Altiplano of Bolivia which is only approximately 20° south. It is possible that variations are due to seasonal changes in quantity and quality of available feed. More complete analysis and conclusions will be possible when data collection is complete.

Management Interventions

The influences of modifications to management has been pursued through the help of the SAIS. These are very large semi-cooperative organizations with numbers of breeding ewes in excess of 100,000. They have many resources and management prerogatives that are denied to members of the surrounding and participating communities, many of whom own small flocks privately with very limited resources. In the spring of 1982, the SR-CRSP made arrangements through SAIS Tupac Amaru to cooperate with some privately owned flocks varying in number of sheep from approximately 30-140. The reproductive and production performance during this first year varied from 60-85% fertility and from less than 10 to more than 25% postnatal lamb loss. At the owner's request, arrangements were made to introduce selected management practices in at least one of these flocks to measure their impact on the existing management system and on levels of production. The practices being considered are parasite control, culling and selection, and limited breeding season.

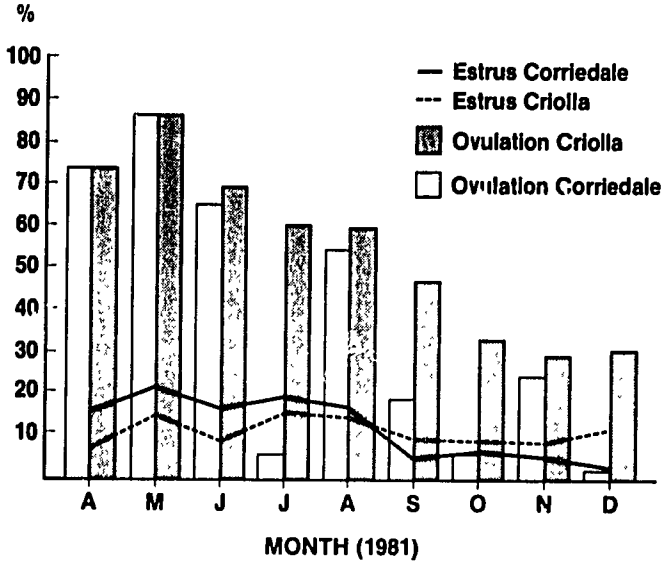

Figure 1. Frequency distribution of the occurrence of estrus and the percentage ewes ovulating by month and breed of sheep in the southern Altiplano (La Raya Station, Peru).

Reproductive Capability of Alpaca

Species of the new world camelidae (e.g., alpaca and vicuna) are restricted in South America almost entirely to the highlands of Peru, Bolivia, and Chile. To the people living within these areas, which often represent the highest and harshest environments, the cameloids are essential for survival. Reproductive performance is low among the alpaca and this appears to involve limitations in both the male and female. These animals exhibit unique reproductive characteristics which cannot be readily solved by extrapolating information from other species. They also provide unique models for studying reproductive processes, such as copulation induced ovulation, long copulation periods and differential uterine horn functions for site of fetus and for luteolysis. Major problems are considered to be low fertilization rate and high embryonic loss. Several studies are being conducted to estimate these parameters and obtain information to help improve these aspects of reproductive performance.

In one study, the occurrence and time of ovulation was determined by laparoscopy on one-year-old and adult females exposed to mating. The proportion ovulating within 30 hours or less postmating, 30-60 hours postmating or that failed to ovulate postmating were 42, 23, and 35% for one year old females and 49, 29 and 23% for adults. The normal or most frequent time for ovulation is approximately 26 hours postmating. Periods of time later than this would result

Host country and USU scientists using new laparoscope equipment to observe the ovaries in the alpaca to complement reproduction research. Photo: W.C. Foote.

in reduced fertilization or increased embryo loss because of sperm aging. These data show that failure to ovulate or delayed ovulation occurs in one-half or more of the cases and constitutes a significant contribution to lowered reproductive performance. The females from this study that became pregnant (as indicated by serum progesterone levels determined by RIA) were examined again at 45 days postmating to estimate the incidence of embryonic or fetal death.

Research underway with males includes methods of collecting semen to measure its quality, variations in quality at different periods of the year, and influence of libido on sexual receptivity and subsequent ovulation in the female.

Development of Facilities

In order to carry on effective reproduction research, facilities to measure tissue levels of hormones is essential. At the beginning of the SR-CRSP in Peru, a Radio-Isotope Laboratory and some equipment were available at UNA. The Reproduction Project team has worked with UNA to obtain support from the International Atomic Energy Agency to help furnish the laboratory and train personnel to conduct Radioimmunoassays (RIA). The Reproduction Project has helped substantially by providing equipment and supplies for hormone analysis. By the end of this fiscal year, we expect the lab to be fully equipped and personnel fully trained for RIA of steroid and protein hormones. Progesterone analyses were begun in 1982.

Significance of Research Findings

A significant aspect of these research findings is that they deal directly with identifying the cause of low reproductive performance and provide information that can contribute to improved reproductive performance.

The findings that low lambing rate is a limiting factor and that this is caused by low ovulation rate points out a major area for focus in improving reproduction. Additional questions remain unanswered, however, since the cause of low ovulation rate is not known. Apparent seasonal variations in the distribution of estrus and ovulation with values dropping to near zero during the period of October through December or January, prompts examination of the traditional breeding season to determine if breeding at another time might improve performance and at the same time take advantage of available feed. Detailed measurements of semen characteristics and related reproductive traits of sheep by breed and age category throughout the year show that if properly selected, the male will not limit reproduction performance of the ewes.

Preliminary information obtained from smallholder production and management programs indicate that lack of resources, especially improved feeds, is a major constraint to adopting alternative practices for improved performance. At least some producers have individual grazing rights assigned to them by the community. In these cases, a relatively simple management practice of culling the non-reproducing animals would significantly increase the amount of feed available for the more productive animals left in the flock. It is important to realize that many of these smallholders are anxious to consider changes in their management systems to improve their offtake.

Implications for Future Research

Areas of major focus envisioned for continuing research in Peru are:

- Develop alternative management practices to increase reproductive performance in sheep. A very low lambing rate, resulting from low ovulation rate and failure of multiple ovulations, has been identified as a major constraint to increased reproductive performance in sheep. Additional efforts will be made to identify causes for low ovulation rate and other causes of lowered reproduction, postnatal lamb loss and fertility in at least some breeds.
- Develop alternative breeding management programs based on synchronized seasonal variation in the incidence of estrus and ovulation with time of breeding.
- Continue to work directly with smallholder or least-resource producers to characterize their management systems and how they relate to reproduction and production and the resources available for generating improvements. There appear to be many such producers that are willing to cooperate in this way. As this information is obtained and evaluated, management practices commensurate with available resources will be recommended to improve livestock performance. These

will be compared to continuing traditional practices, the advantages identified, and additional modifications made to increase level and efficiency of performance. It is expected that cooperating producers can, to some degree, serve as demonstrators to neighboring producers.

- Continue efforts to identify specific reproduction constraints in alpaca and management related procedures to relax them. To date, the factors limiting reproduction appear to be male and female mating behavior and physiology, the occurrence and time of ovulation and subsequent fertilization, and embryo/fetal mortality.
- The Project has contributed in the planning of the goat project in Northern Peru and has provided services in a more or less advisory capacity. These efforts will be expanded into active research participation in providing semen and related breeding/management programs, in measuring reproductive performance, and assisting in developing management practices to improve overall production.
- Participate in an SR-CRSP integrated program for sheep production. This program was accepted and plans were made in January 1983 to set it in motion. The Reproduction Project will cooperate fully in this program which is designed to bring to bear the resources of all SR-CRSP projects in Peru in improving production for the least resource producer.

A Tupac Amaru shepherd displays a marking harness and crayon used by the Reproduction Project at the Consac Unit to detect estrus among an experimental flock of sheep. Photo: W.C. Weir.

Training

All efforts of the Reproduction Project include a training component for overseas personnel. These include degree and non-degree programs in Peru and at Utah State or other locations outside Peru. Indirect training is provided by way of on-the-job training to develop special skills or expertise important to the SR-CRSP, the Peruvian institutions, and the professional development of the individual.

Degree programs are being pursued at Utah State, Cal Poly (Pomona), and UNA. Peruvian graduates have engaged in research in their country as partial fulfillment for an advanced degree (MS or PhD). This allows the development of research programs as an integral part of the University in Peru and the SR-CRSP Reproduction Project as well as having the benefit of supervision by US scientists.

Five scientists are now in the process of receiving advanced degrees. They are:

- Cesar Novoa from San Marcos University (Veterinary Faculty), PhD at Utah State University. He completed research in Peru which is contributing to his dissertation. Additional research, coursework and other requirements are now being completed at Utah State.
- William Vivanco, National Agrarian University (Animal Science Department), MS at Cal Poly. Professor Vivanco conducted research both in Peru and California for his degree and has completed his formal coursework. He is currently supervising SR-CRSP research in Peru and will defend his thesis in June 1983.
- Julio Sumar, San Marcos University (Veterinary Faculty, IVITA, La Raya Station), MS in Sweden.
- Walter Bravo, San Marcos University (Veterinary Faculty, IVITA, La Raya Station), MS at Utah State. He is conducting research for his thesis at the La Raya Station and will begin formal training at Utah during the winter of 1983.
- Victor Alarcon, National Agrarian University (Animal Science Department), MS, National Agrarian University. He is conducting work in the Central Sierra (SAIS Tupac Amaru) for his thesis under the direction of Professor William Vivanco.

Specialized non-degree training has also been provided in the following ways:

- Training in Radioimmunoassay techniques (in Peru and Europe) for William Vivanco by the International Atomic Energy Agency, and supported by the Reproduction Project and the SR-CRSP exchange program.
- A shortcourse entitled, "Management of Reproduction" was held from March 9-13, 1981. Twenty-eight scientists and faculty members from Peruvian universities completed this course.

All Peruvian scientists and technicians working in the Reproduction Project have received the necessary on-the-job training to efficiently and effectively carry out their work in the project. This includes laparotomy and laparoscopy (at least seven persons) semen collection, handling and evaluation, estrus detection, pregnancy diagnosis, and data recording.

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Foote, Warren C. and Edward A. Nelson. 1981. Techniques and Procedures for Small Ruminant Breed Improvement. Sheep and Goat Handbook, Vol. 2. Int'l. Stockmen's School, San Antonio, TX. pp. 122-129.

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Sociological Analysis of Small Ruminant Production Systems

M.F. Nolan
University of Missouri, Columbia

As with the other SR-CRSP worksites, the principal goal of the Sociology Project in Peru is to understand the social and cultural context in which small ruminant production occurs. Unlike the other sites, with the possible exception of Morocco, Peru has a much more highly developed tradition of animal production. Livestock have been an integral element of Andean agriculture for several centuries. The Andean peasant communities, where well over half of the alpaca production in the country and nearly half of the sheep production takes place, are a unique form of social organization and contain a significant majority of Peru's rural poor. For these reasons, among others, the Sociology Project has concentrated on developing knowledge about livestock production in such communities in contrast to studying the cooperative forms of organization which emerged following the agrarian reform. Most previous social science research on livestock production in Peru concentrated on those communities which specialized totally in livestock. Yet, these are not the "typical" cases by any means. Our efforts thus far have focused primarily on what we have termed agro-pastoral communities as we sought to identify and understand the livestock production processes. Thus, much of the work undertaken during the initial period of SR-CRSP activities in Peru involved studying interrelationships between crop and livestock production within Andean peasant communities. Specific objectives were:

- To establish baseline data on livestock production in Peruvian peasant communities.
- To develop an understanding of how Peruvian peasant communities control access to communal grazing land, as part of the development of a broader grasp of the sociology of range management.
- To establish a framework that helps relate animal production strategies to marketing issues.
- As part of the Northern Goat Project, to explore the social aspects of goat production in the Piura/Chiclayo regions.

Research Accomplishments

Baseline Survey

The initial baseline work on Peruvian livestock production is reported by McCorkle (1982a, 1982b and 1983) and West (1981). West's report, focusing on alpaca production in the Department of Puno, is organized into three sections: 1) a general description of animal production in the Puno department; 2) a description of management practices used

by traditional herders and by a successful commercial producer; and, 3) a description of the use and commercialization of small ruminant products in Puno.

West's data indicates that alpaca production declined by over 50% from 1966-1977. There is some indication that it has increased slightly since then. The same was true for sheep production which experienced a 40% decline in the same period again followed by a slight increase. Cattle production stayed relatively stable throughout the entire period. In 1978, there were approximately 450,000 cattle, 3.9 million sheep and 1 million alpaca in the Department of Puno. Alpaca producers, commercial and non-commercial, were interviewed and the report contains a description of the alpaca management calendar followed by one of the most successful commercial producers of that species, Mr. Julio Barreda. Pricing, marketing, and production interrelationships were also examined. It was found that the lower market price of sheep's wool tended to restrict its use to domestic needs, and only when money was urgently needed would it be sold. Alpaca wool, although used domestically, was usually produced for sale. People with 50-60 alpaca were able to sell 300-400 lbs. of wool annually, but poorer households sold only about 25 lbs. In 1980, white fibered wool had a considerably higher market value than colored fiber for all species of wool producing animals. Typically, buyers purchased the wool from peasants in small lots until they accumulated several hundred pounds; the wool was then shipped to Arequipa where it was sold to major export companies.

McCorkle's activities had a quite different focus and content. Her research involved intensive observations and interviews in the southern Andean community of Usi, a mixed agro-pastoral production system with sheep and llama as the predominant livestock. She focused on three primary elements of livestock production: 1) the social organization of production including such factors as labor sharing arrangements, the integration of crops and livestock and the use of animals for ceremonial occasions; 2) animal husbandry practices and techniques, and 3) the management of animal health and disease.

Andean agro-pastoral communities have developed complex and efficient methods of organization to provide labor for the joint production of crops and livestock. There are particularly interesting means by which this is carried out during periods of exceptionally high labor demands such as during crop harvesting and planting. By contrast, labor demands for livestock are much more constant throughout the year; therefore, the preferred form of pastoral labor organization in Usi is structured to provide maximum labor for crop production during peak demand. This is known locally as *t'inkikuy* in which labor is, in essence, traded for labor. Labor services, usually herding, are performed in return for exactly the same service figured on a per day/per person basis and kept in perfectly strict accounts. Usually, *t'inkikuy* involves taking animals out to pasture and supervising another person's herds for relatively short periods of up to a few days. The arrangements are made informally by mutual and friendly consent between two or more households almost always in the same neighborhood.

Indian woman weaving with alpaca fiber at La Raya Station, Cuzco. Photo: B. Quijandria.

Women typically initiate the association since they have primary responsibility for daily pasturing; however, the full membership of each participating household—men as well as children—is often involved in the agreement and their labor may be called upon to meet it. The understanding is that caretaker services are always potentially "on tap", but for each specific occasion prior plans must be made convenient to all concerned. Without such organizational strategies, few families would be able to pursue pastoralism at all. By pooling herds, families are able to free more labor for agricultural and other subsistence activities. In addition, herd aggregation may also facilitate the provision of specialized care and forages for different animal species. The informality and flexibility of the labor sharing arrangements found in Usi allowed villagers to respond rapidly and rationally to their highly changeable physical and social environment. Typically, the Andean peasant families' labor needs and resources vary markedly, not only across the years (e.g., due to periodic droughts and animal epidemics) but also within the space of a few months or weeks, thanks to the fluctuating demands of multicrop agriculture and the health and/or forage needs of different species at different times of the year. By initiating and terminating relationships as necessary, stockowners avoid the material and social costs of more formal permanent arrangements. Only rarely did villagers resort to "contractual" labor which is defined as exchange of labor for payment in cash or kind. Arrangements were carried on among relatively small numbers of households with even as few as two being involved in any given arrangement.

The annual cycle of animal management in Usi and some of the cultural traditions and rituals which are embedded in management practices are described by McCorkle (1983). Relatively regular current pastoral activities such as slaughter-

Goats resting in the shade of an Algarroba tree, Piura. Lower branches have been lopped to provide browse for the animals at a time when grazing is almost entirely absent. Photo: M. Nolan

ing, shearing, docking, castration, breeding and feeding, in addition to more general, non-cyclic aspects of animal husbandry including structures and equipment, herd composition, losses and culls, and management of predation were investigated. It would seem, on the surface, that the Andean peasant's management of herds to optimize private production goals often works to the detriment of pastoral productivity when this is viewed in a larger overall sense. However, when one examines questions of pastoral productivity and efficiency, one must always be cognizant of the subsistence system as a whole, cultivation as well as herding. Peasant agro-pastoralist households must constantly juggle their scarce factors of production between cultivation and herding. They must delicately balance the returns to each as best they can under ever-shifting conditions of climate, herd and domestic unit composition, market prices, household and community needs, and the like. In essence, livestock owners must settle for an "optimizing" as opposed to a "maximizing" strategy in their pastoral activities. This has considerable implications for the management practices they employ.

The third topic McCorkle addressed concerned the management of animal health and disease in Usi. This report provided a description of the approach that community members took toward animal diseases and the terms used to describe diseases and their causes (McCorkle, 1982a). Effective modern medicines for most of the diseases affecting Usi's herds were commonly available in nearby cities. Villagers knew this but typically could not afford such drugs or regarded them as not being cost effective. Yet, when all else fails, occasionally a few Usinos turn to purchased medicines in desperation (usually for llama). However, informants who reported doing so generally expressed great dissatisfaction with such preparations for a number of reasons. First, of course, is the expense. Here peasants, correctly, calculated that at least for sheep, store-bought drugs were generally uneconomical. Usinos can usually only realize $20-30 for the sale of a sheep and thus the slaughter and sale (or home consumption) of ailing sheep is often the most economically rational move. Moreover, of the few informants who reported such attempted cures on sheep, all said their money was thoroughly wasted because the medicines worked only for a week or two or on some of the animals but not others. In part, such failures are likely due to misdiagnosis and the consequent purchase of inappropriate drugs plus imperfect understanding of the directions for their application. Villagers further complained that commercial treatments called for over-frequent applications which the peasant household could not accommodate. This additional shortcoming almost certainly accounted for further failures with such cures. The many conflicting demands of agriculture leave insufficient time and labor for proper attention to curing animal diseases.

Sociology of Range Management

A unifying theme for many of the activities of the Rural Sociology Project in Peru has been the study of the sociology of range management, undertaken in the belief that pasture improvements are the key to upgrading smallholder livestock production in Peru.

Focusing initially on the southern Andean community of Toqra, a study in the sociology of range management

involved intensive field observations and interviews which took place over a nine month period in 1980-81. Jamtgaard (1983) describes the different forms of pasture available to animal producers which included, besides traditional pasture lands located some distance from the village, fallow fields, stubble fields and uncultivated land adjacent to the community itself. This study discussed the strategies different producers used in maximizing use of these resources, and classified producers into four types based on their primary type of pasture use. Briefly, those producers who have relatively large numbers of animals and an adequate labor supply tended to use better quality pastures further away from the village, while those with relatively few animals and little labor relied more on the poorer quality of pastures close to home. Jamtgaard also noted that manure was perhaps the most important commodity produced by animals and that much of the village economy was based upon manure as a medium of exchange. With annual manure requirements for crop production for an average Toqra family of about 1.5 tons, the principal animal management strategy was to provide for a centralized collection point, which often meant bringing the animals back into the family corral at night.

Despite the importance assigned to range management and natural pastures by policy makers, little research emphasis is placed on this area by Peruvian institutions, a discrepancy revealed in a short study by this project. Only 5% (3 of 62) of the INIPA research projects in 1980/81 were concerned with natural pastures. The scientific productivity followed this pattern as only 22 of 423 articles published in Peruvian agricultural research journals reported data on studies of natural pastures.

Social Aspects of Goat Production

The Sociology Project has participated in the integrated Northern Goat Project, an initiative intended to upgrade goat production systems in this low lying desert region in the northwest corner of Peru. Avi Perevolotsky, a member of the project's interdisciplinary team, gathered baseline data on the different goat production systems found in that region and pursued research to show how socioeconomic organization and political and environmental factors influence the management of goat herds. Considerable interchange between pastoralists and agriculturalists was observed, with some migration between these two distinct agricultural occupations under different climatic conditions. In times of severe drought, pastoralists are likely to assume some roles in the irrigated agricultural regions of the coastal northwest, while during periods of heavy rainfall, when land is less useful because of flooding, agriculturalists frequently move into livestock production to exploit the increased availability of forage.

Sociological Dimensions to Development

A number of studies have been conducted which focus on the sociological aspects of development strategies already in effect or in the planning stage.

The development of a classification scheme of peasant community production systems was the object of work undertaken by Keith Jamtgaard during 1982. Such a typology, together with a data base assembled by the Direccion de Comunidades Campesinas, will allow development projects to choose representative worksites with more accuracy than was possible before.

Dr. Juan Gomez began a project in 1982 to study the causes and effects of establishing private lands in communities in the highlands of Arequipa. The analysis of community disintegration is important in that it should help to reveal more about the operation of the peasant community form of production and the advantages and disadvantages that accompany this institution. Dr. Mario Tapia and Jorge Flores of Cuzco have as their goal the publication of a book which unites much of the social and biological reference material written about shepherds and pastures of the *altiplano*. Ricardo Rivera's research documents how family labor is used for herding in two peasant communities in the Montaro Valley. This study will be an important reference point for those attempting to effect changes in the livestock sector of peasant communities. Victor Fernandez's research will shed light on the relationship between communities and cooperatives. Interaction between mining and animal husbandry is also explored as part of this research project. Various patterns of herd management are also described in a forthcoming book by Dr. Juvenal Casaverde in the community of Vichaycocha. Associations between different management strategies and influential factors such as migration history, outside occupations, and number of children are analyzed in this work.

The two studies of meat marketing in Peru by George Primov (1981, 1983) detailed the legal and illegal Cuzco-Puno markets for sheep and alpaca meat. In addition to statistics on meat marketing in the Southern Sierra, the reports described the informal organization of the wholesale and retail meat trade in the region. Wide seasonal variations in the number of animals slaughtered and the average weight of carcasses were reported.

Significance of Research Findings

Any examination or attempt to improve small ruminant production in Peru will at some point have to confront three issues: the importance of the indigenous Andean peasant community in overall livestock production; the importance of range and extensive grazing systems as the principal forage source for small ruminants; and the predominance of agro-pastoral farming systems in the Peruvian agricultural structure. The Sociology Project has attempted to develop an understanding of the dynamics of all three issues as well as the interrelationships between them. Given the complexity of the factors involved, a complete understanding of the dynamics of livestock production is probably impossible. Nevertheless, the research done to date has underscored the importance of having accurate information on these issues before one tries to implement any kind of technological or management intervention. For example, any attempt to

Typical cheese manufacturing technique of goat herders in Piura. Photo: B. Quijandria

change community based range management practices must take into account indigenous systems of managing communal pastures and farmers' motivations in keeping livestock. It would be in error to assume that all farmers keep livestock to maximize profit. In fact, livestock appear to be kept both as a form of savings and as a producer of manure for subsistence crops such as potatoes.

The Sociology Project firmly believes that any attempt to impose changes in livestock production strategies, without taking into account crops, pastures and people, is doomed to fail. In dealing with Andean peasant agro-pastoral communities, it will be crucial to proceed very slowly and only after one has a good foundation of knowledge for proposing change. The studies reported above and those planned for the future provide a good place from which to evaluate proposed changes in the biological system.

The research done to date by the Sociology Project in Peru has a particular bearing on the range-forage program and the animal health program. Thus, the overall production strategy of the smallholder with his multiple uses of livestock and their integration with cropping must be recognized. In addition, before embarking on relatively costly control methods for livestock disease, it would be appropriate to examine the scope and cost effectiveness of indigenous veterinary medicine.

Future Research Directions

Future research in Peru will seek to build on the knowledge already gained and answer questions which might have been explored to date. Among the projects planned are:

- A study of animal production in an intensive agricultural production area where animals clearly play a secondary role to crop production.
- A study of social relationships of production in peasant communities in the highlands of the Montaro Valley.
- A study on the role of women in pastoral production in the Southern Sierra of Peru.
- A study of pasture management by a community which is distinguished by being a pure pastoral community. To date, all work done by the Sociology Project has been in mixed agro-pastoral communities.

Training

One Peruvian student has been trained at the graduate level at the University of Missouri in Rural Sociology. Lidia Jiminez began her graduate training in June 1981 and is expected to complete her studies in December of 1984. Two US students, Keith Jamtgaard and Avi Perevolotsky were sponsored by the Sociology Project to gather data for their MS and PhD programs, respectively. Jamtgaard completed all the requirements for his MS degree in Rural Sociology from the University of Missouri in May 1983 and Perevelotsky will complete the requirements for his PhD in Environmental Studies from the University of California, Davis in December 1983.

In addition, the following students have been supported for bachelor's thesis work in Peruvian Universities by the Sociology Project:

M. Huaman, BS, University of Pedro Ruiz Gallo, Piura
W. Caldes, BS, National Agrarian University, Lima
J. Petit Jean, BS, National Agrarian University, Lima
L. Aguirre, BS, University of Cuzco
R. Echevarria, BS, University of Cuzco
E. Pando, BS, University of Cuzco
H. Espinoza, BS, University of Cuzco
E. Namoc, BS, University of Cuzco
R. Heredia, BS, National Agrarian University, Lima
D. Aquize, BS, San Marcos University

The project has also sponsored informal training sessions to orient the faculty at the National Agrarian University in the use of SAS (Statistical Analysis System) which the SR-CRSP provided to the University.

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Nolan, Michael F. (ed.). 1980. Andean Peasant Economics and Pastoralism. SR-CRSP Technical Report Series No. 1.

Perevolotsky, Abraham. 1982. La Crianza Caprina en Piura-Una Perspective Sobre Ecologia Humana. Paper Presented at Goat Raising Conference, University of Piura.

Perevolotsky, Abraham 1982. Ganaderia y Agricultural en Piura: Intercambio, Dependencia y Conflicto. Paper Presented at IV Session of Andean Ethnohistory.

Primov, George P. 1983. Alpaca Meat Production and Exchange in Southern Peru. SR-CRSP Technical Report Series (Forthcoming).

Primov, George P. 1981. The Regional Structure of Distribution of Mutton in Cuzco, Peru. SR-CRSP Technical Report Series No. 3.

West, Terry L. 1981. Alpaca Production in Puno, Peru. SR-CRSP Technical Report Series No. 4.

Goat Research Project in Northern Peru

B. Quijandria

In 1979, the SR-CRSP selected Peru as one of the overseas worksites for research on sheep with the objective of increasing the body of knowledge on methods and techniques related to improving productivity of this species under Andean range conditions. Upon evaluating the ecological and economic conditions of the Northern desert region, goat production was included in the definition of priorities for the Peru SR-CRSP even though the principal work with this species under tropical desert conditions was being done in Brazil.

During a visit to the SR-CRSP Management Entity Office in April 1980, Dr. Carlos Valverde, Associate Director of INIA, presented a proposal to the SR-CRSP for a Goat Research Project in Northern Peru which had been prepared by the technical staff of the Lambayeque Research Station and given high priority by INIA officials. The proposal was circulated among PIs active in Peru, and while it received generally favorable reactions, its prospects were not bright because funds had already been committed to research projects on sheep and alpaca in the Central and Southern Sierra. A modified design for the proposal, based on a nationwide goat research plan (prepared by Ing. Enrique Nolte), was submitted to the SR-CRSP for contingency funding. The proposal was submitted as a joint endeavor of the University of Missouri, Ohio State, Texas Tech, Utah State, Cal Poly, and Winrock International, under the coordination of the overseas Site Coordinator. The project was finally granted funding in June 1981. Research work started the same month and has continued for the last 18 months. It is expected that funds will be expended by June 1983.

The project goal is to improve the living standards of goatkeepers in the Northern Peru area through an increase in production, productivity, and net income derived from goat production. The main objectives of the project are thus:

- to increase the knowledge of the current goat production system and the factors that limit its performance;
- to develop and test improved technological alternatives adapted to the ecological and socio-economic situation of the goatkeeper which are capable of increasing production, productivity and income;
- to strengthen local universities and research station personnel by collaboration between US SR-CRSP residents and Peruvian animal scientists.

Research Accomplishments

The project is pursuing its research goals through the farming systems approach, which regards the entire farm as the unit to be studied in an attempt to understand the

interaction between man, ecology, and production within the farm boundaries as well as the external socio-economic forces that give final shape to production systems. This approach is expected to result in the opportunity to offer farmers improved production systems, with a choice of alternatives in crop and animal management while at the same time the means to facilitate the decision-making process for the farmer, promoting the conservation and rational use of natural resources and increasing production, productivity and net farm income.

Careful consideration must be given to ensure that any new technology is compatible with farmers' objectives and capabilities within the limits of available resources. This consideration makes it essential to describe existing production systems in some detail in order to develop an understanding of resource constraints and socio-economic factors that impinge on production decisions.

A baseline survey of the key characteristics of the existing goat production system in Northern Peru was conducted in four stages. The first consisted of a preliminary survey of over 20% of producers using a short questionnaire in which general information was gathered on livestock, crop production and other on-farm activities, including marketing. As a result of the survey, producers were classified by location and herd size. The second step, the formal survey, involved a total of 171 questionnaires in Piura and 183 in Lambayeque applied to a sample of 5% of the goatkeepers. The scope of information requested in the survey included: location and farm history, family size and education, land tenure, type of enterprise, goat and livestock production, goat management practices, yields, marketing policies, labor and capital resources, social organization, production limiting factors, and future outlook. Results from the formal survey were used to help define priorities for biological and social research, and to identify additional information needs on key issues. Gathering this additional data comprised stage three of the baseline survey.

The fourth step is the continuous monitoring of representative farms within specified ecological areas. Production data is recorded on a weekly basis on 8 farms in Chiclayo, 8 in Piura and a small number in Lambayeque in order to obtain a dynamic one-year picture of farm activities. Although this stage has been initiated, it will be completed using outside funding sources.

Research Results

Baseline Study

An initial broadly based survey of the region revealed some overall characteristics of goat production systems:

- The systems are mixed with cropping in 73% of the cases studied. Twenty-eight percent of herders own land on which they raise crops and goats while the remaining 62% use marginal lands (river beds, road and hill sides, etc.) and cultivate only when surplus rain is available for irrigation. Fifty-two percent of all herders crop for family use only. Fifty percent maintain other types of livestock (5 cattle, 11 sheep, 2 burros, 2 horses and 5 pigs) together with an average size goat herd of 55 animals.

A goat producer and family in Northern Peru exemplifies one of the several goat production systems of the region that was identified during the Project's survey. Photo: B. Quijandria.

- Management practices are reflected by the 37% who wean kids, 15% who keep does and bucks separated, and 60% who keep all females born within the herd. Sixty percent of all herders have one kid crop per year and select using visual and phenotypic criteria such as color (10%), size (18%), large ears (8%), body shape (7%), good udders (12%), and offspring of a good dam (8%). First kidding occurs at 16 months of age and 84% of the bucks are selected from within the same herd.
- Average milk production per herd during the rainy season is 10.1 liters, of which 1.4 liters are used for home consumption, 2.0 liters are marketed and 6.7 liters are processed into cheese. During the dry season average herd production is 2.8 liters.
- Limitations to goat raising are most often identified as the reduced availability of range forage resources and the lack of water and cultivated pastures.

As this information was gathered, it became clear that this aggregated data concealed complexities that required clarification if improved goat production strategies acceptable to producers were to be designed. Thus, Abraham Perevolotsky, the University of Missouri on-site resident, undertook an in-depth analysis of the various types of goat production systems in the area and the key characteristics of each. He concluded that not less than seven such systems must be specified and that proposed improvements in goat production would have to be adjusted and targeted to the specific needs of each. The systems that he identified can be summarized as follows:

1. Small agriculturalists (0.5-5 ha): found chiefly in peasant communities in Bajo Piura and Bajo Chira; they own small to medium-size herds (5-50 animals), mainly goats.

The income obtained from kid selling is used for supplementing the family income as well as providing necessary cash to agricultural purchases (e.g., seeds, fertilizer or small pumps). The strong linkage between agriculture and livestock determines patterns of livestock marketing.

2. Members of cooperatives: found mainly in middle Piura and mid-Chira, and own small to medium herds, mainly goats. Since they enjoy a permanent salary and access to a private *chacra* (a small agricultural plot) the herd is viewed as a "savings account." Selling occurs mainly when there is a special need—illness in the family or a TV purchase. More kids are consumed by the individual family.
3. "Eventuales": usually neighbors of group 2 but lack permanent salary or economic stability. By and large they attempt to raise more goats, sell kids and adults more frequently, and some are engaged in milk/cheese production.
4. San Lorenzo: more advanced agriculturists, owning small herds of cattle, milk cows or sheep, which can graze easily under the farm orchards. Here too, livestock serves as a source of cash for agricultural purposes but is used in a more sophisticated fashion. Credit is available and used by many people.
5. Alto Piura: similar to systems 2 and 3 except for a higher proportion of sheep, mainly found because during portions of the year the only pasture is "puno de algarrobo" which is more easily picked by sheep. Another important characteristic of this region is the availability of abundant green pasture in the hills after rainfall. Such pasture improves milk production and cheese is produced. Outside of the lowland Piura area at least two additional agropastoral units exist:
6. Mountain slopes where non-irrigated agriculture is practiced with corn as a main crop. Here the predominant livestock, cattle and goats, are stall fed with crop residues since pasturelands are limited.
7. The high Sierra, where sheep raising prevails. The better resistance of sheep to cold and humidity, and the need for wool for domestic use are factors determining the herd composition.

Biological Research

Year-round food supply was the main factor observed in the northern area of Peru that limited goat production. Most of the goats in the area made extensive use of the rangelands and migrated seasonally to agricultural valleys to make use of crop residues. The main lines of research were directed to address the following questions:

- What is the quantity and quality of the biomass produced by the range?
- What are the dietary preferences of goats for the different forage resources available on the range?
- What is the capacity of the range for sustaining extensive goat production?
- What is the nutritional quality and quantity of the crop residues available in agricultural valleys close to the goat production area?
- What is the genetic potential of criollo goats for meat and milk production and reproduction?

Research was started to determine the grazing habits of goats in the rangelands in Northern Peru. Rangeland vegetation is comprised of grasses, herbaceous plants, shrubs, and trees. In the first stage, clearly identified animals were followed during grazing periods over a known area, mapping the time animals use to consume various species and to determine their overall diet. The variation in diet over an 8 month period was also studied. At the same time, samples were taken of species grazed by the goats so that the intake of protein, dry matter and other nutrients could be determined by laboratory analysis.

