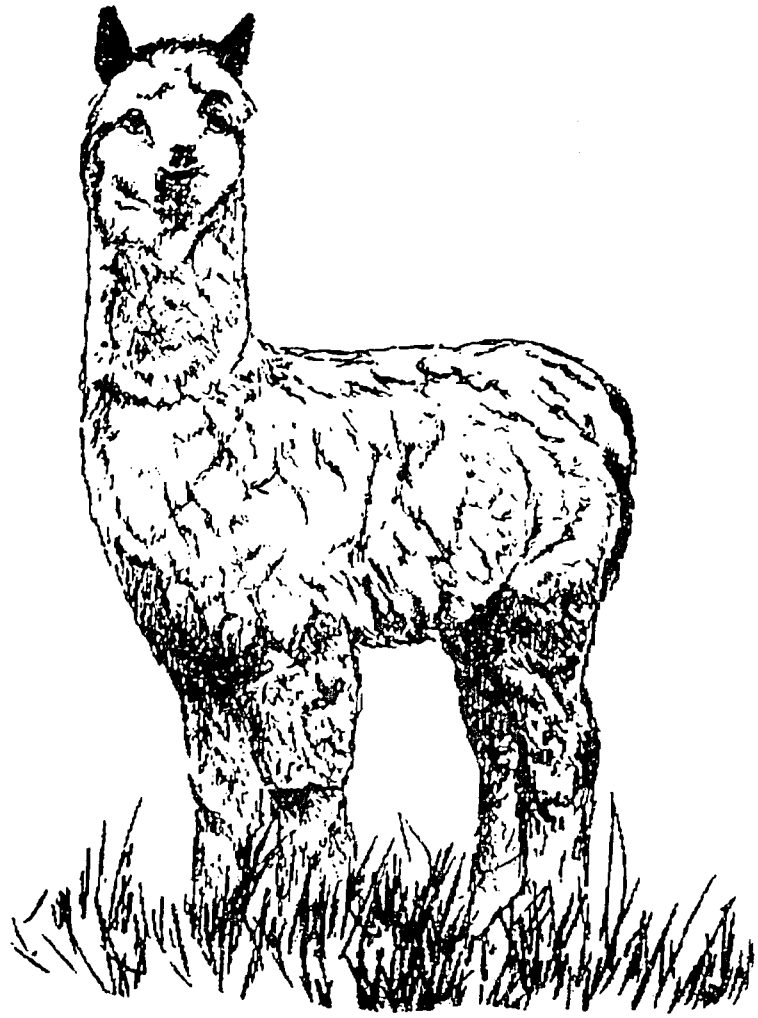
- PN-ABU-695 96170 -

Small Ruminant Collaborative Research Support Program

Annual Report 1994



Small Ruminant Collaborative Research Support Program

Oversight Groups

Global Bureau, United States Agency for International Development (USAID)

Board for International Food and Agricultural Development and Economic Cooperation (BIFADEC)

Joint Committee on Research and Development (JCORD)

Participants

United States Institutions

University of California, Davis

University of Missouri, Columbia

North Carolina State University, Raleigh

Texas A&M University, College Station

Texas Tech University, Lubbock

Utah State University, Logan

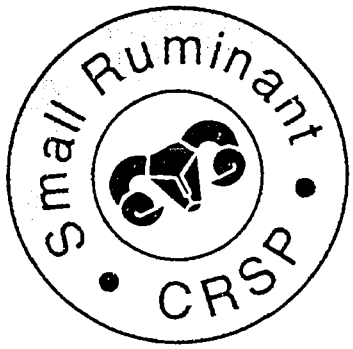
Washington State University, Pullman

University of Wisconsin, Madison

Winrock International Institute for Agricultural Development, Morrilton, Arkansas

International Institutions

Bolivia	Instituto Boliviano de Tecnología Agropecuaria (IBTA)
Indonesia	Agency for International Research and Development (AARD)
Kenya	Kenya Agricultural Research Institute (KARI)



Annual Report
1994

This publication was made possible through support provided by the Office of Agriculture and Food Security, Global Bureau, United States Agency for International Development, under the terms of Grant No. DAN-1382-G-00-0046-00. The opinions expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Agency for International Development.

This publication was produced by the Management Entity, Small Ruminant CRSP, University of California, Davis, California, 95616. Telephone (916) 752-1721, Fax (916) 752-7523

Edited by: Susan L. Johnson
Illustrations by: Joyce Turk

Printed on Recycled Paper

Table of Contents

Preface v

Foreword vii

Introduction xvii

Sustainable Agropastoral Systems on Marginal Lands Component 1
- Utah State University 3
- Winrock International 21
- University of Missouri—Columbia 27
- Texas Tech University 47

Dual Purpose Goat Component 71
- Winrock International 73
- Texas A&M University 79
- University of Missouri--Columbia 87

Animal Health Management Through Biotechnology Component 93
- Washington State University 95
- University of Missouri—Columbia 105

Prolific Sheep and Hair Sheep Production Systems Component 109
- University of California, Davis 111
- Winrock International 119
- North Carolina State University 125

Networks and Linkages Component 147
- University of Wisconsin—Madison 149

Project Expenditures 151
- Expenditures by Program 153
- Approved Program Budgets 155
- Matching Contributions from U.S. Institutions 157
- Summary of Host Country Contributions 159

Glossary 161

Maps
- Bolivia 25
- Kenya 69
- Republic of Indonesia 107
- United States 145

Illustrations
- Alpaca ..... Cover
- Dual-Purpose Goat 71
- Sei Putih Hair Sheep 110

Preface

The Small Ruminant Collaborative Research Support Program is funded through a grant from the U.S. Agency for International Development. In 1994, the program collaborated with eight land-grant universities, a private voluntary organization based in Arkansas and three host country institutions. The host country institutions are located in Bolivia, Indonesia and Kenya. All program collaborators are listed on the front and back cover of this publication.

Each year, the Small Ruminant Collaborative Research Support Program (SR-CRSP) publishes an annual report in compliance with grant requirements. This annual report covers research performed during the calendar year, January 1, 1994 through December 31, 1994. The principal investigators for each project submit reports on research conducted with SR-CRSP funding. Each report is the expression of the principal investigator with grammatical and format editing by the Management Entity. All individual reports give the name, address, telephone, fax number and email address of the principal investigator for that project. Inquiries are welcome.

I would like to take this opportunity to express my gratitude and acknowledge the support of Janette Reyes and Oyahan Gallegos in the production of this document. Also, a very special thanks to Joyce Turk for her undying patience and invaluable assistance.

Susan L. Johnson
Annual Report Coordinator

Foreword

This year has been a tumultuous one for the SR-CRSP. We have been to the brink of fiscal oblivion and back. Apparently SR-CRSP has survived the budgetary battles to allow us to honor our commitments to our host countries, students, universities and NGOs to complete the fifth year of our five year program.

Turmoil, for the most optimistic, represents the opportunity to change, adapt and even expand programs to meet emerging needs and demands. The SR-CRSP originated in time when cattle research dominated much of livestock development and in part the founders of the CRSP likely saw body size as a means of differentiating the new CRSP from the ongoing and strongly supported cattle work. In the 1980's the picture change markedly with a sharp decline in support from donors for cattle research and development. As a result in the 1990's livestock in general and cattle research in particular are underfunded (especially relative to their economic importance in LDCs) and the recent emphasis on the interaction of agriculture and natural resources.

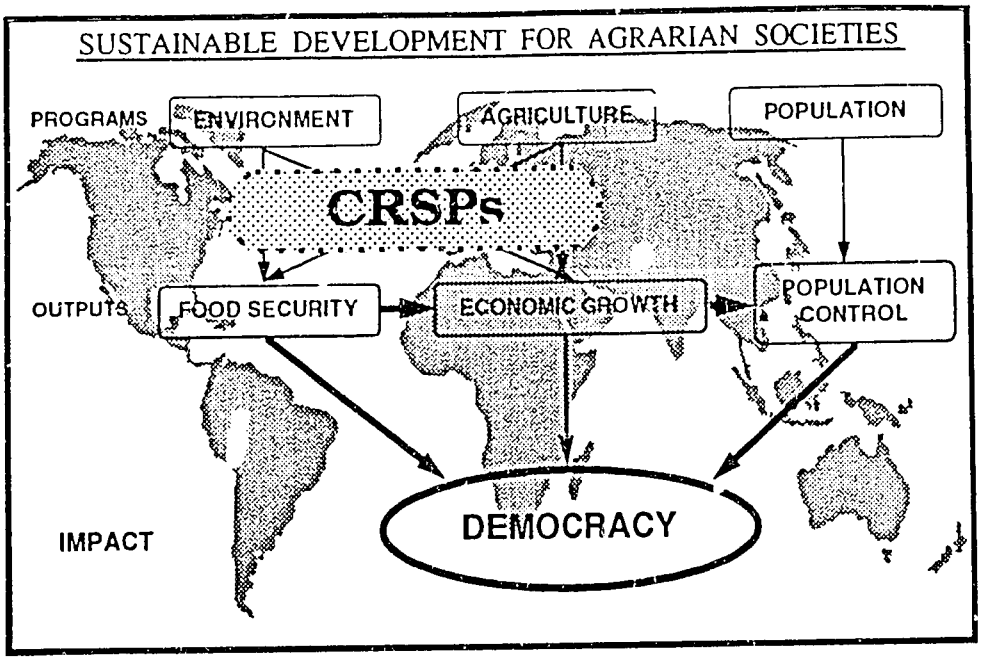
A Model of Foreign Aid

Let me place the CRSP programs in a development context with some personal perspectives. I believe that most of us consider that a democratic world is the ultimate goal for foreign assistance; that the interests of all are best served when we all have a voice in solving the problems that face us and unite us as a global community. We regularly see these problems in images of famine, civil strife, war and poverty and we are constantly struggling with the solutions. The basis of effective and efficient solutions must rest with a proper formulation of the problem. Let me present mine. Figure 1 links democracy with several of the major problem areas. Interestingly they also represent some of the major programs within USAID.

I would like to make the following points about the model:

1. **The elements of the model in figure 1 are inextricably linked.** A perception of the problem exists that I will call the US urban view. This view is held by people who have lived in a society where food security is so great they have lost contact with food production systems, appreciate little of what the lack of food security means for most of the world's population, and do not understand that environment, population and agriculture are an integrated set of challenges. This view, shaped by a rush to address real problems of environmental degradation and expanding populations, has neglected agriculture. Perhaps because of a lack of knowledge or exposure of policy makers, funding for agriculture has been diminished within foreign assistance programs, and the sector isolated from programs in population and the environment. This approach is very damaging because today's global problems can be traced to the impact of agriculture on the environment. Such an interaction links food security to economic and social development and population growth. Agriculture, as the major user of the land, must be a component of any comprehensive view of the environment.

Figure 1.



2. **Agriculture research and development is the engine of economic growth in less developed countries (LDCs) and at the hub of the development problem. Agricultural development drives economic development in LDCs.** A recent Harvard study in Kenya indicates that the multiplier effect for investment in agricultural development is 1.49, while investment in nonagricultural sectors is 0.79. In the largely agrarian societies of LDCs, agricultural development has broad impacts that reach deep into the economy. The success of the agricultural sector directly affects the food security of people. The availability of and access to food that people experience affects their social, political and reproductive behavior. Agriculture is the single greatest use of the land by man, and in LDCs it has the single greatest environmental impact. Development of proper food production systems is essential to a development program that protects biodiversity and the natural resource base upon which production depends.

3. **Food security and economic growth reduce birth rates.** One consistent demographic pattern demonstrates that as societies move into the middle class, birth rates drop; if societies remain poor, birth rates remain high. Few would dispute that high population levels are a major constraint on the road to democracy because they absorb the impact of technological advances, leaving unchanged the per capita growth. The Aswan Dam is a classic example. It doubled energy output for Egypt but in the decade required for its completion the country's population doubled.

   Food security and economic growth can be coupled with population programs to have a major effect. But population control programs conducted in conditions where people perceive risk in the food supply, in social and economic stability, will not succeed. Agricultural development, food security, environmental protection and population control must be balanced and coordinated.

4. **Only when the elements of food security, economic growth and population control are balanced and coordinated does the societal context exist for democracy.**

Major Issues in Foreign Assistance

Famine relief costs vs. development

The appropriate costs of development assistance are often debated. However, there is likely wide agreement that when famine and social unrest emerge, the costs of intervention are orders of magnitude greater than costs of development programs. The estimates of $4 billion for food aid and peace keeping in recent years in the Horn of Africa dwarf our development expenditures. In the long-term, we must find effective solutions that cut the "cycle of despair" where lack of food security and economic growth have constrained progress toward democracy and created growing populations of people competing over ever more limited resources.

The road from LDC to the middle class of nations is paved by the commitment of LDC countries to self-help, and supported by a patient, creative foreign assistance program which understands that development is a long-term process. CRSP programs attempt to address a development continuum from famine relief, on one hand, to development of institutions and human capital on the other. If our policies concentrate only on parts of the continuum, we suffer from and become tied to the inefficiencies of sporadic interventions. For example, donors spent around $100 M per year in the mid-1980s to support 1,200 expatriates on long-term technical assistance assignments in Somalia. This revolving door approach did not achieve the ultimate objective of the UNDP and IBRD which was "the development of national capacity through the permanent transfer of skills and know-how to Somali nationals. In the final analysis, the most self-sustaining impact, the development of people's ability to develop themselves, is the longest-term and most difficult process to sustain in our foreign assistance effort, but the one which must succeed and will, if properly managed and programmed.

Middle class nations and US exports

The recent record trade deficits and the weak dollar are clear reminders that international trade is a critical component of our domestic agenda. The emergence of freer international trade requires that we establish mechanisms that create and open markets for American goods. As a nation we have an advantage producing products for and exporting to the "middle class" nations. As countries like Indonesia and Kenya move to this level of economic development they buy more US goods.

While the process of development creates markets for the US, we develop these markets and establish the links to capture them. Because international competition for the markets emerging in the LDCs is not one of the US comparative strengths, we must support programs that enhance our ability to successfully enter and compete if we are to balance our trade deficit.

Foreign assistance should have domestic impact.

The resources that we direct at foreign assistance should, whenever possible, have both a domestic and international impact. Programs that use American institutions, open and create markets for US commerce, and that train US citizens, should be supported when those programs demonstrate a comparative advantage over other programs.

Collaborative Research Support Programs

The CRSP programs focus at the heart of the foreign assistance model. Eight CRSPs address critical aspects of agriculture, food security and environment. Our individual programs, funded by the USAID's Office of Agriculture and Food Security (whose total office budget represents only .4% of the Agency's allocation from Congress), conducts agricultural development research, training and technology transfer in 40 countries around the world. We accomplish this mission by establishing teams of scientists from land grant universities with expertise in particular disciplines that focus on food security.

Table 1. Present CRSP Programs, management entities, participating universities and host countries.

CRSP	Headquarters	Universities	Countries
Small Ruminants	U. of California, Davis (UCD)	U. of Missouri, North Carolina State, Texas A&M (TAMU), Texas Tech, Utah State, WSU, Winrock, U. of Wisconsin (UW)	Bolivia, Indonesia, Kenya. Former: Brazil, Morocco, Peru
Sorghum/Millet	U. of Nebraska, Lincoln (UNL)	Kansas State, Mississippi State, U of Nebraska, Purdue, Texas A&M	Niger, Mali, Sudan, Botswana, Mexico, Honduras, Columbia
Bean/Cowpea	Michigan State U. (MSU)	UCD & Riverside, Clemson, UG, UNL, U. of Puerto Rico, MSU, Purdue, U. Minnesota, UW, WSU	Cameroon, Dominican Republic, Ecuador, Honduras, Malawi, Nigeria, Senegal, Tanzania
Soil Management	North Carolina State (NCS)	Cornell, U. Hawaii, U. Kentucky, NCS, U. Puerto Rico, TAMU	Peru, Indonesia, Niger, Mali, Brazil, Columbia, Dominican Republic
Peanut	U. of Georgia	TAMU, NCS, UG, Alabama A&M	Senegal, Burkina Faso, Niger, Nigeria, Mali, Philippines, Thailand
Pond Dynamics & Aquaculture	Oregon State U. (UG)	Auburn, MSU, U. Hawaii, OSU, U of Michigan, U of Arkansas-Pine Bluff	Honduras, Indonesia, Panama, Philippines, Rwanda, Thailand, Jamaica, Sierra Leone
Integrated Pest Management	Virginia Polytechnic Inst.	Lincoln U, Montana State, Ohio State, Penn State, Purdue, UC Berkeley, UG, Rodale, USDA Clemson, Kroger, Caito	Guatemala, Jamaica, Mali, Philippines, Uganda, Ecuador
Sustainable Agriculture	U. of Georgia	Tuskegee, UW, Colorado State, WSU, Auburn, VPI, West Carolina State,	Ecuador, Burkina Faso, Philippines, Cape Verde, Costa Rica, Honduras

Key Issues related to CRSPs

1. Do the CRSPs have a comparative research and training advantage in the development of agriculture and food security?

The answer is most certainly, yes! First, by enlisting the US land grant system, CRSPs draw on the richest resource of agricultural scientists in the world. These scientists are fully capable

of moving back and forth along the continuum between basic and applied science, and hence bring the full range of research expertise to bear on development problems. Second, the land grant universities are mission oriented institutions with a wealth of experience in research and training directly related to agriculture and food security. These institutions and this system can claim a major role in the most successful food production system in the history of mankind. Third, the CRSP model has successfully linked research, training and development to provide technical solutions, improve human capital and host institutions, and provide linkages that foster bilateral economic benefit; that is, it makes the long-term changes that "revolving door" approaches fail to accomplish. The graduate education process is a remarkably efficient model to build human resources and accomplish development goals. Graduate education, under the CRSPs, thoroughly integrates science and training, which produces independent scientists who deliver a development product, and who themselves become leaders in host country institutions or are Americans with expertise in foreign markets.

2. Are the CRSPs a cost effective mechanism to accomplish development?

The CRSPs have several dimensions of economic advantage:

a. The CRSP model has the advantage that it draws on existing institutions both domestic and foreign. These institutions provide personnel and infrastructure without cost to the CRSPs. Unlike some of the more prominent assistance programs which must pay for the salaries, overseas housing, laboratory construction and maintenance for their scientists, the CRSPs use American faculty whose salaries are already paid, whose houses are already bought, whose laboratories are already built and maintained. CRSP funds are directly expended on the program's objectives. The marriage between the vast research and training resources of the land grant universities and the goals of USAID is a natural and it should be flourishing.

b. The CRSP model requires cost sharing as part of its partnership between US Universities and host countries. As is displayed in Table 2., USAID funding over the 15 years of the program has been $198 M, universities have contributed $48.5 M, host countries $59.3 M and other funds $7.2 M. By investing about $18 M /year or about $2 M per CRSP, USAID captures a 74% increase in matching contributions. This return is quite high relative to other USAID programs.

3. What are the domestic effects of the CRSPs?

As we move to a freer global economy, foreign assistance takes on new importance as a mechanism to increase our competitiveness on world markets and provide links to the emerging markets in developing nations. The CRSP model has much to offer. At its core, the programs link American scientists working in American institutions with host government agricultural institutions, their scientists and governmental officials. This relationship provides American research expertise and training for host countries while insuring that America shares directly in the technological benefits of this partnership. For example, SR-CRSP genetics and parasite research has identified parasite-resistance in sheep that is estimated to save US lamb producers potentially $40M / year. US commercial sorghum growers rapidly adopted a new green-bug resistant variety that produces one-third more grain (approx. 56 million bushels) and the net benefit from the resistant sorghums has been $389M or a 48.2% annual rate of return on USAID's investment. Through the CRSP program the University of Wisconsin and Agracetus,

Table 2. CRSP Financial Allocations and Cost Sharing (from External Review of CRSPs conducted 1994 by TRD under contract to AID).

CRSP	Total USAID appropriations	Actual USAID authorizations	Actual USAID funds disbursed	Reported university cost sharing	Reported host country cost sharing	Reported total buy-ins	Reported other leveraged funds	Ratio leveraged to AID funds
Soil management	$ 38,946,000	$ 34,00,000	$ 31,607,000	$ 5,564,250	$ 13,309,750	$ 5,500,000	$1,654,480	0.82
Sorghum/millet	47,232,202	46,720,002	46,720,002	11,779,754	3,886,916[a]	20,639,232[a]	n.r.[b]	0.77
Bean/cowpea	48,007,927	41,458,000	38,212,409	8,287,679	6,353,982	1,222,765	767,000[c]	0.44
Fisheries stock assessment	6,000,000	5,614,000	4,581,320[d]	1,286,889	n.r.[b]	0	0	
Pond dynamics and aquaculture	12,200,000	12,119,000	10,925,373	2,960,706	3,828,581	1,855,001[e]	n.r.[b]	0.79
Peanut	23,456,961	20,455,929	18,232,029	4,033,114	n.r.[b]	1,457,800	3,800,000[f]	0.50
Small ruminant	53,366,000	48,777,031	47,843,182	15,845,149	31,860,743[g]	1,670,000	934,287	1.05
Totals CRSP	$229,209,090	$209,146,962	$198,121,315	$48,470,652	$59,239,972	$32,344,798	$7,155,767	0.74

Sources: Information compiled from financial documentation supplied by the individual CRSPs in July and August 1994 and the information contained in the Evaluation Team's Scope of Work.

a. University cost share, host-country cost share, and buy-ins reporting only for current grant, 1990-95
b. Not reported
c. The sum of $767,000 in 1993 only, plus $109,697 from the 1980-86 grant budgeted for doing host-country audits
d. Research costs only reported; figure does not include management entity costs.
e. Figure for project years 1989 to 1994 only.
f. Federal and state contributions to the University of Georgia research funds for peanuts.
g. Figure for project years 6 to 14 only.

Inc. have produced transgenic beans, creating new technologies with a potential value far surpassing beans alone.

In the face of large trade deficits, the opportunity to expand US. agricultural trade must be a priority. Agriculture and agri-business is a sector in which the US is a world leader and is now positioned to take advantage of its heritage of excellence in technology and management, established in large part by the efforts of land grant universities.

The CRSPs can and do advance the role of the US in foreign markets. First, the program establishes the contacts, identifies the opportunities and provides the personnel to facilitate market entry. Most of the CRSPs have more than a decade of in-country experience and have produced cohort of students with a foreign focus in agriculture who play critical roles in international commerce and development. In host countries, CRSP trainees now occupy many of the most important decision making positions in the agricultural sectors of their nations.

The ability of American agriculture to be competitive overseas places different requirements on our system than being competitive domestically. New markets are new environments that require adapted varieties, in-country/overseas research capacities and understanding of the local economies and markets. CRSP programs develop resources for all these areas. The Peanut CRSP developed peanut varieties, drawing on foreign genetic material, that now account for one-third the acreage in North Carolina and Texas. Heat resistant genes brought from Africa by the Bean/Cowpea CRSP are responsible for record yields of cowpeas (7,000 ibs/acre) in California .

The CRSPs have major impacts on the agricultural research institutions. For example SR-CRSP trainees are the core of the animal science and most of the animal disease components of the Kenyan Agricultural Research Institute (KARI). Overall the CRSPs have trained 1,800 degree students. Of these 26% were American and 29% women. A recent external review of the CRSPs indicated, "Development of 'human capital' has been a major output of the program, and over time will likely have a major impact in developing countries as these trained people move into positions of greater responsibility."

Key issues of SR-CRSP

The Small Ruminant CRSP has focused primarily on the improvement of goat and sheep production systems. This focus was chosen to address the economics and well being of small farm production. The program has developed production packages that include new, more productive breeds, health technologies (including vaccines), feed production and animal management systems. These programs are being adopted in the highlands of Kenya, the savannas of Brazil and even in the rubber plantations of Indonesia.

The Indonesian program is a classic example of sustainable development. The conversion of rain forest to plantations in Indonesia has caused considerable concern globally. A growing population and a rapidly expanding per capita demand for meat limit the options to keep pace with requirements and not convert forest to pasture. The SR-CRSP team of Indonesians and Americans foresaw this problem and developed what has been called our "sheep under rubber" production system. By developing a new breed, composed of exotic and local genes, coupled with a forage production system between plantation rows, and animal care technology packages, the Indonesians have increased their capacity to produce meat to such a level that they signed The Northern Triangle Trade Agreement to export three million sheep / year. Significantly this production can be accomplished simultaneously with the preservation of the rain forest and a reduction in herbicide that spares the environment while potentially saving plantation growers $40 M /year.

Important misconceptions and Issues about Livestock

1. Livestock are not essential in the nutrition of people in LDCs.

Perhaps more than any one statement this one represents the clear dichotomy between our world and the LDCs'. One of the most extensive studies of the nutrition of children in LDCs (three countries, five years) was conducted by the Nutrition CRSP. The study focused on the role of diet in child development. The major conclusions of the study were:

a. most children did **not** suffer from shortages of calories and protein;

b. they did suffer from a suite of **micro-nutrient deficiencies;**

c. these deficiencies were linked to **growth retardation, behavioral problems and deficits in cognitive capacities**; and

d. the **only dietary component that predicted growth and performance was animal products in the diet.**

Animal products provide many of the micro-nutrients that are critical for the development of people's ability to develop themselves. This point has vast implications for the future of the developing world. We must understand that while we may view consumption of animal products with a wary eye in the US, for most of the world they represent a critical component of their children's futures. **The small ruminant is the distributional mechanism for those micro-nutrients.**

2. Why are small ruminants important in LDCs?

As populations grow, farm size in LDCs has decreased. The appropriate size of animal to match farm scale is now smaller than a cow. The economic and management flexibility that smaller size provides, means that small ruminants are a primary and critical component of households. Furthermore small ruminants are a critical component of subsistence agriculture. While a debate exists as to whether food is in shortage globally or merely a distribution problem, the subsistence agriculture's of the LDCs represent not just food production but also food production that is close to the mouths it feeds. The value of this agriculture is more than the nutrition it produces; it is also the distributional infrastructure it does **not** require.

In Africa, where I have much of my experience, the household agriculture is the nutritional and financial backbone of most families and the small ruminant a key component of that system. The small ruminant has traditionally been one of the few resources controlled by women and the success of their flocks gives them wealth and power in their families and their communities.

3. Environment and Livestock

The SR-CRSP program conducts applied research and trains both US and foreign students in livestock production. Livestock grazing is the single most anthropogenic use of land globally. This program seeks to minimize environmental degradation in the developing world by proper management practices that have regional implications and encompass everything from soil degradation to CO_2 cycles. The solution to livestock practices that have a negative impact on the environment is not to retreat from research and development in this area. Quite the contrary, well designed programs that combine both environmental and economic constraints

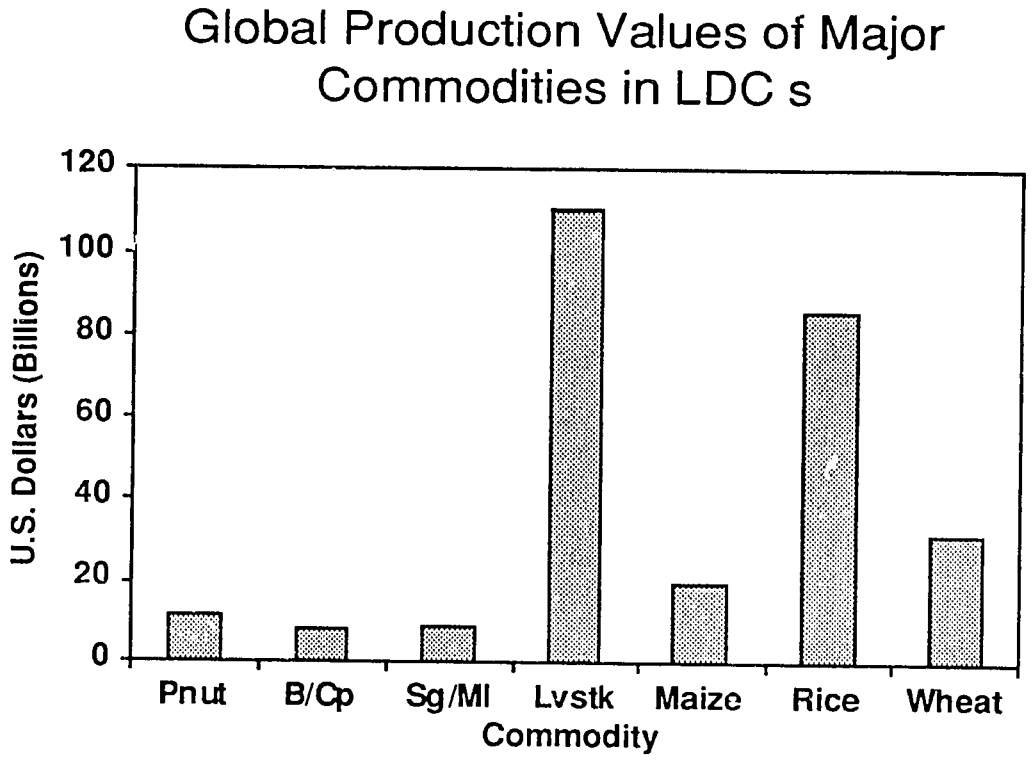
should be conducted. To ignore extensive grazing systems in development programs because they are perceived to be environmentally damaging avoids the issue and surely magnifies the eventual damage.

Livestock research in the 1960-1980 was a major priority of donor agencies in Africa, but lack of impact led to a major decline in funding during the 1980s. The reason for that failure is now clear. Scientists and development specialists from the temperate zones used a temperate model as the basis for their interventions. The characteristics of the range in Africa are very different from the US and only recently have long-term ecological studies revealed the substantial differences between our systems and theirs. In semi-arid African the "ranch" model does not work. Under conditions characterized by unpredictable drought and rainfall, the timing and intensity of interventions must be consistent with the state of the environment. The concept of development in this situation might be labeled "opportunistic management". Understanding that we cannot impose our domestic models on conditions in the LDCs has been a slow lesson for us to learn. With the proper model I am confident that we can make major advances to break the cycle of despair.

4. Livestock and Agriculture

Animal agriculture is the largest single sector of agricultural economies (Fig. 2). As countries develop, the proportion of agricultural GDP represented by animal production increases.

Figure 2.



In poorer LDCs livestock revenues account for approximately 25% of agricultural GDP, while in California, animal production accounts for more than one-half of the state's agricultural revenue.

The importance of livestock as a user of the land, the proper management of intensive livestock production systems, the creative coupling of animal and plant production systems, and the major opportunities for American participation in these future markets is a compelling argument for investment in a CRSP with broad livestock capabilities. We are planning such a CRSP, to be called the Global Livestock CRSP, as our five year grant comes up for renewal with USAID.

Montague W. Demment
SR-CRSP Program Director

Introduction

The Concept and History of the SR-CRSP

The United States, the world's largest producer of surplus food, has provided aid to millions of victims of hunger. Abundant harvests in the United States have been widely distributed through emergency disaster relief programs and on a regular basis to food-deficient nations. It has become apparent, however—especially in the last forty years as the world's population has burgeoned—that supplying the hungry world with food through the distribution of surpluses does not alter the cycle of poverty and deprivation over the long-term. Recent famine in Africa has demonstrated that the only viable solution is to improve the capacity of food-deficient regions of the world to supply their own food.

To promote this, the U.S. Congress passed the International Development and Food Assistance Act of 1975. Included in the act was *Title XII—Famine Prevention and Freedom from Hunger*, which states, "...in order to prevent famine and establish freedom from hunger the U.S. should strengthen the capacities of U.S. land grant.. universities in program-related agricultural institution development and research...[to] improve their participation in the U.S. 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."

The act also specified that the Agency for International Development should administer and fund Title XII from its existing budget and it authorized the President of the United States to create a Board for International Food and Agricultural Development and Economic Cooperation (BIFADEC) to implement the act. The BIFADEC appointed a Joint Committee on Research and Development (JCCRD) to oversee the research-related aspects of Title XII. It was BIFADEC's recommendation that Title XII-sponsored research be implemented through Collaborative Research Support Programs (CRSPs). Small ruminants were among their suggested topics for research.

The Goals of the SR-CRSP

The goal of the Small Ruminant CRSP is to improve the efficiency of small ruminant production by developing technologies and interventions which generate economic development and which enhance and sustain the environment to benefit the social and economic well-being of people. This is carried out through research activities which increase the production of meat, milk, fiber, and by-products from small ruminants in areas of the world where they are a source of income for smallholders. Strengthening the research capability of United States and overseas agricultural institutions, especially through on-site training, is also a goal of the SR-CRSP.

The Small Ruminant CRSP

Fifty-three percent of the world's sheep and ninety-four percent of the world's goats are in the developing countries and are owned primarily by farmers of limited means. Small ruminants contribute significantly to the economy and food supply in these countries and demand for sheep and goat products exceeds the supply.

Improving the performance of small ruminants improves the diet and standard of living of many small holders. The ruminants are inherently well-suited to the capabilities of small-holder farmers and to the conditions prevailing in many developing countries.

Small ruminants:

- Have low initial and maintenance costs.

- Can sustain agriculture through grazing on marginal land and crop residues.
- Produce milk and meat in small, readily usable quantities.
- Produce fiber and skins that sustain cottage industries.
- Are easily cared for by many different family members.
- Enhance income, improve cash flow and employment opportunities, and reduce risk.
- Provide fertilizer to maintain soil fertility and improve crop production.

Organization of the SR-CRSP

The SR-CRSP was organized in 1978 with seventeen institutions. The University of California, Davis, was designated the Management Entity for the program. Since its inception, some projects have been completed, and, in 1994, nine U.S. institutions participated in the program.

The SR-CRSP was organized to include a Technical Committee, an Administrative Council, a Board of Directors, and an External Evaluation Panel. These groups advise the Management Entity on the technical and policy issues.

- The *Technical Committee* develops and implements research projects in the United States and overseas. It consists of all principal investigators and a scientist from each collaborating country.
- The *Administrative Council* is primarily concerned with policy issues. It consists of a representative from each participating U.S. institution and from each participating host country.
- The *Board of Directors* is an executive committee of the Administrative Council. It consists of seven members, who rotate biannually from the Administrative Council to the Board. The Board assesses the content and balance of programs, reviews progress and accomplishments, approves work plans and budgets, and approves the addition or deletion of component projects.
- The *External Evaluation Panel* is an advisory committee that reviews and evaluates SR-CRSP research activities and progress. It consists of a multidisciplinary group of eminent scientists from institutions not participating in the SR-CRSP.

Budget

Funds for the SR-CRSP are granted for a 5 year period by the Agency for International Development. A minimum cost-sharing contribution of 25 percent from participating U.S. institutions is required. The total grant to the SR-CRSP for the first fifteen years will be approximately 52 million dollars. Overseas collaborators have contributed approximately 25 million U.S. dollars equivalent and the U.S. institutions have matched about 17.25 million dollars to date.

Overseas Worksites

Since research in developing countries is considered to be a cornerstone of the SR-CRSP, a special effort is made to select worksites that meet the following criteria:

- Sites must represent the various ecozones and production systems which typify the tropics or arid lands. It is anticipated that SR-CRSP findings will extend beyond the borders of a nation in which the research is conducted and will be useful in other areas of the world having similar climate and topography.
- Countries in which the sites are located must have established agricultural institutions, staffed by scientists and students, with whom the SR-CRSP investigators can collaborate. These institutions provide the extension links that are pivotal to the implementation of SR-CRSP findings. In addition to providing the formal collaboration

linkage, these institutions are the country and regional resource has on small ruminant research.

The overseas sites and collaborating institutions in 1994 were:

- Instituto Boliviana de Tecnología Agropecuaria (IBTA), Bolivia
- Kenya Agricultural Research Institute (KARI), Kenya
- Agency for Agricultural Research and Development (AARD), Indonesia

Research Projects

Individual research projects of the SR-CRSP were designed to help alleviate the major problems that severely hinder small ruminant productivity in developing countries.

Problem	Research Area
Inadequate year-round feed supply	Nutrition and feeding
Improper grazing practices	Range management
Poor reproductive performance	Reproduction in males and females
Non-selective breeding	Genetic improvement of local breeds and crossbreeds
Disease / parasitism	Animal health
Sub-optimum utilization of available resources	Management
Cultural constraints, lack of capital research	Sociology, economics
Lack of coordination & integrated improvement efforts	Systems research

U.S. Institutions Participating in the SR-CRSP

The Small Ruminant CRSP is comprised of the following component research projects at nine U.S. universities and research institutions:

University of California, Davis	Breeding and Genetics
University of Missouri, Columbia	Rural Sociology
North Carolina State University, Raleigh	Animal Nutrition
Texas A&M University, College Station	Animal Breeding
Texas Tech University, Lubbock	Range Management
Utah State University, Logan	Range Management
Washington State University, Pullman	Animal Health
University of Wisconsin, Madison	Network
Winrock International Institute for Agricultural Development, Morrilton, Arkansas	Agricultural Economics, Production Systems

For more information, please contact:
Management Entity
Small Ruminant CRSP
University of California, Davis
Davis, California 95616-8700
(916) 752-1721
(916) 752-7523 (fax)
srcrsp@ucdavis.edu (e-mail)

Sustainable Agropastoral Systems on Marginal Lands

"Most of the world's small ruminants are produced in agropastoral systems on marginal and fragile lands. The key to development of sustainable agricultural systems in these regions depends on the implementation of suitable management strategies for the livestock sector. . . . The goal of this SR-CRSP research is to develop new approaches to strategic interventions for the development of grazing and livestock management systems on marginal and fragile lands. Such interventions must have greater likelihood of success than previous development efforts and must optimize offtake consistent with sustainable ruminant livestock production in an ecosystem context and contribute to the equitable economic and social well-being of all participants. It is not only necessary to gain knowledge and understanding of how to improve animal production, but also to learn how grazing and browsing animals affect their environment. Such knowledge is basic to determining how management practices can be changed or mitigated and production sustained."

p. 38, Extension Proposal, 1990-1995

Range Ecology **3**
Brien E. Norton, Utah State University

Economics of Small Ruminant Production Systems and Markets...21
Enrique Ospina, Winrock Institute for Agricultural Development

Sociological Analysis of Small Ruminant Production Systems.....27
Michael F. Nolan, University of Missouri - Columbia

Range Animal Nutrition **47**
Fred Bryant, Texas Tech University

Range Ecology

Utah State University

Brien E. Norton, Department of Range Science, Utah State University, Logan, Utah, 84322-5230. Telephone (801) 797-2476, Fax (801) 797-3796, E-mail: norton@cc.usu

Narrative Summary

To many casual observers, and ecologists as well, the rangelands of Bolivia's central Altiplano appear to be overgrazed. The Altiplano is the most densely populated region of Bolivia, and most of the rural population pursues an agropastoral lifestyle incorporating sheep flocks and farming, the latter in a crop rotation that begins with potato followed by quinoa and then barley. After 4 to 6 years under cultivation the field is left in fallow for 10 to 20 years, and becomes a source of forage and fuelwood.

Research conducted by the Range Ecology project in 1994 studied range deterioration from three points of view. We examined the role played by soil salinity in range site degradation; we looked at strategies of sheep flock management that are linked to overgrazing; and we developed an index for assessing the relative magnitude of degradation on semiarid shrublands. Previous work has emphasized the value of forage on fallow fields in the first three years of fallow. We complemented that research by quantifying the amount of fuelwood in shrubs that dominate the older stages of fallow. And in the final portion of this report we highlight the importance of sheep manure in the economy of agropastoral households.

More than half the rangelands of San José Llanga (2260 ha) may be considered saline, with low vegetative cover of salt-tolerant species. At first glance these landscapes look severely overgrazed, but the nature of the vegetation is more closely related to salinity stress than grazing pressure. Salt is present in the groundwater, within about a meter of the soil surface, and also higher in the soil profile. The association of salt and silt in these soils indicates that the current soil salinity is derived from ancient lake deposits. Ongoing trials are testing procedures for rehabilitating saline rangelands using salt-tolerant forage shrubs.

Overgrazing is often blamed on a rising rural population, on the assumption that households with less land exert high grazing pressure on their limited resources. In order to examine this more closely, we followed the sheep flocks of five families owning varying amounts of grazing land, and found that land ownership may be less of a limitation to flock size than labor available for herding. A family relatively well endowed with grazing land could not fully exploit its forage resources because the herding was being done by young children who could not move far from the homestead. In contrast, a family owning about one tenth the amount of grazing land had a larger flock herded by two teenage girls who cleverly exploited old fallow fields that become pseudo-communal because of their low grazing value. Although herd size, grazing resources and herd management strategies differed markedly among the five families, they all kept their sheep on a comparable nutritional plane.

There are broad expanses of shrub-dominated rangelands near Santiago de Machaca in which one to several thola shrubs grow on a mound about 10 cm higher than the interspaces. We found that the soil of the shrub mounds was more fertile than the interspace soil and had an infiltration rate about ten times higher. Particle-size analysis of the two soil profiles indicated that the mounds were part of the original soil profile which had eroded in the interspaces, and not the result of litter

accumulation and wind-blown deposition. Therefore the difference in height between the shrub mounds and the eroded interspaces can be used as an index of site deterioration.

During the many years that farmland is left in fallow after cropping, thola shrubs become established and are harvested for fuelwood when they reach 40 cm in height. We found that wood production peaks between 10 and 15 years of fallow, and varies depending on soil type. On the more fertile, young alluvial soils the peak wood yield was over 7 metric tons per hectare, four times the yield obtained on older alluvial soils whose fertility is diminished.

Sheep manure is a major asset of livestock producers at San José Llanga. The average household flock produces 12 tons of manure per year, half of which is deposited overnight in the homestead corral. About half the families of San José Llanga apply sheep manure when planting potatoes instead of using chemical fertilizers, although the trend is toward the chemical form. Those who use manure for fertilizer acknowledge that their potato crop has lower yield but they claim that it increases the forage on fields in early fallow and improves soil structure. Chemical fertilizer tends to have an adverse effect on soil structure, but it is easier to apply than manure. Manure is also a cash crop. Only 8% of the manure left in the corrals is put on potato fields; the remainder is sold to orchardists and vegetable growers in the high valleys, but at a considerable discount. We estimate that the value of manure that leaves the community is approximately $14,000 in equivalent bags of urea fertilizer, but the people of San José Llanga receive only $1,400 in cash from the buyers.

Research

For most of 1994, the SR-CRSP program in Bolivia anticipated a premature termination of effective research on the Altiplano due to retraction of USAID support in 1995. In view of this situation, the range ecology project concentrated its efforts on finishing research efforts initiated in 1993 and ensuring that Bolivian students working with the project fulfill the thesis requirements of their degrees. The outcome of some of the research initiated in 1993 will not be known until after the rainy season of 1994-1995. This is especially true for the range improvement trials described in the 1993 Annual Report; therefore, the results of these resource rehabilitation studies will be discussed in the 1995 Annual Report. The 1993-94 study of High Andean rangelands in the alpaca region near Cosapa will also be covered in the 1995 Annual Report, along with the research on alpaca production strategies being conducted in 1995 by Lita Buttolph, a doctoral student. The soils and vegetation inventory of Santiago de Machaca was discontinued when it appeared that the research program for which the inventories were to supply baseline data would be curtailed as part of SR-CRSP program retrenchment.

Four of the five research activities presented in this Report focus on the community of San José Llanga, which has been the principal site for the SR-CRSP program in Bolivia. The fifth activity, development of an index to assess range condition, was carried out on the shrublands of Santiago de Machaca. As indicated above, coverage of range ecology research at our third site in the alpaca production zone will be included in the next annual report.

Effects of Salinity on Vegetation of San José Llanga Rangelands

Results presented in the 1993 Annual Report showed that ecotones between halophytic plant communities were strongly associated with abrupt changes in soil salinity. The preliminary analyses also suggested that some of these ecotones are migrating, which will eventually alter the areas occupied by the various halophytic vegetation types. In some instances the shift in plant community distribution leads to an expansion of highly saline patches at the expense of less saline ones.

Further analyses conducted in 1994 of the soil and vegetation data collected along these saline ecotones indicate that change in soil salinity is only one factor that determines the occurrence of abrupt ecotones in saline areas of San José Llanga.

Furthermore, contrary to our initial impressions, we discovered that the relationship between soil salinity and underground water is rather weak, suggesting that factors other than groundwater salinity and depth to the water table were also important determinants of soil salinity. Herein we present the results of these final analyses and advance our conclusions as to the processes associated with soil salinity and the distribution of halophytic species in the rangelands of San José Llanga. We believe that much of what we have learned is applicable to other areas of Bolivia's central Altiplano.

This field study undertaken by Marco Garabito was initially designed by Martin Gonzales and later supervised by Joao S. de Queiroz. Mauricio Cuesta provided guidance and assistance with the data analysis.

Factors Associated with Abrupt Ecotones

Soil and vegetation were sampled at 6 points along transects perpendicular to abrupt ecotones. At each of these points vegetation cover was measured and the soils sampled and analyzed. The soil parameters that were measured included particle-size distribution and surface and sub-surface electrical conductivity (EC) and pH. We also determined the depth to the water table and the salinity of the groundwater. These data were subjected to multiple linear regression and cluster analysis.

The execution of the multiple linear regression analyses had two objectives: (1) to identify the factors that were significantly related to plant species cover; and (2) to identify soil and groundwater characteristics that were significantly related to soil salinity. In the first case, species cover was treated as the independent variable and the soil and groundwater parameters were treated as independent variables. The cluster analysis aimed at a stratification of San José Llanga's salinized areas into land-units with distinct ecological characteristics, denominated as ecological sites. In the cluster analysis, the sample points were treated as objects and soil and groundwater parameters as attributes of the sample points.

The significant ($p<0.01$) but weak relationship between halophytic species and salinity is illustrated in Figure 1, where plant cover of *Salicornia pulvinata* (SaPu) is plotted against electrical conductivity of the saturation extract. Similar analysis for *Distichlis humilis* (DiHu) and *Anthobrium triandrum* (AnTr) yielded analogous results over different salinity ranges. Whereas high plant cover for SaPu was concentrated between 40 and 80 mS/cm, for AnTr and DiHu this occurred between 0 and 20 mS/cm. The low correlation between plant cover and salinity argues strongly that other factors besides salinity control the distribution of halophytic plant species in San José Llanga.

Figure 1: Relation between cover of Salicornia pulvinata, a halophytic perennial, and the electrical conductivity of the soil (mS/cm of soil saturation extract)

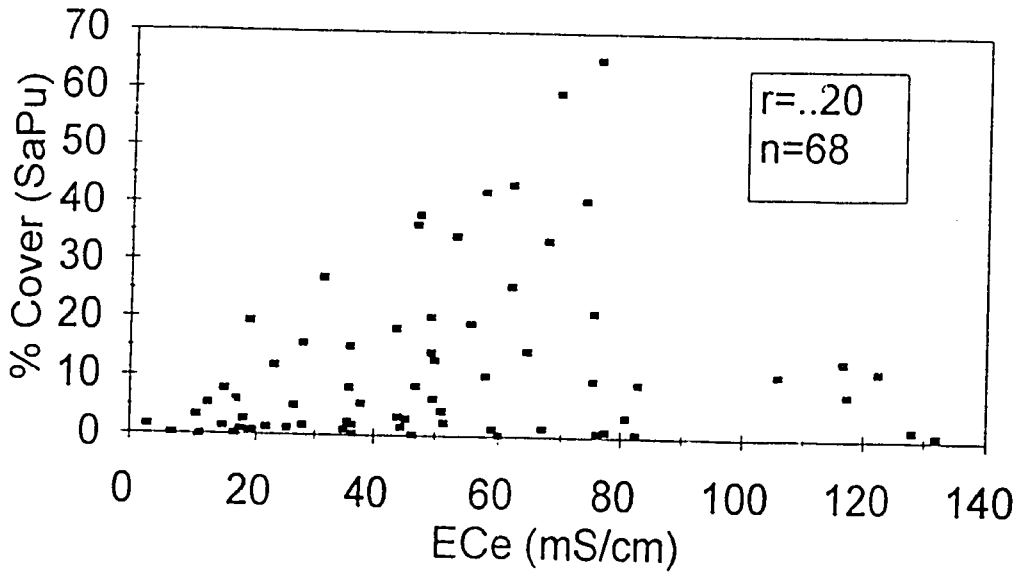


Table 1. Regression coefficients for the edaphic parameters that were found to be significantly associated with cover of Salicornia pulvinata.

Variable	Coefficient	Prob>|t|
pH surface	13.43	0.06
pH subsurface	-14.57	0.004
EC surface	2.18	0.05
EC water table	0.86	0.0001
1/depth water table	15.34	0.002
1*2 (interaction)	-0.27	0.06

The parameters for the linear regression equation relating cover of SaPu and several edaphic factors are presented in Table 1. A complete discussion for similar analysis involving AnTr and DiHu are contained in Garabito's thesis (1994).

The R-squared for the linear equation relating cover of SaPu and edaphic parameters was 0.56. The model was highly significant ($p<0.0001$) indicating that the parameters considered do have an influence over the cover of SaPu. It is readily seen that the conductivity of the surface horizon is only one of several factors and interactions that influence the distribution of SaPu. The fact that depth to the water table and electrical conductivity of the groundwater appeared as significant variables indicates that the distribution of SaPu is strongly influenced by the depth and quality of the groundwater. In the case of San José Llanga, a shallow water table and saline groundwater are associated with increased cover of SaPu.

The parameters of the linear equation describing the relationship between edaphic factors and surface salinity are presented in Table 2. The R-squared for the linear equation was 0.63 and the model was highly ($p<0.001$) significant. The analysis revealed that of the soil factors that were considered, the content of silt had the strongest association with the electrical conductivity of the surface horizon. In other words, silty soils tend to be saline.

In San José Llanga, silty soils are closely related to lacustrine deposits. We conclude, therefore, that the bulk of the salinity in San José Llanga's rangelands is inherited from the parent material which was deposited during a previous climatic regime. The predominance of a high water table and poor internal drainage make the rehabilitation of these soils extremely difficult, as previously indicated in the 1993 Annual Report.

Table 2. Regression coefficients for the edaphic parameters that were found to be significantly associated with soil surface salinity.

Variable	Coefficient	Prob>|t|
Silt	1.147	0.0001
EC water*silt	0.0033	0.06

Stratification of Saline Areas

The cluster analysis in which sample points were treated as objects and soil and vegetation parameters as attributes identified five kinds of saline rangelands in San José Llanga (Table 3). Their spatial distribution is presented in Garabito's thesis (1994). The large area dominated by highly saline clay soils (Site V) points once again to the limitations to production imposed by soil salinity.

Table 3. Characteristics of five ecological sites in the salt-affected rangelands of San José Llanga

Site	EC[1] (mS/cm)	Species	Texture[2]	Depth H_2O (m)	Area (ha)
I	1.4	PaLe-AnTr	S	1.6-2.5	614
II	17.5	AnTr-DiHu	C-CL	0.8-1.4	313
III	10.0	DiHu	C-CL	0.8-0.9	417
IV	56.8	SaPu	C	0.6-1.8	1530
V	118.3	bare soil	Variable	0.7-2.2	minimal

1) EC = conductivity of the saturation extract (milliSiemens/cm)
2) S = sand; C = clay; CL = clay loam.

Relationship Between Land Resources, Grazing Pressure and Flock Performance

The notion that the rangelands of Bolivia's Altiplano are in poor condition is widespread. A call for actions to correct the present situation is repeated in virtually every publication that deals with the ecology of the Altiplano. This clamor, however, is made without a proper understanding of the various factors — both biological and socioeconomic — that lead to what is perceived as range degradation. In the absence of an adequate body of knowledge, overgrazing emerges as the popular, principal villain, and most prescriptions for improved range management include either the implementation of rational/rotational grazing systems or the reduction of stocking rates.

In order to shed some light on the reasons why agropastoralists would tend apply heavy grazing pressure on their forage resources, we conducted a study designed to investigate the relationship between land resources, grazing pressure and flock performance. We hypothesized that households with reduced land resources would be forced to apply higher grazing pressure in order to meet household needs. Thus overgrazing would be a function of the imbalance between land ownership and herd size, and should be reflected in lower levels of animal productivity.

The fieldwork for this study was done by Alcira Ramos Quispe under the supervision of Joao S. de Queiroz, with helpful advice from D. Layne Coppock.

Approach

To test this hypothesis we followed five flocks for 9 months (December through August). Because stocking rates and actual grazing pressure have little practical applicability in the San José Llanga context, we developed an index that reflects the overall quality and quantity of forage that is presented to the flock in a day-long grazing trajectory. The index integrates the results of two equations.

The first equation yields an index (I_{fp}) that reflects the quantity and quality of the vegetation patches that are grazed. It has the following formula:

$$I_{fp} = \hat{A}\frac{(B_i)^*(V_i)}{v_i}$$

where B_i is the biomass of species i; and V_i the forage value of species i. To arrive at values of V_i for the different species we interviewed twelve herders and asked them to rate the species on a scale of 0 to 10 in which the lowest value was ascribed to *Astragalus*, a species deemed useless as forage, and 10 to alfalfa. The interviews were conducted with the assistance of a hand-held herbarium. The second equation integrates the grazing values of all parcels grazed during the day and has the following formula:

$$I_{fd} = \hat{A}\frac{(I_{fp})(T_i)}{T_i}$$

where T_i stands for the time spent grazing in each vegetation patch.

A Diversity of Strategies

The composition of the five families is presented in Table 4. Family 1 has the best labor situation for herding because teenage girls are invaluable animal managers, whereas family 3 finds itself strapped by this production factor due to the large number of young children (5) that are unable to walk for extended periods of time and have limited ability to control the flocks.

Table 4. Family composition of the five households

Family	Children[1]	Teenagers	Adults[2]
1	1	2	2
2	5	0	2
3	5	1	2
4	3	1	2
5	3	1	2

1) 0-10 years old.
2) families 4 and 5 use outside herders

Land tenure by family and adult flock size are presented in Table 5. The distribution of rangelands is relatively equitable but does differ considerably in terms of quality. From the standpoint of area owned, the most pronounced differences are found in the fallow field category, a class of land that is deemed of inferior grazing value by the agropastoralists due to the low biomass of palatable perennial species. The family which manages the largest flock owns a nearly the least amount of land, suggesting that the household may be applying high grazing pressure to its resources. On the other hand, the unexpectedly large size of the sheep flock managed by family 1 and the reduced size of the flock owned by family 3 suggests that other factors besides land area determine the number animals any one family is able to manage. As indicated above, labor may be one of these ancillary factors.