The main species that characterized the Northern Peru range were: Faique *(Acacia tortuosa, A. macrocantha)*, Algarrobo *(Prosopis sp.)*, Overal *(Cordia rotundifolia)*, Sapote *(Capparis angulata)*, Charan *(Caesalpinia corynbosa)*, Membrillejo *(Lantana sp.)*, Pina *(Psitta cantus sp.)*, etc. These species grow as shrubs or trees according to the characteristics of the range where they are located. Predominating grasses and herbaceous species include: Calaberita *(Cnefora hermaphrodita)*, Pajilla *(Aristida adscensionis)*, Yuca de Monte *(Apodanthera biflora)*, Crespillo *(Bouteloua aristidoides)*, Tocon de Campo *(Faseolus lathiroydes)*, etc.

Goats were kept an average of 14 hours in pens without food supply and after milking were left free to graze the range for about 10 hours. Initially, diets comprised 15% of tree species, 40% of grasses and herbs, and 43% of shrubs. After 4 months, tree species contributed only 3% of the diet, grasses and herbaceous species 37%, and shrubs 60%. At the end of the 8 month trial, animals were eating 7% from trees, 40% from herbaceous species and grasses, and 52% from shrubs (Figure 1).

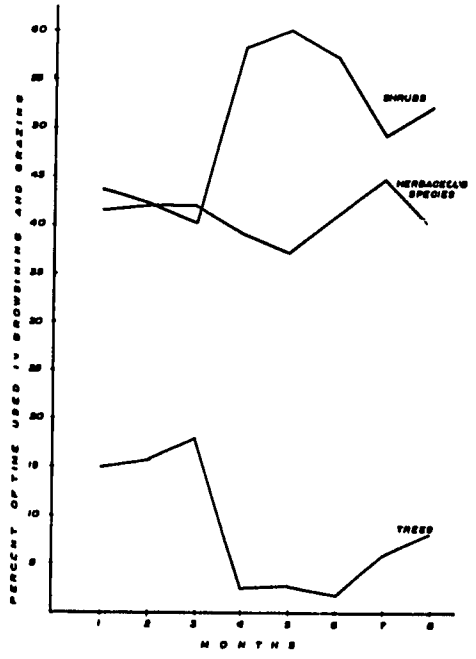
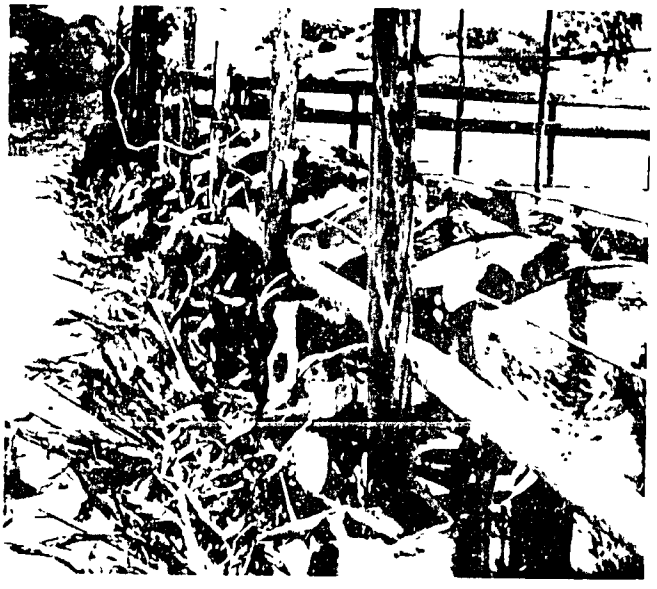


Figure 1. Eight months variation on goat intake on the Olmos Range.



One of a number of feeding trials at Lambayeque goat research station. Photo: B. Quijandria.

Based on the laboratory analysis and an estimate of the species consumed, goats obtained diets with 13.7 to 17.8% protein in the diet. The largest amount of protein was obtained from shrubs and trees, because in dry years grasses and legumes are scarce. In some species where the lignin content was high, digestibility of protein could be impaired. Additional studies will be carried out using fistulated animals in order to evaluate more precisely the total consumption and quality of goat diets.

Another area of research was investigating the nutritional quality of crop residues available in the area. Feeding trials and nutritional analysis of the major crops were conducted. This included residues from corn production, sugar cane, beans, and sorghum. Based on the *in vitro* and *in vivo* digestibility studies on young animals, feeding trials were devised combining several crop residues and forages obtained from the range. The purpose of this was to establish the composition of optimal diets for recommended use by goat producers (Table 1).

During drought, the availability of forages of suitable quality and quantity to maintain animal productivity or even survival is a major problem. *Leucaena leucocephala*, a shrub that is both drought resistant and can provide highly nutritious forage, was examined to determine the best cultural practices for its establishment and sustained production. Nutritional trials combining leucaena with other forage resources were conducted. Best results were obtained with diets containing 30 to 40% of leucaena with molasses, crop residues, salt and mineral supplements.

Studies to appraise biomass production of range shrubs and trees are continuing and involve measurements of total leaf production, trunk diameters and regrowth potential of several important species. Tree cutting at various heights was tested to study potential management techniques that could promote leaf growth at heights easily available to browsing goats. Preliminary results show a potential in Acacia and *Prosopis sp.* for high protein biomass production with four cuts a year at a height of 1.2 m.

The evaluation of genetic potential of Criollo and Criollo x Anglo Nubian crosses was evaluated through the systematic gathering of data on growth, milk production, and reproduction (Table 2). Intensive, semi-intensive, and extensive production systems were monitored on a regular basis, and revealed that the type of production system had a large effect on total milk production, but that under the study conditions, breed had no significant effects on traits studied. Criollo goats had high incidence of twins and triplets even under poor nutritional conditions (Table 3).

Table 1. Digestibility of Crop Residues Commonly Used by Goat Producers in Northern Peru

	Bean Stalks	Corn Stalks	Rice Straw*	Sugar Cane Tops
Voluntary Consumption (DM/100 K.lw)	3.2	3.0	2.1	3.5
Digestibility: DM %	56.8	54.9	46.0	56.7
Crude Protein %	37.4	17.1	9.3	57.5
Crude Fiber %	51.1	66.5	57.7	57.3
Energy %	53.8	55.1	48.0	55.2
Digestible Protein %	2.5	.6	.4	3.3
Digestible Crude Fiber %	21.5	28.0	17.4	21.0
Digestible Energy Mcal/k	2.1	2.3	1.7	2.3
TDN %	49.3	53.6	39.2	54.3

*With 10% molasses added.

Table 2. Average Total Milk Production and Other Related Traits in Criollo Goats Under Semi-Intensive Production Systems

	N° Observations	Total Milk Production (kg)	Lactation Length (days)	Average Daily Production (kg)	Gestation Length (days)	Days Open (days)	Birth (kg)
Parturition 1	80	57.8 ± 3.5	146.7 ± 6.8	.381 ± .009	150.8 ± 1.2	341.3 ± 12.7	2.6 ± .06
2	73	88.8 ± 6.3	177.2 ± 10.7	.483 ± .018	149.2 ± .3	348.0 ± 11.2	2.8 ± .07
3	65	150.1 ± 9.3	200.5 ± 9.0	.740 ± .038	148.7 ± .3	316.0 ± 10.4	2.9 ± .06
4	51	155.2 ± 10.0	184.5 ± 9.5	.840 ± .038	148.4 ± .3	293.4 ± 10.4	3.0 ± .06
Type of Parturition:							
—Single	113	81.0 ± 5.8	159.0 ± 7.3	.472 ± .019	150.0 ± .7	326.4 ± 8.8	3.0 ± .05
—Twin	142	122.9 ± 6.0	187.0 ± 6.2	.643 ± .024	148.9 ± .2	330.1 ± 8.5	3.0 ± .05
—Triplets	14	154.7 ± 18.5	185.1 ± 20.3	.832 ± .086	148.0 ± .7	313.5 ± 21.3	2.7 ± .10
GENERAL	269	107.0 ± 4.3	175.2 ± 4.7	.581 ± .017	149.3 ± .3	327.6 ± 5.9	2.8 ± .03

Table 3. Prolificacy of Criollo Goats Under Extensive Production Systems [1]

	Herd 1	Herd 2
N° kiddings	43	41
Total N° kids born	82	83
Singles, N°	14	8
Twins, N°	38	50
Triplets, N°	30	21
Quadruplets	—	4
%Singles	17.0	9.6
%Twins	46.3	60.2
%Triplets	36.7	25.3
%Quadruplets	—	4.9

[1] Data from farmers under dynamic survey. Feeding on range with no supplementation.

Significance of Research Findings

Goat production in Northern Peru is a complex phenomenon with seven different production systems occurring in adjacent areas. Each system emphasizes its own goals and objectives, and has different marketing strategies and channels. Although several of these systems may have the same limiting factors, new technologies to relax these constraints will need to be presented to each with a different emphasis and alternatives.

Initial research has now accomplished the objective of identifying and understanding existing goat production systems, but additional quantitative information is still needed in order to build a dynamic model representing them. Goat production in this area depends on flexible management strategies which can adjust to the highly variable climate. A climate in which rainy years alternate with droughty periods with a frequency of 4 to 6 years, makes special demands. Herd sizes are adjusted to resources on the range and, due to the prolificacy of criollo goats, can be severely reduced one year and rapidly duplicate or triplicate its size as soon as resources are restored on the range. This variability produces initial difficulties in defining research strategies. Limiting factors change over the years and technological alternatives that apply in a given year are not relevant the next year.

Nutrition has been shown to be the most important constraint to goat production in Northern Peru. Most forage requirements of the goat herds are met by the range, but in some seasons crop residues provide the balance. Grasses and legumes are the best available resources in rainy years, but shrubs and trees become the major forage resource for goats in dry periods. Management of range resources is one of the most important objectives of the program; it requires the understanding of seasonal variations in biomass production and quality throughout the year and over several years. Studies in the present project have provided some insight into grazing and browsing patterns of local goats during an extended dry period, but additional studies are still needed to understand feeding behavior when herbs and grasses are abundant following the rains.

The social aspects of raising goats is an impor ant factor under study in the present project. The relation between agriculture and goat production, traditional systems, and family ties, are among the factors that have to be clearly understood if improved production levels are to be achieved without detriment to social relationships.

Browsing on protein-rich shrubs is an important survival strategy for goats in the northern desert regions. Criollo goats are shown browsing on Algarrobo trees. Photo: B. Quijandria.

These initial studies have indicated that there is indeed potential for increasing the income of low resource farmers through improved goat production. However, due to the erratic character of the environment, special care will be needed to assess potential repercussions of improved technology before it is recommended to farmers. The initial research results reported here have been vital in allowing us to design future research which more fully reflects the needs and idiosyncrasies of the region.

Future Research Directions

The Northern Peru Goat Project was supported by SR-CRSP contingency funds. One of the conditions for the use of this fund was that it should serve as seed money. The initial budget, considered for one year, was stretched, using judicious spending policies, into two years of activities; however, funds will be exhausted before the end of 1983.

A proposal for continuing support to the goat project was presented to the International Development Research Centre (IDRC), from Canada in 1982. By May 1983, the Board of Directors of IDRC approved the request and will grant INIPA an estimated 250,000 Canadian Dollars for a three year period, to be managed by the Site Coordinator's office. The SR-CRSP has provided a "bridging" budget that will permit the continuation of the goat project and help assure a smooth transition.

Future research will address basic questions set up at the beginning of the project and will cover the following activities:

- Dynamic survey: A total of 16 goat producers will be monitored over a 2 year period. Information gathered on a weekly basis on animal performance, economic parameters, and social aspects will be used in developing a dynamic model of goat production which will allow economic aspects and various production alternatives to be explored.
- Evaluation of range: Continuing trials will evaluate the capacity (quantity and quality) of the local range for sustained forage production. Particular emphasis will be placed on understanding seasonal variations in nutrient availability. Experimental work on developing management techniques for browse production from shrubs and tree species will be continued.
- Nutrition. Evaluation of crop residues as supplementary food for goats will continue, with emphasis on systems in which residues provide the bulk of the diet. Evaluations of diets containing various levels of residues in growing and in milk producing goats will be performed, and research on *leucaena leucocephala* as supplementary forage will be continued.
- Genetics and reproduction: The evaluation of the genetic potential and reproductive capacity of criollo goats for meat and milk production will be made under different production systems. Cross breeding trials with exotic breeds will also be conducted to explore the scope for genetic improvements should the local breeds prove unresponsive to improved nutrition and management.
- Socio-economics: Research into economic and social factors related to goat production will be continued to improve our understanding of the production decisions made by goat producers.

Improved models of goat production systems will also be tested with cooperating goatkeepers and new technologies will be tested for their biological, economic and social effects.

Training

Training has always been considered an integral part of this project. In Peru, a lack of well training professionals in goat production techniques has been one of the main factors limiting research and extension. The training portion of the project has two related objectives. One is training local personnel from INIPA and Peruvian universities in specific aspects of goat production, so that teams of professionals can orient research and extension efforts toward specific problems. This objective has been attained by encouraging attendance at short postgraduate courses offered outside Peru. Since goat production in the north is sustained by rangeland and crop residues, emphasis is being given to range, forage, and crop residue utilization. Enrique Nolte, a leading Peruvian goat scientist, was selected by Ohio State for a PhD program in goat nutrition, sponsored by Texas Tech, and will complete his requirements by July 1984.

The second aspect of training is related to production systems research methodology. Training is oriented to familiarize INIPA staff with this approach. Goat project participants have attended seminars and workshops in Peru and Costa Rica sponsored by the Canadian IDRC where

issues such as baseline methodology and design of improved models were addressed.

Training activities can be summarized as follows:

Graduate Training:

- PhD training for Mr. Enrique Nolte.
- Assistantship awarded for MS program at Universidad Nacional Agraria (UNA) for Mr. Edgar Romero, 1983-1984.
- PhD research funded for A. Perevolotsky, 1981-1982.

Shortcourses:

- Attendance at a four week postgraduate course on tropical forages by Francis Villena (UNPRG) and Rosa Higaona (INIPA) at CATIE, Costa Rica. This was partially sponsored by a Kellogg Foundation training program.
- Attendance at an eight week postgraduate course on goat production in the tropics by T. Cordero, MS, and M. Callacna, INIPA. This was sponsored by a Kellogg Foundation training program and the Regional Office for Central America and Panama—AID/ROCAP research program.
- Attendance by T. Cordero, INIPA, and B. Quijandria, UCD, at workshops on Methodology of Livestock System Research fully sponsored by IDRC. Meetings were held at Pucallpa. Peru, in January 1982, and CATIE, Costa Rica, in February 1983.

Assistantships for Undergraduate Students:

The following students were supported by total or partial assistantships by the goat project to support their theses for the Ingeniero Zootecnista title (after obtaining BS):

UNPRG: Laura Baquedano, Silvia Calderon, Hugo Garcia, Agustin Silva, Victor Soto, Martha Huaman, Bertha Chuman, and Julio Chafloque.

UNA: Maritza Garcia and Blanca Arce.

UNP: Alfredo Bayona and Eberth Sandoval.

Selected Publications

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Cordero, T., H. Vidal, R. Cochran, and L. Baquedano. 1983. Utilizacion de Hojas de Faique en Caprinos en Crecimiento. SR-CRSP Technical Report Series No. 20.

Cordero, T., and J. Puicon. 1982. Urea en el Engorde de Caprinos Criollos en Crecimiento. Abstract. V Scientific Ann. Mtg. Peruvian Assoc. Ani. Prod.

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Vidal, H., T. Cordero, R. Cochran, and S. Calderon. 1983. Evaluacion de Parametros Digestivos y del Consumo Voluntario de Residuos de Cosecha en Ganado Caprino. SR-CRSP Technical Report Series No. 21.

BASIC SUPPORTING RESEARCH

The CRSP concept is based on a mutuality of interests of USAID and participating institutions both in the US and overseas. It depends on the convergence of two needs: the needs of USAID to provide developing countries with technical assistance in tackling research problems; the needs of US research institutions for funds to continue research both at home and overseas and for access to overseas worksites.

The CRSP mode becomes a possibility when the research interests of US institutions and the needs of a developing country match. This is the rationale for the SR-CRSP grant being a matching funds grant, requiring a minimum of 25% of the cost of the program to be borne by the participating US institutions. Program funds (grant plus matching contributions) are used by PIs to continue their research and training activities and expand them into a major effort at the overseas worksites. The division of the research agenda of each project between work carried out in the US and in the overseas worksite is the responsibility of each PI, acting in consultation with overseas collaborators and the Technical Committee. In general, however, there is a natural dividing line separating site specific research from research which is conducted in the US. Virtually all applied research, whatever its scope, is sooner or later constrained by obstacles that call for studies of a more fundamental nature. The portion of each project's work that is done in the US tends towards this more basic research, which promises results that will not only be directly relevant to the worksites in particular, but will also have a much wider applicability. Some phases of site specific work are also completed in the US because of availability of specialized facilities, such as computers with staff trained in the particular applications needed by the project.

It is these more basic aspects of the research, together with activities requiring specialist services, that form the bulk of this section. Because each research project tends to see the various parts of its program meshing in with each other, the contributions to this section need to be understood in the context of the research endeavors at the overseas sites.

Breeding Research

R.L. Blackwell
Montana State University

Montana State (MSU) activities in the US which contribute to the overall goals of the SR-CRSP Breeding Project include developing and testing methodology for genetic improvement of sheep under extensive conditions and analyzing sheep data from MSU and Columbia to elucidate principles for animal improvement through genetic means.

The major emphasis has been genetic improvement in sheep for fertility and growth rate. This work provides valuable information on basic problems as well as finding ready application in the overseas worksite. It includes:

- Selection of sheep for high and low prolificacy based on their dams' lifetime reproductive performance.
- Evaluation of ¼ Finn crossbred ewes compared to western white-face ewes managed under extensive range conditions.
- Development of a data management system for recording research data collected at the US worksite and application of the principles and methods to data collected at the overseas worksite.
- Analysis of data previously collected (MSU and Colombia) which contributes to new knowledge and understanding of genetic principles relating to growth and prolificacy pertinent to SR-CRSP work overseas.

Research Accomplishments

A long-term selection study for high and low prolificacy, initiated in 1968, was based on the dam's lifetime reproductive performance. Rams within the high prolificacy line were selected from dams with high lifetime records and, in the low line, rams were selected from ewes with low lifetime records. Evaluation of the effects of selection is currently underway. The regression of the number of lambs born per ewe bred on year of birth of the ewe was .007 and -.015 for the high and low prolificacy lines, respectively. The realized heritability estimates for number of lambs born per ewe bred were .13 and .05 for the high and low lines, respectively. Since selection had been effective in separating the two lines (H and L), studies were undertaken to evaluate physiological parameters that may have changed as the result of selection. Presently, high line ram lambs have larger scrotal circumferences and more libido as measured by the number of mounts and services performed with estrus induced ewes than do the low line rams (Tulley and Burfening, 1981; Burfening and Tulley, 1982). Further, by top crossing Rambouillet rams with the Columbia ewes, it was observed that the crossbred ram lambs had larger scrotal circumferences and more libido than did the straightbred Rambouillet ram lambs (Tulley, 1982). More recent work indicates that there is no difference in the epididymal sperm reserve between high and low line rams.

Research is currently underway to evaluate the maternal performance of ¼ Finn ewe under range conditions. The results indicate that of the ewes exposed for breeding at 8 months of age, 37% of the ¼ Finn ewe lambed vs. 2% of the contemporary white-faced ewes. At 2, 3, and 4 years of age, the ¼ Finn ewes produced 137, 158, and 170 lambs per 100 ewes bred vs. 106, 114, and 154 lambs per 100 ewes bred for the white-faced contemporary ewes. Weaning weights were essentially the same. Therefore, for the 2, 3, and 4 year old ewes, the ¼ Finn ewes produced 41, 41, and 48 kg of lamb weaned per ewes bred vs. 31, 38, and 41 kg of lamb weaned per ewe bred (Burfening and Van Horn, 1980). This project serves as a comparison to the evaluation of ¼ Finn ewes in the Peruvian Highland which our group is currently conducting.

These results suggest that under extensive conditions but at lower elevations than the Peruvian Highland, a small percentage of highly prolific breed can substantially improve reproductive rate. It remains to be seen whether the same results will occur in the Andean Highland where reproductive rate is low.

One of the first steps in the analysis of previously collected data was the development of a computerized data base management system. Records collected over the last 20 years were entered into the data base in a systematic manner to make them readily available for all future needs. At the same time, a system was developed which allowed for rapid input of currently collected data. This system permits ready access to data needed for analysis and breeding management of the experimental sheep.

The same principles and techniques of data management are being applied with the computer at UNA in Peru so that data collection, storage, and retrieval will require less transcription, reduce errors, and permit greater access. Students and technicians will spend less time in routine data transcription and more time in data analysis.

With the establishment of the data mentioned above, several studies have been undertaken.

- A Dorset-Columbia crossbreeding experiment was completed. The maternal performance of Columbia ewes mated to either Columbia (C) or Dorset (D) rams and CD ewes mated to either D or CD rams was evaluated. The results indicate that in all crossbred matings more ewes lambed ($P < .05$) and gave birth to more lambs per ewe lambing ($P < .05$) than did the straightbred Columbias. There was no significant difference in weaning weight of the lambs but the crossbred ewes produced less wool ($P < .05$) that was shorter stapled ($P < .05$) and finer ($P < .05$) than the Columbias (Burfening and Van Horn, 1983).
- To evaluate the effect of preweaning environment of the ewe on her subsequent productivity, the ewe's most probable producing ability (MPPA) for birth weight, 60-day weight and 120-day weight was calculated. These MPPA's were then related to the ewe's own birth weight, 60-day weight, and 120-day weight. The results in general

indicate that there was a very low phenotypic relationship between preweaning traits of the ewe and her subsequent MPPA (Trowbridge et al., 1983). Work is currently underway to separate the genetic and environmental components associated with direct and maternal effects. Preliminary estimates indicate that there is a negative co-variance between direct and maternal effects for birth weight, 60-day weight, and 120-day weight.

- Data from a long-term sheep breeding project in Colombia were made available to a UC Davis MS graduate, Miss Anne Alderson, working in Colombia as a Peace Corps Volunteer. The project involved comparison of lamb and wool production of four imported breeds (Rambouillet, British Romney, American Romney and Corriedale) from temperate countries, with that of the local Criollo. Our SR-CRSP Breeding Project had an interest in collaborating in this project, and a collaborative arrangement was worked out with Dr. Bradford, Principal Investigator from the UCD Breeding Project. Data analyses were completed at Montana. The results (Alderson et al., 1982) reveal that the reproductive performance of local breeds in a tropical country is consistently better than that of imported temperate breeds. Even where tropical temperature is not a relevant factor, this phenomenon persists for at least several generations after the temperate breed was imported.

Training

Three graduate students, Druska Tullye, Robert Lewis, and Dale Trowbridge, have been associated directly with the Breeding Project at MSU since 1979. Miss Tullye completed the MS degree in 1981. Part of her research results have been published and two additional manuscripts are prepared for journal submission. Her research was partially supported by our SR-CRSP sub-grant. The other two students whose graduate work is in progress, are fully supported by MSU.

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Breeding Research

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A major emphasis of the SR-CRSP has been genetic improvement of dairy goats. Work done in the US by the UC Davis Breeding Project which serves as a valuable backup for the needs of several overseas sites, includes:

- Genetic evaluations using US production (DHIA) records. Since such records had not previously been used for this purpose, development of new methodology was required.
- Selection of males, based on the genetic evaluations for milk and fat production and use of semen from these bucks overseas (Kenya, Mexico) and in the US.
- Development of a dairy goat facility on the Davis campus, as a place to house the males and to collect, process and store semen, and for other dairy goat research and training activities.

The work has also involved ongoing sheep breeding research at the University of California, which has contributed to the development of new knowledge relating to genetics of growth and prolificacy pertinent to the SR-CRSP work overseas, and provided research training for students from the US and developing countries.

This training has included students from both Kenya and Indonesia (and by the end of 1983, is expected to involve students from our third worksite, Morocco), as well as from Chile, Uruguay, Venezuela, Mexico, and the US. Our philosophy is that while the major part of SR-CRSP funds should go to support work in the primary worksite countries, the objective of improving small ruminant production in developing countries is not confined to the five worksites. In several cases, a small allocation of funds, e.g., to meet computing costs, has contributed to training a professional in the area of small ruminant breeding, and resulted in analysis of data that probably would not otherwise have been undertaken.

The interaction of personnel from several countries working with small ruminants, and the comparisons of results from different breeds, locations and production systems has been a very stimulating research experience. For example, knowledge gained from working with the UC multiple birth-selected sheep and with the Finnish Landrace breed and its crosses, provides ideas for analysis of the data from prolific sheep in Indonesia and Morocco and vice versa. Comparison of rankings of dairy goat breeds as purebreds in the US and the same breeds in crosses in Venezuela for different traits provides information on characteristics particularly critical to adaptability in the tropics, and on what kinds of information can and cannot be transferred between temperate and tropical environments.

Research Accomplishments

Goat Breeding

Genetic Evaluation of US Dairy Goats. The first step in this analysis was to edit a large data set not previously used for research or genetic evaluation. This was followed by estimation of environmental effects on production, i.e., age, parity (parturition sequence), and season. The one paper available from the US in this area prior to our study had reported some unexpected patterns in effect of age on milk yield. We examined effects of parity, and found it had a very large effect on production independent of age (Kennedy et al., 1981). For example, does kidding for the first time at 24 months of age produced 15-20% less milk than those kidding for the second time at the same age, in four independent samples of data. The parity effect in dairy cattle is less than 5%, and is normally assumed to be negligible. In this and other ways, we are finding it may not be correct to assume that goats are small cows.

Based on records adjusted for age, parity and season, we carried out a genetic analysis of California dairy goat DHIA records, and reported the rankings of 503 sires and 390 elite does (Finley et al., 1982). These rankings were used in selecting goats for purchase to ship to Kenya, and in choice of males for production of semen for the SR-CRSP projects. The permit to ship goats to Kenya was rescinded by the Kenya Ministry of Livestock Development (MLD) at the last moment, but a shipment of semen was sent, from which dairy x local crossbred progeny have been produced. Semen from this project has also been used in California, Arkansas and Mexico.

Following this initiation of genetic evaluation of dairy goats by the Breeding Project, the USDA Animal Improvement Programs Laboratory became involved, and in January 1983, published the first National Dairy Goat Sire Summary. The evaluations were based on records utilizing the UCD age-parity-season correction factors; portions of the UCD editing procedures were also used. Thus initiation of this work under SR-CRSP sponsorship has resulted in availability of information which will make it possible for the first time to select dairy goats, for use in other countries as well as the US, on the basis of estimated breeding values for production.

A second UCD study with dairy goat DHIA records dealt with relationships between production and reproduction. These relationships in dairy goats are complicated by seasonal breeding: does born late in the season tend to kid for the first time in their second rather than first year, and does kidding late in the season tend to have shorter lactations and hence lower yields. These factors introduce strong associations between the different variables due to an environmental effect which can interfere with desired genetic improvement if not taken into account. The study showed that selection on the basis of first lactation milk yield (without adjustment for age, parity, and season) would tend to select for later ages at kidding and lower probability of kidding the first year. Adjustment of yield records using the age-parity-season correction factors developed earlier apparently can eliminate this problem completely. Thus, adjust-

ment of the records not only improves accuracy of selection for yield, but reduces the risk of including undesirable correlated responses in reproduction which accompany increased yield.

Evaluation of Imported Dairy Goats Under Tropical Conditions. Data from a 13-year crossbreeding study in Venezuela involving dairy goats imported from the US and the local Criollo goat have been used for a Genetics PhD thesis at UC Davis by Dr. Omar Garcia of the Venezuelan FONIAP research staff. SR-CRSP Breeding Project funds were used to augment Mr. Garcia's computing budget, permitting a more comprehensive analysis of the data than would otherwise have been possible.

The results show that the breeds ranked in the order Alpine, Toggenburg, and Nubian in terms of milk yield in the Venezuelan crosses. The difference between the first two was quite large, in contrast to no significant difference in milk or fat between these two as purebreds in the US. In mortality, the order for the three crosses was reversed, but an overall index for milk and meat production indicated that the Alpine ranked slightly ahead of Nubians, with both superior to Toggenburg crosses, in estimated total productivity. This information led to the decision to include Alpine crosses in the Kenya SR-CRSP dual-purpose goat Breeding Project.

Sheep Breeding

Breed Evaluation at High Altitude. Data from a long-term sheep breeding project in Columbia were made available to a UC Davis MS graduate, Miss Anne Alderson, working in Colombia as a Peace Corps Volunteer. The project involved comparison of lamb and wool production of four imported breeds from temperate countries with that of the local Criollo. Dr. Blackwell of Montana State, as PI for the Peru Breeding Project, had an interest in collaborating in this project. A collaborative arrangement was worked out and analyses of the data were completed at Montana. The results (Alderson et al., 1982) provide a striking example of superior reproductive rate of local breeds in a tropical country compared to imported temperate breeds. This feature persists for as long as two or three generations after the importation even where high environmental temperature is not a factor.

Evaluation of Effects of Long-Term Selection. The analyses of a long-term selection experiment for liveweight at 120 days in sheep (Lasslo, 1982) produced a number of important conclusions:

- Selection for weaning weight led to a significant increase in this trait, but also led to declines in fertility and lamb viability which resulted in no net increase in lamb production per ewe.
- Selection under good feed conditions produced more increase in growth rate than selection under range conditions. Use of males from the line selected in the better environment under range conditions resulted in improved growth rate as much as did selection in the environment of use. However, overall fitness of the line was lower, suggesting advantages in overall performance for selecting in the environment of use.

Examination of ovulation rate and prenatal survival in the stocks from this selection experiment (Quirke et al., 1982) indicated that selection for multiple births results in increases in several parameters of reproduction (ovulation rate, fertility, litter size, and possibly prenatal survival) with no components decreasing. Selection for growth rate increased ovulation rate, but appears to result in decreases in all other components of reproduction measured. These findings have potentially wide applicability to sheep improvement.

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Range Management Research

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The primary focus of Texas Tech research in the US has been on basic studies to improve our understanding of short duration grazing and management of cultivated forages. A significant but less important focus has been on soil-plant interrelationships and animal fiber evaluations. The work is important to the development of concepts and philosophies that support our research in Peru or that have potential application in the Andes for improving native range or animal production.

Research Accomplishments

Short Duration Grazing

This grazing management system has been a topical issue in the US for the past three years. Proponents suggest that it offers dramatic increases in the carrying capacity of the land. As a result, an initial study was designed to determine the impact of short duration grazing and higher stocking rates on livestock performance and vegetation. The major finding suggests that carrying capacity can be increased 20-30% without suppressing animal performance. We observed no significant improvement in range condition after 4 years of study. Furthermore, nutrient quality of steer diets was not affected by the grazing system when compared with continuous yearlong grazing (Figure 1).

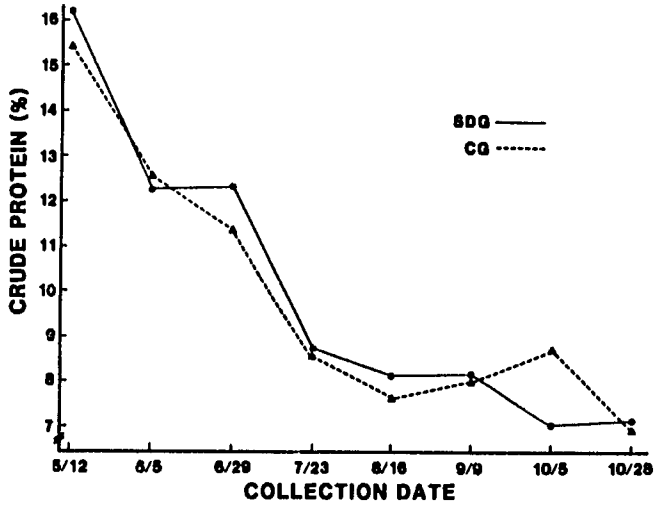

Figure 1. Crude protein content in steer diets under short duration and continuous grazing in Texas.

Another project was established to evaluate dramatic increases in stocking rate (up to 3.5 times normal) on the nutritional quality of sheep diets. Based on these results, selective grazers like sheep can harvest nutritionally similar diets regardless of stocking rate (Table 1). Higher protein levels at higher stocking rates were attributed to sheep being forced to eat broad-leafed plants and forbs that usually are higher in protein. It seems, however, that the controlling factor in promoting animal performance under short duration grazing might be the quantity of forage available.

Table 1. Nutrient Quality of Sheep Diets as Affected by Stocking Rates (Means were averaged across 9 collection periods from May 1981 to July 1982)

Multiple of Stocking Rate	Crude Protein (%)	Phosphorus (%)	Digestible Organic Matter (%)
1.0 x SR[1]	14.2	0.43	67
1.5 x SR	14.8	0.46	63
2.0 x SR	15.8	0.48	65
2.5 x SR	15.3	0.48	65
3.0 x SR	16.0	0.45	63
3.5 x SR	16.1	0.43	65

[1]SR=normal stocking rate of 1 au/13.3 ha.

Management of Cultivated Forages

Several studies, implemented in 1982 by Dr. A.G. Matches, are focused on understanding how the animals are best managed in order to make successful use of improved, cultivated forages. This research will contribute to our understanding of the plant:animal interface on cultivated forage pastures. The studies implemented have the following research objectives:

- To develop improved forage systems for grazing livestock.
- To determine the optimum management practices for improved water use efficiency by forages.
- To determine what effects different rates of mefluidide treatment applied at different stages of growth have on forage yield, plant growth and morphology, and forage quality.
- To determine whether mefluidide treatment of a silage sorghum will effect *in vivo* digestibility, rate of passage and intake by sheep.
- To evaluate the first-last grazer concept as compared to continuous grazing for steer production on native short grass range.
- To determine the influences of forage quality and availability on animal performance.

The first two objectives are designed to provide basic understandings necessary to avoid excessive fluctuations in the seasonal feed-flow patterns. Several combinations of improved forages will be evaluated for their potential in

providing a continuous supply of nutrients to livestock. Some 97 different legume entries representing 14 legume species are under initial evaluation. Legumes include alfalfa, sanfoin, cicer milkvetch, birdsfoot trefoil, barrel medic plus arrowleaf, crimson-, ball-, and rose- berseem, persian-, subterranean-, strawberry- and red- clover. Three species of *Elymus* and sixteen of *Agropyrons* are also being evaluated.

The third and fourth objectives noted above help support evaluation of effects of mefluidide on the growth, composition and quality of forage sorghums. Mefluidide is a growth inhibitor that may have potential to keep improved forage in a growth form suitable for livestock grazing. Preliminary results indicate that mefluidide reduced sorghum height between 5 and 50% by the time of first harvest. The magnitude of the decrease depended on the timing and rate of application, being greater when it was applied at the intermediate growth stages (plants 38 to 72 cm tall) and the highest rates (0.14 and 0.28 kg/ha). Yield data corresponded closely with height measurements. Mefluidide treatments resulted in yield reductions ranging from 7 to 61%. Generally, the higher the dosage, the greater the reduction in dry matter yield. When mefluidide was applied at the later stage (plants 89 cm tall) yield depressions were the smallest. No response was observed by the time of the second harvest nor had mefluidide any effect on stem/leaf ratios.

The last two stated objectives are part of an experiment to understand forage allowance and its relationship to animal production. Plans include the initiation of grazing experiments with sheep and small-plot experiments to determine the compatibility of weeping lovegrass, kleingrass and Oldworld bluestems with selected legumes.

Soil-Plant Interrelationships

That soil governs and controls the composition of plants and communities growing from it is well recognized, and characterization of soil is an important ingredient of intelligent management of rangelands. Characterization of soil types from the Peruvian Andes on the US classification scheme was accomplished through the expert guidance of Dr. B.L. Allen, soil scientist at Texas Tech. This information, not previously available, suggests that most soils in central Peru are organic, loamy to sandy with clay percentages ranging from 19-30%. The low pH in the upper profiles was unexpected, considering the relatively low precipitation and apparent youth of the geomorphic surfaces. Decomposition of the abundant organic matter probably has had a strong acidifying effect. Leaching was evident, and extractable cations were dominated by Ca. Clay mineralogy of the soils were dominated by smectite; illite and kaolinite also occurred, but in lesser quantities. In classifying soils of the Andes, base saturation percentages were seen to be an important criterion affecting plant growth.

Plant communities identified with varying topographical features and parent material are found in Table 2. Basically, these communities were characterized as mid-grass communities. The most important on the site were *Festuca dolichophylla-Carex ecuadorica-Calamogrostic vicunarum* (Fedo-Caec-Cavia) and a *F. dolichophylla-Poagilgiana* (Fedo-Pogi) located in glaciated uplands.

Table 2. Topographic Position and Approximate Number of Hectares Encompassed by the Community Types Present on the Study Area at Corpracancha

Community Type	Topographic Position and Parent Material	Hectares
Fedo-Caec-Cavi and Fedo-Pogi	Glaciated upland	12,700
Fedi-Stbr	Glaciated and siltstone slope	2,000
Care	Andesite colluvial slope	1,500
Cabr-Fedo	Glaciated upland	550
Cama-Fedo	Glaciated and limestone slopes	253
Stbr-Care	Red siltstone slope	147
Feri-Azcr	High elevation ridge	100
Pltu-Hyta	Glaciated upland	100
Pogi-Fedo-Cabr	Food plain	37

Animal Fiber Evaluations

Wool from grazing treatments at Corpracancha and SAIS Pachacutec are being evaluated in terms of fleece weights, fiber length, and fiber diameter. Data will appear in the MS thesis of Jim Carey. Research findings from the first year indicate similar high levels of wool production/ewe from sheep under continuous, yearlong grazing at 3 ewes/ha and rotational grazing at 2 ewes/ha (Table 3). Lowest wool production/ewe was under complementary grazing where cattle and sheep shared the range at heavy stocking rates, suggesting that care must be taken when cattle are stocked with sheep if production is not to be depressed. In addition, high stocking rates of sheep alone (4 and 6 ewes/ha) depressed wool production/ewe but had high wool production/ha. Data from years 2 and 3 are needed to evaluate more fully wool production/ha at high stocking rates.

Table 3. Wool Production From Grazing Treatments at Corpracancha During the First Year of Study

Grazing Treatment (stocking rate)	N	Wool Production per ewe (Kg)	Wool Production per ha (Kg)
Continuous (3/ha)	60	3.57	10.7
Rotation (2/ha)	20	3.53	7.1
Rotation (3/ha)	60	3.33	9.9
Rotation (6/ha)	20	3.16	19.2
Rotation (4/ha)	20	3.13	12.5
Complementary (3/ha + cattle)	21	3.06	9.7

Training

John S. Pitts, funded in part by the SR-CRSP, will complete his MS degree in June of 1983 at Texas Tech University in Range Management. He will be employed as a Research Associate at Texas Tech.

Jim Carey is funded by the SR-CRSP pursuant to the MS degree in Animal Science at Texas Tech University.

Selected Publications

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Systems Analysis Research

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The primary supporting research activity of the Systems Analysis Project has been the development of simulation models of sheep and goat production systems based on a cattle model previously developed by Texas A&M (TAMU). These mathematical models endeavor to describe functional relationships between biological parameters as these influence production. The experience and intuition of scientists working in pertinent areas has been necessary to help integrate this component knowledge and especially, to provide "best estimates" for knowledge voids. Some of these scientists were invited to Texas A&M specifically for this purpose; others from the Texas Agricultural Experiment Station (TAES) faculty contributed knowledge based on ongoing sheep and goat research. Summaries of this work are available in the most recent annual TAES Sheep and Goat, Wool and Mohair Progress Report.

Model Concepts

There are many simulation models that relate to ruminants. These range from models at the level of tissues or organs, to models of entire biomes that include aggregate animals to represent each of several species. Intermediate to these extremes are models of whole animals that reflect differences due to sex, age, pregnancy, lactation, and other individual animal attributes. Some of these whole animal models simulate only a single animal at a time while others simulate many animals grouped into an entire herd or flock. These herd or flock models are the most appropriate for evaluating management practices because the herd or flock is the management unit that encompasses all segments of the production systems.

Early simulation models at Texas A&M assumed some level of animal performance (i.e., fertility, milk production, growth rate) and simply calculated the nutrients required to meet this productivity. However, it was always recognized that the primary role of ruminants is to utilize forage which have large seasonal differences in quality and availability. Hence, modeling activities have now been directed to developing models so that sheep or goats respond to their environment in a similar manner that a real herd or flock would respond to its environment. The biological concepts of the current TAMU models came from these previous efforts.

In the sheep and goat models, an animal's genotype is described in terms of potential for mature size, maturing rate, and milk production. This genotype interacts with the externally specified environment (nutrition and management practices) to predict (simulate) performance. The ratio of structural size and empty body weight is used as a measure of condition and reflects current and previous nutritional

treatment at any given time. The models also partition nutrients among various requirements and allow for storage and mobilization of body tissue. The simulation of the effects of past and present nutrition on fertility (puberty, post-partum estrus, and conception) is a major contribution.

The sheep model, with over 5,000 lines in its program, was developed first and then modified to represent goats. The major difference between these models relate to feed intake and body composition. A bulletin describing both models in detail is in preparation. This bulletin includes a description of model structure, all of the functions (e.g., voluntary forage intake, growth and fertility which in turn includes functions for puberty and effects of body conditions, weight gain/loss, lactation and maintenance and activity requirements on estrous cycling), and validation and verification runs.

Data Requirements

The first step in the application of the TAMU models to a specific location (e.g., Western Kenya) is the successful validation of a baseline simulation of existing conditions. This validation requires forage and animal production data. Simulations are run with genotype, forage and management specified in the model to correspond, as near as possible, with existing conditions. Simulated results are compared with actual animal production in order to validate the model and input parameters for that location. Validation is usually a fairly lengthy procedure that requires input from plant and animal scientists as well as individuals with first-hand knowledge of the production system. Considerable judgement is required to clarify and adjust input data without simply manipulating them to fit the specific situation. Once model and parameter inputs have been fine tuned to attain validation for the specific area, the validation run (of actual existing conditions) is set as the baseline run as a comparison base for examining alternative production practices.

Genotype of each animal is set equal to the mean of its breed group (i.e., no within-breed genetic variability). The main components of genotype are mature size, maturing pattern (i.e., shape of growth curve) and milk production. Prolificacy, seasonality of estrus, and parasite resistance data are also required. These genetic potentials are estimated as the values for mature females in good condition that have never been restricted by nutrition or health. These values can sometimes be estimated from the location in question, but lacking these data, may be obtained from the literature, unpublished or other experimental data, or estimates of knowledgeable persons.

Forage data are the most difficult model input parameters to obtain. Quality of the ingested diet in terms of dry matter digestibility and crude protein are required for each two-week period of the year. Ideally, this would be determined by diet studies but may be approximated by hand plucking or other estimation techniques. In addition, maximum per head availability of this quality forage must be estimated for circumstances when it becomes the limiting factor in the production system. The best estimate of this quantity would come from intake studies but these are seldom available, and estimates must therefore rely on the experience and intuition of forage/livestock specialists.

The models simulate most of the measurable performance traits (e.g., weight at any age, condition, fertility, survival, and milk production) that can be measured on live animals. The more of these traits available in the baseline production data set, the more useful it is for validation. Minimal data include growth rate of immature stock, weights of mature females at several times during the year, pregnancy rates by age group, and mortality frequency by class and time of year.

In early 1979, the Systems Analysis Project began to communicate model capability, data requirements, and simulation output to each of the other SR-CRSP projects active in Kenya. This involved meetings to explain the Systems Analysis Project and to request inputs from other disciplines.

Nutritional Components

The nutritional concepts and assumptions of the TAMU models largely determine their usefulness for evaluating management alternatives. The most recent version of these nutritional concepts is viewed as a major step forward, and provides the model with more sophistication in this area than is the case with other model components (e.g., genetic variability, forage growth). This version was developed with the assistance of N. Mc C. Graham and utilizes many of the specific equations in the sheep model published by Graham. An overview of these nutritional concepts is provided as a basis for better understanding the content and usefulness of these models.

Maintenance. Maintenance requirements for energy are not considered as the amount necessary for zero energy gain but rather as the sum of basal metabolism, endogenous urinary loss, and work. The estimation of work requirements requires that time spent eating and ruminating and distance walked daily be provided. Protein maintenance requirements are estimated in an analogous manner allowing for metabolic requirement as well as fecal loss. Maintenance is increased during lactation by 30% of the ratio of the individual's milk production to the peak lactation average for the breed. Fetal maintenance requirements are included with those of the ewe (doe) when nutrients are partitioned among various requirements. Handling maintenance in this fashion facilitates the estimation of tissue mobilization.

Growth. An underlying potential growth curve is assumed to be linear from birth until a constant fraction (50%) of mature weight is reached and to decline after that point. The time taken to reach this fraction is assumed to generally be in proportion to the 0.3 power of mature weight. Normal fat percentage for animals in good condition is assumed to be 3% at birth and 25% at maturity for ewes and 15% for does and to increase in direct proportion to degree of maturity.

Gain is partitioned between fat and lean (all non-fat) and these in turn partitioned between essential and nonessential. An animal can gain a unit in structural size (measured as weight in good condition) while gaining only a portion of the actual empty body weight. Structural size can never decrease but can undergo periods of reduced or even zero growth because of undernutrition; however, there can be no

permanent stunting. Any nonessential fat or lean can be mobilized; hence, empty body weight can increase or decrease.

Animals that have fat and protein levels below amounts expected for their structural size have a propensity to bring their composition back to normal. Unlike the cattle model, this composition correction does not influence their appetite, but does become part of the upper limit on lean gain.

Milk Production. Lactation potential is a function of units of available lactation capacity and secretion rate per unit. Genetic potential and time postpartum set an upper limit on available lactation capacity whereas units previously used set a lower limit. Either the intake capacity of nursing young or nutrition may restrict the units of lactation capacity used below those available. Secretion rate reflects differences in ewe age, time postpartum, and genetic differences in persistency.

Pregnancy. Potential birth weight is determined from number (single, twins) and fetal genotype and structural size of the ewe. Expected conceptus growth rate is based upon day of gestation and total potential birth weight of all fetuses. Mammary gland weight is assumed to increase from day 105 of gestation through day 30 of lactation. Restricted conceptus growth is possible during periods of under-nutrition but abortion occurs if it falls below a prescribed level.

Fiber. Genetic potential for clean wool or hair growth is adjusted for photoperiodicity, age, and degree of maturity. Clean wool is 100% protein that is assumed to be deposited with an efficiency equal to the biological value of protein. The gross energy content of grease wool is assumed to be equal to 6.0 mcal/kg and to be deposited with an efficiency of 20%.

Efficiencies. The net availability of metabolizable energy (ME) is dependent upon source (feed vs. milk) and digestibility of nutrients and upon physiological (lactational) status of the animal. The biological value of absorbed amino acids is assumed to be constant as is the percentage protein of lean tissue. The amount of crude protein available for absorption is estimated from ME and crude protein intake of dry feed and added to that obtained from milk.

Feed Intake. Feed intake is set as the minimum of a physiological, physical, or externally specified availability limit. A maximum rate of energy gain for a mature animal in good condition is assumed. This rate is adjusted downward in immature animals and is inversely proportional to condition. The rate goes to zero when animals reach maximum body fat of 40% (25% for goats). The energy required for this maximum energy gain is added to that required for maintenance, lactation, fiber production, and gestation to estimate the physiological limit on energy intake.

A physical limit on feed intake that corresponds to gut capacity and rate of passage is estimated from structural size and diet digestibility. This estimate is not explicitly reduced for low protein diets; however, the high correlation between digestibility and protein will result in indirect adjustment for protein level. The physical limit is increased in lactating ewes (or does) as a function of time postpartum and level of milk production. It is decreased in late gestation dependent upon fetal number and ewe (or doe) structural size. The externally set maximum per head availability is adjusted slightly downward for immature animals.

Tissue Mobilization. Body tissue, if available, is mobilized if either energy or protein intake are inadequate to meet an animal's nutrient requirements for maintenance, fiber, gestation, lactation, and essential growth. The efficiency of using stored energy is assumed to equal 100% when used for maintenance and to equal the ratio of the net availability of ME for production to the net availability for maintenance when used for a specific production function. Mobilized lean is assumed to have the same percentage protein as lean deposited during growth and to be used with 100% efficiency for either maintenance or production. Mobilization is assumed to be in the following order: (1) lean for protein, (2) lean and fat simultaneously for energy and (3) ext a fat for energy.

The maximum amount of lean and fat that can be mobilized is the amount necessary to meet the maintenance energy requirement if fasting. The ratio of fat and lean available for mobilization is the same as the ratio of nonessential fat and lean. In a nonfasting animal these maximum amounts are reduced in direct proportion to the ratio of nutrient intake to requirements except that lactating females can mobilize an extra amount dependent upon their condition.

Partition of Nutrients. If intake plus tissue mobilization of energy and protein fail to meet an animal's requirements for maintenance, lactation, gestation, fiber and essential growth, the available nutrients are partitioned among the various uses. The relative shapes and positions of the geometric figures (containers) representing each physiological function (Figure 1) depict the relative priorities assumed in the model. Each container is expanded in depth until its volume equals the requirement for that function, though containers will sometimes have zero depth. The relative shapes and positions of the different containers are based primarily upon intuition but were chosen to fit general expectations such as maximum fiber growth in nonlactating, nonpregnant, mature females fed to maintain weight. The model can easily accommodate changes in these relative priorities to correspond to any known differences among breeds or to reflect different physiological status. For instance, the container for lactation could be elevated in late gestation to give priority to regaining body condition or, perhaps, widened at the bottom to reflect breeds selected for milk production.

Essential to the joint accounting of protein and energy effects is the assumption that the relative priorities are the same for both. Hence, the model assumes two sets of identical, adjustable-depth containers with the volumes of one set equal to the energy requirements of an animal for that period and the volumes of the other set equal to its protein requirements. The total availability of both energy and protein are "poured" into their respective set of containers at rates controlled by the intake and mobilization functions. The set filled to the lowest level is the limiting nutrient. The

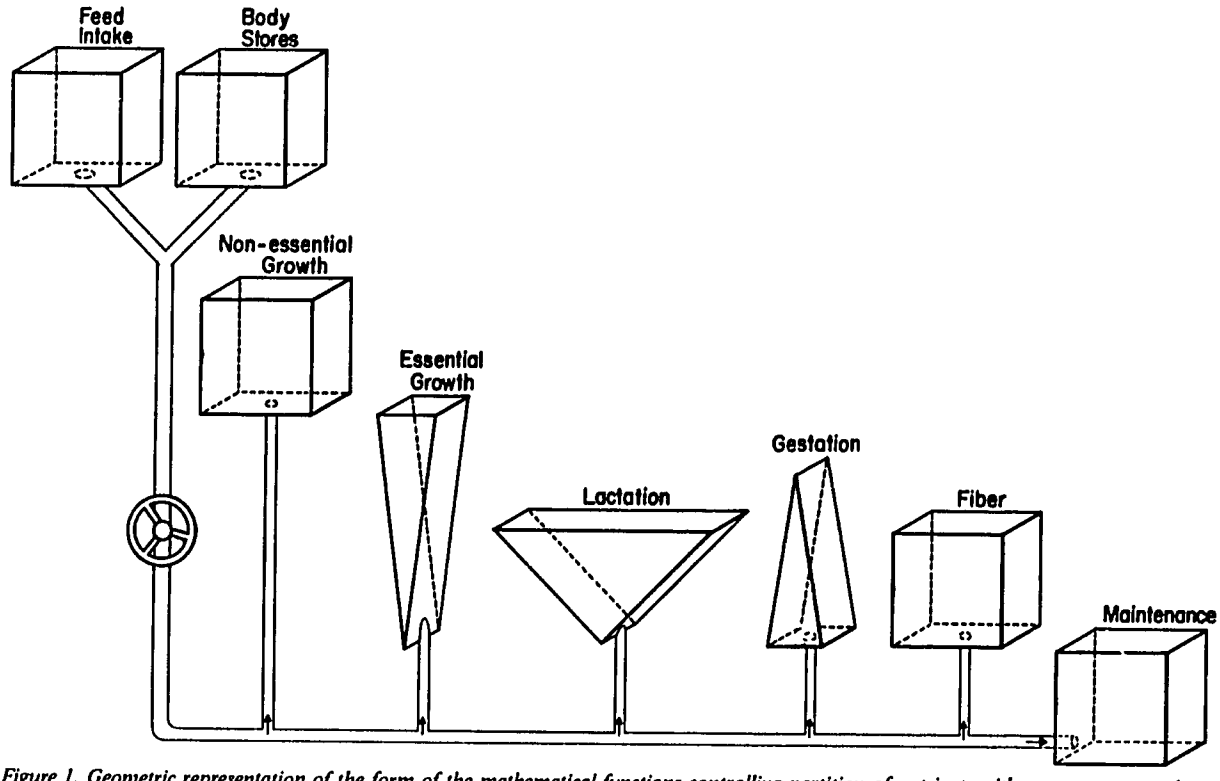

Figure 1. Geometric representation of the form of the mathematical functions controlling partition of nutrients, either energy or protein, among different requirements. Nutrients are conceptualized as fluids entering the system directly from a feed source or mobilized from body tissue stores; the amount of the "fluid" entered is always limited by feed availability, intake or mobilization so that the level that the "fluid" reaches depicts the quantitative utilization of nutrients. The depth of each container varies so that the volume equals the requirements for that function; e.g., lactation volume could be zero.

fraction of the volume filled for each container in this set determines the fraction of potential productivity attained for that function. If protein is the limiting nutrient, the energy above the level reached by protein is deposited as fat.

Reproduction. A key component of the models is the accounting for previous and present nutritional effects on fertility. This is done by setting genetic potentials for the effective ovulation rate, and for the probability that a female will begin to cycle, a cycling female will continue, and a cycling female will conceive if mated. These maximal levels are adjusted downwards for the effects of season, degree of maturity, condition, weight change, lactation, and post-partum intervals. For example, the probability of initiating estrous cycling after a given time postpartum decreases as the ratio of weight to genetic potential for weight (a measure of condition) decreases from 1.0 to .75 at which point the probability is zero. The rate and pattern of this decrease may reflect characteristics of the particular breed simulated; e.g., dairy breeds are expected to have a higher probability of initiating cycling in a thin condition than nondairy breeds.

Health. The models simulate the effects of season, condition, age, parturition and reduced structural growth (in young animals) on death rates. In addition, the effects of internal parasites (viz., *Haemoncus contortus*) on animal performance and survival have been added to the model during the past year. The number of ingested larvae, genetic resistance, physiological status, management practices and treatment with anthelmintics determine the viability of the haemoncus organisms in becoming established, developing and reproducing, thus determining the effect of these parasites on the host and on reinfestation of pastures.

Programming. The models are programmed in FORTRAN and are on 15-day time steps. Two versions of the model are used, each with the same biological components: a single-animal version that simulates one female and her fetuses and/or nursing offspring and a flock model that simulates the performance of each individual animal in the flock. The single-animal version, used to debug new biological components and to evaluate forage parameters, requires less computer capability and is currently being used in Kenya. The flock model allows the more realistic treatment of stochastic elements associated with fertility and death and provides the information necessary to assess net productivity of management alternatives.

Integration. The model is designed so that, after validation for a specific area and set of management practices, alternative practices may be submitted for evaluation in terms of leading toward the production objectives, e.g., to maximize family income, family food, or a combination of both. The simulations are designed to provide forage and animal scientists with the means to examine alternatives of interest to them. For example, productivity of goats that may be obtained from a given forage production program can be simulated. Another example is the simulation of the effect of milking does at various rates on kid growth and survival and overall flock productivity. The simulations also provide "data" for any given production system in a convenient form suitable for economic analysis. How integration with the

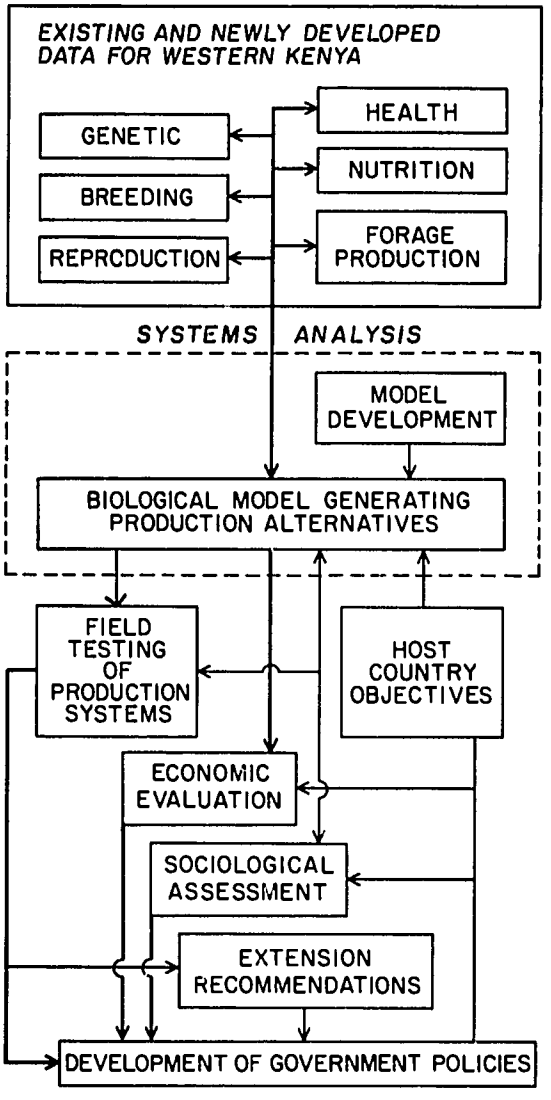

Figure 2. Diagrammatic representation of the role that systems analysis can play in linking SR-CRSP projects. Heavy lines indicate flow of quantitative information, light lines the flow of qualitative information.

sociology component on a quantitative basis is to be achieved is not clear, but the sociological dimension is critical in choosing production practices and systems to simulate and analyze. Our view of the role of systems analysis in integrating project elements is depicted in Figure 2. This integration phase capability of the Systems Analysis Project has been reached but applied on only a limited basis.

Training

In addition to the Kenya students listed in the Kenya breeding section of this report, the Systems Analysis Project has provided support for students training in the US and these include: L. Coronado (Peru), MS Animal Breeding; A. Muljadi (Indonesia), MS Agricultural Economics; P. Howard (US), PhD Animal Breeding/Systems Analysis, January 1982-December 1985; G. Hawariat (Ethiopia), PhD Animal Breeding, September 1979-January 1981; and G. Brenni (Switzerland), PhD Animal Breeding, September 1979-May 1980 and September 1980-December 1980.

Other students at TAMU have received funding from other sources but have contributed directly to the SR-CRSP Systems Analysis Project. They are: M. Majid from Malaysia who is analyzing Winrock International dairy goat data for a PhD in Animal Breeding at TAMU; and R. Stobart, PhD, who analyzed Montana State University sheep data for use in the development of the sheep model.

In spite of the emphasis on the accomplishments of formal training, the benefits that accrue from less formal project activities should not be ignored. Personal communication between PI and CoPI is an important component of the Title XII training mission and can make major contributions to professional development. Education of US research and extension scientists to the conditions, opportunities, constraints and uniqueness of host country production systems is a valuable part of the many different SR-CRSP projects. Professional and institutional development is further fostered by interaction at the project level, workshops, seminars, and the exchange of personnel through visits.

Selected Publications

Blackburn, H. 1983. Simulation of Genetic by Environmental Interactions of Sheep Performance in Northern Kenya. PhD Thesis, Texas A&M University (In Preparation).

Cartwright, T.C. and G.M. Smith. 1983. Application of the Kenya Dual Purpose Goat Model. TAMU Mimeograph (Update of Original Version Distributed in 1979).

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Cartwright, T.C. 1982. Net Herd Productivity as a Selection Objective. Proc. Austr. Assoc. Ani. Breeding and Genetics (In Preparation).

Cartwright, T.C. 1980. Objectives in Beef Cattle Improvement. Proc. World Congress on Sheep and Beef Cattle Breeding. J. Ani. Sci. 11:19-27.

Gathuka, Z. 1982. Milk Production of Spanish Does and Milk Intake and Growth of Their Kids. Prof. Paper Ani. Brd. Sect. Texas A&M Univ.

Mathenge, J.W. 1981. Growth Curve Analyses of Rambouillet Ewes. MS Thesis, Texas A&M Univ.

Smith, G.M. 1983. Simulation Models for Evaluating the Management of Ruminants in Developing Countries. Int'l. Network of Feed Info. Centers, 3rd International Symposium. Sydney, Australia.

Stobart, R. 1982. Genetic and Phenotypic Analysis of Liveweight Maturing Patterns and Their Relationship to Ewe Productivity in Columbia, Rambouillet and Targhee Sheep. PhD Thesis, Texas A&M Univ.

Agricultural Economics Research

A.J. De Boer
Winrock International

The US headquarter activities of the SR-CRSP Economics Project have revolved around three quite distinct pursuits:

- Computer-related activities supporting overseas worksites including statistical analysis, mathematical programming, and development of new programs tailored specifically for the needs of this project.
- Research in support of the US small ruminant industry, emphasizing the dairy goat sector, which is expected to generate results for use in the US as well as Kenya and Indonesia.
- Policy-oriented research on small ruminants that is worldwide in scope, but in which the primary research is carried out at headquarters.

These activities have involved a large number of US and international institutions in various components of small ruminant research and have contributed significantly to the development of a core group of staff at Winrock with knowledge of small ruminant research and research problems as well as involving institutions which had not previously worked with small ruminants.

Research initiatives undertaken through the SR-CRSP have led to increased interest in small ruminants by international agencies. This has allowed additional work to be carried out at headquarters using non-SR-CRSP funding. In addition, several methodological developments which have been accomplished through the US-based work are now ready to be used in overseas worksites. For example, the Dairy Goat Budget Generator program is particularly appropriate for the analysis of more commercially-oriented producer groups in several SR-CRSP worksites as well as in other countries such as Mexico and Venezuela.

Research Accomplishments

Quantitative Support

Development of Livestock Survey Modules. A major effort carried out during 1980 was the development of farm survey modules for both baseline data collection and for long-term farm management data collection. The first effort started in early 1980 for Brazil, followed by work on a module for Kenya (January-March 1980), Indonesia (April-September 1980) and a joint project with the Farm Management and Production Economics Service Section, Agricultural Services Division of FAO in Rome. The latter effort was an attempt to set up a generalized survey instrument and analytical package for field surveys to complement FAO's existing Farm Management Data Collection and Analysis System (FMDCAS). A Winrock International Computer Specialist spent five weeks in Rome developing the program. After evaluation of both the FMDCAS system as well as the module developed for the livestock component, it was decided not to proceed further with development of the program because most of our overseas worksites had neither the computer machine capacity for storing and running the entire program nor the programming expertise to set up and run it. In addition, many of the SR-CRSP data needs were too specialized to fit into the constraints of the canned package and our field researchers were recognizing the need for shorter, less demanding surveys which focused on very specific or marketing constraints. However, the results of this work are now being used by the FAO in a number of its overseas projects, many of which have a small ruminant component.

Development of Models for Analysis of Crop/Livestock and Grazing/Livestock Systems. The research objectives for Kenya and Brazil required the development of a model for farm management analysis. In Kenya, model requirements focused on the need to examine the economic implications of introducing dual-purpose goats onto small mixed farms, while in Brazil, the need was for a model that could handle on-farm simulations of research results being generated by the research station as well as simulating the impact of investments in improved grazing systems. Both problems focused on feed supply-animal feed requirement interactions, family food consumption requirements, resource competition, and farmer objectives. A linear programming model was developed for this purpose and verified at Winrock during 1980. The model fulfilled the above research needs and was set up first for analysis of the Egyptian small farm sector. The excellent results generated by this study led us to make the necessary modifications for PhD thesis research topics which were completed for Kenya (Job, 1983) and Brazil (Gutierrez, 1983). By June 1983, both models will be in routine use in the host countries, and will provide individual farm planning capability.

Policy Support for Small Ruminant Sector

A total of four minor studies were conducted which dealt in part with the role of small ruminants in small farm systems. In the first (Fitzhugh and De Boer, 1981), production possibilities under intensive systems were reviewed. In the second (De Boer, 1981), the potential role of dairying in developing countries was assessed and situations favorable to dairy goats were specified. The third study (DeBoer, 1982a) focused on a review of livestock development constraints and potentials in Asia. The role of small ruminants was specifically addressed and national research program needs were outlined. In a fourth (Bernsten, 1982), the problems of technology transfer on small mixed farms were developed and a methodology developed for the on-farm conduct of research trials involving animals. The approach outlined in this study is being tested in Indonesia and Kenya for small ruminants. A final paper (De Boer, 1982b) deals specifically with international and domestic marketing and pricing aspects of small ruminants. The long-term prospects for

marketing small ruminants and their products are specifically addressed. These four studies have contributed to a better public understanding of the role of small ruminants in support of man.

One major study was completed under a World Bank contract which dealt with a wide range of policy issues focused specifically on small ruminants (Winrock International, 1982). SR-CRSP funds were used for staff support over and above the World Bank contract funds.

The policy oriented research is relevant to developing countries in general and helps support institutional interest in small ruminants by setting out priorities and needs for lending institutions and research agencies.

Studies of US Dairy Goat Sector

In support of the US smallholder dairy goat industry, a study was completed which examined the economics of producing and marketing a variety of goat milk products. These results were synthesized by incorporating them in a feasibility study for establishing a goat milk processing plant in the Ozarks region of Arkansas. In the first study (Norman, 1982), an MS student at the University of Arkansas in Fayetteville conducted a production cost survey for dairy goat producers in the Ozark mountain region of Northwest Arkansas-Southwest Missouri. The data was used to create a budget generator which then developed a series of production cost estimates for a matrix of situations including three different lactation levels and three different herd sizes. As an example of the information generated by this study, it was predicted that a 50-doe herd with an 1,800 lb herd average weight would not cover total fixed and variable costs, even when all labor charges were excluded. To examine the possibilities for increasing producer prices to help cover costs, a product market analysis (Howard, 1983) was carried out as an MS thesis topic at the University of Florida. Processing, marketing, and distribution costs were calculated for fresh milk, powdered milk, condensed milk, and cheese. Likely product prices were estimated for major market areas and the costs relevant to each product/market area combination were subtracted from the price, thus arriving at the price payable to the producer. These prices were then used in a break-even analysis using the budget generator (Redfern et al., 1983). The budget generator model developed in this study is directly applicable to the situation in Indonesia on farms which are producing goats on a semi-commercial basis.

Training

Two MS thesis projects were sponsored on the US dairy goat industry study. The first, by Mr. M. David Norman, entitled "An Economic Analysis of the Dairy Goat Industry in Northern Arkansas and Southern Missouri," was submitted to the University of Arkansas in Fayetteville in 1982. A second by Ms. Pamela Jo Howard is entitled "The US Dairy Goat Subsector: An Analysis of Production and Marketing Structures" and will be submitted to the Department of Food and Resource Economics at the University of Florida, Gainesville, in 1983.

Selected Publications

Bernsten, R.H. 1982. Analytical Approaches to Farming Systems Research with an Emphasis on Animal Production. *In* J.C. Fine and R.G. Lattimore (eds.), Livestock in Asia: Issues and Policies. pp. 180-185. IDRC-202e. Int'l. Dev. Res. Centre, Ottawa, Canada.

De Boer, A.J. 1982a. Livestock Development: The Asian Experience. *In* J.C. Fine and R.G. Lattimore (eds.), Livestock in Asia: Issues and Policies. pp. 13-26, IDRC-202e. Int'l. Dev. Res. Centre, Ottawa, Canada.

De Boer, A.J. 1982b. Goat and Goat Product Markets and Market Prospects. An International Perspective. Proc. III Int'l. Conf. on Goat Prod. and Dis. Tucson, AZ. pp. 37-44.

De Boer, A.J. 1981. Socioeconomic Aspects of Dairying in Developing Countries. J. Dairy Science 64(12):2453-2462.

Fitzhugh, H.A. and A.J. De Boer. 1981. Physical and Economic Constraints to Intensive Animal Production in Developing Countries. *In* A.J. Smith and R.G. Gunn (eds.), Intensive Animal Production in Developing Countries. BSAP Occasional Pub. No. 4, pp. 23-50. Brit. Soc. of Animal Prod., Reading, England.

Howard, P.J. 1983. The US Dairy Goat Subsector: An Analysis of Production and Marketing Structure. MS Thesis, University of Florida, Gainesville.