Table 5. Land ownership and adult flock size for the five families

Family	Range (ha)	Fallow (ha)	Food Crop (ha)	Alfalfa (ha)	Adult Sheep
1	7.0	7.0	1.75	5.0	85
2	3.5	9.0	1.25	0.25	23
3	12.0	60.0	3.25	0.5	48
4	18.75	101.0	0.75	3.0	72
5	11.25	30.0	4.0	3.0	64

Examination of the grazing trajectories followed by families 1 and 3 (Figure 2) reveals that both families follow distinct grazing strategies. Land-strapped family 1 used fallow land under long fallow period (FA>3) throughout most of the study period. These fields have relatively low grazing value and their use require great herding skill. In contrast, family three, which has control over a relatively large expanse of land, prefers to graze areas dominated by chilliwa (*Festuca dolichophylla*). The short periods the flock spends walking (WALK) attests to the proximity of these areas to the homestead. Both families change their strategies in August when greater use is made of cultivated forages (ALFA, RESD) and distant areas dominated

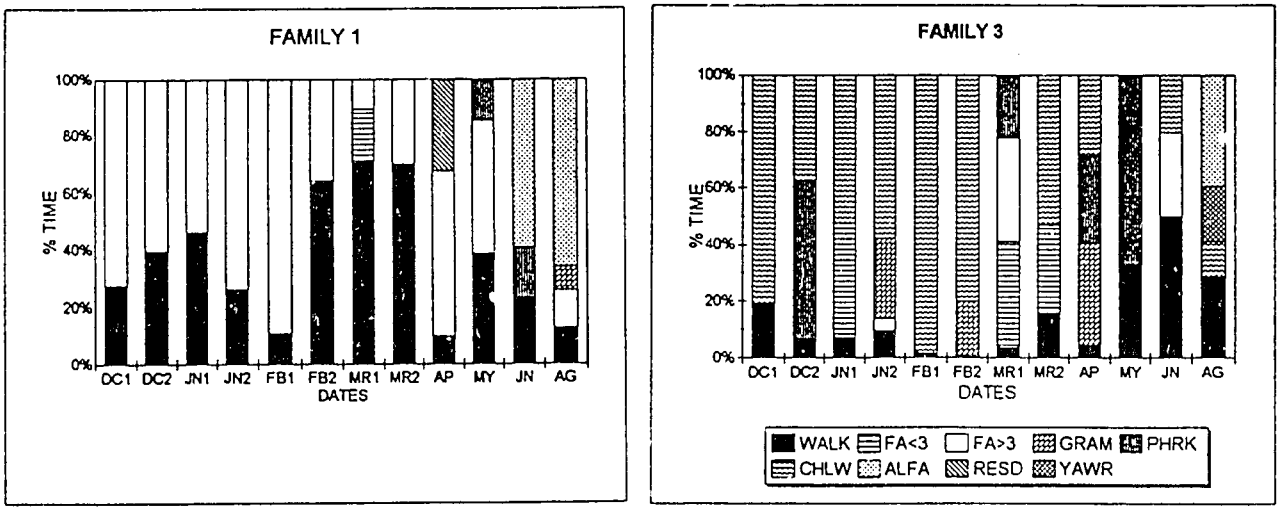


Figure 2: Grazing strategies (percent of time) of a land-limited family (1) and a family well endowed with land (3) from December 1993 through August 1994. [WALK=time spent walking; FA<3=fallow fields 1-2 years old; FA>3= fallow fields 3 or more years old; GRAM=gramadales dominated by Distichlis/Muhlenbergia; PHRK=low-lying vegetation dominated by Calamagrostis species; CHLW=Festuca dolichophylla communities; ALFA=alfalfa fields; RESD=crop residues; YAWR=Hordeum muticum grassland]

by yawara (*Hordeum muticum*).

The distinct strategies followed by families 1 and 3 illustrate how different households utilize available resources to seize opportunities and compensate for limitations imposed by characteristics of the production units, such as shortages of labor or land. In these examples, land-poor family 1 makes intensive use of fallow fields, characterized by relatively low forage value and therefore treated as a pseudo-communal grazing resource, to make up for the small land area that it possesses. Family 1 is able to follow this strategy and keep a large flock due to its labor pool that includes two experienced teenage female herders. In contrast, family 3 opts to graze high quality rangelands near the homestead, probably due to the large number of young children that precludes large displacements. In order to compensate for the reduced mobility, family 3 is forced to keep a relatively small flock.

Grazing Pressure and Animal Performance

The result of the different grazing strategies is reflected by changes in the daily grazing index (Ifd) over the study period (Figure 3). An analysis of variance showed that its value did not differ significantly between families. On the other hand, significant differences were detected between dates with December and January registering the lowest mean values for the five families and August the highest. At first glance, these results contravene common sense; however, closer scrutiny reveals that this behavior stems from rational grazing strategies.

December and January of 1993-1994 were characterized by torrential rains and flooding in the San José Llanga area. This restricts grazing to well-drained areas, primarily fallow fields (families 1, 2, and 4) and gramadales (families 2, 4, and 5) dominated by *Distichlis humilis*. Mud and rain also forced families to graze in the vicinity of the homestead (families 3 and 4). In the case of the fallow fields, it is during the early rainy period when forage value of fallow fields reaches its peak.

The surprising increase in the Ifd that occurred in August is associated with grazing of crop residues, dried alfalfa fields and distant grazing areas that are out of reach during the rainy season due to flooding and mud.

The wisdom of the grazing strategies utilized is reflected by the performance of the flock (Figure 4). The average weight gain curve for young lambs closely followed the grazing index. In spite of the relatively

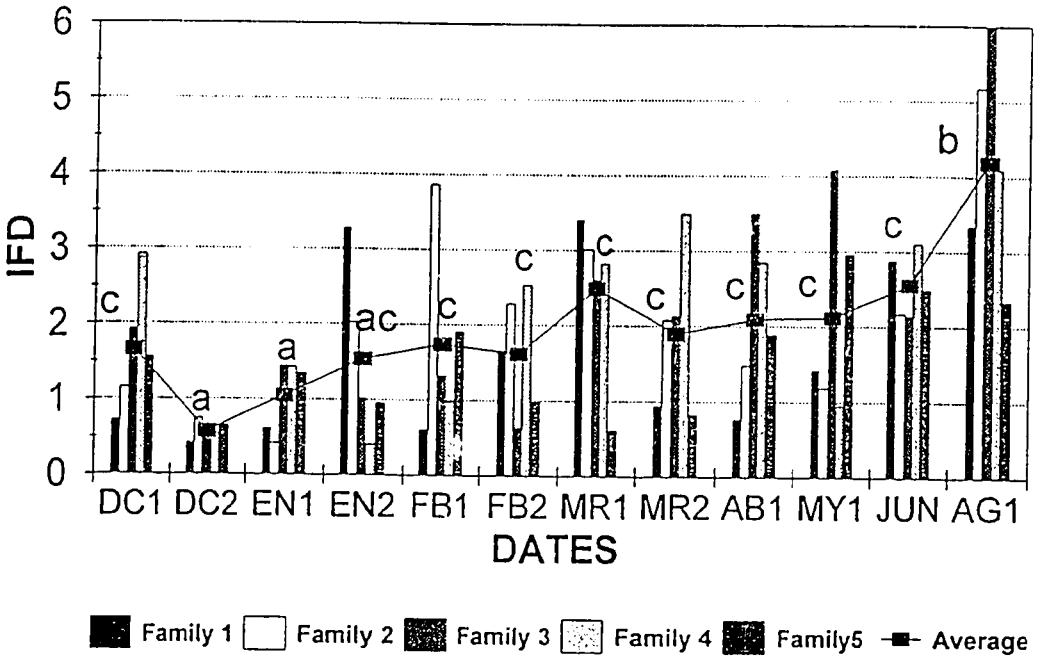
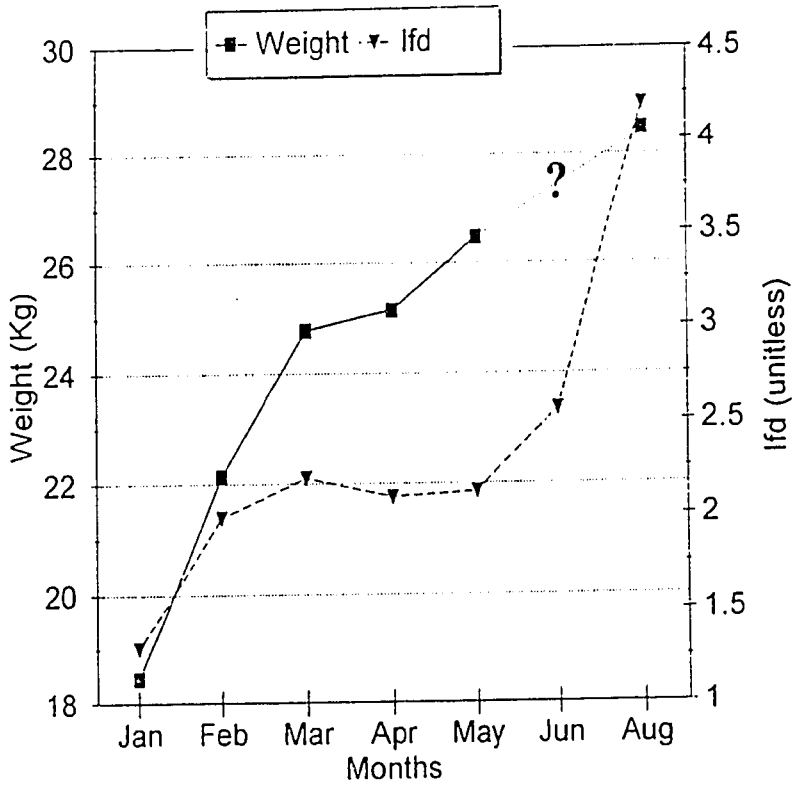


Figure 3: Daily grazing index (an indication of quantity and quality of forage on offer) of sheep flocks herded by five families from December 1993 through August 1994.

low value of grazing in January, nutritional requirements were apparently met.

The above leads us to conclude that the grazing strategies followed by the agropastoralists in San José Llanga are rational and efficient. There is little to be gained from a modification of grazing management *per se*. We believe that to increase flock productivity it is necessary to increase the availability of feed resources in rangelands and from cultivated agriculture. In the first case, this may be accomplished by the rehabilitation of saline areas and gramadales. This study also demonstrates that labor availability may limit the full utilization of a production unit's land resources. Unused land becomes available for use by other families.

Figure 4: Lamb live weight and the daily grazing index over the 1994 study period. [No lamb weight data is available for June.]



Shrublands dominated by *Parastrephia lepidophylla*, a low-growing shrub regionally known as thola, cover extensive areas of Bolivia's altiplano. During our soil and vegetation surveys in the Santiago de Machaca area, we observed that relatively large (2-3 m diameter) shrub-covered patches were usually associated with hummocks that stood between 5 and 15 centimeters above the surrounding interspaces.

Hypotheses and Test Predictions

We hypothesized that the difference in relief between shrub-occupied hummock and shrub interspace resulted from differential erosion between the uncovered and shrub-covered areas. If this were the case then the hummock would be pedogenetically related to the underlying soil horizon. On the other hand, if deposition from wind-blown materials and litter, e.g., were the process that resulted in the microtopographic differences between hummocks and interspaces, then we would expect to find a lithological discontinuity between the hummock and underlying soil material.

Indicators of Range Degradation in Shrublands of Santiago de Machaca

The degree of range degradation is generally determined through comparison of reference areas deemed to be in good condition to the sites being assessed. In regions where lightly used patches are may be found, as in the western United States, the identification of these ecological points of reference does not pose an intractable problem. In the case of Bolivia and many other countries where rangeland use has been intensive for centuries, the identification of sites that may be used as ecological reference areas is difficult. In these cases alternative approaches must be found. One possibility is

the utilization of small-scale patches within a given area of land that represent remnants of a pre-existing and superior ecological status.

Approach

We undertook a test of these hypotheses on two geomorphic units in the community lands of Santiago de Machaca; one an alluvial terrace and the other a broad alluvial fan. The first was covered by Luvisols with surface textures that ranged from sandy loam to loam; the second by Cambisols with clayey surface horizons.

Within each geomorphic unit we excavated, described and sampled two soil profiles: one located in the hummock, the other in the interspace adjacent to the hummock. We determined the particle-size distribution (6 particle-size classes), bulk density, and organic carbon, phosphorus, and nitrogen content. Using a single-ring infiltrometer we measured infiltration rates in four paired plots — hummock and interspace locations forming a pair — in each of the two geomorphic units.

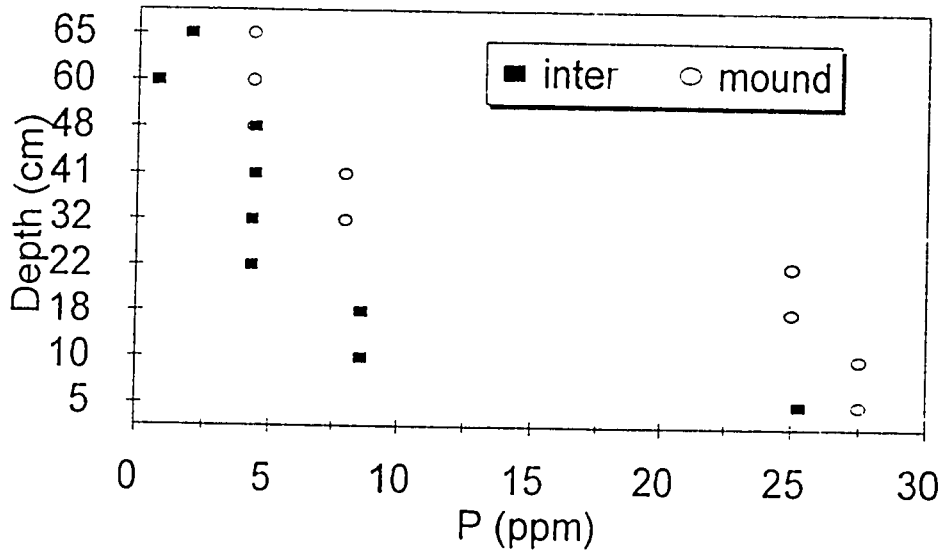
To investigate the presence of lithologic discontinuities, we subjected the soil horizons of each geomorphic unit to a cluster analysis. The horizons were treated as objects and the particle-size classes as differentiating attributes. We used a smoothing routine to graphically depict the differences in infiltration rates between the hummocks and interspaces.

Results

The results for the two geomorphic units were analogous. Here we present only those that pertain to the alluvial terrace.

The Ah horizons of the profiles differed in thickness by 5 cm, a discrepancy similar to the height of the hummock mound. The differences in surface soil structure between the two profiles were striking. The surface horizon of the mound soil had a strong medium granular structure whereas the surface of the interspace soil was characterized by a well-developed platy structure.

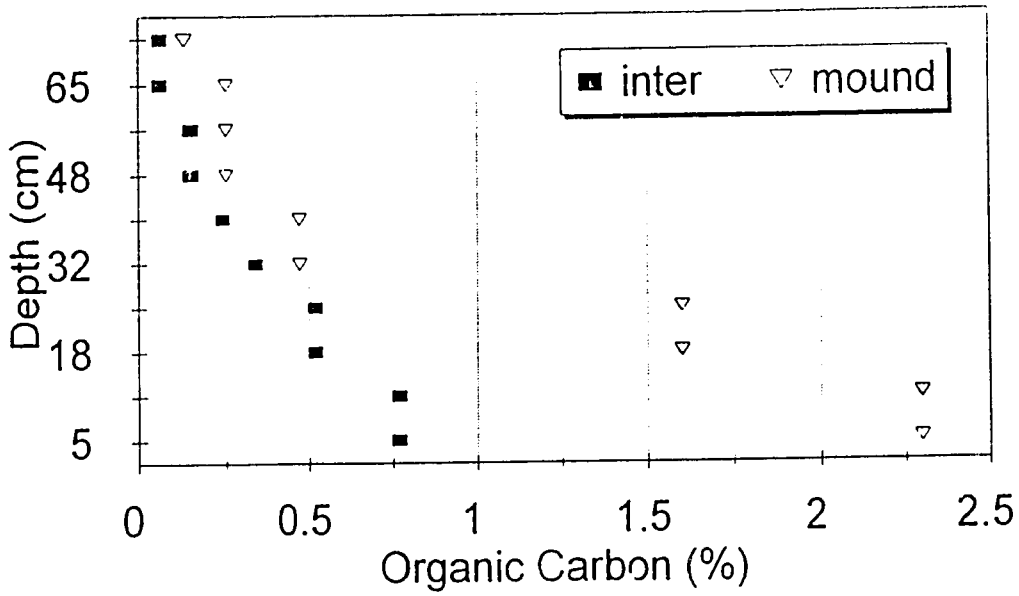
Figure 5: Phosphorus concentration at different depths in the profile for mound and interspace soil profiles of thola shrub rangelands.



Differences in the distribution of P with depth between the soil on the mound and the interspace are pronounced (Figure 5). Whereas the 5 surface cm of the two profiles contained similar amounts of P, the interspace profile exhibited an abrupt decrease in the concentration of this nutrient within the top 10 cm. In contrast, the P content of the mound profile remained high throughout the first 20 cm of depth. Similar trends were encountered with respect to the organic carbon content of the two profiles (Figure 6).

The differences in surface structure between the two soils were strongly related to different infiltration rates. This is shown in Figure 7, which portrays infiltration rates on the shrub-occupied mounds up to ten times that of the interspace soils.

Figure 6: Organic matter content at different depths in the profile for mound and interspace soils of a thola shrub rangeland.

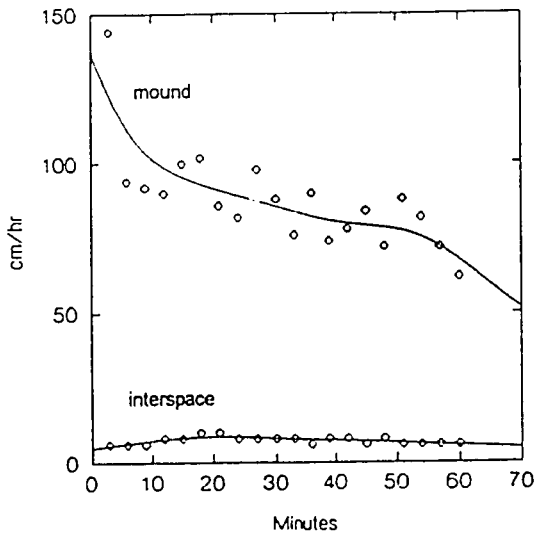


The cluster analysis of the soil horizons identified four lithologic discontinuities represented by clusters "A," "B," "C" and "D." This was expected due to the alluvial origin of the deposit. The features of particular interest are: (1) all Ah horizons from both profiles clustered together; and (2) the two Ah horizons of the mound soil were very similar (Figure 8). The above results suggest that the material in the mound, represented by horizon Ah1(m), and the material in the underlying horizon Ah2(m) are derived from the same parent material and therefore pedogenetically related. This is a strong indication that the difference in height between the mound and interspace results from accentuated erosion in the interspace.

Conclusions

Based on our analyses we concluded that small-scale soil differences may serve as indicators of range degradation in the tholares of the altiplano. Changes in soil structure may drastically reduce infiltration rates and contribute to the aridization of the region. To what extent this approach is applicable to other regions of the world has yet to be determined, but the theoretical concept has considerable promise and its application is feasible.

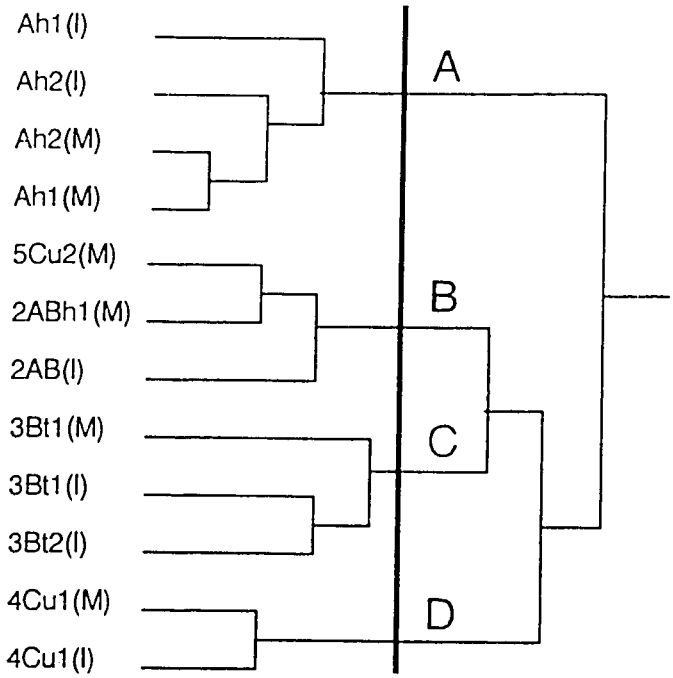
Figure 7: Infiltration rate (cm per hour) at the surface of mound and interspace soils in a thola shrub community



Fallow Fields and Fuelwood Production

After 4 to 6 years of cropping, agricultural fields on the sandy- soil uplands of San José Llanga enter a fallow period

Figure 8: Dendrogram of the cluster analysis of particle-size characteristics of soil horizons for the mound (M) and interspace (I) profiles.



animal nutrition projects have identified a drop in the forage value of fields beyond the first three years. The effect of the long fallow period on soil fertility, and thus subsequent crop yield, is still under investigation.

From the standpoint of forage production alone, it would appear that much can be gained from a reduction of the fallow period to only three or four years. However, this may have a negative impact on the fuelwood situation for families in the community. Thus, we undertook this study to investigate the relationship between length of fallow, land-use history of the field, and its soil characteristics, on the fuelwood production of fallow fields in San José Llanga.

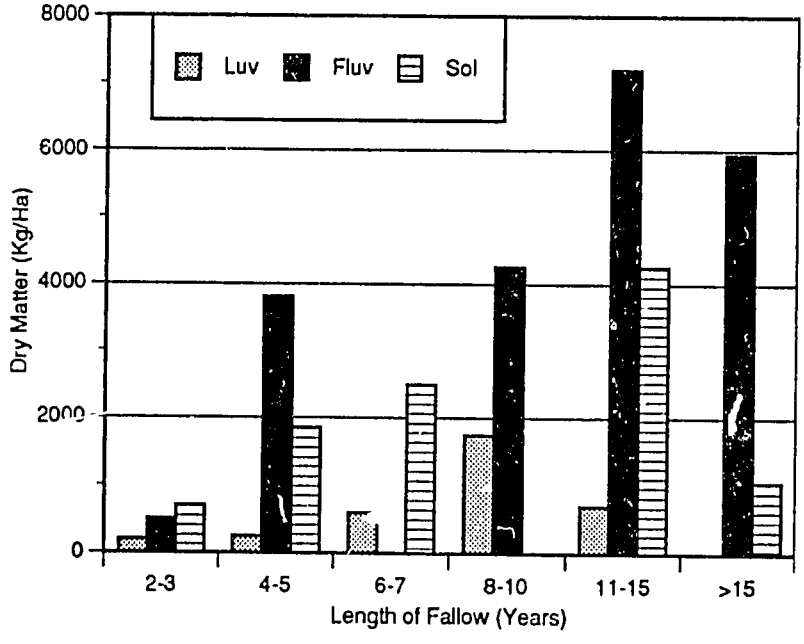
The field study was conducted by Ciro Barrera under the supervision of Joao S. de Queiroz and Jaime Valdivia. Mauricio Cuesta contributed his expertise to the data analysis.

The methodology and results related to species composition were presented in the 1993 Annual Report.

which usually lasts at least 10 years and may be as long as 20 years. Fallow fields are an important category of land in agropastoral production systems at San José Llanga. They produce forage for livestock and fuelwood for households. Elsewhere we have shown that in San José Llanga fallow fields provide crucial grazing for land-limited households.

As stated in the 1993 Annual Report, the forage value of fallow fields does not tend to increase with length of fallow. In fact, studies undertaken by both the range ecology and the

Figure 9: Biomass of standing crop of thola shrubs (Parastrephia lepidophylla) on fallow fields of different ages on three soil types: Lubisols (Luv), Fluvisols (Fluv) and Solonchaks (Sol).



The current report is concerned with data related to fuelwood produced by the dwarf-shrub *Parastrephia lepidophylla*, locally known as thola. A complete treatment of land-use history and other aspects of fallow field management and ecology are covered in detail by Ciro Barrera in his thesis (1994). The biomass data presented below are from a sample of 54 fallow fields of varying ages distributed amongst three soil types. The woody biomass for each field was estimated in 6 randomly located plots utilizing the reference unit technique. The land-use history for each field was obtained through interviews with the owners.

Effect of Length of Fallow Period

The amount of biomass of *Parastrephia lepidophylla* (PaLe) for fallow fields of different fallow length classes is presented in Figure 9. The accumulation of total biomass reaches its maximum (1697 kg/ha) on Luvisols in fields with 8-10 years of fallow. On Fluvisols (7221 kg/ha) and Solonchaks (4218 kg/ha) this occurs in fields that have been under fallow for between 11 and 15 years. The production of biomass on Fluvisols is over four times that on Luvisols.

All woody biomass, however, is not used as fuelwood. Therefore, we conducted an analysis of the vertical structure of thola populations in fields that had been under fallow for different periods of time. The results for fields on Fluvisols are depicted in Figure 10.

Through interviews and observations we determined that fuelwood extraction is restricted to plants that exceed 40 cm in height. The density of this size-class peaks in fallow fields in the 11 to 15 years age category. Beyond this there is a decrease in the density of plants suitable for fuelwood and a surprising increase in plants less than 21 cm in height. We advance two possible reason for these results: (1) the removal of tall plants for fuelwood results in a decrease in the density of tall plants; (2) the churning of the soil surface during the extraction of tall plants fosters the germination and establishment of a young (short) cohort of shrubs. The latter explanation implies that the traditional thola extraction technique which entails hand-removal of the shrub with a pick may be included in sustainable thola management schemes.

The interactions between fuelwood extraction and length of fallow period lead to a peak accumulation of biomass in areas under fallow for 11-15 years (Figure 11) for all three soil types. Fluvisols exhibit the highest fuelwood accumulation of the three soil types studied, due to a relatively higher level of fertility and more favorable groundwater quality. The production of fuelwood on Luvisols is but a fraction of that on Fluvisols and Solonchaks, indicating that a reduction of fallow periods in Luvisol areas would not have a significant negative impact on fuelwood availability for the community as a whole.

Figure 10: Vertical structure of thola shrub populations on fallow fields of different ages located on Fluvisols. Structure is presented in terms of 4 height classes (1-20, 21-40, 41-60, and >60 cm).

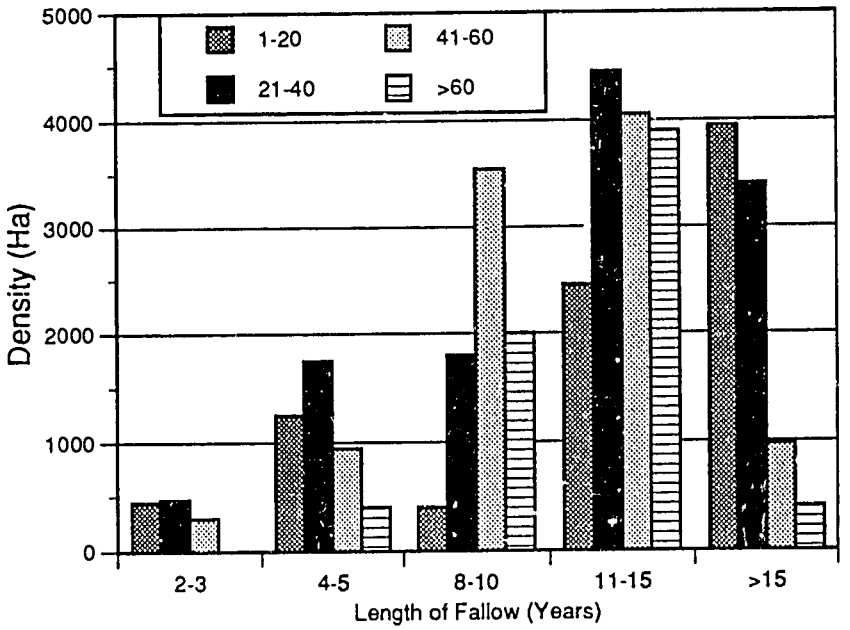
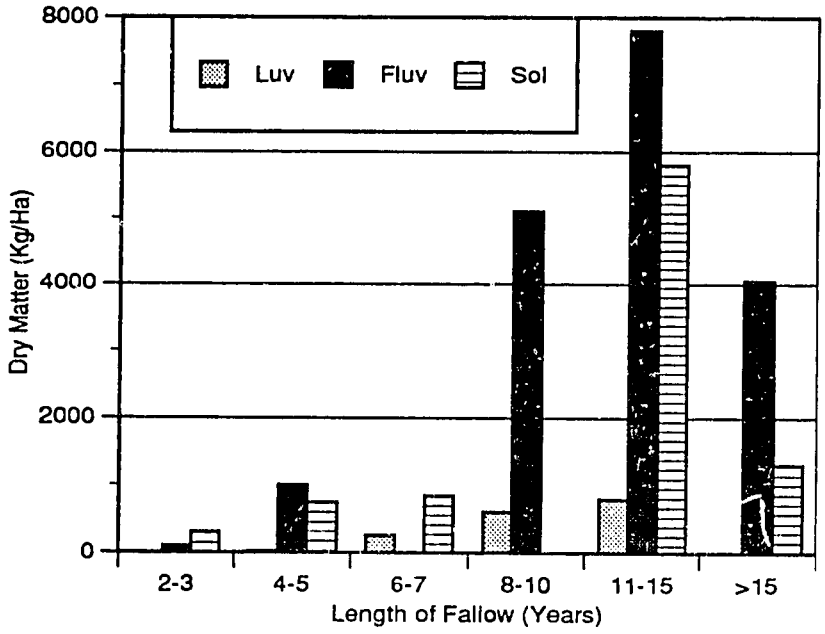


Figure 11: Dry matter accumulation of fuelwood on fallow fields of varying age and soil type: Luvisols (Luv), Fluvisols (Fluv), and Solonchaks (Sol).



camelid dung has been a key agropastoral interaction on Bolivia's altiplano. Although this remains a common custom, with the improvement of the region's infrastructure and commerce there has been a recent tendency for agropastoral communities to replace this time-tested practice with chemical fertilizer application. Unused manure is sold and transported from San José Llanga to areas with higher agronomic potential.

The shift from the utilization of a locally produced organic soil amendment to imported

Influence of Land-Use History

Finally, the multiple regression analysis in which thola density was related to land-use history revealed that the use of tractors to plough land, instead of animal traction or hand-held implements, leads to higher shrub density. This was reflected by a positive and significant ($p<0.01$) regression coefficient associated with the use of this machinery (Table 6). Other factors that have a significant influence over the density of thola are the length of fallow, fallow periods preceding the present cycle of less than five years, and the soil type. The fact that the use of tractors for cultivation and high frequency of soil surface disturbance leads to relatively high densities of thola indicates that plant establishment is favored by thorough and frequent soil surface manipulation.

Table 6. Regression coefficients of the linear multiple regression in which density was treated as a dependent of land-use practices

Variable[1]	Coefficient	pvalue
INTERCEPT	13638.00	0.0001
D2	-16532.00	0.0001
D3	-15298.00	0.0001
D4	-11195.00	0.0001
D5	-11037.00	0.0001
D6	-11439.00	0.0001
D7	-8297.13	0.0001
D10	-7557.46	0.0001
D15	-7154.77	0.0001
TRACTOR	2506.04	0.0087
PRELESS5	2631.89	0.0110
SOLONCHAK	1735.85	0.0481

1) D2, D3, D4, D5, D6, D7, D10, and D15 represent length of fallow. PRELESS5, represents length of fallow period prior to the present cycle of less than 5 years. All variables were treated as binary "dummy" variables.

Manure Production, Management, and Nutrient Movement

Over the centuries, the manuring of cultivated fields with sheep and

chemical fertilizers may have important implications for the long-term biological and economic performance of the agropastoral production systems. Manure, in spite of its relatively low macro-nutrient content, is cheap, improves soil condition via enhanced organic matter, and adds important micro-nutrients to cultivated fields that are lacking in chemical fertilizers. On the other hand, chemical fertilizers contain high concentrations of macro-nutrients but their long-term use is often associated with a deterioration in the physical properties of farmland soils. Further-more, nutrients added as chemical fertilizer are more prone to leaching and volatilization.

This SR-CRSP study conducted by Zulma Victoria under the supervision of Joao S. de Queiroz, attempted to quantify the movement of manure (and associated macro-nutrients Nitrogen and Phosphorus) derived from manure production and management practices. In San José Llanga rangelands act primarily as a nutrient source, whereas cultivated fields and external markets are nutrient sinks. Therefore, the study quantified the amounts of bulk manure and nutrients (N and P) that move from rangelands to the corrals; the amounts that move to cultivated fields in the community; and the amounts that leave the community through sales.

The results presented herein are a preliminary view of the large amount of information generated in the course of this study.

Figure 12: Total production and accumulation of sheep manure in household corrals versus manure deposited on range land, over the 8-month study period.

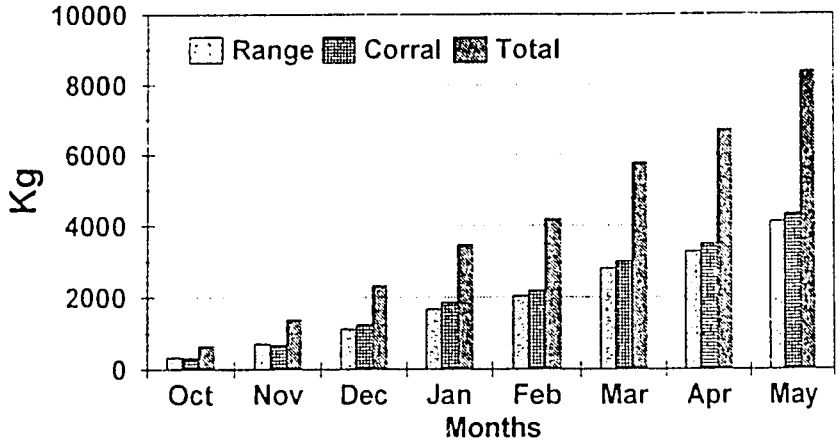
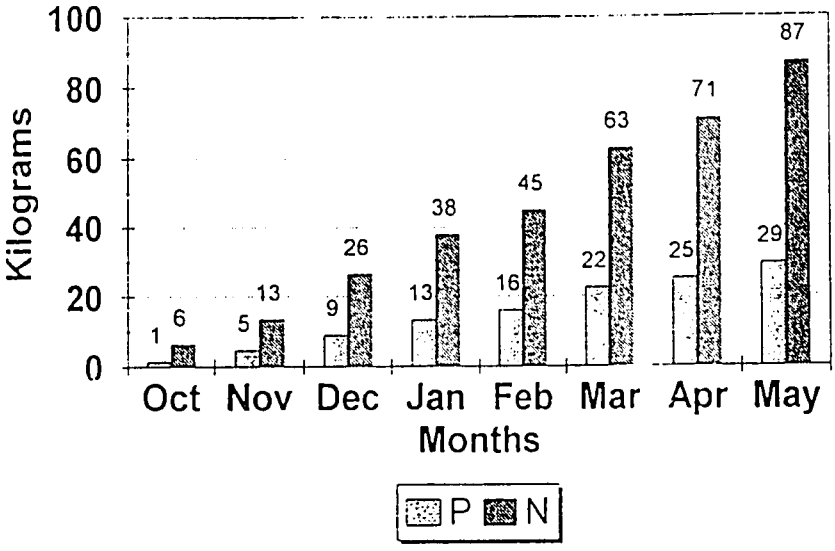


Figure 13: Accumulation of nitrogen (N) and phosphorus (P) in household corrals via manure deposition during the 8-month study period..



Manure Production and Nutrient Redistribution

We monitored fecal production of 4 flocks twice per month. Manure accumulating in fecal collection bags from 3 male sheep in each flock was measured every morning and evening to determine production and to differentiate deposition in overnight corrals

and grazing areas. Fecal subsamples were collected, dried and analyzed for nitrogen and phosphorus content. A sub-set of fresh manure analyzed for N provided an estimate of the proportion of N lost through volatilization as a consequence of our experimental procedures. To determine the amounts of manure applied as fertilizer to cultivated fields, the amounts sold and prices obtained, we interviewed 32 families.

Over 8.1 metric tons of sheep manure were produced by the 47 adult animals present in an average flock during the 8-month study (Figure 12). Of these, 4.1 metric tons (51.8%) were deposited overnight in the household corrals and 4.0 metric tons were left on the rangelands.

The average concentrations of N and P present in the feces during the study period were 2.02% and 0.67%, respectively. The average difference in N concentration between fresh and dried manure for 12 samples was 0.64%, indicating that volatilization of N from fresh manure reduces the nitrogen concentration to 1.38% in the dried form. This agreed with measurements of N present in two samples of untreated manure collected from a corral. We did not detect significant differences in concentration of nutrients between sampling periods, which means that the amount of nutrients present in the feces is directly related to the amount of dung produced.

We calculated that 87 kg of N and 29 kg of P were deposited in the corral during the study period by an average flock of 47 adult sheep (Figure 13). In terms of total N this corresponds to 4.6 fifty-kilogram bags of Urea, a source of chemical N used widely for fertilizer in San José Llanga.

In October, 1994, one bag of Urea could be purchased in the nearby town of Patacamaya for US$21.40 (100 Bvs). Thus, the market value of the nitrogen in manure deposited in an average household corral in eight months is approximately US$98.40. On an annual basis, this amounts to about US$148.00 worth of manure-N per household corral.

Manure Management and Its Economic Value

The potato crop, the first crop in the rotation, is the only one fertilized with manure; only 52% of households interviewed regularly apply sheep manure to their potato crop, placing it in a band directly over the potato seed. The estimated application rate in the 1993-1994 farming season was a mean of 46 bags of air-dried manure per hectare, each bag weighing 20 kg. This translates into an application rate of 920 kg/ha, placed in a band directly over the potato seed. Since the average area fertilized with manure was 0.53 ha per household, we estimate that the average amount of manure applied by families that use this product as fertilizer was about 487 kg.

The number of families in San José Llanga fluctuated between 106 and 96 over the study period. If we assume a population of 100 families with sheep flocks as a basis for calculation, we find that the total amount of sheep manure applied by 52 families (i.e., 52% of households) is 48.7 metric tons. This amounts to only 7.7% of the 630 metric tons (6.3 tons/family flock/year x 100 families) produced by all the sheep flocks in the community. We presume that most of the remainder of the material (586 metric tons) is sold because there is no evidence of long-term accumulation of manure in San José Llanga and decomposition is minimal under the altiplano's climatic regime. The net result is the export of 3,925 kg of P and 11,835 kg of N from the community each year. In terms of Urea N this is equivalent to 654 bags of Urea with a value of US$14,012.

According to the agropastoralists' own estimates, they sell a 46-kg bag of manure for 11 cents (US$). Thus the total cash generated by the community from the sale of 586 metric tons of sheep manure is only US$1,401 per year, a meager 10% of the true commercial value in terms of Urea N content alone.

Advantages and Disadvantages of Manure and Chemical Fertilizers: The Agropastoralists' Perspective

To gain an understanding of the reasons for observed manure management practices we interviewed 25 heads of household to the find out why they use guano or prefer chemical fertilizer; what they perceive to be important differences between the two; and the advantages of one over the other. [These questions were deliberately related to one

another in order to detect inconsistencies in responses.]

A categorization of 91 replies to the three queries stated above are presented in Tables 7 and 8. These tables differ somewhat from the data published recently in an article in RERUMEN because we re-interpreted the survey results utilizing different categories and also included an additional question in the analysis.

Seventy-five percent of the respondents identified the increased forage produced during the fallow when manure is applied as an advantage of using organic soil amendment. Fifty-seven percent of the respondents felt that the application of sheep manure improved soil condition, and 36% noted that when sheep manure is applied to the potato crop it has a beneficial residual effect on the second crop of the rotation, often quinoa. Other important advantages included the low cost of sheep manure (16.0%) and better tasting potatoes (28%). Twelve percent noted that when manure is used *in lieu* of chemical fertilizers the fallow period may be shortened from the customary 10 to 20 years due to a more rapid recovery of soil fertility.

Low potato production from fields fertilized with sheep manure was viewed by 64% of the respondents as a disadvantage of this soil amendment as compared to chemical fertilizers. Other disadvantages listed included reduced moisture availability (40.0%), presumably due to water retained by organic matter in the manure and made inaccessible to the potato plants, and high labor requirements (36.0%).

The short-term gains in potato production achieved through the application of chemical fertilizer and the lower labor requirements of this synthetic soil amendment versus sheep manure, must be weighed against its detrimental effects on soil physical properties, reduced forage production during the fallow period, and lower productivity of the second crop in the rotation, which is not normally fertilized.

Table 7. Advantages of sheep manure over chemical fertilizer as perceived by 25 agropastoralists in San José Llanga

Category	% of respondents
Improves soil	57.6
More forage in fallow	74.8
Higher production of 2nd crop	36.0
Low cost	16.0
Better-tasting potato	28.0
Shorter fallow	12.0

Table 8. Disadvantages of sheep manure compared to chemical fertilizer as perceived by 25 agropastoralists in San José Llanga

Category	% of respondents
Low crop production	64.0
Dries the soil	40.0
High labor requirement	36.0
Nematode infestation higher	8.0

The principal disadvantages of sheep manure, compared to chemical fertilizers, may be addressed through problem-solving research. An increase in the amount of sheep manure applied may overcome the production concerns of the agropastoralists; the reduced soil moisture availability may be solved through treatment of this resource and changes in current application practices; and the high labor requirements associated with the application and transport of sheep manure may be diminished through the development of appropriate farm implements and changes in cultivation practices.

Training

In progress

Lita Buttolph, Ph.D The Environmental, Social and Economic Implications of Expansion of the Alpaca Wool Economy in Cosapa, Bolivia: 1996, Rangeland Resources, Utah State University.

Humberto Alzerreca, Ph.D. Spatial and Temporal Dynamics of Plant Populations in Salt Desert Shrub Vegetation Grazed by Sheep: 1996, Rangeland Resources, Utah State University. [World Bank Scholarship; graduate supervision and some research expenses paid by SR-CRSP.]

Roberto Miranda, B.Sc. The Physico-Chemical Characteristics of the Soils in the Community of San José Llanga and their Relation to the Vegetation Communities: February 1995, Agronomy, Universidad Mayor San Andreas, La Paz.

Julio Pablo Valencia, B.Sc. Low-input Techniques to Improve Thola (*Parastrephia lepidophylla)* Dominated Rangelands in the Santiago de Machaca Region: April 1995, Agronomy, Universidad Mayor San Andreas, La Paz.

Julio Cesar Montecinos, B.Sc. Small Scale Soil Differences as Indicators of Range Degradation: April, 1995, Agronomy, Universidad Mayor San Andres, La Paz.

Alcira Ramos Quispe, B.Sc. The Relationship Between Grazing Resources, Grazing Pressure and Animal Productivity in San José Llanga: March 1995, Universidad Autonoma Tomas Frias, Potosi.

Completed

Robert Washington-Allen, MS Historical analysis of land use/land-cover change on the Bolivian altiplano: a remote sensing perspective: defended July 1993, graduated June 1994, Range Science, Utah State University.

Nelson Massey, B.Sc. Characteristics of Vegetation Communities in San José Llanga: Graduated January 1994, Agronomy, Universidad Técnica de Oruro.

Marco Antonio Garabito, B.Sc. A Synecological Study of Populations of *Salicornia Pulvinata* and *Anthobrium Triandrum* in the Rangelands of San José Llanga: November 1994, Agronomy, Universidad Autonoma Tomas Frias, Potosi.

Ciro Barrera, B.Sc. Land-use and Characteristics of Thola Populations in the Fallow Fields of San José Llanga: September 1994, Agronomy, Universidad Mayor y Pontifica de San Francisco Xavier, Sucre.

Demetrio Luna, B.Sc. Characteristics of Vegetation Communities in the High Andes Area of Aguas Calientes: November 1994, Agronomy, Universidad Técnica de Oruro.

Workshops/Shortcourses

Dr. Joao S. de Queiroz, Resident Scientist for Utah State University conducted a 2-day workshop on methods of rangeland evaluation at the Universidad Autonoma Tomas Frias, Potosi, January 25-26, 1994.

Dr. Joao S. de Queiroz conducted a 2-day workshop on methods of rangeland evaluation at the Universidad Mayor y Pontifica de San Francisco Xavier, Sucre, June 22-23, 1994.

Collaborating Personnel

United States

Brien E. Norton, Principal Investigator, Utah State University

D. Layne Coppock, Co-Principal Investigator, Utah State University

Bolivia

Joao S. de Queiroz, Resident Scientist, Utah State University

Jaime Valdivia, Co-Investigator, Instituto Boliviano de Tecnologia Agropecuaria

Collaborating Institution

Instituto Boliviano de Tecnologia de Agropecuaria
CALLE: Batallon Colorados #24
EDIFICIO: El Condor
Casilla No. 10436
La Paz, BOLIVIA

Publications

Queiroz, J.S. de, C. Barrera, J.V. Valdivia. 1994. La estructura y composición botanica de los campos agrícolas en descanso de la comunidad de San José Llanga, Altiplano Central, en función de los suelos y periodo de descanso. In Hervre, D., D. Genin

y G. Riviere, Dinamica del Descanso de la Tierra en los Andes, ORSTOM-IBTA, La Paz.

Victoria, Z.R., J.S. de Queiroz, B.E. Norton. 1994. Producción y utilización del estiércol en una comunidad agropastoril de Altiplano Central de Bolivia. Bulletin of the Small Ruminant Network (RERUMEN) 3:14-15.

Abstracts

Washington-Allen, R.A., R.D. Ramsey, B.E. Norton and N.E. West. 1994. Historical analysis of land degradation on the Bolivian Altiplano. 79th Annual ESA Meeting, Knoxville, Tennessee, August 7-11. Supplement to Bulletin of the Ecological Society of America 75:242.

Economics of Small Ruminant Production Systems and Markets

Winrock International Institute for Agricultural Development

Enrique Ospina, Winrock International Institute for Agricultural Development, Petit Jean Mountain, Route 3, Morrilton, Arkansas, 72110. Telephone (501) 727-5435, Fax (501) 727-5426, E-mail enriqueO@ollie.winrock.org

Narrative Summary

Primary field activities during this year centered on analyzing the survey results from San José de Llanga (SJL) and gathering information in Santiago de Machaca. Three students completed and defended their thesis work while assisting students supported by other SR-CRSP components. Results from SJL showed that the main factors in determining the herd composition included milk price, natural pasture owned, area of cultivated forage (alfalfa, barley, oats), and the education level of the farmer.

Using herd live weight measures (Animal Units), available biomass estimates, and daily dry matter requirements, biological stocking rates (BSR) were compared with physical stocking rates (PSR). Research showed that PSR was greater than BSR suggesting that the average farm is overgrazing the pasture fields in the community. It was estimated that 57% of the farmers follow a sustainable level of farming while 43% may overgraze their resources.

Land prices were also estimated. The estimated land revenues coincide with the observed rental prices in the community. The land price of a typical farm was found to be about 3800 Bs/ha (US$807/ha at 4.71 Bs/US$). This figure was estimated on the annual rent for each type of production area.

Time and effort was dedicated to collaboration with the Range Ecology component especially in the analysis of field data through statistical analysis (multiple regression with binary regressors). Other activities consisted of conceptual discussions and editing.

Research

The long-term goal of the economics component is to contribute to the development of sustainable crop and livestock production systems which are compatible with the needs and risks faced by small producers in drought-prone agropastoral systems. Three main activities, based on the global plan, constitute the focus of the economics program:

- assessing the resources available for small ruminant production
- evaluating the institutional structure to identify major constraints and propose changes
- analyzing the economic implications of gender roles in production of small ruminants and of processing and marketing products

Production costs

The typical farmer in SJL plants an average of 3.16 crops per year (potato, quinua [*Chenopodium quinoa*], barley, wheat, and faba bean) on an average of 3.56 ha. The typical farming practice is crop rotation for three years (potatoes the first year after fallow, quinua the second year, and wheat or barley the third year before fallowing the land for six years). Agricultural production returns (without considering labor) range from 216% in potato production to 669% in wheat production.

A quadratic production function for each crop (potato, quinua, wheat, and barley) as a function of labor was estimated. The total value of the physical product generated at different levels of labor use was calculated.

There exists a common level of labor involvement (16 days/ha) in crop production that generates an income of approximately 500 Bs/ha. This income generation represents the farmer's off-farm opportunity cost (31.25 Bs/day).

Stocking rates

The existing biomass in natural pastures, fallow fields, and cultivated forages was estimated using data gathered during the growing period of 1992-1993. Live weights of cattle and donkeys owned by SJL farmers were estimated using body measurements from a sample of animals. Average sheep live weight was calculated by using actual weights, the data collected during March of 1992 by SR-CRSP students. The animal units (AU) that the available biomass can support was calculated relating the existing dry matter of usable biomass in the fields with the daily dry matter requirement of an AU. This relationship yields the biological stocking rate (BSR). It can be compared to the AU that the farmer holds per unit area called the physical stocking rate (PSR). The total income (TI) generated by the animal production in the community was calculated, expressed as a function of the BSR and PSR this gave the optimal income (TI^{*BSR} and TI^{*PSR}) for a given AU/ha called the economics stocking rate (ESR).

Results show that PSRs are greater than the BSRs (0.39>0.29 AU/ha). These figures suggest that the average farmer is overgrazing the pasture fields in the community and contributing to the environmental degradation of the altiplano. On a farmer by farmer basis it can be stated that 43% of the SJL farmers are overstocking their fields, but looking at the community as a whole, only 32% of the families are degrading the pastures. This lower percentage of degradation can be attributed to the communal practice of resource management observed among altiplano farmers.

The estimated TI^{*BSR} is 0.31 AU/ha and the TI^{*PSR} is 0.37 AU/ha. When the ESR is greater than the BSR it suggests that there exists economic incentives (market prices) for degrading the fields. Farmers in this group are practicing an unsustainable animal production. On the other hand, when the ESR is less than the PSR, it suggests the existence of inefficiencies in the resource use. Farmers in this group are practicing an inefficient cattle production.

Combining the optimal ESR with the BSR results result in an efficiency (inefficiency)-sustainability (unsustainability) matrix of the animal production in SJL. This analysis shows that 57% (16 families) of the producers are practicing a sustainable animal production. Within this sustainable group, six families (21%) are efficient producers and ten families (36%) are inefficient producers (this group needs assistance to reach the optimal level of resource allocation). The rest of the families (43% of the farmers) are practicing an unsustainable animal production. Within the unsustainable producers, five families (18%) are overusing the resources, efficiently extracting as much as possible from the environment given the existing market prices and farmer's resource ownership. Seven families (25%) are inefficient producers and practice an unsustainable cattle production (this group requires intervention to stop degradation).

Results from the estimation of production costs, stocking rates, and technology analyses are used to estimate land prices. The average SJL farm is 44% fallow fields, 32% native pastures, 13% cultivated forages, and 10% crop land. The estimated annual land revenues coincide with the observed rental prices in the community. Discounting these rents at the long term discount rate, the land price of a typical farm results in 3800 Bs/ha (US$ 807/ha at 4.71 Bs/US$). This figure was estimated based on the annual rent for each type of production area.

Willingness to accept new technologies

It was determined that farmers face a relative price conflict in confronting agronomic practice recommendations when the cost of the recommended agronomic practice is higher than the additional revenues it generates. For example, in potato production use of improved seed requires a

48% cost increase while it generates a 32% revenue increase. The same pattern of revenue generation is observed with a recommendation of tractor use at planting. Its cost increase is greater than the generated revenues by the adoption of such practice (37% vs. 22%).

The median additional income generated by the new cattle production system (calf and milk production) over the old one (calf only) represents the farmer's willingness to accept (WTA) the new cattle production. This WTA implies the farmer's time preference. Farmers discount the future at a rate of 70.5% in nominal terms and at 34.0% in real terms.

Training

Economics students who have completed thesis research:

Rosa Lizarraga. Thesis title: "Cost function and benefit determination on potato production in SJL." (Thesis successfully finished and supported.)

Patricia Illanes. Thesis title: "Technology adoption in milk production among SJL farmers." (Thesis successfully finished and supported.)

José Luis Eyzaguirre. Thesis title: "Labor efficiency of household production systems among SJL farmers." (Field research completed and thesis nearly complete.)

Active support was provided for students funded by other SR-CRSP components. Thesis drafts were reviewed and students were advised on the statistical interpretation of their data on the following subjects: "The effects of fallow periods on vegetation density in the fallow fields in SJL" by Ciro Barrera, USU range ecology student; "Factors related to identification of soil salinization in SJL" by Marco Garabito, USU range ecology student; "Management of vegetation and introduction of forages in native rangelands of Santiago de Machaca" by Julio Valencia, USU range ecology student; "Determination of influencing factors on weight gain in SJL sheep herds" by Betty Villanueva, TTU range nutrition student; "Production and nutrient content of sheep manure among SJL herds" by Zulma Victoria and J. De Queiroz; and "Economic feasibility of feeding discarded llamas" by Jeovana Guzman, University of Wisconsin thesist.

Contribution to Agricultural Sustainability

By identifying the contributing factors to the income generation in the animal production system it is possible to know what makes the efficient farmer efficient and why the unsustainable producer practices an unsustainable production. Sustainable production is practiced by farmers having less labor availability (4.37 vs. 4.58 persons older than 6 years of age), less percentage of improved sheep herds (59% vs. 78%), and less cultivated forage area of alfalfa (2.22 ha vs. 4.14 ha) and barley (1/01 ha vs. 1/37 ha) than those farmers that practice an unsustainable animal production. Efficient farmers possess less labor availability (4.2 vs. 4.61 persons older than 6 years of age), higher percentage of improved sheep herds (88% vs. 56%), higher planted area of alfalfa (3.56 ha vs. 2.76 ha) and barley (1.52 ha vs. 0.9 ha) than inefficient farmers. Additionally, although not statistically significant, the quality of the pasture land owned differentiates these two types of farmers. Farmers practicing a sustainable animal production have less usable biomass in their pasture land (fallow fields, natural pasture fields, plus cultivated forage) than farmers who practice an unsustainable animal production (657 tons vs. 1,494 tons of usable dry matter/ha). The same relationship of pasture quality is observed among efficient and inefficient farmers. Efficient farmers have less amount of available usable biomass than the inefficient farmers (958 tons vs. 10,481 tons of dry matter/ha).