Norman, M.D. 1982. An Economic Analysis of the Dairy Goat Industry in Northern Arkansas and Southern Missouri. MS Thesis, University of Arkansas, Fayetteville.

Redfern, J.M., P.J. Howard, M.D. Norman, J.A. Yazman, and A.J. De Boer. 1983. The Goat Milk Industry of Northern Arkansas and Southern Missouri: An Economic Analysis. Manuscript Forthcoming as Winrock Int'l. Report.

Winrock International. 1982. Assessment of the Current Status and Projected Potential for Sheep and Goats in Developing Countries. Report Prepared for Agriculture and Rural Development Dept., World Bank, Washington DC.

Animal Health Research

J.C. DeMartini
Colorado State University

In keeping with the overall goals of the SR-CRSP, it was considered essential to develop and maintain research activity in ovine disease investigation at Colorado State University (CSU). The purposes of such activity were generally: to develop approaches and specific investigative techniques fundamental to the success of research at the overseas site; to maintain a core activity of relevant research to serve as a generator of ideas and a sounding board for research planned at the overseas worksite; and to develop and maintain a research training environment for SR-CRSP funded students.

Health research priorities in Peru were based on analysis of available data in Peru and additional surveys conducted by the CSU Health Project. Three broad areas were selected for investigation: (1) chronic viral respiratory diseases of adult sheep; (2) bacterial diseases of alpaca and sheep such as neonatal enteritis, alpaca fever, and ram epididymitis; and (3) epidemiologic analysis of infertility, neonatal lamb mortality, intestinal parasitism, and heavy metal toxicity. Research conducted at CSU was designed to support these areas of investigation.

Research Accomplishments

Chronic Respiratory Disease

The "thin ewe" syndrome is a multifactorial syndrome which causes morbidity and mortality in flocks of range sheep in the United States. Economic losses result from both loss of breeding animals and decreased reproductive efficiency. A high prevalence of ovine progressive pneumonia virus (OPPV) antibodies in US sheep flocks has been previously documented but there have been few attempts to correlate seroconversion with actual disease related to this widespread infection.

In order to determine the role of lymphoproliferative interstitial pneumonia due to OPPV in the genesis of the thin ewe syndrome, OPPV antibody positive ewes manifesting signs of chronic debilitation were examined. To date, complete necropsies have been performed on 34 OPPV-antibody positive sheep from two flocks. Characteristic lymphoproliferative interstitial pneumonia was found in 11 animals, suggesting that OPPV-mediated disease plays a significant pathogenic role in clinically affected antibody-positive sheep. Caseous lymphadenitis caused by *Corynebacterium ovis* was implicated as a major cause of debilitation in 7 animals without OPPV-mediated interstitial pneumonia. These results are comparable to previous reports and support the notion that OPPV is an important cause of economic loss to the sheep industry. Further studies are currently underway to dissect pathogenic mechanisms which allow viral persistence and chronic disease development.

Other supporting research in OPPV involves development of viral culture, isolation, and characterization schemes. Two isolates of OPPV have been obtained from Dr. R. Cutlip, Ames, Iowa, and Dr. A. Haase, San Francisco. Attempts have been made to culture these agents in a variety of cell types with variable success. Primary ovine fetal lung, cornea, tracheal and skin cells have given the best results to date. Presence of virus is indicated by syncytium formation in the cultures, ultrastructural evidence of viral particles, positive agar gel immunodiffusion tests, and positive immunofluorescence for viral antigens. A plaque assay for titration of virus in ovine tracheal calls has also been developed. Current work at CSU involves separation of viral proteins by electrophoresis, production of antibody in rabbits to major polypeptides and development of an enzyme-linked immunosorbent assay, as a rapid sensitive technique for detection of viral antigen and antibody. Additionally, attempts are underway to develop a reverse transcriptase assay which can be used to detect retrovirus in cell culture supernatant fluids or extracts of infected tissues.

To date, all pathology and electron microscopic examination on Peruvian case material has been done at CSU. This includes 80 cases collected for histopathology and 16 for electron microscopy. Results of this work are described in the Peru worksite report. We hope to develop the capacity for tissue processing, sectioning, and examination at San Marcos University in the near future.

The approaches and techniques referred to above are of direct relevance to work involving chronic respiratory disease of sheep in Peru. The clinical manifestations, lesions, and serologic reactions in OPP cases can be compared between Peru and the US. Since there is strong evidence for an association between retrovirus and sheep pulmonary adenomatosis (SPA), the approaches and techniques developed to work with this class of agents will be valuable as the research in Peru progresses. A synergistic effect between basic research on SPA retroviruses in the US and applied research in Peru is anticipated.

Clostridial Enterotoxemia Studies

Clostridium perfringens type A enterotoxemia accounts for a significant percent of neonatal sheep and alpaca deaths in both Peru and the US. Methods for purifying enterotoxin are necessary so that preventive measures can be initiated.

Clostridium perfringens Type A was isolated from cases of lamb enterotoxemia. Horses were injected with a partially purified enterotoxin derived from a *C. perfringens* Type A isolated from a typical case of enterotoxemia. The anti-enterotoxin produced in the horses was used to treat lambs affected with enterotoxemia. A therapeutic effect was noted for most lambs treated with antitoxin, whereas nontreated lambs usually died.

This indicates that a toxoid or combination bacterin-toxoid might be used to stimulate protective antibodies in sheep and alpaca. For these antibodies to be effective, they

would need to be produced by the dam and transmitted to the neonate via the colostrum and milk. This mechanism is well defined for sheep, but is virtually unknown for alpaca. This is the subject of another study.

The equipment necessary for purification of the *C. perfringens* enterotoxin is not totally available in Peru. Thus, further purification and characterization of the enterotoxin and methods for controlling enterotoxemia will be conducted in the US by a Peruvian graduate student. Along with these studies, a better method for diagnosing enterotoxemia will be developed and will probably utilize enzyme linked immunosorbent assays (ELISA) for detection of enterotoxin in intestinal fluids. An ELISA anti-enterotoxin will also be developed so that detection of antibodies directed against *C. perfringens* enterotoxin will be possible. This will enable vaccine studies to progress and be monitored.

Neonatal Lamb Mortality Studies

From March 1982 through May 1982, daily observations were made of the overall lambing mortalities on a southeastern Wyoming ranch. The number of lambs born, lamb deaths, and lamb death rate/1,000 are tabulated in Table 1. The death rate was seen to vary from band to band and was the highest during bad weather conditions, as would be expected.

A total of 383 perinatal lambs from the five bands of ewes were necropsied and evaluated by bacterial culture, histopathology, and electron microscopy (for fecal viruses). Smears of placentas, fetal lung and liver were examined for chlamydia. Blood was also obtained from ewes for detection of chlamydial bodies. The overall death rate for lambs in this study was 71.8/1,000. The leading causes of death were, in decreasing frequency, enteritis (38.4%), starvation (21.1%), and stillbirths (17.3%) (Myers, 1982).

Bacteria isolated from intestines of lambs with enteritis included *E. coli, Pasteurella* sp. and *Clostridium perfringens. E. coli* K99 plus antigen was demonstrated on 57.4% of all *E. coli* cultures. K99 is very important for colonization of the intestine by *E. coli* and is present on ovine enteropathogenic *E. coli.* Eight different serotypes of *P. haemolytica* were isolated, with 34% of the isolates serotype 11. *C. perfringens* Types A, B, C, D, and E were isolated. The majority of the typable *C. perfringens* isolates were either Type A or E.

Chlamydial abortion was diagnosed in three bands of ewes. In one band, 24.7% of the ewes were not pregnant. This could likely have been due to agents such as chlamydia, which cause abortion and/or infertility in ewes.

The above research coincides with similar epidemiologic and microbiologic research done in Peru by Drs. Reif and Ameghino. Many similarities exist in both levels and causes of lamb mortality in Peru and the Western US. Information gained and technical skills developed will be applied to the problems encountered in Peru.

Ram Epididymitis

Ram epididymitis caused by *Brucella ovis* is generally considered to be the most important cause of male infertility in sheep throughout the world and is widespread in Peru. Approaches to the control of this disease depend on improved detection of the presence of *B. ovis.* Our research has focused on assessing the value of the current method of diagnosis by detection of lesions and on developing more sensitive diagnostic tests.

Techniques for the assessment of cells in semen other than spermatozoa were developed and were found to be very useful in detection of subclinical *B. ovis* infection in rams. In a study of 824 rams, without palpable lesions of epididymitis, 10.6% had leukocytes in their semen and *B. ovis* was cultured from the semen of 71.3% of these. Rams with positive *B. ovis* cultures had significantly lower motility and higher sperm defects than rams in a control flock uninfected with *B. ovis.* It was concluded that present control programs based on culling rams with palpable epididymal lesions and vaccination of the remaining animals are ineffective and that the presence of leukocytes and/or separated sperm heads in the semen of adult rams may be a useful indicator of subclinical *B. ovis* infection.

The conventional test for determining antibody titers to *B. ovis* is complement fixation (CF). We have developed an enzyme-linked immunosorbent assay (ELISA) to detect antibodies which is more sensitive, more rapid, and more versatile than the CF test. It will be used to determine whether vaccine titers can be distinguished from titers related to natural infection. The equipment and reagents for the *B. ovis* ELISA have been taken to San Marcos University so that similar tests can be conducted in Peru.

Table 1. Mortality Rate of Perinatal Lambs From Five Bands of Ewes on a Southeastern Wyoming Ranch

Band Number	Lambing Dates	Number of Lambs Born	Number of Lamb Deaths	Death Rate per 1000
1	March 4-March 15	2382	207	86.9
2	March 24-April 23	2082	92	43.7
3	March 31-April 16	2795	252	90.2
4	April 17-April 26	838	92	109.8
5	May 5-May 17	1858	73	39.3
All Bands	March 4-May 17	9955	715	71.8

Improved means for detection of *B. ovis*-infected rams will enable culling of these rams and improved fertility in the breeding population. It may be possible, through appropriate culling and vaccination programs, to practically eliminate *B. ovis* epididymitis as a significant cause of infertility.

Selected Publications

Ellis, J.A. Ovine Caseous Lymphadenitis. Comp. Contin. Ed.

Fiscus, S.A., J.C. DeMartini, and L D. Pearson. 1983. Mitogen-Induced Blastogenesis of Peripheral Blood and Efferent Lymph Lymphocytes from Normal Sheep. Amer. J. Vet. Res. 43:629-632.

Hoopes, P.J., S.P. Snyder, and S.A. Fiscus. 1981. Serologic Evaluation of Ovine Progressive Pneumonia in Bighorn Sheep using a Micro-immunodiffusion Test. Wildlife Dis. Assoc. Conf. Abstract No. 53.

Kimberling, C. 1981. Ram Epididymitis. Service in Action. Colorado State University Extension Service Bulletin No. 8.016.

Myers, R.P. 1982. Perinatal Mortality in Lambs in a Southeastern Wyoming Ranch. MS Thesis, Colorado State University.

Tengerdy, R.P., D.L. Meyer, L.H. Lauerman, D.C. Lueker, and C.F. Nockels. 1983. Vitamin E Enhances Immunity to *Clostridium Perfringens*. Type D, in Sheep. Brit. Vet. J. 139:147.

Production Systems Research

H.A. Fitzhugh
Winrock International

Support activities conducted in the US at Winrock International in Arkansas include computer processing and statistical analysis of data collected in Kenya, search and review of literature relevant to Kenya research, and compilation of a bibliography of the international literature on goats. Results from the data analysis and literature review activities are reported in the section on Kenya.

Entries in the bibliography include authors, title, publication data, and source. Each entry is accompanied by key words which allow rapid searches by topic, breed, region, and country. Started in 1980 with 1,395 entries from "A World Bibliography on Goats" compiled by M.W. Sands and R.E. McDowell, the current number of entries is 3,936. Searches by key words are performed on request. A listing of the file sorted alphabetically by last name of first author indexed by the full set of key words was distributed in May 1983.

Winrock International staff are engaged in other projects (funded from sources other than the SR-CRSP), involving dairy and dual-purpose goats which directly and indirectly support the research in Kenya. These projects include a smallholder goat production improvement program in Haiti which involves breeding and multiplication of improved dual-purpose goats and development of management systems appropriate to small farm crop-livestock systems; technical assistance to members of the Central States Dairy Goat Cooperative (Arkansas, Missouri, Oklahoma) in the production and marketing of milk and breeding stock; and compilation of 1,000 computer-based technical information modules covering goat nutrition, health, reproduction, and genetics which will be maintained on-line for remote access by producers, educators, and other users.

Animals and facilities in the Petit Jean Goat Dairy, a 150-doe commercial dairy operated by Winrock International, were used in experiments during 1980 to evaluate effects of kid rearing regimes on survival and growth of kids and lactation yields of their dams. Five breeds, Alpine, La Mancha, Nubian, Saanen, and Toggenburg, were included. Three kid rearing regimes involving type and source of milk consumed between 3 and 42 days of age were compared. Two regimes involved *ad lib* feeding of fresh goat milk and lamb milk replacer, kept cold in nipple fitted plastic jugs. The third regime involved twice-daily suckling of does. These does included a test group which had already been machine milked so that kids were stripping residual milk and another group of does which was suckled (several kids per doe) for the first 30 days after parturition and then machine milked for the remainder of their lactation.

Results from the experiment indicated that lamb milk replacer could not be recommended for rearing goats, especially when fed *ad lib,* because of high incidence of bloat and diarrhea and poor growth rate; kids fed *ad lib* fresh goat milk and those suckling does had adequate preweaning growth rates and low incidence of gastrointestinal problems. There were no significant differences between suckled and nonsuckled does in milk yield or mastitis incidence subsequent to the period of suckling.

Selected Publications

Collins, J.A., J.M. Rakes, N. Kasireddy, C.H. Mannasmith, and J.A. Yazman. 1980. Bacterial and Somatic Cell Evaluation of Grade-A Goat Milk Herd in Arkansas. J. Dairy Sci. 63 (Suppl. 1):40.

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Yazman, J.A. 1980. Rajas Caprinas, Alimentacion y Produccion de Leche en los Estados Unidos. Proc. Primer Encuentro Int'l. para Impulsar la Produccion de Leche de Cabra, Mexico. Diego Palacio, Diego, Mexico.

Yazman, J.A., L. Turillo, and H.A. Fitzhugh. 1980 Systems of Feeding Preweaning Dairy Goat Kids. *In* 6th Annual Dairy Goat Day, Univ. of California. pp. 42-52.

Yazman, J.A. 1979. Economics of Commercial Dairy Goat Milk Production in Central Arkansas. Proc. 1979 California Dairy Goat Day. Univ. of California, Davis.

Reproduction Research

W.C. Foote
Utah State University

Basic supporting research activities carried out in the US by the Reproduction Project have pursued the following themes:

- Research on reproductive physiology and endocrinology of the female.
- Research on reproductive physiology of the male particularly as it relates to semen.
- Development and adaptation of techniques and procedures for training and conducting research in overseas worksites.

Ongoing research in reproduction, breeding, and management carried out at Utah State University (USU) and California State Polytechnic University (CSPU), also make a valuable contribution to the SR-CRSP efforts in research and training.

All basic supporting research and related activities planned and carried out by this project provide information, research help in terms of new procedures and techniques, and training to the overseas worksites, as well as contributing to livestock production and training programs at Utah State.

The research underway deals with measuring reproductive phenomena such as age at puberty, fertility, prolificacy, postpartum anestrus and seasonal changes in reproduction in the male and female, and determining the genetic and environmental influences on these phenomena.

Several breeds or genetic types of sheep and goats are maintained for use in this research and teaching. They include Rambouillet, Suffolk, Targhee, and their crosses, and crosses with the Finnsheep, and the Cheviot, St. Croix and Karakul sheep and Spanish or brush goat.

The activities projects have also included a component in which scientific techniques and procedures needed in programs at the overseas sites are adapted for use under local conditions. Several of these have proved useful and include semen related procedures, laparatomy and laparoscopy, radioimmunoassay, and ultrasound procedures for pregnancy diagnosis. The use of such procedures increase the quantity and quality of research as well as the capabilities of the individual scientists and the group with which they work.

Research Accomplishments

Female Reproduction

Comparisons of several reproductive characteristics have been conducted or are underway between the Rambouillet and the St. Croix, a hair sheep imported from the US Virgin Islands by the International Sheep and Goat Institute in 1975 (Table 1). The length of the breeding season (occurrence of both estrus and ovulation) is long and almost identical between the two breeds (termination in May and resumption

Table 1. Mean Reproduction and Production Values Calculated per Year by Genotype [a]

	St. Croix	Rambouillet
Number	102	60
No. parturitions/ewe/year	1.82	1.00
No. lambs born/ewe/year	3.98	1.52
No. lambs weaned/ewe/year	2.49	1.39
Kg lamb born/ewe lambing/ year	11.02	6.81
Kg lamb weaned/ewe lambing/year	19.80	23.10
Percent lamb born/ewe body weight/year	25.31	11.46
Percent lamb weaned/ewe body weight/year	39.92	42.68
Kg ewe body weight	43.54	62.96
Percent lamb born/ewe metabolic body weight	35.80	32.06
Percent lamb weaned/ewe metabolic body weight	100.60	120.48

[a]Ewes were exposed for breeding two times a year; August 1-September 9 and February 1-March 12.

in August). However, the capability for reproduction is much higher for the St. Croix than the Rambouillet in age at puberty and first parturition, prolificacy (1.99 vs. 1.52) and postpartum interval (30 vs. 60 days) when measured separately and as the ability to lamb twice per year. Eighty-seven percent of the St. Croix lamb at one year of age and a significant proportion (approximately 30%) lamb consecutively on a twice yearly schedule. This contrasts with the Rambouillet which fail to commence lambing at one year of age and subsequently lamb only once per year. The difference in lambing interval is due to the much shorter postpartum period in the St. Croix. Under conditions of confinement, however, early lamb loss was less in the Rambouillet than the St. Croix.

Progesterone and LH profiles were established for Spanish x dairy cross goats during the estrous cycle and for comparable time periods during seasonal anestrus and early postpartum (first 21 days) to determine basic endocrine differences during these three reproductive phases. The mean progesterone level during the follicular phase of the estrous cycle was intermediate between the higher mean level for seasonal anestrus and the lower mean level for early postpartum does. Mean tonic LH levels during the luteal phase of the estrous cycle and during seasonal anestrus were similar and higher than during early postpartum. Release of LH as a response to injected GnRH occurred during the late luteal phase of the estrous cycle and during seasonal anestrus and early postpartum with the response being less during early postpartum than during the other two periods. These results demonstrate that the endocrine system is more dynamic during seasonal anestrus than early postpartum.

Male Reproduction

Age at puberty (presence of sperm in ejaculate obtained by electroejaculation) was youngest in the St. Croix followed by the Suffolk, Hampshire, and Rambouillet. Significant differences occurred only between the St. Croix (20.0 weeks) and Suffolk (20.3 weeks), vs. Rambouillet (28.5 weeks). Positive relationships were shown between body weight and testicular girth.

Seasonal variations in semen production and quality and in sexual activity were minimal in rams with no statistically significant variation among breeds. Greater seasonal variations occurred in bucks due both to season of year and among breeds resulting in season and breed interactions. The semen quality criteria used were volume, concentration, initial motility, pre and post thaw motility, and post stress motility (Table 2).

Table 2. Effect of Breed on Semen Characteristics

Breed	Rambouillet	Suffolk	St. Croix	Finnsheep	Hampshire
No. of samples	685	517	674	323	144
Volume (ml.)	1.40	1.18	0.88	0.97	0.95
Concentration ($x10^9$/ml.)	3.14	2.99	2.80	3.47	3.42
Initial motility (%)	60.6	53.2	61.4	55.4	54.9
Prefreeze motility (%)	51.8	47.9	53.8	46.5	47.2
Post-thaw motility (%)	22.6	19.7	24.3	21.2	21.6
Post-stress motility (%)	13.5	10.8	15.5	12.4	12.3

Source: CSPU, 1983.

Development and Adaptation of Techniques and Procedures

Several techniques and procedures have been adapted and adopted at Utah State and CSPU for use in conducting research and related activities such as training in the US and at the overseas worksites.

Through efforts at CSPU, all available information on semen processing, freezing, and artificial insemination has been collected and selected, laboratories visited, an evaluation of existing procedures made, and research conducted to develop and test improved methods of processing and freezing semen. These methods have been developed with alternative procedures for sheep and goats and have been shared with other SR-CRSP projects and scientists outside the SR-CRSP.

Techniques useful in female reproduction work particularly under conditions of the foreign worksites have been evaluated. These include laparatomy, laparascopy, and pregnancy diagnosis using ultrasound equipment with procedures such as Real-Time Scanning to determine the number of fetuses. Research at Utah State and particularly in Australia have shown that Real-Time Scanning, which is used in human medicine, can be effectively applied for determining the number of fetuses as well as making observations on other reproductive processes such as ovarian changes.

The standard Radio-Immuno Assay (RIA) procedures are being used at USU for research training and as a backup for RIA work in Peru and Brazil.

Embryo culture and transfer have been modified for use in research to determine the mode and route of vertical transmission of scrapie. This procedure is not being used currently in the Reproduction Project but holds potential use in terms of disease control, optimizing the number of offspring from selected dams, and in environmental and/or genetic studies.

The importation of animal tissues and body excrements into the US is not allowed because of the hazard of introducing disease. Such regulations limit the import of blood to the US for RIA because chemicals used to destroy blood borne disease organisms also denature or alter the hormones to be measured. The Reproduction Project discovered that very large doses of gamma irradiation was being used in some cases to destroy disease organisms in tissue and other materials to be imported. Arrangements were made with USDA/APHIS and Plum Island Quarantine Station personnel to test the influence of gamma irradiation on the hormone constituents of blood. This work is now underway and will soon be completed. If the hormone structures are not altered, then this procedure can be used on imported blood for RIA.

Additional research at USU, which complements the SR-CRSP but is funded and conducted separately, deals with the time and route of vertical transmission of scrapie. This research makes use of embryo transfer and is important to small ruminant and other livestock work because it serves as a model that is being used to study transfer of other diseases and particularly because, if successful, can provide a procedure to obtain scrapie free animals from scrapie infected areas. In many countries, a limiting factor to international movement of animals is the risk of scrapie. If the transmission of this disease can be controlled, then procedures are available to establish policy for importation of sheep and goats from most countries of the world into the US as well as among other countries with similar policies.

Training

The close complementary relationship between research in the US and that in Brazil and Peru enables graduate students to conduct a major part of their theses research in their home countries. Supplemented with additional and more detailed research carried out in the US, this provides a training regime that can be linked to their future roles in their own countries. The following persons are receiving graduate training as a result of the basic supporting research activities of the Reproduction Project.

Name	Country	Degree	Granting Institution
William Vivanco	Peru	MS	CSPU
Cesar Novoa	Peru	PhD	USU
Walter Bravo	Peru	MS	USU
Aurino Simplicio	Brazil	PhD	USU
Jose Ubiraci	Brazil	MS	USU

Shortcourses and other training programs have also been developed for specific training in areas of small ruminant reproduction and production.

Each of these degree and non-degree programs draws upon the resources provided through the basic supporting research activities.

Selected Publications

Clark, Dana D. 1982. Endocrine and Physiological Responses of the Female Goat During Three Reproductive Phases. MS Thesis, Utah State University, Logan.

Ekpe, Ekpeni 1981. Some Effects of Crossbreeding on Reproductive and Productive Programs in Nigeria. MS Thesis, Utah State University, Logan.

Ferris, Charles F. 1983 Quantitative Autoradiographic Analysis of Unoccupied Luteinizing Hormone Receptor Sites in Ovine Ovarian Follicles. PhD Thesis, Utah State University, Logan.

Foote, Warren C. 1981. Hormonal Regulation of Reproduction in Small Ruminants to Increase Production. Sheep and Goat Handbook, Vol. 2. Int'l. Stockmen's School, San Antonio, TX. pp 136-139

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Gebrelul, Sebhatu 1979. Factors Affecting Ewe Reproduction and Lamb Production Traits in Targhee and Crossbred Targhee Range Ewes and Relationships Among Important Traits. MS Thesis, Utah State University, Logan.

Madison, Valerie 1980. Embryo Transfer in Sheep: The Influence of Selected Factors. MS Thesis, Utah State University, Logan.

Plummer, William E. 1979. Anterior Pituitary and Ovarian Response to Infused GnRH and Progesterone Pretreatment in Ewes. PhD Thesis, Utah State University, Logan

Romm, Stephanie 1979. The Progesterone and LH Levels in Female Goats During Selected Reproductive Stages and Following Hormone Treatment. MS Thesis, Utah State University, Logan.

Whittier, Jack. 1981. Production of Cattle and Sheep Under Continuous Rotational Grazing Systems on High Elevation Summer Range. MS Thesis, Utah State University, Logan.

Small Ruminant Nutrition Research

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North Carolina State University

Small ruminant research underway at Raleigh is supportive of both the research and training objectives for all overseas locations. Questions asked are more basic in nature than would be appropriate at the overseas sites where applied problems demand immediate attention. We can devote time and resources to investigating why the biological systems we deal with behave as they do, thus gaining better insight as to how to improve the efficiency of small ruminant production anywhere.

We are also concerned with research methodology. New techniques for feed evaluation and animal nutrition research can be tested and perfected (or discarded) in Raleigh with less at stake than there would be if they were first tried at an overseas location. Occasionally, analyses can be done at Raleigh for which overseas laboratories are not equipped.

The training mission of our program works in two directions. First, graduate students from our host countries or from other lesser developed countries (LDCs) where small ruminants are important can learn the philosophy and tools of the scientific approach to problem solving. Secondly, students from the US and other more developed countries who have career objectives in international animal agricultural development or in small ruminant husbandry can serve as program apprentices. In selected cases, they can become part of the research team in one of the collaborating countries. This dimension of student training is vital to assure the formation of a new generation of animal scientists who are prepared to deal with problems in LDCs.

We would be remiss not to mention the benefits accruing to the domestic sheep and goat industry. As the Department of Animal Science at NCSU becomes better equipped in both the human and physical sense to conduct small ruminant research, it can more readily respond to the needs of its domestic clients. The world-wide information exchange that is facilitated by the SR-CRSP is also helpful in this regard. Benefits to both domestic and foreign programs are maximized if the entire project is perceived to be an integral part of the departmental fabric and not just an added activity. The traditional research, teaching and extension missions are strengthened by the international dimension, and the international project gains by its access to the broadest possible pool of expertise.

Generalities aside, several specific objectives to the on-campus research which are complementary to the objectives overseas, are to:

- Investigate the feeding value of common crop residues and by-products for small ruminants;
- Develop guidelines for using crop residues, by-products, and cultivated forages in rations for small ruminants;

- Test storage and treatment methods for preserving or enhancing the nutritive value of high fiber feeds;
- Investigate the relationships between plant fiber characteristics and the performance of the small ruminants which consume them, with the objective of improving the predictability of animal performance;
- Investigate the basic physiology of rumen function in sheep and goats, including their comparative efficiencies.

The sections which follow summarize activities and progress toward fulfillment of these objectives. The reader who desires more detailed information may consult the list of publications which follows this discussion.

Research Results

Feeding Value of Crop Residues

Wheat straw was the major fiber source in diets fed to 9 Toggenburg x Saanen wether kids and 9 Suffolk x Barbados wether lambs. As shown in Table 1, voluntary intake of these rations was considerably lower than for forages such as fescue or alfalfa with similar concentration of total cell wall fiber. Digestibility was also somewhat lower. These results underline the difficulty in trying to predict animal performance from chemical composition alone. In a separate trial, wheat straw was compared to soybean straw and maize stover in diets for goats and sheep.

Factors Influencing the Nutritive Value of Forages and Crop Residues for Ruminants

The influence of temperature and daylength on the chemical composition and *in vitro* digestibility of three forage grasses at four ages of regrowth after harvest have been investigated. The range of temperatures studied was 16° to 28° C (average day/night temperature). The cellulose, lignin, and total cell wall fractions increased in concentration with warmer temperatures at all stages of regrowth (1.5 through 6 weeks) in coastal bermuda grass and in *Penninsetum flaccidum,* both of which are warm-season or tropical grasses. In tall fescue, a grass better adapted for cool growing seasons, the fiber components increased through the range of 16° to 24° C, then levelled off. Cell wall fiber content was positively correlated with total DM yield in all cases. Crude protein content and *in vitro* digestibility of the cell wall fraction and the total DM decreased as temperature and DM yield increased. These observations were partially explained by changes in plant morphology and anatomy (for example, higher stem/leaf ratio at higher temperatures). The range of daylength differences studied did not influence these results.

Another factor which we have looked at is the effect of mineral nutrition of the animal on forage utilization. In a trial not yet published, we have tested the effect of zinc supplementation for growing lambs, with a low quality and a high quality hay. Zinc concentrations in the two hays were similar. The lambs fed supplemental zinc consumed more forage DM and grew faster than the unsupplemented lambs, but only with the high quality hay. This is good evidence that improving the energy and protein nutrition of animals can cause a previously non-limiting mineral to become limiting.

Strategies of Feeding Small Ruminants

The question of whether to feed ewe-lambs for accelerated growth and early breeding is of practical significance in many environments. McCann et al. (1983) fed either a growing or a finishing ration to 46 Dorset, Suffolk and Barbados Blackbelly lambs. Growth rates until puberty were 153, 168 and 86 g/day for the three breeds in the growing ration, and 217, 230 and 120 g/day for the three breeds, respectively, on the finishing ration. Puberty occurred at 238 days for the slower-growing animals and 197 days for the accelerated-growth group (breed differences were not significant). Lambing rates differed among breeds but not between dietary treatments. However, milk production from the accelerated group at 3 to 4 weeks after parturition was lower than from the slower-growing ewes. Milk yield within breeds was negatively correlated with fat score, indicating that a metabolic price is paid when ewes become adapted to laying down adipose tissue during their growth period. In most situations, the economic advantage of gaining one month in age of breeding would probably not offset the additional costs in feed consumed and lost milk yield.

Another issue of interest is the comparative utilization of urea by small ruminants. The efficacy of urea supplements for cattle and sheep has been well demonstrated but few reports are available from goats. Ordoveza and Johnson (1982) conducted two experiments to test the utilization of urea by goats and sheep fed diets based on wheat straw. In the first experiment, wheat straw/alfalfa hay diets, supplemented by 0, 1 or 2% urea to achieve 7, 10 or 13% crude protein equivalent, were fed to Toggenburg wether kids. Performance of animals on the 1 and 2% urea diets was similar, and significantly better than the zero urea control in terms of voluntary intake, digestibility, and nitrogen balance. In a second trial, urea was compared with soybean oil meal, in diets with two levels of wheat straw fed to growing Toggenburg wether kids and Suffolk wether lambs. All diets were adjusted to 11 to 12% crude protein equivalent. There were no important differences in crude protein digestibility or nitrogen retention either between animal species or among diets. It appears, therefore, that urea utilization by goats will follow patterns already established for sheep.

Preservation and Treatment of Crop Residues

Maize stover was ensiled with broiler litter or soybean oil meal. The product was fed to lambs along with 227 g of ground maize grain per animal/day. Intake of the broiler litter silage was low and rates of gain unsatisfactory. Intake and gains by lambs and stocker steers were improved when the maize stover was ensiled after high-moisture grain harvest, compared to mature dry stover harvested after regular grain harvest. Both stovers were inferior to standard maize silage (ensiled with the grain intact). In small-scale fermentation studies, the addition of either maize grain or molasses improved the fermentation characteristics of maize stover; a lactic-acid producing bacterial culture had no beneficial effect.

Studies are currently in progress by Harvey and associates on the ammoniation of low quality forages and crop-residues as a means of improving their digestibility and crude protein value.

Predicting Animal Performance from Chemical Composition and In Vitro *Digestibility*

The relationships between *in vivo* and *in vitro* evaluation of forages and crop residues have been examined in several experiments. In trials with cattle it was first observed that the daily intake of non-digested cell wall fiber was relatively constant across a wide range of cell wall fiber concentrations in the diet. In other words, the pass-through and excretion rate of undigested plant cell wall residue seemed to place a ceiling on the amount of the diet which could be consumed by the animal, especially for diets medium to high in plant cell wall concentration. Brown (1982) and Luginbuhl looked at these same relationships with sheep and goats. The sheep responded similarly to cattle in that the pass-through rate of non-digested cell wall was quite constant across dietary differences in quality. Goats, however, responded to the lowest quality diets (high cell-wall concentration) with a higher pass-through rate for undigested fiber, and higher total daily DM intake. This was accompanied by a lower digestibility of DM and cell wall fiber by the goats on the same high fiber diets.

Even if the relationships were slightly different among animal species, they could be useful for prediction if they were constant across plant species. *In vitro* digestibility of the cell-wall fiber could then be used as an accurate predictor of total DM intake. However, the experiments with cattle cited above have shown that alfalfa is an exception; when dietary fiber is mostly from alfalfa, actual intake levels are much higher than predicted. Subsequent work with soybean straw (Johnson and Gaskins, 1983) indicate that it too is an exception. Also, as demonstrated by Sitorus-Silitonga (1983) for alfalfa and bromegrass, there may be associative effects when forages are offered in combination rather than as the sole fiber source. It appears, therefore, that more work is needed before these predictive relationships are refined to the level of usefulness necessary for application.

A different approach to the estimation of intake would be to use external markers to estimate total fecal output, along with *in vitro* digestibility estimates to back-calculate DM intake. Work of this nature at NCSU has recently mushroomed under the leadership of Dr. Kevin Pond. There are many practical obstacles to be overcome before this methodology can be useful as a routine management or extension tool, not the least of which is the high cost of reliable markers and the sophistication of equipment required for their analysis in large sample numbers.

Comparative Rumen Physiology

Do goats, sheep and cattle function in the same way when presented exactly the same diet? Conjecture on this subject has filled the literature, especially with regard to goats where opinions range all the way from ideas that they can get along on almost nothing (except sand and tin cans!) to the notion that they are very highly selective and must be able to choose a highly digestible diet if they are to thrive.

Brown and Johnson (1983) have reviewed existing literature on the comparative utilization of fibrous feeds by goats and sheep, and found a mixed situation. With regard to DM intake (corrected for metabolic size), seven reports indicated higher intakes by sheep, three reports indicated higher intake by goats, and three additional reports showed ambivalent results. The only consistent pattern was that nearly all instances of no difference in intake occurred when the diet was of relatively high quality, and that goats showed relatively higher intakes only with low quality forage or by-products. Similarly, in 50 separate comparisons of DM or organic matter digestibility, from 16 authors, there were no differences between goats and sheep in about one-half the comparisons. The remaining comparisons were split nearly equally between higher digestibility by sheep and higher digestibility by goats. In the cases where sheep showed a higher digestibility, the diet consisted mainly of low quality feeds. Thus, a working hypothesis was formulated that for diets relatively low in cell wall fiber, fed to sheep and goats, very little difference in digestibility or intake (corrected for metabolic size) might be expected. On the other hand, for low quality, high fiber diets, there may be differential, partially compensatory advantages: more complete digestion of fiber by the sheep, made possible by a longer retention time in the rumen; but higher intake by the goat, possibly related to a faster rate of removal of partially-digested fiber particles.

Three experiments which we have conducted seem to corroborate this working hypothesis. In Table 1, the feeds offered in these experiments are arranged in descending order by cell wall fiber concentration. As the table shows, intakes by goats were higher than by sheep for all diets having more than 60% NDF, and at the same time, DM digestibilities were higher for the sheep. For low NDF diets, this relationship disappeared or tended to reverse itself.

In the search for physiological explanations for these results, Luginbuhl has completed a literature review on the comparative anatomy of digestive systems of goats and sheep. He found reports of numerous anatomical differences, but none that could be directly related to known differences in physiological function. Part of the problem is that investigators did not usually attempt to relate their findings to physiological differences, nor were they necessarily equipped to do so because much of the pertinent physiological information came later. If comparative anatomical observations were to be repeated, the points of concentration might be the teeth (and fiber particle breakdown), the omasum (including its role in controlling passage to the abomasum or retrograde flow to the reticulum), and the duodenum and its role in retrograde passage to the rumen. These functions all need to be examined on diets with a wide range of fiber concentration and quality.

Preliminary observations on the rate of passage of alfalfa and coastal bermudagrass have been made by Haryanto and Johnson (1983). In animals on *ad libitum* intake the passage rate was faster by goats than sheep for the high fiber coastal, but very similar between the two species when alfalfa was

Table 1. *Ad libitum* Intake and Apparent Digestibility of Several Feedstuffs by Goats and Sheep

Diet	Total Cell Wall[a]	Dry Matter Intake per $W^{.75}$		Apparent Digestibility			
				Dry Matter		Cell Wall[a]	
		Goats	Sheep	Goats	Sheep	Goats	Sheep
	%	%	%	%	%	%	%
CBG[b] (1)	80	74	52	49	56	56	61
CBG (2)	76	82	64	56	63	63	68
CBG (3)	75	78	63	56	61	59	64
Tall fescue (1)	69	69	55	53	59	56	62
65% wheat straw[c]	62	48	47	52	57	44	51
Tall fescue (2)	61	74	58	60	63	62	64
50% wheat straw[c]	52	55	53	63	64	47	51
Alfalfa	49	86	98	67	63	57	54
35% wheat straw[c]	41	59	63	71	70	50	49

[a]Neutral detergent fiber (NDF)

[b]Coastal bermudagrass

[c]These three diets also contained ground maize grain (4, 20, and 37%, respectively), soybean oil meal (13, 15, and 16%, respectively) and diluted molasses (15%).

consumed. Apparently, at least part of this difference is due to rates of particle degradation, rather than being entirely due to passage, since volatile fatty acid concentration was noted to be higher in rumen fluid collected from goats (Haryanto, 1983; Brown, 1982). A more detailed study of fiber particle degradation in goats is currently underway.

Haryanto and Johnson (1982) found no differences in the *in vitro* degradation of forage fiber when the rumen fluid inoculum was collected from goats or sheep. This tends to rule out gross differences in rumen microbial species as a major cause for differences in rumen physiology.

All these considerations point to two necessities: one, the need to carry out research separately for goats, sheep and cattle, when it comes to fine tuning feeding systems based on low quality roughages, because we cannot yet be certain how to adjust the results with one species to apply to either of the others. Secondly, there is a need for basic rumen physiology studies to continue in the search for the common denominator of rumen function, if one exists.

One such problem is with the adjustment of intake data. The concept of metabolic size (body weight $^{.75}$) is conventionally used to correct differences in body weight within and among ruminant species. Our studies on the relationship of non-digested fiber intake (pass-through rate) to total *ad libitum* DM intake, have yielded non-digested fiber intakes (g/kg $BW^{.75}$/day) within the ranges of 12 to 16 for sheep, 13 to 23 for goats, and 20 to 28 for cattle. Evidently, the correction for metabolic size does not adequately account for the different relationship of gastro-intestinal tract capacity to total body weight, across species.

Within each species, there may exist some important breed differences in digestive and metabolic function. At NCSU, research has been carried out for more than a decade with the Barbados Blackbelly sheep, a non-wool breed originating from tropical African genetic stock but isolated for many generations in the Caribbean (Goode et al., 1983). Several differences in adaptive response between this breed and the breeds of Northern European origin have been documented (Goode et al., 1980) such as improved heat tolerance and higher prolificacy. Extreme caution is therefore warranted before applying conclusions on optimum feeding strategies from temperate breeds directly to tropical situations.

One point of interest from studies with the Barbados breed was the apparent heterosis effect observed in Barbados x Dorset ewes. When fed alfalfa, tall fescue, or a diet consisting of 50% fescue and 50% maize stover, the Barbados x Dorset ewes consumed more forage DM (per $BW^{.75}$) and had higher digestibilities than purebred contemporaries of either parent breed (Brasfield, 1980).

Another line of research being pursued is the study of compounds which might favorably alter rumen function. The antibiotic avoparcin was fed to mature crossbred wether sheep receiving diets that were medium (24%) or low (12%) in lignocellulose (acid-detergent fiber) concentration. Pelleted alfalfa was the principal fiber source in both rations. Compared to sheep fed the same diets without avoparcin, the treated animals had a higher ruminal pH and lower concentration of total volatile fatty acids (but higher molar proportions of propionate) with both fiber levels, and decreased ruminal ammonia and increased alpha amino

nitrogen with the low fiber diets (Froetschel et al., 1983). Previous reports of improved feed efficiency when avoparcin is fed are supported by the present study and its demonstration of the ability of this antibiotic to stimulate rumen propionate production and inhibit the rumen degradation of dietary amino acids, thus enhancing rumen bypass.

Significance of Research Findings

The research at Raleigh can be related to problems at the overseas worksites at three levels: results for immediate application, ideas for testing and possible future application, and basic biological understanding of the plant or animal systems which are at the center of the farming systems at each site. Some of the Raleigh work is relevant to all five overseas locations of the SR-CRSP, while other parts are more relevant to one or a few sites.

Of immediate interest to Morocco is the work with wheat straw, the principal crop residue available in that country. Rations proven effective in trials at Raleigh could be tested virtually without modification with Moroccan breeds of sheep.

The urea studies with goats could also be applied immediately, especially in Northeast Brazil or anywhere else where natural protein feeds are in short supply during the dry season. Urea supplements for sheep might also be tried during the dry season in Morocco or winter in the Peruvian Andes.

McCann's data on the accelerated feeding of prepubertal ewe lambs can be applied in all locations where sheep are raised. A similar experiment was conducted with tropical hair sheep in Brazil, with similar conclusions—that feeding too much energy during the growth period can actually reduce the productive and reproductive efficiency of ewes.

Experience with external markers as a research tool has proven satisfactory and will be applied in 1983 for intake measurements by village animals in Indonesia and for indirect estimates of intake by grazing animals in Northeast Brazil. Tentatively, markers will also be used in Morocco in 1984, for intake estimates by sheep while grazing wheat stubble.

Ammonia treatment of low-quality feeds is a concept that likely will have later application wherever a severe dry season problem exists. The cost issue will have to be faced, however, and treatment methodology will have to be adapted to rural or village conditions in collaborating countries.

The relationship between mineral nutrition and forage utilization is of urgent importance to all overseas sites. Dr. Spear's work in this area will help give direction to similar studies overseas.

Other work at Raleigh has been helpful toward understanding the underlying biology of tropical systems. The work of daSilva, for example, has shown the natural disadvantage in nutritive value for tropical forage grass species. It is well known that tropical grasses lay down poorly digestible lignified tissue at a faster rate than temperate grasses. That high ambient temperatures accelerate this effect has also been demonstrated. We have seen, with daSilva's microscopic measurements of the leaf and stem area occupied by lignified vascular tissue, how the basic structure of tropical grasses places a ceiling on their usefulness in feeding ruminants.

For small ruminants, particularly, the highly lignified grasses impose severe limitations. Compared to large ruminants, their smaller gastrointestinal tracts, yet higher energy requirements (per unit of weight) for homeostatic maintenance, make them less able to produce efficiently when the feed offered to them requires a long rumen residence time before significant cell wall digestion can occur. As shown in comparative fiber utilization studies at Raleigh, the goat seems to have made the adaptation of passing fibrous feed through its digestive tract faster than the sheep, therefore being able to consume more. The shorter retention time, however, makes it all the more imperative to emphasize forage quality (rapid cell wall degradability) if productive levels of the goat are to be improved. In Brazil and Indonesia this implies that napier grass should be de-emphasized for the goat, at least until a management scheme can be devised that is compatible with the goat's requirements. Native tropical grasses in Indonesia should also be used with caution and probably supplemented with more readily degradable crop by-products.

Basic research in rumen physiology must continue, in order to elucidate the underlying mechanisms of fiber degradation and utilization, if rapid improvements in forage-based ruminant production systems are to be expected.

For those situations where higher feed intakes are necessary (finishing lambs; maintaining high milk yields by dairy goats) the research on rumen intervention strategies by Croom and co-workers has relevance. If the animal's requirements for amino acids and metabolizable energy exceed the turnover capacity of a forage-adapted rumen microflora, rumen bypass becomes an important goal. Feedlot fattening of lambs is now only a sporadic activity in the collaborating countries but has potential importance, depending on market development, in Peru, Brazil and Indonesia. Dairy goat feeding strategies for Brazil, Peru, and Kenya may also eventually reach the point where artificial manipulation of the rumen will be advantageous.

Training

At a land grant institution, research and education go hand-in-hand, and training at various levels—undergraduate, graduate, and continuing education for producers and professionals—is an integral part of every day's activities.

Training activities at Raleigh have contributed directly to the overseas programs. From Indonesia, Budi Haryanto has completed his MS program and has embarked on studies for the PhD. Andi Djajanegara and Sorta Silitonga have participated in short-term activities, including travel support to professional meetings for both, and studies in laboratory management for Mr. Djajanegara. Other Indonesians are slated to come to Raleigh in the near future. From Brazil, Ederlon Oliveira visited the Raleigh campus for a short-term

consultancy, and Nelson Barros has been assisted in beginning a doctoral thesis project in Brazil. Fron Kenya, Mark Owango of the Research Division of the Ministry of Livestock Development is a peripheral participant in small ruminant activities while engaged in PhD studies in poultry nutrition.

Indirect contributions to overseas research programs have been made through the training of PhD candidates (Burstein and Luginbuhl) who are participants in Brazil and Morocco, respectively. During residence at the overseas sites, these research associates interact daily with less experienced young researchers, technicians, producers, and extension workers, all of whom benefit from this contact.

Training at Raleigh, both short-term and long-term, directly contributes to the SR-CRSP outreach effort. A USAID scholar from Panama, presently a candidate for the MS degree, is completely immersed in the small ruminant research program. USAID scholars from Cameroun were involved to a lesser degree. Visiting scientists from the Philippines and Mexico have spent 3 to 6 months at Raleigh specifically to participate in the SR-CRSP project.

Apart from these documented traineeships, there have been many more instances of undergraduate and graduate students "learning while doing" as a result of their involvement as research associates or assistants, and numerous instances of information shared with interested visitors, or SR-CRSP results imported to the university community in the classroom or seminars. These are but some of the by-products of physically locating an international research program of this dimension in a land grant Department of Animal Science.

Selected Publications

Brasfield, J.C. 1980. A Comparison of Voluntary Intake and Digestibility in Sheep Breeds and Crosses Fed Diets Varying in Composition and Quality. MS Thesis, North Carolina State University, Raleigh.

Brown, L. and W.L. Johnson. 1983. Comparative Intake and Digestibility of Forages and Byproducts by Goats and Sheep: A Review. Int'l. Goat and Sheep Res. (In Press).

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Crickenberger, R.G., R.W. Harvey, and A.C. Linnerud. 1983. Movement of Liquid Supplement Injected into Corn Stover Stacks. Dept. of Animal Science Report No. 235. North Carolina State University, Raleigh. pp. 27-30.

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Luginbuhl, J.M. and W.L. Johnson. 1982. Coastal Bermudagrass and Tall Fescue Intake and Digestibility by Goats, Sheep and Steers. Proc., III Int'l. Conf. Goat Prod. and Dis. Tucson, AZ. p. 280.

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Ross, T.T. 1982. The Effects of High Environmental Temperature on Fetal Development and Selected Physiological Variables in Three Breeds of Sheep. PhD Thesis, North Carolina State University, Raleigh.

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Animal Health Research

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The herd health component of the SR-CRSP in Kenya has, over the years of its existence, shifted its emphasis from work performed in the United States to studies in Kenya conducted primarily by Kenyans with the assistance of WSU scientists. After the project began, there was considerable delay before collaborators and facilities in Kenya could be identified and scientific research related to herd health initiated. Initially, therefore, basic supporting research was conducted in the US in areas that were considered to have future application in Kenya. This work has focused on three areas: parasitology, caprine arthritis-encephalitis, and neonatal mortality. Work continues at WSU in all three of these areas, partly under SR-CRSP sponsorship, but now Kenyan scientists are much more heavily involved in the research particularly as it applies to the situation in their own country.

Research Accomplishments

The SR-CRSP provided partial support for research by scientists in the WSU Department of Veterinary Microbiology and Pathology that resulted in a report by Reddington et al., entitled "A Survey of Washington Dairy Goats for Internal Parasites." This report has significance for work in Kenya because it provides an indication of the varieties of internal parasites in small ruminants that might influence herd health. The researchers performed the study using fecal and necropsy examinations to estimate the prevalence of internal parasites in goats from eastern Washington. Approximately 100 fecal samples from five non-commercial dairy goat herds were obtained at four sampling dates, October, February, June, and September. Examination of these samples revealed that all host animals were infected with *Eimeria* spp. and most harbored trichostrongyloid nematodes. Five other parasites were observed, but less frequently. Necropsy of seven representative goats, and collection and identification of the parasites they contained showed that five types of trichostrongyloids were represented in significant numbers.

While data were derived from animals from five different herds, all were subjected to similar parasite control procedures. A rather high prevalence of infection was found in spite of the fact that most of the sampling dates were approximately one month after deworming, suggesting that control measures were not entirely satisfactory and that most goats were immediately re-exposed to oocysts and infective larvae. The number of trichostrongyloid eggs decreased in samples taken during the winter, a factor attributed not to control measures but to a reduction in exposure to infective larvae and development of arrested stages.

One study supported, in part, by the SR-CRSP (Westcott and LeaMaster, 1982), was based on two experiments in which researchers examined the activity of ivermectin against common nematode parasites of sheep. In the first experiment, 14 sheep with naturally acquired infections were assigned to two groups of seven sheep each and either treated with ivermectin or left as untreated controls. In the second experiment, 15 sheep with experimentally supplemented infections were assigned to three groups of five each and treated with either ivermectin or thiabendazole, or left as untreated controls. Ten to twelve days after treatment, all sheep were euthanized and necropsied and the parasites they harbored were recovered and identified. Efficacy of ivermectin was excellent or good against all the parasites, although it was poor against early fourth-stage larvae. Thiabendazole's efficacy was poor against one of the parasites and against early fourth-stage larvae, but approached 100% for most of the other parasites.

WSU scientists, in conjunction with a researcher at the University of Idaho and a veterinarian practicing in Hot Springs. Montana, described clinical fascioliasis in goats in Montana (Zimmerman et al., 1982). Twenty-eight goats in the Montana herd died after a month-long clinical course of symptoms associated with fascioliasis. Of the remaining animals, 45 were treated twice with albendazole oral suspension 30 days apart while 15 goats were untreated controls. Treatment with albendazole, on the basis of necropsy findings, was regarded as greater than 99% effective against adult *F. hepatica*. Fifteen percent of the treated goats died, compared to 73% of the untreated goats.

The SR-CRSP has supported research on developing an improved diagnostic technique for *Fasciola hepatica* infections in sheep. In this study, the authors evaluated use of an ELISA for diagnosis of *Fasciola hepatica* infections in sheep maintained under isolation and drylot conditions. Consideration was given to use of an ELISA test to detect this parasite because the most common diagnostic tool, microscopic examination of host feces for fluke eggs, requires giving the mature egg-producing flukes so much time to develop that pathologic changes occur before diagnosis is possible. Sheep were exposed to various numbers (100 to 500) of metacercariae and blood was collected for assay at regular intervals thereafter. The ELISA values of controls were low and varied little. Although the ELISA detected antibodies to the flukes as early as postinoculation week 2, ELISA values suggested as diagnostic (1.75 times control values) did not occur until 6 to 8 weeks postinoculation. Positive diagnosis of the infections by fecal examination for fluke eggs was not established until after postinoculation week 10. Results also indicated that ELISA values were not generally correlated with magnitude of infection, concurrent nematode infections, or husbandry practices (Zimmerman et al., 1982).

Caseous lymphadenitis, a worldwide disease of goats and sheep, is caused by *Corynebacterium pseudotuberculosis*. Several laboratory tests are available but none is completely satisfactory in terms of simplicity, accuracy, sensitivity, and economy. Using the ELISA test, a significant antibody rise was evident two weeks post infection and peaked at five

weeks, then declined slightly, but persisted. Abscesses were seen 8 to 10 weeks post infection. All goats which had abscesses were positive to ELISA in a manner slightly more sensitive than the synergistic hemolysis inhibition test (Shen et al., 1982).

Scientists at the USDA Animal Disease Research Unit at WSU and in WSU's Department of Veterinary Microbiology and Pathology jointly worked on transmission of caprine arthritis encephalitis (CAE), a serious disease of goats found world-wide. CAE virus from goat milk was isolated and found to be transmitted most efficiently to kids through both milk and colostrum. Intrauterine infection may have occurred in two of 23 Caesarean derived goats but postpartum horizontal transmission could not be ruled out. No transmission by the aerogenous route was demonstrated and even short term direct contact between virus infected bucks and virus free does during breeding did not result in demonstrable transmission. Prolonged direct contact for over 12 months between weaned Caesarean derived goats and virus infected goats was necessary before horizontal transmission could be demonstrated. Heat inactivation at 56°C reduced approximately 10^5 tissue culture infectious doses of CAE to below titratable levels and the virus was not transmitted to kids fed virus infected colostrum that had been heated at 56°C for one hour. The authors suggest a program of eradication in which kids are immediately removed from their dams at birth, fed safe sources of colostrum and milk, and isolated from other goats until weaning.

A further concern involving CAE was that the lentiviruses, CAE virus and progressive pneumonia (PP) virus of sheep which cause major diseases in their respective hosts have not been examined for their infectivity in closely related species. Experiments were conducted to determine if CAE virus would infect sheep and if PP virus would infect goats. Upon inoculation with CAE virus, lambs developed a non-suppurative arthritis and antibody to CAE virus. The virus was reisolated up to four months after infection. Exposure of three lambs to CAE-infected adult goats did not lead to infection after 18 months. Young goats inoculated with PP virus replicated the virus and developed arthritis and antiviral antibody. The results demonstrate that these distinctly different lentiviruses may infect and cause diseases in species other than their customary hosts. Currently used techniques may not be effective in differentiating which lentivirus is responsible for infection of sheep and goats. The research also suggests that mixing sheep and goats could adversely affect attempts to eradicate lentiviruses from these species (Banks et al., In Press).

Most infection-caused neonatal mortality (2-3 months) in ruminants is predisposed by failure to obtain maternal antibodies. Normally, maternal antibodies are obtained by the neonate from the colostrum, but there is a failure of this passive transfer in a high percentage of neonates even though they nurse and obtain colostrum. Research to identify the cause of failure of passive transfer, was seen to have an important bearing on the situation of kid survival in Kenya, where neonatal mortality is often very high. This study involved measuring the concentration of immunoglobulin G_1 (IgG_1) in the sera of 590 24- to 36-hour-old lambs, 20 of whom suffered from failure in passive transfer (FPT) of immunoglobulin. Of the 20 FPT lambs, 45% died before three weeks of age compared with only 5% of the 570 lambs with adequate passive transfer that died before three weeks of age. The researchers attributed the low percentage of FPT to management practices that ensured suckling by the lambs, and possibly to influences from several years of selecting ewes on the basis of weaned lamb production. The correlation between the concentration of IgG_1 in 257 postpartum, presuckle ewe colostrum samples and the IgG_1 concentrations in 362 lamb sera from those ewes was low. The mean serum IgG_1 concentration in 20 lambs from ewes with the lowest postpartum, presuckle colostrum IgG_1 concentrations was, however, significantly lower than mean serum IgG_1 concentrations in 24 lambs from ewes with the highest postpartum, presuckle colostrum IgG_1 concentrations. Postpartum, presuckle colostrum IgG_1 was measured in seven ewes whose lambs had FPT and the IgG_1 values varied throughout the colostrum IgG_1 range. Inadequate colostrum IgG_1 concentrations could not, therefore, be used to explain FPT or to identify ewes likely to have lambs with FPT (McGuire et al., In Press).

Significance of Research Findings

The major significance of research conducted at WSU as part of the SR-CRSP is that it is being applied in Kenya. The parasitology research is being used to study better ways of controlling parasites among goats in Kenya and research involving caprine arthritis-encephalitis is being used to keep the disease out of the country. Neonatal mortality of several species is a research area for WSU scientists and the results of these studies will be applied to Kenya in the hopes of reducing loss due to deaths of young kids and lambs. As exotic breeds of goats are introduced into Kenya to improve the production of meat and milk, knowledge of the diseases of these animals both in the US and Kenya will be crucial in establishing proper disease control measures, which is the overall goal of this component of the SR-CRSP.

Selected Publications

Banks, K.L., D.S. Adams, T.C. McGuire, and J. Carlson. (In Press). Experimental Infection of Sheep by Caprine Arthritis-Encephalitis Virus and Goats by Progressive Pneumonia Virus. Am. J. Vet. Res.

Leathers, C.W., W.J. Foreyt, A. Fetcher, and K.M. Foreyt. 1982. Clinical Fascioliasis in Domestic Goats in Montana. J. Amer. Vet. Med. Assoc. 180:1451-1454.

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Zimmerman, G.L., L.W. Jen, J.E. Cerro, K.L. Farnsworth, and R.B. Wescott. 1982. Diagnosis of *Fasciola Hepatica* Infections in Sheep by an Enzyme-Linked Immunosorbent Assay. Am. J. Vet. Res. 43:2097-2100.

Range Management Research

J.C. Malechek
Utah State University

Work supporting our research in Brazil has been done entirely in Utah and has typically focused on problems that are of a more fundamental orientation than the majority of work being done overseas. This research has been largely undertaken by graduate students and has concentrated on the problem area of nutrition and feeding behavior of free-ranging sheep and goats.

The range ruminant, unlike its pen-fed counterpart, is free to pick and choose its diet from the complex smorgasbord of plants typically available on the range. Until we understand how this selection is made and the nutritional consequences of it, we cannot go far in making management-related predictions and recommendations for range livestock production systems.

This kind of information is especially important on arid and semi-arid rangelands where woody plants (trees and shrubs) are important components of the vegetation and often dominate animals' diets. In contrast to grasses, these woody species often contain high concentrations of so-called "secondary" phytochemicals that can act as both deterrents to selection and as nutritional impediments. Tannins are an example of such compounds that are prevalent in many US species and are ubiquitous in tropical trees and shrubs. Most of our supporting work has focused on how such compounds affect animal feeding behavior and nutrition.

A related line of investigation has pursued the question of how sheep alter their feeding behavior in response to dwindling supplies of range forage. This latter work has obvious relevance to the conditions in Northeastern Brazil where forage scarcity is the overriding production problem during much of the year.

The third general kind of supporting research has been adaptation of hypotheses and methods from experimental psychology to problems of managing domestic livestock.

Research Accomplishments

Shrub Tannins and Goat Browsing

Research by Frederick Provenza in southwestern Utah was directed at the possible use of goats to manipulate the spiny shrub blackbrush *(Coleogyne ramosissima)* to increase its forage value for cattle. He found that goat browsing during winter stimulated twig production in much the same way as pruning stimulates an ornamental hedgerow. The new twig material was more digestible and higher in crude protein and phosphorus than were old, unbrowsed twigs. However, the twig regrowth was also much higher in tannin compounds than old twigs which effectively acted as a feeding deterrent to goats and cattle. This research demonstrated that tannins can be important to temperate species and effectively deter browsing by goats and cattle. Also, due to this deterrence, currently recommended stocking levels for blackbrush ranges are probably much more conservative than justified. This work relates directly to studies in Brazil through the abundance of tannin-containing species in the *caatinga* vegetation type.

Further research is in progress to clarify whether these compounds act mainly as feeding deterrents or if they exert a direct effect on nutrition through mechanisms such as reducing digestion and complexing dietary proteins. Studies by Mr. Mohamed Hussein, an MS student from Sudan, were started in late 1982 to gain insight into this question, but it is premature to discuss the results from this research.

Sagebrush Monoterpenoids—Sheep and Goat Browsing

Work by Moroccan PhD candidate Hamid Narjisse was oriented toward understanding whether another class of secondary phytochemicals, the monoterpenoids, acted as feeding deterrents and digestion-reducing substances for the highly unpalatable shrub big sagebrush (*Artemisa tridentata* subsp. *tridentata*). This shrub is highly undesirable on western US rangelands.

Narjisse's major finding was that dietary selectivity for sagebrush, although always limited, was strongly correlated in a negative sense to the seasonal trends of monoterpenoids in the shrubs. However, there appeared to be no malnutritional consequences from various dosage levels of several purified monoterpenoid compounds to either sheep or goats. This was in direct contrast to literature reports from earlier studies in Colorado. Subsequent research by an independent group in Utah has corroborated Narjisse's findings.

Another important result of this research was that dietary experience with unpalatable species can greatly influence the amounts of such plants animals are willing to ingest. For example, sheep with prior experience of grazing on sagebrush range selected as much as 30% of their diet from big sagebrush, compared to only 5% for their sagebrush-naive counterparts. Inexperienced goats virtually never selected sagebrush.

This research relates directly to problems of range use in Morocco. There, closely-related species of *Artemisia* are important species analogs to western-US *Artemisia*'s. In a general way, the research relates to work in Brazil through the fundamental connection of dietary experience to food selection. It opens the door to possible application of recent developments in behavioral psychology to problems of livestock management. Food imprinting and behavioral conditioning might prove to be strong tools in manipulating free-grazing range animals to eat plants they would normally find unpalatable and objectionable but that are otherwise nutritious.

Adapting Behavioral Psychology Methods to Goats

Another USU researcher, Deborah Mueller, received partial research support from the SR-CRSP Range Project to conduct studies on the possible application of operant analysis, a powerful research approach of experimental

psychology, to goats. Dr. Mueller, who used this research as the basis for her PhD thesis, successfully adapted methodology to fit small ruminants and devised a preference scale for several feeds that was based strictly on the animals' perception of gustatory rewards from the individual foods. Most common preference scales are relative rankings of various foods in relation to all others arranged in a particular cafeteria-type presentation. Such an approach has the important limitation that the relative acceptance of a particular food depends entirely upon the other choices available. A food deemed highly preferred in one array of choices may be completely rejected in a different array.

The importance of this and related fundamental research on feeding behavior is that it opens possibilities for applying theories and methods that have proven extremely powerful in experimental psychology to questions of domestic animal production. Until we know more about the fundamental mechanics and motives whereby range animals select their diets, we will not rapidly progress in developing management programs to foster animal production on the one hand and maintain stable, properly grazed plant communities on the other.

Available Forage Levels and Dietary Selection by Sheep

Researchers George Ruyle (PhD candidate) and Don Dwyer have employed the feeding station technique to test the effects of cattle grazing on diets selected by sheep, where the two species share the range. The hypothesis is that forage disappearance under joint cattle and sheep grazing will influence diets selected by sheep differently than a similar level of forage disappearance caused by sheep grazing alone.

The most notable difference found to date is the response of sheep to feeding stations on snowberry *(Symphoricarpos oreophillus)*, a common shrub on high-elevation ranges in the western US. As with goats on shrub feeding stations in Brazil, sheep were found to spend markedly longer time on shrub feeding stations than on stations containing herbaceous forage. Also, time spent per feeding station declined as forage availability decreased.

This work is directly related to plant-animal studies in Brazil through definition of fundamental principles of feeding behavior and through development of approaches and techniques useful to defining these principles.

Training

US training under the "supporting" component of the Utah State Range Management Project is shown below.

- Frederick D. Provenza, PhD, Range Animal Nutrition. Present position: Assistant Professor, Utah State.
- Hamid Narjisse, PhD, Range Animal Nutrition. Present position: Head, Dept. of Animal Science, National Agr. College, Meknes, Morocco. Nationality: Moroccan.
- Deborah Mueller, PhD, Animal Behavior. Present position: Consultant, Denver, Colorado.
- Hussein Mohamed, MS, Range Animal Nutrition. Present position: Graduate Research Assistant, Utah State. Nationality: Sudanese.
- Wilson Yabann, MS, Range Animal Nutrition. Present position: Graduate Research Assistant, Utah State. Nationality: Kenyan.
- Lisa Urness, BS, Nutrition Lab Procedures. Present status: Student.
- George Ruyle, PhD, Range Animal Nutrition/Grazing Management. Present position: State Extension Range Specialist, University of Arizona.

Selected Publications

Gifford, G.F., F.D. Provenza, and J.C. Malechek. 1983. Impacts of Goats on Infiltration Rates in Southwestern Utah. J. Range Mgmt. 35:(In Press).

Howell, L.A. 1981. A Review of Tropical and Sub-Tropical Brush Management Techniques with Special Reference to Northeast Brazil. MS Thesis, Utah State University, Logan. 142 pp.

Mueller, D.L. 1981. Scaling Relative Preference for Dietary Items in an Ungulate. PhD Thesis, Utah State University, Logan. 77 pp.

Narjisse, H. 1981. Acceptability of Big Sagebrush to Sheep and Goats: Role of Monoterpenes. PhD Thesis, Utah State University, Logan. 137 pp.

Provenza, F.D., J.E. Bowns, J.C. Malechek, P.J. Urness, and J.E. Butcher. 1983. Improving Blackbrush Ranges. Utah Sci. 43.90-95.

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Animal Health Research

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Though the research focus of the Animal Health Project is on goat diseases in Brazil, some experimental work is performed at UC Davis because of the availability of animal and laboratory facilities and scientific and technical support not presently available or reasonably duplicated by the project in Brazil. For example, well controlled isolation facilities for holding animals and for performing experiments with infectious agents without endangering the local livestock population are beyond the budgetary means of the project in Sobral, but such experimentation is necessary for an understanding of basic mechanisms of pathogenesis and control of infectious diseases. In some instances, the project has provided support for the investigation of naturally occurring goat disease in Northern California and has taken advantage of the numbers of animals or specimens and the technical support which has been available to develop techniques and information applicable to field investigations. In general, knowledge and skills developed in Davis can be readily transferred to the Brazilian worksite as has occurred with cultural and serologic techniques for caseous lymphadenitis and mycoplasmosis. With special dispensation, some test materials from Brazil could be transferred to UC Davis for processing. A major benefit of the work sponsored by the project is that it provides an impetus for collaboration of senior scientists at UC Davis in the Brazilian project and for the development of international graduate research programs. In order to fulfill these goals, the Animal Health Project has provided partial support for a dairy goat research facility at UC Davis. This unit, under the able direction of Karel Hedrick, has provided scientists of the SR-CRSP Animal Health and Genetics projects with access to well managed animals and facilities that would not otherwise have been available.

Research Accomplishments

A disease of major interest to goat and sheep producers on small farms in Brazil is caseous lymphadenitis which is caused by the bacterium, *Corynebacterium pseudotuberculosis*. A dependable test is needed to study the prevalence and the dynamics of the infection in order to develop rational means of control. An assessment of the synergistic hemolysin inhibition assay to test goats was made by Knight, McGowan, and Hietala. The method was chosen because of its ease of performance and proven reliability in testing horses. The study began with 200 doe kids ranging from 2 weeks to 6 months of age which were bled 6 times during a year of observation. Of 150 animals remaining at the end of one year, 15 had abscesses from which *C. pseudotuberculosis* was isolated, and 14 of these had titers of 1:32 to 1:256. However, the positive titers had varied from 35% on the initial test to 4% on the fourth bleeding at 8 months and 70% on the final test. During the year, individual animals converted from negative to positive and vice versa. This test will be utilized in further testing of herds at Davis and in Brazil.

A three year investigation of the causes of abortion in a large goat dairy was carried out by East and Brooks. The dairy of approximately 1,000 does had endemic abortions primarily affecting does kidding for the first time. Materials from 400 abortions were examined for chlamydia, Q fever, toxoplasmosis, mycoplasmosis and bacteria by necropsy and various microbiologic methods. Chlamydia and Q fever accounted for most of the abortions diagnosed.

A necropsy study was done on 58 of 218 goats culled as unsuitable for sale or slaughter from a dairy of 900 goats. Most animals had multiple disease problems with chronic bronchopneumonia, caseous lymphadenitis and chronic degenerative joint disease accounting for 64% of the diagnoses. *Pasteurella hemolyticum, P. multocida* and Mycoplasma spp. were the common causes of pneumonia. *Mycoplasma mycoides* subsp. *mycoides* was isolated from 3 of 8 diseased joints cultured. Septicemias caused by Mycoplasma sp., Proteus, *E. coli*, Pseudomonas sp. and *Staphylococcus aureus* associated with parturition, mastitis, and metritis were responsible for 9% of the cases.

Investigations by Brooks, Da Massa and Adler have indicated Mycoplasma sp. to be a major cause of mortality in kids in California. Acute arthritis, pneumonia, and meningitis with high fevers in kids 2 to 8 weeks of age and mastitis and chronic joint disease in adults are the salient findings. *M. mycoides* subsp. *mycoides* is the etiologic agent. Transmission is usually by ingestion of infected colostral milk. Morbidity and mortality of about 90% can be reduced to less than 5% by feeding only colostrum tested free of the mycoplasma and removing does secreting the organism in the milk from the herd. These investigations, performed by East, Da Massa, Brooks, and McGowan, were extended to demonstrate control of the clinical disease occurring in commercial herds. The project will continue to support development of techniques and reagents for investigations of mycoplasma infections at Davis and in Brazil.