Collaborating Personnel

United States

Enrique Ospina, Principal Investigator
Henk Knipscheer, Co-Investigator
Mark Wilson, Intern

Bolivia

Mauricio Cuesta, Resident Economist
John Vargas, Bolivian Co-Investigator
Jim Yazman, Site Coordinator and Range Nutrition Resident Scientist

Collaborating Institution

Instituto Boliviano de Tecnologia Agropecuaria (IBTA)
Edificio El Condor
Calle Batallon Colorados No. 24
La Paz, Bolivia
tel. 011 591 239 2551

Publications

Cuesta, M. 1994. Land prices and wealth holdings by SJL farmers. Documento de Trabajo. SR-CRSP/IBTA. La Paz, Bolivia.

Cuesta, M. y J. L. Eyzaguirre. 1994. Estructura de costos y determinación de beneficios del sistema de producción del agricultor típico de SJL. Documento de Trabajo. SR-CRSP/IBTA. La Paz, Bolivia.

Cuesta M. y P. Illanes. 1994. Factores determinantes en la adopción de tecnologia entre agricultores de San José Llanga. Documento de Trabajo. SR-CRSP/IBTA. La Paz, Bolivia.

Cuesta, M. y R. Lizarraga. 1994. Función de costos y determinación de beneficios en la producción de papa en San José Llanga. Documento de Trabajo. SR-CRSP/IBTA. La Paz, Bolivia.

Cuesta, M. y N. Massy. 1994a. Estimación del peso vivo de bovinos y asnos por barimetria. Documento de Trabajo. SR-CRSP/IBTA. La Paz, Bolivia.

Cuesta, M. y N. Massy. 1994b. El intercambio ingreso-carga-animal en tierras de pastoreo. Documento de Trabajo. SR-CRSP/IBTA. La Paz, Bolivia.

Republic of Bolivia

República de Bolivia

At 1,098,581 sq. km (424,164 sq. miles), Bolivia is roughly the size of California and Texas combined. It is a country of tremendous topographical diversity. To the west the Andes reach heights of over 6,000m. (20,000 ft.). The Altiplano, a high plateau 3,660m (12,000 ft.) above sea level runs over 500 miles long and lies between two cordilleras having three of the highest peaks in South America. The east is primarily tropical rain forests and in the southeast are the llanos or lowland plains of Gran Chaco. Bolivia has rich mineral deposits of tin, silver, copper, tungsten, bismuth, antimony, and zinc. But despite these mineral riches, most Bolivians are subsistence farmers, raising sugarcane, potatoes, corn, wheat, and rice; cotton and soybeans are the major cash crops.

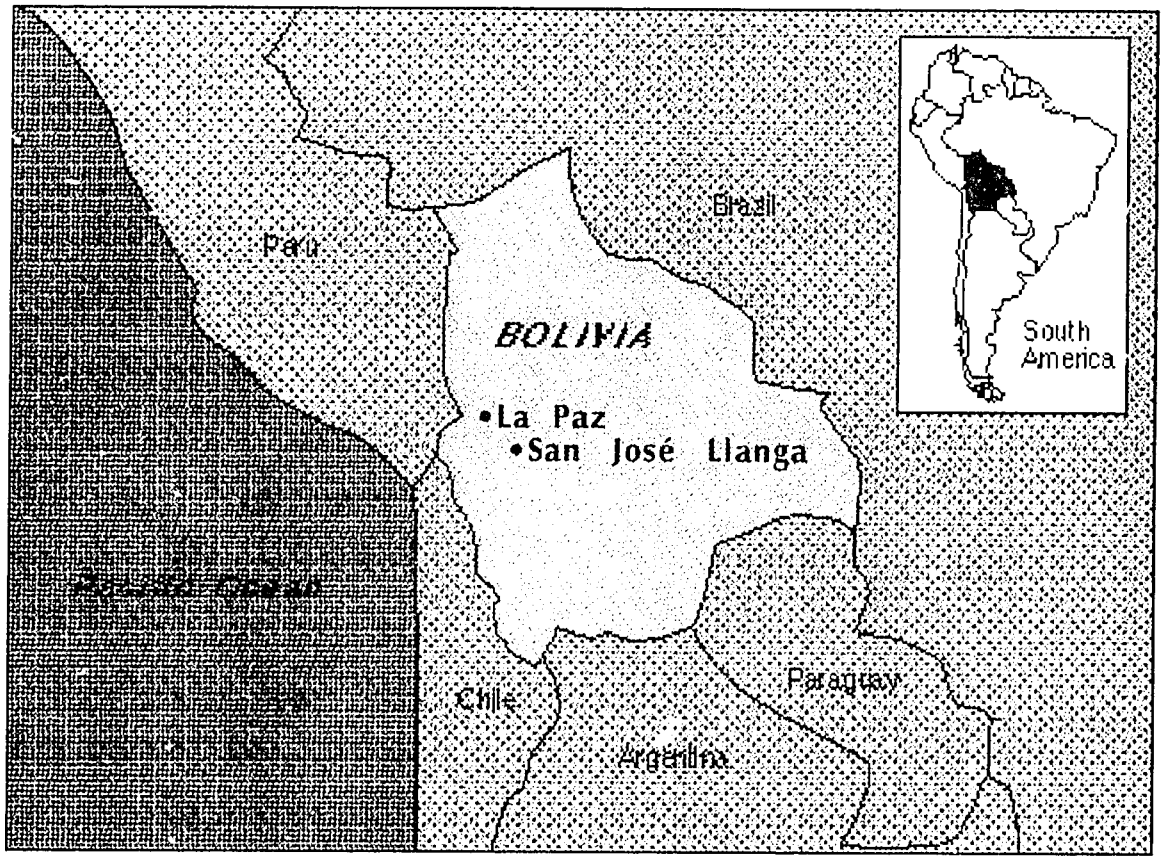
Population (1992 est.): 7,832,000.
Age distrib. (%): 0-14: 41.1; 15-59: 52.4; 60+: 5.5.
Urban (1990): 51%.
Ethnic groups: Quechua 30%, Aymara 25%, mixed 30%, European 14%.
Languages: Spanish, Quechua, Aymara (all official).
Religions: Roman Catholic 95%.
Capitals: Sucre, (legal), La Paz (administrative).
Cities (1989 est.): La Paz 1,049,800; Santa Cruz 615,122; Cochabamba 377,259.

Economy: Industry: Textiles, food processing, mining, clothing.
Other resources: rubber, cinchona bark.
Arable land: 3%.
Labor force: 50% agric., 10% ind. & comm, 26% serv. & govt.
Finance: Monetary unit: Bolivianos (1994: 4.30 = $1 US). Gross domestic product (1990): $4.8 bln. Per capita GDP: $690.

Livestock (1992): Cattle 5,779,000; Pigs 2,226,000; Sheep 7,300,000; Goats 1,440,000.

Livestock Products (1992, in metric tons): Beef and veal 127,000; Mutton and lamb 13,000; Goat's meat 4,000; Pig meat 58,000; Cow's milk 120,000; Sheep's milk 33,000; Goat's milk 12,000.

Communications: Television sets: 1 per 16 persons. Radios: 1 per 1.8 persons. Telephones in use: 1 per 37 persons.



Sociological Analysis of Small Ruminant Production Systems

University of Missouri-Columbia

Michael F. Nolan, International Agricultural Programs, 215 Gentry Hall, University of Missouri, Columbia, Missouri, 65211. Telephone (314) 882-2745, Fax (314) 882-5147, E-mail: agmike@muccmail.missouri.edu

Foreword

This has been a difficult year for all our SR-CRSP researchers and support staff in Bolivia. The uncertain future of the research program, the funding cuts imposed by USAID/Washington that forced the reduction of research activities in order to secure completion of those considered essential (e.g. guaranteeing guidance for our Bolivian students, the present and future researchers of livestock and the peasant communities of the agricultural sector and small peasant producers of the highlands).

This report documents what was accomplished in Bolivia during 1994. However, it is important to note what was NOT done due to the condition noted above over which we had little control. Specifically two areas of high priority to us deserve attention:

- We are finding again the important role that small ruminants play in crop livestock systems with low rainfall and high climatic variability. We had hopes of moving this year to a full research activity in our second site. We decided otherwise because of the ethics involved in "invading" a community to carry out research, with no opportunity to "pay them back" with results that could benefit them in the future.
- Another important area curtailed by the cuts, is the role of livestock in permitting capital accumulation and the ability of households to persist in their communities. A migration study, to understand the push-pull effect of rural-urban relations was postponed, in hopes that the funding situation will change.

No research project like this operates without the support of a great many dedicated people. We who work at the University of Missouri, are certainly indebted to:

- All the members and families of the Peasant Communities San José Llanga and Santiago de Machaca for allowing us to work there. For us this was an indication, a strong one, of their interest in finding alternative technologies and policies that will improve their livelihoods and retain some of the family member in their communities.

  We would like most of all to extend our thanks to the people of San José Llanga who welcomed our team and its endless questions and perambulations with patience, good humor and warmth. We thank especially the community authorities who since 1992 have been willing to take time to ensure the mutual understanding that allows research to go forward.

  We also want to extend our thanks to the people of Santiago de Machaca, especially the people of Okata, and to CIPCA (Centro de Investigación Para la Promoción del Campesinado) for collaborating with us in this research endeavor.
- USAID/Bolivia, through Ing. Hernán Muñoz and Mr. Bill Baucum, ARD, for facilitating the PL-480 funds that have allowed us to

continue research, collaborating directly with our Bolivian counterparts. We want to thank Ms. Joyce Turk (USAID/Washington) for all her efforts and advice through the years she has worked with the program. Finally, thanks are due IBTA for the opportunity of working with them in research, and especially Dr. Edmundo Espinoza and the technical staff of the Livestock and Forages Program at the Patacamaya Experimental Station who have offered friendship and collegiality through these years.

- Special thanks to Lisa Markowitz (Resident Scientist-Sociology) and Christian Jetté (Co-Investigator Sociology) for their continued work with our students and the comuneros of San José Llanga. Their professionalism, dedication and commitment to work in peasant communities with on-farm research methodologies is critical to developing an understanding of the production system and the potential technologies and policies feasible for these environments, the fragile or marginal lands.
- Finally, big thanks to Dr. Jim Yazman and his family for being in Bolivia through these difficult times. Without their willingness to stay in Bolivia, many of the research and training efforts of this year would have been lost. Also, many thanks for all the support of the SR-CRSP Bolivia staff: Guillermo Calderón, Patricia, Katia, Eduardo, and Lic. Mercedes Cuellar.

As of October 1994 the University of Missouri became the coordinator for social science research (economics and sociology) in the Bolivian SR-CRSP. A co-investigator for economics was hired by IBTA in December of 1994. We hope to be able to complete some research activities that will help integrate the social and economic factors conditioning and affecting household crop-livestock systems in the first months of 1995.

Narrative Summary

Several research activities were conducted in San José Llanga and Santiago de Machaca during 1994. Mapping of resources in both communities took place. In the later work was undertaken only in the *estancia* Okata. Access and control of land and livestock in both sites were complete, with different degree of detail and sample size. Though access to land and its management is distinct in these sites, sheep were found to be important determinants of food purchases by peasant households.

The use and perception of technology was studied through a student thesis in the community San José Llanga. A study of manure use was also considered since this animal by-product plays a role in the crop-livestock interactions important to these production systems. Perception of the young about their future in the community and migration were also undertaken in San José Llanga. Information on migration was also elicited in the second site, finding that the population between 19 and 29 migrates to other areas. This second site has a greater emphasis on livestock production the combination of sheep and camelids. Unfavorable market conditions for the latter had impact on household income generation. Demand and consumption behavior in urban areas for meat from llama was studied to understand the social causes of adverse market prices.

Finally diversification as a strategy against the risky or variable conditions imposed by climate, government policies and the markets, was studied. Cluster analysis shows how the combination of resources, age, education, and access mechanisms explain the different portfolio combinations that household families present in San José Llanga.

Two students successfully defended their thesis in Bolivia, one has submitted her final draft and the last two students have completed their field work and are writing their theses.

Research

Activity I:

Baseline studies and ex-ante analyses:

Problem Statement and Approach

These studies are developed in response to the needs of the biological sciences and identified producer problems and constraints pertaining to crop-livestock systems, small ruminants and sustainability.

The decisions of *comunarios* in San José to use sheep manure or purchased phosphates to fertilize food crops pertains to a larger debate in Andean agriculture over the role of imported vs indigenous farming technologies. The material presented below capsulizes the thesis research of Ms. Juana Huanca (directed by Markowitz). These findings also inform our understanding of long-term social perturbations to the production system, and how people's use and perception of environmental resources has changed over time.

The Process of Technology Change: An Andean Dialectic

Problem Statement and Approach

The appropriateness of agro-pastoral technologies for peasant producers are frequently discussed with little reference to or knowledge of micro-level constraints on rural livelihood. On one side, is an indigenous vision heralding the re-valorization of local Andean practices, while on the other are perspectives that simply assume imported technologies are best for improving agricultural production. However, in many small communities like San José, what one finds is use of a combined technology, a mixture of customary practices and recently introduced inputs and tools. And the worst polemics and ethnocentrism aside, the important issues are the reasons any specific technology suits farmers, and the advantages and drawbacks of each. Data of this sort can provide researchers and extentionists a base of information to improve effective interventions and avoid those the producers reject.

Recent years have witnessed attempts in archaeological and ethnological circles to recuperate Andean technologies that have fallen into disuse. Andean in this context means the knowledge, practice and tools used before the European invasion, expressions of the creativity and vitality of indigenous societies. The widespread diffusion of western technologies and the devaluation of local cultures, many now recognize, has meant a loss of technologies created specifically to deal with the challenges of *altiplano* and *cordillera* environments. Proponents of "Andean solutions for Andean problems" also stress the need to conserve natural resources for future generations. Such views correspond with Aymara religious faith, and its reverence for Pachamama, the Earth Mother who encompasses soils, rivers, vegetation, and animals. These constituents of the natural world cannot be subject to mere economic cost/benefit analysis, since all belong to the harmony of nature. This vision, consonant with the notion of sustainable production, has appeal for even the non-religious.

However, as a result of extension programs in the last four decades, a great proportion of Aymara small-holders now raise such non-indigenous products as introduced potato varieties and cattle, and rely on the cash these sectors generate. To maintain this production (more profitable in some years than others) they must buy inputs, creating even greater dependence on cash income, and so the cycle continues. Moreover the new technologies bring additional benefits: among others, they save time, are easier to use, and increase yields. In the San José region, technology transfer programs in the 1960s and 70s promoted the cultivation of imported potatoes, with a technology package that included mechanized tillage, chemical fertilizers and herbicides. The programs aimed to improve production to increase sales to urban markets. Later came programs of improved sheep, new varieties of quinua, and new forage crops. Most recently, through the efforts of the parastatal Milk Promotion Program, about

Table 1. Planting Technology

Technology	Frequency	%
Plow	17	56.7
Tractor	11	36.7
Both	2	6.6
Total	30	100.0

half the community is involved in commercial dairying. The study identifies describes and analyses current agricultural practices from the perspective of *comunarios* by exploring changes in potato cropping of the past 30 years. This has involved characterizing contemporary agricultural technologies in San José, identifying the factors that influence technology decisions, and documenting the cultural values associated with these practices.

Methods. To collect these data, Ms. Huanca resided in San José for the agricultural year of 1992-93, working closely with a sample of 30 households, selected on the basis of residence, accessibility and demographic characteristics, that includes a high proportion of elderly *comunarios* as possible. Her techniques included participant observation, especially of farming tasks and ritual events, structured interviews, casual visits, collection of oral history, and review of archival materials.

Progress. In sum, she found that *comunarios* make decisions on the basis of household resources and concern with short-term results, considering the price of a technology and the amount of labor it requires. While they are well aware of the advantages and shortcomings of technologies, both for short and long-term, people opt for the more immediate benefits. The following data pertain to potato cultivation.

Tractor vs plow (*yunta*). To plow lands all of the producers sampled use the tractor because it represents an enormous saving of time. To plow one hectare with animal traction one person needs four days. In contrast a tractor can cover the same field in two hours. In 1993 renting this service cost about US $25.00. Further with the rise of dairying, most producers prefer to sell their bulls, which means using cows for traction and people prefer not to place this energetic stress on their livestock. However as Tables 1 and 2 indicate, *comunarios* find it more convenient to use animal traction for potato planting and soil mounding (*el aporque*) performed a few months after sowing.

Using either manure or chemical fertilizers poses a series of contradictions for farmers since each has benefits and disadvantages. First, chemical fertilizer is much easier to apply since it involves carrying a load weighing about 45 kgs, the amount normally used, to fields rather than hauling some 60 quintals by burro to parcels often a kilometer away. At planting time two people can spread the chemicals; manure requires three. Its use also results in fewer weeds and worms, and a larger potato. On the other hand, *guano* makes for a tastier potato, and its use allows families to avoid spending over U.S. $20.00 on the purchase of fertilizers. Finally, *comunarios* have noted deterioration in their soils; they seem "tired," they say, and that potato yields have diminished over the last decade. In turn this decrease has reduced the overall importance they attribute to potato cropping.

Table 2. Soil Mounding (el aporque)

Technology	Frequency	%
Plow	22	77.3
Tractor	3	10.0
Both	2	6.7
Manual	3	10.0
Total	30	100.0

Another technological consideration is what is known in the literature as symbolic technology. An indispensable part of the agro-pastoral cycle, it includes religious ceremonies performed over the course of the year that relate to production and the natural world. Through ritual practice, *comunarios* express reverence and appreciation of Pachamama and other deities. Symbolic technology also includes knowledge of the natural world and its relationship with crops and herds. People in San José use such natural indicators as wild animals and the stars to predict the climate

and the qualities of the year's harvest. The most widespread practice is to set planting time by the phase of the moon. Of 30 families interviewed, 22 or 73.3% said they scheduled sowing by lunar observation and 8 households or 26.7% said they did not.

Discussion. People in San José credit much importance to the new agricultural technologies that have made their lives easier. In spite of the expense, and the recognition that chemical fertilizers and tractors pose a potential threat to the quality of soils, producers are inclined to use them because they drastically lower labor requirements. An interesting outcome of the greater dependency on purchase inputs has been the tendency to give more importance to the cultivation of forages than subsistence food crops. *Comunarios* have replaced *papa amarga* (bitter potato) and beans with alfalfa and barley and have reduced the size of lands destined for potato cultivation. Some irony attends this trend given that the original intent of the potato technology package was to increase the volume of production for urban sales. Today *comunarios* participate more in markets but not in the manner earlier extensionists intended.

Table 3. Fertilizer use

Type	Frequency	%
Manure	3	10.0
Chemical	11	36.7
Both	16	53.3
Total	30	100.0

Assessment of Technologies: Ex-Post Analysis of a Technology Diffusion Program in the Altiplano

Problem Statement and Approach

Lack of follow-up evaluation on technology transfer projects poses a two-fold loss for researchers and extentionists: knowledge about effective methods are lost along with the possibilities to learn from past mistakes; and data specific to the region can disappear, unavailable for future efforts. Mindful of this, in 1993 researchers began to investigate the impacts of improved sheep technology extension work conducted the Province of Aroma during the 1960s. A focus of the study is the role of the Patacamaya Experimental Station (EEP). Since its establishment in 1958, scientists there have carried out experiments dealing with sheep breeding, management, health and nutrition. In the 1950s and 60s, the Station served as a base for programs of international cooperation like the InterAmerican Agricultural Service and Utah State University/USAID.

Methods. The study consisted of an archival and a fieldwork phase. The first was to review and evaluate the achievements of station research to the end of identifying the ways findings had been incorporated into local technology extension efforts, and to see the directions for new research existing work suggests. The next phase was to conduct interviews with smallholders in the Province of Aroma (within the general zone of influence of the EEP) about their sheep production systems in order to assess the impact of the extension campaigns over the past 30 years, and to identify which emphases would most benefit contemporary producers. Summary and evaluation of the accomplishments of the station required review of all technical reports and other available documents in the EEP by collaborating scientist, Ing. Eliseo Quino. Community level fieldwork was carried out in seven villages which had been sites of vigorous extension efforts in 1960s: Ayamaya, Culli Culli, Chiarumani, Hauri Belen, Incamaya, Patarani and Pomani. These communities lie in distinct ecological settings, with differences in kinds and availability of forage, soil and climatic conditions, and access to irrigation. Collaborating scientist, Ing. Federico Mamani, with several years of extension and research experience in the region, coordinated data collection from heads (60 men, 20 women) of 80 families - 8 to 15 households per community. The interviews themselves were conducted by local farmers, selected by their peers at a community meeting. The questions deal with the household sheep production system, practices of auto-consumption, commercialization, management, nutrition, health and finally the producer's experiences with training and extension

Table 4. Composition of Flocks

	Type of Sheep*				
Community	Halfbred+	Halfbred	Criollo	Total #	%
Ayamaya	3	244	1009	1256	24.7
Community %	0.2	19.4	80.3		
Culli Culli	0	144	237	381	7.5
Community %	0	37.8	62.2		
Chiarumani	0	208	430	638	12.5
Community %	0	32.6	67.4		
Huari Belen	96	671	450	1217	23.9
Community %	7.9	65.1	37.0		
Incamaya	322	455	204	981	19.3
Community %	32.8	46.4	20.8		
Patarani	1	79	163	243	4.8
Community %	0.4	32.6	67.1		
Pomani	150	186	37	373	7.3
Community %	40.2	49.9	9.9		
Total Sheep	572	1987	2530	5089	
% of Type	11.2	39.0	49.7	100.0	

**Sheep terms: halfbred is typically a 50/50 Corriedale/Criollo cross. Halfbred+ is a more than 50% improved mix.*

programs, and current interest in institutional support.

Progress

The review of Patacamaya research reveals several important accomplishments by station staff. Most notable is the development of a cross-bred sheep (Corriedale/*criollo*) well adapted to the elevation and climatic extremes of the *altiplano*, and able to produce more meat than other crosses in the zone. Another achievement was determination of the zoometric indices for *criollo*, and mixed and introduced (pure-blood) sheep under new environmental conditions. However, the reviewer did observe a tendency to depend solely on-station tests, and not consider on-farm conditions. Along the same line, nutrition research tended to focus on feed resources too expensive for most peasant producers. Finally basic health problems received little attention compared to research on less commonly occurring ailments.

The analysis of survey data to date provides trends in local sheep raising and the interests and concerns of the producers. It should be pointed out that the figures presented here reflect just a small part of the "Technology Impact Data Base"; budgetary uncertainties have slowed the process of completing this analysis.

The data indicate an increase in the raising of improved sheep, Table 5 combines half-blood and more-than-half as improved.

Sheep Sales. Those interviewed consider *puitos* or yearling rams (48%) the best of all age/sex categories to sell. Their second

Table 5. Change in the number of Improved Sheep: The producer has the same/a greater/ a lesser/ number of improved sheep than 10 years before:

	% of Sample	No. of Producers
the same:	5	4
more:	41	33
fewer:	24	20
don't raise:	21	23

choice is selling *jorras*, sterile ewes (11%). Producers much prefer to sell live (53.75%) than butchered sheep (5%) although a large number say they sell both (41.25%). The number of sheep sold per year varies by community. The residents of Ayamaya and Huari Belen sell an average of 15 per year, while those of Chiarumani vend only 8; in the other communities 10 or 11 are sold. Income from the sales is allocated to family food (72.5%0 school expenses (11%) general expenses, and lastly, productive inputs.

Health. Extensionists in 1960s focused on animal health, especially control of external and internal parasites. As one veteran of these campaigns commented "we must have built 2-3,000 *baños antisárnicos* (troughs for dipping against external parasites) in the *altiplano*." *Comunarios*, he continued, supplied labor and materials. Contemporary practices reflect this effort: all producers interviewed dip their sheep, the majority, 57.50%, in the fall months and 40% in the spring. In contrast, only 33.8% of producers de-worm (*desparasitación*) their flocks.

Table 6. Training

Community	No. Attending	% of Community Sample
Ayamaya	3	20
Culli Culli	2	25
Chiarumani	0	0
Huari Belen	3	20
Incamaya	1	9
Patarani	4	40
Pomani	7	64
Total	20	25

Training. Despite the active extension of the 1960s, only a quarter of the sample has had any sort of formal training experience.

Half of those participating went to workshops at the Patacamaya Station, or the *granja*, as it is known locally. Another five took a class in their home community, while the rest attended programs of another institution. Despite, or perhaps because of the narrow first hand experience with extension programs, nearly all the interviewed expressed much interest in receiving more technical support from the EEP, and other agencies. Response to the open question "What should be done?" in respect to technical assistance points up the enthusiasm of the producers for all sorts of training via workshops, visits, and demonstrations. Several women commented that it is difficult for them to leave home, and it would better to hold training programs in their own communities. The technical areas most frequently mentioned include: livestock improvement through sales, loans or advice, training in animal health, water and pumps.

Discussion. Although the data presented here represents only a fraction of what has been collected, it is clear that improved sheep comprise a significant part of local livestock production systems. Adoption of these sheep has proceeded gradually, suggesting caution in the ways producers manage their resources. The strong demand for technical support indicates that farmers are aware of the potential to improve their flocks and practices, and would welcome appropriate extension at the community level.

Baseline Assessment of Santiago de Machaca (Second Site)

A *sondeo* and a baseline survey were planned for this calendar year. Because of uncertainties about the future of the program and the lack of funding for 1994-1995 to complete our research program we decided not to undertake this activity. We decided instead to study land tenure transformations and strategies for household reproduction in some *estancias* of Santiago de Machaca. The results are presented under social mapping of resources.

Activity II:

Local perceptions of problems and evaluation

Elicit and understanding of local views and perceptions on constraints pertaining to the production system at the household, community, and producer organization levels. Understanding the reasons for migration, as a

pull or push effect or as a strategy of risk reduction, and the role of small ruminants in this process. Understanding the expectations of young adults, and their impact on the household production system is crucial to developing appropriate technologies and policies.

Consequences of Young Peoples' Values and Aspirations for the Production System.

Problem Statement and Approach

The out-migration rate from the *altiplano* is very high and San José is no exception to this pattern. According to data collected by the Sociology Program in the agricultural year 1992-93, approximately one half of the siblings of adult household heads had left the community. This trend appears to continue among the younger generation. In the age group 14 to 25 females outnumber males by two to one. In the 108 families noted on the latest census, May 1994, are only four families headed by couples 25 or under. Finally in the course of informal interviews we found that nearly all teenagers wanted to leave San José, boys and girls alike. This situation may have worrisome implications for the future of the productive system if one assumes that the youth are the most dynamic community members. Many questions come to mind but very little research has been carried out on this theme in the Andean region. What does it mean for the community when the majority of its children migrate? Why do they go? Have they any desire to return? Do they retain land and animals in the community? And, more generally, how do they see their future in the community? How would they want to improve their animals and crops? What types of extension projects would interest them? What kinds of changes would induce them to stay in town and invest more resources and effort into the improvement of their livestock?

The following hypotheses were formulated based on familiarity with the community and some of the general literature on migration.

1) Youth in San José do not think much about their future until they have finished *colegio* (junior high).
2) Most young people want to leave to pursue better education or employment possibilities.
3) Those who stay belong to families with more resources (land, herds) than the average.
4) Youth consider it important to maintain ties with San José.
5) Boys have much more freedom to leave than do girls.

Research objectives

a. Identify young people between 12 and 22 who live temporally and/or permanently in SJL.
b. Document their life stories.
c. Correlate existing data on their parental households and fill in any holes.
d. Identify their attitudes for the future: goals, notions of a good life, employment and location preferences.
e. Determine how they see their responsibilities in San José: care of family resources, participation in community projects, protection of natural resources, assistance to younger siblings and elderly parents.
f. Understand their specific aspirations: education, marriage, military service.

Methods. Fieldwork was carried out in the summer of 1994 by two research assistants, Rigoberto Espejo, a former Sociology *becario*, and Freddy Flores, on loan from Animal Nutrition. Since both had lived in San José for a year, and had good relations with local children they were logical choices to work with teenaged boys. Meanwhile Sociology *becaria* Valeria Paredes was already interviewing teenaged girls about similar issues in her own thesis research, and her observations are also included. As participants, Espejo and Flores selected 15 young men out of the 22 present in San José. Since the interview format is strange and uncomfortable for youngsters, all the researchers took time to build friendship and trust, Paredes through days of herding and informal evening visits, and Espejo and Flores by organizing a football tournament. This created opportunities to hang out, drink

soda and talk, appropriate for bringing up more personal topics. Although the interviews were informal in style, they touched upon the same themes with each youth. A final technique was a meeting with a group of six boys, to see what different perspectives and comments the peer setting might elicit.

Progress. Virtually all the youth want to leave San José, for at least several years to learn a trade or enter into business. The desire to earn cash money is very strong, either to the end of making such long term investments as constructing a house in San José, or clothing purchases today. The scarcity of cash and the difficulty of finding paid employment constitute the most negative aspects of the life in the community. Most youth sampled would find the existence of more opportunities to earn money a strong incentive to stay put. Girls want to leave but face a more complicated situation than their brothers. As shepherds they supply essential labor to the household pastoral productive regime and their parents, especially their mothers are reluctant to lose their assistance. Most of the young women mention becoming seamstresses as the most appealing career, and want to learn how to make jackets and other garments since they have heard it is lucrative and pleasant. Meanwhile the common prospect for young peasant women of becoming an urban maid or *empleada,* is considered a demeaning punishment to be avoided. Tailoring appeals to young men as well but they list more occupational options, ideas often acquired from the experiences of older brothers and cousins.

In the group meeting the boys expressed interesting attitudes concerning military service, which is semi-obligatory in Bolivia. Initially participants spoke of the importance of entering the military (something of a rite-of-passage for rural male youths). Then after one of the older individuals described his own miserable days as a soldier, the boys started to question the value of serving, finally concluding that the main inducement for signing up was avoiding the stigma and ridicule that attends non-service. All the young people felt responsible for the well-being of their parents and siblings, saying it was important to provide physical or financial assistance, e.g, the education of a younger brother. The boys spoke of eventually returning to San José to increase and improve their flocks and herds, especially dairy cattle. All recognize responsibilities toward the community, commenting that it is necessary to participate in work projects, and to assume community offices when asked. Only one youth expressed interest in becoming an active community leader. (Although a few participants were sons of the "informal leadership" of San José, those men continually visible in community projects, in or out of office, these boys seemed no more interested in community activism than their peers.)

Discussion. This project opens a window into the lives of a key group in agro-pastoral production, but little known, altiplano youth. As a group, youths have much interest in livestock husbandry and improving the community. However, within the community exist very few opportunities to obtain cash or learn a profitable trade, and therefore they look for work elsewhere. Although the majority interviewed voiced a wish to return to San José, their future undertakings has most to do with the personality of each individual, the size of their family, and the network of kinship and support outside of the community.

Activity III:

Social mapping of the communities: land, animals, labor allocation and gender/age

Problem Statement and Approach

In order to contribute to an understanding of the farming systems and the household production strategies, there is need to understand the social and economics mechanisms that secure access to resources through time. Land, livestock and labor are some of the crucial resources considered in technology choices as well as in policy interventions to mitigate drought and frosts, and production losses. We undertook these activities through a combination of surveys,

participant observation, interviews, oral histories and 24 hour recall methodologies. Participatory rural appraisal methodologies have also been implemented. A mapping or resource access and control has been developed through research on land tenure, animal tenure and labor/gender access. A land tenure study was completed as well as a livestock tenure study. Pastoral labor allocation is currently being studied.

Out of the evaluation of resources in San José has developed a more synthetic understanding of the flows of social and biological resources in the community. These largely inter-household flows are key in the operation of the production system since they provide people with a greater range of livelihood options, through a network of mutual support and accommodation. The ability to leave land and animals behind with neighbors and relatives in the community affords rural to urban migrants a degree of economic security and, simultaneously these practices provide more resources for *comunarios*, for example, sheep left behind in *al partir* enable young couples to build up their flocks. A variety of social mechanisms permit land poor households to expand their agricultural production by acquiring short-term rights to cultivable fields owned by others. The ability to continually shuffle family members between tasks and to temporarily increase household labor through reciprocal arrangements frees adult workers for participation in new economic sectors and community projects. Flexibility facilitates the diversification, which through time and space, serves to avert risk in the unpredictable Andean environment. Residents of San José have over the past twenty years responded to institutional and market incentives to adopt new technologies despite potential long term environmental costs. The willingness to experiment, to expand the range of resources utilized includes possibilities offered by NGO support in improving community conditions. These interwoven processes are described in an article abstracted below, recently submitted for publication "Social Practice and Persistence in a Fragile Environment: A Case Study from the Bolivian Altiplano" by Markowitz and Jetté.

In the world's marginal lands, mountainous and arid regions with low agricultural productivity, information based technologies are expected to take on greater importance in global food security. The roles of local knowledge and resource management strategies including forms of social organization may eclipse those of exogenous and expensive technologies. Andean agro-pastoralist smallholders in the semi-arid central Bolivian *altiplano* maintain a diversified household and community resource base through reliance on an array of social arrangements. In the community of San José Llanga, farmers raise sheep and cattle, and cultivate potatoes, quinua and barley in an environment subject to climatic risk and the perturbations of changing governments, market forces, and institutional interventions. Results from nearly three years of SR-CRSP farming systems research indicate that customary agreements and understandings between families foster flexible manipulation of limited resources. These practices reduce potential income disparities between poor and less poor households, facilitate migration to urban centers and enable producers to expand their access to labor, land and livestock in response to changing circumstances. Further, despite high levels of out-migration, the vital Aymara community structure serves a means for protecting existing resources and acquiring new ones.

Social Mapping of land resources and strategies of household reproduction in Santiago de Machaca

During 1994 two main research activities were conducted in Santiago de Machaca. The first one consisted of the study of land tenure transformations induced in this region by the Land Reform of the beginning of the seventies (see report by Edgar Cala on Santiago de Machaca). The second one consisted of a case study of households' socio-economic reproduction strategies and tenure of resources. This study was undertaken in one *estancia* (peasant community) named Okata where twelve households live at present. Methodologies used included livestock and human population census, review of local

documents, participant observation in communal meetings, ritual celebrations grazing activities and agricultural tasks, interviews with individuals, and group discussions. A sociology student lived in Santiago for six months and regular visits (one week a month) took place during the following six months.

Progress. Okata is located in the *pampa* five kilometers south of the town of Santiago de Machaca. The total area of the *estancia* is 1,389 hectares, of which approximately 80% are made of grazing land. There are also three low hills on the territory of the community where agriculture is practiced.

Production Activities. The main productive activity in Okata is sheep and camelid (llamas and alpacas) husbandry. Potatoes and quinua (Chenopodium quinoa) are grown by the majority of the households on the hillsides. Some also have a few cows and grow barley. Male heads of household frequently go to Santiago de Machaca or elsewhere to work temporally in construction or commercial activities.

The members of the twelve households total 83, 57 of which live in Okata and 26 outside the region. Fifty-six percent of the people living in Okata are under the age of 19, and 25% above 50. Nobody between 19 and 29 years resides in the community. Women make 62% of the total household members and 68% of those who have stayed in Okata. All but one child between 6 and 18 attend school in Santiago de Machaca. According to local documents, in 1981 there were 21 households and 77 habitants in Okata. The decrease in population is mainly attributed to the 1982-83 drought which has since been followed by several bad agricultural years. Another important factor is that the relative value of the main resource in the region has been dropping in the last decades. This is especially true for llamas which are no longer used as a means of transport, and whose meat is sold at the lowest prices in the urban markets of the Department of La Paz (see Sammels and Markowitz, 1994).

Crops. Agriculture is organized according to the rules of sectorial fallowing. Cropping land on the hillsides is divided into seven sections which are planted for two or three years and then left fallowed for seven years. During the fallow period the sectors are converted to open grazed areas. The decisions about which sector will be cultivated each year, and when to initiate the cropping year are made by the community. The majority of households own plots in each sector; the number and the size of the plots vary according to the demographic history of each household. Arrangements are made with migrants to cultivate the land that belongs to them. If a migrant leaves some plots without use for a long time and doesn't have any more close relatives in the community, the authorities may decide to redistribute this land among those who have less.

In 1993 and 1994, half of Okata households also cultivated some plots of land in neighboring *estancias*, generally thanks to the relationship that the female head of household maintained with the community where she was born. Indeed, it is expected that a woman who marries should go to live in her husband's *estancia* (weddings between people of the same estancia are very unusual). However, there are several exceptions to this rule: for example if a woman doesn't have brothers or if they have left the community, then her parents would prefer that she stays in the *estancia* with her husband.

Production Practices. Land is ploughed with a yoke hauled by a couple of oxen while on the steepest part of the hills, with a manual instrument called *chakitaclla* ("foot plow"). Potatoes are fertilized with llama (sour varieties) and sheep (sweet varieties) manure. Men are mainly responsible for cultivation. Agricultural products are exclusively for household consumption. The 1993-94 agricultural year has been very good according to the producers. Based on interviews with the eight households that sowed potatoes this year, we have estimated an average harvest of 1,920 pounds by household. Forty five percent of the harvest was processed into *chuño* (dehydrated potatoes), which allow people to store food for future needs. Seventeen percent were stored as seed for next year; a small proportion was given to relatives who live in town and the rest was for 1994-95 household consumption.

Livestock. The grazing lands are communally owned. However there exists a division between two large family groups.

The larger portion of the territory is for the Huanca (nine households) and the other one is for the Tuco (three households). Beyond this large division, there are no restrictions to herds movement and to the number of animals. Grazing strategies are determined by the availability of labor and by the characteristics of the season of the year. Women are mainly responsible for grazing and they are helped by the kids (above nine) when they are not at school. During the rainy season households will tend to graze towards the outer limits of the community where they have a shelter. Indeed, when the rains start the accumulation of dung around the main residences fosters the growing of *qura* (Tarasa tenella), a forb whose consumption when it blossoms could cause bloating among sheep. Sheep grazing is also more demanding because the lambs easily fall prey to foxes. Rams are separated from the herds from January to July and are given to a herder from another community who specializes in grazing these breeding stock. During the dry season households supplement animal nutrition with salt, *qura* hay and *quinua* stubble. Nevertheless the September-November period could be very critical for the animals and mortality rate increases significantly. The herders are aware that it would be necessary to restrict access to some range areas throughout the year in order to have forages on reserve for this period. This has been tried but the community has not been able to enforce the restrictions agreed upon. The owners of the largest flocks were the ones usually breaking the rules. Another solution would be fencing some areas but at present this is an investment that producers cannot afford.

As a result of these difficulties, some of the herders with fewer animals have proposed that since community obligations (for infrastructure building for example) are the same for all, that grazing land should also be divided equally between households. But the fact is that such partition would be difficult to execute because water resources and some important types of vegetation are not uniformly distributed on the territory. In July 1994, there were a total of 1,384 sheep, 339 llamas, 239 alpacas, 14 cows and 8 donkeys in Okata. The largest household herd was made of 206 sheep, 59 llamas and 28 alpacas. The smallest one was made of 15 sheep and 6 alpacas. Seven households had more than one hundred sheep. Data about changes in herds due to consumption, sales and losses during 1994 are still being processed. In the households, individuals are the real owners of the animals that comprise the flocks. No decision can be taken about the consumption or sale of an animal without its owner's approval. Women own a larger number of sheep than their husbands, whereas men tend to possess a larger number of llamas (however there are several cases where women have an equal or larger number of llamas). This situation allows women to play an important role in the decision making process of the household. Animal ownership places them in a strong position in the bargaining process regarding intrahousehold allocation of resources. Some women have held important offices in the communal organization.

Income sources. Meat and wool are the main sources of income. Slaughtered animals are either consumed or sold (sales of live animals are very unusual), and the price for sheep is slightly higher than for llama ($US 1.3 a kilo vs $US 1.1). On average, a sheep (2 years old) carcass weights 10 kilos, an alpaca 25 kilos and a llama (3 or 4 years old) 45 kilos. Sheep can be sold in Santiago de Machaca or in La Paz city. Llamas are sold in La Paz (five hours from Santiago) by bus or truck. Income from sales of sheep is usually allocated to small purchases of food, clothes, and school supplies. Income from llama sales are rather allocated to the purchase of tools and furniture, or invested in the city. These investments may also be funded by male heads' of household off-farm activities. Each household member older than five years of age dedicates him/herself to sheep and alpaca wool spinning. On average one person, according to its age and ability, will spin one to three pounds of wool or fiber a week. One pound of spun sheep wool is sold for $US 1, the price for alpaca fiber being higher at the moment: $US 6 a pound.

Discussion. As we have seen, all the young adults of the community have migrated; some of them are studying at the university or in a technical institute, whereas the majority is trying to earn a

living in the cities. The great majority of heads of household also reported to have lived outside the community during some years when they were younger. They expect that one of their sons will come back to the *estancia* to take care of their land and animals when they will be too old. However, the decline in the number of households during the last decades indicates that these households' continuity (reproduction) may be disrupted. According to the community members, a significant improvement in production conditions in the region would be the only way to revert this tendency. It is important to note the role that livestock, especially sheep play in food security. Income generated through this activity is the main source of food purchases for the household. Observations also indicated that sheep are milked and the milk is consumed by the household.

Age and Gender in Small Ruminant Husbandry

Survey data collected in 1992-93 agricultural cycle, as well as daily observations of work activities in San José indicated that teenaged girls and children do much of the herding. Curious about the implications of this pattern for animal care, and about the perspectives of the young shepherds themselves, Sociology undertook the Youth Aspiration Study (see above) and designed a thesis research project focusing on the activities and perspectives on young women in small ruminant husbandry. In-mid 1994 Valeria Paredes completed fieldwork for her sociology thesis, which examines the role of gender in pastoral labor. The study looks at the concepts and ideas *comunarios* have about male and female roles to see how these structure the organization and distribution of responsibilities in the production system. Specific research objectives included documenting the division of labor by age and sex, observing the differences in performance of husbandry tasks, and determining the atitudes of the shepherds concerning their work and their future.

Methods. To obtain these data Paredes lived in San José and conducted intensive participant-observation during the planting, rainy and harvest seasons, to identify patterns in labor allocation according to the type of work and household composition. During these periods she accompanied family members as they herded, tracking flock movements in and out of vegetation communities, noting the shepherd's and other household members' activities. These long days allowed her to conduct long informal interviews and develop trusting relationships with the shepherds. She also met regularly with daughters of the seven families in her sample and their friends to chat about a range of matters important in their lives.

Progress. Paredes work confirms more anecdotal information on the way herding tasks are allocated by *comunarios*. First a lot of shepherd switching off occurs each day depending on the conflicting demands of agriculture, community projects and school. A child of 9 is considered capable of herding on her/his own although more typical configuration might be an 11 year old in charge of her 8 year old sibling, and the two bickering and playing. Children as young as 4 have been left alone with flocks but in an "easy" place, usually near the house. By the age of 13 mothers say their daughters can herd well, but an adult may still come to take over when cows and sheep are permitted to graze in alfalfa fields, since for part of the year bloating poses a danger. Although little boys accompany their mothers and sisters to herd sheep, as a boy approaches adolescence, this takes on something of the stigma of "girls work" to be avoided. The girls meanwhile are split in their views: some say they fear herding cattle because of the bloating danger, while others say watching cows is much easier, an opinion shared by all the boys in the youth study. Mothers say younger children need instruction:

> I tell the 10 year old not to go through other peoples pastures so there won't be problems. I also tell her to water the sheep twice if there's no well, if there is, then make them drink as many times as they want. When you don't make them drink, they

> don't want to graze and they just stop. Also I tell her the places where she has to take them, what time she has to come back because sometimes she comes home too early. With my 15 year old it's different, she knows where to go and very few times do I tell her, only when she asks. She already knows how to herd and how to lead the flock.

Currently underway is analysis of field observations to quantify the time that older and younger herders pasture flocks in different vegetative communities over the year. By the age of 15 most girls have completed their formal education. The local *colegio* continues only to the equivalent of 8th grade, and very few girls in the community (we know of one case) have exceeded this level. Thus they have the time and skills to assume the place of a full-time worker in their family but unlike their mothers do not make decisions about the culling or acquiring of livestock. In contrast to Santiago de Machaca ownership of livestock is thought of in more household than individual terms.

Methodologies on Social Mapping and Training on Methodologies

Problem Statement and Approach

One project goal in the global plan was to develop practical methodologies for research in zones of low productive potential. This has implied some experimentation in our field methods as we seek to apply some of the recent innovations in techniques for rapid qualitative research. Sociology found the use of ECO-GEN (Ecology, Community and Organization, and Gender) participatory methodolcgies for eliciting differences and similarities in the ways men and women perceive and utilize resources to be effective, and has adapted them accordingly. For example, an exercise developed for banana palms in the Philippines that features a picture of a tree, and then a series of questions about the ways leaves, flowers, fruits, etc. are used, became the template for a similar exercise with pictures of sheep and cows.

Through the first half of 1994, Markowitz, with the support of *becarias* Valeria Paredes, Magali Caceres, Alcira Ramos and Patricia Ilanes, led five group meetings with small groups (4-7) of women household heads to discuss management and control of animal resources and decision making. Although the participants gathered in early evening after a long work day, sometimes arriving directly from herding, they seemed to enjoy the meetings, staying till late at night. The women's explanations and comments confirmed participant-observation and survey data that sheep-herding is a women's "enterprise." Women and girls perform most of the daily herding, watering, seasonal shearing and cheese-making associated with sheep, and female household heads also make decisions about when and how to proceed with these activities. They also independently decide when to sell animals, how to dispose of the income, and predominate in making decisions about such by-products as wool, hides and dung. Men tend to be much more involved in marketing cattle; the women say that selling a cow is a joint decision, and the couple or man will handle the actual transaction. When women discuss the seasonal dimension of their work, they use cultivation activities as their yardstick of "busyness," while animal husbandry and domestic tasks are viewed as a constant.

In the *estancia* of Okata in Santiago de Machaca, the team (scientists and students from Range, Nutrition and Sociology) met with residents for an evening of resource mapping. (This was part of the mini-*sondeo*, discussed presently.) Men and women split into separate groups to draw, and a few individuals put together their own small maps. The differences were interesting. The women's picture was more oriented toward social networks, detailing all houses and *cabañas* by name, and sketching in the small paths connecting homesteads with one another, and pastures. The men carefully identified major roads, streams, political boundaries and forage zones. Researchers acquired an overview of the community layout and spatial organization of grazing in a couple hours. Again, it seemed that the *comunarios* enjoyed themselves.

Women, labor availability and technological innovations.

A similar methodology was utilized by Valdivia and research assistants in San José Llanga to elicit information on the reasons for frequent statements from women from the community, that today they have less time than before available for leisure activities. The hypothesis that we worked with was that technological innovations of the type observed in San José Llanga were affecting the size of the household enterprise, requiring increases in labor investment. A process of temporary migration was believed also to play a role in the reduction of leisure time by women in the community. Technological interventions such as increasing the area of cultivation through mechanized tillage, white/commercial potato varieties, irrigation channels, dairy production and marketing, and access to markets seem to have increased the amount of labor women invest in productive activities. The group meetings with the female heads of household were undertaken to help us define constraints in the production system (labor availability). Budget cuts have not allowed us to pursue this activity further.

Activity IV:

Environmental Economic and Political Variables: Risk and Diversification

Problem Statement and Approach

Peasant households in semi-arid environments confront risk in their day-to-day production decisions. Risk presents itself in the forms of environmental or climatic variation, with droughts and frosts that can lead to partial or complete losses of their crops and livestock. Economics and institutional variability, such as changing price policies, land reforms, and macroeconomic changes that translate into price risks. Importation policies, changes in the exchange rates and subsidy policies, such as that affecting dairy have an effect on peasant household incomes and their ability to secure food and their livelihood (household reproduction). Research in this area has contributed to our understanding of the diversification strategies that the households in San José have pursued. As past studies by Jetté on changing emphases on commodities through time, and Dunn and Valdivia's study on household income and dairy have shown, producers have tended to undertake a portfolio of production enterprises (food and forage crops, dairy and sheep production and marketing. As reported in Valdivia et al households, according to their access to resources, demographic characteristics, such as age and family composition, number of adult members, and income have shown different combinations of activities. A strategy pursued by those with lower levels of income has been to increase their labor sales, mainly trough temporary migration. Based on the household survey on gender and income, of 45 families, a cluster analysis was performed. The range ecology project supported this activity, with Jetté and Valdivia of the sociology project. The objective was to determine groups of homogeneous strategies and similar resources. This cluster had two purposes. The first to identify groups of producers for which a technology would be appropriate, the second to test the hypothesis that cash crop activities (such as dairy) were add on activities rather than substitutes for others that contributed to food production.

Progress

The gender and livestock survey showed that all families dedicated an important part of their resources to secure the production of potatoes and other food crops. Income from sheep sales was consistently used for food purchases and in some cases for school supplies. Cash from dairy production was also used to purchase food and some of the milk also went to pay seeds and resources used in forage production. Preliminary results from a cluster analysis considering sheep (criollo and improved) cattle (criollo and improved) labor available by the household, wages from employment outside the production unit, age of the household head (male head of household) hectares of cultivated forages, consumption of food and

income generated by cattle (milk production was discounted) resulted in two distinct groups, each subdivided into two sub-groups. The first group, which we classified as the "older group," in general had old people with low access to labor, the "wealthier subgroup having more sheep. Within this group criollo sheep was highly significant (T test on means). Significant differences were present in access to grazing and income from cattle. In the second group "the young," actually there were significant differences with respect to age between these two subgroup, 38 and 47. Highly significant differences were found with respect to type of sheep and cattle, income from agriculture, forages, milk sales, hectares of cultivated forages, total income, and food consumption. Significant differences were found between fallow and irrigated lands, income for food, age, sales to PIL and investments. We are continuing analysis of this data. The cluster results show that all groups have wage income as an activity to reduce risk. And in different combinations according to access to resources some activities are emphasized more than others, but not substituted for.

Training

Students

Bolivian Becarios. Intensive supervision and advising of five students from the Universidad Mayor de San Andreas (UMSA) in La Paz. *Becarios* contribute to the Sociology Program as they develop skills in qualitative social science research, systems approaches, word processing and spreadsheet manipulation, database management, and making oral and written presentations. All five students are bilingual in Aymara and Spanish. Each student carries out an independent research project that falls within the Sociology workplan.

Degrees Completed

Cala Chambi, Edgar. B.A. Sociology, El Sistema de Tenencia de Tierras en la Comunidad San José Llanga, Provincia Aroma del Departamento de La Paz, Bolivia. Unpublished BA thesis. UMSA January, 1994

Espejo, Rigoberto. Prácticas Socioeconómicas de Tenencia y Adquisición de Ganado, Estudio de Caso: Comunidad San José Llanga. Unpublished BA Thesis, Sociology, UMSA. November, 1994.

Fieldwork Completed

Juana Huanca Tarifa, B.A. (anticipated) 1995, Anthropology.

Valeria Paredes, B.A. (anticipated) 1995, Sociology.

Silvia Valencia, B.A. (anticipated) 1995, Sociology.

U.S. Students

Sammells, Clare. Harvard University. Residents and Co-Investigators provided institutional support and mentoring for undergraduate honors thesis in Folklore and Mythology "Llama Meat in La Paz." Based on her Bolivian fieldwork in 1993, Ms. Sammells won grants to support a second summer of research from the Weissman International Internship Program and the Harvard Committee on Latin American and Iberian Studies.

Joyce, Susan. Cornell University. A doctoral candidate in Development Sociology, she received a pre-dissertation fellowship from the Social Science Research Council to look at the relationship between export artisan production and rural fiber markets in Bolivia. The Social Science components agreed to have Ms. Joyce formally affiliated with the program as a volunteer in order to facilitate her research and provide her with an institutional link within Bolivia. Ms. Joyce met with Residents and Co-Is to discuss her research interests and to develop a pilot research to be carried out in San José Llanga as part of her fellowship's training program. She completed a month-long pilot research project on wool production and marketing in San José, and the role of intermediaries in the local market structure. SR-CRSP-Bolivia provided her with institutional support, transportation, and living quarters so that she could accomplish her research

goals. The presence of SR-CRSP - Bolivia allowed Ms. Joyce access to a rural community, allowing her through her pilot study to begin to integrate local, community-level research with broader theoretical concerns in her discipline.

Collaborating Personnel

United States

Michael F. Nolan, Principal Investigator, University of Missouri Columbia
Corinne Valdivia, Co-Principal Investigator, University of Missouri Columbia
Jere L. Gilles, Collaborating Scientist, University of Missouri Columbia
Elizabeth G. Dunn, Collaborating Scientist, University of Missouri Columbia

Bolivia

Lisa Markowitz, Resident Scientist Sociology, University of Missouri Columbia
Christian Jetté, Co-Investigator Sociology, Instituto Boliviano de Tecnologia Agropecuaria
Joao de Queiroz, Resident Scientist, Range Ecology, Utah State University
Guillermo Prieto, Co-Investigator Ecology, Instituto Boliviano de Tecnologia Agropecuaria
Jim Yazman, Resident Scientist Nutrition and Program Representative, Texas Tech University
Mauricio Cuesta, Resident Scientist Economics, Winrock International

Collaborating Scientist

Christian Jetté, Co-Investigator Sociology, Instituto Boliviano de Tecnologia Agropecuaria

Collaborating Institution

Instituto Boliviano de Tecnologia Agropecuaria
P.O. Box 5783
La Paz, Bolivia
Phone: 591-2-370883
Fax: 591-2-370883

Publications, Reports, Abstracts and Theses

Cala, E. B.A. Sociology. El Sistema de Tenencia de Tierras en la Comunidad San José Llanga, Provincia Aroma del Departamento de La Paz, Bolivia. Unpublished BA thesis. UMSA. January, 1994.

Cala, E. 1994. Características de Tenencia de Tierra en algunas Comunidades en el Cantón Santiago de Machaca. Sociology Program Report.

Cala, E. and C. Jetté. 1994. Posesión y Control de Tierras en una Comunidad del Altiplano Central. IBTA 138/Boletín Técnico 07/SR-CRSP.

Céspedes, Jorge. 1993. Income Impacts of Cash-Crop Introduction into Subsistence System in the Bolivian Altiplano. Unpublished MS thesis, Agricultural Economics, University of Missouri, Columbia. Dec.

Céspedes, Jorge, C. Valdivia and E. Dunn. Introducción de Cultivos Comerciales e Ingreso Familiar: El Caso de una Economía de Subsistencia del Altiplano de Bolivia. (draft) Prepared for Investigación Agraria.

Dunn, E., J. Céspedes, J., C. Valdivia. 1994. Impacts of Cash Crop Expansion on Income Components in an Agropastoral Community of the Bolivian Altiplano. Latin American Studies Association, 18th International Congress, Atlanta, GA. March.

Espejo, Rigoberto. 1994. Prácticas Socioeconómicas de Tenencia y Adquisición de Ganado, Estudio de Caso: Comunidad San José Llanga. BA Thesis, Sociology, UMSA, La Paz.

Huanca T., Juana. Procesos de Cambio en la Tecnología Agrícola: Un Estudio de Caso.

(submitted to the university) BA Thesis, Anthropology, UMSA, La Paz.

Huanca T., Juana. 1994. Evaluación de recursos en una comunidad agropastoril. Co-authored with C. Jetté. RERUMEN. 3(3), November.

Markowitz, L. End of Tour Report. University of Missouri: Columbia.

Markowitz, L. and C. Jetté. Social Practice and Persistence in a Fragile Environment: A Case Study from the Bolivian Altiplano.(submitted to Agriculture and Human Values)

Markowitz, L. and C. Jetté. 1994 . Estrategias Sociales Hacia la Sostenibilidad Andina: Un Estudio de Caso del Altiplano Central. IBTA 139/Boletín Técnico 08/SR-CRSP. La Paz.

Sammells C., and L. Markowitz. ?Porque no se Consume la Carne de Llama en La Paz? Co-authored with C. Sammells. In Waira Pampa: Un Sistema Pastoril Camelidos-Ovinos del Altiplano Arido Boliviano. D. Genin et al., eds. La Paz: OSTROM, CONPAC, IBTA. (in press)

Carne de Llama: Alta Viabilidad, Baja Visibilidad. IBTA 140/Boletín Técnico 09/SR-CRSP. La Paz.

Presentations

Jetté, C., L. Markowitz, C. Valdivia. Bolivia Synthesis Workshop. Utah State University. Logan, UT. December, 1994.

Markowitz, L. Options on the Altiplano: Local Strategies for Resource Utilization in an Agro-pastoral Community. Department of Anthropology, University of Missouri, Columbia, October, 1994.

Consideraciones Socio-Culturales en la Transferencia de Tecnología Agropecuaria. IBTA, La Paz, August, 1994.

Resource Management Strategies of Altiplano Families, Brown Bag, USAID Mission, La Paz, August, 1994.

Sammells, C. La Carne de Llama dentro de la Comida del La Paz. CRSP Seminar. La Paz, July, 1994

Forthcoming Technical Reports

Sherbourne, J.L., E. G. Dunn, C. Valdivia and M. F. Nolan. 1995. Agropastoral Production Systems, Intra-Household Resource Allocation and Household Members' Domains: Five Case Studies From the Community of San José Llanga.

Valdivia, C., E. Dunn and J. Sherbourne. 1995. Cash Crops and Food Production: Dairy and Sheep Household Diversification Strategies in the Crop-Livestock Systems of San José Llanga, Bolivia.

Valdivia C. and C. Jetté. 1995. Peasant Households in Semi Arid San José: confronting risk through diversification strategies.

Observations

The budget cuts affected the Sociology Project in several ways. Initiated and partially developed projects were never completed and logical next steps to complete work could not be carried out. Concomitant was the uncomfortable sense of uncertainty that pervaded the project. Here are a just a few examples.

Training. Our intent had been to use the proposed RRA (Rural Rapid Appraisal) in Santiago de Machaca as means to familiarize collaborating biologists with methods of qualitative social science research. We planned to first hold a workshop at Patacamaya, and then conduct fieldwork over the course of two 4 or 5 day visits in Santiago de Machaca. Jetté, along with de Queiroz from Range Ecology made several visits to community meetings to secure permission. Markowitz had begun preparing training materials. Sociology led a mini-*sondeo*, mentioned above, in early February to try out experimental methodologies, and to better plan the RRA. After we were advised of pending budget cuts in March, we halted all new projects in Santiago de Machaca, and limited most fieldwork to Okata. Conducting an RRA in five *estancias* as we had planned would have meant a huge imposition on people with whom we were unlikely to have further

dealing, and potentially compromised local perceptions of other projects.

Gender analysis. The women's meetings in San José were immensely informative, clarifying women's perspectives on work and resource control. However, the idea of gender analysis is not to study women but to see if and how a producer's sex situates them differently in the production process. We wanted to conduct similar meetings with small groups of men to see what their perspectives were on the same issues. While colleagues and students evinced considerable enthusiasm for this, they just ran out of time.

NGO linkages. The many non-governmental organizations active on the *altiplano* are logical candidates to become involved with programs - technology transfer, income generation, resource conservation - that would appeal to residents of San José. Sociology is well poised to help development organizations avoid one of the most common causes for project failure: ignorance of local social dynamics. Early in 1994 we proposed a graduate student trainee to address this theme. No funds were available, and again residents and co-Is lacked time to pursue this important issue.

Concluding our Research. There are many loose ends. As we have so vigorously asserted in recent E-mails: we know how an "O.K." year looks like but we have nothing to compare it to; we have not been able to commit ourselves for lack of funds and uncertainties about the future, to gathering information on the probable consequences of the rain delays resulting in no potato planting. The study of post-harvest technologies could have addressed an important question that has arisen from Paredes' and Huanca's research. They find an increasing or changing work/time burden on women, which we suspect has to do with forage technologies - hay making - but we need a time allocation to see just how.

Range Animal Nutrition

Texas Tech University

Fred C. Bryant, Department of Range and Wildlife Management, Texas Tech University, Lubbock, Texas, 76409-2125. Telephone (806) 742-3884, Fax (806) 742-3892, E-mail: refcb@ttacs.ttu.edu

Characterization of sheep management practices in a Central Altiplano community

(Betty Villanueva, Carlos Salinas and Jim Yazman)

Problem statement and approach

An understanding of present sheep management practices on small farms in the Bolivian Altiplano and estimates of current levels of production are essential to the design of research and extension programs aimed at increasing flock productivity. The present study involved monitoring of sheep productivity in one flock in each of six zones in and around the community of San José Llanga. The system of management employed by the family was characterized through periodic interviews and direct monitoring over a one-year period. Lambing date, number of lambs born, ewe weight at lambing and post-lambing, lamb birthweight, lamb weight at 60 days of age, weight and age weaning, and sales and deaths of lambs and adult sheep were recorded.

This study served as the thesis research project for Ms. Betty Villanueva, a graduate of the Technical University of Oruru.

Results

Sheep in San José Llanga graze crop residues, fallow fields, and native grass pastures. Landholding area, type of land owned, land use, access to communal pastures, and genetic composition of the flock are the main determinants of flock productivity. Little or no supplementary feed is provided to sheep. Land area owned ranged from 18.4 to 67.7 ha and total ewes from 20 to 66 head among the six families involved in the study (Table 1). Area of annual forage planted and land area maintained in alfalfa are related to overall landholding size, ownership of dairy cattle, and participation in the communities milk market. More important for sheep production is fallow land and native grass pastures. Farm families in San José Llanga with dairy cattle tend to have fewer, but higher grade sheep. Families tend to maintain a higher percentage of criollo ewes, which are able to better withstand the harsh production conditions of the region, and utilize crossbred rams to produce market lambs. Crossbred rams are generally 50% or more Corriedale or Targhee.

The families in this study can be grouped into three "production systems." While landholdings lie at the extremes of the overall range, the families in Espíritu Wilki and Incamaya have a small percentage of improved ewes and a relatively large percentage of their landholdings in native grass pastures. The families in Callunimaya and Tholatía have a greater amount of their land in crops and alfalfa, produce little annual forage, and maintain a higher percentage of crossbred (50% improved) ewes in their flock. The families in Barrio and Sabilani are distinguished by the high percentage of crossbred (50% and >50% improved blood) ewes and a greater percentage of their landholdings in forage and alfalfa compared to families in the other two groups.

Table 1. Landholding, land use and flock size and genetic composition for six flocks, San José Llanga

	Espíritu Wilki	Incamaya	Callunimaya	Barrio	Sabilani	Tholatía
Landholding (ha) 1/	23.0	67.7	24.5	18.4	61.8	32.9
Land use:						
Cropping	4.3	10.0	2.0	4.2	4.6	7.0
Fallow	4.0	22.2	16.7	6.9	32.7	7.4
Forage	2.0	0.0	1.0	2.1	2.2	0.0
Alfalfa	1.7	2.0	1.5	3.9	3.9	9.0
Pasture	11.2	33.4	3.3	1.3	18.4	9.5
Total ewes	24	66	42	20	33	46
Breeds (% of adult ewes):						
Criollo	94.8	86.3	78.2	5.5	9.1	79.9
50% improved	5.1	13.6	16.8	16.6	22.9	22.0
>50% improved	0.0	0.0	4.9	77.7	67.8	0.0
Total dairy cows 2/	2	5	8	6	5	6

1/ Source: Cala, 1994
2/ Source, Espejo, 1994

Lambing percentage and the distribution of births (% by season) is presented in Table 2. Month of lambing is highly influenced by rainfall, mediated through pasture growth, in the Altiplano. Ewe breed may also influence month of lambing, though there is probably a very significant genetic X environment interaction. Generally two lambing periods are reported by San José Llanga residents: May-June and November-December.

Lambing percentage over the period of the study ranged from 74.7% for the flock in Incamaya to 142.2% for the flock in Sabilani. A management problem which is common to many flocks in San José Llanga is the lack of sufficient breeding rams in relation to breeding ewes. Ewes tend to come into heat over a very short period following rains which bring out herbs and young grasses in pastures. The number of ewes in heat often exceeds the breeding capacity of available rams. Many families in need of cash sell breeding rams first because of the high price they bring. Some families maintain small numbers of rams and rely on young ram lambs to breed ewes.

The highest lambing percentage among the six flock, in Callunimaya and Sabilani, occurred in the flocks with the greatest number of breeding rams in relation to breeding ewes (4:42 and 5:33, respectively). The lowest percentage, 74.7%, resulted in Incomaya where only one breeding ram was maintained to service 66 ewes. These results indicate that when the ratio of rams to ewes exceeds 1:10, lambing performance suffers.

The rainy season in San José Llanga occurs during the months of November through February. Across breed groups, most lambings occurred in the "transition" period following the rainy season (March through June) or in the dry season (July-October). This is indication of the important effect of rainy season "flushing" and March-June "carryover" forage resources on ewe physiological status, mostly native grasses, during the March-June transition period. This same seasonal pattern to lambing tended to be seen in the two flocks with predominantly criollos ewes (Espiritu Wilki and Tholatía) and those with high percentage of crossbred ewes (Barrio and Sabilani).

Bodyweights at 150 days of age tended to be higher in crossbred lambs and lambs born in the rainy and post-rain transition season (Table 3). Bodyweights in Table 3 are

averaged across lamb sex. Male lambs in all three breed groups tended to be heavier at birth and at all ages. The often low, and uneven number of lambs in each breed X season subclass are a result of deaths and sales and make statistical analyses difficult, a problem common to on-farm research with livestock. The numbers do indicate some differences between flocks in "production systems groups." The flock in Tholatía, one of two flocks with predominantly criollo ewes, tended to have lambs born in the transition and dry seasons with higher bodyweights at 150 days of age compared to the flock in Espiritu Wilki. This may be due to the greater area of crop and fallow land (Table 1) which, during the rainy season during which time these lambs matured provides important sources of fresh growth of herbs and grasses. The family in Tholatía also has a greater area of alfalfa, which, with its deep root system, emerges with fresh growth in the late dry season (September and October) and forms an important source of nutrients before being reserved for cutting.

Among the herds with greater percentages of crossbred ewes, the tendency of the flock in Sabilani to have higher bodyweights among crossbred lambs at 150 days of age is probably related to the greater land resources of this family (Table 1). The superior bodyweights of the lambs in the flock in Barrio may be related to the small number of ewes in the flock relative to overall land resources.

The data in Tables 2 and 3 indicate the need for further, more intensive studies focusing on the relationship between flock size, genetic composition of the ewe flock,

Table 2. Lambing performance by flocks in different zones, San José Llanga, February 1992 to Feb. 1993.

	Espiritu Wilki	Incamaya	Callunimaya	Barrio	Sabilani	Tholatía
Total ewes	24	66	42	20	33	46
Relation breeding rams:ewes	1:24	1:66	4:42	3:20	5:33	3:46
Litters	26	62	47	20	43	38
Lambing percentage	104.2	74.7	123.8	100.0	142.2	86.0
Lambings by season (%): 1/						
Criollos:						
Nov. - February (1)	20.8	3.3	2.0	4.8		2.6
March - June (2)	20.8	54.1				31.6
July - October (3)	58.4	16.4				28.9
50% Improved:						
Nov. - February (1)					2.2	7.9
March - June (2)		21.3	6.3		8.9	10.6
July - October (3)		4.9	2.0	4.8	6.7	18.4
>50 % Improved:						
Nov. - February (1)			14.3	9.5	6.7	
March - June (2)			34.6	28.6	46.6	
July - October (3)			40.8	52.3	28.9	
Total	100.0	100.0	100.0	100.0	100.0	100.0

1/ Seasons 1: Rainy; Season 2: Transition; Season 3: Dry

Table 3. Average lamb BW at 150 days age, by family, breed and season of birth, San José Llanga /1

	Espiritu Wilki	Incamaya	Callunimaya	Barrio	Sabilani	Tholatia
Criollos:						
Nov. - February (1)	4.9	12.0				
no.	(4)	(1)				
March - June (2)	7.7	11.0				13.7
no.	(5)	(19)				(12)
July - October (3)	6.3	7.7	16.0	7.0		11.9
no.	(13)	(5)	(1)	(1)		(10)
50% Improved:						
Nov. - February (1)						17.0
no.						(1)
March - June (2)		12.5	20.0	11.0	17.5	16.3
no.		(12)	(3)	(1)	(3)	(4)
July - October (3)		6.3	13.0		20.3	10.2
no.		(2)	(1)		(3)	(6)
>50 % Improved:						
Nov. - February (1)			16.0	26.0		
no.			(1)	(2)		
March - June (2)			19.8	24.3	26.1	
no.			(15)	(4)	(11)	
July - October (3)			14.2	17.6	19.7	
no.			(20)	(10)	(13)	

1/ Seasons 1: Rainy; Season 2: Transition; Season 3: Dry

available land resources and lambing performance and lamb growth. Some obvious recommendations can be made based on the data available, such as the need to pay close attention to the ratio of rams to breeding ewes. In order to refine recommendations on management practices, especially breed selection, greater attention should be given to characteristics of production systems and their impact on lamb performance. Results from these "production system" studies should be evaluated against data from market studies to determine optimum market lamb size and seasonal distribution of prices. Options for farmers with limitations due to land area and land quality need to be characterized, especially in relation to efforts to upgrade flock genetic composition through the use of breeds such as Corriedales and Targhees which result in large ewe body size.

Effect of supplementation on the growth of lambs and reproduction in ewes in San José Llanga

(Germán Méndez M., Jim A. Yazman and Magalí Cáceres M.)

Problem statement and approach

Campesino families in the Bolivian Altiplano maintain sheep for home consumption of meat, for the sale of lambs, cull ewes, hides and wool. Wool is both marketed raw and converted to yarn for production of clothing and handicrafts. Small quantities of milk are harvested from lactating ewes during the rainy season (November-February) for production of cheese. Criollo (native) sheep are relatively

prolific (3 lambings in two years is common) but produce market lambs (12 to 18 months of age) of low liveweight (20 to 25 kg). Criollos also yield quantities of wool (<0.5 kg per head per year) of very poor quality. Various programs, including the Livestock and Forage Research Program of IBTA, have introduced improved breeds (Targhee, Merino, and Corriedale) originally imported from the U.S. and other South American countries (Uruguay and Argentina). Crossbreeding to the 50 to 75% level of improved genetics increases market lamb liveweight (25 to 30 kg) and wool yield and quality, thus increasing family income.

Under traditional management systems typical of the Altiplano, however, sheep must survive and produce on grazing of native pastures, crop residues, and fallow fields, with only limited grazing of harvested alfalfa fields. Larger crossbred ewes (40 to 45 kg liveweight) have higher nutritional requirements than criollo ewes (30 to 35 kg liveweight) and often suffer nutritional deficiencies, especially during the long Altiplano dry season (March to October). Crossbred ewes often exhibit delayed age at first lambing (<18 month) and long lambing intervals (period between births). Ewe reproduction further suffers as lambs are rarely weaned and continue suckling until sold at 12 to 18 months of age. In the dry season, limitations on intake of dry matter and nutrients may limit ewe milk production with resulting impact on the growth rate of crossbred lambs.

Supplementation of ewes and lambs under traditional grazing systems in the Altiplano may increase flock productivity and produce positive net returns to the cost of the supplement. Locally available feedstuffs in the Central Altiplano include alfalfa (fed fresh or as whole or ground hay), oats, barley, and milling byproducts of wheat and quinua (an Andean foodgrain).

The purpose of this study was to test the effect of supplementation on ewe and lamb performance. Two trials were undertaken. In trial I crossbred and criollo ewes were provided a supplement from approximately 30 days pre-lambing to 90 days post-lambing. Given results of thesis research by Ing. Agron. Carola Lopez (Lopez 1994) which indicated crude protein levels in the diet selected by sheep on grazing in the range 12% to 18%, the supplement was formulated to be approximately 13% crude protein.

The effect of the supplement was measured in terms of lamb birth and weaning weights, feed conversion (lamb weight weaned per kg of supplement consumed by the ewe), changes in ewe liveweight, lambing interval (days to subsequent lambing), and changes in time spent grazing. The supplement consisted of ground alfalfa hay, brans of wheat and quinua, ground barley and salt and minerals.

In trial II a supplement consisting of the same ingredients was fed *ad libitum* directly to pre-weaning lambs as a "creep feed" from 10 to 90 days of age. A creep fence was constructed which allowed experimental lambs to enter and leave but excluded ewes. The creep feed supplement was designed to make maximum use of locally available ingredients but not to exceed more than 40% ground alfalfa. Target crude protein level was 14%.

The effect of the creep feed was measured in terms of lamb weaning weights, feed conversion (lamb weight weaned per kg of supplement consumed) and changes in ewe liveweight. Effort was made to determine the impact of lamb supplementation on ewe lambing interval (days to subsequent lambing).

Some difficulty was experienced in identifying appropriate herds to participate in the two trials. Effort was made to find herds relatively close together, to facilitate feeding of experimental diets and monitoring of consumption and those which had an adequate number of "improved" (Targhee or Corriedale crossbreds, 50% or greater) ewes. Two families were identified for each trial and divided according to size of landholdings and ewe flock. Differences between the families within each trial, which could influence trial outcome include amount of fallow and pasture land owned and genetic composition of the ewe flock (Table 4). Most notable among the four families identified to participate is family 1097 which has four hectares of fallow land and eight hectares of grazing land and whose ewe flock is highly improved (56.9% of ewes 50% improved, 9.8% >50% improved).

Table 4. Characteristics of land and livestock resources on farms involved in ewe (trial 1) and lamb (trial 2) supplementation trials, San José Llanga

	Trial 1		Trial 2	
Family code	1020	1173	1097	1161
Landholdings (ha):	13.0	8.5	18.0	11.0
Land use (ha):				
Cropping	2.0	0.8	1.5	1.0
Fallow	0.0	0.0	4.0	0.0
Forage	2.0	2.0	2.5	2.0
Alfalfa	5.0	1.3	2.5	4.0
Pasture	4.0	4.5	8.0	4.0
Total sheep	73	68	61	46
Ewes	64	57	51	39
Rams	2	5	1	1
Ewe lambs	7	6	9	6
Ewe breeds (%):				
Criollo	67.2	64.9	33.3	53.8
50% improved	32.8	35.1	56.9	46.2
>50% improved	0.0	0.0	9.8	0.0
Total cattle	8	3	7	5
Dairy cows	3	2	4	2
Bulls	1			1
Heifers	1	1	1	2
Calves	3		2	
Burros	2	1	2	1

The trials served as the Ingeniero Agrónomo degree thesis research of SR-CRSP student Germán Méndez Machicado. Mr. Méndez is a student of the Facultad de Agronomía of the Universidad Mayor de San Andrés in La Paz. The trials were initiated in April and concluded in November, 1994.

Results

Providing ewes with 300 gms per head per day of a ground alfalfa-based supplement resulted in a 1.5 kg increase in lamb BW at 90 days of age (Table 5). Lambs of supplemented ewes also had significantly higher rates of gain, 127.8 gms per head daily, compared to 109.1 gms for lambs of unsupplemented ewes. The supplement had no effect on change in ewe BW from parturition to 90 days or on lamb BW at 90 days as a percent of ewe BW at parturition.

Interaction effects between treatment and herd, ewe breed, ewe parturition number, season of lambing, and lamb sex were not significant. Ram lambs in both supplemented and unsupplemented ewes were significantly heavier ($P<0.05$) at 90 days (14.3 kg) compared to ewe lambs at the same age (12.9 kg). Across the two experimental groups, ewes nursing ram lambs lost 2.3 kg over the 90-day test period, compared to only 1.0 kg for ewes nursing probably a result of the more aggressive nursing behavior on the part of the larger ram lambs.

Interestingly, though not significant, across the two supplement groups lambs of criollo ewes at 90 days weighed 46.5% of their dam's BW at parturition compared to 39.7% for lambs of crossbred ewes. Part of this difference is due to more ram lambs being born to criollo ewes compared to crossbred ewes. Also, this difference needs to be reviewed further for lambs closer to the 150- to 180-day weaning weight typical of Altiplano family flocks. However, this indication of difference in efficiency bears further study, especially in relation to input-output modeling of Altiplano sheep production systems.

Supplementation of lambs via creep feeding had no effect on lamb BW at 90 days of age, change in ewe BW from parturition to 90 days post-parturition, and lamb weight at 90 days of age as a percentage of ewe BW at parturition (Table 6). Lambs in this trial, both supplemented and unsupplemented, were an average 2.0 kg lighter at 90 days of age compared to lambs in trial 1, a result that is contradictory to what was expected. Variation in birthweights in the two herds

Table 5. Least squares means for effect of ewe supplementation on lamb weight at 90 days, lamb ADG, change in ewe bodyweight, and lamb weight as a percentage of ewe weight at lambing, for lambs born to supplemented and unsupplemented ewes, San José Llanga

	Supplemented 1/	Unsupplemented
No. of observations	20	20
Lamb BW at 90 days of age (kg)	14.3 a	12.8 b
Lamb ADG birth to 90 days (gms/hd/day)	127.8 a	109.1 b
Change in ewe BW parturition to 90 days (kg)	-1.8	-1.6
Lamb BW at 90 days as % of ewe BW at parturition	44.2	42.0

1/ Means in the same row with different letters are significantly different (P<0.05)

Table 6. Least squares means for effects of lamb supplementation via creep feeding on lamb weight at 90 days, change in ewe body weight, and lamb weight as a percentage of ewe weight at lambing, San José Llanga

	Supplemented	Unsupplemented
No. of observations	20	19
Lamb BW at 90 days of age (kg)	12.0	10.0
Change in ewe BW parturition to 90 days (kg)	-0.1	-1.5
Lamb BW at 90 days as % of ewe BW at parturition	35.5	38.5

participating in the creep feeding trial was high (CV>20%). Lamb birthweight was used as a covariate in the computation of least square means reported in Table 6. One lamb weight at 90 days of age (21.0 kg) was removed from the analysis as being significantly outside the range of all other weights.

There were no significant interactions between treatment effect and that of herd, ewe breed, ewe parturition number, season of lambing, and lamb sex. Lambs were assigned to treatments in birth order within the two herds participating in the trial. Both herds used crossbred, improved rams for breeding ewes. However, five lambs born to criollo ewes in one herd appeared to be sired by criollo rams, a result of uncontrolled breeding on pasture by rams from other flocks, or by young uncastrated ram lambs in the same flock. Across the two treatment groups and without consideration for lamb sex, 34 crossbred, improved lambs, were significantly heavier at 90 days (12.6 kg) compared to 5 "criollo" lambs (9.5 kg).

This was a "pioneering" trial and several problems were encountered. One of the two farmers in trial I (supplementation of ewes) moved his flock to a remote location of the canton of San José Llanga half-way through the trial in order to take advantage of available grazing and prepare his land for planting. This caused serious problems in monitoring the use of supplement and collecting data. The experimental protocol in trial I called for ewes to be supplemented 30 days prior to lambing and for 90 days post-partum. Predicting lambing date was difficult to determine as campesinos keep no breeding records. In one flock in trial I breeding was delayed in the season prior to the start of the trial resulting in ewes being supplemented for upwards of 60 to 90 days pre-parturition. Supplement intake prior to one month of age by lambs in trial II was very low.

The results in Tables 5 and 6 have to be evaluated against cost of supplement and impact of supplementation on overall flock performance. These results indicate that under the production conditions of San José Llanga, supplementing ewes has a more significant impact on lamb performance than does supplementation of nursing lambs. The supplementation provided in trial I may have allowed ewes to better utilize the high plant nitrogen reported for some pasture grasses in San José Llanga by Lopez (1994) and thus boost milk production and subsequent lamb growth. The consumption of supplement by lambs may reduce their milk intake and intake of forage, resulting in a no net increase in growth relative to unsupplemented lambs.

These results indicate further study is needed before supplementation to ewes and pre-weaning lambs can be recommended to farmers in the Altiplano. An ongoing

companion study by Ing. Ximena Sandy on diet intake by grazing rams receiving the same supplementation as ewes in trail I will provide additional information to evaluate the impact of ewe supplementation on ewe performance. Further studies of lamb supplementation are warranted, especially as farmers in the Altiplano adopt heavier breed rams for upgrading their flocks and in light of possible seasonal market demand.

Comparison of yield and nutritive value of local and improved varieties of forages and grain straws in San José Llanga

(Jim A. Yazman, Magalí Cáceres M., Ricardo Vera, and Germán Méndez M.)

Problem statement and approach

Annual forages and straws of food grains are an important source of supplementary nutrients for livestock feeding in the Bolivian Altiplano. Especially where there exists opportunity to market milk, a large proportion of available cropland in Altiplano communities is planted with barley and oats. Campesino families acquire seeds of improved forages and legumes through local agricultural development programs or at weekly markets and save a portion of harvested seed for subsequent plantings.

Faba beans (*Vicia faba*) are traditionally grown on irrigated land, or on rainfed lands with soils with adequate drainage and nutrient levels. Faba beans are an important source of protein in the diet of Altiplano families and a market crop. Faba beans are also an important market crop and certain varieties have export potential. Faba beans straw is mainly fed to dairy cattle. Because of its high protein content, faba bean straw could be conserved, chopped and used an ingredient in supplemental feeds for ewes and lambs as well as cattle.

The Forage Research Center of the Universidad Mayor de San Simeon, Cochabamba, and the IBTA Small Grains and Grain Legume Research Programs, both also based in Cochabamba, have developed improved varieties of forage and food grains. Little is known of the performance of these new varieties under the management and soil conditions of the Altiplano, and their yield relative to "local" varieties planted by campesinos. Even less is known about the nutritional value of the whole plant (e.g. barley, oats, and triticale) or the crop residue (straws of faba beans, barley, oats, and wheat).

Three trials were carried out. In trial 1, in a sandy loam soil, four improved varieties of faba bean were acquired from the IBTA Grain Legume Research Program at Cochabamba and planted alongside a local variety in the field of a collaborating campesino in San José Llanga. "Local" faba bean seed was purchased from a San José Llanga family.

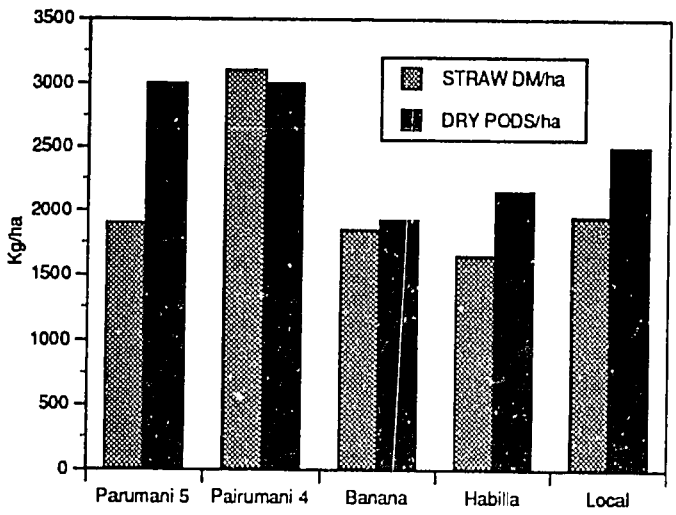
In trial 2, in the same field, improved and local varieties of barley (4 improved varieties) and oats (4) were sown, as well as three varieties of triticale.

In trial 3, in a sandy soil, yield of green and dry matter of oats (local plus 4 improved varieties), barley (local plus 3 improved varieties) and triticale (2 varieties) were compared. Varieties sown were those recommended for the Altiplano and sold by a commercial seed firm based in Cochabamba (Semillas Forrajeras, S.A.).

In all three trials, varieties were sown in randomized complete block design (block size 50 m^2) with three (trials 3 and 4) or four replications (trials 1 and 2). Fields were fertilized with 40 kg/ha 18-46-00 and 50 kg/ha urea. Fifteen (15) one-meter square blocks were harvested to estimate green matter yield (kg/ha). Samples were collected from harvested biomass for subsequent drying and determination of seed and yield of whole plant or straw dry matter.

Prior to harvest a "field day" was held during which time eight residents of San José Llanga were invited to view and evaluate the standing crops. Invited farmers, among them two women, were asked to rank varieties by expected yield and "feeding value." Rankings by farmers will be compared to rankings for actual green and dry matter yield and nutritive value as determined by laboratory analysis.

Figure 1. Yield of dry pods and straw dry matter for five varieties of faba bean grown on clay soil, San José Llanga



1/). When the higher level of straw dry matter per hectare is factored in, Pairumani 4 produced over twice as much straw dry matter crude protein compared to all other varieties. These results indicate that farmers can increase the nutritive value of the straw component of livestock diets through selection of variety. Other factors should be factored into the comparison of faba bean varieties, including the market value of the pod, its acceptability as a family food and susceptibility of the growing plant to drought, pest and disease.

Trial 2: Preliminary yield data for improved and local varieties of barley and oats, and three varieties of triticale, all grown on a clay soil are presented in Tables 8 and 9 and Figures 2, 3 and 4. The local variety of barley, and improved variety "Row 906" produced superior yields of complete plant dry matter per ha and equaled the grain yield of "Kolla" (Table 8 and Figure 2). These results are interesting in that "IBTA-80" is widely distributed by development programs and government agencies as the recommended barley variety for Altiplano soil and growing conditions. As for faba beans and oats, farmers maintain seed from harvested barley for subsequent year's planting. The

Table 7. Least squares means for kg dry pods and straw DM per ha, and percent crude protein (CP) in the straw and yield (kg) of straw crude protein per ha for five varieties of faba beans grown on clay soil, San José Llanga

Variety	Kg dry pods per ha 1/	Kg straw DM per ha	Percent CP in the straw	Kg straw CP per ha	Kg straw CP relative to local
Local	1040.2 a	793.0 a	12.7	100.7	100.0
Pairumani 5	1123.0 a	807.3 a	11.6	93.6	92.9
Pairumani 4	1524.6 b	1538.4 b	13.5	207.7	206.2
Banana	920.4 a	872.4 a	11.5	100.3	99.6
Habilla	872.3 a	657.3 a	11.5	75.6	94.9

1/ Means in the same column with different letters differ significantly (P<.05)

Samples of all forages and straws were dried and ground for nutritive value analysis at the Forage Analysis Laboratory at the IBTA Patacamaya Research Station. Analyses performed included crude protein (Kjeldahl nitrogen), Van Soest acid and neutral detergent cell wall fiber, sulfuric acid lignin, and 48-hour *in sacco* dry matter digestibility estimation using nylon bags in rumen-fistulated sheep.

Results

Trial 1: Pairumani 4 presented the highest level of crude protein (% of dry matter) in the straw (Table 7 and Figure 1

1/ Yields in tables are least square means while those in figures are simple means.

Table 8. Least squares means for kg total barley DM, grain DM and straw DM per ha for five varieties of barley grown on clay soil, San José Llanga

Variety	Kg total plant DM per ha	Kg grain DM per ha	Kg straw DM per ha	Kg total plant DM relative to local
Local	4991.6 a	2251.3 a	2740.4 a	100.0
IBTA-80	3728.3 b	1636.7 abc	2091.6 b	74.7
Kolla	3499.0 b	2193.6 abc	1305.0 bc	70.1
Kochala	3502.1 b	1611.0 b	1891.2 c	70.2
Row 906	5021.5 a	2234.6 a	2786.0 a	100.6

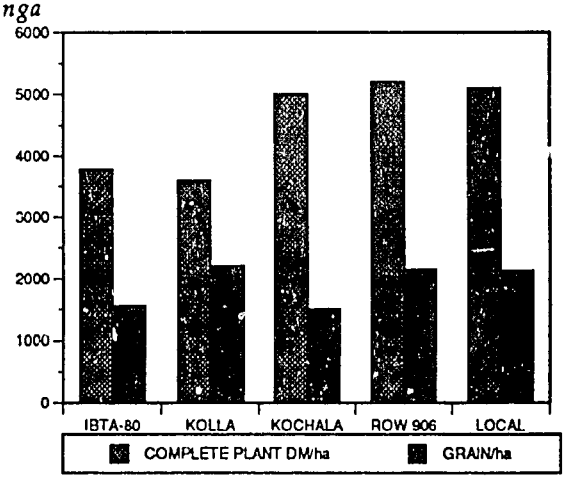
1/ Means in the same column with different letters differ significantly (P<.05)

forage and grain yield superiority of the "local" variety in this trial indicates some degree of selection for adaptability to local growing conditions, either natural or under farmer control.

Oat dry matter yields per ha are generally similar to those for barley (Table 9 and Figure 2), though farmers prefer barley as the seed is also used as a human food. Farmers consider barley to be a hardier crop than oats, especially more resistant to saline soils and frost, both of which are important limitations to crop production in the Central Altiplano. Local oats produced higher levels of complete plant dry matter in comparison to the variety "V-13" but were surpassed in yield by an average 35% by the improved varieties Littoral and V-7. The variety Littoral, with superior complete plant dry matter and seed yield, appears to be the recommended variety for the clay soils and growing conditions of San José Llanga.

Triticale is a new fodder crop in the Central Altiplano. The variety "Corcos" produced over 5.0 metric tons of dry matter per ha, upwards of 25% more dry matter than the highest yielding barley and oat varieties grown in the same soil (Figures 2 and 3). Triticale is a hybrid and seed must be purchased yearly, a problem given lack of supply and for farmers in remote regions of the Altiplano. The high yields of dry matter produced by triticale indicate that it is an important technology to consider for increasing livestock production in the Central Altiplano.

Figure 2. Yield of complete plant dry matter and grain for five varieties of barley grown on clay soil, San José Llanga



Trial 3: Yields of barley, oats and triticale grown in sandy soils are presented in Tables 10 and 11 and Figures 4, 5, and 6. All three improved varieties produced significantly higher levels of complete plant dry matter and seed in comparison to the local variety (Table 10). IBTA-80 grown in sandy soil was superior to the "local"

Table 9. Least squares means for kg total DM, grain DM and straw DM per ha for five varieties of oats grown on clay soil, San José Llanga

Variety	Kg total plant DM per ha	Kg grain DM per ha	Kg straw DM per ha	Kg total plant DM relative to local
Local	3072.0 a	1161.2 a	1910.8 a	100.0
Littoral	4129.9 b	1763.5 b	2366.4 b	134.4
V-13	2377.8 c	1127.1 a	1250.7 c	77.4
V-7	4145.8 bd	1206.4 a	2939.3 d	135.0

1/ Means in the same column with different letters differ significantly (P<.05)

variety but produced less than 50% of the yield obtained in the clay soil (Figure 2).

IBTA-80, "Lucha" and "Lucy" all produced similar yields of grain, but Lucy yielded higher levels of whole plant dry matter, though the yield difference related to the other two improved varieties was not statistically significant.

Whole plant dry matter yield was similar to all five oat varieties recommended for sandy soils. SEFO-1 is the oat variety promoted by agricultural development programs and sold in local markets in the Altiplano. The results in this trial indicate that the local variety and the variety "Gaviota" are superior to SEFO-I in both total plant dry matter and grain production.

Figure 4. Yield of dry matter for three varieties of triticale grown on clay soil, San José Llanga

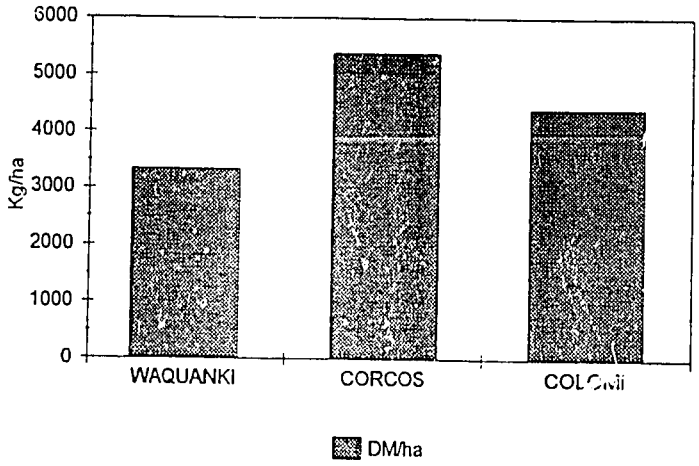
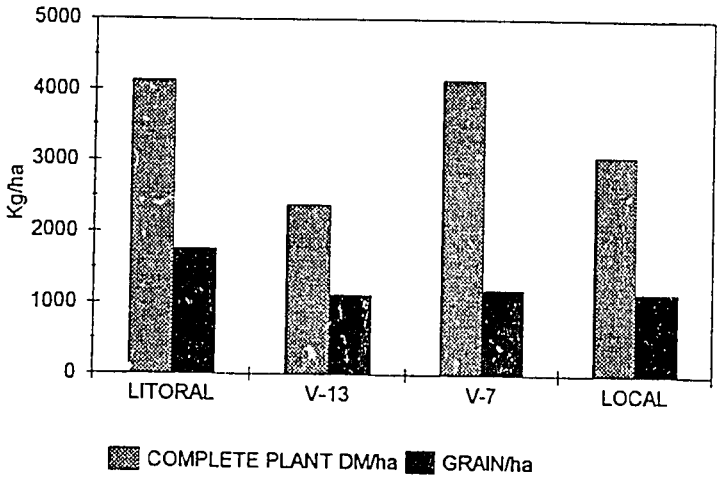


Figure 3. Yield of complete plant dry matter and grain for four varieties of oats grown on clay soil, San José Llanga



The two triticale varieties in this trial, Renacer and Eromagar (Figure 7), produced less total plant dry matter (least square means 1008.2 and 1382.3, respectively) than did three of the four barley varieties, and less than 50% of the yield of the lowest-producing triticale variety, "Waquanki," grown on the clay soil in trial 2. Triticale appears not to be a recommendable forage for production on sandy soils under the growing conditions of San José Llanga.

These preliminary results indicate that triticale is not an attractive alternative to barley and oats for farmers who are limited to sandy soils for production of fodder crops. However, choice of fodder crop variety, especially for barley, is important to Altiplano farmers limited to sandy soils for growing fodder crops. The

Table 10. *Least squares means for kg total DM, grain DM and straw DM per ha for five varieties of barley grown on a sandy soil, San José Llanga*

Variety	Kg total plant DM per ha	Kg grain DM per ha	Kg straw DM per ha	Kg total plant DM relative to local
Local	900.0 a	250.2 a	649.8 a	100.0
Lucha	1502.9 b	477.9 b	1025.0 b	166.9
Lucy	1765.7 b	510.3 b	1255.4 c	196.2
IBTA-80	1477.5 b	432.9 b	1044.6 bd	164.2

1/ Means in the same column with different letters differ significantly (P<.05)

Figure 5. Yield of complete plant dry matter and grain for four varieties of barley grown on sandy soil, San José Llanga

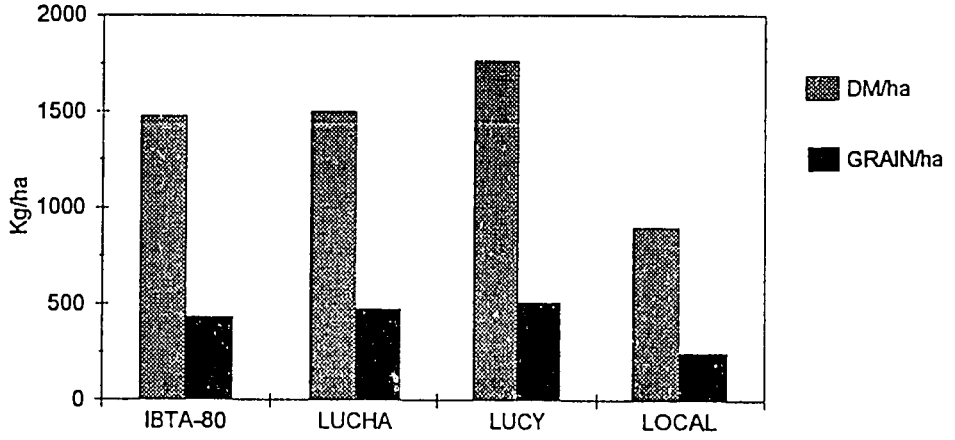


Figure 6. Yield of complete plant dry matter and grain for five varieties of oats grown on sandy soil, San José Llanga

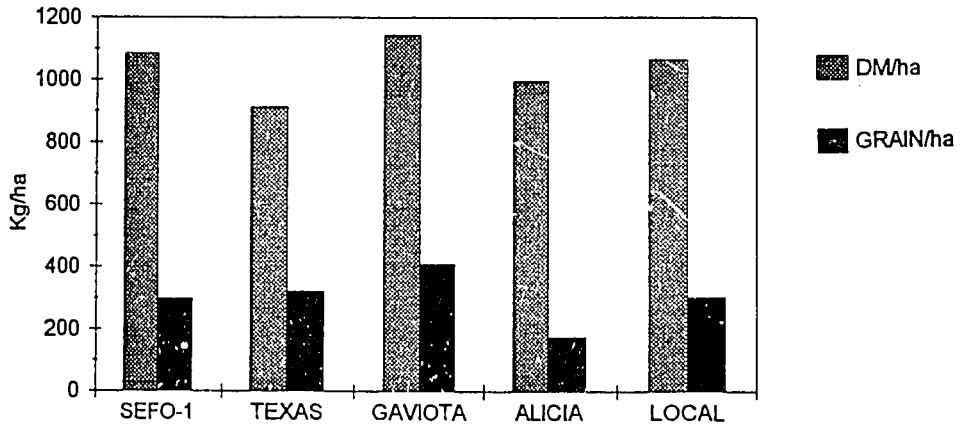


Figure 7. Yield of dry matter for three varieties of triticale grown on sandy soil, San José Llanga

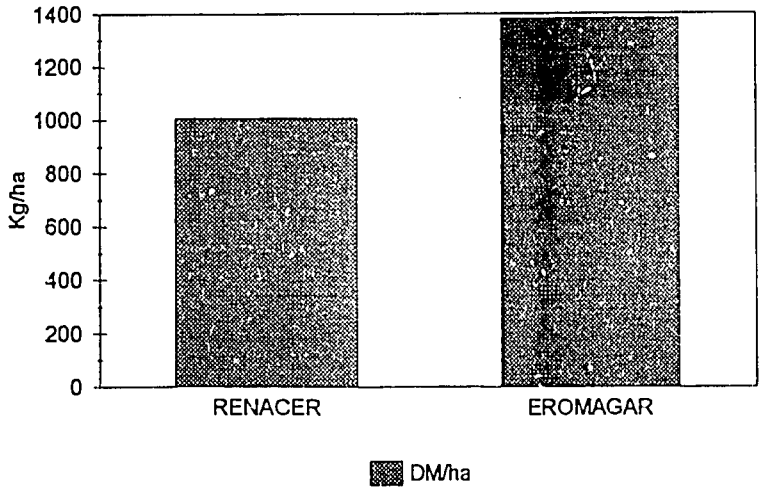


Table 11. Least squares means for kg total DM, grain DM and straw DM per ha for five varieties of oats grown on a sandy soil, San José Llanga

Variety	Kg total plant DM per ha	Kg grain DM per ha	Kg straw DM per ha	Kg total plant DM relative to local
Local	1139.0 a	434.0 a	705.0 abc	100.0
Texas	912.7 b	323.9 b	588.9 b	80.1
Gaviota	1144.3 a	411.9 a	732.3 bc	100.5
Alicia	998.6 a	176.5 c	822.1 c	87.7
SEFO-i	1085.3 a	298.4 bd	786.9 c	95.3

1/ Means in the same column with different letters differ significantly (P<.05)

widely promoted barley variety, IBTA-80, appears to be an appropriate choice for farmers with either clay or sandy soils. Triticale, and some new oat varieties (e.g. Littoral and V-7) may offer higher-yielding alternatives to barley on clay soils. Barley tends to be more resistant to frost than oats. Frost resistance must be factored in when recommending fodder crop alternatives to barley.

These results also indicate that soil quality can be a major limitation to livestock production where fodder crops are necessary to supplement harvested alfalfa and grazing of fallow fields, crop residues and native pastures. Farmers with limited areas of clay soils for fodder crop production may have less opportunity to diversify their production system with high-grade sheep and dairy cattle which demand higher levels of nutrition than criollo sheep and cattle. For these farmers, fodder crop variety (e.g. Lucy variety of barley and Gaviota variety of barley) is as important a consideration as which fodder crop to grow (e.g. oats or barley vs. triticale).

Botanical composition, nutritional value and dietary competition of three domestic species (llamas, alpacas and sheep) in the Central Altiplano of Bolivia

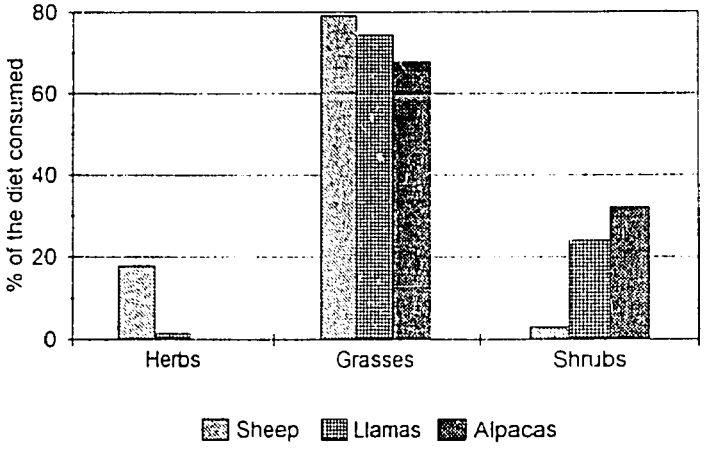
(Magalí Cáceres M. and Jim A. Yazman)

Problem statement and approach

Pastures of native grasses, legumes, shrubs and forbs provide the major portion of the diet of small ruminants in the Bolivian Altiplano. Campesino families in the Altiplano commonly graze together llamas, alpacas and sheep. Little is known about the different plants selected by these livestock species when grazing native grass pastures. Where competition for common plant species is found there is danger of overgrazing resulting in pasture degradation unless campesinos carefully balance animal numbers, area grazed and grazing days. Mixed grazing also allows for complementarity, the exclusive use of specific plant species by different livestock species promoting more efficient us of available plant biomass. The need to manage grazing of mixed herds is particularly important during the dry season when plant growth is limited. An understanding of the diet selected from grazing also allows for the development of recommendations on diet supplemention.

The study was carried out in the estancia of Okata, in the community of Santiago de Machaca, in José Manuel Pando Province, Department of La Paz, at an altitude of approximately 3,800 m.a.s.l.

Figure 8. Percentage composition of the diet of sheep, llamas and alpacas grazing Parastrephya lepidophylla-Stipa spp. pastures ("tholar-pajonal"), Santiago de Machaca



Rainfall in Santiago de Machaca averages 440 mm per year, with most precipitation occurring from November through January.

The principal objectives of the study were:

- describe in general form the vegetation of the areas grazed by the community;
- determine the botanical composition and nutritive value of the dominant species in the diet of the three ruminants; and
- characterize the degree of dietary competition or complementarity among the three species.

Direct observation, "bite counts," was used to determine botanical composition of the diet selected during the critical dry season months of May through October. Llamas, alpacas and sheep from 11 families in Okata were randomly selected for observation during grazing in communal pastures and fallow fields. Observations were made from May to October, 1994 over a period of 6 days per month, with two days dedicated to observation of each animal species.

Dietary selection was estimated based on the observation of 200 bites for llamas and alpacas and 100 bites for sheep. Bite counts were measured in six llamas, six alpacas, and 10 sheep.

In order to estimate the nutritive value of the diet selected a collection was made once per month of the principal plant species selected by each livestock species. Estimated diets were constructed by mixing species selected in proportion to the amount consumed, as measured by bite counts. Laboratory analyses were carried out at the Forage Analysis Laboratory of the IBTA Patacamaya Experiment Station to determine crude protein, fiber level (neutral and acid detergent fiber) and sulfuric acid lignin of the species selected and the constructed diets. Dry matter digestibility was estimated using *in sacco* procedures with nylon bags placed for 48 hours in rumen-fistulated sheep.

Results

Preliminary results indicate that during the dry season (May through October) the grazing herds primarily utilized two pasture types: (1) "tholar-pajonal" dominated by the shrubs *Parastrephya lepidophylla* and *Tetraglochin cristatum*, the grasses *Muhlengbergia fastigiata, Nasella pubiflora, Bouteloa simplex,* and *Stipa spp.* and the halophyte *Anthobrium triandrum* and (2) "gramadal-chillihuar" dominated by the grasses *M. fastigiata, M. peruviana, Festuca dolichophylla* and *Distichlis humilis.* The composition of the first association is 10% herbs, 64% grasses and 26% shrubs. The vegetative composition of the second association consists of 5% herbs, 92% grasses and 3% shrubs

When grazing the tholar-pajonal association sheep select a greater percentage of herbs than do llamas and alpacas (Figure 8). In comparison to the sheep and alpacas llamas utilize primarily grasses. Alpacas select a higher proportion of shrubs (32%) than do llamas and sheep.

Grasses make up the larger part of the diet of sheep (95%), llamas (97%) and alpacas (84%) grazing the "chillihuar-gramadal" association (Figure 9). The remainder of the diet selected by alpacas is constituted by shrubs.

Table 12. Number sheep, llamas and alpacas for three families in Okata, Santiago de Machaca, Bolivia

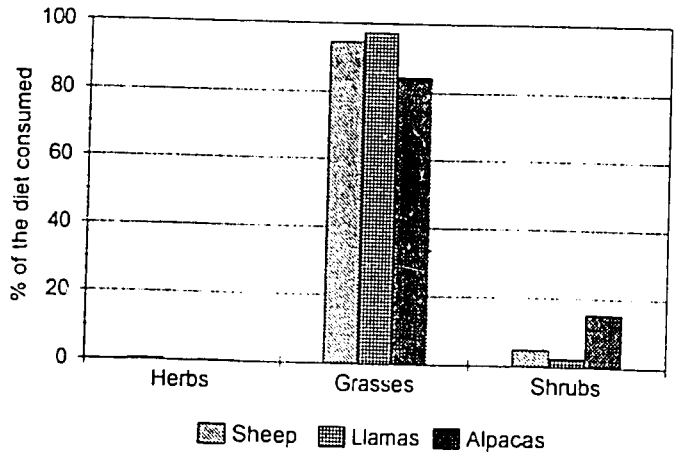
Family	Number of head	Sheep	Llamas	Alpacas
1	Total	206	59	28
	Adult females	131	30	14
	Adult males	54	15	3
	Youngstock	21	14	11
2	Total	176	49	17
	Adult females	110	24	9
	Adult males	30	14	1
	Youngstock	36	11	7
3	Total	60	25	0
	Adult females	40	13	
	Adult males	12	10	
	Youngstock	8	2	

During the dry season sheep primarily consume Tarasa tenella ("k'ora"), Bouteloa simplex ("llapa"), Muhlenbergia fastigiata ("chija negro"), Stipa spp. ("paja") and Nasella pubiflora (also called "paja"). Llamas primarily consume Stipa spp., N. pubiflora, M. fastigiata while alpacas consume Junelia minima ("q'ota"), M. fastigiata, Tetraglochin cristatum ("kailla") and P. lepidophylla. ("thola").

These initial findings indicate that sheep, llamas and alpacas compete for grass species in both associations. Sheep consume more herbs and alpacas more shrub dry matter than the other species. Given a range of vegetative species, selection is also influenced by mouth physiology (e.g. alpacas grazing low-growing, spiny J. minima). Species palatability may be as important a factor as availability in the dietary selection made by alpacas.

In the tholar-pajonal association the diet of llamas and alpacas is also largely determined by availability while that of sheep appears to be determined more by palatability of available species. The analysis to date indicates that alpaca and sheep are more highly selective under the grazing conditions of Santiago de Machaca than are llamas.

Figure 9. Percentage composition of the diet of sheep, llamas and alpacas grazing Muhlenbergia Fastigiata-Festuca Dolichophylla pastures ("gramadal-chillihuar"), Santiago de Machaca



Characterization of growth and reproduction in sheep, llamas and alpacas in Santiago de Machaca

(Ximena Sandy and Jim A. Yazman)

Problem statement and approach

Grazing of sheep, llamas and alpacas on pastures of native grasses, herbs, and shrubs to produce meat, milk, fiber and breeding stock is the main economic activity of families in Santiago de Machaca, a Central Altiplano community located approximately 125 kilometers southwest of La Paz at an altitude of 3,980 m.a.s.l. Annual rainfall in Santiago de Machaca averages 440 mm. Development of technical assistance programs to improve small ruminant productivity in the Central Altiplano requires basic information on the growth and reproduction of these species at the farm level.

Bodyweight was measured in sheep, llamas and alpacas in the herds of three families in the estancia of Okata, a community of 14 families some five kilometers from Santiago de Machaca. Okata has a land area of 1389 ha, of

which approximately 85%, or 1180 ha, are communal pastures. From each family herd a sample of 15% of each livestock species, of different ages and different physiological stage, was selected. Animals were ear-tagged. Bodyweights were measured during the critical dry months of June through September. Information on health and nutritional management was collected at the time of monthly weighing.