A study on the infectious causes of caprine mastitis has been carried out by Birnie, East and Da Massa. Samples were collected from 2,522 dairy goats from 17 herds in Northern California. In 3 sampling periods, the prevalence of bacterial mastitis varied from 20.0 to 23.1% and mycoplasma spp. varied from 0.8 to 1.6 percent. Coagulase negative staphylococci were the most common isolates. *Staph. aureus* was low in prevalence, and *Streptococcus* spp. were rare. Gram negative bacteria were also low in occurrence. Nubian goats were at greater risk than other breeds, and in increased length of dry period or of duration of lactation were related to an increased risk of infection.

The causes of neonatal mortality in dairy goat kids raised in confinement has been studied by East. In a 2 year period,

E. coli infection caused 24-30% of the deaths, mycoplasma infection caused 12-43% and bacterial pneumonia caused 8-10 percent.

A study is being conducted by Brown, Biberstein, and Olander to compare the infectivity of various strains of *C. pseudotuberculosis* in kids by various routes of inoculation. The progression of disease is being followed by clinical, serologic, bacteriologic and pathologic techniques.

Training

Elizabeth F. Birnie, DVM, was provided support for thesis research on mastitis in goats leading to the Masters of Preventive Veterinary Medicine (MPVM) in 1983.

Nancy E. East, DVM, received support for research on bluetongue in cattle, sheep, and goats in partial fulfillment of work for the MPVM in 1981.

Corrie Brown, DVM, is receiving research support for work in caseous lymphadenitis leading to the PhD. She began her training in comparative pathology in 1981 and expects to complete her work in 1985.

Karen Carberry, working toward the MPVM, has received support since October 1982 for research on mastitis in goats.

Fred Anguello, working toward the MPVM, has received support since October 1982 for research on mastitis in goats.

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Breeding and Management Research

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The efforts of the Texas A&M (TAMU) Breeding Project in the US have been directed at conducting work to establish breeding and management practices useful to US producers and at the same time be transferrable to overseas sites. Major areas of interest include: a study of genetic influences on diet selectivity; methods of selecting for increased fertility; examination of the value of various carcass components in meat animals and the potential for changing these through selection; and characterization of broad genetic groups in respect to adaptation. These interests have been pursued with meat-type goats, hair sheep and fat-tail sheep, and involved initial establishment of experimental flocks of these ruminants.

Meat-type goats (Spanish goats) and hair sheep (Barbados Blackbelly) are found in the United States and although the industries based on these are small, they are increasing. However, they have not been the subject of substantial or meaningful research in this country. The meat-type goat found in the US has a great deal of similarity to those found throughout much of the world, including Brazil, and work with these should be largely transferable to other sites.

The tropically adapted hair sheep holds a great deal of interest in the SR-CRSP because the breed is found in many developing countries and research on the animals has been largely neglected. The Barbados Blackbelly and St. Croix, as representatives of hair sheep and of sheep carrying the prolificacy trait, have been chosen for research by the Breeding Project.

The Barbados Blackbelly in Barbados is considered a high fertility sheep, but this does not seem to be the case in the US. Data are being collected to determine if there is evidence of a single gene for prolificacy in the US Barbados and hence how the prolificacy of this breed can be best manipulated.

The Booroola Merino has been introduced into experimental flocks in order to study the high fertility trait for the US sheep industry and the possibility of transferring the gene for high prolificacy to other breeds which might hold interest outside the US.

The fat-tail sheep, concentrated in arid regions, is perhaps the most widespread of any sheep in the world, and no doubt makes the most important contribution to man's direct needs. These sheep are represented in the US by the Karakul breed and were thought to be nearly lost as a gene source in this country. The goal in establishing an experimental flock of these sheep was to preserve them as a genotype in the US and to study their uniqueness in terms of adaptation. As originally conceived, the Breeding Project was expected to develop a collaborative relationship in areas where the fat tail sheep was prevalent. To date, this has not happened except to a limited degree in Brazil. These flocks have all been

established and are involved in long-term data collection programs directed at animal breeding efforts. Generally, these efforts have not come to fruition in the approximately three years the project has been underway.

Research Accomplishments

Inheritance and Foraging Behavior of Sheep and Goats

One of the first lines of investigation to be initiated by the Breeding Project was to explore the possible influence of inheritance on diet selectivity. The rationale for this was that problems are encountered in the US and elsewhere in the world with invading plant (browse) species; for instance, mesquite invasion of grazing lands of the US Southwest which has reduced the value of these lands. In certain areas of Africa, the large number of ruminant species result in near complete utilization of the vegetative complex. By contrast, in areas where rangelands are largely utilized by one grass-eating species such as the cow, browse invasion is creating serious problems. Thus, one might logically ask what the possibility is for selecting between or within species for domesticated animal types that would more completely utilize these resources. On an international basis, one might logically ask the question "what would be the result of moving one genotype to a different country or resource area with different forage types?" At the outset of the SR-CRSP, there was much interest and expectation in the potential for identifying and relocating superior genotypes on an international basis.

The existence of species differences in grazing behavior was well documented prior to the initiation of this project. However, one study was conducted in which cattle, goats, and deer were compared in their utilization of available forage in an area of the South Texas Plains where browse invasion is a major problem. In this study, cattle consumed 10.8% browse, goats consumed 54.0% browse, and white-tailed deer consumed 93.9% browse. This suggests that deer would be the preferred animal to reduce browse invasion, but deer are not a domesticated species and the numbers present were not sufficient to accomplish the goal. It was concluded that in this case, the area would benefit from adding goats to the grazing system.

Prior to initiation of this work, there was little data on variation existing within species. Extensive data have now been collected which provides a basis for comparing different breeds of sheep and goats. Significant breed differences within species were observed. The most marked of these was a greater browsing tendency for meat-type goats compared to Angora goats. Barbados or hair sheep also browse more than finewool sheep. This difference was small or substantial, depending on the forage available (Figure 1), suggesting that grazing behavior warrants concern between countries or resource areas. Also, it might be suggested that hair sheep may be more successfully transplanted to a browsing environment than certain other breeds.

Data have been collected over two years in which sire effects were investigated in respect to diet selectivity. Significant sire effects were noted for the level of intake of a

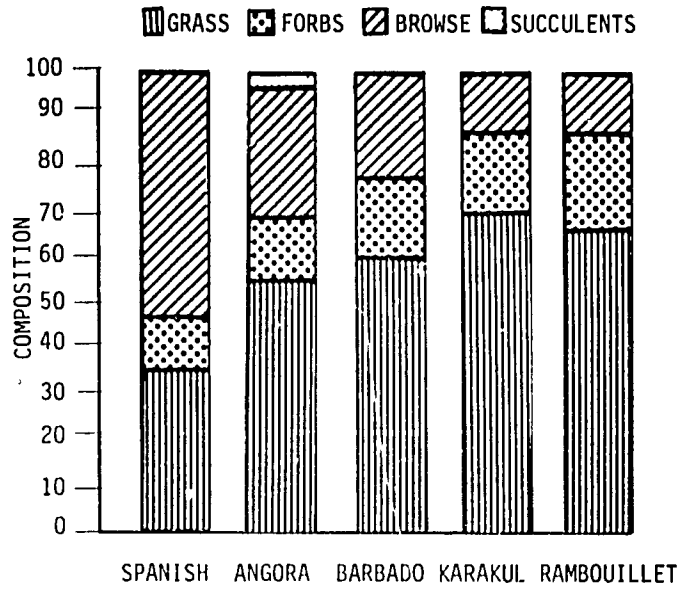

Figure 1. Mean percentages of grass, forbs, browse, and succulents in diets of various breeds of sheep and goats.

number of plant species, with a mean heritability intake level of individual plant species of approximately 30%. However, the sample size and great variability involved suggests that only within species (and breed) can sire effects be demonstrated. No conclusion can be made at this time regarding the feasibility of initiating selection programs designed to select animal populations that will consume a given plant species.

Current efforts are directed at elucidating the mechanisms influencing intake of various plant species. At present, tannin content and its relationship to intake are being investigated.

Investigation of Meat Characteristics of Sheep and Goats

Only a relatively small proportion of the world's goat population is used for milk or fiber production, in spite of the fact that the monetary value of milk or milk products obtained from goats is thought to be slightly greater than for meat (Shelton, 1978). It is surprising, therefore, that though most goats are used only for meat and skin production, little research has been reported on the use of goats for meat production.

Most sheep are used for both meat and fiber with a relatively small percent used for milk production. Extensive research has been conducted on meat production from sheep, but this largely involves finewool or mutton breeds with few studies involving fat-tail or hair sheep which predominate in tropical areas and are an important meat source.

Studies conducted on this section of the project have compared yields of carcass and its components and dress-off items, quality measures (shear force values), consumer acceptance values and fat chemistry for various types of meat goats and hair sheep. These studies have involved young

Table 1. Percent of Various Dress-Off Items at Slaughter of Meat Goats and Hair Sheep (Barbados Blackbelly)

	Percent of Live Weight	
Dress-Off Items	Goats	Hair Sheep
Blood	3.77	4.06
Head	6.35	7.50
Feet	1.28	1.12
Pelt	7.09	7.37
Lungs	1.46	1.87
Liver	1.38	1.54
Heart	0.66	0.59
Viscera	20-25	19-24

males or castrates and older females which should be the two primary slaughter groups. We have also looked at sire differences in carcass components of meat-type goats.

Among animals used for meat production in the US, essentially all emphasis is placed on the carcass. Beyond this only the pelts or skins are normally considered in establishing market value. In LDC environments, a larger percent of the animal parts, including those removed at slaughter, are used directly for human consumption. It thus seemed desirable to look at the various dress-off items as they might be related to value. A number of animals of various breeds of both species were slaughtered with the dress-off items recorded (Table 1). These data have been adjusted to a carcass yield of 46% for goats and 49% for sheep in order to acknowledge the widely variable degree of fill at slaughter. The major components of liveweight are represented in carcass and viscera. The latter is highly variable depending on the amount of gut fill. It is considered that the viscera has little human food value because a large part is gut fill. Other major dress-off items are pelt or skin, head and blood. The skin is not normally used for human consumption. The head would contain a large portion of bone. The blood would be made up mostly of moisture. The liver and heart, which constitute the most edible dress-off items, constitute only a total of approximately 2% of the liveweight. In the method of slaughter used in these studies, the kidneys were left with the carcass.

In summary, it must be recognized that in most LDC environments, a higher portion of animal parts are utilized for human consumption. As far as known (to the writer), the food value of these dress-off items is comparable to muscle tissue in terms of quality protein. However, it should be realized that the carcass still constitutes most of the value for human consumption, and should receive emphasis in evaluating animals for purposes of meat production even in developing countries. This would be especially true in those cases where attempts are made to commercialize meat production for movement to population centers for the hotel and restaurant trade.

Sensory panel ratings were obtained for the various breeds and species utilizing a US and foreign panel. The assumption was that US panels were less likely to be regular sheep and goat consumers and that they would be more critical of quality traits. The foreign panel universally gave higher scores than domestic panelists, but this was significant for only a few traits such as tenderness, juiciness, or overall palatability of leg steaks. This suggests that LDC consumers would be less critical of "so called" quality traits, but in the manner tested in this study, differences were small. In terms of species comparisons, sheep tended to receive higher panel ratings than goat carcasses. Breed differences among goats appeared to be insignificant, but among sheep were significant for several traits. These studies do not confirm a superior meat quality for hair sheep or fat-tail sheep. In practice, it appears likely that increased tendency to fatten meat breeds of sheep would make a positive contribution to such quality traits as juiciness and tenderness, and that this also explains in part the differences between sheep and goats. Goats put on very little fat. By contrast, for those uses or for those population groups where the fat of the sheep imparts an undesirable taste response, the hair sheep and fat-tail sheep may show an advantage because of their tendency to place fat either internally or in the tail as contrasted to subcutaneous or intramuscularly. In these studies, age differences made surprisingly small differences in sensory panel ratings.

Fatty acid determinations were made for animals of various age, breed, and species subgroups. Significant differences were observed for each of these variables. A discussion of the details and interpretation of these variations will not be attempted at this point.

In another study, slaughter data were collected with young, intact male meat-type goats of known sire groups. A number of live animal measures were made. The objective was to look for differences in carcass value and methods of predicting these and to appraise the potential for change of these through genetic means. Live animal measures showed significant relationship with quantitative measures of retail cuts, but when adjusted for differences in body weight, these relationships tended to disappear. Observed sire differences in various carcass measures were small.

Investigation of Caseous Lymphadenitis

The frequency of visible external lesions of caseous lymphadenitis has been recorded in a large flock (400-500 head) of goats in Texas and a similar number of goats and hair sheep in Brazil. Approximately 2% of range-raised goats in Texas exhibited visible symptoms. By contrast, a much higher frequency was observed in Brazil. In some older age groups, as many as 30% exhibited or had been treated for the disease. Although a number of obvious differences exist between the sites (genetics, climate, etc.), a very obvious one appears to be the amount of confinement. In Texas, the animals are free ranging and are only infrequently confined to barns or corrals, whereas most animals in Brazil are confined to or spend time in corrals at night. Within the

experimental flock in Texas, *Corynebacterium pseudotuberculosis* was isolated from all animals identified as having caseo. On a larger collection of 100 diseased animals, 37% yielded no viable bacteria. Of those which did yield viable bacteria, all contained *C. pseudotuberculosis,* but several samples contained other bacteria as well. Brazilian workers report a much lower percent of the lesions with *C. pseudotuberculosis* present and suggest that other organisms may be involved in the expression of this disease.

In other work at Texas, not directly supported by SR-CRSP funds, the organism involved has been shown to live up to one year in some soil, 70 hours in some water samples and up to two months on materials that might be associated with confinement to corrals. This tends to support the suggestion that close confinement is a major factor in contraction of this disease. Though this hypothesis is being tested in Brazil using non-confined experimental flocks, there remains some doubt about the significance of this to herd owners, who prefer close confinement to minimize losses from theft and predation.

Investigations Relating to Prolificacy

Lambing rate has an important bearing on efficiency of meat production from sheep and goats. The degree of gain from increased prolificacy is closely related to environmental or feed conditions or the feed:meat price ratios which influence the ability to capitalize on higher lambing rates.

Increased lambing rates may be obtained by introducing the single gene trait (such as the Booroola Merino and perhaps others) or through selecting within existing breeds. The soundest or most valid way to select within existing populations is to select sires or dams based on lifetime productivity, but this requires extensive recordkeeping and long generation intervals. These represent substantial obstacles to selection for reproductive rate in both US or LDC environments. An alternative approach is to attempt to develop proxy measures of prolificacy in the young animal or more specifically the young male.

One such indicator of prolificacy which has been suggested is testicular size in the male and selection experiments using this criterium have been pursued. In a study involving 42 male goats, it was shown that circumference of the testis was the best measure of actual testis weight or volume. The appropriate correlations were .80-.83. In another study involving data from 909 young growing rams, testis circumference was shown to be greatly influenced by animal age and size. When adjusted for these factors, the residual variation was markedly reduced, but significant flock and sire differences remained. In another study involving four breeds of sheep varying in reproductive rates, it was shown that testicular size, as a function of body weight, develops more rapidly in the prolific breeds such as the Finnish Landrace. This is thought to be related to early sexual maturity and the fact that testicular size can be used as a measure of early sexual maturity. LH and testosterone levels were also measured in both pre- and post-puberal rams and following GnRH injections. When comparing breeds, both LH and testosterone appeared to provide a good measure of early sexual maturity. Data are not available to provide within breed correlations. However between breeds, post-pubertal testosterone values measured without stimulation with GnRH appeared to offer more promise as a measure of prolificacy.

Factors Contributing to Adaptation

A large portion of the world's sheep and goat population are found in potentially stressing environments. For instance, approximately 2/3 of the world's goat population is found within 30° of the equator (Shelton, 1978). Although this is not true with sheep, their contribution in LDC environments require that they be adapted to nutritional or climatic stress. Some studies on broad groups of sheep and goats have been conducted contrasting their adaptation or traits contributing to adaptation. A few conclusions from these efforts warrant mention.

The fat-tail or fat-rump sheep are the most prevalent sheep breeds found in arid or nutritionally stressing environments. Studies on the Karakul as a representative of these types conclusively show that when given an opportunity, they are characterized by a high level of feed intake (per head or per unit of body weight) and a very marked tendency to deposit a large amount of body fat. It is, no doubt, this tendency to deposit a large amount of fat that allows them to survive long periods of nutritional stress. The exact location in the body of the fat deposit may well have some significance for adaptation, but this is still under investigation.

In respect to temperature adaptation, it has been shown that, as reflected by respiratory rate, goats are less stressed by high environmental temperatures than are sheep. Body temperature measures have shown that goats may also have the ability to allow their body temperature to vary over a wider range than some other types of domestic livestock without being critically stressed. These traits, no doubt, contribute to their prevalence in equatorial regions and their ability to be more active under these conditions.

Management

Several studies have been completed which seek to improve productivity by modified herd management practices. Project research on manipulation of kidding intervals, abortion control, and on lactation in meat goats will be briefly reviewed.

In the US, as well as most LDC environments, males are run continuously with females in meat-goat flocks. In the US, this is largely a labor-saving mechanism. In LDC environments, producers often have little in the way of an alternative due to communal grazing practices and/or failure to castrate males. Data have been analyzed for two flocks of goats which have been run continuously with males. These data have shown that in Texas (30-31°N. latitude), the photoperiod has an important influence on seasonality of production and length of the kidding interval. In order for does to show a short kidding interval, they must mate sufficiently early in the spring or early summer to kid in early

fall and to rebreed before going into a seasonal anestrus. The alternative is to have the postpartum anestrus merge with the seasonal anestrus resulting in a very long kidding interval. Thus, research directed at obtaining a short kidding interval should concentrate on early breeding and a short postpartum anestrus. Studies devoted to ways of inducing early season breeding have not yielded conclusive results. It has been possible to reduce the postpartum interval through early weaning or limited suckling. These treatments are difficult to implement in most US flocks, but they may be applicable in other production systems where kids are sold at a young age for cabrito production, where they are removed from their dams for milk production, or as a part of the management routine.

Abortion has been identified as a problem with goats in many LDC environments. The heavy losses tend to be concentrated in the mid-trimester of pregnancy. One study has been completed which offers a way of identifying this stage and is based on prediction of fetal age from fetal measurements. Another study tends to confirm low-blood glucose, hence nutrition as a predisposing factor to abortion. It has also been shown that a supplemental progestin can be employed with the goat without the treatment itself causing problems. However, it remains to be seen if this treatment holds promise for controlling or reducing abortion. There is a need to explore nutritional stress as a cause of abortion with meat-type goats in Northeast Brazil and other similar environments.

One extensive set of data was obtained on the milk production of meat-type does and the relationship of milk production level to kid development. Though the lactation record obtained for meat-type goats was poor, lactation levels were highly correlated with weight gains in the kids. As expected, the relationship of does' lactation and weight gains of the kid decreased with advancing age of the kid. These data suggest that in both the US and LDC environments, improved doe lactation may be a major factor in early growth, age of marketing, or post weaning survival. Work is being done in Brazil on methods of improving lactation both with a view of improved kid survival and possibly merchandizing surplus milk.

Training

Training in the US has consisted primarily of work with graduate students, seven of whom have research projects completed or in process for thesis or dissertation purposes.

In addition, three graduate students have completed special projects utilizing sheep and goat data, but which have not been used for thesis projects. Three students in all are from developing countries.

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INSTITUTION BUILDING

Training Accomplishments

Though fewer words are required to document training accomplishments than to present research achievements of the SR-CRSP, both training and research have been accorded equal priority throughout the program.

Training in all five overseas worksites has been developed in close collaboration with participating institutions in the host country. In this way, the SR-CRSP's contribution to training research scientists is not limited simply to programmatic interests, but is accepting of the longer term needs of the national research system.

A strenuous effort has been made to dovetail the SR-CRSP into other training activities in the overseas programs to conserve the resources of the SR-CRSP. Some of the trainees working on SR-CRSP campuses, participating in sheep and goat research and destined to return to SR-CRSP activities, have been financed by such agencies as FAO (Kenya), USAID scholarships (Kenya and Indonesia), World Bank (Indonesia and Kenya), Minnesota (Morocco), EMBRAPA (Brazil), and INIPA (Peru). Most, however, have been supported directly by the SR-CRSP.

The types of training sponsored by the program have covered a wide spectrum, from informal, on-the-job training of technicians at one extreme, to training of research scientists through overseas doctoral programs at the other.

Table 1 sets out the numbers of students that are sponsored by the SR-CRSP in various types of degree programs in the US and developing countries. The emphasis on producing graduates with research capability is shown by the predominance of master's and doctoral level students. In all, 71 graduates are being trained or have recently completed their MS or MA degrees; of the 32 students in doctoral programs, 21 have been selected from host countries.

Table 1. Degree Related Training Activities

	Numbers of Degree Students Sponsored by SR-CRSP[1]				
	BA/BS	MA/MS	PhD	MPVM	DVM
Overseas Students at US Universities	1	36	20	—	—
Overseas Students at Universities in Developing Countries	16	24	1	—	2
US Students in Programs at US Universities[2]	—	11	11	1	—

[1] Includes 6 students who are jointly sponsored by organizations not otherwise participating in the SR-CRSP.

[2] Students in these programs conduct research directly on SR-CRSP projects both overseas and on basic supporting research in the US.

A major portion of the program's training activities are not degree-related, but instead address the immediate needs of the projects for particular skills. The range of non-degree training and the levels of participation are summarized in Table 2. This type of training has involved, for example, bringing 9 overseas professional collaborators to the US for individual specialized training in advanced techniques. On average, each has spent some 15 weeks in the US before returning home to apply the newly acquired skills in the service of the SR-CRSP.

Table 2. Non-Degree Training Activities

Technical Training	Number Personnel	Total Duration	Administrative Training	Number of Visits	Total Duration
Specialized Training of Overseas Staff in US	9	31 months	Overseas Staff to US	6	19 weeks
12 Overseas Short Training Courses	330	15 weeks	ME Staff to Overseas Sites	4	10 weeks

Shortcourses intended to train technical support staff have been mounted in all sites but Morocco. To conserve funds, these courses have been conducted only in response to major training needs identified for each site. The same courses have therefore not been conducted in each country involved, and participation in short courses has been limited to in-country staff. The 12 courses conducted to date have covered a variety of biological topics, and have been practically oriented; a summary of these is given in Table 3.

On-the-job training provided by both US and senior counterpart scientists has inevitably been an important dimension of the program's training activities. It is unfortunately hard to document, since even where it has been structured or formal in nature, records have not been uniformly maintained.

To enable the administrative requirements at the overseas worksites to be met increasingly by host country staff, three people have been brought to the US for administrative training. Each of these visits has lasted for an average of one month and has been backed up where necessary by overseas visits by ME staff to assist in the smooth transition from expatriate towards indigenous administration.

Table 3. SR-CRSP Sponsored Shortcourses

Course	Sponsored By	Where Held	Dates
Sheep Production 23 participants	All Projects	Bogor, Indonesia	6-7/80 (2 wks)
Reproduction 18 participants	Utah/Cal Poly Reproduction	Sobral, Brazil	9/80 (2 wks)
Management of Reproduction 26 participants	Utah/Cal Poly Reproduction	Lima, Peru	3/81 (5 days)
Forage-Vegetation Sampling 16 participants	Utah/Range	Sobral, Brazil	5/81 (2 days)
Veterinary Lab Techniques	Washington	Kabete, Kenya	6-7/81 (6 wks)
Animal Breeding 65 participants	Montana	Lima, Peru	11/81 (5 days)
Training on Pathology & Immunology Lab 5 participants	Colorado	Lima, Peru	2/82 (2 wks)
Diet Analysis Techniques 9 participants	Utah/Range	Sobral, Brazil	3/82 (2 days)
Animal Breeding & Systems 21 Participants	TAMU/Breeding & Systems	Sobral, Brazil	5/82 (2 days)
Nutrition Update for Sheep & Goats 20 participants	North Carolina	Sobral, Brazil	7/82 (5 days)
Practical Training in Feed Analysis Procedures 10 participants	North Carolina	Sobral, Brazil	8/82 (5 days)
Management & Improvement of Natural Pastures 117 participants	Texas Tech	Lima, Peru	8/82 (4 days)

Organization Strengthening

Although the primary objectives of the SR-CRSP were to conduct research and to train scientists and technical staff, it was always expected that the program would generate organizational improvements in the participating institutions. The program did not, however, establish a formal design for organizational development; benefits accruing were seen largely as a spin-off from other program activities. Though not amenable to quantification, a number of these benefits are now clearly visible and part of a continuing trend.

It has been the philosophy of this CRSP to undertake administrative institution building efforts so that overseas colleagues could successfully manage their own components of the program. Thus, initially 70% of the resident expatriate administrator's time was required on average per site; this has now shrunk to less than 20%. The balance is made up by the input of host country administrators trained as part of the program's activities.

Site development overseas has also been significant. SR-CRSP resources have been used as seed money—the catalyst that has inspired substantial investment from local governments. Many lasting facilities are in place that would not have been there had the SR-CRSP not collaborated with particular counterparts.

The benefits of this program are not, of course, limited to overseas institutions. Teaching and research at US institutions has materially changed as a result of the SR-CRSP. New courses, improved facilities, short courses and campus-wide interest have all been generated to a substantial degree. Moreover, the activities of the SR-CRSP have been made public at national scientific meetings of scientists and producers alike so benefits accruing to the US from this program can be quickly understood and implemented.

A feature of research systems in developing countries that is frequently regarded as an impediment to problem-solving applied research is the fragmentation of national research agencies. This fragmentation goes much further than separation of physical facilities or mandates. Too often the crux of the problem is lack of meaningful communication between agencies that need to collaborate if practical solutions to national problems are to be found. A glance at the number of institutions in any one country that are collaborating with the SR-CRSP gives some idea of the potential of this program for catalyzing new communication linkages where these have become moribund. It has been stated that:

> "One of the most satisfying accomplishments of the CRSP has been the linkages we have been able to provide among institutions, projects and departments overseas. These have included joint work with institutions that have had little contact with each other for decades, until the CRSP came along." (Program Director, Annual Report, 1981)

Fostering the growth of linkages between institutions is only one part of the prerequisites for successful problem-solving research. The multifaceted approach of this kind of research, and its inherent multidisciplinary approach, make new demands on the scientists involved. Their behavior as scientists will need to adjust from the classical one of a solitary pathway and narrow focus, to one based on inter-disciplinary teams.

By its very nature, the SR-CRSP encourages an approach which relies on joint inputs from different disciplines. Many scientists and technical staff in the countries where the SR-CRSP is working are being exposed to this approach for the first time. The experience they are gaining as members of interdisciplinary teams is invaluable for developing the capability for systematic integration of diverse disciplines to solve practical problems connected with the rural development of their countries.

PROJECT DEVELOPMENT AND PUBLIC SERVICE

In virtually any program so broadly conceived as the SR-CRSP, unexpected opportunities arise for furthering the main objectives in ways apart from the main strategic approach. Working in many disciplines and in several countries, the SR-CRSP has been fortunate in not only recognizing such opportunities, but also in being able to provide resources to initiate activities in these areas. A case in point is the involvement of the SR-CRSP in the caprine arthritis encephalitis (CAE) disease problem in Kenya.

Some time ago, perhaps as far back as 1976, CAE was introduced into Kenya via shipments from Europe and the USA by other bilateral programs, and the disease went unnoticed. SR-CRSP scientists, on arrival in Kenya, were quick to spot the disease, diagnose it as CAE, initiate widespread testing and propose complete control and eradication measures that have now been adopted by the Kenyan government. It is no exaggeration to say that this alone, although it will never appear as a research paper, book or other visible contribution, may have justified the expenditure of the entire $15,000,000 invested in the SR-CRSP.

The SR-CRSP has also taken some major initiatives in the entire field of prolific sheep. Prolificacy in sheep can be genetically determined and is a trait found in certain indigenous breeds in the Near East, Java, the Caribbean, and Australia. It is a trait which, when linked to appropriate feed resource management, can enormously increase the productivity of sheep. In spite of the potential for thus increasing the reproductive performance of the ewe, very little work has been done to develop the technology and production systems for developing countries. The SR-CRSP has taken these initiatives in trying to stimulate work in this neglected area:

1. In October 1981, the SR-CRSP sponsored a major workshop on Prolific Sheep which drew together the world's leading scientists in the field. The workshop was held in Cairo, Egypt, and Rabat, Morocco, and led to prospects for new collaborative research in Egypt and Morocco by SR-CRSP participants and other scientists.
2. The Morocco workshop was followed in July 1983 by a second Prolific Sheep workshop, sponsored jointly by the SR-CRSP and ABRO (Animal Breeding Research Organization). This was held in Edinburgh, and capitalized on the presence of many leading sheep geneticists who were attending an international conference on reproduction and fertility in the UK. The proceedings of this workshop are being published in hardback form by Butterworth Press and should be available in 1984.
3. An independent consulting firm, Development Design Associates, specializing in project planning and design, was commissioned to work with the ME to prepare a proposal for a project on prolific sheep research. The proposal, completed in September 1982, outlined a plan for using multidisciplinary development of prolific sheep technology as a vehicle for building effective livestock research systems in developing countries. The proposal has been circulated to potential funding agencies, and some initial responses have indicated that it might go forward under separate funding.

The SR-CRSP's initial workplan for Peru focused entirely on sheep and alpaca production as representing the major livestock of limited resource farmers. More recently, after the program was underway, a proposal was received for research on goat production in the northwest lowland desert region. Recognizing the value of the proposed research, but not wishing to divest funds already committed to sheep and alpaca research, the ME supported the proposal by providing seed money from contingency funds. From these slender resources, the Goat Project was able to conduct nearly two years initial research and apply successfully for additional funding from the Canadian International Development and Research Centre. A more complete report of the Goat Project is included in the Peru section of this report.

Appendices

Appendix I. Program Expenditures

Appendix I.A. Summary of Program Expenditures from USAID Grant Funds (US$)

Institution	Project	Planning Year 1978/79	Program Year 1 1979/80	Program Year 2 1980/81	Program Year 3 1981/82	Program Year 4 1982/83*	Program Year 5 1983/84*	Total
Cal Poly	Reproduction	1,400	42,100	110,600	97,800	—	—	251,900
UC Davis	Health	5,600	63,800	264,500	261,300	168,300	175,000	938,500
UC Davis	Breeding	7,400	87,400	233,500	318,000	275,200	200,000	1,121,500
Missouri	Sociology	13,400	112,700	244,700	233,600	349,900	225,000	1,179,300
Washington	Health	2,900	81,100	306,100	215,200**	246,300	175,000	1,026,600
North Carolina	Forage/Nutrition	3,800	94,900	232,000	293,700	330,800	250,000	1,205,200
Ohio	Forages	15,000	104,800	256,900	120,400	—	—	497,100
Texas A&M	Systems/Breeding	9,500	161,700	243,600	199,200	289,600	150,000	1,053,600
Texas A&M	Breeding/Management	—	99,000	209,000	115,000	327,700	200,000	950,700
Texas Tech	Range Management	8,500	122,400	286,300	217,000	342,400	250,000	1,226,600
Tuskegee	Management	14,600	81,600	113,600	158,200**	—	—	368,000
Utah	Range Management	22,500	91,000	363,700	285,700**	323,200	250,000	1,336,100
Utah	Reproduction	2,300	81,000	154,300	129,900	224,100	200,000	791,600
Colorado	Health	—	75,500	297,400	188,100**	250,000	175,000	986,000
Montana	Breeding	25,700	112,700	230,900	185,500	160,200	150,000	865,000
Winrock	Production Systems	17,400	56,100	179,300	213,200	284,600	200,000	950,600
Winrock	Economics	14,000	107,400	335,000	272,400	131,500	153,000	1,013,300
SUBTOTALS		164,000	1,575,200	4,061,400	3,504,200	3,703,800	2,753,000	15,761,600
	Centrally Adm.[1]	191,700	450,900	429,400	530,100	966,300	1,332,000	3,900,400
TOTAL		355,700	2,026,100	4,490,800	4,034,300	4,670,100	4,085,000	19,662,000

[1]Represents administrative expenditures plus non-administrative funds which go through ME accounts. See Tables I.C, I.D.
*Projected expenditures.
**Subject to final accounting.

Appendix I.B. Summary of Program Expenditures from Matching Funds and Contributions (US$)

Institution	Project	Planning Year 1978/79	Program Year 1 1979/80	Program Year 2 1980/81	Program Year 3 1981/82	Program Year 4 1982/83*	Program Year 5 1983/84*	Total
Cal Poly	Reproduction	0	105,400	110,700	74,800	0	0	290,900
UC Davis	Health	15,800	72,100	88,200	62,900	63,600	59,200	361,800
UC Davis	Breeding	3,000	32,800	108,800	79,100*	91,900	90,200	405,800
Missouri	Sociology	9,200	56,000	81,300	86,300	92,100	80,700	405,600
Washington	Health	0	58,100	73,200	58,000	65,200	58,300	312,800
North Carolina	Forage/Nutrition	5,100	41,200	93,900	85,600	103,300	88,200	417,300
Ohio	Forages	19,200	76,000	190,400	114,200	0	0	399,800
Texas A&M	Systems/Breeding	16,300	45,900	110,900	52,900	88,800	50,000	364,800
Texas A&M	Breeding/Management	0	44,000	70,500	45,700	80,000	66,700	306,900
Texas Tech	Range Management	4,800	61,000	59,400	54,300	104,400	87,000	370,900
Tuskegee	Management	6,700	26,100	41,100	31,000	0	0	104,900
Utah	Range Management	65,300	72,400	175,400	115,100	106,800	103,300	638,300
Utah	Reproduction	19,900	86,700	112,600	85,500	182,600	268,700	756,000
Colorado	Health	0	47,900	101,500	58,300	97,800	58,300	363,800
Montana	Breeding	68,500	52,200	171,300	54,800*	73,700	59,800	480,300
Winrock	Production Systems	7,800	24,100	65,500	71,200	106,700	87,500	362,800
Winrock	Economics	8,000	32,300	80,400	85,800	73,300	66,100	345,900
		249,600	934,200	1,735,100	1,215,500	1,330,200	1,224,000	6,688,600

*Projected expenditures.

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Appendix I.C. Summary of Sub-Grant Program Expenditures of USAID Grant Funds By Category (US$)

Budget Category	Planning Year 1978/79	Program Year 1 1979/80	Program Year 2 1980/81	Program Year 3 1981/82*	Program Year 4 1982/83**	Program Year 5 1983/84**	Total
Salaries	122,100	676,700	1,566,700	1,494,300	1,675,700	1,480,200	7,015,700
Equipment		46,200	247,700	68,700	109,800	42,800	515,200
Supplies	4,200	132,500	634,800	571,100	610,100	341,800	2,294,500
Travel							
International	1,500	146,900	431,200	380,800	334,800	342,600	1,637,800
Domestic	7.500	40,600	83,600	81,700	41,600	30,300	285,300
Other[1]	500	256,700	522,400	505,400	469,200	44,300	1,798,500
Overhead[2]	28,200	275,600	575,000	402,200	462,600	471,000	2,214,600
TOTAL	164,000	1,575,200	4,061,400	3,504,200	3,703,800	2,753,000	15,761,600

*Subject to final accounting.
**Projected expenditures
[1] Includes Site Coordinator for years 1-4 and miscellaneous expenditures.
[2] Composite based on rates from different institutions, varying from 14.7% to 65%.

Appendix I.D. Summary of Centrally Administered Funds (US$)

	1978/79	1979/80	1980/81	1981/82	1982/83*	1983/84*	TOTAL
Salaries							
ME Office	57,600	105,400	131,700	158,500	200,000	208,900	862,100
Site Coordinators	—	—	—	—	—	139,200	139,200
Fees							
External Evaluation Panel	—	9,400	16,900	29,800	23,000	20,000	99,100
Auditors	—	—	38,500	—	12,300	10,000	60,800
Other	—	—	—	9,200	40,500	41,000	90,700
Travel							
ME Staff	11,200	20,900	34,900	42,600	58,700	18,100	186,400
BIR	6,800	12,800	19,200	21,300	13,900	8,300	82,300
EEP	—	13,400	22,200	28,500	22,000	25,600	111,700
TC	41,900[1]	42,100[1]	11,900	12,200	81.700	16,600	206,400
Other	—	2,500	9,300	38,400	52,200	269,700	372,100
Equipment & Supplies	37,900	67,500	65,800	109,800	337,700	377,400	996,100
UCD Overhead Cost	36,300	176,900	79,000	79,800	124,300	197,200	693,500
TOTAL	191,700	450,900	429,400	530,100	966,300	1,332,000	3,900,400

*Projected expenditures.
[1] Includes site selection visits.

Appendix I.E. Expenditures of Centrally Administered Funds, By Function (US$)

	1978/79	1979/80	1980/81	1981/82	1982/83*	1983/84*	Total
ME Office[1]	133,400	313,700	302,700	302,100	396,100	350,000	1,798,000
EEP[2]	—	27,400	46,800	69,800	53,800	55,000	252,800
BIR[3]	8,100	15,300	22,900	25,500	16,600	10,000	98,400
TC[3]	50,200	50,400	14,300	14,700	97,800	20,000	247,400
Contingency[4]	—	—	1,500	44,500	175,000	32,500	253,500
Site Development[5]	—	41,100	35,400	56,600	67,000	—	200,100
Morocco	—	3,000	5,800	16,900	—	—	25,700
Site Coordinator	—	—	—	—	—	275,000	275,000
Exchange Funds[6]	—	—	—	—	100,000	100,000	200,000
Prolific Sheep Conference	—	—	—	—	60,000	—	60,000
Publications	—	—	—	—	—	24,000	24,000
Research Deficits	—	—	—	—	—	200,000	200,000
Country Workgroups	—	—	—	—	—	172,000	172,000
Research Supplementals	—	—	—	—	—	78,500	78,500
Medevac Emergency	—	—	—	—	—	15,000	15,000
TOTAL	191,700	450,900	429,400	530,100	966,300	1,332,000	3,900,400

*Projected expenditures.

[1] Includes staff salaries, rent, supplies and equipment, travel expenses for ME staff, program audit costs, communications, publishing reports, and UCD overhead cost

[2] Includes consultancy fees, travel expenses, and UCD overhead cost.

[3] Includes travel, site selection visits, hire of meeting rooms, and UCD overhead.

[4] Bulk of these funds used for augmentation of research budgets.

[5] $200,000 set aside by AID to establish basic research facilities at foreign sites.

[6] Funds for exchange of scientists from LDC sites.

Appendix II. Program Administration Personnel

Appendix II.A. Board of Institutional Representatives

Name	Institution	Dates
Max Lennon	Texas Tech University	October 1978-June 1979
Robert Albin	Texas Tech University	July 1979-Present
George Dennison	Colorado State University	October 1978-December 1979
Arch Alexander	Colorado State University	January 1980-Present
Lark Carter	Montana State University	October 1978-December 1981
Arne Hovin	Montana State University	January 1982-Present
Anthony Cunha[1]	Cal Poly, Pomona	October 1978-December 1980
Allen Christensen	Cal Poly, Pomona	January 1981-September 1982
Warren Foote	Utah State University	October 1978-October 1980
Doyle Matthews	Utah State University	October 1980-Present
Terrence Greathouse	Texas A&M University	October 1978-June 1982
Carl Menzies	Texas A&M University	June 1982-Present
William Huber	Washington State University	October 1978-September 1982
James Henson	Washington State University	September 1982-Present
Charles Lassiter	North Carolina State University	October 1978-Present
Fred Hill	University of California, Davis	October 1978-December 1979
Allen G. Marr	University of California, Davis	January 1980-Present
Bennie Mayberry[2]	Tuskegee Institute	October 1978-September 1982
J. Wendell McKinsey	University of Missouri	October 1978-June 1983
Robert Moser	University of Missouri	June 1983-Present
Mervin Smith[2]	Ohio State University	October 1978-March 1982
Harold Bauman	Ohio State University	March 1982-September 1982
Richard Wheeler	Winrock International	October 1978-Present

[1] Cal Poly, Pomona no longer a lead institution and therefore not represented on Board. Effective date: October 1982.
[2] Tuskegee and Ohio State no longer participating institutions on the SR-CRSP and thus have no representation on the Board. Effective date: October 1982.

Appendix II. B. Technical Committee

Name	Institution	Dates
Robert Blackwell (Breeding)	Montana State University	October 1978-Present
Eric Bradford (Breeding)	University of California, Davis	October 1978-Present
Donald Burzlaff (Range Management)	Texas Tech University	October 1978-September 1980
Fred Bryant	Texas Tech University	September 1980-Present
Thomas Cartwright (Systems Analysis/Breeding)	Texas A&M University	October 1978-present
John DeBoer (Economics)	Winrock International	October 1978-Present
Cleon Kimberling (Animal Health)	Colorado State University	January 1979-February 1980
James DeMartini	Colorado State University	February 1980-Present
Henry Fitzhugh (Production Systems)	Winrock International	October 1978-Present
Warren Foote (Reproductive Physiology)	Utah State University	October 1978-Present
William Huber (Animal Health)	Washington State University	October 1978-May 1980
Francis Abinanti	Washington State University	June 1980-March 1982
Travis McGuire	Washington State University	April 1982-Present
William Johnson (By-Products & Nutrition)	North Carolina State University	October 1978-Present
Blaine McGowan (Animal Health)	University of California	October 1978-November 1982
Harvey Olander	University of California	November 1982-Present
John Malechek (Range Management)	Utah State University	October 1978-Present
Edward Nelson[1] (Reproductive Physiology)	Cal Poly, Pomona	October 1978-September 1982
Michael Nolan (Rural Sociology)	University of Missouri	October 1978-Present
Doris Oliveira[2] (Management)	Tuskegee Institute	October 1978-May 1980
Nancy Stott	Tuskegee Institute	June 1980-September 1982
Maurice Shelton (Breeding)	Texas A&M University	October 1978-Present
Robert Van Keuren[2] (Forages)	Ohio State University	October 1978-September 1982

[1] Cal Poly no longer a lead institution and thus has no representation on the Technical Committee. Effective date: October 1982. Present status: subcontractee to Utah State/Reproductive Physiology.

[2] Tuskegee Institute and Ohio State no longer participating institutions and thus have no representation on Technical Committee. Effective date: October 1982.

Appendix II.C. External Evaluation Panel

Name	Affiliation
Saul Fernandez-Baca	UNAM Ciudad Universitaria, Mexico
James Fransen[1]	World Bank
Robert McDowell	Cornell University
William Moulton	United States Department of Agriculture
Arthur Pope (Chairman)	University of Wisconsin
Jan Rendel	FAO/Swedish University of Agricultural Sciences

[1] Retired Spring 1981. Position not replaced.

Appendix II.D. Current AID Washington Staff

Name	Affiliation
John Robins	Agency Director, S&T/FA
Anson Bertrand	Director of the Office of Agriculture/S&T
Nyle Brady	Senior Assistant Administrator/S&T
Fred Hutchinson	Executive Director, BIFAD
Charles Haines	Project Officer, AID
Morton Darvin	Contract Officer, AID

Appendix II.E. Host Country Counterparts

Name	Location
Luiz Carlos Freire	Brazil
Jan Nari	Indonesia
S. Chema	Kenya
L. Firdawcy	Morocco
Carlos Valverde[1]	Peru
Alfredo Montes	Peru

[1] Host Country Counterpart from March 1980-December 1982.

Appendix II.F. Overseas Site Coordinators

Name	Location	Dates
Yves Berger	Kenya	July 1980-July 1982
Sam Chema	Kenya	July 1982-Present
Thomas Miller	Brazil	April 1980-August 1982
Thomas Robb	Brazil	August 1982-Present
Benjamin Quijandria	Peru	August 1980-Present
Neil Thomas	Indonesia	August 1980-August 1982
Henk Knipscheer	Indonesia	August 1982-Present
Foaud Guessous	Morocco	October 1981-Present

Appendix II.G. Management Entity Office and Overseas Support Staff

Name	Location	Dates
David W. Robinson	ME-Davis	November 1978-Present
William C. Weir	ME-Davis	July 1981-Present
Richard Waters	ME-Davis	April 1979-Present
Michele Lipner	ME-Davis	February 1980-Present
Marcella Pieratt	ME-Davis	October 1982-Present
Helaine Burstein	ME-Davis	November 1979-July 1981
Rose Naliaka	ME-Kenya	July 1982-Present
Celia Pinto de Amorim	ME-Brazil	November 1982-Present
Joao Conrado	ME-Brazil	July 1982-Present
Graciela Prado	ME-Peru	July 1982-Present

Appendix III. SR-CRSP Research Participants

Brazil

Title	Name	Institution	Dates
Economic Analysis of Small Ruminant Production and Marketing Systems			
Principal Investigator	A.J. De Boer, PhD	Winrock International	October 1978-
Co-Principal Investigator	Odorico de Moraes Eloy da Costa, MS	EMBRAPA/CNPC	June 1982-
Senior Investigator	Nestor Gutierrez, PhD	Winrock International	April 1983-
Research Associates	Nestor Gutierrez, MS	Winrock International/Purdue University	September 1979-March 1983
	Jose de Souza Neto, MS	Federal University, Ceara	June 1980-November 1981
	Odorico de Moraes Eloy da Costa, BS	Federal University, Ceara	June 1980-February 1982
	Maria de Fatima Damasceno Moura Fe, BS	Federal University, Ceara	October 1981-
Collaborators	Earl Kehrberg, PhD	Purdue University	January 1980-
	Mario Amin, PhD	Federal University, Ceara	June 1980-February 1982
	Joao Ambrosio de Araujo Filho, PhD	Federal University, Ceara	October 1981-
	Valter Vieira da Silva, MS	EMBRAPA/CNPC	October 1981-
	Jose Ubiraci, BS	EMBRAPA/CNPC	October 1981-
Improving Reproductive Performance of Small Ruminants			
Principal Investigators	Warren C. Foote, PhD	USU	October 1979-
	Edward A. Nelson, PhD	CSPU	October 1979-July 1983
Co-Principal Investigators	Aurino A. Simplicio, MS	EMBRAPA/CNPC	October 1979-August 1982
	Jose F. Nunes, PhD	EMBRAPA/CNPC	August 1982-July 1983
Senior Investigators	Antonio E.D.F. Silva, PhD	EMBRAPA/CNPC	August 1982-July 1983
	Jose U. Alves, BS	EMBRAPA/CNPC	March 1981-July 1983
	Gilberto B. Primo, MS	UFRPE	September 1981-March 1983
Collaborator	Gerardo S. Riera, PhD	IICA/OAS	February 1980-December 1982
Goat and Sheep Nutrition and Feeding Systems Research			
Principal Investigator	William L. Johnson, PhD	NCSU	May 1978-
Senior Investigators	Ederlon R. de Oliveira, MS, DVM	CNPC	January 1979-
	Nelson N. Barros, MS	CNPC	January 1980-
	Thomas W. Robb, PhD	NCSU	May 1981-
Research Associates	Francisco de Arruda, MS	CNPC	January 1979-
	Helaine Burstein, MS	NCSU	May 1982-
Collaborators	Aurino Simplicio, MS, DVM	CNPC	January 1979-
	Simon Riera Guzman, PhD	CNPC/IICA	September 1980-December 1982
	Antonio de Souza, MS	Federal University, Ceara	June 1981-December 1982
	Francisco Pinto, BS	EMATER-CE	January 1979-
	Luiz Vale, MS	CNPC	January 1979-
	Jerry W. Spears, PhD	NCSU	August 1982-
	Luiz Carlos Freire, PhD	CNPC	September 1981-
	Paulo Leite, MS	EMEPA	September 1981-
	Aldomario Rodriguez, DVM	EMEPA	September 1981-September 1982
	Wandrick Hauss, BS	EMEPA	September 1981-
	Emedio Dias e Silva, PhD	CNPC	January 1981-
	Expedito Lopes, MS	CNPC	June 1982-
	Carlos Zometa, PhD	TAMU	September 1982-
	Joao Janes Vlana, MS	EMEPA	September 1981-
	Eneas Leite, MS	EMEPA	September 1981-

Brazil

Title	Name	Institution	Dates
Range Research for Increasing Small Ruminant Production			
Principal Investigator	John C. Malechek, PhD	USU	October 1978-
Co-Principal Investigator	Expedito Lopes, MS	EMBRAPA/CNPC	March 1982-
Senior Investigators	Robert Kirmse, MS	USU	June 1980-
	Ederlon Oliveira, MS	EMBRAPA/CNPC	January 1980-
	Thadis W. Box, PhD	USU	May 1981-
	B.E. Norton, PhD	USU	October 1978-
	Don D. Dwyer, PhD	USU	October 1978-
	Fred D. Provenza, PhD	USU	May 1981-
	Louis Vieira Vale, MS	EMBRAPA/CNPC	September 1980-
	Sandra Maria Souza Silva, BS	EMBRAPA/CNPC	October 1981-
Research Associates	James A. Pfister, MS	USU	October 1979-
	Joao S. de Queiroz, MS	USU	June 1980-
	Linda H. Hardesty, MS	USU	June 1980-
	Roberto Mesquita, MS	EMBRAPA/CNPC	September 1980-
	Sandra Mara, BS	Federal University, Ceara	June 1982-January 1983
Collaborators	Joao Ambrosio, PhD	Federal University, Ceara	January 1981-
	Orlando Monteiro de Carvalho Filho, MS	EMBRAPA/Aracaju	May 1982-
	Roger McCoy, PhD	University of Utah	June 1980-
	Tomm Robb, PhD	NCSU	May 1982-
	Eneias Mendez-Bezerra, PhD	Federal University, Ceara	June 1982-
	Nestor Gutierrez, PhD	Winrock International	May 1982-
	George Primov, PhD	University of Missouri	September 1982-
Sociological Analysis of Small Ruminant Production Systems			
Principal Investigator	Michael F. Nolan, PhD	University of Missouri	October 1978-
Senior Investigator	George Primov, PhD	University of Missouri	August 1981-March 1982 July 1982-June 1983
Research Associate	Marisa Neumaier, MS	University of Missouri/EMBRAPA	June 1981-September 1983
Small Ruminant Flock/Herd Health Program in Smallholder Systems			
Principal Investigator	Harvey J. Olander, DVM, PhD	UC Davis	October 1982-
	Blaine McGowan, DVM	UC Davis	October 1978-October 1982
Co-Principal Investigator	Marina da Silva, DVM, MS, PhD	CNPC	March 1981-
Senior Investigators	Mary Sawyer, PhD	UC Davis	February 1983-
	Donald Hansen, DVM	UC Davis	December 1980-December 1982
	Emedio da Silva, DVM	CNPC	March 1981-
	John Sawyer, DVM, MS	UC Davis	February 1983-
Research Associates	Carlos Costa, DVM, MS	CNPC	October 1978-
	Janete Santa Rosa, DVM, MS	CNPC	February 1981-
	Luia Vieira, DVM	CNPC	October 1982-
	Cristina Almeida, DVM	CNPC	January 1983-
	Jorge Kleber, DVM	EMEPA	February 1983-
	Nancy East, DVM	UC Davis	August 1979-January 1980; March 1981

Brazil

Title	Name	Institution	Dates
Collaborators	Norman Baker, DVM, PhD	UC Davis	October 1978-
	Bennie Osburn, DVM, PhD	UC Davis	October 1982-
	E. Biberstein, DVM, PhD	UC Davis	October 1982-
	Carlos Zometa, PhD	TAMU	October 1982-
	Dale Brooks, DVM, PhD	UC Davis	October 1978-
	Al Da Massa, PhD	UC Davis	October 1978-
	Robert Bondurant, DVM	UC Davis	October 1978-
	Blaine McGowan, DVM	UC Davis	October 1982-
	Nancy East, DVM	UC Davis	March 1981-
	Linda Hardesty, MS	USU	February 1983-

Breeding and Management of Sheep and Goats

Principal Investigator	Maurice Shelton, PhD	TAMU/TAES	October 1978-
Co-Principal Investigator	Elsio Antonio P. de Figueiredo, MS	EMBRAPA/CNPC	October 1978-
Senior Investigators	J.O. Sanders, PhD	TAMU	October 1978-
	C.A. Zometa, PhD	TAMU	August 1982-
	Francisco de Assis Melo Lima, MS	EMBRAPA/CNPC	October 1981-
	Abel Ponce de Leon Bravo, PhD	IICA/CNPC	October 1981-
	K.P. Pant, PhD	IICA/CNPC	October 1981-
Collaborators	Francisco Helio Ferreira Machado, BS	EPACE	September 1979-
	Joao M. de S. Andrade, PhD	EPACE	October 1982-
	Antonio Amaury Oria Fernandes, BS	EPACE/TAMU	January 1980-
	Paulo Roberto de Miranda Leite, MS	EMEPA	October 1982-
	Aldomario Rodrigues, DVM	EMEPA	October 1982-
	Wandrick Hauss, BS	EMEPA	October 1982-

Indonesia

Title	Name	Institution	Dates
Genetic Improvement of Sheep and Goats for Smallholder Production Systems			
Principal Investigator	G.E. Bradford, PhD	UCD	October 1978-
Co-Principal Investigator	P. Sitorus, DVM	BPT	February 1980-
Senior Investigators	J. Levine, PhD	UCD	October 1979-December 1980
	F.L. Bell, MS	UCD	July 1982-July 1983
Research Associates	Subandriyo, BS	BPT	February 1980-
	E. Triwulanningsih, BS	BPT	February 1980-
	Ismeth Inounu, BS	BPT	January 1981-
	Bess Tiesnamurti, BS	BPT	August 1982-
Collaborators	Maria Astuti, PhD	Gadjah Mada University, Jogjakarta	February 1980-
	D. Torell, MS	UCD	June 1980-July 1980
	J.F. Quirke, PhD	Irish Ag. Inst., Dublin	April 1983-May 1983
Economic Analysis of Improved Small Ruminant Production Systems			
Principal Investigator	A.J. De Boer, PhD	Winrock International	October 1978-
Co-Principal Investigator	M. Sabrani, MS	BPT-Bogor	February 1980-
Senior Investigators	H.C. Knipscheer, PhD	Winrock International	September 1981-
	R.H. Bernsten, PhD	Winrock International	November 1981-December 1982
	Tjeppy Soedjana, MS	BPT-Bogor	October 1981-
Research Associates	Agus Muljadi, BS	BPT-Bogor	February 1980-
	Syahrir Mawi, BS	BPT-Bogor	December 1981-
	Sugiyanto, MS	Brawijaya University/IPB-Bogor	August 1980-January 1983
	Uka Kusnadi, MS	BPT-Bogor	March 1982-
	Sri Wahyuni, BS	BPT-Bogor	October 1982-
Collaborators	John Petheram, MS	BPT-Ciawi	January 1983-
	John Ihalauw, PhD	Satya Wacana University	January 1982-
Nutrition and Feed Systems Research			
Principal Investigator	William L. Johnson, PhD	NCSU	January 1980-
Senior Investigators	M. Rangkuti, MS	BPT	January 1980-
	Andi Djajanegara, MS	BPT	August 1980-December 1982
	Neil Thomas, PhD	UCD/NCSU	August 1980-May 1983
	Hamzah Pulungan, MS	BPT	January 1980-
	J.E. van Eys, PhD	NCSU	June 1982-
Research Associates	Budi Haryanto, MS	BPT	January 1980-
	Wayan Mathius, BS	BPT	January 1980-
	Achmad Prabowo, DVM	BPT	January 1980-
	Marudin Sitorus, MS	BPT	January 1980-
	Busniar Betta, MS	BPT	January 1980-
	Darwinsya Lubis, BS	BPT	January 1983-
	Sorta Silitonga, MS	University of Minnesota	April 1981-
	Prapti Mahyuddin, MS	BPT-Ciawi	April 1982-

Indonesia

Title	Name	Institution	Dates
Collaborators	M.E. Siregar, MS	BPT	January 1980-
	Leo Batubara, BS	BPT	January 1980-August 1980
	Abdul Rais, BS	BPT	January 1980-
	Toha Sutardi, PhD	Bogor Agricultural Institute	January 1980-
	S. Lebdosoekojo, PhD (deceased)	Gadjah Mada University	January 1980-January 1983
	W.J. Croom, PhD	NCSU	April 1982-
	P. Sitorus, DVM	BPT	January 1980-
	Ismeth Inounu, BS	BPT	August 1980-
	E. Triwulanningsih, BS	BPT	August 1980-
	S. Reksohadiprodjo, MS	Gadjah Mada University	January 1983-
	Hari Hartadi, PhD	Gadjah Mada University	January 1980-
	Thamrin Panggabean, MS	BPT-Ciawi	April 1982-
	M. Winugroho, MS	BPT-Ciawi	April 1982-

Sociological Analysis of Small Ruminant Production Systems

Principal Investigator	M.F. Nolan, PhD	University of Missouri	October 1978-
Co-Principal Investigators	K. Suradisastra, MS	BPT	January 1983-
	M. Sabrani, MS	BPT	February 1980-December 1982
Senior Investigator	H. Knipscheer, PhD	Winrock International/ University of Missouri	January 1982-December 1982
Research Associates	Sri Wahyuni, BS	BPT	September 1982-
	Syahrir Mawi, BS	BPT	September 1982-
	K. Suradisastra, MS	BPT	July 1980-December 1982
Collaborator	John Ihalauw, PhD	Satya Wacana University (Salatiga)	June 1980-

Kenya

Title	Name	Institution	Dates
Genetic Improvement of Sheep and Goats for Smallholder Production Systems			
Principal Investigator	G.E. Bradford, PhD	UCD	February 1980-September 1982
Co-Principal Investigator	D. Kimenye, PhD	University of Nairobi	February 1980-
Senior Investigator	Y.M. Berger, MS	UCD	July 1980-June 1982
Research Associates	W.O. Odenya, MS	MLD	February 1980-September 1982
	A. Okeyo-Mwai, BS	MLD	August 1980-
Development and Breeding of Genetically Improved Goats/Systems Analysis and Synthesis of Livestock Herds			
Principal Investigator	T.C. Cartwright, PhD	TAMU	September 1978-
Co-Investigator	G.M. Smith, PhD	TAMU	December 1978-
Co-Principal Investigators	A.B. Carles, PhD	University of Nairobi	February 1980-
	D. Kimenye, PhD	University of Nairobi	July 1980-
Senior Investigator	F. Ruvuna, PhD	TAMU	November 1981-
Research Associate	H. Blackburn, MS	TAMU	October 1978-
Collaborators	N. Graham, PhD	CSIRO, Australia	April/May 1980
	J. Schwartz, PhD	University of Nairobi	February 1982-
	C.R. Field, PhD	UNESCO	February 1980-
	D. Herlocker, PhD	UNESCO	February 1980-September 1982
	P. Semenye	ILCA	February 1980-
Economic Issues in a Dual-Purpose Goat Production System			
Principal Investigator	A.J. De Boer, PhD	Winrock International	October 1978-
Co-Principal Investigator	Fanny Nyaribo, MS	MLD	October 1982-
Senior Investigators	R.W. Matthewman, M. Ag. Sci.	Winrock International	September 1981-May 1982
	M.O. Job, PhD	Winrock International/Purdue University	March 1980-October 1982
	D.L. Mortimer, MS	Winrock International/WSU	September 1980-August 1981
	James Njukia, MS	TAMU	January 1981-July 1981
Collaborator	B.A. McCarl, PhD	Purdue University/Oregon State	September 1981-October 1982
Dual-Purpose Goat Production Systems for Smallholder Agriculturalists			
Principal Investigator	H.A. Fitzhugh, PhD	Winrock International	October 1978-
Senior Investigators	R.D. Hart, PhD	Winrock International	August 1981-
	D.L. Brown, PhD	Winrock International	July 1981-
	S.L. Russo, PhD	Winrock International	August 1981-
Investigators	M. Mathuva, BS	MLD	June 1981-August 1982
	K. Otieno, BS	MLD	June 1981-
	M. Salim, BS	MLD	June 1981-
Research Associates	M.W. Sands, MS	Winrock International	January 1980-August 1982
	M. Nderito, Dip.	MLD	June 1981-February 1983
	K.J. Boor, BS	Winrock International	May 1982-
	E. Chavulimu	Winrock International/MLD	May 1982-

Kenya

Title	Name	Institution	Dates
Research Assistants	H. Kiguhi	CBS	October 1980-
	P. Amuhinda	CBS	October 1980-
	L. Ongecha	CBS	October 1980-December 1982
	J. Orydho	CBS	October 1980-January 1982
	O. Evanns	CBS	October 1980-
	E. Ochieng	CBS	October 1980-
	W. Ngige	Winrock International	June 1982-February 1983
Collaborator	M. Onim, PhD	University of Nairobi	August 1982-

Animal Health Constraints on Small Ruminant Performance

Principal Investigators	Travis McGuire, DVM, PhD	WSU	April 1982-
	Francis Abinanti, DVM, PhD	WSU	June 1980-March 1982
	William Huber, DVM, PhD	WSU	October 1978-May 1980
Senior Investigators	F.J. Bell, MD, PhD	WSU	October 1981-
	Paul Sayer, DVM	WSU	January 1980-October 1981
Research Associates	Johnson Bari, DVM	MLD	January 1980-
	Stanley Mbwiria, DVM	MLD	September 1980-
	James Njanja, DVM	MLD	March 1981-
	Derrick Mwamachi, DVM	MLD	March 1982-
	Elizabeth Olouch, BS	University of Nairobi	September 1982-
	Raul Rosadio, DVM, MS	University of San Marcos (IVITA)	February 1982-
	Antonio Garmendia, DVM, MS	University of Cusco	September 1982-
Collaborators	Richard Westcott, DVM, PhD	WSU	October 1978-
	John R. Gorham, DVM, PhD	USDA/WSU	October 1978-
	D. Scott Adams, DVM, PhD	USDA/WSU	October 1980-
	John O. Dickinson, DVM, PhD	WSU	October 1979-
	N. Sriranganathan, DVM, PhD	WSU	October 1980-
	S. Chema, DVM, PhD	MLD	October 1979-
	S. Waghela, DVM, MS	MLD	October 1979-
	J.M. Gathuma, DVM, MS	University of Nairobi	October 1980-March 1982
	P. Kariuki, DVM, MS	MLD	October 1979-March 1982
	E. Mwangi, BS	MLD	October 1981-
	B.M. Mugenya, BS	FAO/SGDP	October 1980-January 1982
	R. Heinonen, DVM	GPZ/MLD	October 1979-April 1983
	E.W. Allonby, PhD	FAO/SGDP	October 1979-September 1981

Sociological Analysis of Small Ruminant Production Systems

Principal Investigator	Michael F. Nolan, PhD	University of Missouri	October 1978-
Senior Investigator	J. Eric Reynolds, PhD	University of Missouri	August 1982-
Research Associates	Amanda Noble, MS	University of Missouri	July 1980-August 1982
	Collette Suda, MS	University of Missouri	September 1980-December 1981
Collaborator	Rex R. Campbell, PhD	University of Missouri	March 1980-

Morocco

Title	Name	Institution	Dates
Prolificacy and Productivity of Moroccan Breeds of Sheep			
Principal Investigator	G.E. Bradford, PhD	UCD	April 1982-
Co-Principal Investigator	A. Lahlou Kassi, DSc	IAV	April 1982-
Senior Investigator	Y.M. Berger, MS	UCD	August 1982-
Research Associates	L. Derqaoui, MS	IAV	April 1982-
	I. Boujenane, MS	IAV	April 1982-
	M. Bourfia, MS	IAV	April 1982-
	I. Drissi, BS	IAV	October 1982-
Collaborators	D. Torell, MS	UCD	April/May 1982
	M. Marie, PhD	IAV	April 1982-
Nutrition and Feeding Systems Research			
Principal Investigator	W.L. Johnson, PhD	NCSU	October 1981-
Co-Investigator	Fouad Guessous, Docteur d'Etat	IAV	October 1981-
Research Associates	Nacif Rihani, MS	IAV	May 1982-
	A. Kabbali, MS	ENA, Meknes	September 1982-
	Jean-Marie Luginbuhl, MS	NCSU	May 1982-
	Ahmad Igmoullan, MS	IAV	October 1981-July 1982
	Mohamed Khal, MS	IAV	October 1981-July 1982
	Abdelatif Sahnoun, MS	IAV	October 1981-July 1982
	Ismaili Driss, MS	IAV	October 1982-July 1983
Collaborators	A. Lahlou-Kassi, PhD	IAV	May 1982-
	Yves Berger, MS	UCD	October 1982-
	Hamid Narjisse, PhD	ENA, Meknes	May 1982-
Rangeland Research for Increasing Small Ruminant Production			
Principal Investigator	John C. Malechek, PhD	USU	July 1979-
Co-Principal Investigators	James T. O'Rourke, PhD	USU	July 1979-
	Hamid Narjisse, PhD	ENA, Meknes	July 1979-
	Ahmed El Aich, Eng. d'Etat	IAV	May 1981-
	Omar Berkat, Eng. d'Etat	IAV	May 1981-
Research Associates	Abdelaziz Chergaoui, Eng. d'Etat	IAV	September 1980-March 1982
	Ahmed Boudiab, Eng. d'Etat	IAV	September 1980-July 1981
	El Mostafa Darfaoui, Eng. d'Etat	IAV	September 1981-July 1982
	Mohammed Harkousse, Eng. d'Etat	IAV	September 1981-July 1982
	Mohamed Chami, Eng. d'Etat	IAV	September 1981-July 1982
	Abdelouahed Chryaa, Eng. d'Etat	IAV	September 1981-July 1982
	M. El Honsali, Eng. d'Etat	IAV	September 1982-
	Thami Ait M'hand, Eng. d'Etat	IAV	September 1982-
	Neal E. Artz, BS	USU	June 1981-
	Val Jo Anderson, BS	USU	April 1983-
	Walter H. Schacht, MS	USU	September 1982-

Morocco

Title	Name	Institution	Dates
Collaborators	B.E. Norton, PhD	USU	March 1982; June/July 1983
	Larry Rittenhouse, PhD	CSU	May/June 1982
	John D. Olsen, PhD	USU	February/March 1983
	James H. Richards, PhD	USU	April/May 1983
	M. Atiqui, Eng. d'Etat	Direction de L'Elevage, Meknes	August 1981-
	E. Laraisse, Eng. d'Etat	Direction Provincial de Agricole, Oujda	January 1982-
	Kendall Johnson, PhD	USU	August/September 1981
	Carl J. Goebel, PhD	USU	August 1981-
	Alan M. Gray, PhD	USU	August 1981-
	C.L. del Castillo, PhD	USU	August 1981-
	Richard S. Aro, PhD	USU	August 1981-
	John W. Harding, BS	USU	September 1982-
	Roger E. Banner, PhD	USU	March 1983-

Sociological Analysis of Small Ruminant Production Systems

Principal Investigator	Michael F. Nolan, PhD	University of Missouri	October 1981-
Co-Principal Investigators	Abdellah Hammoudi, PhD	IAV	October 1981-
	Jere Gilles, PhD	University of Missouri	October 1981-
Senior Investigator	Rachid Doucali, MS		July 1982-December 1982
Research Associates	Mahdi Mohammed, MS	IAV	April 1983-
	Thami Ait M'hand, MS	IAV	October 1982-
	M. Chami, MS	IAV	October 1981-August 1982
	M. Darfaoui, MS	IAV	October 1981-August 1983