Results

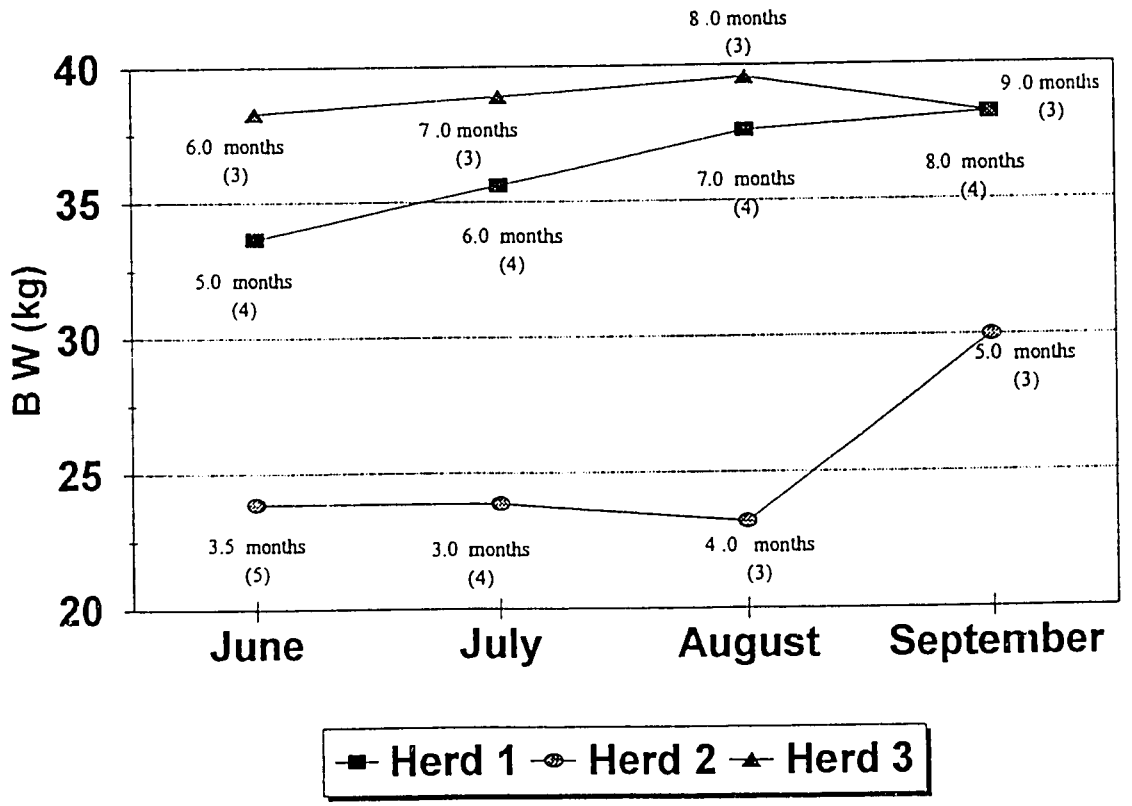
Herd size for the three families is presented in Table 12. Herd size for families 001 and 002 are similar. Family 003 has no alpacas and a smaller number of sheep and llamas.

All three families grazed their herds on communal pastures dominated by grass species Muhlenbergia fastigiata, M. peruviana, Festuca dolichophylla, Distichlis humilis, Nasella pubiflora, Bouteloa simplex, and shrubs species Parastrephia lepidophylla, Tetraglochin cristatum and Anthobrium trandrum.

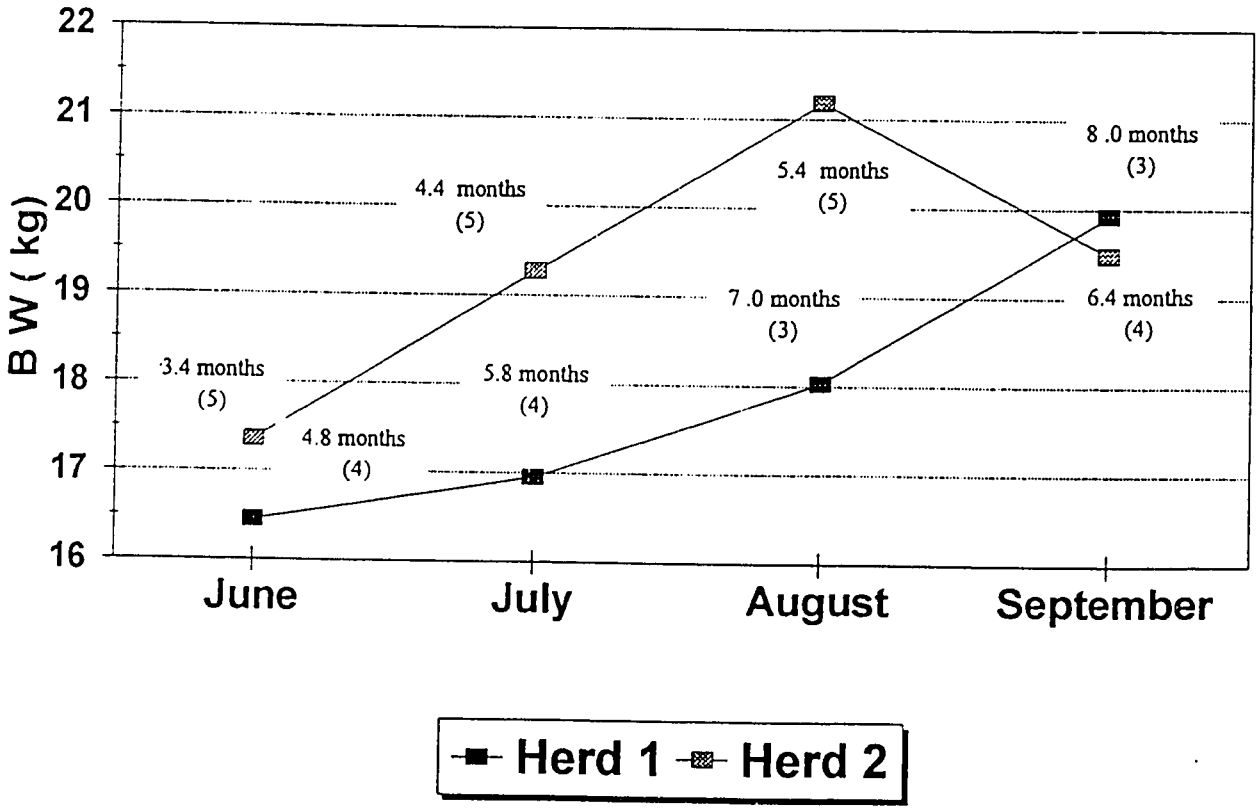
Bodyweight curves pre-weaning for young llamas in the three herds during the early dry season are shown in graph 1. In general, young llamas continue to grow in all three herds until the month of August. Young llamas in herd 3 are more advanced in age. In August, dams in herd 3 begin to cease lactation and growth of youngstock falls off. In herd 2, youngstock are much younger and llama females are in earlier lactation. With limited pasture, little growth is seen in suckling llamas until September when early rains and snowfall result in growth of new pasture and increased milk in their dams.

Growth curves for alpaca youngstock in herds 1 and 2 are shown in Graph 2. Youngstock in herd 2 show rapid growth relative to those in herd 1 partly due to their younger age and the earlier stage of lacation of their dams.

Graph 1: Average birthweight of growing llamas in three herds.



Graph 2. Average bodyweight of growing alpacas in two herds



Training

In progress

Mr. Freddy Flores is expected to receive his Ingeniero Agrónomo degree in March, 1995. Freddy is a student in the Facultad de Agronomía of the Universidad Mayor de San Andréas, La Paz. He has carried out his IA thesis research in range animal nutrition under the guidance of Dr. Morty Ortega of TTU with assistance from Ing. Jaime Valdívia of IBTA and Dr. Jim Yazman, range animal nutrition resident scientist. Freddy's thesis is entitled "Comparative utilization of native grass pastures by three domestic livestock species (sheep, cattle and equines) in San José Llanga, Aroma Province, Department of La Paz."

Oscar Peña is expected to receive his Ingeniero Agrónomo degree in February, 1995. Oscar is a student in the Facultad de Agronomía of the Universidad Mayor de San Andréas, La Paz. He has carried out his IA thesis research in the range animal nutrition component under the guidance of Dr. Morty Ortega of TTU. Oscar's thesis is entitled "Evaluation of the water resources of the Canton of San José Llanga."

Betty Villanueva is expected to receive her Ingeniero Agrónomo degree in March, 1995. Betty is a student in the Facultad de Agronomía of the Universidad Técnica, Oruru. Betty carried out her IA thesis research in the range animal nutrition component under the guidance of Dr. Carlos Salina, previously the range animal nutrition component IBTA counterpart, now a professor at UMSA. Betty's thesis is entitled "Characterization of sheep management practices in a Central Altiplano community."

Germán Méndez Machicado has completed his field research and is expected to receive his Ingeniero Agrónomo degree in March, 1995. Germán is a student of the Facultad de Agronomía of the Universidad Mayor de San Andréas, La Paz. He has carried out his IA thesis research in the range animal nutrition component under the guidance of Dr. Jim Yazman. Germán's thesis title is: "Effect of supplementation on the growth of lambs and reproduction in ewes in San José Llanga."

Completed

Magalí Cáceres Mendoza successfully defended her thesis and was awarded her Ingeniero Agrónomo degree in January, 1994. Magalí was a student in the Facultad de Agronomía of the Tomás Frías University, Potosí. She carried out her IA thesis research in the Range Animal Nutrition research component under the guidance of Dr. Morty Ortega of TTU. Magalí's thesis title was: "Behaviour and dietary competition of three domestic species (sheep, cattle and equines) on the Central Altiplano of Bolivia."

Zulma Victoria Rocio successfully defended her thesis and was awarded her Ingeniero Agrónomo degree in May, 1994. Zulma was a student in the Facultad de Agronomia of the Tomás Frías University, Potosí. She carried out her IA thesis research in the range animal nutrition research component under the guidance of Dr. Morty Ortega. Zulma's thesis title was: "Distribution and grazing behaviour of domestic livestock on the Central Altiplano of Bolivia."

Esther ("Carola") Lopez successfully defended her thesis and was awarded her Ingeniero Agrónomo degree in October, 1994. Carola was a student in the Facultad de Agronomía, Technical University, Oruru. She carried out her IA thesis research in the range animal nutrition research component under the guidance of Dr. Morty Ortega. Carola's thesis title was: "Nutritional content of the grazing diet of three domestic animals (sheep, cattle, and equines on the Central Altiplano."

María Eugenia Jiménez successfully defended her thesis and was awarded her Ingeniero Agrónomo degree in November, 1994. María Eugenia was a student in the UMSA Facultad de Agronomía, La Paz. She carried out her IA thesis research in the Range Animal Nutrition research component under the guidance of Dr. Morty Ortega. María Eugenia's thesis title was: "Effect of grazing on the establishment and

development of 10 vegetative species in fallow lands."

Short term

IBTA/SR-CRSP Short Course on Nutrition of Grazing Ruminants

February 28 - March 4, 1994
Patacamaya Research Station,
Patacamaya

Background

Knowing what and how much ruminants (sheep, cattle, goats, and llamas) consume from available forage biomass is key to the design of sustainable grazing land management systems and the formulation of recommendations to improve the feeding management of grazing herds and flocks. The "Short Course on Nutrition of Grazing Ruminants" was held February 28th through March 4th at the IBTA Patacamaya Research Station. The purpose of the course was to present to IBTA and IBTA/SR-CRSP staff, and staff and students of collaborating institutions, information on relevant techniques for measuring intake, selection, and digestibility of forages under free-grazing conditions. The course was sponsored by the USAID Bolivia Small Ruminant Collaborative Research Program (SR-CRSP), Texas Tech University, and the Instituto Boliviano de Tecnología Agropecuaria (IBTA). Funding was also provided by the USAID/Bolivia PL-480 Program.

Participants

Twenty four students participated in the course. A list of participants is attached. Of the 23 registered participants, six were women. The participants represented IBTA/ Patacamaya (5), the IBTA/SR-CRSP Program (7), national research development agencies (7 participants from the Development Corporations of La Paz and Oruru, the Center for Research and Promotion of Campesinos (CIPCA), and Danish Church Aid), bilateral cooperation programs (2 participants from IDRC and ORSTOM), and Bolivian Universities (2 participants from the Universidad Tomás Frías, Potosí and the Escuela Militar de Ingenieria, La Paz). Several staff of the Patacamay Experiment Station "audited" parts of the course as it proceeded.

Organization

Drs. Edmundo Espinoza and Jim Yazman, IBTA/SR-CRSP, planned and coordinated the course with the assistance of Lic. Guillermo Calderón, SR-CRSP/Bolivia administrative officer. The course was opened by Ing. Tito Rodriquez, at the time acting head of the IBTA Livestock and Forage Research Program. In attendance at the opening was Ing. Gualberto Espíndola, acting chief of the Patacamaya Research Station.

The course was led by Dr. Carlos Villalobos of Texas Tech University, Lubbock, Texas and Ing. Agrón. Einstein Tejada, IBTA Livestock Research Sub-Program, Patacamaya. Drs. Roberto Quiróz (IBTA/IDRC) and Didier Genin (IBTA/ORSTOM) made presentations to the assembled participants. Four students and recent graduates (Zulma Victoria, Magalí Cáceres of the IBTA/SR-CRSP, Percy Omar Abastos, ORSTOM, and Juan Carlos Cáceres, DANCHURCHAID) presented results of their thesis research completed or in progress.

Two sessions were held each day, morning and afternoon. Lecture sessions were maintained as informal as possible with ample opportunity for questions and commentary by participants.

Two afternoons were devoted to practical demonstrations. On one afternoon an esophageal-fistulated llama was taken out and allowed to graze. Fistula extrusa was collected (somewhat crudely with a plastic shopping bag as no fistula collection bag was available!) and examined by the students with commentary by Dr. Villalobos and Ing. Tejada. During the last afternoon of the course (Friday) students participated in the esophageal-fistulation of a llama led by Ing. Tejada.

Results and Evaluation

The course was very successful largely thanks to the excellent preparation of Dr. Villalobos and the enthusiasm of presenters and participants. The contributions of Ing. Tejada and Drs. Genin and Quiroz were very

important. Participation by IBTA Patacamaya staff during the week-long course was extensive, illustrating the relevance of course topics to the IBTA Livestock and Forages Research Program. Until he was called to La Paz on Wednesday, Ing. Rodriquez, the then newly-appointed IBTA Director of Research, was an active participant in the shortcourse, participating in question and answer sessions and providing useful commentary. Several Patacamaya-based students and technical staff not registered as participants sat in on course sessions as their schedules allowed.

Research techniques presented for measuring selectivity and intake by grazing ruminants ranged from simple, low-cost direct observation to more sophisticated microhistological techniques involving the examination of fistula extrusa, rumen, and fecal samples. Dr. Villalobos provided in-depth background to, and a ranking of 13 techniques for measuring selectivity of free grazing ruminants based on precision, cost, and labor required. Dr. Quiróz reviewed several direct and indirect methodologies for measuring consumption, including total collection of feces and the use of internal and external "markers." Valuable commentary was provided by Ing. Jaime Valdívia of IBTA/SR-CRSP who has had extensive experience using markers as a graduate student in Belgium. Dr. Quiróz further discussed methodologies for measuring digestibility *in vitro* and *in situ*. He stressed *in situ* techniques as being more appropriate to Bolivia where laboratory chemicals are expensive and closely controlled and where power supplies are erratic.

Several presentations of completed and in-progress research projects illustrated the use of techniques discussed in the lectures. Dr. Genin presented a summary of extensive research work in Baja, Mexico and Turco, Department of Oruro, using bite count methodology with goats (Mexico) and llamas (Bolivia). Dr. Villalobos reviewed work from northern Mexico using esophageal-fistulated sheep, goats, and cattle. Students from the IBTA/SR-CRSP, ORSTOM, and DANCHURCHAID presented thesis research completed or in progress in which research techniques and methodologies discussed during the course were being employed.

Throughout the shortcourse emphasis was placed on research techniques which are effective and efficient, but also appropriate to the resources of Bolivian institutions and to Bolivian livestock production environments. Stress was placed on the need to balance precision of measurements against cost of equipment, chemicals, and manpower and the need to select research methodologies that serve research goals and objectives. The social and cultural environment within which on-farm research projects operate were also stressed. For instance, in many Altiplano communities, campesinos will not tolerate the use of esophageal- or rumen-fistulated animals, especially llamas and alpacas. In such cases direct observation or microhistological examination of feces is the only way to estimate diet selection.

Participants were asked to provide written evaluations of course content and organization. Responses indicate that the course was well-received, provided a good background to appropriate research methodologies, and stimulated interest in further, more in-depth study.

Conclusion

Too little time at the Patacamaya Research Station, and among Bolivian agricultural research scientists in general, is devoted to exchange of research experiences and review of up-to-date methodologies. This shortcourse will contribute to the success of IBTA and IBTA/SR-CRSP ruminant nutrition research programs in the Altiplano, and that of collaborating institutions. Participants received the necessary information to allow them to select nutrition research techniques which are appropriate to their research objectives. Consideration should be given to a follow-on course, with fewer participants drawn from the just-completed shortcourse, focusing on a select number of appropriate research techniques once the nutrition research facilities at Patacamaya are more fully developed.

Comments

The SR-CRSP Bolivia Program counterpart organization, the Instituto Boliviano de Tecnología Agropecuaria (IBTA) receives support for counterpart funding from the USAID/Bolivia Mission's PL-480 (Title III) Program. In 1994 PL-480 provided US$ 110,824 to IBTA to support the IBTA/SR-CRSP Program (Table 13). This support provided for the salaries of IBTA administrative staff working full-time on the Program (one controller and one secretary) and four counterpart technicians, rental of Program offices in La Paz, and scholarships for four Program students. In 1994 IBTA also was able to use PL-480 funds to pay a substantial portion of operating costs for the Program office and for Program vehicles, as well as provide support for the development of the Forage Analysis Laboratory at Patacamaya. The support provided by PL-480 was very important to the ability of the Program to continue operating in Bolivia past September 30th, 1994, and into 1995.

Table 13. Support (US$) provided the IBTA/SR-CRSP Program by the USAID/Bolivia PL-480 Program

Item	Amount
Salaries and benefits	$70,422
Services	$20,077
Materials and supplies	$13,798
Equipment	$1,026
Scholarships	$5,500
Total	$110,823

Literature cited

Cala, Edgar, 1994. Estructura dinámica de la tenencia de tierras. Thesis submitted to the Facultad de Sociolgía, Universidad Mayor de San Andréas, La Paz, in partial fulfillment of the requirements for Licenciatura in Sociology. Small Ruminant Collaborative Research Support Program (SR-CRSP), Bolivia.

Espejo, Rigoberto, 1994. Ganadería en el proceso de diferencia social. Thesis submitted to the Facultad de Sociolgía, Universidad Mayor de San Andréas, La Paz, in partial fulfillment of the requirements for Licenciatura in Sociology. Small Ruminant Collaborative Research Support Program (SR-CRSP), Bolivia.

Lopez, Carola, 1994. Contenido nutricional de la dieta al pastoreo en tres especies de animales domésticos. Thesis submitted to the Facultad de Agronomía, Universidad Técnica de Oruru, Oruru, in partial fullfillment of the requirements for the degree of Ingeniero Agrónomo. Small Ruminant Collaborative Research Support Program (SR-CRSP), Bolivia.

KENYA

As part of the Greater Horn of Africa, Kenya lies south of Ethiopia, with neighboring countries of Somalia, the Sudan, Uganda and Tanzania. The topography is one of sharp contrasts. Practically every landform type -- ranging from glaciated mountains and permanent snow to a true desert landscape is present. Within the borders of Kenya one can find bush-covered plains in the interior; high-lying scrublands in the northwest; a narrow, dry coastal strip; fertile grasslands and highland forests in the southwest; and the Great Rift Valley in the west, location of some of the country's highest mountains, including Mt. Kenya (17,058 ft/5,199 m). Except for the temperate highlands, the climate is hot and dry. The great majority of Kenyans engage in subsistence farming. Coffee, tea, petroleum products, and fresh vegetables, fruits, and flowers are the chief exports. Large numbers of cattle are pastured in the grasslands.

Republic of Kenya
Jamhuri ya Kenya

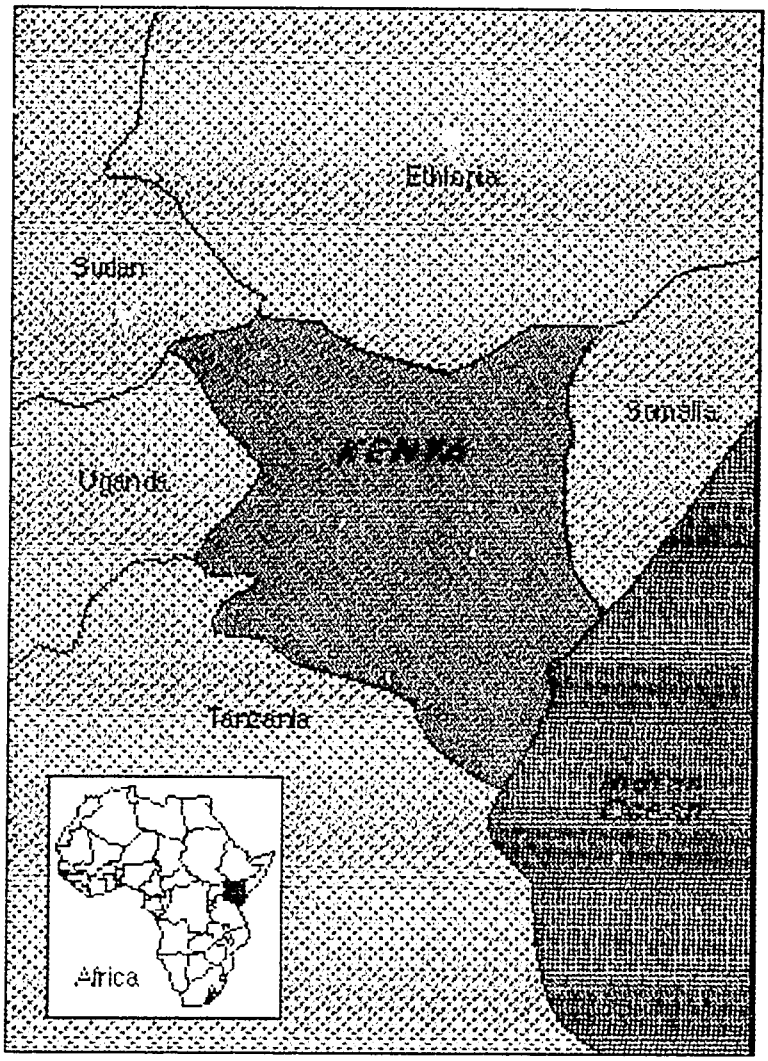
Population (1992 est.): 26,164,000.
Age distrib. (%): 0-14: 49.6; 15-59: 50.0; 60+: 3.4.
Urban (1991): 26%.
Ethnic groups: Kikuyu 21%, Luo 13%, Luhya 14%, Kelenjin 11%, Kamba 11%, others, including Asians, Arabs, Europeans.
Languages: Swahili (official), Kikuyu, Luhya, Luo, Meru.
Religions: Protestant 38%, Roman Catholic 28%, Moslem 6%, others.
Education (1989): Literacy: 50%. 86% attend primary school.

Industries: Tourism, light industry, petroleum products.
Chief crops: Coffee, corn, tea, cereals, cotton, sisal.
Minerals: Gold, limestone, diatomite, salt, barytes, magnesite, felspar, sapphires, fluospar, garnets.
Other resources: Timber, hides.
Arable land: 4%.
Fish catch (1990): 144,000 metric tons.
Labor force: 78% agric.

Finance: Monetary unit: Shilling (Nov. 1994: 49= $1 US). Gross domestic product (1991): $9.7 bln. Per capita GDP : $385.

Livestock (1991): Cattle 13,700,000; Sheep 6,550,000; Goats 8,100,000; Pigs 105,000; Camels 820,000.
Livestock Products (1991, in metric tons): Beef and veal 326,000; Mutton and lamb 26,000; Goats' meat 31,000; Cow's milk 2,189,000; Sheep's milk 29,000; Goat's milk 101,000.
Principal Crops (1991, in metric tons): Sugar cane 5,350,000; Maize 2,250,000; Coffee 90,000; Tea 204,000.

Communications: Television sets: 1 per 100 persons. Radios: 1 per 6 persons. Telephones: 1 per 67 persons.



Dual Purpose Goat

"Research in Kenya clearly shows that the dual purpose goat (DPG) has the potential for contributing significantly to the nutritional and economic welfare of households of small farmers. The milk-producing potential is the most important factor in the adoption of DPG by such farmers. . . .At the end of three years, the additional work is expected to have: (a) established a nucleus herd of 1,000 DPG does and 75 bucks; (b) released 500 DPG does and 1,000 bucks to farmers; (c) tested up to 50 technical interventions; (d) in operation a sustained DPG multiplication program; and (e) established a farming systems unit within the Kenya Agricultural Research Institute (KARI)."

p. 36, Extension Proposal, 1990-1995

Production Systems Project 73
Will R. Getz, Winrock International Institute for Agricultural Development

Breeding a Genetically Improved Dual Purpose Goat Adapted For Production in Kenya 79
Jeremy F. Taylor, Texas A&M University

Sociological Analysis of Small Ruminant Production Systems - Kenya 87
Michael F. Nolan, University of Missouri-Columbia

Production Systems Project

Winrock International Institute for Agricultural Development

Will R. Getz, Winrock International Institute for Agricultural Development, Petit Jean Mountain, Route 3, Morrilton, Arkansas, 72110. Tel: (501) 727-5435, Fax (501) 727-5426, E-mail: will@winrock.org

Narrative Summary

The transition of SR-CRSP production systems into the small ruminant program of the Kenya Agricultural Research Institute (KARI) continued this year so that the final stages of institutional strengthening became solidified.

The most evident elements of the transition included (1) the naming of Dr. Semenye by KARI to direct the national small ruminant program through an appointment with the MIAC/University Missouri system and their involvement with the Kenya national agriculture research project; (2) an agreement within the program advisory committee that Dr. Semenye would coordinate Kenya-based activities of the dual-purpose goat (DPG) component; and (3) investigations, monitoring, and evaluation of the DPG technology package in two major new sites representing semi-arid and coastal humid climatic environments.

The very severe and unplanned cuts in USAID allocations to the SR-CRSP after 1994 began required that the Production Systems Project (1) abandon continued active support to networking efforts in Tanzania and other parts of Africa, and (2) that the solidification support to NGOs working with DPG production systems in western Kenya be eliminated. Efforts were made to get the facts to USAID administrators as well as to members of the legislative branch of the U.S. Government so that cuts would be restored or additional allocations made to enable the DPG component to terminate with adequate data to assess final small farmer impact. In another forum, but toward the same targeted need, the Production Systems principal investigator made a presentation on justification for livestock research initiatives at a Congressional Briefing using SR-CRSP impact and examples of collaboration, institutional capacity building, and sustainable development.

To determine impact of the DPG on smallholder farms the production systems staff worked with other DPG component personnel in organizing and conducting research with 100 farmers. The impact assessment research used an FSR approach, and involved baseline measurements and monitoring the quality and quantity of inputs

Table 1. Mean Performance of KDPGs on Farms

Village	Milk Yield/ Day (ml/sd)	Birth Weight (kg/sd)	4 mo. Weight (kg/sd)	Doe Weight (kg/sd)
Kimtwa	610/300	2.5/0.6	16.5/2.6	33.0/4.0
Kitanga	840/400	2.8/0.5	15.3/5.3	37.0/9.0
Vuga	640/200	2.6/0.5	16.0/4.0	38.0/7.0
Matuga	560/220	2.6/0.5	15.9/5.0	34.0/6.0
Kakanjuni	-	2.6/0.5	-	34.0/6.0

Kakanjuni site just beginning to produce data
Average lactation length at time of report = 40 days
Milk yield does not include that consumed by kids
sd = standard deviation

and outputs of DPG production systems. At the end of the year a total of 85 Kenya DPGs (4-breed composite) were located on 25 farms, while the other 75 farms provided continuing baseline information as they awaited transfer of young does born from the original farm placements.

Except for some variation between farms, most KDPGs are managed on free-range grazing with limited supplementation. Supplementation included cut-and-carry forage, and at the humid coastal sites, maize bran by farmers selling milk. All farmers in the study participated in a 1-day course on the husbandry of KDPGs. Courses were conducted jointly by KARI and Ministry of Agriculture extension officers posted in each geographic area.

Until further data suggests modification, farmers are encouraged to dip or spray their goats once a week, to drench quarterly, and to vaccinate against enterotoxemia biannually. Once the ticks are typed and the worm burden profiles established for each village, the recommendations may change.

Mortality rate of kids on the farms has been an acceptable 10%. The 26% mortality rate for does placed on farms is unacceptably high. Experience gained by farmers with the does may be reflected in the lower mortality of the kids. The learning curve of farmers first receiving DPGs is relatively steep, and when attitudes toward animal keeping are factored in, the random selection of farmers for participation in this research may be a contributing factor.

Kenya Dual Purpose Goat technologies developed in western Kenya continued to be modified for the new sites, during this period of impact assessment. The modifications are necessary in the face of different environmental conditions in the Machakos District (semi-arid) and the Coast Region (hot, humid). Technology developed by KARI scientists using napier grass, leucaena and clitoria spp at the coast, is being tested with KDPG farmers. Grazing behavior studies are resulting in intervention points for animal management and feeding. Multiplication of forage seed materials is being undertaken at Katumani, in order to resolve the unavailability of fodder at farm level. Sunflowers are being grown as a cash crop and source of a high protein residue for dual-purpose goats.

Because of the on-farm research approach promoted by the SR-CRSP, a significant number of additional extension staff are being brought into the production systems research work. Thirteen of 41 participants in the National Small Ruminant Research Program Workshop were extension personnel. This is creating stronger linkages between research and extension in a country where very limited resources require that more efficiency exist in providing technology to small farmers.

Research

The function of production system research in this final phase of the Dual-purpose Goat Component is to integrate and test production systems which combine biological, economic, and social aspects for consideration. The assessment of impact is primarily focused on social and economic elements of small farmers. Data are being collected by SR-CRSP colleagues for this information.

Dual-purpose goat production systems add diversity to the farming system, provide desired soil amendments, provide critical nutrients for child survival, enhance household income, often providing discretionary funds for women, create the necessary inputs for feast and ceremonial days, and work best in systems that encourage better soil management, a mix of crops, and viable food security strategies. Data to verify these functions and associated impact are being collected by the Kenya DPG Component group and is coordinated by the Production Systems resident scientist.

Training

The production systems project supported no degree training in 1994. Several non-degree training events occurred. These were 1-day farmer training for participants in the on-farm research activities with Kenya Dual Purpose Goats.

A 3-day workshop was conducted at Mbagathi from November 8-10, 1994 for the purpose of developing a viable small

ruminant research agenda for KARI. The production systems resident scientist has a lead role in organizing and follow-through.

Other Contributions

Environmental impact and relevance

The production systems project looks for ways to combine farming and environmental needs. The use of forages and trees in goat production systems enhances soil conservation. The use of animal manure in cropping systems enhances soil fertility thus reducing the amount of marginal land that must be maintained in production. The use of nitrogen-fixing tree and forage species reduces the amount of costly commercial fertilizer required for food crops. And the use of crops in the production system that can serve people and animals in a dual-purpose function has lead to the use of sweet potato vines for early weaning of kids, the promotion of pigeon peas as a legumeous human foodstuff, and the use of maize and sorghum leaves for animals after the grain crop is set.

Agricultural sustainability

The production systems project seeks to promote crop and enterprise diversity. This diversity strengthens the sustainability of the whole farming system. By working directly with farmers in identifying the existing production constraints, and involving farmers in determining possible interventions, the resulting solutions are more likely to be adopted and therefore sustained. Part of the reason for this is because the interventions tested on farms are those most likely to depend on locally available, reasonably priced and socially acceptable interventions ...therefore sustainability. The methodologies tested and put into place by the SR-CRSP are now being incorporated on an institutional basis because they are seen as being the foundation to a sustainable research program for the national research institution.

Contributions to U.S. Agriculture

Many of the research methodologies developed through production systems work in the SR-CRSP have been taken up by American researchers who have re-discovered the fact that farmers can be viable members of the research team. The systems approach is now recognized as having a central place in the U.S. research system. Therefore the benefit to U.S. Agriculture is that more of the research conducted in the U.S. is based upon a more realistic view and realistic constraints. Several of the feeding methods researched in Kenya have now found application among goat producers in the U.S. e.g. sweet potato leaves for low-cost early weaning.

Contributions to Host Countries (Kenya/eastern Africa)

The contributions are two-fold. First, viable options have been developed for dual-purpose goat production systems in line with responsible natural resource use and local economies. Secondly, the production systems group has created an awareness in the Kenya Agriculture Research Institute that on-farm, systems research is good research and should be incorporated into institutional strength. Hence there has been important institutional and human resource development.

Linkages and networking

The production systems group has been involved on three fronts in this regard.

PanAfrica. Dr. Semenye has participated in and is currently a member of the board of directors of the ILCA-based Small Ruminant Network (SRNET) which involves researchers from many parts of Africa. The SRNET secretariat is located on the ILRAD campus in the Kabete area. This close proximity gives the SR-CRSP resident scientist an opportunity to have positive impact on SRNET even on an informal basis.

Tanzania. The Tanzania Livestock Research Unit of the Division of Research and Training has benefited from SR-CRSP technical and financial support for a goat research endeavor in southern Tanzania

(Newala District), an area traditionally tied to cashew nut production and with little experience with small ruminants production systems. The small ruminant is seen as a means to enhance the local diet and diversify the sources of household income in times of a depressed cashew nut market. Because of the drastic cuts in 1994 USAID funding, active participation by the production systems group in this effort at establishing meaningful linkages with other countries in eastern Africa came to a halt.

In February 1994, Dr. Semenye and Dr. Getz were invited as observers to a workshop (organized through a Dutch-funded farming systems research initiative) in Morogoro, Tanzania where the topic was the review and planning of the national livestock research program. The meeting occurred at a time when we had planned to review the goat research activities beginning in Newala District, but allowed us to make contributions to the thought on small ruminant research in that country. At the time we were not aware that subsequent production systems research cuts would mandate that support for Tanzania be totally withdrawn in 1994.

Zimbabwe and Southern Africa. No further action was taken in regard to a promised small ruminant systems research methodologies workshop in Zimbabwe for participants in southern Africa. The financial resources to supplement such an undertaking, even with potential contributions from other sources, simply were not there. Furthermore, the USAID Mission in Zimbabwe would not give travel approval for any resource persons invited to participate through USAID funds. Therefore the lack of local USAID endorsement as well as the Washington cut in allocations meant that this networking initiative could not go forward.

Gender Issues and Analysis

The SR-CRSP as a whole has been especially sensitive to the role of women and the need to enhance their ability to control resources, receive training, and be engaged the field research endeavors. During 1994 the production systems project worked with women farmers in the on-farm research and engaged women researchers within the KARI system. The Assistant Director - Livestock Production Research is a woman who influences research policy and contributes to overall KARI research management.

Collaboration with IARCs and other CRSPs

The production systems project had no significant interaction with other CRSPs in 1994. There are none operating in Kenya, and the Bean/Cowpea CRSP which is operational in Tanzania had no points at which useful collaboration could occur.

The production systems project personnel did collaborate with ILCA staff at the Mtwapa where they are working on the economics and forage/management needs of dairy cattle in a humid, coastal environment. Contact was also made with ICRAF in regard to collaboration in connection with an expanded small ruminant research program in eastern Africa and the role of tree species for feed and farm wood supplies. The eastern Africa representatives of CIP hosted discussions on possible collaboration on sweet potatoes, and in fact these discussions lead to joint field activities in Machakos District. The research and findings of ILRAD as well as the work of the SR-CRSP animal health project were applied to the production systems work in Kenya.

Support for Free Markets

Farming in Kenya for small-holders is free and risky. The efforts to create viable small ruminant production systems will assist small farmers who want to diversify and produce products very much in demand. Private enterprise is the core of what these small farmers do. In order to help them remain economically active the small ruminant adds stability. The development of viable DPG production systems has created or strengthened markets for goat forage materials, goat manure, goat milk, for breeding stock, and for slaughter animals. These markets add cash for the household or establish a stronger base for acquiring barter labor...often a constraint in the labor intensive farming systems.

Contributions to and Compliance with Mission Objectives

The production systems project, as with the whole SR-CRSP, is concerned with economic viability, the human condition, and creating viable small agribusiness units. Economic development comes from the ability of people to feed themselves and to produce products that have cash value and contribute to the local economy. Small ruminant production systems enhance the economic well-being of farmers and therefore the local rural economy.

The local Mission has also been promoting institution capacity building for many years. The SR-CRSP production systems project has enhanced the ability of KARI to conduct systematic on-farm research with livestock, thus involving numerous small farmers in producing research information and ultimately creating more acceptable technologies for use by the extension service. The production systems research capacity has been fully integrated in the KARI system. The former resident scientist (Dr. Semenye) now serves as coordinator of all small ruminant research for the nation. The capacity of KARI to do good and useful systems research with farmers involved, is significantly enhanced because of the SR-CRSP.

Concern for Individuals

The production systems research group worked with 100 individual small farmers and their families in 1994. The whole focus is on individual farmers who have the capacity to contribute to the research base of information, but also to their neighbors who observe the outcome of the research. The on-farm orientation of production systems research requires that individual farmers be directly involved.

Support for Democracy. Few small farmers work in isolation from their neighbors or communities. Farmer group formation is encouraged by the SR-CRSP and these groups function in a democratic fashion with open discussion, election of officials, reaching consensus, open voting, and providing a venue for complaints. The production systems research group has helped coordinate the farmers organization role in multiplication of dual-purpose goats. Those farmers who received the initial placement of does have an obligation to pass-on female offspring to other farmers in the group to serve as new seedstock. The farmer's groups monitor management practices and provide peer pressure on those individuals already involved with the animals.

Humanitarian Assistance. Concern for the human condition and the central role of food security are major factors driving the production systems research agenda. Testimony from numerous small farmers, especially women, to the fact that milk from goats has changed the appearance and behavior of their children for the better verifies the impact on humans. Yet what the SR-CRSP has done in 1994 is not short-term emergency driven, but long-term capacity building. The research provides individual farm families to sustain themselves over the long term. That approach is meaningful humanitarian assistance.

Collaborating Personnel

In the United States the production system project collaborates with Washington State University, University of Missouri-Columbia, and Texas A&M University in obtaining the information and results necessary for this holistic approach.

In the Host Country (Kenya) we are collaborating most directly with the Kenya Agriculture Research Institute. In addition the production systems group collaborates with a number of local and international nongovernment organizations in field research and in providing leadership for endeavors in implementing small ruminant programs.

One of the primary local collaborating scientists (based at Katumani) is Dr. S.M. Bawni, an animal nutritionist who received his doctorate from Oklahoma State University. Before departing for further studies, Mrs. Wanyama was collaborating scientist designate, and head of animal production research at Katumani. In the Coast Region, Dr. Mirithi, director of the livestock section at the Mtwapa Research

Centre has served as prime collaborating scientist.

Collaborating Institution

Kenya Agriculture Research Inst. (KARI)
Attn: Dr. Agusta Abate, Asst. Director
P.O. Box 57811
Nairobi, Kenya
Phone: 254 2 444030
Fax: 254 2 747986

Publications

Semenye, P.P. and W.R. Getz. 1994. How farmer-oriented research with dual-purpose goats in western Kenya evolved. In: Proceedings of 11th SR-CRSP Scientific Workshop, Nairobi, Kenya. March 3-4, 1993. pp 71-78.

Presentations

Semenye, P.P. and W. R. Getz. 1994. Performance of dual-purpose goats on farms. Presented at 12th SR-CRSP Scientific Workshop. ILRAD-Kabete, Nairobi. March 2-3.

Semenye, P.P. 1994. Small Ruminant Research: History and Future. Presentation at Workshop on National Small Ruminant Research Strategies. Mbagathi, Kenya. November 8-10.

Comments

The SR-CRSP research and NGO solidification work in western Kenya has created a foundation from which a new initiative in on-farm productivity enhancement was launched in 1994 by Winrock International. Much of the western Kenya work is funded through a grant from the Fund for International Cooperation in Hunger Alleviation (FICHA) and is tied to a larger productivity enhancement program being implemented in Uganda, Senegal, and The Gambia through funding from the Office of Private and Voluntary Cooperation, USAID, Washington. The focus of OFPEP is on soil management, seeds, extension services. Small ruminants (goats) are often a factor in soil fertility, conservation enhancement, and cash for cropping inputs.

The level of frustration for the production systems project in 1994 has been high. This is because we have come so close to reaping useful data on production systems impact at a time when the financial resources upon which we were depending were pulled from under us after commitments were already made. Further frustrations occur when officials of the funding agency seem not to be able to find time to observe impact in the field for themselves. Fortunately on the technical side we have received undying support from the USAID program manager in Washington.

We were encouraged by the outcome and observations made by a USAID appointed CRSP evaluation team regarding the SR-CRSP in general and the production systems project in particular. We are also encouraged by what appears to be a positive attitude toward small ruminant research by the newly appointed USAID director of agriculture programs in Washington. However, the role of agriculture in general in the current USAID mandate remains problematic and that is not encouraging.

Considerable time has been invested in collaboration with other organizations in Kenya working in livestock development initiatives. These include World Bank, FARM-Africa, Heifer Project International, Kenya Studbook, and numerous indigenous NGOs.

Breeding a Genetically Improved Dual Purpose Goat Adapted For Production in Kenya

Texas A&M University

Jeremy F. Taylor, Department of Animal Science, Texas Agricultural Experiment Station, Texas A&M University, College Station, Texas, 77843. Telephone (409) 845-2616, Fax (409) 845-6970, E-mail: jtaylor@zeus.tamu.edu

Narrative Summary

The elimination of funding for the SR-CRSP for the fifth year of the current grant extension caused a redirection of project efforts towards effecting the registration, multiplication and distribution of the Kenya Dual Purpose Goat breed. In collaboration with the Socioeconomic and Farming Systems projects of the Dual Purpose Goat Component and the Animal Health Component, farmer training and impact assessment studies were facilitated and will be reported by these projects. All Breeding project financial and personnel resources were directed toward facilitating objectives of registration, multiplication and distribution of the Kenya Dual Purpose Goat (KDPG) breed rather than address research objectives concerning resistance of the KDPG to the gastrointestinal tract parasite *Haemonchus contortus*.

Following a flock inspection conducted on June 24, 1994, the Breeding project (under the driving forces of Mr. Joséph King oku and Dr. Joséph Kogi) successfully registered a new breed of goat in Kenya with the Kenya Stud Book, an organization under the umbrella of the national Agricultural Society of Kenya (A.S.K.) that caters for breeders of various livestock species. The new breed is known as the Kenya Dual Purpose Goat with a herd prefix of Magogo dual (DM). The breed was launched in the Kenya Stud Book grading up register initially with 215 4-way composites whose ancestry includes the Small East African, Galla, Toggenburg and Nubian breeds. The registered composites are the progeny of a 4-way buck and 4-way doe and meet the standards of excellence established for the new breed. The registered composites form the foundation stock from which the process of breed stabilization will produce KDPG registered as intermediate (progeny of foundation animals), appendix (progeny of intermediate animals) and pedigree (progeny of appendix animals). Further registration of existing second and third generation KDPG animals and the progeny of the foundation KDPG flock will lead to the registration of pedigree KDPG animals by 1997.

Between December 1993 and November 1994, the number of KDPG increased by 20% from 790 (371 males, 419 females) to 947 (391 males, 556 females). This increase allowed the Breeding project to meet its objective of producing 500 KDPG does by 1995. Of these, 100 males and 115 females at Ol Magogo have been registered with the Kenya Stud Book as foundation animals of the KDPG breed. A total of 110 KDPG animals are now participating in the Impact Assessment study involving smallholders located in the central Katumani and coastal Kilifi and Kwale locales. The role of the Breeding project in the Impact Assessment study has been to organize the small-scale farmers into breeding groups, provide training on goat management, provide advice on the sale of composite bucks and on the distribution of KDPG does to other smallholders within each group. A particular emphasis has been placed on the involvement of women smallholders in the distribution phase of the KDPG.

Table 1: Distribution of Genotypes at Ol'Magogo, Katumani, Kwale and Kilifi

	December 1993			November 1994		
	EA/Galla	F_1	KDPG	EA/Galla	F_1	KDPG
Does	76	256	419	17	229	556
Bucks	21	58	371	3	33	391
Total	97	314	790	20	314	947

Research

Dr. Joséph Kogi was the Breeding project Resident Scientist located at Kabete following completion of graduate training in Animal Breeding at Texas A&M University and his return to Kenya in February of 1993. To conserve project funds, Dr. Kogi was hired by the Kenya Agricultural Research Institute on the NARP II project during the year. His responsibilities remained as the Breeding project Resident Scientist. Mr. Joséph King'oku continued in the role of Livestock Officer during 1994.

Activity: Multiplication and Distribution

Problem Statement and Approach

The multiplication and distribution phase of the KDPG project is expected to be facilitated with the cooperation of NGOs and private breeders. The KDPG is now registered as a breed and the philosophy of our approach is that NGOs and private breeders will possess a vested interest in the multiplication of the KDPG. The SR-CRSP and KARI will provide technical backstopping to the management of programs at each collaborating site to ensure that animal losses are minimized and that a minimum amount of critical data are collected to allow the evaluation of impact and adaptation of the breed at each site. These data will also allow the identification of elite bucks which can contribute to the development of the nucleus flock gene pool at Ol'Magogo.

Progress

Table 1 gives the current inventory of the number of KDPG. The table reflects the culling of purebred does, includes 215 registered animals and the 110 KDPG involved in the impact assessment study at Katumani, Kwale and Kilifi. The table reveals a 20% increase in the number of KDPG animals produced over the last 11 months. This increase was achieved in the presence of a severe drought in 1993 which extended into 1994.

The annual rate of multiplication is consistent with our goal of producing 500 KDPG breeding does by September 1995.

During the year the collaboration between the Breeding, Farming Systems and Socioeconomic projects of the KDPG Component, the Animal Health Component, and Heifer Project International (HPI) continued to distribute the KDPG in an impact assessment study. The disbursement of animals continued with 110 KDPG now in the possession of smallholder farmers at Katumani, Kilifi and Kwale. The role of the Breeding project in the Impact Assessment study has been to organize the small-scale farmers into breeding groups, provide training on goat management, provide advice on the sale of composite bucks and on the distribution of KDPG does to other smallholders within each group. A particular emphasis has been placed on the involvement of women smallholders in the distribution phase of the KDPG. The Breeding project Resident Scientist participated in a seminar at Mombasa organized by Heifer Project International held on 16-22 July focusing on Women in livestock development and presented a paper entitled "The Kenya Dual Purpose Goat and Women in Livestock Development in Kenya."

The Breeding project Resident Scientist currently sits as the chair of a "Breeding,

Multiplication and Distribution" committee formed by the ME and KARI to design a program for the future development of the KDPG. The report from this committee should by now have been received by the ME. The process of identifying private farmers interested in commercializing the KDPG has commenced.

Activity: Development of the KDPG

Problem Statement and Approach

The breeding program was designed to focus on the genetic aspects of producing a low maintenance and high milk producing KDPG for Western Kenya, which could be adapted to other areas of Kenya. The primary selection objectives are to produce an animal of mature size of 40 kg and with a peak lactation milk production of 4.0 kg/d.

Progress

Research in 1994 was constrained to the gathering of milk production and growth data in order to allow the estimation of breeding values of KDPG for use in breeding to stabilize the performance of the breed.

Activity: Genetics of Disease Resistance

Problem Statement and Approach

A major production constraint of cattle, sheep and goats in tropical and subtropical areas is the detrimental effect of the stomach worm *Haemonchus contortus*. These effects include reduced productivity, cost of continuous treatment and dangers to smallholders handling the anthelmintics. Through field testing, this project has established that there is wide ranging variability for resistance/resilience to *Haemonchus contortus* in the genetically segregating KDPG population and that various measures of the phenotype of resistance (EPG and PCV) have a genetic basis. Since drugs have been only marginally effective for control in LDCs and there is evidence that parasites may develop resistance to these drugs, development of genetically mediated resistance or resilience in small ruminants has been recommended. If strains of resistant/resilient goats could be identified and selected, a major constraint to production and food chain contamination could be alleviated. Further, these animals would be of considerable economic benefit to the host country as the export demand for live animals, semen and embryos would likely be great.

This project activity has followed two approaches to the characterization of phenotypes and genotypes of resistance/resilience:

- With the collaboration of the Washington State University Animal Health project and the University of Nairobi, all kids born are screened for EPG and PCV for initial phenotype determination. These data provide the basis for estimation of heritabilities within the total population. Those animals putatively resistant or resilient (defined as possessing EPG < 1,000 eggs/g of feces) are then experimentally challenged to confirm phenotype. Animals identified as resistant are those in which no detectable level of parasitism (as measured by EPG) is obtained. Animals in which EPG < 1,000 for the duration of the experimental protocol are defined as resilient. Animals in which EPG > 1,000 during the experimental challenge are defined as susceptible and are returned to the susceptible breeding flock at Ol'Magogo.
- The resistant/resilient flock is being used in matings to determine whether resistance and/or resilience of the KDPG flock can be improved through the more usual breeding methods utilizing artificial selection. Matings among resistant/resilient and susceptible animals will also provide goat families that should segregate for the phenotypes of resistance and resilience. This approach was followed to provide animals from which DNA could be extracted to screen DNA markers for associations with quantitative trait loci (QTL) or major genes associated with these phenotypes. Key to this approach is

the development of both the segregating families and a suite of molecular markers distributed through the genome that would allow the detection of such genes wherever they are located on one (or more) of the caprine chromosomes (2N=54). The detection of genes influencing resistance or resilience to *Haemonchus contortus* using molecular genetic approaches would allow for much greater opportunities to make genetic improvements using genotypes identified at the DNA level rather than phenotypic level. Further, detection of marker genes associated with resistance or resilience may allow the identification of desirable genotypes in small ruminant populations worldwide to effect rapid and cost efficient genetic progress.

Progress

Dr. Joséph Kogi successfully defended his M.S. thesis on February 11, 1994 and graduated with an M.S. degree in Animal Breeding in May, 1994.

Due to funding constraints, no research in the area of disease resistance was pursued in 1994. Research conducted in our laboratories was only peripheral to this project but utilized technology developed under the Breeding project. In particular, we examined the utility of microsatellite markers developed in the bovine, ovine and caprine for population studies in other related artiodactyls. DNA microsatellites have proven extremely useful as markers in gene mapping studies due to their high level of polymorphism and broad genomic distribution. These properties suggest that they will be useful for studies of population structure. The limiting factor is the development of PCR primer sets for each new species of interest, as this requires the construction and screening of genomic DNA libraries, DNA sequencing and primer design. We found that the degree of genetic conservation of microsatellite loci was such that PCR primers designed for bovine, ovine or caprine loci successfully amplified microsatellites in many other artiodactyl species. When 20 primer sets were tested on 10 bovid and six cervid species, polymorphic products were obtained for at least 7 of the 16 species with 12 of the primer pairs. This success in using heterologous PCR primers to amplify microsatellite loci in a number of different species eliminates the need to develop new primer sets for each species and therefore facilitates the use of DNA microsatellites as markers in population genetic studies. A manuscript describing this research and acknowledging the SR-CRSP has been accepted by the Journal of Mammology.

Training

Completed

Dr. Joséph K. Kogi successfully completed an M.S. degree in Animal Breeding at Texas A&M University graduating in May 1994. His thesis research involved developing genetic markers for resistance to *Haemonchus contortus*. Dr. Kogi was completely supported by the Breeding project. Dr. Kogi returned to Kenya as the Breeding project Resident Scientist.

Ms. Elizabeth McDonald completed an M.S. degree in Animal Science with an emphasis in small ruminant production graduating in August 1994. Ms. McDonald returned to a research position with the Jamaican Agricultural Development Foundation.

In Progress

Ms. Chen-Chen Yeh has completed the course work requirement for a M.S. degree in Genetics. However, a severe and prolonged illness in her family caused her to withdraw from her research program during the spring and summer semesters of 1993. She has now resumed her research and we anticipate that she will graduate in May 1995.

Other Contributions

Environmental Impact and Relevance

Small ruminants, and goats in particular, have unjustifiably been criticized for contributing to the degradation of much of

the world's agricultural lands. Often, such degradation is due to non-sustainable human agricultural practices, such as slash and burn cropping, but when overgrazing is a contributing factor, the fault is again due to non-sustainable human management practices. Even where overgrazing is a contributing factor to degradation, critics of small ruminants must not overlook the fact that goats are usually the only livestock species that can utilize these marginal lands to convert browse to human food protein. The SR-CRSP KDPG component has addressed these issues in the design of the program which focuses on the integration of small ruminant and crop production in the small-holder context. The central theme of the component has been the production of a Techpack, published in English and Kiswahili, designed to present an integrated production technology to producers that will ensure that small ruminant production will enhance soil conservation and fertility rather than contribute to its degradation. The Techpack is undergoing testing in the smallholder context with the distribution of 110 animals to the semi-arid Katumani and the tropical Kilifi and Kwale coastal regions.

Agricultural Sustainability

The premise of all research and development conducted by the SR-CRSP KDPG component is agricultural sustainability. The program is directed at the development of a dual-purpose goat designed to meet milk and meat components of human protein consumption with the context of a sustainable farming-systems model. This model integrates crop and restricted-grazing animal production using by-product feeding and low-tillage agriculture that incorporates animal manure as fertilizer. The Techpack is designed to ensure that the small ruminant component contributes to soil conservation and fertility rather than allowing degradation due to human allowance of overgrazing. *Haemonchus* resistance research is designed to ultimately allow the elimination of dependence on chemicals for parasite control.

Contributions to U.S. Agriculture

The genetic studies on *Haemonchus contortus* are of importance to the US due to the importance of parasite resistance to chemotherapy, and due to the estimated annual $45 million cost due .o losses in sheep and goat production. While we have detected 4 markers associated with phenotypes of resistance to *Haemonchus*, we have not been able to continue research to validate the utility of these markers for breeding for resistance. However, if these marker-QTL associations are genetically based, we may at last have a tool to utilize in breeding programs to select for resistance in domestic small ruminant populations.