Peru

Title	Name	Institution	Dates
Evaluation and Genetic Improvement of Sheep and Goats in Extensive Management Systems			
Principal Investigator	R.L. Blackwell, PhD	MSU	October 1978-
Co-Principal Investigators	Manuel Carpio, MS	UNA	July 1979-
	Alberto Pumayalla, MS	UNA	June 1981-
	Jorge Velasco, PhD	IVITA	July 1979-
	Rolando Alancastre, BS	UNTA	June 1982-
Senior Investigators	P.J. Burfening, PhD	MSU	October 1978-
	D.D. Kress, PhD	MSU	October 1978-
	B. Quijandria, PhD	UCD/MSU	August 1980-
Research Associates	Humberto Rodriguez, MS	UNA	July 1979-July 1981
	Gladys Huapaya, BS	UNA	January 1980-
	Prospero Cabrera, BS	UNA	January 1980-
	Juan Roque, BS	UNA	June 1981-
	Diana Chavez, BS	UNA	January 1982-
	Gladys Garay, BS	UNA	June 1982-
	Juan Bueno, BS	UNA	January 1982-
	Juan Chavez, MS	UNA	June 1982-
	Eugenia Montesinos, BS	UNTA	September 1982-
	Esther Lencinas, BS	UNTA	September 1982-
Collaborators	Carlos Valverde, PhD	INIPA	July 1979-January 1983
	Maximo Gamara, DVM	SAIS Tupac Amaru	July 1979-
Improving Small Ruminant Nutrition, Management and Production Through Management of Native Range and Improved Forages			
Principal Investigators	Donald F. Burzlaff, PhD	Texas Tech	September 1979-August 1980
	Fred C. Bryant, PhD	Texas Tech	September 1980-
Co-Principal Investigators	A. Florez, PhD	UNA	September 1979-
	R. Valdivia, PhD	IVITA	September 1979-
	R. Farfan, MS	IVITA	December 1981-
	J. Astorga, MS	UNTA	December 1981-
Senior Investigators	A. Schlundt, PhD	Texas Tech	August 1980-September 1983
	C. Fierro, MS	Texas Tech	January 1982-
	F. Craddock, PhD	Texas Tech	September 1981-
	R. Sosebee, PhD	Texas Tech	June 1982-
Research Associates	E. Flores, MS	UNA	January 1983-
	E. Malpartida, Ing.	UNA	September 1980-
	A. Rosales, Ing.	IVITA-La Raya	January 1982-
	D. Holgado, Ing.	IVITA-La Raya	September 1980-
	F. San Martin, MS	IVITA-Lima	August 1982-
	F. Villena, Ing.	UNPRG-Lambayeque	June 1981-June 1983
	J. Otto, Ing.	UNP-Piura	June 1981-June 1983
	J. Pacheco, Ing.	UNSAA-Cuzco	January 1982-
	M. Tapia, PhD	UNSAA-Cuzco	January 1982-
	B. Wilcox, MS	Texas Tech	December 1980-December 1982-
	R. Reiner, MS	Texas Tech	June 1982-
	L. Aguirre, Ing.	Texas Tech/UNSAA	December 1982-
	S. Rikert, BS	Texas Tech	May 1983-

Peru

Title	Name	Institution	Dates
Economic Aspects to Increased Productivity of Small Ruminants			
Principal Investigator	A.J. De Boer, PhD	Winrock International	October 1978-
Co-Principal Investigators	Julio Echevarria, PhD	UNA	March 1980-June 1981
	Domingo Martinez, MS	UNA	June 1981-
	Corinne Valdivia, MS	UNA	June 1981-
Senior Investigators	Edward Lotterman, MS	Winrock International	April 1980-July 1982
	Terri Capps, MS	Winrock International	September 1981-
Research Associates	Jesus Ruiton, BS	UNA	March 1980-July 1982
	Ruben Velarde, BS	UNA	March 1980-
	Marta Cruces, BS	UNA	March 1980-July 1982
	Roxana Diaz, BS	UNA	March 1980-
	Luis Millones, BS	UNA	December 1980-January 1983
	Ghorki Llerena, MS	UNA	December 1980-January 1982
	Isabel Luque, BS	UNA	June 1980-August 1980
An Investigation of Small Ruminant Health Problems			
Principal Investigators	C.V. Kimberling, DVM	CSU	January 1979-February 1980
	J.C. DeMartini, DVM, PhD	CSU	February 1980-
Co-Principal Investigators	Eddo Caletti, DVM, PhD	SMU	June 1980-
Senior Investigators	Enrique Ameghino, DVM	SMU	June 1980-
	R.P. Ellis, PhD	CSU	October 1981-
	J.S. Reif, DVM, MS	CSU	October 1980-
Research Associates	J.A. Ellis, DVM	CSU	August 1980-
	A. Ramirez, DVM	SMU, CSU	June 1980-
	R. Rosadio, DVM	SMU, CSU	September 1983-
Collaborators	D. Barreto, Biol.	SMU	June 1980-
	J. Barsallo, DVM	SMU	November 1981-
	H. Bazalar, DVM	SMU	February 1983-
	F. Chang Say, Chem.-Pharm.	SMU	June 1980-
	A. Chevera, DVM	SMU	July 1982-
	G. Guerrero, DVM, MS	SMU	February 1982-
	D. Huaman, Biol.	SMU	June 1980-
	L. Inope, DVM	SMU	February 1981-
	C.V. Kimberling, DVM	CSU	January 1979-
	E. Lopez, DVM, MPVM	SMU	January 1981-
	D.T. Nelson, DVM, PhD	South Dakota State University	July 1982-
	C. Morales, DVM	SMU	February 1981-
	H. Rivera, DVM	SMU	June 1980-
	R. Sam, Biol.	SMU	June 1980-
	H. Samame, DVM, MPVM	SMU	September 1979-
	S.P. Snyder, DVM, PhD	CSU	January 1981
	J. Sumar, DVM	SMU	November 1980-
	L. Tabacchi, DVM	SMU	February 1982-
	A. Vargas, Chem.-Pharm.	SMU	June 1980-

Peru

Title	Name	Institution	Dates
Improving Reproductive Performance of Small Ruminants			
Principal Investigator	Warren C. Foote, PhD	USU	February 1980-
Co-Principal Investigators	H. William Vivanco, MS	UNA	February 1980-
	Julio Sumar, MS	IVITA	February 1980-
	Cesar Novoa, MS	IVITA	February 1980-
Senior Investigators	Edward A. Nelson, PhD	CSPU	February 1980-November 1981
	G. Simon Riera, PhD	USU	January 1983-
	Gary Sides, PhD	USU	January 1981-July 1982
	Maximo Gamarra, MV	IVITA, SAIS Tupac Amaru	March 1979-
Research Associates	Cesar Novoa, MS	IVITA	December 1981-
	Walter Bravo, MV	IVITA	February 1980-
	Victor Alarcon, MV	UNA	March 1980-
Sociological Analysis of Small Ruminant Production Systems			
Principal Investigator	Michael F. Nolan, PhD	University of Missouri	October 1978-
Senior Investigators	Keith Jamtgaard, MS	University of Missouri	January 1982-
	David Guillet, PhD	University of Missouri	July 1983-
	Avi Perevolotsky, MS	University of Missouri	September 1981-December 1982
Research Associates	Keith Jamtgaard, MS	University of Missouri	June 1980-December 1981
	Lidia Jimenez, BS	University of Cuzco	July 1980-
Collaborators	Mario Tapia, PhD	University of Cuzco	January 1981-
	Jorge Flores Ochoa, PhD	University of Cuzco	January 1981-
	Juvenal Casaverde, PhD	Institute for Peruvian Studies	January 1981-
	Victor Fernandez, MS	UNA	January 1981-
	Ricardo Rivera, MS	UNA	January 1981-
	Juan Gomez, PhD	Univ. de San Agustin (Arequipa)	December 1982-
	Jose Portugal et al.	Dirrecion de Comunidades Campesinas	July 1982-
	Hugo Rojas, BA	Center for Agric. Research (Chiclayo)	February 1982-
	Christina Espinoza, BS	Center for Agric. Research (Chiclayo)	February 1982-
	Gloria Martes, BA	Catholic University	January 1982-
	Lucia Aculio Jarramallo	Catholic University	January 1982-
	Marta Huaman, BS	CIPA Lambayeque	July 1982-
	Richard Sedano, BA	University of Piura	January 1982-December 1982
	Raul Santana, BA	University of Huancayo	March 1983-
	Constance McCorkle, PhD	University of Missouri	February 1980-June 1980
	Terry West, PhD	University of Missouri	February 1980-June 1980
	George Primov, PhD	University of Missouri	January 1980-
	Jere Gilles, PhD	University of Missouri	January 1980-
Goat Research Project in Northern Peru			
Principal Investigator	B. Quijandria, PhD	UCD	June 1981-
Co-Principal Investigator	T. Cordero, MS	INIPA	June 1981-
Senior Investigator	H. Vidal, MS	UNPRG	June 1981-
Research Associate	A. Perevolotsky, MS	UCD/University of Missouri	September 1981-December 1982

Peru

Title	Name	Institution	Dates
Collaborators	M. Avila, PhD	CATIE	September 1982-October 1982
	J. Atto, Ing. Zoot.	UNP	January 1982-
	L. Benzaquen, DV	INIPA	June 1981-
	Nicole Bernex, PhD	UNMSM	September 1982-
	M. Callacna, Ing. Zoot.	INIPA	June 1981-
	Terri Capps, MS	Winrock International	June 1981-April 1983
	R. Higaona, Ing. Zoot.	INIPA	June 1981-
	R. Cochran, MS	Ohio State	June 1981-March 1982
	K. Jamtgaard, MS	University of Missouri	June 1981-
	H. Li, PhD	IDRC	July 1982-
	E. Lotterman, MS	Winrock International	June 1981-July 1982
	H. Rojas, Rural Sociol.	—	July 1982-March 1983
	G. Sides, PhD	USU	June 1981-July 1982
	F. Villena, Ing. Zoot.	UNPRG	June 1981-

Basic Supporting Research

Title	Name	Institution	Dates
Breeding Research			
Principal Investigator	R.L. Blackwell, PhD	MSU	October 1978-
Senior Investigators	P.J. Burfening, PhD	MSU	October 1978-
	D.D. Kress, PhD	MSU	October 1978-
Research Associates	Dale Trowbridge, BS	MSU	January 1982-
	Druska Tulley, MS	MSU	September 1979-August 1981
	Robert Lewis, MS	MSU	June 1982-
	A. Alderson, MS	MSU/UCD	June 1980-October 1980
Collaborators	R.L. Friedrich, MS	MSU	July 1979-October 1981
	D.J. Patterson, MS	MSU	September 1980-June 1981
Breeding Research			
Principal Investigator	G.E. Bradford, PhD	UCD	October 1978-
Senior Investigators	D.T. Torell, MS	UCD	October 1978-October 1981
	E.J. Pollak, PhD	UCD	July 1979-June 1980
	B.W. Kennedy, PhD	UCD	July 1979-June 1980
	J.R. Thompson, PhD	UCD	July 1981-
	T.R. Famula, PhD	UCD	July 1981-
	J.F. Quirke, PhD	UCD/Irish Ag. Inst.	July 1981-August 1982
Research Associates	C.M. Finley, MS	UCD	April 1979-
	K. Hedrick	UCD	August 1980-
	O. Garcia, PhD	UCD/FONIAP/Venezuela	January 1980-August 1981
	G.E. Gonzalez, PhD	UCD/Uruguay	July 1980-September 1982
	L. Lasslo, PhD	UCD	July 1979-August 1982
	A. Alderson, MS	UCD/ICA, Columbia/MSU	June 1980-October 1980
	R. Neira, MS	UCD/University de Chile, Santiago	April 1982-August 1982
	E. Drobnis, MS	UCD	September 1981-January 1983
	D. Van Liew, MS	UCD	July 1980-
Collaborators	N.M. East, DVM	UCD	April 1980-September 1983
	S.R. Morrison, PhD	UCD	October 1982-
Range Management Research			
Principal Investigator	Fred C. Bryant, PhD	Texas Tech	September 1980-
Senior Investigators	F. Craddock, PhD	Texas Tech	September 1981-
	G. Matches, PhD	Texas Tech	August 1982-
	R. Sosebee, PhD	Texas Tech	June 1982-
	C. Britton, PhD	Texas Tech	June 1982-
	B. Dahl, PhD	Texas Tech	June 1982-
	R. Pettit, PhD	Texas Tech	June 1982-
	B.L. Allen, PhD	Texas Tech	August 1980-
	R. Richardson, PhD	Texas Tech	December 1980-
	R. Preston, PhD	Texas Tech	January 1982-
	J. Bassett, PhD	TAMU	October 1982-
Research Associates	J.S. Pitts, MS	Texas Tech	June 1980-
	M. Gannaway, BS	Texas Tech	January 1980-
	L. Blodgett, BS	Texas Tech	January 1980-December 1982
	J. Carey, BS	Texas Tech	January 1982-

Basic Supporting Research

Title	Name	Institution	Dates
Systems Analysis Research			
Principal Investigator	T.C. Cartwright, PhD	TAMU	October 1978-
Senior Investigator	G.M. Smith, PhD	TAMU	December 1978-
Investigators	J.W. Bassett, PhD	TAMU	October 1978-
	J.O. Sanders, PhD	TAMU	October 1978-
	C.R. Long, PhD	TAMU	October 1978-July 1982
	N. McGraham, PhD	CSIRO	April/May 1981
	A.B. Carles, PhD	University of Nairobi	October 1980-
	J. Schwartz, PhD	University of Nairobi	January/February 1982
	S. McClintock, PhD	Animal Genetics & Breeding Unit, NSW Dept. Ag.	October/November 1982
Research Associates	H.D. Blackburn, MS	TAMU	October 1978-
	R. Stobart, PhD	TAMU	September 1979-December 1982
	P.J. Howard, BS	TAMU	January 1982-
Collaborators	M.M. Kothmann, PhD	TAMU	September 1979-
	T. Craig, PhD, DVM	TAMU	September 1982-
	M. Shelton, PhD	TAMU	October 1978-
	Z.L. Carpenter, PhD	TAMU	October 1978-January 1982
	G.C. Smith, PhD	TAMU	July 1982-
	G. Schelling, PhD	TAMU	September 1979-
Agricultural Economics Research			
Principal Investigator	A.J. De Boer, PhD	Winrock International	October 1978-
Senior Investigators	R.H. Bernsten, PhD	Winrock International	November 1981-
	J.H. Perkins, MS	Winrock International	September 1980-November 1981
	J.A. Yazman, PhD	Winrock International	January 1981-April 1983
Research Associates	P.J. Howard, BS	University of Florida	January 1981-April 1983
	M.D. Norman, MS	University of Arkansas	June 1981-September 1982
Collaborator	M.J Redfern, PhD	University of Arkansas	June 1982-April 1983
Animal Health Research			
Principal Investigator	James DeMartini, PhD	CSU	February 1980-
Senior Investigators	R.P. Ellis, PhD	CSU	October 1981-
	C.V. Kimberling, DVM	CSU	January 1979-
	L.H. Lauerman, DVM, PhD	CSU	January 1979-August 1981
	J.S. Reif, DVM, MS	CSU	October 1980-
	S.P. Snyder, DVM, PhD	CSU	January 1981-
Research Associates	J.A. Ellis, DVM	CSU	August 1980-
	R. Myers, DVM	CSU	March 1981-December 1981

Basic Supporting Research

Title	Name	Institution	Dates
Production Systems Research			
Principal Investigator	H.A. Fitzhugh, PhD	Winrock International	October 1978-
Senior Investigator	J.A. Yazman, PhD	Winrock International	October 1979-December 1980
Computing Scientists	G. Perkins, MS	Winrock International	June 1980-September 1981
	W. Hinerman, BS	Winrock International	May 1982-
Research Assistants	L. Turillo, BS	Winrock International	December 1979-September 1980
	E.A. Henderson, BS	Winrock International	October 1979-
Reproduction Research			
Principal Investigator	W.C. Foote, PhD	USU	October 1978-
Senior Investigators	E.A. Nelson, PhD	CSPU	October 1978-
	G. Simon Riera, PhD	USU	January 1983-
	Darrell H. Matthews, MS	USU	October 1980-
Collaborator	Gary E. Sides, PhD	USU	October 1980-January 1981
Small Ruminant Nutrition Research			
Principal Investigator	W.L. Johnson, PhD	NCSU	May 1978-
Senior Investigators	W.J. Croom, PhD	NCSU	January 1979-
	L. Goode, PhD	NCSU	January 1979-
	R.W. Harvey, PhD	NCSU	January 1979-
	K.R. Pond, PhD	NCSU	September 1982-
	J.W. Spears, PhD	NCSU	January 1981-
Research Associates	John Brasfield, MS	NCSU	January 1979-May 1980
	Lynn Brown, MS	NCSU	January 1979-
	Anne S. Bryson, BS	NCSU	January 1979-
	Helaine Burstein, MS	NCSU	August 1981-
	Jose daSilva, PhD	NCSU	January 1979-February 1981
	H.R. Gaskins, BS	NCSU	January 1980-
	Mark Froetshel, MS	NCSU	September 1980-
	Budi Haryanto, MS	NCSU	January 1981-
	Patricia Hatch, BS	NCSU	January 1983-
	Ellen Leonard, BS	NCSU	January 1979-
	Jean-Marie Luginbuhl, MS	NCSU	September 1980-
	Debora Mann, MS	NCSU	September 1980-
	M.A. McCann, MS	NCSU	September 1980-June 1982
	Jeff Parris, BS	NCSU	September 1982-
	J.D. Pettyjohn, MS	NCSU	January 1979-
	Roberto Quiroz, Ing. Agr.	NCSU	May 1982-
	Sharon Ray, MS	NCSU	May 1981-
	T.T. Ross, PhD	NCSU	January 1979-May 1982
	L.J. Samsell, BS	NCSU	July 1981-
	Sorta Silitonga, MS	University of Minnesota/BPT	April 1981-February 1983
	E.H. Taylor, BS	NCSU	January 1979-

Basic Supporting Research

Title	Name	Institution	Dates
Collaborators	J.C. Burns, PhD	NCSU	January 1979-
	E.V. Caruolo, PhD	NCSU	January 1979-
	R.G. Crickenberger, PhD	NCSU	January 1979-
	J.M. Leatherwood, PhD	NCSU	May 1982-
	A.C. Linnerud, PhD	NCSU	January 1979-
	A.L. Ordoveza, PhD	NCSU	October 1979-May 1980
	Federico Rodriguez G., MS	NCSU	January 1983-April 1983
	M.D. Whitaker, DVM	NCSU	January 1979-

Animal Health Research

Principal Investigators	Travis McGuire, DVM, PhD	WSU	April 1982-
	Francis Abinanti, DVM, PhD	WSU	June 1980-March 1982
	William Huber, DVM, PhD	WSU	October 1978-May 1980
Research Associates	Johnson Bari, DVM	MLD	January 1980-
	Stanley Mbwiria, DVM	MLD	September 1980-
	James Njanja, DVM	MLD	March 1981-
	Derrick Mwamchi, DVM	MLD	March 1982-
	Raul Rosadio, DVM, MS	IVITA	February 1982-
	Antonio Garmendia, DVM, MS	University of Cusco	September 1982-
Collaborators	Richard Westcott, DVM, PhD	WSU	October 1978-
	John R. Gorham, DVM, PhD	USDA/WSU	October 1978-
	D. Scott Adams, DVM, PhD	USDA/WSU	October 1980-
	John O. Dickinson, DVM, PhD	WSU	October 1979-
	N. Sriranganathan, DVM, PhD	WSU	October 1980-

Range Management Research

Principal Investigator	John C. Malechek, PhD	USU	October 1978-
Senior Investigators	B.E. Norton, PhD	USU	October 1978-
	Thadis W. Box, PhD	USU	May 1981-
	Don D. Dwyer, PhD	USU	October 1978-
	Fred D. Provenza, PhD	USU	May 1981-
	Robin Scherting, BS	USU	July 1979-
	Deborah Mueller, PhD	USU	September 1979-January 1981
Research Associates	Hamid Narjisse, PhD	ENA, Meknes	September 1979-August 1981
	Mustafa Mohamed Hussein, MS	USU	October 1982-
	George B. Ruyle, MS	USU	September 1980-
	Wilson Yabann, BS	USU	January 1983-

Basic Supporting Research

Title	Name	Institution	Dates
Animal Health Research			
Principal Investigators	Harvey J. Olander, DVM, PhD	UCD	October 1982-
	Blaine McGowan, DVM, PhD	UCD	October 1978-October 1982
Senior Investigators	Norman Baker, DVM, PhD	UCD	October 1978-
	Ernest Biberstein, DVM, PhD	UCD	October 1982-
	Dale Brooks, DVM, PhD	UCD	October 1978-
	Al Da Massa, PhD	UCD	October 1978-
	Blaine McGowan, DVM, PhD	UCD	October 1982-
	Bennie Osburn, DVM, PhD	UCD	October 1982-
	Mary Sawyer, PhD	UCD	February 1983-
	John Sawyer, DVM, MS	UCD	February 1983-
	Robert Bondurant, DVM	UCD	October 1978-
	Humphrey Knight, DVM, PhD	UCD	October 1978-October 1981
	Henry Adler, DVM, PhD	UCD	October 1978-October 1982
Research Associates	Nancy East, DVM	UCD	August 1979-
	Karel Hedrick, RN	UCD	August 1980-
	Corrie Brown, DVM	UCD	October 1982-
	Elizabeth Birnie, DVM	UCD	August 1981-January 1983
	Sharon Hietala, BA	UCD	October 1982-
	Karen Carberry, DVM	UCD	October 1982-
	Fred Anguello, DVM	UCD	October 1982-
Breeding and Management Research			
Principal Investigator	Maurice Shelton, PhD	TAES	October 1978-
Senior Investigators	James O. Sanders, PhD	TAMU	October 1981-
	D.N. Ueckert, PhD	TAES	June 1979-
	G.C. Smith, PhD	TAMU	June 1979-September 1981
	Charles Long, PhD	TAMU	June 1979-September 1981
Research Associates	J. Broadway, MS	TAES	January 1980-August 1981
	L.E. Warren, MS	TAES	October 1979-
	P.V. Thompson, MS	TAES	June 1979-
	Gary Snowder, MS	TAES	June 1979-
	Janet Lawson, MS	TAES	January 1981-
	R.R. Riley, BS	TAMU	June 1979-September 1980
	C.L. Griffin, BS	TAMU	September 1980-June 1982
	M.W. Orcutt, BS	TAMU	September 1980-June 1982

Appendix IV. Overseas Institutions Participating in On-Site SR-CRSP Activities

US Institutions	Country	Major Institutions/Locations	Type Project
1. North Carolina State University	Brazil	—EMEPA (Fazenda Pendencia at Paraiba) —EMBRAPA/CNPC (Sobral)[1] —Federal University of Ceara (Fortaleza) —EMATER	By-Products & Nutrition
2. Utah State University	Brazil	—EMBRAPA/CNPC (Sobral)	Reproductive Physiology
3. Winrock International	Brazil	—Federal University of Ceara (Fortaleza) —EMBRAPA/CNPC (Sobral) & CPATSA (Petrolina)	Agricultural Economics
4. University of Missouri	Brazil	—EMBRAPA/CNPC (Sobral) & CPATSA (Petrolina) —EMEPA (Fazenda Pendencia at Paraiba) —EPABA (Bahai)	Rural Sociology
5. Utah State University	Brazil	—EMBRAPA/CNPC (Sobral) —Federal University of Ceara (Fortaleza) —EPACE (Fazenda Iracema, Quixada)	Range Management
6. Texas A&M University	Brazil	—EMBRAPA/CNPC (Sobral) —EPACE (Fazenda Iracema, Quixada) —EMEPA (Fazenda Pendencia at Pariaba)	Animal Breeding & Animal Management
7. University of California, Davis	Brazil	—EMBRAPA/CNPC (Sobral)	Animal Health

[1]Official host country collaborating institution.

US Institutions	Country	Major Institutions/Locations	Type Project
1. University of California, Davis	Indonesia[1]	—BPT (Bogor & Ciawi) —BPT Stations at Cicadas & Cilebut —Gajah Mada University (Jogjakarta) —Margawati Animal Breeding Station (West Java)	Animal Breeding
2. North Carolina State University	Indonesia	—Margawati Animal Breeding Station —IPB (Bogor) —West Java (Ciburuy, Cirebon, Garut) —BPT (Bogor & Ciawi) —BPPH (Bogor) —Gajah Mada University (Jogjakarta)	By-Products & Nutrition
3. University of Missouri	Indonesia	—BPT (Bogor) —Satya Wacana University (Central Java) —West Java	Rural Sociology
4. Winrock International	Indonesia	—BPT (Bogor & Ciawi) —BPPH (Bogor) —West Java (Garut, Cirebon)	Agricultural Economics

[1] The parent organization of BPT and BPPH (AARD—Agency for Agricultural Research and Development) is the official host country collaborating institution.

US Institutions	Country	Major Institutions/Locations	Type Project
1. Washington State University	Kenya	—Ministry of Livestock Development[1] (Kabete & Naivasha Research Station) —FAO/SGDP (Kabete) —Nyanza & Western Provinces	Animal Health
2. Winrock International	Kenya	—Ministry of Livestock Development (Kabete & Maseno Vet Station) —Central Bureau of Statistics (Ministry of Finance & Economic Planning) —Nyanza & Western Provinces	Agricultural Economics
3. Winrock International	Kenya	—Ministry of Livestock Development (Kabete, Maseno Vet Station, & Naivasha Research Station) —Central Bureau of Statistics (Ministry of Finance & Economic Planning) —Nyanza & Western Provinces	Production Systems & Forages
4. University of Missouri	Kenya	—Ministry of Livestock Development (Kabete & Maseno Vet Station) —Central Bureau of Statistics (Ministry of Finance & Economic Planning) —Nyanza & Western Provinces	Rural Sociology
5. Texas A&M University	Kenya	—Ministry of Livestock Development (Kabete, Naivasha Research Station & Ol Magogo Farm) —University of Nairobi —FAO/SGDP (Kabete)	Systems Analysis & Breeding

[1] Official host country collaborating institution.

US Institutions	Country	Major Institutions/Locations	Type Project
1. North Carolina State University	Morocco	—IAV, Hassan II[1] —Tadla Field Station —Moghrane Station —Er Rachidia Station —National School of Agriculture (Meknes)	By-Products & Nutrition
2. University of Missouri	Morocco	—IAV, Hassan II —High Atlas	Rural Sociology
3. University of California, Davis	Morocco	—IAV, Hassan II —Tadla Field Station	Animal Breeding
4. Utah State University	Morocco	—IAV, Hassan II —National School of Agriculture (Meknes) —Ain Beni Mathar —Forest of Jaaba —Pastoral Perimeter de L'Aarid —Talsint —Perimeter de Timahdite —Rharaya Valley	Range Management

[1] Official host country collaborating institution.

US Institutions	Country	Major Institutions/Locations	Type Project
1. Texas Tech University	Peru	—UNA (Lima) —IVITA (La Raya) —Pedro Ruiz Gallo University (Lambayeque) —University of Piura (Piura) —INIPA (Lima)[1] —UNTA (Chuquibambilla, Puno) —Central & Southern Sierra; Northern Coast	Range Management & Forages
2. Colorado State University	Peru	—IVITA (La Raya, Lima & Huancayo Stations) —INIPA (Lima) —Central Sierra	Animal Health
3. Montana State University	Peru	—UNA (Lima) —IVITA (La Raya) —INIPA (Lima) —UNTA (Puno) —Central and Southern Sierra	Animal Breeding
4. Utah State University	Peru	—IVITA (La Raya) —UNA (Lima) —INIPA (Lima) —Central & Southern Sierra	Reproductive Physiology
5. University of Missouri	Peru	—UNA (Lima) —University of Cusco —INIPA (Lima) —Direccion des Comunidades Campesinas (Lima) —University of San Agustin (Arequipa) —University of Huancayo —University of San Marcos (Lima) —Central & Southern Sierra; Northern Coast	Rural Sociology
6. Winrock International	Peru	—INIPA (Lima) —UNA (Lima) —Central Sierra	Agricultural Economics

[1]Official host country collaborating institution.

Appendix V. Chronology of Important SR-CRSP Events

June 1977	BIFAD approval of SR-CRSP for planning grant
July 1977	Approval of BIFAD recommendation by AID Administrator
August 1977	RTI engaged as Planning Entity
October 1977	Initiation of planning activities
February 1978	Research proposals received from 28 US institutions
April 1978	JRC approval of RTI's selection of component projects for the SR-CRSP
May 1978	UC Davis selected as Management Entity
June 1978	Final project outlines, budgets, and program design submitted to JRC
September 1978	USAID signed grant document AID/DSAN/XII-G-0049
September 1978	Cables sent out to every USAID Mission describing SR-CRSP and requesting expression of interest
November 1978	First Technical Committee Meeting
November 1978	Program Director appointed; Technical Committee and Board of Institutional Representatives established
December 1978/ Spring 1979	Visits to potential worksites made by USAID Officer with Principal Investigator teams
February 1979	Meeting of Technical Committee
April/May 1979	Overseas worksites identified and draft of integrated plan prepared
May 1979	Meeting of Board of Institutional Representatives
May 1979	External Evaluation Panel established
May 1979	End of planning phase and beginning of Program Year One
October 1979	Guidelines for SR-CRSP developed by JRC, recommended by BIFAD and approved by USAID
November 1979	Meeting of Board of Institutional Representatives
December 197	EEP holds first Annual Meeting
February 1980	EEP prepares Initial Annual Report
February 1980	MOU signed with Indonesia (AARD)
February 1980	MOU signed with Kenya (MLD)
March 1980	MOU signed with Brazil (EMBRAPA)
March 1980	MOU signed with Peru (INIA)
April 1980	Annual Meeting of Technical Committee
May 1980	Annual Meeting of Board of Institutional Representatives
Summer 1980	Site Coordinators appointed for Brazil, Indonesia, Kenya, Peru
June 1980	Beginning of Program Year Two
July 1980	EEP makes on-site review of UC Davis, Cal Poly and Colorado State projects; prepares Second Annual Report
September 1980	All site coordinators in place overseas
October 1980	Meeting of Board of Institutional Representatives
January 1981	EEP makes on-site review of Ohio State, Tuskegee and Texas A&M Projects
February 1981	Meeting of Board of Institutional Representatives
April 1981	Annual Meeting of Technical Committee
June 1981	Annual Meeting of Board of Institutional Representatives
July 1981	Associate Program Director appointed to Management Entity
August 1981	EEP on-site review of Kenya projects
August/ September 1981	EEP on-site review of Brazil projects
October 1981	Beginning of Program Year Three
October 1981	EEP meets and prepares Third Annual Report
January 1982	Annual Meeting of Technical Committee[1]
January 1982	MOU signed with Morocco (Hassan II)
March 1982	Meeting of Board of Institutional Representatives
June 1982	Annual Meeting of Board of Institutional Representatives
June 1982	EEP on-site review of Indonesia projects
June 1982	AID review of SR-CRSP projects
July 1982	EEP makes on-site review of Washington State and Montana State projects; prepares Fourth Annual Report
September 1982	Termination of subgrant with Cal Poly, Pomona but project continues as sub-contractee to Utah State Reproduction Project
September 1982	Termination of subgrant with Ohio State and Tuskegee Institute
October 1982	Beginning of Program Year Four
May 1983	Annual Meeting of Board of Institutional Representatives
May 1983	EEP on-site review of Peru projects
July 1983	EEP makes on-site review of North Carolina State University and Winrock International projects; prepares Fifth Annual Report
September 1983	End of initial five year grant period

[1] For 1983 only, Annual Meeting of Technical Committee replaced by in-country Principal Investigator meetings.

Appendix VI. Acronyms

AARD	Agency for Agricultural Research and Development
ABRO	Animal Breeding Research Organization
ADG	Average Daily Gain
AI	Artificial Insemination
AID/ROCAP	AID/Regional Office for Central America and Panama
AU	Animal Units
AWW	Adjusted Weaning Weight
BIFAD	Board of International Food and Agricultural Development
BIR	Board of Institutional Representatives
BNB	Banco Nacional do Brasil
BPPH	Balai Penelitian Penyakit Hewan
BPT	Balai Penelitian Ternak (Animal Research Institute)
CAE	Caprine Arthritis-Encephalitis
CATIE	Centro Agronomico Tropical de Investigacion y Ensenanza
CBS	Central Bureau of Statistics
CCPP	Contagious Caprine Pleuropneumonia
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CNPC	Centro Nacional de Pesquisa de Caprinos
CPATSA	Centro de Pesquisa Agropecuaria no Tropico Semi-Arido
CNPCOT	Centro de Pesquisa en Caprinos e Ovinos Tropical
CRIAS	Central Research Institute for Animal Science
CSIRO	The Commonwealth Scientific and Industrial Research Organization
CSPU	California State Polytechnic University
CSU	Colorado State University
DE	Digestible Energy
DM	Dry Matter
EEP	External Evaluation Panel
ELISA	Enzyme Linked Immunosorbent Assay
EMATER	Empresa de Assistencia Tecnica e Estensao Rural
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria
EMBRATER	Empresa Brasileira de Assistencia Tecnica e Extensao Rural
EMEPA	Empresa Estadual de Pesquisa Agropecuaria da Paraiba
ENA	Ecole Nationale d'Agriculture
EPABA	Empresa de Pesquisa Agropecuaria de Bahia
EPACE	Empresa de Pesquisa Agropecuaria do Ceara
ERC	Experimental Research Center
FAO/SGDP	FAO Sheep and Goat Development Project
FMDCAS	(FAO) Farm Management Data Collection and Analysis System
FPT	Failure in Passive Transfer
FSR	Farming Systems Research
IAV	Institut Agronomique et Veterinaire (at Hassan II)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre
IICA/OAS	Interamerican Institute for Agricultural Cooperation of the Organization of American States
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Centre for Africa
INIA	Instituto Nacional de Investigacion Agraria
INIPA	Instituto Nacional de Investigacion y Promocion Agropecuara
IPAL	Integrated Project in Arid Lands
IPB	Institute Pertanian Bogor (Bogor Agricultural Institute)
IRRI	International Rice Research Institute
IVITA	Instituto Veterinario de Investigaciones Tropicales y de Altura (at San Marcos University)
JRC	Joint Research Committee
LDC	Less Developed Country
LPP	Lembaga Penelitian Peternakan (Animal Husbandry Research Institute)
ME	Management Entity
ME	Metabolizable Energy
MLD	Ministry of Livestock Development
MOU	Memorandum of Understanding
MPPA	Most Probable Producing Ability
MSU	Montana State University
NCSU	North Carolina State University
NDF	Non-Digestible Fiber
NPN	Non-Protein Nitrogen
OPP (V)	Ovine Progressive Pneumonia (Virus)
PI	Principal Investigator
RIA	Radio-Immuno Assay
RTI	Research Triangle Institute
SAIS	Sociodad Agricola Interes Social
SR-CRSP	Small Ruminant Collaborative Research Support Program
SMU	San Marcos University (Lima)
SPA	Sheep Pulmonary Adenomatosis
TAES	Texas Agricultural Experiment Station
TAMU	Texas A&M University
TC	Technical Committee
UC	University of California
UCD	University of California, Davis
UFRPE	Universidade Federal Rural de Pernambuco
UNA	Universidad Nacional Agraria (La Molina)
UNMSM	Universidad Nacional Mayor de San Marcos
UNP	Universidad Nacional Piura
UNPRG	Universidad Nacional Pedro Ruiz Gallo
UNSAA	Universidad Nacional San Antonio Abad (Cusco)
UNTA	Universidad Nacional Technica del Altiplano
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USU	Utah State University
WSU	Washington State University