The Breeding project has now developed 20 polymorphic caprine microsatellite markers which are published and available to other U.S. researchers.

Dr. Ruvuna is Co-PI and Dr. Taylor is Co-investigator on a $500,000 5-yr. USAID Linkages program grant to establish collaborations between the UNAM (Mexico) and Texas A&M University to research limitations to the free trade of agricultural commodities between Mexico and the US.

Linkage and Networking

The Kenya Stud Book has registered the KDPG as a breed.

An Impact Assessment project involving Heifer Project International, KARI and all of the Kenya projects is underway to evaluated the potential of the KDPG to benefit smallholder farmers.

A Breeding, Multiplication and Distribution committee involving SR-CRSP, KARI, ILCA and University personnel has been formed with the charge of planning a course for the sustainability of the KDPG.

Gender Analysis

The Breeding project Resident Scientist participated in a seminar at Mombasa organized by Heifer Project International held on 16-22 July focusing on Women in livestock development and presented a paper entitled "The Kenya Dual Purpose Goat and Women in Livestock Development in Kenya."

Ms. Elizabeth McDonald, a Jamaican national supported by the Jamaica Agricultural Development Foundation completed an M.S. degree in small ruminant production at Texas A&M University and has returned to a research position with the JADF.

Ms. Chen-Chen Yeh, a Taiwanese national is pursuing an M.S. degree in Genetics at Texas A&M University utilizing the KDPG DNA.

Collaboration with IARCS and other CRSPs

Dr. Leyden Baker of ILCA visited the Breeding project at Texas A&M University in September 1994 to review research progress and to consult on the genetics of disease resistance in small ruminants.

Ms. Elizabeth McDonald, a Jamaican national was provided support by the Jamaica Agricultural Development Foundation (JADF) to complete an M.S. degree in small ruminant production at Texas A&M University.

Support for Free Markets and Broad Based Economic Growth

The project has recruited HPI as a collaborating NGO in the implementation of the KDPG impact assessment study. This study follows a model of privatization and decentralization for the multiplication and distribution of the KDPG. A total of 110 KDPG animals have been distributed in this study.

Contributions to and compliance with Mission Objectives

Consultations with the USAID/K Mission ADO during the Kenya PAC meeting in March 1994 were to ensure that the design of the multiplication and distribution phase of the KDPG Breeding project was in accordance with Mission objectives.

Concern for individuals

The major contribution of the Breeding project indicative of a concern for individuals is the commitment of the project to training to provide a mechanism for life-long advancement. In addition to providing M.S. training for Dr. Kogi, a Kenyan national, the Breeding project provided resources to support the M.S. programs of Ms. Elizabeth McDonald (Jamaica) and Ms. Chen-Chen Yeh (Taiwan). The project also continues to support the research of Dr. R.M. Waruiru, a faculty member at the University of Nairobi, through collaborative research regarding the genetics of *Haemonchus* resistance.

Support for democracy

Distribution of 110 KDPGs to smallholders supports the concept of privatization and free trade inherent to the democratic principle.

Training of Dr. Kogi at Texas A&M University in an M.S. degree provided him with exposure to the principles of the U.S. democratic system.

Humanitarian assistance

In collaboration with HPI more than 30 smallholder families benefited from receiving KDPG does and technical training through the distribution of KDPGs in the Impact Assessment study.

Collaborating Personnel

United States

Francis Ruvuna, Research Scientist, TAES (until November 1994); Associate Professor, Alabama A&M University (from December 1994).

Scott K. Davis, Associate Professor, TAES.

Kenya

Joséph Kogi, Resident scientist, KARI.

Joséph M. King oku, Livestock Officer, TAES.

R.M. Waruiru, Lecturer, University of Nairobi.
S.M. Mkuu, Technical Officer, KARI.
F. Rurangirwa, Associate Professor, Washington State University.

Collaborating Institutions

Kenya Agricultural Research Institute
P.O. Box 57811
Nairobi
Kenya
Tel: 254-2-444-144
Fax: 254-2-440-771

University of Nairobi
Dept. Vet. Pathology & Microbiology, and
Dept. Animal Production
P.O. Box 29053
Kabete, Kenya
Tel: 254-2-632-211
Fax: 254-2-630-818

Publications

Ruvuna, F. and J.F. Taylor. 1994. The genetics of parasite resistance. Sheep and Goat Research J. 10:178-187.

Holder, D.A., E. Arevalo, M.T. Holder, J.F. Taylor and S.K. Davis. 1994. Bovine microsatellite dinucleotide repeat polymorphism at the TEXAN-1, TEXAN-2, TEXAN-3, TEXAN-4, and TEXAN-5 loci. Animal Genetics 25:201.

Arevalo, E., D.A. Holder, J.N. Derr, E. Bhebhe, R.A. Linn, F. Ruvuna, S.K. Davis, and J.F. Taylor. 1994. Caprine microsatellite dinucleotide repeat polymorphism at the SR-CRSP-1, SR-CRSP-2, SR-CRSP-3, SR-CRSP-4, and SR-CRSP-5 loci. Animal Genetics 25:202.

Bhebhe, E., J.K. Kogi, D.A. Holder, E. Arevalo, J.N. Derr, R.A. Linn, F. Ruvuna, S.K. Davis, and J.F. Taylor. 1994. Caprine microsatellite dinucleotide repeat polymorphism at the SR-CRSP-6, SR-CRSP-7, SR-CRSP-8, SR-CRSP-9, and SR-CRSP-10 loci. Animal Genetics 25:203.

Kogi, J.K. 1994. Characterization of genetic resistance to helminths in goats using microsatellite genetic markers. M.S. Thesis. Texas A&M University College Station, TX.

Ruvuna, F., J.K. Kogi, J.F. Taylor, and S.M. Mkuu. 1994. Lactation curves among crosses of Galla and East African with Toggenburg and Anglo Nubian goats. Small Ruminant Res.

Burns, B.M., K.L. Herring, J.F. Taylor, A.D. Herring, M.T. Holder, J.S. Collins, T.M. Guerra, J.O. Sanders and S.K. Davis. 1994. Bovine microsatellite dinucleotide repeat polymorphisms at the TEXAN6, TEXAN7, TEXAN8, TEXAN9, and TEXAN10 loci. Animal Genetics (accepted).

Burns, B.M., J.F. Taylor, K.L. Herring, A.D. Herring, M.T. Holder, J.S. Collins, T.M. Guerra, J.O. Sanders and S.K. Davis. 1994. Bovine microsatellite dinucleotide repeat polymorphisms at the TEXAN11, TEXAN12, TEXAN13, TEXAN14, and TEXAN15 loci. Animal Genetics (accepted).

Engel, S.R., R.A. Linn, J.F. Taylor and S.K. Davis. 1994. Conservation of microsatellite loci across species--implications for population studies in different taxa. J. Mamm. (accepted).

Abstracts

Thallman, R.M., J.F. Taylor, C.R. Young, and S.K. Davis. 1994. Application of molecular selection to DNA fragments that contain microsatellites. Proc. 5th World Congress on Genetics Applied to Livestock Production. Guelph, Aug. 7-12.

Kogi, J.K., J.F. Taylor, F. Ruvuna, S.K. Davis, E. Bhebhe, C.C. Yeh, R.M. Waruiru, F.R. Rurangirwa, S. Mkuu and J. King oku. 1994. Genetic markers: Associations with *Haemonchus contortus* and growth traits in goats. Proc. 12th annual SR-CRSP workshop, Nairobi. March 2-3, 1994.

Jones, M.B., J.F. Taylor, F. Ruvuna, J.O. Sanders, J.W. Turner, P.F. Dahm, J.K. Kogi, J. King oku and S. Mkuu. 1994. Estimation of heterosis and heterosis retention in the development of the Kenya Dual Purpose Goat. Proc. 12th annual SR-CRSP workshop, Nairobi. March 2-3, 1994.

Presentations

King oku, J.M., J.K. Kogi, J.F. Taylor and F. Ruvuna. 1994. The Kenya Dual Purpose Goat and Women in Livestock Development. Proc. Conf. Women in Livestock Development. Heifer Project International. Mombasa 16-21 May. pp3.

Sociological Analysis of Small Ruminant Production Systems- Kenya

University of Missouri-Columbia

Michael F. Nolan, International Agricultural Programs, 215 Gentry Hall, University of Missouri, Columbia, Missouri, 65211. Telephone (314) 882-2745, Fax (314) 882-5147, E-mail: agmike@muccmail.missouri.edu

Foreword

This has been a difficult year for SR-CRSP Socio-economics project, scientists and support staff in Kenya. The uncertain future of the research program and the funding cuts imposed by USAID/Washington forced the reduction of research activities in order to secure completion of those considered essential, such as assessing the extent to which the Kenya Dual Purpose Goat is acceptable and contribute to the welfare of household farmers in new sites. Health research activities were suspended, and only those that could be based only on information gathered through the impact assessment baseline survey in Machakos and the Coast, and the monitoring surveys that would follow were undertaken.

This report documents what was accomplished by the socio-economics team in Kenya, for both the Kenyan Dual Purpose Goat and Animal Health Components during 1994. However, it is important to note what was not undertaken as a result of the condition noted above over which we had little control. Specifically, an area of high priority to us that deserves attention is the research in animal heath and demand for veterinary services. Understanding the demand for small ruminant health services, prevention vs. treatment decisions, is an important area pertaining to the success of the Dual Purpose Goat technologies and small ruminants in general. We decided not to continue this activity because priority was set on the assessment of KDPG technologies in new sites. We decided to continue gathering information on animal diseases and prevention practices only on the sites where impact assessment activities were undertaken. The collaborating scientist in socio-economics, researchers at KARI, have been able to obtain supplementary funds from National Agricultural Research Project through their proposals to continue the activity of impact assessment of the KDPG in new sites.

We are certain that our collaboration will continue through the years. We are proud to have been, through the SR-CRSP, contributors to the process of institution building at KARI, through the strengthening of the social sciences in biological and interdisciplinary research. If we had to single out what we consider our most important contribution to the Kenya SR-CRSP, we feel this is it.

No research project like this operates without the support of many dedicated people. All of us involved with this project at the University of Missouri, are certainly indebted to:

- All the farmers and families of western Kenya that in past years worked with our research project. We are also indebted today to the farmers and their families of our research clusters in Machakos and the Coast.
- We would like to extend our appreciation and thanks to Dr. Cyrus Ndiritu, Director of KARI, and to Dr. Chema in the past, for their support of social sciences, when there was no socio-economics division at KARI. Their support contributed to the successful incorporation of social sciences to the SR-CRSP research in Kenya and later on, to the

development of social sciences within KARI. We are also grateful to Dr. Agusta Abate, Assistant Director in charge of animal production for all her support.

- We are specially grateful to our resident scientist Dr. Nkonge Mbabu, for his drive and successful efforts through these years to integrate social sciences with biological research. We are also grateful to Ms. Dekha Sheikh for her leading role in our research project, as our collaborating scientist for socio-economics.
- We are also indebted to many collaborating scientists, Mohamed Lutta, Leonard Otieno, Elizabeth Wekesa, Grace Njeru, Destiny Mwangolo, Francis Asambu. We want to also thank Julius Mungai and the SR-CRSP support staff Nancy Ngugi, David Njojo, Margaret Kiinya.

We are fortunate to have Dekha Sheikh and Grace Njeru in Columbia, Missouri pursuing their Doctoral degree and B.Sc. degree respectively in these coming years. This will allow us to continue our work with them on both research components, animal health and impact assessments of the KDPG.

Narrative Summary

Impact Assessment of KDPG

A baseline survey was carried out in the new sites. A monitoring survey designed to generate information needed for the assessment of various aspects of the socio-economics impacts of the KDPG technology on low income farm households is currently being administered. This information including farming activities, farm inputs, farm production, farm and household aspects and adoption will be used to assess: the economic impact of the KDPG technology on the generation of farm income, the impact of the KDPG technology on the division of labor and relative welfare of gender and age groups in the family, the impact of the KDPG on the farming systems (with emphasis on crop-livestock interactions), the potential flexibility of the KDPG package facing different economic and environmental scenarios, to determine KDPG and associated externality effects and the adoption patterns.

Gender roles in the production of DPG

This work has been completed for western Kenya. A one time survey will be conducted approximately one year after the completion of the monitoring process.

Research

Activity I. Impact Assessment of KDPG

Problem Statement and Approach

The objective has been to assess the impact the KDPG and supporting technological package will have on the target area and production systems.

On-farm Monitoring work for the impact assessment of the KDPG started in August 1994 with a "Monthly Questionnaire". Information contained in this form includes milk (consumption, sales, and price), changes in family structure, household labor supply, general labor use, agricultural labor use, wage rates on-farm and off-farm, goat and cow milk use, live animal sales and prices.

An "Output Questionnaire" is also being applied once during the harvesting season (two times in the year), containing information on Outputs per crop and/or plot and crop destination (whether consumed or sold, where sold and prices).

An "Input Questionnaire" is being administered once per planting season (twice in a year) to gather information on the use of agricultural inputs, the origins of these inputs and costs of these inputs.

Finally, an "Agricultural Questionnaire" is being administered six times in a year (at planting, harvesting, and in between seasons) for the two cropping seasons (short and long rains). Information to be gathered in this process include, land use and crop portfolio (including output of perennial crops).

Progress

The baseline (ex-ante) survey results showed that the participating clusters in the Machakos area are representative of small holder farmers that are a mandate for The National Dry-land Farming Research Center (NDRC). The mandate area covers Mwingi, Kitui, Makueni and Machakos administrative districts in Eastern Province; and Kajiado district in the Rift Valley Province.

The 1979 Kenya population census indicated that there were 456,000 farms of at least 8 hectares, 10,000 between 8-50 hectares and 163 greater than 50 hectares in the NDRC of Katumani. The areas where livestock could be kept include small areas within individual holdings that are unsuitable for cropping, communal grazing areas within the intensive farming districts and the extensive open range areas.

The main constraints to crop and livestock production in the mandate area include erratic and unreliable rainfall as well as poor soils. There are three main production systems identified in the area. These are the hill masses (high potential) account for seven percent of the total mandate area and is densely populated. Dairy grade cattle are kept under intensive management systems. The lowlands (plains) account for the bulk of land resources, majority of the population and are subsistence oriented Finally the settlement areas which represent both the settlement and hill masses.

The baseline (ex-ante) survey conducted in November/December 1993 indicated that the clusters were representative of the small holder community in the general area with respect to resource endowment, farm enterprises, technological levels and dietary consumption patterns. The settlement area showed a slight difference compared to the lowlands with respect to per capita land and crops grown.

The survey results indicated that households in the settlement areas had more land compared to households in the lowland areas which represents the traditional farming area. The mean acreage for the Kimutwa cluster was 11.29 hectares compared to 6.22 in the Kitanga cluster. Of the total land area, cropped land was 2.23 hectares (19.8%) in the Kitanga cluster compared to 2.2 hectares (35.4%) in the Kimutwa cluster. Incidence of land fragmentation were more pronounced in the Kimutwa area than in Kitanga (compare 1.6 to 1.4 parcels per household). The predominant forms of land ownership include owned without title followed by owned with title followed by jointly owned.

Farmers in the Machakos area keep cattle, goats and sheep under extensive grazing management systems. Higher average numbers of cattle were kept in the Kimutwa area despite the lower land area compared to Kitanga, indicating a higher stocking pressure in Kimutwa. This could be explained by the observation that farmers in Kitanga had some grade cattle unlike the Kimutwa farmers who kept only local cattle. This may also be an indication that the Kitanga farmers are moving more towards an intensive mode of livestock production.

Maize was the most important cereal and beans the most important legume crop. The proportion of land devoted was 57% and 19% to maize and beans respectively of the cropped area. These are the most important subsistence crops and could therefore indicate that farmers would first allocate limited resources to these crops up to the point where subsistence requirements are met and only then consider other activities including the KDPG. It is to be noted that these crops produce substantial amounts of by-products and residue that could be used to feed the DPGs. The maize and beans together with other crops including pigeon peas and fruits were generally grown in mixed stands.

All the milk consumed in the two areas was obtained from cattle. The average milk production was 3 liters per household per day. 35% of the households in Kitanga sold some of the milk produced compared to 45% in Kimutwa. The reason for higher milk sales in Kimutwa could be explained by the observation that Kimutwa is located close to a shopping center. Almost all the farms utilized the manure from livestock enterprises on crops.

Thirty-seven of the total households interviewed were involved in non-farm income earning activities including petty trade and wage employment. The average

income was in the region of Kenya Shillings 4,295 in Kimutwa compared to 5,138 in Kitanga per year per household.

Apart from the climatic and soil related constraints, labor shortages affects both crop and livestock production enterprises. About 90% of the total households interviewed reported that they have to supplement household labor from external sources. The constraints that are specific to the livestock enterprise include limited water supply and feed resources especially during the dry periods. Feed availability was more critical in Kimutwa whereas water availability was more critical in Kitanga. Other constraints were animal health related problems including worm infestation, diarrhoea, nagana, pneumonia and liver flukes.

Training

Short Term

Mbabu A. N. - Institutionalizing Farming Systems Approach - participated as a resource person in a week long workshop on institutionalizing farming systems approach to research in KARI. The purpose of the workshop was: to expose the team to sociological perspectives (to supplement the predominant agricultural economics perspective); to assist the team in applying disciplinary knowledge (sociology and economics) in agricultural research and development; to develop consensus on research areas for socio-economists in KARI (priority setting, conceptualization and development of agricultural technologies, impact assessments and policy environment studies); and to agree on the necessary institutional mechanisms to accomplish the identified tasks. Also participating were co-investigators sharing the SR-CRSP experience in integrating social sciences to biological research.

Dekha Sheikh - Attended the Regional Scientific Training Workshop focusing on Impact Assessment Methodologies, held in Harare, Zimbabwe, 7th to 18th march 1994.

Scientists also participated in the training of Kilifi cluster farmers on nutrition and management, feed resources and animal health as well as forming the Kenya Dual Purpose Goat (KDPG) farmers association.

Collaborating Personnel

United States

Michael F. Nolan, Principal Investigator, University of Missouri-Columbia
Corinne Valdivia, Co-Principal Investigator, University of Missouri-Columbia
Domingo Martínez-Castilla, Research Associate, University of Missouri-Columbia

Kenya

Nkonge Mbabu, Sociology Resident Scientist, University of Missouri-Columbia
Dekha Sheikh, Host Country Socio-economics Co-Investigator, KARI
Mohammed Lutta, Collaborating Scientist, KARI, Katumani, Machakos
Grace Njeru, Collaborating Scientist, KARI, Katumani, Machakos
Leonard Otieno, Collaborating Scientist, KARI, Mtwapa
Elizabeth Wekesa, Collaborating Scientist, KARI, Mtwapa

Collaborating Scientist

Ms. Dekha Sheikh, Host Country Socio-Economics Co-Investigator, KARI

Collaborating Institution

Kenya Agricultural Research Institute (KARI)
PO Box 57811
Phone: 254-2-444156
Fax: 254-2-630818

Abstracts and Presentations

Lutta M. Smallholder Production Systems in the Semi-arid Eastern Kenya. 12th SR-CRSP Scientific Workshop, ILRAD - Kabete, Kenya. March 2-3, 1994.

Mbabu A. N. The Institutional Process Supporting Planning and Priority Setting

in KARI. KARI Workshop addressing the issue of priority setting, Nairobi, Kenya.

Sheikh D. and Valdivia C. Gender Roles in the Production of Dual-Purpose Goats. The XXII International Conference of Agricultural Economists, Harare Zimbabwe, August 22-29, 1994.

Animal Health Management Through Biotechnology

"Mortality and morbidity rates at SR-CRSP worksites show that infectious diseases continue as an important constraint to sheep and goat production. Because of the difficulty of obtaining and applying local reliable, economical univalent (single disease) vaccines, few farmers vaccinate their animals. Lessons learned in SR-CRSP research in Kenya provide the foundation for proceeding. The proposed work represents a concerted interdisciplinary effort to develop multivalent vaccines for small ruminants. Such a vaccine would provide small ruminant producers with low cost multivalent vaccines that can be used to treat, at one time, several of the most important infectious diseases that affect small ruminants. Moreover, SR-CRSP scientists expect to obtain results in a relatively short time and to evaluate the economic potential and acceptability of new multivalent vaccines."

p. 39, Extension Proposal, 1990-1995

Multivalent Virus-Vectored Vaccine for Goats and Sheep..95
Travis C. McGuire, Washington State University

Kenya Multi-Valent Vaccine.....105
Michael F. Nolan, University of Missouri-Columbia

Multivalent Virus-Vectored Vaccine for Goats and Sheep

Washington State University

Travis C. McGuire, Department of Veterinary Microbiology and Pathology, College of Veterinary Medicine, Washington State University, Pullman,. WA 99164-7040. Telephone (509) 335-6045, Fax (509) 335-6094, E-mail: mcguiret@vetmed.wsu.edu

Narrative Summary

Several important diseases of sheep and goats cannot be controlled or treated by administration of antibiotics. For such diseases, vaccination may be the only effective control method. This strategy has been successfully used in the control of some diseases of humans and cattle. Even though the need for effective vaccines for small ruminants is crucial, development of these vaccines has lagged behind. Therefore, the overall component on animal health management through biotechnology has the specific goal to develop multivalent virus-vectored vaccines for sheep and goats. The component includes a focused research goal, strong inter-institutional collaboration, and current limitation to one primary site, Kenya. Researchers from the United States collaborate with resident scientists as well as researchers from the Kenya Agricultural Research Institute (KARI) and other laboratories to use biotechnology in developing virus-vectored multivalent vaccines for important infectious and parasitic diseases of goats and sheep in Africa and other parts of the world. Once developed, the proposed recombinant DNA vaccine will protect against sheep pox, goat pox, Rift Valley fever, Nairobi sheep disease and haemonchosis.

The development of a safe and reliable virus vector to deliver the multivalent vaccines to goats and sheep is a major activity of the component. The initial virus vector developed is based on the KS-1 strain of capripoxvirus (CPV). This strain has been attenuated and is currently used as a vaccine for goat and sheep pox. A recombinant capripoxvirus has been made that contains and expresses the genes encoding the Rift Valley fever virus (RVFV) glycoproteins known to induce a protective immune response. This recombinant is designated rCPV-RVFV and a request was made to USAID for containment testing of its vaccine potential. If rCPV-RVFV induces protection against both CPV and RVFV, it would be bivalent and appropriate genes from other organisms could be added, increasing the valency. While awaiting permission to test this vaccine, additional improvements of the insertion plasmid were begun.

As proposed, the DNA sequence of a *Haemonchus contortus* gene, Hcga13, that expressed similar epitopes to those present on isolated parasite proteins that induced a protective immune response was determined using chain termination with dideoxy nucleotides.

The gene sequence included an open reading frame that encoded a 100 kDa polypeptide that contained the sequence for the 46 and 52 k Da polypeptides previously identified using monoclonal antibodies. This group of *H. contortus* microvillar surface proteins was designated GA1. Apparently the 100 kDa precursor is cleaved into the 46 and 52 kDa products. Of interest, the amino acid sequence of the 46 and 52 kDa GA1 proteins deduced from the nucleic acid sequence had 47% identity. The gene encoding the GA1 proteins was excised and inserted in-frame into p1114, which is the pox virus insertion vector.

The objective for Nairobi sheep disease was to identify a cDNA clone of the M

segment of NSDV that expressed viral glycoproteins. Polyclonal antisera was made in sheep to purified virus, and monoclonal antibodies were made that reacted with viral glycoproteins (gp) 100 and gp 70, as well as other viral structural proteins. Viral RNA was purified, size-selected and a cDNA library prepared in E. coli using the plasmid Superscript. The inserts of a number of the clones were identified by Southern hybridization and antibody screening. A partial nucleotide sequence was determined for 12 of the clones with the largest inserts. Presently, these sequences are being analyzed for homology with known gene regions of viruses related to NSDV to determine if they encode the M segment. It is anticipated that several of the clones will include overlapping M segment gene sequences

Training activities continued during the year with 2 more students completing MS degrees and 4 students continuing Ph.D. thesis research.

Research by Activity

General problem statement and approach

The occurrence of Infectious diseases, including internal parasites, continues to constrain efficient goat and sheep raising and to limit the introduction of improved goat breeds. Vaccines are a successful method to control many infectious diseases, but current univalent vaccines derived from attenuated or inactivated organisms are expensive to produce and distribute one-by-one. The goal of the project on multivalent virus-vectored vaccines is to use biotechnology to develop a single vaccine that is economical and that will protect animals against several infectious diseases. Research on this goal is shared by this component's CSU subproject, which is focused on the identification of vaccine genes from a major sheep disease that can be incorporated in the multivalent virus-vectored vaccine. It should be noted that the same virus vector may be used for both goat and sheep vaccines and these vaccines may include some similar components since some of the diseases needing vaccines occur in both species. In fact, all the diseases being studied by this component occur in both goats and sheep.

One problem that continues to receive research attention is the development and evaluation of attenuated capripoxvirus (CPV) as a virus vector for foreign genes. To develop a multivalent virus-vectored vaccine, a safe virus vector is needed. Possible use of CPV meets many requirements because it is already being used as a univalent vaccine for goat and sheep pox. Addition of appropriate foreign genes from other organisms will make the CPV vaccine multivalent. A CPV vector could be used to deliver a multivalent vaccine in the host country (Kenya), the rest of Africa, all of Asia, and possibly several other areas of the world. Other specific problems are identifying vaccine genes from organisms causing goat diseases. The primary targets for 1993-1994 were haemonchosis and Nairobi sheep disease. Haemonchosis is a parasitic disease of both goats and sheep that occurs in most countries of the world, including the United States. Nairobi sheep disease virus also infects both goats and sheep and the disease occurs throughout East Africa and may occur in many other African countries. Infection of flocks causes heavy losses due to acute gastroenteritis and abortion.

Activity 1. Evaluate protective immunity induced by recombinant CPV expressing Rift valley fever virus glycoprotein genes.

Note: The activities listed in this report are those in the workplan for program year 15 covering the period for October 1, 1993 - September 30, 1994.

Problem statement and approach

The problem continues to be the development of a vector that is safe and that will also express foreign genes in a way that induces protective immune responses to the proteins encoded by the foreign genes. CPV, the cause of goat and sheep pox, was selected because pox .. an important disease in

countries throughout Africa and Asia and because CPV is attenuated and is being used as a monovalent vaccine in sheep and goats. In addition, some gene insertion sites and insertion plasmids have been described that work with CPV.

Last year's progress report described the construction of a recombinant capripoxvirus (CPV) that expressed Rift valley fever virus (RVFV) glycoprotein genes. These genes were selected because a recombinant vaccinia virus expressing the encoded glycoproteins induced a protective immune response against RVFV challenge in sheep. Based on the strategy described in the previous report, a recombinant CPV, designated rCPV-RVFV, was isolated. This rCPV-RVFV met the appropriate definitions at the genetic level by containing the RVFV glycoprotein genes after plaque purification. The immunologic data derived from immunofluorescence and western blotting using both polyclonal and monoclonal antibodies demonstrated that rCPV-RVFV made the appropriate RVFV glycoproteins. Based on these results, an application was made to USAID to do containment testing to determine its vaccine potential. The plan was to identify 20 goats and 20 sheep that lacked antibodies to both capripoxvirus and Rift Valley fever virus. Ten goats and ten sheep were to serve as uninoculated controls. The remaining ten goats and ten sheep were to be inoculated intradermally with 108 TCID50% with the rCPV-RVFV virus-vectored vaccine. The vaccinated animals would be given a booster inoculation one month later and evaluated for antibodies to capripoxvirus and to Rift Valley fever virus using ELISA and virus neutralization tests. Whether a second booster inoculation would be given was to depend on the amount of antibody present to the two viruses. When a suitable antibody titer was obtained, immunized and control goats and sheep were to be challenged with live viruses to determine the level of protective immunity induced by vaccination.

Progress

Unfortunately, these important experiments in animals could not be done. A primary reason was that we were unable to obtain permission from USAID for the animal inoculations to proceed. This was caused by changes in USAID that resulted in the termination of the committee that reviewed proposals involving recombinant DNA inoculations into animals even in containment as was proposed in our request. In the last few months, responsibility for this area was assigned to a new person and our request was referred to a new committee. While waiting for a response, we continued to evaluate our rCPV-RVFV by trying to show that the RVFV genes were inserted into the CPV TK gene. The RVFV genes were expected to be in the TK gene because the genes of interest were flanked by vaccinia TK genes in the insertion plasmid. However, the RVFV genes were not found in the TK gene and although this does not preclude the use of this recombinant virus in animals, it makes it hard to explain how it was made. We assume that the genes were inserted in some other non-essential gene of the CPV. In view of these findings and since we were awaiting permission for animal studies, it was decided to make a new plasmid insertion vector using the TK gene from the capripoxvirus causing lumpy skin disease in cattle.

The lumpy skin disease virus TK gene was obtained from collaborators in South Africa and is more homologous with the capripoxvirus TK gene than the vaccinia virus TK gene used in the original insertion vector. Use of this new insertion vector should result in the RVFV glycoprotein genes being cloned into the TK gene of CPV. This insertion plasmid is currently being made and can be used to make an improved rCPV-RVFV for immunization. It is anticipated that permission for containment testing will be obtained soon and that one of the rCPV-RVFV will be tested in animals before the end of the program. Some of these experiments are being done by Reuben Soi, a KARI employee and a WSU graduate student partially supported by SR-CRSP. His WSU thesis advisor is Dr. Timothy Crawford and

while he is completing his Ph.D. thesis in Kenya his advisor is Dr. Fred Rurangirwa. Important collaborators on this project include Dr. James DeMartini (CSU) and Dr. Paul Rwambo (RS-Kenya). The need for Reuben Soi to do some of the recombinant capripoxvirus studies in animals in order to complete his thesis makes it necessary to do whatever is possible to complete this work before the end of the program in 1995.

Activity 2. Evaluate vaccine genes from Haemonchus contortus.

Problem statement and approach

Haemonchosis affects most goats and sheep in the world and in tropical and subtropical countries, it causes severe disease requiring expensive and regular drug treatment. A vaccine for haemonchosis would be of significant benefit to small ruminant owners, a benefit that would be enhanced by its inclusion in a multivalent vaccine. Our immunization trials using parasite gut homogenate to immunize young goats resulted in a significant protective immune response against *H. contortus* larvae challenge. A likely explanation for these results is that the parasite ingests antibody and immune cells as it feeds on blood and that these immune components kill or injure the worm. The current problem is to identify the active antigenic component in the homogenate that induced the desired immune response. In last year's report we described immunization with isolated gut proteins and the protection obtained was considered to be moderate, although very significant because the results identify specific gut surface antigens that induced protection against a blood-sucking nematode parasite. To identify the genes encoding these proteins, it was proposed that a cDNA expression library prepared from isolated mRNA be screened with polyclonal antisera from the goats immunized with the isolated parasite antigens described in a published manuscript. It should be noted that identification of a gene for testing does not guarantee that it will induce the protective immune response against *H. contortus* that we are seeking. It does mean that we can engineer the gene into a rCPV using techniques that were successful with the RVFV glycoprotein genes. In addition, the resulting recombinant virus vector can be tested for expression of *H. contortus* gene in invitro infected cells. If expression occurs in vitro, then the recombinant virus vector can be used to inoculate goats to determine if a protective immune response to *H. contortus* gene product was stimulated by vaccination.

Progress

As proposed the DNA sequence of the identified gene Hcga13 that expressed epitopes recognized by monoclonal antibodies used to isolate parasite proteins that induced a protective immune response was determined using chain termination with dideoxy nucleotides. The gene sequence included an open reading frame that encoded a 100 kDa polypeptide that contained the sequence for the 46 and 52 kDa polypeptides that were previously identified using monoclonal antibodies. This group of *H. contortus* microvillar surface proteins was designated GA1. Apparently the 100 kDa precursor is cleaved into the 46 and 52 kDa products. Of interest, the amino acid sequence of 46 and 52 kDa GA1 proteins deduced from the nucleic acid sequence had 47% identity. The gene encoding the GA1 proteins was excised and inserted in-frame into p1114, which is the pox virus insertion vector containing the E. coli xanthine-guanine phosphoribosyl transferase gene (gpt), a dominant selectable marker for the construction of recombinant poxviruses. Mycophenolic acid inhibits the growth of poxviruses, including capripoxvirus. When the gpt gene is inserted with the foreign gene of interest into capripoxvirus, the recombinant capripoxvirus will grow in the presence of mycophenolic acid and can be selected from the non recombinant capripoxvirus. If GA1 expression occurs in cultured cells, goats lacking antibodies to the *H. contortus* protein of interest will be inoculated with 108 TCID50% of the recombinant capripoxvirus expressing the *H. contortus* gene. After a booster inoculation, the goats will be checked for antibody to the *H. contortus* protein using ELISA and western

blot procedures. If antibodies are detected, inoculated and control goats can be challenged with *H. contortus* larvae.

The first part of this research was done at WSU to the point of having the p1114 insertion vector containing the *H. contortus* gene. The investigators for this part of the project were Dr. Doug Jasmer and Travis McGuire. Since capripoxvirus cannot be imported into the U.S., the vector was sent to Kenya where the recombinant capripoxvirus expressing the *H. contortus* gene can be made and tested. Dr. Fred Rurangirwa and Dr. Francis Karanu (KARI employee and WSU-SR-CRSP graduate student) will be responsible for the later part of this experiment.

Activity 3. Clone and express vaccine genes from Nairobi sheep disease virus

Problem statement and approach.

Nairobi sheep disease virus (NSDV) causes heavy losses in susceptible sheep resulting from adult mortality and fetal abortion. Presently, NSD can only be prevented by control of the tick vector, Rhipicephalus appendiculatus, using expensive and labor-intensive methods. Furthermore, tick control programs are prone to failure and besides their negative environmental impact, are not sustainable especially with the dwindling economies of many countries. Thus, an effective vaccine against NSD remains a major developmental concern for Eastern Africa. Our strategy to identify and clone relevant genes of NSDV is based on a recombinant vaccinia vectored vaccine developed for a related virus of sheep, Rift Valley fever virus (RVFV). After preparing a cDNA library, we planned to select clones that contain the glycoproteins encoded by the M segment RNA and use these to prepare a rCPV-N SD vaccine. The immunoprotective capacity of this vaccine could then be evaluated in the same way as the rCPV-RVFV. Since NSDV and RVFV are structurally similar viruses, it is likely that immunogenic viral proteins and host immune responses will be similar in nature. This will simplify and facilitate development of immunologic screening assays and design of virus challenge experiments in immunized sheep. Our objective for the 1993-94 year was to identify a cDNA clone of the M segment of NSDV that expresses viral glycoproteins.

Progress

A cDNA library to the three genome RNA segments of NSDV has been developed. The library has been screened for the expression of viral antigens in E. coli using hyperimmune sera. Several antibody positive clones were identified and the plasmid DNA analyzed by digestion with restriction endonucleases NotI, SalI, EcoRI, PstI and BamHI. Clones with inserts over one kilobases were selected for partial sequencing to identify useful information that can indicate presence of open reading frames. Twelve clones have been partially sequenced using SP6 and T7 forward and reverse primers respectively. The nucleotide sequence data are currently being analyzed. A major characteristic revealed is the presence of a variable number of homopomeric in the 5' end. The variable number of Ts reflects a problem in cloning negative stranded RNA viruses. Polyadenylic (poly-A) tails were added to the 3' end of viral RNA using E. coli poly (A) polymerase (BRL) so as to allow the oligo-dT priming of first-strand cDNA synthesis. The variable length of poly T tails also reflects the uncontrollable nature of the process of adding poly As to the 3'-end using poly(a) polymerase. Because of the problems associated with RNA degradation, especially with increased manipulations, it was thought prudent to start with total viral RNA rather than trying to isolate M segment RNA from agarose gels. While this strategy has worked very well, it also makes identification of the clone for M segment rather difficult and time consuming. We have, however, also generated a number of monoclonal antibodies (47 have been characterized up to the isotype level), which will greatly assist in the identification of the clones. In addition, sequence comparison with other Nairoviruses will also help in clone identification. The western blot assay using polyclonal sera has

been used to probe for recombinant NSDV antigens expressed in E. coli. There are indications that three clones may be expressing non-fused products of approximately 45 kilodaltons. These could represent the protein backbone of the viral glycoproteins.

This experiment was the primary responsibility of Dr. Paul Rwambo, who had done the previous work on the isolation of NSDV RNA segments. Those coliaborating on the project were Drs. DeMartini, Rurangirwa and Soi. This work is difficult and tedious and required the almost full-time commitment of an experienced molecular virologist such as Dr. Rwambo in order for the research to progress.

Training

All training involves degree candidates in the WSU Department of Veterinary Microbiology and Pathology or in the CSU Department of Pathology; we have no non-degree training. All students are natives of Kenya. The students receiving training in the WSU program complete coursework at WSU as USAID participants under the provisions of Handbook 10 then return to Kenya to do research. Once they return to Kenya, the Kenya Agricultural Research Institute pays their salaries and the WSU SR-CRSP component pays for supplies, equipment, travel and other costs of research in addition to paying part of Dr. Fred Rurangirwa's salary.

Francis Karanu, a KARI employee and a WSU graduate student funded by SR-CRSP, has completed his M.S. degree, and has also completed his Ph.D. course work and preliminary examination at WSU and returned to Kenya to begin his thesis research. His thesis advisor at WSU is Dr. Doug Jasmer and his advisor in Kenya, where most of the research will be done, is Dr. Fred Rurangirwa. The Ph.D. thesis research is in the area of identifying *H. contortus* genes that encode proteins that induce a protective immune response in animals. He will return to WSU in 1995 to complete his thesis research and final defense with an anticipated completion date of the Fall of 1995. He will be fully supported by SR-CRSP funds until the project ends.

Leah Ndung'u completed her M.S. degree in 1994 and submitted her thesis research for publication. It has been accepted in a peer reviewed journal (Infection and Immunity).

Reuben Soi completed his course work and preliminary examination for a Ph.D. at WSU and in now doing his thesis research in Kenya. His salary is paid by the Kenya Agricultural Research Institute and projected completion date has been rescheduled for Fall 1995. SR-CRSP is now paying about 33% of his research costs.

Donald Siamba, a KARI employee, finished his M.S. at the University of Nairobi in veterinary parasitology. His research was supported by the WSU SR-CRSP project with tuition support from Kenya SR-CRSP matching funds.

Dufton Mwaengo, a Kenyan scientist, is being support by SR-CRSP project funds through a subcontract with CSU. His Ph.D. thesis research at CSU on the immunology of ovine lentivirus infections will be completed in 1995.

Flora Mbithi, a KARI employee, is pursuing a M.S. in virology/immunology at CSU. She expects to complete her program in 1997 and is mainly supported by NARP II/KARI through the University of Missouri.

Other Contributions

Environmental impact and relevance

The principal impact that multivalent virus-vectored vaccines can make on the environment is to make small ruminant production more efficient. Use of effective vaccines should reduce the number of animals needed to produce the required amount of milk, meat and fiber.

Agricultural sustainability

It is difficult for small ruminant production to be sustainable if deaths and production losses due to diseases exceed a fairly low threshold. The SR-CRSP project has continued close collaboration with diagnostic laboratories of the Ministry of Agriculture, Livestock Development and

Marketing, the International Laboratory for Research on Animal Diseases (ILRAD), and the University of Nairobi Veterinary School. By developing an inexpensive, reliable and effective multivalent virus-vectored vaccine for sheep and goats, the project aims at improving the production of small ruminants in Eastern Africa.

Contributions to U.S. agriculture

The primary contribution of this research to U.S. agriculture is in the area of haemonchosis research. Research on vaccines for *H. contortus* has a similar benefit for U.S. producers as it does for other countries. The SR- CRSP has funded research over several years on ovine and caprine retrovirus-induced diseases (OvLV, OPC, CAE) that are of considerable economic importance to U.S. agriculture. The investigators conducting this research have been recognized as important national resources for current information regarding the diagnosis and control of these important diseases. For example, Dr. DeMartini served on an American Sheep Industry Animal Health committee to prepare a producer information publication on ovine progressive pneumonia.

Contributions to host country

Contributions of this project to the host county are in degree training for host country scientists, developing research facilities, seeking vaccines for diseases of small ruminants that occur in several countries including the host country, and assisting the host country in developing related projects.

Virus vectors are of interest to ILRAD, Nairobi, Kenya and scientists from ILRAD have been collaborating with us on the CPV vector development. Also, scientist from ILRAD have participated in the training of SR-CRSP graduate students.

Support for free markets and broad-based economic growth

If effective vaccines are developed they should be made and distributed by private companies in the countries in which they are used.

Contributions to and compliance with Mission objectives

The Mission officials have stated on many occasions that they support small ruminant development in Kenya. Our research on disease control has enabled that goal in the past and will in the future.

Concern for individuals

We have tried to involve women in our project by recruiting women graduate students from Kenya (1 for SR-CRSP, 1 for a related project) and to involve women faculty from WSU (1 visited the SR-CRSP project in 1993 and is developing collaborative research).

Support for democracy

We try to contribute to this issue by example.

Humanitarian assistance

Our efforts have been based on the belief that training host country people is one of the long term contributions we can make to the area of humanitarian assistance. Also, improving the health of sheep and goats helps farmers with small land holdings.

Other comments. The research on Nairobi sheep disease has been enhanced by a 3-year USAID PSTC grant for development of a diagnostic test based on monoclonal antibodies and recombinant antigens. The funding for this project is in place and it is administered by KARI. Funding from this PSTC has been used to purchase equipment for ELISA (Dynatech Model 4100). In addition, funds from USAID NARP II have been used to purchase two new high speed rotors (Type 19 and SW41Ti) for use with an ultracentrifuge previously repaired with SR-CRSP funds. This money has greatly improved the facility in the laboratory. CSU research on ovine retrovirus-induced diseases is being enhanced by two National Institutes of Health grants.

Collaborating Personnel

United States

Dr. James C. DeMartini, Principal Investigator SR-CRSP Animal Health subcontract Department of Pathology Colorado State University, Ft. Collins, CO 80523

Other Collaborators in the U.S.

Dr. S. Hecht, CSU
Dr. Joséph Esposito, Scientist, Centers for Disease Control, Atlanta, GA
Drs. J. Smith and C. Schmaljohn, Scientists, USAMRID, Frederick, MD
Dr. Timothy B. Crawford, WSU
Dr. Douglas P. Jasmer, WSU
Dr. Guy H. Palmer, WSU
Dr. Katherine M. Byrne, WSU
Dr. Donald Knowles, WSU

Kenya

Dr. Fred Rurangirwa Associate Professor, WSU SR-CRSP Resident Scientist in Nairobi
Dr. Paul Rwambo CSU SR-CRSP Resident Scientist in Nairobi
Dr. C. Ndiritu Director, Kenya Agricultural Research Institute Nairobi, Kenya
Dr. J.S. Wafula Assistant Director (Animal Health)/KARI Nairobi, Kenya
Sankale Shompole, BVM, MS, Ph.D., Primary Collaborating Scientist in Kenya
Dr. M. Shaw, Scientist, ILRAD, Kenya

Collaborating Institutions

Primary

Kenya Agricultural Research Institute
P.O. Box 57811 Nairobi, Kenya
Telephone 254-2-748150/69
Facsimile 254-2-630818

Secondary

International Laboratory for Research on Animal Diseases
Nairobi, Kenya

Division of Virology
Centers for Disease Control
Atlanta, GA

U.S. Army Medical Research Institute of Infectious Diseases
Ft. Detrick, MD

Dept. of Microbiology
University of Cape Town
Republic of South Africa

Inst. of Virology and Environ. Microbiology
Oxford University, UK

Publications

Refereed Publications

Brodie, S.J., A. de la Concha-Bermejillo, G. Koenig, G.D. Snowder, and J.C. DeMartini. 1994. Maternal factors associated with prenatal transmission of ovine lentivirus. J. Infect. Dis. 169:653-657.

Hecht, S.J., J.O. Carlson, and J.C. DeMartini. 1994. Analysis of a type D retroviral capsid gene expressed in ovine pulmonary carcinoma and present in both affected and unaffected sheep genomes. Virology 202:480-484.

Belton, D., Leach, R.H., Mitchelmore, D.L. and Rurangirwa, F.R. 1994. Serological specificity of a monoclonal antibody to Mycoplasma capricolum strain F38, the agent of contagious caprine pleuropneumonia. Veterinary Record. 134:643-646.

Mahan, S.M., McGuire, T.C., Semu, S.M., Bowrie, M.V., Jongejan, F., Rurangirwa, F.R. and Barbet, A.F. 1994. Molecular cloning of a gene encoding the immunogenic 21kDa protein of Cowdria ruminantium. Microbiology. 140:2135-2142.

Ndung'u, L.W., Aguirre, C., Rurangirwa, F.R., McElwain, T.F., McGuire, T.C., Knowles, D.P. and Palmer, G.H. Detection of Anaplasma ovis infection in goats using the MSP5 competitive inhibition ELISA. Infection and Immunity. In press.

Rurangirwa, F.R., Wambugu, A.W., Kihara, S.M. and McGuire, T.C. Mycoplasma F38 growth inhibiting monoclonal antibody (MW-25) identifies an epitope on a surface exposed polysaccharide antigen. Submitted for publication.

Presentations at the 11th and 12th SR-CRSP workshop (published in 1994):

Karanu, F.N., Rurangirwa, F.R., McGuire, T.C. and Jasmer, D.P. Identification of proteases with diverse characteristics in adult Haemonchus contortus excretory-secretory products. Proceedings of the 11th Small Ruminant CRSP Scientific Workshop, Nairobi, Kenya, 1993, pp. 11-18.

Rurangirwa, F.R., Kihara, S.M., Wambugu, A.N. and McGuire, T.C. Integral membrane surface protein of Mycoplasma F38 (F38) mediates invitro growth inhibition of F38. Proceedings of the 11th Small Ruminant CRSP Scientific Workshop, Nairobi, Kenya, 1993, pp. 19-22.

Kihara, S.M., Rurangirwa, F.R. and McGuire, T.C. Identification of Mycoplasma F38 surface antigens with goat serum antibodies. Proceedings of the 11th Small Ruminant CRSP Scientific Workshop, Nairobi, Kenya, 1993, pp. 23-33.

Soi, R.K., Rurangirwa, F.R., McGuire, T.C., DeMartini, J.C., Rwambo, P.M. and Crawford, T.B. Expression of Rift Valley fever virus (RVFV) glycoproteins in a recombinant capripoxvirus. Proceedings of the 11th Small Ruminant CRSP Scientific Workshop, Nairobi, Kenya, 1993, pp. 45-49.

Siamba, D.N., Rurangirwa, F.R. and Ndarathi, C.M. Immunization of sheep against Fascioliasis using non-ionic detergent soluble materials of Fasciola gigantica metacercariae. Proceedings of the 11th Small Ruminant CRSP Scientific Workshop, Nairobi, Kenya, 1993, pp. 50-61.

Ndungu, L.W., Rurangirwa, F.R., McGuire, T.C. and Palmer, G.H. Antibody to MSP-5 detects Anaplasma ovis-infected goats in Kenya by a competitive inhibition ELISA. Proceedings of the 12th Small Ruminant CRSP Scientific Workshop, Kabete, Kenya, 1994.

Jasmer, D.P., Rurangirwa, F.R., Karanu, F.N., Perryman, L.E. and McGuire, T.C. Identification of genes useful for control of parasitic diseases of small ruminants. Proceedings of the 12th Small Ruminant CRSP Scientific Workshop, Kabete, Kenya, 1994.

Rwambo, P.M., DeMartini, J.C., Rurangirwa, F.R. and Kairu, A. Cloning and expression of the RNA genome of Nairobi sheep disease virus, a Nairovirus. Proceedings of the 12th Small Ruminant CRSP Scientific Workshop, Kabete, Kenya, 1994.

Kogi, J.G., Taylor, J.F., Ruvuna, F., Davis, S.K., Bhebhe, E., Chen, C., Waruiri, R.M., Rurangirwa, F.R., Mkuu, S. and King'oku, J. Genetic markers: Associations with Haemonchus contortus and growth traits in goats. Proceedings of the 12th Small Ruminant CRSP Scientific Workshop, Kabete, Kenya, 1994.

Presentations during the year including published abstracts

Hecht, S.J., J.O. Carlson, J.M. Sharp, and J.C. DeMartini. Endogenous and exogenous Type D/B retroviruses in ovine pulmonary carcinoma of sheep. Abstract P25-2. 13th Annual Meeting of the American Society for Virology, Ithaca, New York, July 9-13, 1994.

A. de la Concha-Bermijillo, S.B. Brodie, S. Magnus-Corral, and J.C. DeMartini. Studies on semen infection and prenatal transmission of ovine lentivirus. Abstract, p. 45. 13th International Symposium of the World Association of Veterinary Microbiologists, Immunologists, and Specialists in Infectious Diseases, Perugia, Italy, October 2-7, 1994.

DeMartini, J.C. The pathogenesis of ovine lentivirus-induced lymphoid interstitial pneumonia. Lecture and abstract. Second European Workshop on Ovine and

Caprine Lentiviruses. La Londe les Maures, France, September 27-30, 1994.

Wesonga, F.D., Mukolwe, S.W. and Rurangirwa, F.R. Cowdria ruminantium identified in Amblyomma using a DNA probe pcs20. Revue D Elevage et de Medecine Veterinaire des Pays Tropicaux. 46:179-181, 1993.

Rwambo, P.M. and DeMartini, J.C. Replication and morphogenesis of a lentivirus isolated from lungs of sheep with severe respiratory distress and emaciation. Second African Immunology Conference of the Federation of African Immunological Societies. Nairobi, Kenya, October 24-27, 1994.

MS thesis

Ndung'u, L.W. Detection of Anaplasma ovis infection in goats using the MSP-5 competitive inhibition ELISA. Washington State University. Pullman, Washington, 1994.

Kenya Multi-Valent Vaccine

University of Missouri-Columbia

Michael F. Nolan, International Agricultural Programs, 215 Gentry Hall, University of Missouri, Columbia, Missouri, 65211. Telephone (314) 882-2745, Fax (314) 882-5147, E-mail: agmike@muccmail.missouri.edu

Narrative Summary

The Small Ruminant CRSP has successfully developed an inactivated CCPP vaccine that is thermal stable. Although extensive field tests have not been carried out, it is used for vaccinations against CCPP. Unavailability of funds has been the most limiting factor in these tests.

The two new sites where the KDPG impact assessment work is being conducted are also used to look into demand for veterinary services as well as the preventive mechanisms used by farmers. The socio-economics project also estimated vaccination costs against CCPP compared to treatment of the animals once infected by the disease.

Current estimates indicate that the Field Services Division of the Department of Veterinary services uses an average of one million doses of CCPP at Kenya Shillings 1.00 per dose. These vaccinations are mainly in the Kitui and Baringo Districts. In most cases the vaccination campaigns are carried out simultaneously with other diseases including rinderpest, CBPP and lumpy skin disease. The division spends an average of Kenya Shillings 2,700,000 as transport and operating expenses when delivering these vaccines to the various districts. The cost of delivery per dose of CCPP to Baringo district has been estimated by the socio-economics project. According to reports from the vaccine production unit of The Kenya Veterinary Vaccines Production Institute (KEVEVAPI), the current average annual production of CCPP stands at 200,000 doses compared to annual requirements of 3,000,000 doses. This implies an annual shortfall of approximately 2,800,000. As a result of the shortfalls, farmers either treat their animals using antibiotics or have to lose them to the disease.

Research

Activity I: Vaccination Versus Treatment Using Antibiotics: CCPP

Problem Statement and Approach

The use of CCPP vaccine is not very widespread. This is due to the shortfall in the supply of the vaccine. Some farmers (especially those with large herds of goats) use the treatment method using antibiotics once the disease has set in. The key to a successful treatment using antibiotics is early diagnosis of CCPP. A drawback to this is the limited number of veterinary personnel to carry out diagnostic work. Treatment using antibiotics leads to a 50% chance of success or the recovery of the animal. In some cases death is the first sign of the disease. Despite treatment using antibiotics, the animals undergo stress due to the disease and therefore require extra care. The path chosen (vaccination vs. treatment) would depend on the condition (housing of animals), the herd size and the value placed on the animals. In the long run, vaccination may be the answer.

Progress

We compared vaccinating against CCPP versus treatment using antibiotics. The following information was used:

100 ml. of Combiotic antibiotic goes for Kshs. 1,105 or 11.05 per ml.

The required dosage is 2 mils. per 10 Kg body weight.

An average DPG or Galla goat weighs approximately 40 Kgs.

Using the above data, it implies that, an average goat requires 8 mils. of antibiotic and probably a repeat.

Therefore 8 mils. x 2 x 11.05 = **Kshs. 176.80**

A dose of CCPP vaccine costs Kshs. 1.50. The suggested dosage is twice per year, therefore 1.50 x 2 = **Kshs. 3.00.** The price of Kshs. 1.50 is a Government subsidized price. Taking the estimated market price of CCPP vaccine at Kshs. 20.00 would give an annual vaccination cost per animal of **Kshs. 40.00.**

It is clear that vaccination costs are way below treatment by antibiotics. On top of the expenses, treatment using antibiotics is risky as there is not only a 50% chance of success but that there is no assurance. There is also the possibility of lower levels of production with respect to weight gain and milk production when the animal is sick.

Collaborating Personnel

United States

Michael F. Nolan, Principal Investigator, University of Missouri-Columbia

Corinne Valdivia, Co-Principal Investigator, University of Missouri-Columbia

Kenya

Nkonge Mbabu, Sociology Resident Scientist, University of Missouri-Columbia

Dekha Sheikh, Host Country Socio-economics Co-investigator, KARI

Paul Rwambo, Resident Scientist, Colorado State University

Mohammed Lutta, Collaborating Scientist, KARI, Katumani, Machakos

Grace Njeru, Collaborating Scientist, KARI, Katumani, Machakos

Leonard Otieno, Collaborating Scientist, KARI, Mtwapa

Collaborating Scientist

Dekha Sheikh, Host Country Socio-economics Co-investigator, KARI

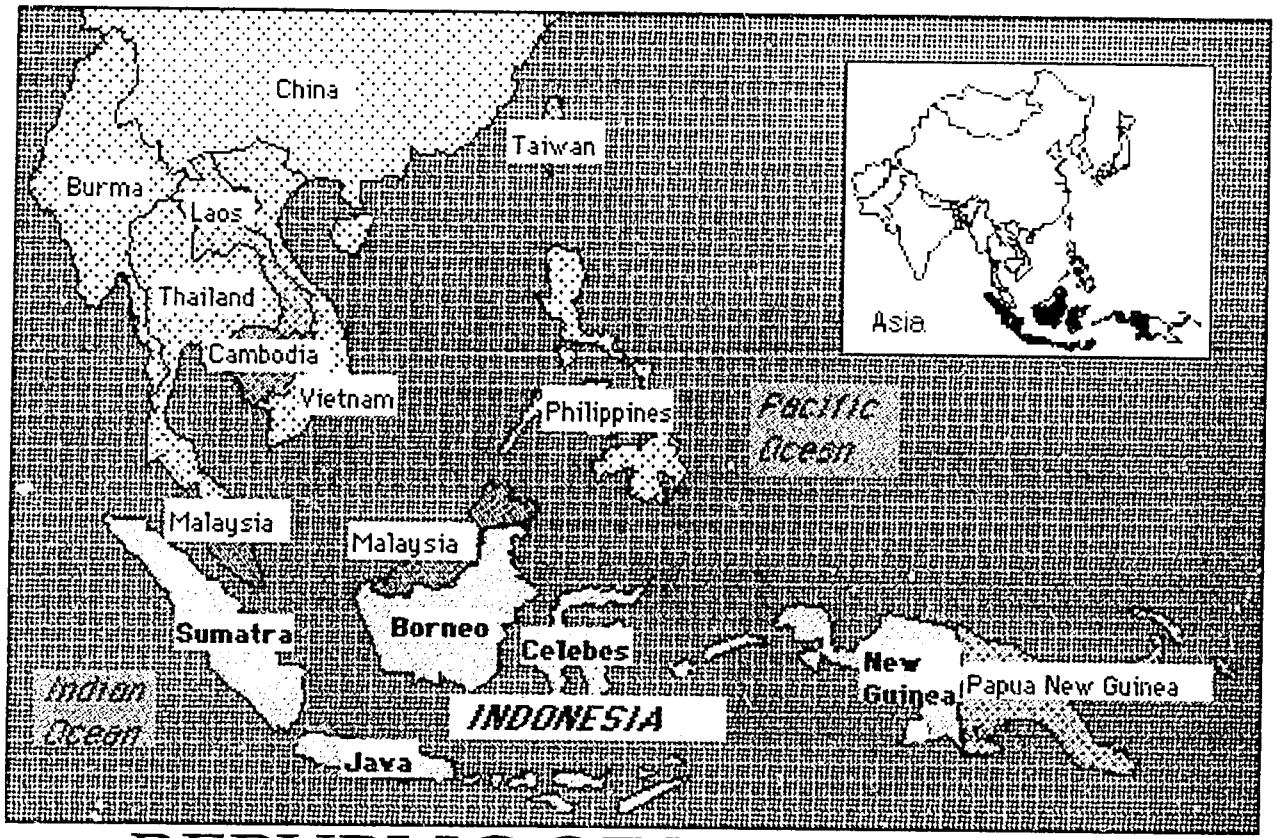
Collaborating Institution

Kenya Agricultural Research Inst. (KARI)
P. O. Box 58137
Nairobi, Kenya
254-2-630818

Abstracts and Presentations

Lutta M. Smallholder Production Systems in the Semi-arid Eastern Kenya. 12th SR-CRSP Scientific Workshop, ILRAD - Kabete, Kenya. March 2-3, 1994.

Sheikh D. The Socio-economics of Animal Health Interventions. 12th SR-CRSP Scientific Workshop, ILRAD - Kabete, Kenya. March 2-3, 1994.



REPUBLIC OF INDONESIA

Republik Indonesia

Indonesia is located in southeast Asia and is made up of more than 17,000 islands. The most populated island, Java, is also one of the most densely populated areas in the world. (Approx. 1,500 inhabitants per sq. mile). The total area of Indonesia is 1,904,443 sq. km. (735,310 sq. miles).

Population (1993 est.): 188,327,300.
Age distrib. (%): 0-14: 39.2; 15-59: 56.5; 60+: 5.3.
Urban (1991): 31%.
Ethnic groups: Malay, Chinese, Irianese.
Languages: Bahasa Indonesian (Malay) (official), Javanese, other Austronesian languages.
Religions: Moslem 88%.
Capital: Jakarta. Cities (1990 census): Jakarta 8,222,515; Surabaya 2,472,272; Bandung 2,056,915; Medan 1,730,052.
Education (1990): Literacy: 85%. 84% attend primary school.

Industries: Food processing, textiles, cement, light industry.
Chief crops: Rice, coffee, sugar.
Minerals: Nickel, tin, oil, bauxite, copper, natural gas.
Other resources: Rubber.
Arable land: 8%.
Fish catch (1990): 3.1 mln. metric tons.
Labor force: 56% agric.; 23% ind. & comm.; 16% services.
Finance: Monetary unit: Rupiah (Aug. 1994: 2,150 = $1 US).
Gross domestic product (1991): $122 bln. Per capita GDP: $630.

Livestock (1992): Cattle 11,000,000; Sheep 5,900,000; Goats 11,400,000; Pig 7,000,000; Buffaloes 3,400,000

Livestock Products (1992, in metric tons): Beef and veal 193,000; Buffalo meat 50,000; Mutton and lamb 45,000; Goat's meat 55,000; Pig meat 286,000; Cow's milk 330,000; Sheep's milk 72,000; Goat's milk 180,000.

Principal Crops (1992, in metric tons): Rice (paddy) 47,770,000; Coffee ; Coconuts 13,015,000; Sugar Cane 23,121,000; Natural Rubber 1,294,000.

Communications: Television sets: 1 per 24 persons. Radios: 1 per 8 persons. Telephones: 1 per 172 persons.

Prolific Sheep and Hair Sheep Production Systems

"Results of SR-CRSP research in Brazil and Indonesia suggest that by improving feed supplies, health practices, management techniques, and genetic potential, the productivity of hair sheep can be increased and made more cost-effective. Widely distributed in the tropics, hair sheep are important sources of income and food for small farmers. While they constitute about 10% of the world's sheep population, little has been done to develop and exploit their potential. Unlike wool sheep, which do poorly when exposed to heat, humidity, diseases, and parasites of the lowland tropics, hair sheep evolved under such conditions and do well. Preliminary evidence indicates considerable phenotypic and genetic diversity among types of hair sheep. Scientists can use such variations to develop more suitable animals for warm, humid areas, and research results can be extended easily to other sites in the tropics. . . . The projected 5-year research and development activities will produce information useful in the development and adaptation of hair sheep production systems to the needs of small farmers in the humid and semi-humid regions. These systems will be based on local vegetation and feed by-products because of the close integration between the cropping system and livestock components."

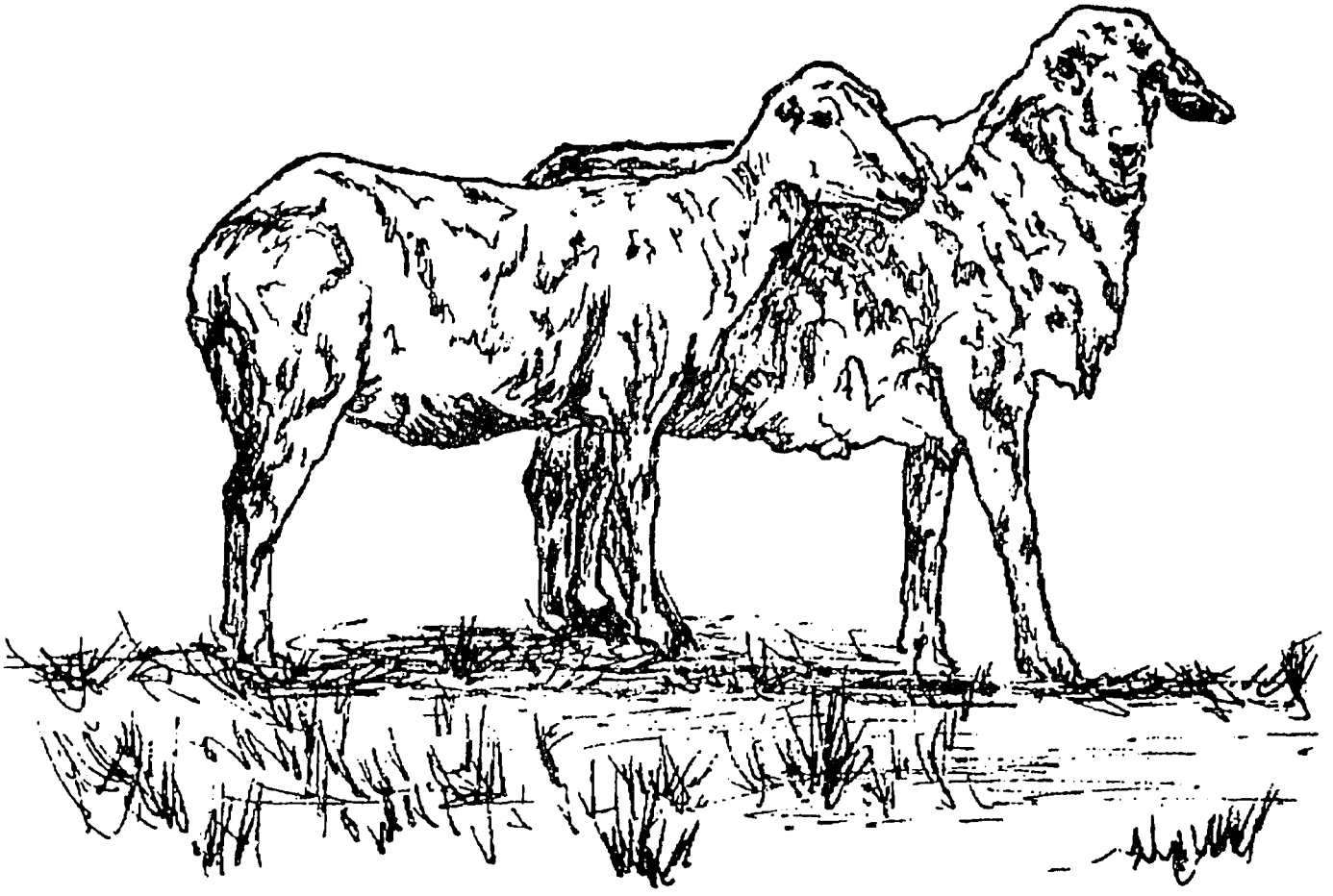
p. 37-8, Extension Proposal, 1990-1995

Genetic Improvement of Sheep and Goats-Morocco.....111
Eric G. Bradford, University of California - Davis

Genetic Improvement of Sheep and Goats-Indonesia.....114
Eric G. Bradford, University of California - Davis

Economics of Small Ruminant Production Systems and Markets.....119
Enrique Ospina, Winrock International Institute for Agricultural Development

Feed Resources and Nutrition of Small Ruminants.....125
Kevin R. Pond, North Carolina State University



Genetic Improvement of Sheep and Goats

University of California, Davis

Eric G. Bradford, Department of Animal Science, University of California, Davis, CA 95616-8521. Telephone (916) 752-7602, Fax (916) 752-0175, E-mail: gebradford@ucdavis.edu

Narrative Summary

There was very limited SR-CRSP funding for this component in 1993-94.

The Morocco linkage funds were terminated by ME at the start of the grant year without advance notice, with only $1,500 allocated to cover expenses already incurred. We do not have a report of activities from Morocco for the year. However, a paper based on results from the prolific sheep project in Morocco was presented at the 5th World Congress on Genetics Applied to Livestock Production in Guelph, Canada, in August 1994.

At the conclusion of direct SR-CRSP support for the prolific sheep research in Indonesia in September 1993, collaboration with CRIAS on the project was taken over by Australia's CSIRO under the direction of Dr. J. Hetzel. SR-CRSP support for Ismeth Inounu's Ph.D. studies at IPB, Bogor, was continued. His dissertation on economic evaluation of ewes of different genetic levels of prolificacy should be completed in 1995. Mr. Inounu has continued to supervise the matings and data collection for the project. A paper from the project by Subandriyo and Inounu was presented at the Guelph Congress.

The CSIRO project involves efforts to map the $FecJ^F$ (prolificacy) gene identified in Indonesian sheep by the SR-CRSP breeding project. Parallel work is being conducted at UC Davis, funded primarily from non-CRSP sources. The objective is to identify a marker or markers for the $FecJ^F$ gene, which would greatly facilitate the identification of animals of known genetic potential for prolificacy. Preliminary results suggest, but do not prove, that the $FecJ^F$ gene maps to the same chromosomal region as the $FecB^F$ (Booroola) gene for prolificacy. Identification of the FecJ locus genotype is important since, as reported earlier, in some production situations in Indonesia the less prolific animals are more productive, while under better feed and management, animals carrying the $FecJ^F$ gene are much more productive.

Research

The Morocco project involved evaluation of the effects of crossing the prolific D'Man breed with the non-prolific but larger and hardier Sardi breed. The objective was to develop a sheep with intermediate genetic potential for prolificacy for more efficient production in the better agricultural areas of Morocco. Based on the results of the crossing studies, it was concluded that a composite breed with 50% each D'Man and Sardi inheritance would meet the objectives for the better feed and management situations existing in the country, and would provide rams for crossing with non-prolific breed ewes where a lesser increase in prolificacy was desired. Work at the end of the project was focusing on selecting within the DS composite population, which has the potential to increase lamb production per ewe by 50% or more, compared to standard Moroccan breeds, in the better production environments.

The prolific sheep research in Indonesia has shown that the exceptional variation in prolificacy observed in the sheep of this country is due to segregation of a gene, designated $FecJ^F$, which markedly increases ovulation rate and therefore litter size. As reported by Subandriyo and Inounu (1994), ewes lacking this gene ($FecJ^+$ $FecJ^+$) had a

mean litter size of 1.15, those with one copy ($FecJ^F$ $FecJ^+$) had 2.14, and those with two copies ($FecJ^F$ $FecJ^F$) had 2.48. Total weight of lambs weaned (90 d) by ewes of the three groups was 15.4, 18.0 and 20.3 kg, respectively. Thus the gene has the potential for increasing production per ewe substantially. However, under less favorable conditions, it does not increase production due to high mortality of lambs in the larger litters (Inounu et al., 1993). Thus the optimum genotype depends on the production environment. It is therefore important to be able to identify the genotype at this locus of both rams and ewes so that the breeding program will produce animals suited to each production environment. For this reason, efforts have been directed to identifying marker genes for the FecJ locus.

SR-CRSP funding for the prolific sheep component was terminated in 1993, except for support for one trainee and some very limited funding for the marker research. Fortunately, Dr. J. Hetzel of CSIRO, Australia was able to obtain a grant to assist with maintenance of the flock and with the search for markers. Matings have been set up to facilitate the mapping work. Preliminary results from their studies using micro-satellite markers suggest the $FecJ^F$ gene may map to the same chromosomal region as the Booroola ($FecB^F$) prolificacy gene.

The UC Davis work has focused on identifying RAPD (randomly amplified polymorphic DNA) markers for sheep chromosomes. Although to date none of the markers identified is clearly linked to either FecB or FecJ, 20 markers have been identified, and most of these have been placed on the sheep genome map through collaboration with a group of New Zealand scientists. Thus this work is contributing to mapping sheep genes in general.

The other relevant ongoing work on this project is Ismeth Inounu's Ph.D. research on economic assessment of the effect of FecJ locus genotype on productivity and profitability of sheep under Indonesian production conditions.

Training

The project continues to support Ismeth Inounu's Ph.D. in Animal Breeding studies at Institute Pertanian, Bogor (IPB). He should complete degree requirements in 1995.

Other Contributions

Environmental Impact

Feed to meet maintenance needs of the ewe is the largest single cost of producing meat from sheep. A ewe that raises two lambs spreads her maintenance costs over more output than a ewe with one lamb, increasing the efficiency of resource use. In general, sheep in Indonesia are used to convert weeds, roadside grasses, by-products and waste products to meat. In the process, they produce manure which increases soil fertility for crop production and reduces the need for chemical fertilizers.

Agricultural Sustainability

By using forages and by-products, which otherwise would be unused, and by producing organic fertilizer, sheep contribute importantly to sustainability of Indonesia's smallholder agricultural systems. More efficient animals, i.e. animals better suited to specific production systems, would encourage more farmers to incorporate sheep into their operations. Research from this project shows how to match genetic potential more closely to production environment.

Contributions to U.S. Agriculture

We cannot import Indonesia's prolific sheep into the U.S. for animal health reasons, but the gene mapping work in which we are collaborating will contribute to improved breeding tools for U.S. producers. The training of U.S. graduate students in sheep genetics is important to future research capability in this area in the U.S. The CRSP has also facilitated the publication of research results from our long-term research project in California on selection for growth and prolificacy in sheep.

Contributions to Host Country

The CRSP has had a major impact on sheep production and research expertise in both Morocco and Indonesia, as well as on direct development of relevant research results. We have helped train women as well as men and have contributed in this way and through example, e.g. by employing a highly capable expatriate woman as resident scientist to lead our project, to breaking down gender barriers.

The major international collaborations on the prolific sheep component have been with Australian and New Zealand scientists in the gene mapping work as described above.

Collaborating Personnel

United States

Eric Bradford, Ph.D., Professor Emeritus, Animal Science Department, UC Davis, Principal Investigator

Juan Medrano, Ph.D., Associate Professor, Animal Science Department, UC Davis

Hakan Sakul, Ph.D., Assistant Research Geneticist, Animal Science Department, UC Davis

William Cushwa, M.S., Ph.D. Candidate in Genetics, UC Davis.

Indonesia

Subandriyo, Ph.D., Project Liaison Officer and Research Scientist, CRIAS; Ismeth Inounu, M.S., Research Scientist, CRIAS.

Morocco

Ismail Boujenane, Ph.D., Chair, Department of Animal Production, IAV, Hassan II, Rabat.

Other

D.J.S. Hetzel, Ph.D., CSIRO, Brisbane, Australia

G.W. Montgomery, Ph.D., University of Otago, Dunedin, New Zealand.

Collaborating Institutions

IAV
Hassan II
Rabat, Morocco
212-7-776434

Central Research Institute for Animal Science (CRIAS),Jalan Raya Pajajaran
Bogor 16003, Indonesia
62-251-328384

Publications

Boujenane, I. and A. Chafik. 1994. Heterosis retention in advanced generations of crosses among D'Man and Sardi sheep. Proc. 5th World Congress Genetics Applied to Livestock Production, Vol. 18:75-78. Guelph, Canada.

Bradford, G.E., H. Sakul, R. Neira, T.R. Famula, M.R. Dally and C.M. Finley. 1994. Reproduction in sheep selected for weaning weight or litter size in a range environment. Proc. 5th World Congress on Genetics Applied to Livestock Production, Vol. 18:95-98. Guelph, Canada.

Sakul, H., G.E. Bradford and Subandriyo. 1994. Prospects for genetic improvement of small ruminants in Asia. Proc. Symp. on Strategic Development for Small Ruminant Production in Asia and the Pacific. Denpasar, Bali, Indonesia. pp. 3-13.

Sakul, H., G.E. Bradford, M.R. Dally, T.R. Famula and C.M. Finley. 1994. Growth rate in sheep selected for weaning weight or litter size in a range environment. Proc. 5th World Congress on Genetics Applied to Livestock Production, Vol. 18:59-62. Guelph, Canada.

Subandriyo and Ismeth Inounu. 1994. Genetic and environmental factors affecting birth weight, weaning weight and preweaning survival rates of prolific Javanese sheep. Proc. 5th World Congress Genetics Applied to Livestock Production, Vol. 18:127-130.

Genetic Improvement of Sheep and Goats

University of California, Davis

Eric G. Bradford, Department of Animal Science, University of California, Davis, CA 95616-8521. Telephone (916) 752-7602, Fax (916) 752-0175, E-mail: gebradford@ucdavis.edu

Narrative Summary

The breeding project has as its goals the development of a productive strain of hair sheep, with superior genetic potential for resistance or tolerance to internal parasites, that is well-adapted to the climate, forage, resources and management systems of the humid and sub-humid tropics. Because of the interest in genetic resistance to parasites and other stresses of this environment, this project has incorporated a substantial animal health component. There is also collaboration with the nutrition/forages project in developing animals and forage production and management systems which work well together, and with the economics project on assessing characteristics of sheep desired by farmers and field testing of types of sheep developed at the station.

The focus of the genetic component has been comparison of the performance of the local Sumatra strain of sheep with crosses between the Sumatra strain and three introduced breeds of hair sheep: The St. Croix from the U.S. Virgin Islands, the Barbados Blackbelly from the island of Barbados, and the East Java Fat Tail. Briefly, the Virgin Island and Barbados crosses grow significantly more rapidly and have less wool than the Sumatra or Fat Tail x Sumatra crosses, while all four groups are quite similar (and very satisfactory) in several reproduction parameters: fertility, age at first lambing, lambing interval, litter size and lamb survival. No consistent differences were detected in grazing behavior or in parasite loads. As a result, the St. Croix and Barbados cross groups have significantly higher output per ewe. A ewe productivity index was calculated as total kg of lamb weaned per ewe through second lambing, divided by age of the ewe at second lambing minus 200 days, i.e., the index is a measure of lamb production per ewe per unit time. The values from the first group of ewes evaluated are 16.7, 19.7, 21.9 and 24.5 for Sumatran and the Fat Tail, St. Croix and Barbados crossbred groups, respectively. This does not necessarily represent net efficiency since presumably the larger ewes consume more forage. However, some increase in market weight of animals is desired, and any fixed costs are spread over more output for the larger types.

Maintaining a systematic crossbreeding program is logistically difficult, especially in smallholder production systems. It was therefore decided to create a composite population, which can be maintained as a single breeding population while capitalizing on the advantages of the introduced breeds and retaining most of any heterosis expressed in the crosses. Since the St. Croix and Barbados cross groups were both superior in terms of freedom from wool, as well as growth rate, a composite containing 25% each St. Croix and Barbados and 50% Sumatran inheritance is being created. It appears such sheep will be acceptable to local farmers, have relatively little wool, function well in grazing under tree crops, and be at least as resistant to or tolerant of the local parasite and heat stresses as the local Sumatran sheep, while producing substantially more weight of lamb per ewe per year. This composite population has been designated as the Sei Putih Hair Sheep.

Table 1. Performance of Sumatra and F1 groups

Breed group	Initial # of ewes	Age (d) at[1] 1st lambing	Age (d) at[1] 2nd lambing	Lamb wt. (kg) at Birth	Lamb wt. (kg) at 90 days	Ewe prod. index[2]
S x S	46	505	699	1.46[a]	8.3[a]	16.7[a]
E1 x E1	53	504	685	1.62[b]	9.0[b]	19.7[ab]
H1 x H1	65	503	693	2.00[c]	11.4[c]	21.9[b]
B1 x B1	32	514	696	2.10[c]	12.0[d]	24.5[c]
		n.s.	n.s.			

1) incomplete.

2) wt. (kg) of lamb weaned at first and second lambing; age of ewe at second lambing - 200 d.

Research

During 1994, the primary breeding project activity was a comparison of the reproduction and lamb production of ewes of four breed groups, Sumatran (S) with three F_1 crossbreeds: Java Fat Tail x S (E1), St. Croix x S(H1) and Barbados Blackbelly x S (B1). The groups compared were all born in 1992 and lambed first in 1993. Ewes of each group were mated to rams of their same breed group; 10 randomly selected rams were used in each group. Ewes were mated first at 10 or 13 months, with four 34-day mating seasons per year beginning in January, April, July and October. Thus, most lambing intervals are either 6 or 9 months. Some production parameters are summarized in Table 1.

At the time the data in Table 1 were summarized, a few ewes had not weaned their second lambs, so these data are incomplete. However, the percentage of ewes which had lambed for the second time favored the crossbred groups (68, 72, 83 and 79% for S, E1, H1 and B1 groups, respectively), so the conclusion that the crossbred groups have at least as good reproduction as the Sumatra group is conservative.

Based on these results and the significantly lesser wool cover of the H1 and B1 groups, we have decided to create a composite population by intermating H1 and B1 rams and ewes. There are several reasons for this decision:

a. a single breeding population is much easier to manage than a systematic crossbreeding program, especially in a smallholder production system.

b. the greater the number of breeds contributing to a composite, the higher the level of heterosis retained. This is the primary reason for using H1 and B1, rather than just the top-performing B1; also, the H1 group has been well-tested and well-received in smallholder farmer flocks.

c. selection within a single composite population is easier and more effective than within two or more pure breeds maintained for crossing.

The three-way cross, carrying 50% Sumatra, 25% St. Croix, 25% Barbados Blackbelly inheritance, has been designated the Sei Putih Hair Sheep. The flock will be selected primarily for total lamb production (ewe productivity index, see Table 1). There will also be some attention to freedom from wool and individual growth rate in rams and to low parasite loads, as indicated by fecal egg counts and packed blood cell volume, in both sexes. Based on a survey of factors affecting selling price of sheep in the region (Doloksaribu et al., 1994), it appears the only physical characteristic affecting value of sheep in local markets (other than size) is presence of horns. Since Sumatran breed rams are horned and the gene for horns is recessive, the horned condition (in rams) can be readily fixed in the Sei Putih Hair Sheep population.

Other activities of the project during 1994 include studies of lambing behavior and of performance of sheep in farmer flocks, and several studies of health status and parasite loads in the various groups. Results are detailed in the annual report of the Sungai Putih CRSP project and elsewhere; references are given at the end of this report. One

report (Romjali et al., 1994a) suggests B1 lambs have lower strongyle loads than the other groups, while another (Dorny et al., 1994) suggest ewes of all crossbred groups have a lower peri-parturient rise in fecal egg count than ewes of the Sumatran group. As for reproduction, the crossbred groups may not be just equal but, in fact, superior to the local breed, although the variability within groups and between studies (see, for example, Batubura et al., 1994a; Roberts et al., 1994) in parasite loads make this conclusion tentative as yet.

In general, the project has proceeded on schedule and, in fact, ahead of schedule. We had originally anticipated waiting to decide on the long-term breeding plan for this environment until January 1995, when all ewes of the main breed group comparison would have completed their second reproductive cycle. However, the prospect of termination of SR-CRSP funding necessitated an earlier decision in order to leave a breeding program that could be managed with more limited resources. Thus, a decision was taken in early 1994 to create the 3-breed composite, and the first lambs were born in September 1994. Data on reproduction, production and health accumulated during 1994 provide additional support for this decision. The SR-CRSP breeding project will be leaving a flock and a breeding program which has the potential for a very positive impact on the future genetic potential of sheep of Southeast Asia.

Training

Degree

The SR-CRSP Breeding project has supported the training of Endang Romjali for his M.S. degree, in collaboration with the EEC parasitology project. Mr. Romjali took his course work (1992 to early 1994) at the University of Gaja Mada, Jogyakarta, with CRSP support and has collected extensive parasitology data from the Sei Putih flock. In late 1994, he went to Antwerp, with EEC support, for additional training and to write his dissertation. His degree, from UGM, should be completed in 1995.

Short-Term

Three of the Sei Putih scientific staff accompanied Dr. Ruth Gatenby on a trip to Malaysia in April 1994 to review sheep breeding and production research in a similar production environment in that country.

Other Contributions

The hair sheep production system under tree crops being developed with SR-CRSP support in North Sumatra has a number of environmental and other benefits:

a. grazing sheep under tree crops reduces the need for herbicides for weed control and thus can contribute to sustainability of the system.
b. it utilizes a forage resource otherwise wasted.
c. it provides an opportunity for women and children to contribute to household income.
d. it provides the potential for export income for the region since meat is in high demand and deficient supply. (However, local demand is strong enough that major exports are unlikely in the short- or, quite possibly, long-term).

Collaborating Personnel

United States

Eric Bradford, Ph.D., Professor of Animal Science, Emeritus. PI.
Ruth Gatenby, Ph.D., Assistant Research Animal Scientist. Resident Scientist and Project Coordinator.
Hakan Sakul, Ph.D., Assistant Research Animal Scientist (to July 31, 1994).

Host Country

Aron Batubara, B.S., Research Scientist, SBPT.
Leo P. Batubara, M.S.; Director, SBPT.
M. Doloksaribu, B.S., Research Scientist, SBPT.
I. Mirza, DVM, Research Scientist, SBPT.

E. Romjali, B.S., Research Scientist, SBPT.
Subandriyo, Ph.D., SR-CRSP Coordinator, BPT, Bogor.

Other

P. Dorny, DVM, Ph.D., Belgium. (Consultant 3/94-6/94)
V.S. Pandey, DVM, University of Antwerp, Belgium.
A.S. Wilson, DVM, INIANSREDEF

Collaborating Institution

Sub Balai Penelitian Ternak
P. O. Box 1, Galang 20585
North Sumatra, Indonesia
62-61-530813

Publications

Batubara, A., P. Dorny, E. Romjali, R.M. Gatenby, M. Hutauruk and V.S. Pandey. 1994a. Experimental infection of ram lambs with *Haemonchus contortus*. Annual Report, SR-CRSP, Sei Putih, North Sumatra. pp. 60-64.

Batubara, A., I. Mirza, M. Hutauruk, R.M. Gatenby and A.J. Wilson. 1994b. Monitoring of levels of gastro-intestinal nematodes at Sungai Putih. Working Paper No. 156. SR-CRSP/SBPT, Sei Putih, North Sumatra.

Doloksaribu, M., A.D. Pitono and R.M. Gatenby. 1994. Physical characteristics of sheep and their effect on sale price. In: Sustainable Animal Production and the Environment, Vol. III, pp. 237-235. Proc. 7th AAAP Congress, Bali, Indonesia, July 1994. (Also reported pp. 37-39, SR-CRSP Annual Report, Sei Putih.)

Dorny, P., I. Mirza and A. Batubara. 1994. Abattoir survey of gastro-intestinal helminths in sheep. Annual Report, SR-CRSP, Sei Putih, North Sumatra. pp. 48-52.

Dorny, P., E. Romjali, A. Batubara, M. Hutauruk and V.S. Pandey. 1994. Peri-parturient rise in faecal strongyle egg counts of sheep at Sungai Putih. Working Paper No. 158. SR-CRSP/SBPT, Sei Putih, North Sumatra. (Also reported pp. 53-55, SR-CRSP Annual Report, Sei Putih.)

Gatenby, R.M., A. Batubara and M. Doloksaribu. 1994. The behaviour of sheep at lambing. Working Paper No. 160, SR-CRSP/SBPT, Sei Putih, North Sumatra. (Also reported p. 33, SR-CRSP Annual Report, Sei Putih.)

Gatenby, R.M., M. Doloksaribu, G.E. Bradford, E. Romjali, A. Batubara and I. Mirza. 1994. Comparison of the reproductive performance of Sumatra ewes and F_1 Hair Sheep crosses. Annual Report, SR-CRSP, Sei Putih, North Sumatra, pp. 27-32.

Gatenby, R.M., M. Doloksaribu, G.E. Bradford, E. Romjali, A. Batubara, I. Mirza and L.P. Batubara. 1994. The selected flocks of sheep at Suke Dame and formation of the Sei Putih Hair Sheep. Annual Report, SR-CRSP, Sei Putih, North Sumatra, pp. 34-36.

Gatenby, R.M., M. Doloksaribu and E. Romjali. 1994. The potential of Hair Sheep for the humid tropics of Southeast Asia. In: Strategic Development for Small Ruminant Production in Asia and the Pacific, pp. 25-36. Proc. of Symposium held in conjunction with 7th AAAP, July 1994, Bali, Indonesia.

Gatenby, R.M., M. Doloksaribu and E. Romjali. 1994. Improvement of genetic quality in local sheep by crossbreeding. In: L.P. Batubara et al. (eds.) Produksi Peternakan Domba di Sumatera Utara Dan Prospek Pengembangannya Mendukung Segitiga Pertumbuhan Utara, Indonesia, Malaysia dan Thailand, pp. 63-70. Proc. of Seminar held in Sei Putih, March 1994. Sub-Balai Pengembangan Peternakan, Indonesia.

Gatenby, R.M., Jeplin Sihombing and Darwin Simangunsong. 1994. Performance of sheep in the OPMM Outreach Project. Annual Report, SR-CRSP, Sei Putih, North Sumatra, pp. 40-43.

Hill, T., R.M. Gatenby, I. Mirza, A. Batubara, M. Hutauruk and A.J. Wilson. 1994. Field study of sheep with "Wasting Disease" and the potehtial pathogenic fluke. *Eurytrema pancreaticum*. Annual report, SR-CRSP, Sei Putih, North Sumatra. pp. 68-70

(Also reported in SR-CRSP Working Paper No. 163.)

Mirza, I., R.M. Gatenby, A. Batubara, A.J. Wilson, M. Hutauruk and Immanyato. 1994. Morbidity and deaths in an experimental flock of sheep grazing in a rubber plantation. Annual Report, SR-CRSP, Sei Putih, North Sumatra. pp. 44-47.

Mirza, I., R.M. Gatenby, A. Batubara, M. Hutauruk and Immanyanto. 1994. Evaluation of the effectiveness of three traditional medicines against gastro-intestinal nematodes in sheep. Annual Report, SR-CRSP, Sei Putih, North Sumatra. pp. 65-67.

Pandey, V.S., A. Verhulst, R.M. Gatenby, S. Saithanoo, P. Barcelo and L.S. Monteiro. 1994. Genetic resistance to internal parasites in sheep and goats and its exploitation for increasing animal productivity in Southeast Asia: An example of international collaborative research. In: Strategic Development for Small Ruminant Production in Asia and the Pacific, pp. 39-50. Proc. of Symposium held in conjunction with 7th AAAP, July 1994, Bali, Indonesia.

Roberts, J., E. Wiedosari and E. Estuningsih. 1994. Comparison of the resistance of different breeds of sheep to liver fluke (*Fasciola gigantica*). Annual Report, SR-CRSP, Sei Putih, North Sumatra, pp. 71-72.

Romjali, E., A. Batubara, I. Mirza, M. Hutauruk, R.M. Gatenby and H. Sakul. 1994a. Effects of natural infection of worms on weaning weight of local and crossbred lambs in North Sumatra. In: Sustainable Animal Production and the Environment, Vol. II, pp. 411-412. Proc. 7th AAAP Congress, Bali, Indonesia, July 1994. (Also in SR-CRSP Annual Report, Sei Putih, pp. 49-52.)

Romjali, E., A. Batubara, M. Hutauruk, V.S. Pandey and R.M. Gatenby. 1994b. Experimental infection of rams by *Haemonchus contortus* larvae. Annual Report, SR-CRSP, Sei Putih, North Sumatra, pp. 56-59.

Sakul, H., G.E. Bradford and Subandriyo. 1994. Prospects for genetic improvement of small ruminants in Asia. 1994. In: Strategic Development for Small Ruminant Production in Asia and the Pacific, pp. 3-13. Proc. of Symposium held in conjunction with 7th AAAP, July 1994, Bali, Indonesia.

Simanihuruk, K., J. Sianapar, P.M. Horne, L.P. Batubara and K.R. Pond. 1994. Growth of lambs of different breed types in response to supplementation. Annual Report, SR-CRSP, Sei Putih, North Sumatra, pp. 107-110.

Subandriyo and R.M. Gatenby, Editors. Strategic Development for Small Ruminant Production in Asia and the Pacific. Proc. of Symposium held in conjunction with 7th AAAP, July 1994, Bali, Indonesia, 181 pp. ISBN 979-8383-03-6.

Economics of Small Ruminant Production Systems and Markets

Winrock Institute for Agricultural Development

Enrique Ospina, Winrock International Institute for Agricultural Development, Petit Jean Mountain, Route 3, Morrilton, Arkansas, 72110. Telephone (501) 727-5435, Fax (501) 727-5426, E-mail enriqueO@ollie.winrock.org

Narrative Summary

The Economics program in Indonesia focuses on research and technology transfer and institution building. It works with farmers who raise sheep in conjunction with rubber plantations in the humid tropical lowlands through the Outreach Research Project (ORP) and the Outreach Project Membang Muda (OPMM). Both sites are part of the Animal Health Delivery Network (AHDN). The AHDN showed the potential for the privatization of the drug supply input system in North Sumatra, and also identified some input marketing restraints such as calibration and application. The marketing studies proved the strong demand potential for small ruminants in North Sumatra. Demand potential exists within Indonesia, in neighboring countries (Malaysia and Singapore), and in the Near East.

A special survey was conducted in a transmigration area to determine the role of women in small ruminant rearing. The preliminary results confirm that role is significant.

Research

Problem statement and approach

The world's humid tropical lowlands contain a large amount of underutilized feed resources. Agricultural development in these regions has emphasized the monoculture of commercial tree crops, such as rubber, oil palm, cocoa, and coconuts. These crops are produced by commercial estates and by smallholders. Cash flow is a barrier to successful smallholder production of tree crops during the period between the establishment of trees and their maturity. Small ruminants are one means of increasing cash flow and reducing risk.

The long-term goal of the economics component in Indonesia is to contribute to the development of an integrated production system to benefit sheep producers whose animals graze under plantation crops. Included are health and grazing management aspects of production and analysis of marketing and agribusiness opportunities. The economics program focused research on three main analytical activities, integrated production systems, animal health, and marketing.

Feasibility studies of integrated production systems

Various studies have been conducted to illustrate the economic benefits of introducing sheep in rubber plantations. Grazing sheep in rubber plantations can be a good source of additional income for the farmers. In addition to the cash income, grazing sheep under rubber trees has other advantages. It can reduce overtapping rubber, thus preventing a reduction in the lifetime of a plantation. It also reduces the need for weeding between rubber trees.

The contribution of sheep rearing to farmers' income can further be increased by increasing flock size. The ongoing collaborative work between SR-CRSP and PTPs provides 10 ewes and 1 ram to each smallholder. These relatively small flocks will increase farmers' income by more than 30%.

Marketing studies

Demand for small ruminants remains very strong. Consistent high income (over 5% per year) and population growth (1.6% - 2% per year) will lead to a doubling of demand for small ruminants over the next 10 years. Whether this potential demand can be realized depends primarily on Indonesia's ability to expand production at the same rate. Indonesia has extensive areas of plantation and rangeland that are currently underutilized for grazing. Preliminary research results indicate that substantial economic benefits can be achieved by integrating small ruminant farming into plantations. The integration of sheep and goats into plantations can reduce the labor cost of weeding, herbicide and fertilizer use, and yields a carrying capacity of at least 27 million animals in 10 million hectares of plantations. Better utilization of agricultural products could greatly expand small ruminant production and maintain low feeding costs. About 40 million tons of paddy rice production per year could yield a substantial amount of rice straw and rice bran for expanding small ruminant production. Palm kernel meal, a by-product from processing palm oil, is used for export instead of feeding domestic livestock to increase meat production. Indonesia has rich resources to provide good feeding materials as well as plenty of available labor. Collaborative research with foreign assistance projects, particularly SR-CRSP and RIAP has significantly improved small ruminant rearing technologies and management practices. Therefore, the prospect is great for Indonesia to expand small ruminant production on a large commercial scale.

AHDN

Anthelmintic Distribution by AHDN in Membang Muda, Galang and surrounding areas was evaluated and has been presented in an AHDN workshop on June 2, 1994. The results show active suppliers of anthelmintic, SR-CRSP field staff, and non-active suppliers, extension workers of Sub District Livestock Services and poultry shop employees. Traders also have a role in the expansion of anthelmintic use to farmers in Membang Muda, Galang, and their vicinities. However SR-CRSP field staff dominated distribution of anthelmintics in both locations. In addition, distribution costs of anthelmintic via SR-CRSP field staff were slightly cheaper than that of the traders.

Farmer groups and associations

In association with AHDN activities, the usefulness of organizing farmer groups or associations was analyzed. This was based on the notion that farmer associations would minimize anthelmintic costs and increase sheep producers' bargaining power. Based on field study results, interviews, and discussions with farmers focusing on technologies needed by farmers, farmer groups may facilitate the following technologies; fattening systems, additional feeding, ram rotation using St. Croix (Virgin Island) crossbred rams, health and disease control, planting legumes as protein resources for animal feed, and sheep marketing management.

The preliminary results show that the farmer associations are not strong enough to be self supported and they still need more guidance from SR-CRSP/SBPT. The members reported that the associations were useful, but most of the members are apathetic about increasing the cash of the associations. Most of the members have already read the rules and regulations of the association, but they do not want to give comment for the reason that the contents were beyond their comprehension. They hope that the association will survive and help them to solve the problems in sheep farming from production activities to marketing sheep.

Adoption by non-ORP farmers of SR-CRSP promoted new technologies was studied. The results show that the best way to transfer new sheep raising technology to Non-ORP farmers is "learning by doing." The potential for adoption by non-ORP farmers looks promising. Level of adoption in Deli Serdang is higher than in Labuhan Batu. More detailed analysis is recommended to investigate levels of

adoption and economic feasibility of adopting new technologies.

Credit

Lack of initial capital to start a sheep flock is an often identified constraint for sheep expansion in North Sumatra. A financial credit analysis showed that commercial lending to sheep farmers is economically quite feasible. The analysis shows that all participating farmers could return live ewes as credit installment. Bank of Indonesia and PTP are willing to provide credit for sheep small businesses with different credit arrangements. Additional return to investment is positively related to the number of credited live sheep, but it was not followed by the ability of paying credit. The higher sheep credit, the lower the ability to pay credit. Elasticity of production was less than one, and even less than zero.

Deregulation on livestock credit should be taken into consideration to the satisfaction of both the participating farmers and the money lender institution. To increase elasticity of production, higher numbers of sheep credit should be followed by increased sheep farming skills and technologies.

Training

Mr. Elianor Sembiring started an M.Sc. degree in agricultural economics at the Bogor Agricultural University (IPB) in June 1993. All his funding is provided by SR-CRSP. He is expected to complete his coursework in May of 1995, and complete data collection for his thesis by September of 1995. He will have to complete his work with his own resources.

Ms. Nu Nu San, Ph.D. candidate at the University of Missouri, Columbia, conducted her field research at Sei Putih. Her study focuses on the optimal integration of sheep in small holding tree crop systems. She is expected to complete her thesis in 1995.

Again, two interns from Wageningen Agricultural University were hosted by the economic program, Mr. Thomas Hoogerwerf and Mr. Jos van Oostrum. These interns are largely self-sponsored and their input implies a leverage of Dutch funds by SR-CRSP funds.

Gender analysis

Sheep rearing is particularly appealing to women farmers. Small ruminant rearing requires relatively low initial investment and they are easy to raise using available farm resources. The demand for meat, especially for small ruminants in Indonesia, will continue its strong growth due to high population and consistently rapid growth. The potential for Indonesia's rural households to improve household income by involving women in raising small ruminants is very good. Women's participation in livestock activity can improve living conditions in rural areas and reduce social problems associated with under-privileged social status.

Several small ruminant credit projects have been implemented through the collaboration of The Research Station for Animal Production (SBPT) in Sei Putih with SR-CRSP, Rubber Research Institute, Government Estate Crops Companies (PTP), and the Department of Transmigration. These pilot credit projects give sheep as credit to selected farmers in various transmigration areas in North Sumatra under different animal returning schedules. For the Sosa Transmigration Project, the questionnaire survey was designed to evaluate the contribution of women to improving household income by raising sheep. Forty household wives were surveyed, 30 households participated the Outreach Sheep Credit and the other 10 were non-participants and weren't involved in any sheep raising activity.

The first phase of the Outreach Project for the Sosa (OPS) transmigration area started in January 1993. The sheep credit project participants were given 1 ram and 5 ewes and required to pay back double the original number of rams and ewes within 3 years. The participants were provided with a supply of mineral block and were given training on building barns. In order to increase the flock size, the OPS participants were not allowed to sell animals before the

end of the 3 year term. Therefore there was no increase in farm income through sheep farming during the survey. However, after 1 - 1.3 years the value of barn animals was about 0.7 million Rps.

CRSP-SBPT's outreach project in Sosa transmigration area indicates that farm income of families participating in the sheep program was about 10 percent higher than non-participating families. This income differential will continue to increase once the participants pay-off the required number of sheep and begin to generate income from marketing their flock. The survey results also indicate that women from participating households are contributing more to food crop farming than non-participant women.

Preliminary results show that survey data most likely underestimates women's contribution in agriculture because women perform a greater share of un-paid farming jobs and family chores than men. In addition, women have a greater potential for increased productivity than men due to opportunities for training, credit access and some improvement in technologies that are more suitable to their physical capabilities.

Collaborating personnel

United States

Enrique Ospina, Principal Investigator
Henk Knipscheer, Co-Investigator
Shwu-Eng Webb, Co-Investigator

Indonesia

Agus Mulyadi, Resident Economist
Setel Karo Karo, Indonesian Co-Investigator
Artaria Misniwaty
Elianor Sembiring
Juniar Sirait

Collaborating institution

Sub-Balai Penelitian Ternak
(Research Institute for Animal Production)
P.O. Box 416
Medan, North Sumatra, Indonesia

INI ANSREDEF
Indonesia Institute for Animal Research and Development
Bogor, West Java, Indonesia

Publications

Artaria Misniwaty, M. Doloksaribu, Iskandar Mirza and A. Muljadi. 1994. Evaluation of Anthelmintic Distribution by Animal Health Delivery Networks in Membang Muda, Galang and Surrounding Areas. SR-CRSP/SBPT Working Paper No. 161.

Elianor Sembiring, Setel Karo Karo and A. Muljadi. 1994. Level of Adoption of ORP Promoted Technologies by Non-ORP Farmers. SR-CRSP/SBPT Working Paper No. 157.

Elianor Sembiring, Juniar Serait, Stetl Karo Karo and A. Muljadi. 1994. Establishment of Sheep Producer Associations in ORP and OPMM Villages in North Sumatra. SR-CRSP/SBPT Annual Report 1993-1994, pp. 16-19.

Kartamulia I, Setel Karo Karo and J. DeBoer. 1994. Economic Analysis of Sheep Grazing in Rubber Plantations in a Case Study of OPMM Membang Muda. SR-CRSP/SBPT Annual Report 1993-1994, pp. 13-15.

Knipscheer, H.C. 1994. Policies and Priorities for Farming Systems Research in Indonesia. Palawija News, Vol. 11, No. 3, CGPRT Center Newsletter, Bogor, Indonesia. pp. 10-14.

Knipscheer, H.C., S.H. Webb and A. Muljadi. 1994. Opportunities for Commercialization of Small Ruminant Production in Indonesia, in: Strategic Development for Small Ruminant Production in Asia and the Pacific (Subandriyo and R.M. Gatenby, Eds). SR-CRSP, University of California Davis, Davis, CA.

Nu Nu San and H. Knipscheer. 1994. A Dynamic Supply Response Model for Sheep and Goat Industry in Indonesia. SR-CRSP/SBPT Working Paper No. 154.

Nu Nu San, Karyudi, Bachtias Ismail, Artaria Misniwaty and Juniar Sirait. 1994. Dynamics of Latex Production and Relative Productivity of Smallholders. SR-CRSP/SBPT Working Paper no. 155.

Setel Karo Karo. 1994. Economics and Marketing Research for Sheep and Goats in Tree Cropping Systems in North Sumatra. SR-CRSP/SBPT Annual Report 1993-1994, pp. 5-8.

Setel Karo Karo, Uhendi Harris and R.M. Gatenby. 1994. Introduction of Sheep Husbandry to Smallholder Rubber Farmers in a Nucleus Estate. SR-CRSP/SBPT Annual Report 1993-1994, pp. 9-12.

Feed Resources and Nutrition of Small Ruminants

North Carolina State University

Kevin R. Pond, Department of Animal Science, Box 7621, North Carolina State University. Raleigh, North Carolina 27695-7621. Telephone (919) 515-4009, Fax (919) 515-4463, E-mail: kevin_pond@ncsu.edu

Narrative Summary

The successful integration of genetically improved sheep into rubber tree plantation systems requires that adequate nutrition is provided. Systems have been developed and tested for the integration of sheep in Indonesia into both the farming systems of limited-resource small holders and the tree crop plantations. In tree crop plantations, sheep are now integrated to utilize the forage under the tree canopy thereby reducing mowing and herbicide costs. Nutritional supplementation with locally available feedstuffs and agro-industrial by-products have improved productivity and profitability of both small and large scale producers.

The use of tree legumes as a source of protein for growing lambs has improved growth rates of weaned lambs to over 150 grams per day. Tree legumes offer the farmer an alternative to feeding concentrate feeds with similar average daily gains. Tree legume species evaluated as good supplements for lambs include *Gliricidia sepium, Paraserianthes falctaria* and *Calliandra calothyrsus.*

Identified shade tolerant forages were established in new growth rubber tree plantations for evaluation in large scale grazing trials. However, premature ending of USAID funding necessitated closing of the grazing project. These established areas now are the base forage areas for harvesting high quality feed for the core flock at the Sei Putih research station.

Complementary work in the United States continued the evaluation of hair sheep breeds for use in the Southeastern United States. The Katahdin, St. Croix and Barbados blackbelly breeds of hair sheep are adapted to the hot and humid climate of North Carolina and have been distributed to sheep and cattle farmers.

Research

Problem Statement and Approach

Sheep in Indonesia are integrated into farming systems of small holders and on the island of Sumatra are integrated into tree-crop (rubber and oil palm) plantations. In highly populated and in many village areas, sheep are kept by small limited-resource farmers. In some cases the sheep are allowed limited grazing and in other cases are confinement fed in a cut and carry system. For families employed by or families living near tree crop plantations, sheep are becoming integrated to utilize the forage under the tree canopy thereby reducing mowing and herbicide costs. The sheep are often cared for by children in the afternoon, after school. The critical need is to develop systems of management which will improve productivity and sustainability within the existing farming and family system. Lack in quantity and quality of feed is one of the major problems in all systems.

The introduction of hair sheep germplasm with increased size and growth potential may also change the feeding systems required. Potential local feed resources need to be identified and developed if sheep production is to be sustainable and economical.

Characteristics of many of the hair sheep breeds (heat tolerance, parasite

resistance, nonseasonal estrus, etc.) are important traits needed to improve adaptation of sheep to the hot and humid Southeastern United States. Developing systems for utilizing the traits of hair sheep in the southeastern US is highly desirable. Evaluation of the productivity of the hairsheep breeds (Barbados blackbelly, St. Croix and Katahdin) and crosses with wool breeds in the climate of North Carolina Piedmont and Mountains allows producers to view the sheep under local conditions. North Carolina State University has served as a resource for the germplasm of these breeds and breed crosses.

Progress

Feed resources utilized by small ruminants in the villages of Sumatra, Indonesia

The feeding value and limitations to productivity of native forages in rubber plantation have been well documented. Moderate productivity per animal that can be maintained if animals graze at low stocking rates can be dramatically increased by supplementation with agro-industrial by-products. For smallholder limited-resource farmers, however, few by-products are locally available or inexpensive enough to make them viable.

Development of improved feeding strategies for village small ruminant production necessitates a clear understanding of the current practices and limitations of the existing feed resources. Feeding practices and preferred feeding systems were evaluated for four groups of farming families (total of 77 farming families) living in two areas of Sumatra. Within each area, one group had received sheep and technology from the SR-CRSP while the other group consisted of neighbors who had no direct contact with the SR-CRSP. The four groups evaluated were:

- Outreach Research Project (ORP) farmers (27 farm families). These smallholder farmers live on the edge of rubber plantations but do not own plantation land. These farmers were given a credit packet of four ewes and a ram between 1988 and 1992 (SR-CRSP sponsored and monitored).
- Non ORP farmers (20 farm families). These farmers live in the vicinity of the above ORP farmers and have started to raise small ruminants independently, without direct assistance from the SR-CRSP, but with the benefits of technology passed along from their ORP neighbors.
- Outreach Research Project - Membang Muda (OPMM) farmers (12 farm families). These farmers are smallholder rubber producers who each own 2 hectares of rubber and 0.5 hectares of cropland. They were each given a credit packet of four ewes and a ram in 1991 with continued monitoring and technical intervention by the SR-CRSP.
- Non OPMM farmers (18 farm families). These farmers were employed by the plantation company and were given credit packets of varying sized ewe flocks by the plantation company. These farmers had no direct assistance from the SR-CRSP, but indirectly received the benefits of technology passed along from their OPMM neighbors.

The standard feeding practices were monitored on each farm. There was no differences between ORP and OPMM or between SR-CRSP sponsored or neighbors, so data from all 77 farmers was combined. It is very interesting to note that technology transfer between farmers is rapid and seems to be effective.

The majority of the farmers (85%) used a combination of grazing and cut feed. The standard feeding practice was for the flock to be grazed in the afternoon for an average of 3.9±1.2 hours. The flock was either taken grazing by a child (72%) or the farmer (18%). The average distance of the grazing area from the barn as 0.8±0.5 km. Only 3% of farmers grazed their sheep on their own land, with the majority grazing on rubber estates (42%), oil palm estates (13%) or on the edges of rice fields, roads and river banks (42%). In almost all cases the grazing was

communal, with no present opportunity for grazing management or forage propagation.

Cut feed was collected either by the farmer (46%) or by a child in the family (41%). An average of 1.6±0.1 hours was spent cutting feed on each occasion, traveling an average of 1.7±0.2 km to collect it. Most farmers (73%) cut feed every day, with the majority of farmers cutting in plantations (78%) or on the edges of rice paddies, roads and rivers (50%). The average quantity collected was 42±4 kg fresh/d (equivalent to 2.6±0.3 kg fresh/head), but there was a large variation in the quantity offered per total flock bodyweight. Given the generally good body condition of sheep in these flocks, it appears that the current practice provides adequate feed. The quantity collected appeared to be dictated more by the capacity of the collector than the size of the flock. Over half (56%) of the farmers fed to obtain substantial refusals (>25%) each day, therefore, allowing animals to select the most desirable forage.

Most of the farmers (77%) reported that they selected the species to cut, with the most commonly preferred species being *Axonopus compressus, Brachiaria mutica, Ottochloa nodosa, Cyrtococcum acrescens and Ischaemum timorensede*.

Eighty percent of the farmers had used rice bran as a feed supplement for their sheep but few were still using it because of the cost involved and, in some cases, effort required to obtain it. The farmers associated with the SR-CRSP/SBPT were using mineral blocks but few of the adjacent farmers had adopted this technology. Twenty-eight percent of the farmers reported using the leaves from the tree legume Gliricidia as a feed supplement but intermittently, when other sources of cut grass were scarce, when ewes had just given birth or when there was a surplus of Gliricidia leaf locally. A small number of farmers reported using it regularly (more than 3 times per week).

The major problems of raising sheep identified by the farmers included: 41% reported disease, 54% reported poor forage availability in the dry season and 14% a lack of labor. Twenty percent reported no major problems. The average desired flock size was 34±2.7, with the major reasons for this choice being limitations of labor, for bigger flocks and this flock size satisfied most farmers' needs for cash to pay school fees.

The feeding system in these villages (based on afternoon grazing with cut feed in the barn) provided adequate nutrition, but simple improvements can be made. Feed supplements (particularly, Gliricidia leaf and rice bran) were used only intermittently. Seasonal feed shortages are perceived by a majority of farmers to be a major problem, which could be most easily overcome by incorporation of tree legume leaf (and byproducts, where cheap and available) into the flock diet. Gliricidia is currently the most promising of the tree legume species (high DM and CP digestibility, ease of propagation and management) and four high yielding accessions from the Oxford Forestry Institute collection are currently being evaluated at SBPT, along with several other promising species in the genera *Leucaena, Sesbania, Cratylea, Albizia, Para-serianthes, Flemingia* and *Calliandra*.

Dry matter intake of sheep raised in villages in North Sumatra, Indonesia.

Forages in young rubber plantations have adequate protein and low to adequate energy content, but these decline rapidly as the plantation ages, due to changes in both botanical and chemical composition. As a result, adequate levels of dry matter, energy and protein intake by sheep can be maintained at moderate stocking rates in traditionally planted young plantations, but supplementation may be necessary for sheep grazing in mature plantations. This is especially true for sheep raised in villages in North Sumatra, where grazing times are rarely longer than four hours per day. Under such management it is easily possible that inadequate dry matter intake is the major nutritional limitation to sheep productivity.

In the Outreach Research Project (ORP), located near Sungei Putih, most of the farmers graze their sheep on nearby land of the rubber estate for only 3.5-4 hours in the afternoon. The SR-CRSP recommended additional grass be cut and fed to the animals in the barn in the mornings, which most farmers now do. However, in other areas this is not the case, with either

grazing or cut-and-carry being the sole source of forage for sheep flocks. To develop improved feeding strategies for rearing of sheep in villages near rubber plantations, an experiment was conducted to determine the adequacy of dry matter intake of ewes that were both grazed in rubber plantations in the afternoon and given cut forage in the barn.

Table 1. Range in botanical composition and dry matter disappearance of grazed and cut forge and refusals

	Graze %	Cut %	Refusals %
Grass	38-65	68-88	43-76
Legume	25-32	4-12	3-36
Shrub/Forb	0-27	8-17	13-27
Tree Legume	0-5.2	0-4.2	0-6.7
Dry matter disappearance	62-75	60-76	48-60

Four non-lactating ewes from each of four ORP farmers were selected for the study. In each barn, the four ewes were separated from the rest of the flock. As the aim of the study was to determine the adequacy of dry matter intake under the existing feeding system, the four farmers were asked to continue cutting forage as usual. Three of the farmers cut plantation forage and one cut only *Gliricidia sepium* leaf to be fed in the barn. No other feedstuffs were provided to the flocks.

Over a period of 14 days, measurements were made of the total forage dry matter cut each day; the dry matter consumption of cut forage in each group of four ewes in the barn (by twice daily weighing of feed offered and refused); the dry matter digestibility (DMD) of grazed and cut forage and refusals using the in *sacco* technique; total dry matter consumption by each ewe was determined using Cr_2O_3 to estimate total fecal output with the above DMD: intake = (fecal output)/((100-DMD)/100); and botanical composition of grazed (plucked samples) and cut forage and refusals.

Each of the four farmers selected the species of forage to cut by quality rather than cutting only the highest yielding species. Preferred species included the grasses *Axonopus compressus*, *Brachiaria mutica*, *Ottochloa nodosa*, *Cyrtococcum acrescens* and *Ischaemum timorense*. The botanical composition of forage samples confirmed predominance of these species in the cut forage (68-88%) (Table 1). However, during grazing, the ewes selected a much larger proportion of legume (25-32%). Average dry matter percentages of grazed, cut and refusals were 27+3%, 34+2% and 47+6% respectively.

The quantity of forage cut varied from 1.4 - 4.3% of flock BW and the DMD of cut forage was moderate to

Table 2. Mean dry matter consumption as estimated from Cr_2O_3 analysis. Standard errors in brackets

	Farmer			
	Mis.	Sar.	Sup.	Sum.
Ewe bodyweight (kg)	26.6 (2.4)	21.9 (1.5)	18.8 (2.5)	26.6 (2.4)
Faecal output (g/head/d)	476 (35)	1305 (18)	296 (27)	344 (30)
Intake of cut forage (g DM/head/d)	985 (55)	442 (56)	572 (75)	295 (17)
Intake of grazed forage (g DM/head/d)	596 (114)	819 (75)	224 (88)	728 (98)
Total DM intake (g DM/head/d)	1581 (114)	1261 (75)	796 (88)	1023 (98)
Total DM intake (g DM/(kg BW)$^{0.75}$)	134.7 (3.1)	124.7 (3.9)	88.7 (2.8)	87.2 (3.0)
Grazed intake as % of Total	36.7 (4.6)	64.5 (2.2)	25.470.3 (8.3)	

high (60-77%) with refusals lower (Table 1). The DMD of grazed forages were all high.

The total dry matter intake (Table 2) averaged over 1000 g DM/d or over 100 g DM/(kg $BW^{.75}$). This level of dry matter intake should meet the requirements for a 25 kg lactating ewe. These estimates for dry matter intakes are higher than the 72 g DM/(kg $BW^{.75}$) observed in experiments on the research station where crossbred lambs gained 121 g/d. There was a great deal of variability between flocks in the proportion of dry matter intake that was obtained while grazing (25-70%) indicating that the proper feeding and nutrition can be met by either cut and carry or grazing.

It is unknown whether the farmers in this study increased the amount of forage cut or the time that the animals were grazed to please the researchers. In future studies it is recommended to reduce the number of samples taken for Cr_2O_3 from 14 to 5 (reducing cost and labor) and to monitor the farmers without warning prior to and after the study to compare the quantities of grass cut and the times of grazing with those measured during the study.

Improving establishment of forage grasses for rubber plantations in North Sumatra

Past and current experiments to determine the best adapted forage species and mixtures for rubber plantations in North Sumatra have been hampered by problems associated with establishment. Some of the problems were inherent in the seed of some of the promising species that have been selected, including *Paspalum notatum*, *Brachiaria humidicola* and *Arachis pintoi*. These species are known for their slow establishment and unreliable seed quality. In some environments, these establishment problems can be alleviated by removing soil, climatic and biotic limitations to establishment.

Although clean seed bed preparation is costly and exposes the soil to erosion, it is an integral part of replanting rubber plantations and gives sown species the best chance of successful establishment. The major establishment problem for forages in these clean seedbeds, apart from poor germination, is weed competition. Tropical leguminous forages generally establish more rapidly from seed than grasses and have a better chance to overcome competition from weeds. However, even the leguminous plantation cover crops still require hand weeding during the first two months to ensure establishment success. Management practices to improve forage establishment in rubber plantations, especially for grasses, should focus on enhancing the ability of seedlings of the sown species to overcome weed competition.

This experiment examined the effects of several pre-sowing treatments with the potential to reduce weed competition (seed placement, fertilizer application and placement, planting material (seed versus cuttings) and pre-emergent herbicide) on the establishment success of tropical forage grasses.

Two promising tropical forage grasses were selected as models of grasses with widely differing establishment potential in the acid soils of North Sumatra. *Panicum maximum* var trichoglume cv. Petrie is a rapidly establishing bunch grass adapted to soils of higher fertility whereas *Brachiaria humidicola cv* Tully is adapted to acid soils of low fertility and is very slow to establish from both seed and stolons but, once established, is a vigorously spreading stoloniferous grass that can out compete most weeds.

The treatments consisted of:

1) a complete factorial combination of:
   - 2 seed placement factors (broadcasted versus drilled)
   - 2 pre-emergent herbicide factors (+)
   - 2 starter-fertilizer factors (+ NPK at 50kg N/ha). Each combination was replicated three times giving 48 plots.
2) in addition to using seed, establishment of *Brachiaria humidicola* from rooted stolon cuttings was evaluated with a complete factorial combination of:
   - 2 pre-emergent herbicide factors (+)
   - 2 starter-fertilizer factors (+ NPK at 50kg N/ha). Each combination was replicated three times giving 12 plots.
3) a positive control was provided for both species established from seed consisting of:

•drilled seed + pre-emergent herbicide + starter-fertilizer + handweeding. The two treatments were replicated three times giving 6 plots.

The site was disc cultivated twice and harrowed once before the 66 plots (measuring 2m x 2m) were prepared. A pre-emergent grass herbicide (alachlor) was sprayed on the appropriate treatments 14 days prior to sowing. A special rake was used to produce slots for the drilled seed treatments (50cm wide and lcm deep). Starter fertilizer was either drilled or broadcasted depending on the seed treatment. Stolons (at 50cmx50cm spacings) and seed (at a rate of 6 kg/ha) were sown on March 28, 1994. Following sowing there was no rain until April 9, 1994 but thereafter rainfall was regular and adequate for unrestricted growth. Rainfall in April and May totaled 153mm and 199mm respectively.

Weekly measurements of germination, seedling dynamics and ground cover commenced on April 17, 1994 and continued until harvest on June 8-9, 1994 (10 weeks after sowing).

Viability of *Brachiaria* seed was low (<10%) compared with *Panicum (>60%). Panicum* emerged rapidly and in large numbers whereas emergence of *Brachiaria* from seed was slow and patchy. Establishment of *Brachiaria* stolons was also slow.

The rapid establishment of *Panicum* led to it dominating most treatments at harvest compared with *Brachiaria,* which contributed less than 20% to the dry matter yield of all treatments. The total dry matter yield of all plots was significantly higher ($p<0.01$) in the *Panicum* plots than the *Brachiaria* plots. This was mostly due to the large yield contribution of *Panicum* to total dry matter yields. The grass dry matter yield in the *Panicum* plots (390±51g/m2) was significantly higher ($p<0.01$) than in the *Brachiaria* plots (30±51g/m^2). By comparison, in handweeded plots, grass dry matter yields for *Panicum* and *Brachiaria* respectively were 537±51g/m^2 and 151±21g/m^2.

Across all treatments there were significant differences in the numbers of plants/m2 in the order *Panicum* broadcast (26±2) > *Panicum* drilled (14±2) all *Brachiaria* treatments (5±2).

Across both species there was a significant positive effect ($p<0.01$) of starter fertilizer and herbicide on both grass and total dry matter yields. The herbicide effect was due to a significant positive effect on dry matter yields of *Panicum* (520±55g/m^2 vs 260±56g/m^2) but not *Brachiaria* (17±54).

The percentage contribution of grass to total dry matter yields (% grass) was significantly improved ($p<0.01$) by herbicide in the order *Panicum* + herbicide (70±5) > *Panicum* -2 herbicide (45±5) > all *Brachiaria* treatments (7±5). Fertilizer affected % grass in the order *Panicum* + fertilizer (75+5) > *Panicum* - fertilizer (41±5) > all *Brachiaria* treatments (8±5).

The final cover measurements showed that in all *Brachiaria* treatments, *Brachiaria* contributed less than 30% to total ground cover (mostly less than 10%). In the drilled *Panicum* treatments, *Panicum* contributed 59-63% of total ground cover except in the unfertilized and unherbicided control (13%). In the broadcast plots *Panicum* contributed 45-71% of total ground cover, the highest being in the fertilized and herbicide treatment.

The main conclusions from the experiment were:

Panicum maximum, which is adapted to soils of higher fertility, was able to respond rapidly to fertilization and herbicide to gain a competitive advantage over weeds. By comparison, the inherent establishment problems of *Brachiaria humidicola* (poor germination rate and slow early growth) were not overcome by either seed drilling or herbicide and there were only minor establishment gains in response to fertilizer.

Drilling of seed and/or fertilizer, which is a technique known to enhance establishment in dry and infertile soils, did not improve establishment success of either species.

Brachiaria stolons were more successful in aiding establishment than seed. Given the difficulties involved in producing good quality seed, vegetative propagation (where possible) is currently the best option for distributing slowly-establishing species in Indonesia.

Handweeding following planting in the wet season remains the most effective method of establishing promising but slowly establishing species such as *Brachiaria humidicola*, *Paspalum notatum* and *Arachis pintoi*, so long as it is an economically viable option. It must be remembered that the costs of establishment failure are high.

Asystasia intrusa - a potential problem weed in Sumatra, Indonesia.

Asystasia intrusa is often regarded as the most serious weed of rubber and oil palm plantations in Malaysia, because of its high demand for nutrients. However, it is highly palatable for sheep and is able to grow well in full sun as well as deep shade. *A. intrusa* has been reported in North Sumatra since 1940, but there have been no reports of it becoming a serious weed in plantations. It was introduced to Sungai Putih, North Sumatra from Malaysia in 1988 for field studies on its value as a forage for sheep. It soon spread to the immediate surrounding areas through transport of seed by forage gatherers, seed on car tires and seed dispersed through explosion of its pods. In 1993, unrelated outbreaks were discovered at Ack Loba (200 km south of Sungai Putih) and Torgambar. It is likely that *A. intrusa* has been accidentally introduced with oil palm seeds imported from Malaysia. Unfortunately, with the continuous importation of oil palm germplasm from Malaysia, it appears that the likelihood of Asystasia intrusa causing problems in Sumatra are high. Eradication in the Sei Putih area was only possible with intensive, repeated use of herbicide and hand labor for over two years.

Utilization of Ex Decanter Solid waste from palm oil processing as a feed supplement for sheep

Readily-available agro-industrial byproducts that can be used as supplementary feeds for fattening sheep in the plantation areas of North Sumatra include palm kernel cake (PKC), molasses, cassava meal and coconut meal. However, there are competing markets for most of these byproducts and some, such as PKC, are currently relatively expensive. Palm oil mill effluents (POME), which are waste products of the steam pressing method of palm oil extraction, have considerable potential as animal feed. They are locally available and inexpensive. There are at least five types of POME and their quality for feeding varies according to the method of extraction and processing.

The POME that has been the subject of most recent research is a slurry known as wet sludge. However, of the two main oil extraction methods, solid waste produced by the decanter process (ex decanter solid waste; EDSW) has the highest potential feeding value of all POME. The decanter process, which is common in privately-owned mills in Indonesia, separates crude oil into purified oil, EDSW and waste water. There are nine such factories in North Sumatra. In one day, a typical factory based on the decanter system processes 800 tons of fresh fruit and produces 12 tons of fresh EDSW.

Two growth trials and one digestibility trial were conducted at SBPT to examine the feeding value of EDSW for young sheep.

Trial 1. Growth of lambs supplemented with fresh EDSW, cassava meal, PKC and molasses.

The aim of this experiment was to evaluate the use of a simple concentrate based on EDSW as a supplement for lambs on a grass-based diet. Thirty-two 6-7 month old lambs (16 Sumatra (S) and 16 St. Croix crossbred (HC) were fed four rations (R0, R1, R2 and R3) varying in content of EDSW offered at 3.5% of bodyweight:

- R0: 100% chopped grass leaf diet (Brachiaria sp.). (DE=2.4Mcal/kg, CP=9%)
- R1: 70% grass, 10% EDSW, 10% PKC, 4.5% molasses, 4.5% cassava meal and 1% urea on a DM basis. (Concentrate composition: DE=3.3 Mcal/kg, CP=13.9%).
- R2: 60% grass, 20% EDSW, 10% PKC, 4.5% molasses, 4.5% cassava meal and 1% urea on a DM basis. (Concentrate composition: DE=3.1 Mcal/kg, CP=13.7%).
- R3: 50% grass, 30% EDSW, 10% PKC, 4.5% molasses, 4.5% cassava meal and 1% urea on a DM basis. (Concentrate composition: DE= 3.0 Mcal/kg, CP=12.0%).

The PKC, molasses and cassava meal were added on the assumption that energy would be limiting and these were locally available byproducts. Lambs averaged 21.8±3.8kg at the start of the experiment. A two week adaptation period was followed by measurements of intake and liveweight gain for two months.

Trial 2. Growth of lambs fed supplement containing three levels of dried EDSW

The aim of this growth trial was to evaluate the use of EDSW as a component of a standard concentrate for use as the main feed component of a sheep fattening scheme. The experiment was conducted in individual pens with 32 recently weaned lambs (16 Sumatra (S) and 16 St. Croix crossbred (HC)) fed four diets (D0, Dl, D2 and D3) offered at 3.5% of bodyweight:

- D0: 30% chopped grass leaf (Brachiaria sp.; DE=2.4Mcal/kg, CP=9%) and 70% standard concentrate (containing no EDSW).
- Dl: 30% grass and 70% concentrate (containing 15% EDSW).
- D2: 30% grass and 70% concentrate (containing 30% EDSW).
- D3: 30% grass and 70% concentrate (containing 45% EDSW).

All concentrates were formulated to be isonitrogenous (CP=14.2%) and isocaloric (3.0 Mcal DE/kg) and were based predominantly on palm kernel cake, coconut meal, cornmeal, rice bran and molasses. Lambs averaged 14.0±0.4 kg at the start of the trial. A two week adaptation period was followed by measurements of intake and liveweight gain for three months. Twenty four lambs were then placed in metabolism crates for 13 days to measure the digestibility of dry matter, protein and energy of each diet.

Trial 3. In *vivo* and in sacco dry matter and protein digestibility and fiber-fraction of diets containing EDSW

The in vivo study was based on the same feed treatments as used in experiment 1 fed to twelve sheep in metabolism crates for a total of twenty days. Feed offered, dry matter intake and fecal output were measured over the last seven days and samples of feed and feces collected for N, energy and fibre analysis. Dried, ground samples of EDSW (1.5mr. screen) were also incubated in nylon bags in the rumens of three fistulated rams for 6, 12, 24 and 48 hours to measure the rate of disappearance of protein and dry matter in EDSW.

The decanter process was designed to have a drier for the EDSW to make it less of a pollution hazard but few factories (none in North Sumatra) have installed these high energy requiring driers. As a result, the major drawback of EDSW as a feed supplement is its low dry matter content (20-25%). It has a moderately high ash (15-25%) and copper (20-50ppm) content and a high ADF (58%) which may cause intake and metabolic problems at high levels of EDSW in the diet.

The use of EDSW as an animal feed is limited by the high water content and by problems with processing and storage. Having a high water content, it should ideally be dried but sun drying of EDSW results in formation of rock-hard aggregates that are difficult to reprocess. However, if stored fresh, molds begin to form within a day. For the purposes of these experiments, three storage methods were evaluated:

- fresh EDSW stored in drums covered with a thin layer of molasses (~3cm)
- sun-dried EDSW
- fresh EDSW mixed into concentrates before drying

Sun drying of EDSW took between 7 and 21 days and resulted in storage times of only 30 days before molds would form, since the moisture content of sun-dried EDSW was still 15-20%. Sun drying of concentrates containing up to 45% EDSW took only one day and eliminated the problems of reprocessing the sun-dried EDSW, but still resulted in safe storage for only 30 days. Storage of fresh EDSW in drums covered with layers of molasses was simple and allowed for storage up to at least 3 months. In the first experiment there was no significant effect of breed on all variables except the actual dry matter consumed as a percentage of bodyweight (which varied in the order of HC (2.6%BW) > S (2.4%BW). The significant effects of ration on lamb growth are summarized in Table 3.

Average daily gain was significantly improved by the addition EDSW in the diet as a result of increased total dry matter intake, a lower percentage of grass intake, higher energy and protein intake and a stimulation of higher dry matter intake as a % of bodyweight. Highest mean ADG was from R3 with a daily intake of 218 g EDSW DM/head/day, which was 33% of total DM intake and equivalent to 0.9% of bodyweight.

In trial 2, growth was linear over the 120 days of the experiment with no plateau. There was a significant effect ($p<0.05$) of diets on ADG, with D3 (90±5.3g) < D0 (115±4.4g) < D1 (129±4.7g), D2 (132±4.4g). There was also a significant main effect of breed type on ADG with HC (123g) > S (110g). The highest mean ADG (from D2) was associated with a daily intake of 110 g EDSW DM/head/day, which was 19% of total DM intake and equivalent to 0.6% of bodyweight. The inhibition of ADG by D3 was associated with a daily DM intake of EDSW of 151 g/head, which was 28% of total DM intake and equivalent to 0.8% of bodyweight. This reduction in growth rate of lambs consuming D3 was not associated with a significant reduction in feed intake (mean of 583g/head/d or 60.1±1.5 g DM/(kg BW)$^{0.75}$ being 2.9% of bodyweight across diets and breeds). Nor was it associated with a significant reduction across diets and breeds in digestible energy intake (mean of 1.5±0.2 Mcal/head/day), digestible protein intake (mean of 62±11 g/head/day) or feed conversion ratio (mean of 5.1 g intake/ g ADG).

Analyses of the metabolism trial in experiment 3 revealed no significant effect due to the rations on dry matter digestibility (mean 58.3%). However, the rations had a highly significant effect on protein (60.2^a, 62.5^a, $59.5^{a,b}$ and 56.4^b%) and energy (52.9^a, 61.8^b, 63.2^b and 65.4^b%)digestibility (for R0, R1, R2 and R3, respectfully). The ration that had the highest ADG (R3) had the lowest protein digestibility. All rations with concentrate had significantly higher ($p<0.05$) energy digestibilities than the grass only ration. There were no effects of ration on fiber digestibility.

Dry matter, protein and energy digestibilities of dried EDSW, as determined in *sacco* indicated that the rates of digestion were slow but the 48 hour digestibilities were reasonably high (66, 58 and 65% for DM, protein and energy respectively). These results point to digestible protein and energy contents in EDSW of 81g/kg and 2.73Mcal/kg respectively.

Results of an economic analysis of the potential of the rations in trial 2 for fattening of HC lambs over the period of 120 days, incorporating major variable costs (grass, concentrate, anthelmintic, barn, labor and purchase of lambs) are summarized in

Table 3. Least squares mean (±SE) of final bodyweight, average daily gain (ADG), total dry matter intake, proportional intake of grass and calculated intake of digestible energy and crude protein for experiment 1.

Ration	ADG (g/head/d)	Total DM Intake (g/hd/d)	Grass Intake (% of TDN)	DE Intake (Mcal/hd/d)	CP Intake (g/hd/d)	DM Intake (%of BW)
	(5.1)	(34)	(1.7)	(0.08)	(3.3)	(0.09)
RO	29.9^a	455^a	100.0^a	1.09^a	41.0^a	2.3^a
R1	58.3^b	562^b	61.4^b	1.54^b	61.1^b	2.4^a
R2	64.6^{bc}	632^{bc}	53.9^c	1.72^c	70.5^{bc}	2.7^b
R3	70.0^c	669^c	45.5^d	1.82^c	71.0^c	2.7^b

^{a,b,c}Means within columns with different superscripts are significantly different ($P<0.05$).

Table 4. Net returns from using the rations from experiment 2 to fatten HC lambs for 120 days

Diet	Net Benefit (Rp./head/day)	Concentrate Cost (Rp./kg)
DO	109	253
D1	163	235
D2	195	182
D3	158	169

Table 4. After 120 days, starting with a 14kg lamb, offtake weight will be about 26-29kg.

From the combined results of the three trials, it can be concluded that:

- Fresh EDSW can be easily handled, stored and incorporated into sheep diets. Mixed with small quantities of molasses, PKC and cassava meal, it provides a useful source of energy and protein.
- EDSW can improve the growth of lambs when incorporated in diets at 20% of dry matter intake. This is true for both concentrate-based and grass-based diets. Older lambs on simple supplements produced best results when EDSW was 33% of dry matter intake but growth of younger lambs was depressed when EDSW was 28% of dry matter intake. This possible anti nutritive factor needs to be clarified to provide recommendations for commercial use.
- Incorporation of EDSW in concentrate-based diets for fattening lambs reduced feeding costs by 30-40% and increased economic benefits by 80% over the 120 days of the trial.

Forage Characteristics that Influence Preference in Sheep Identified Using Multidimensional Scaling. (Ph.D. research of Silvia Buntinx)

Voluntary intake is one of the critical factors in meeting an animal's nutrient requirements. Selectivity is one of the factors that complicates the determination of voluntary intake and it depends, in great measure, on the palatability of the forages on offer. The purpose of this research was to elucidate the factors or cues that make a plant desirable to an animal. To accomplish this the methodology of multidimensional scaling was used. Multidimensional scaling is a mathematical tool that arranges stimuli (or objects) in space in such a way that stimuli judged to be similar to one another are represented as points close to each other and stimuli judged to be dissimilar are represented as points distant from one another.

A hay and a fresh forage experiment were conducted. In the Hay experiment (Exp. 1), six individually-penned wethers were used to obtain preference ratings on nine hays, each compared two at a time giving 36 pair combination. These hays were alfalfa (positive control, ALF), reed canarygrass (RCG), Forager tall fescue (FTF), Johnstone tall fescue (JTF), Triumph tall fescue (TTF), Tifton 44 bermudagrass (TIF), flaccidgrass (FLG), immature switchgrass (ISG, cv. Kanlow), and mature switchgrass (MSG). The combinations were randomized across the wethers and after an adaptation period of 2 d per hay, the wethers had access to each of the 36 pair combinations for 3 d. Masticate samples of each hay were obtained using five esophageally-cannulated wethers. In the Fresh Forage experiment (Exp. 2), six individually-penned ewes were used to obtain preference ratings on nine fresh forages also evaluated in pairs. The forages were ALF, RCG, FTF, TTF, TIF, FLG, Coastal bermudagrass, Alamo switchgrass, and Cave-in-Rock switchgrass. The combinations were randomized across ewes and after and adaptation period (2 fresh forages per day), one pair combination per day was offered to the ewes, who had access to them for 2-3 hours. Masticate samples of each fresh forage were obtained with three esophageally-cannulated wethers. Laboratory analyses included the determination of in vitro dry matter disappearance (IVDMD), Van Soest fiber fractions, nitrogen, and total non-structural carbohydrates in the hays, fresh forages, and masticate samples. Mean and median particle size for each hay and fresh forage were also calculated. The multidimensional scaling program of PROC ALSCAL (SAS) was used to analyze the preference ratings, and analyses of variance, correlations, and

multiple linear regressions were also performed.

In Exp. 1, the preference ratings for the first day of exposure to each hay combination (Day 1) and the mean preference ratings during the three days were analyzed. Multidimensional scaling of these ratings resulted in a three-dimensional response, in which dimension 1 was more important than dimension 2 and dimension 2 more important than dimension 3, in both analyses. The three-dimensional space for preference during Day 1 was defined by five variables: IVDMD-dimension 1; ADF-ash and lignin/NDF ratio—dimension 2; lignin/NDF ratio, monosaccharide + disaccharide concentration, and short-chain polysaccharide (SCP) concentration—dimension 3. The three-dimensional space for mean preference was defined by eight variables: IVDMD, monosaccharide concentration, SCP concentration, and disaccharide concentration— dimension 1; ADF-ash, monosaccharide concentration, SCP concentration, and masticate NDF—dimension 2; disaccharide concentration and starch concentration— dimension 3. In Exp. 2, dimensions was: dimension 1 and 2 were equally important and dimension 3 the least important. The three-dimensional space for fresh forage preference was defined by four variables: disaccharide concentration and median particle size- dimension 1; starch concentration and monosaccharide + disaccharide concentration— dimension 3. No variable satisfactorily explained dimension 2.

It was concluded that in the case of the hays, nutritive value (expressed as IVDMD), the monosaccharide concentration, and texture were important in determining preference. In the case of the fresh forages, which were all of good nutritive value, preference was determined by a lower disaccharide concentration, maybe by smell, and by the concentration of non-structural carbohydrates. The technique of multidimensional scaling systematized the data in these trials and made it easier to relate physicochemical characteristics of forages to preference.

Relationship of Thyroid Hormones and Digesta Kinetics as Affected by Heat Stress in Wool and Hair Sheep (Ph.D. research on José Luis Romano Munoz).

Two experiments were conducted to evaluate the effect of high temperature on respiration rate (RR), rectal temperature (RT), digestibility of dry matter (DDM), plasma levels of thyroid hormones (thyroxine, T4 and triiodothyronine, T3) and on retention time of digesta in the gastrointestinal tract of wool and hair sheep. And two experiments were conducted to evaluate the effect of induced hypo- and hyperthyroidism on digesta kinetics and DDM.

In Exp. 1. Six Katahdin (KTN) (hair) and six Dorset (DST) (wool) sheep were distributed to treatments in a 2 x 2 factorial arrangement in a crossover design. The factors were 2 room temperatures and 2 breeds of sheep. Three animals of each breed were individually penned in either a thermoneutral (TN, 20.8 °C and 61% RH) or in a high temperature (HT, 29.9°C and 56% RH) room for a 35 day period and switched for a second period. Chopped Tifton 44 bermudagrass hay was fed twice a day. Blood samples to measure T4 and T3 were taken by venipuncture to the jugular vein on days 30, 33 and 35 of each period. Single doses of Ytterbium-fiber and Cobalt, for digesta kinetics estimation, were given on day 30. T4 and T3 were measured by radioimmunoassay. Analysis of variance for a crossover design was performed on RR, RT, DDM and kinetics of digesta data. Concentrations of T4 and T3 were analyzed by repeated measures analysis. The daily average of dry matter intake was 41.6 g/W75. The DST sheep showed higher ($P<0.01$) RR and RT than the KTN sheep in both TN and HT. DDM was similar ($P>.10$) between temperatures and between breeds. Katahdin sheep showed about a 20 % faster ($P<.01$) rate of passage of the solid fraction of digesta than wool sheep at both temperatures. No effect of room temperature was observed ($P>.10$). Total retention time of solids (STRT), 67.5 h, was similar between treatments ($P>.10$). Plasma concentration of T4 showed a temperature x breed interaction. Total T4 was increased in DST sheep when they were exposed to HT ($P<.01$). The KTN

sheep had a higher T3 than the DST in both rooms. Fitting the data to a multiple correlation model, considering temperature, breed, intake, digestibility of dry matter, plasma T3 and T4 as independent variables and retention times as dependent variables, resulted in a negative correlation between T3 and ruminal mean retention time of solids (SRRT) and STRT.

In Exp. 2, six wether lambs from each of two wool (DST and Suffolk, SFK) and 3 hair breeds (KTN; Saint Croix, SC and Barbados blackbelly, BB) were used in a 2 x 5 (2 room temperatures and the 5 breeds) factorial arrangement in a crossover design. Three animals of each breed were individually allocated to either the TN (21.8 C and 72 % RH) or HT (30.4 C and 64 % RH) in a crossover design for two 21-d periods. Coastal bermudagrass hay was fed twice a day. RR and RT were recorded every three days. DDM and retention times of digesta in the gastrointestinal tract were determined during the last 7 d of each period. Blood samples to determine T4 T3 and Cortisol (CSL) were taken on d 4, 8, 11, 15 and 18 of each period. Analysis of variance for a crossover design was performed on RR, RT, DDM and retention times. Analysis of variance for repeated measures was performed on T4 T3 and CSL. Sheep in HT had higher (P<0.01) RR than those in the TN. The interaction temperature x breed was significant (P<0.01) for RT, all breeds but BB had higher RT in the HT. DDM was higher (P<0.01) in the HT (60.6%) than in the TN (59°/O). The BB had the lowest DDM . Ruminal mean retention time was similar (P>0. 15) among treatments. STRT was shorter (P <.01) in BB and KTN. Analysis of the mean across time of T4 and T3 showed a significant (P <.01) temperature x breed interaction. T, and T3 decreased in hair but not in wool breeds after exposure to high temperature. Results from repeated measures analysis on T4 showed a significant interaction of day x temperature x breed. Repeated measures analysis on T3 showed a borderline (P <.06) day x breed interaction. Fitting the data to the same multiple correlation model as that used in Exp. 1, indicated a negative correlation between T3 and SRRT and STRT.

Experiments 3 and 4 were conducted to evaluate the effect of temporary induced hypo- and hyperthyroidism on the kinetics of digesta in the gastrointestinal tract. Hypo- and hyperthyroidism were temporary induced by subcutaneous pellet implantation of the thyroid gland inhibitor propyl-thiouracil (PTU) and triiodothyronine, respectively. The doses used in Exp. 3 were 0.416 mg and 2.34 µg/kg BW/day of PTU and T3, respectively.

In Exp. 3, twelve whether lambs were randomized to one of three treatments control (CNTL), PTU-induced hypothyroidism (PTU-hypo) and T3-induced hyper-thyroidism (T3-hyper) and allocated to individual crates in the TN room (21°C) for a 33 day period. Chopped Alfalfa hay was fed twice a day. Pellets were implanted on day 19. Fecal collection for determination of digestibility and estimation of digesta kinetics was from day 26 to 33.

Blood samples were taken before the morning feeding on days 14,16,19-23,26,28 and 30. Analysis of variance for a completely randomized design was performed on DMI, DDM and retention times. Analysis of variance for repeated measures was performed on T4 and T3. Plasma levels of T4 and T3 during the week of sampling for estimation of digestibility and retention times were similar (P >.10) between treatments. DDM and retention times were similar between treatments. The means for DDM, SRRT and STRT were 61.1%,29.5 and 47.1 h, respectively. The doses used of PTU and T3 were not high enough to obtain the planned hypo- and hyperthyroidism. Experiment 4 was initiated 52 days after finishing Exp. 3, to prevent any carryover effect. Animals were re-randomized to the three treatments previously described in Exp. 3. The doses used were 0.83 mg and 7.436 µg/kg BW/day of PTU and T3, respectively. The duration of this experiment was 30 d. Pellets were implanted on d 16. Fecal collection for determination of digestibility and estimation of digesta kinetics was from day 23 to 30. Blood samples were taken before the morning feeding on days 13, 16-20, 23, 25 and 27. The average of DMI was 56.7 $g/kg^{.75}$. The DDM and CSL were not different (P >.10) between treatments.

Ruminal rate of passage, ruminal and total mean retention time were no affected by treatment (P>.10). A significant (P<.01) date x treatrnent interaction resulted in the repeated measures analysis of T4. While T4 in the CNTL group remained constant during the whole experiment, it decreased in animals from PTU-hypo and T3-hyper groups. The date x treatment interaction was significant in T3 (P<.01). Concentration of T3 in T3-hyper animals was elevated on the day after implanting, dropped on days 2 and 3, and increased from day 4 to 7 and dropped to normal levels during the week of digesta kinetics measurement. In the animals of the PTU-hypo group, T3 dropped on the first two days post-implant and increased to reach normal levels on day 4. Plasma T3 remained constant during the experiment in animals of the CNTL group. Levels of T3 were similar on the week of digesta kinetics estimation. The general conclusion is that wool and hair sheep respond differently to high temperature.

Tannins in Tree Legumes: Effects on Growth, Intake, Digestibility and N Utilization in Indonesian Lambs. (Ph.D. research of Roger Merkel).

The effect of phenolic compounds and proanthocyanidins present in three tree legumes, *Parasenanthes falcatana*, *Calliandra calothyrsus* and *Gliricidia sepium*, upon growth, intake and diet utilization were evaluated. Tree leaves were evaluated when fed as a supplement to a concentrate basal diet at 25 and 50% of dietary crude protein (15 and 30% of dry matter intake) and, along with the grass *Brachiaria brizantha* and herbaceous dicot *Asystasia intrusa*, when fed alone. Rate and extent of dry matter disappearance *in sacco* of the three tree species were also determined.

Calliandra calothyrsus had the highest concentration of soluble phenolics (SPHE), 37.8%, and soluble proanthocyanidins (SPRO), 13.7 absorbance units per gram dry matter *(AU/g)*. *Gliricidia sepium* had less than 5% SPHE and 0.1 to 0.3 AU/g SPRO. *Parasenanthes falcataria* had intermediate levels of 15.2% SPHE and 4.8 AU/g SPRO. Insoluble proanthocyanidins were highest in *G. sepium*, reaching 296 AU per gram neutral detergent fiber (NDF).

Supplementing tree legumes to a concentrate basal diet resulted in decreased average daily gain and lower dry matter (DM) and nitrogen (N) digestibilities than the control diet of concentrate supplemented with B. *brizantha*. Intake was not affected. Urinary N loss tended to be lower in tree legume supplemented groups. Increasing the amount of tree legumes fed from 25 to 50% of dietary crude protein resulted in further decreases in apparent and true N digestibilities and increased fecal output of neutral detergent fiber bound nitrogen (NDF-N). Lambs supplemented with C. *calothyrsus* exhibited lower N and DM digestibilities than lambs fed either P. *falcataria* or G. *sepium*.

When fed alone, tree legume fed lambs showed lower DM, NDF and N digestibilities than both B. *brizantha* and A. *intrusa* fed lambs. *Calliandra calothyrsus*, having the lowest intake at 2.0% of body weight, exhibited digestibility percentages of 54.9, 36.3, 50.5 and 56.8 for DM, NDF apparent N and true N, respectively, lower than both P. *falcataria* and G. *sepium*. *Paraserianthes falcataria* and G. *sepium* recorded digestibility percentages of DM, 60.9 and 62.6, NDF, 41.2 and 42.9, apparent N, 66.0 and 66.5, and true N, 74.6 and 75.6, respectively. *Asystasia intrusa* fed lambs exhibited digestibility percentages of 72.1, 64.8, 73.7 and 83.5 for DM, NDF, apparent N and true N, respectively. *Brachiaria brizantha* fed lambs recorded digestibilities of 64.8, 56.1, 76.1 and 92.8 for DM, NDF, apparent N and true N, respectively.

The main action of proanthocyanidins in these tree species was to irreversibly bind protein rendering it less available for microbial and enzymatic degradation and digestion. *Calliandra calothyrsus*, having the highest SPHE and SPRO concentrations, was most affected. *Paraserianthes Salcataria* had higher SPHE and SPRO concentrations than G. *sepium*, however, digestibilities and N utilizations were similar. *Gliricidia sepium* showed the fastest rate of dry matter disappearance (0.13 per hour) followed by P. falcataria (0.06 per hour) with C. *calothyrsus* the slowest (0.02 per hour).

Oven drying tree legume samples resulted in higher NDF, ADF and lignin concentrations as well as higher fiber bound N levels and lower *in vitro* dry matter disappearance than in freeze dried samples of identical material. Proanthocyanidins may have bound with cellular constituents during oven drying and formed complexes which contaminated recovered fiber fractions and reduced in *vitro* digestibility.

The tree legumes, P. *falcataria* and G. *sepium*, have potential for increased use as animal feeds. *Calliandra calothyrsus* may have potential negative effects upon animal productivity through reduced N utilization and poor digestibility. The usefulness of A. *intrusa is* limited, at present, by its highly competitive and invasive growth habit.

Training

The completion of graduate training has coincided with the September 30, 1995 funding deadline for the Hair Sheep Production System Nutrition Component. In 1994, three students completed the requirements for the Ph.D. in Nutrition and one student completed the requirements for a MS in Nutrition from North Carolina State University. The Ph.D. program of Simon Ginting (Indonesian counterpart scientist) is on schedule to be completed September 30, 1995.

In Progress

Simon Ginting is a citizen of Indonesia and has been the Co-Principal Investigator in Indonesia. He completed all coursework and the written and oral qualifying exam. He will complete field research at the Sungei Putih experiment station in Spring 1995 and return to North Carolina State University to complete laboratory analysis and write his thesis. He is expected to complete a Ph.D. in September 1995 in Nutrition at North Carolina State University, Raleigh, NC. in the area of nutrition/ grazing/ parasite interactions. He will return to Indonesia September 30, 1995.

Completed

José Luis Romano-Munoz is a citizen of Mexico who completed a Ph.D. in Nutrition in May 1994 at North Carolina State University, Raleigh, NC. He returned to Mexico as a scientist and director of a research station working with hair sheep.

Silvia Buntinx is a citizen of Mexico who completed a Ph.D. in Nutrition in August 1994 at North Carolina State University, Raleigh, NC. She returned to Mexico in September 1994 and is employed as a research scientist in the faculty of Veterinary Medicine at the University of Mexico in Mexico City.

Roger Merkel is a citizen of the United States who completed a Ph.D. in Nutrition in October 1994 at North Carolina State University, Raleigh. He conducted research in Indonesia.

Kathy Dugan is a citizen of the United States who completed a M.S. in Nutrition in May 1994 at North Carolina State University, Raleigh, NC. She is employed by the North Carolina Extension Service as an area extension agent in southeastern North Carolina with responsibilities with goats, waste management and forages.

Other Contributions

Environmental impact and relevance

Utilizing sheep to graze in tree-crop plantations reduces the use of herbicides which has both economic and ecological significance. Sheep grazing under tree-crops also improve nutrient cycling and reduces soil erosion without affecting soil compaction.

Agro-industrial by-products are utilized as feedstuffs for sheep and thereby reduce disposal problems and provide needed nutrients to sheep. Utilization of palm oil mill effluent as described in this annual report is an example.

Traditional cover crop species used under tree-crops are slow to establish and are usually established at the beginning of the rainy season when soil erosion risks are greatest. Some of the improved forage species currently being researched establish more rapidly and reduce risks of erosion. In

addition the research on forage establishment techniques could aid in reducing soil erosion and time for establishment.

Agricultural Sustainability

Sheep are an integral part of the farming systems in Asia. They consume materials not used by humans and by-products of food agriculture, many times reducing the need for disposal.

Incorporating sheep grazing into the tree-cropping system also diversifies income for both the limited-resource farmer and large plantations. Manure collected from underneath the barns is efficiently utilized for fertilizing crops and ornamentals or is sold for extra income. Without the use of sheep manure, the system would require more inorganic fertilizers to maintain productivity. Sheep also utilize weeds and unwanted vegetation thereby reducing the need for mechanical weeding or the use of herbicides which can expose soil and cause higher soil erosion.

From monitoring ORP farmers, the use of revenues from sale of sheep is most often to pay for the school expenses of the children. In fact the flock size is often established by the number of sheep needed to cover the costs of schooling.

Contributions to U.S. Agriculture

Training of US students who now have expertise with small ruminants is a long term investment in US agriculture. One Master of Science student, Kathy Dugan, is working for the extension service in rural Eastern North Carolina with responsibilities in small ruminant production and waste management. Roger Merkel, a Ph.D. student completed his degree requirements and has extensive experience overseas and will be well qualified for international positions.

The work on hair sheep has identified breeds that are tolerant of high temperatures and humidity that are appropriate for the southeastern United States. Over seventy-five ewes and six rams of Katahdin, St. Croix and Barbados blackbelly breeding were distributed to sheep and cattle producers in North Carolina. These sheep are in high demand because of their heat tolerance, ability to produce year round and their ease in management.

Contributions to Host Country

The Indonesian Small Ruminant Network was fully supported by the SR-CRSP and produced two newsletters each year, maintained a directory of small ruminant scientists and others interested in small ruminant production and sponsored at least one conference or workshop on small ruminants each year. The network provides a framework for expanded and improved communication and aids in moving research from the station to use and adoption in the field. The funding from the SR-CRSP laid the foundation for this interactive network.

Through the On-the-Farm-Research programs (ORP and OPMM) the SR-CRSP has worked with producers and caretakers of sheep. In most cases these are women and children. Providing information and training to them has improved their production and therefore income. In addition these participants have extended the technologies that the SR-CRSP has developed to their neighbors and others interested in small ruminant production. This has been a very successful method of extending research to the end users.

Training of scientists at North Carolina State University and in Indonesia has been a long term contribution that the SR-CRSP has made to Indonesia. The area of research and development that the SR-CRSP has been involved with is recognized and incorporated as one of the main parts of the five year plan for agriculture. The SR-CRSP project has distributed/sold over 3,500 improved sheep to small farmers and plantation cooperatives. These sheep will be the basis for improved sheep production in Indonesia.

Continued exchange of germplasm and expertise with CIAT (International Center for Tropical Agriculture), NFTA (Nitrogen Fixing Tree Association) and ACIAR (Australian Center for International Agricultural Research) has aided in the

search for adapted forages/trees that are productive and adapted to our research sites.

Support for free markets and broad based economic growth.

The Outreach Research Project at Membang Muda (OPMM) began in September 1991 with twelve Nucleus Estate (NES) Farmers receiving credit packets of four ewes. These farmers have 2 hectares of rubber plantation and 0.1 hectares for a house and garden. The debt is paid back by returning eight ewes lambs. All farmers have repaid their debt. These ewes lambs are then given to other farmers in the immediate area. The Nucleus Estate company (in this case PTPIII) developed a sheep credit scheme for their own employees at Membang Muda, 19 farmers received packets of between 2 and 20 ewes. These farmers repaid the debt by monthly deductions from their salaries. A problem with this scheme, compared with that managed by the SR-CRSP and SBPT, is that it doesn't result in extra ewes being made available to extend the scheme. Given the success of the SR-CRSP/SBPT scheme, PTPIII has started a new scheme based on the SR-CRSP model, for their employees along the same lines involving 500 ewes. The current problem is that PTPIII cannot find a readily available supply of ewes.

PTPIII have asked that any future extension of the SR-CRSP/SBPT project in the area should also involve a small number of credit packets for PTPIII field employees. The average income of the NES farmers with sheep, now that rubber is being tapped (Rp.400,000 - Rp.500,000 ($200-250) gross per month), is much higher that for PTPIII field employees. A tapper employed by PTPIII earns a base salary of about Rp.75,000 ($37.50) per month plus a premium on above-quota latex yields of about Rp.35,000 - Rp.40,000 ($17.50-20) per month. Most lower-level administrative employees earn around Rp.100,000 - Rp.150,000 ($50-75) per month. Unlike the NES areas, where the rubber plantations are all of a similar age, the PTPIII employees' villages are surrounded by plantations of all different ages. The significance of this is since young plantations cannot be grazed, when the old plantations in the NES areas are replanted, they will have to find non-plantation areas to graze. The PTPIII employees have continuous access to old plantations for grazing.

Indonesia-Malaysia-Thailand Northern Growth triangle ("Segi Tiga"). In July 1993, the Indonesian government became a partner in a broad-based agricultural trading group known as the Indonesia-Malaysia-Thailand Northern Growth Triangle ("Segi Tiga"). One of the five major projects within this trading agreement is the production of 3 million head of sheep per year in Aceh and North Sumatra for export to Malaysia and the Middle East. Given the shortage of sheep in northern Sumatra (both local and hair sheep crosses), the plan calls for the importation of sheep from Australia, 80% of which would be fattened and re-exported and 20% kept for breeding stock. While supporting this commercial push to increase sheep production in rubber plantations, the SR-CRSP and SBPT are not supportive of the plan to import Australian sheep, which are not climatically adapted to this region. A similar importation of wool sheep to Malaysia resulted in high losses. A further risk is the unwitting introduction of gastrointestinal nematodes from Australia which are resistant to anthelmintics. The SR-CRSP and SBPT should aim to provide concrete, commercially viable recommendations on sheep breeds and management for Segi Tiga in northern Sumatra before the end of this phase of the project.

Contributions to and compliance with Mission objectives

Good working relationship continues with the Mission. The commercialization of sheep enterprises and developing markets fits in directly with the Mission goals.

Concern for Individuals

The SR-CRSP provided employment for 50 permanent and 50 casual workers in an area of high unemployment. Unfortunately, with the termination of the SR-CRSP these families are no longer employed.

Collaborating Personnel

United States

Dr. Joséph C. Burns, USDA Agronomist (Co-Investigator)
Dr. Dwight S. Fisher, USDA Plant Physiologist
Dr. Jerry W. Spears, Nutrition
J. Vann Cooper, Technician
Vicki W. Fouts, Technician

Indonesia

Bogor
Agency for Agricultural Research and Development (AARD)
P.O. Box 210, Bogor, West Java 16001 (BPT)
Telephone/FAX: 62/251/328384

Dr. Budi Haryanto, Animal Nutritionist, BPT
Dr. Andi Djajanegara, Animal Nutritionist, BPT
Marwan Rangkuti, Animal Nutritionist, BPT
Dr. Budi Tagendjaja, Animal Nutritionist, BPT
Dr. Subandriyo, Animal Breeder, CRIAS

Sungai Putih, North Sumatra (SBPT)
P.O. Box 1, Galang, North Sumatra
Telephone/fax: 62/61/530813

Leo Batubara, Station Director, SBPT
Mursul Boer, Animal Production, SBPT
Simon Ginting, Animal Nutritionist, (Ph.D. candidate at NCSU, funded by the SR-CRSP),SBPT
Tatang Ibrahim, Forage Agronomist, SBPT
Setel Karo-karo, Socio-Economist, SBPT
Junjungan Sianipar, Animal Nutritionist, SBPT
Eleanor Simbiring, Animal Production, SBPT
Artaria Misniwaty Panjaitan, Sociologist and Forage, SBPT
Lermansius Haloho, Forage Agronomist, SBPT
Kiston Simanihuruk, Forage Agronomist, SBPT
Dr. Ruth Gatenby, Animal Physiology, Resident Scientist, UCD
Dr. Peter Horne, Forage Agronomist, Resident Scientist, NCSU

Rubber Institute, Sungai Putih
National Center for Rubber Research
P.O. Box 416, Medan, North Sumatra
Telephone: 62/251/323103

Dr. Nong Alwi, Statistician, BPP
Dr. Asril Darussamin, BPP
Ibu Tuti, Botanist

Collaborating Scientist

Leo Batubara, Station Director SBPT Sugai Putih

Collaborating Institutions

Indonesia

Animal Husbandry Research Institute
Agency for Agricultural Research and Development (AARD)
P.O. Box 210, Bogor, West Java 16001 (BPT)
Telephone/FAX: 62/251/328384

Sungai Putih, North Sumatra (SBPT)
P.O. Box 1
Galang, North Sumatra
Telephone/FAX: 62/61/530 813

National Center for Rubber Research
P.O. Box 416
Medan, North Sumatra
Telephone: 62/61/539 045

Publications

Burns, J.C., D.S. Fisher, and K.R. Pond. 1994. Chapter 12 - Measurement of intake. In: G.C. Fahey, D. Mertens and M. Collins (eds.). Proceedings of National Conference on Forge Quality, Evaluation, and Utilization. 13-15 April, Lincoln, NE.

Burns, J.C., J.L. Villalobos, G.P. Cosgrove, D.S. Fisher and K.R. Pond. 1994. Dietary nutrient estimates of masticated samples from tropical and temperate pastures using NIRS. In: Proc. of 7th Animal Science Congress. Austral-Asian Association for Animal Production. July 11-16, Bali, Indonesia. p 275-276.

Cosgrove, G.P., J.C. Burns, D.S. Fisher, J. P. Mueller and K.R. Pond. 1994. Near infrared reflectance spectroscopy prediction of quality from masticated temperate forage species. Crop Sci. 34:789-792.

Luginbuhl, J-M., K. R. Pond, J. C. Burns and D. S. Fisher. 1994. Evaluation of the Captec controlled release chromic oxide capsule for fecal output determination in sheep. J. Anim. Sci. 72:1375-1380.

Merkel, R.C., K.R. Pond, P.M. Horne, R.M. Gatenby, D.S. Fisher, J.C. Burns and T.C. Sari. 1994. Freeze drying versus oven drying of tree legumes: effect on fiber and N concentrations and in vitro digestibility. In: Proc. of 7th Annual Animal Science Congress. Austral-Asian Association for Animal Production. July 11-16, Bali, Indonesia. p. 315-316.

Merkel, R.C., K.R. Pond, P.M. Horne, R.M. Gatenby, J.C. Burns and D.S. Fisher. 1994. Preference of *Gliricidia sepium* fed to sheep at 3 different wilting levels. In: Proc. of 7th Annual Animal Science Congress. Austral-Asian Association for Animal Production. July 11-16, Bali, Indonesia.

Pond, K.R. 1994. La integración de sistemas de producción como una aproximación a la problemática de la nutrición de ruminantes menores. En: L. Iniquez and E. Tejada (eds.). Producción de Ruminantes Monores en los Valles Interandinos de Sudamérica. Memorias de un Taller Sobne Metodologias de la Investigacion. Tarija, Bolivia. 16-21 de Agosto de 1993. 224 p. La Paz, Bolivia.

Pond, K.R., J.A. Moore and T.G. Goodwin. Nutrient digestibility and kinetics of digesta passage in hair breeds of sheep. Small Ruminant Research (accepted).

Pond, K.R., M.D. Sanchez, P.M. Horne, R.C. Merkel, L.P. Batabara, T. Ibrahim, S.P. Ginting, J.C. Burns and D.S. Fisher. 1994. Improving feeding strategies for small ruminants in the Asian region. In: Strategic Development for Small Ruminant Production in Asia and the Pacific, edited by Subandriyo and R.M. Gatenby. Small Ruminant Collaborative Research Support Program, University of California-Davis.

Sanchez, M.D., K.R. Pond, L. Iniguez and G.E. Bradford. Supplementation of ewes grazing in rubber tree plantations: effects of strategic supplementation and genotype. J. Anim. Sci. (review).

Sanchez, M.D., K.R. Pond, L. Iniguez and G.E. Bradford. Supplementation of ewes grazing in rubber tree plantations: continuous molasses supplementation for Sumatra Thin-tail ewes. J. Anim. Sci. (in review).

Abstracts

Buntinx, S.E., K.R. Pond, D.S. Fisher and J.C. Burns. 1994. Multidimensional scaling as a tool in the interpretation of dietary preferences in sheep. J. Anim. Sci. (Supp. 1) 72:3.

Luginbuhl, J.-M., K.R. Pond, J.C. Burns and D.S. Fisher. 1994. Short fiber cotton textile mill waste as a feed resource for cattle. J. Anim. Sci. (Supp. 1) 782:382.

Presentations

Burns, J.C., J.L. Villalobos, G.P. Cosgrove, D.S. Fisher and K.R. Pond. 1994. Dietary nutrient estimates of masticated samples from tropical and temperate pastures using NIRS. In: Proc. of 7th Animal Science Congress. Austral-Asian Association for Animal Production. July 11-16, Bali, Indonesia. p 275-276.

Merkel, R.C., K.R. Pond, P.M. Horne, R.M. Gatenby, D.S. Fisher, J.C. Burns and T.C. Sari. 1994. Freeze drying versus oven drying of tree legumes: effect on fiber and N concentrations and in vitro digestibility. In: Proc. of 7th Annual Animal Science Congress. Austral-Asian Association for Animal Production. July 11-16, Bali, Indonesia. p. 315-316.

Merkel, R.C., K.R. Pond, P.M. Horne, R.M. Gatenby, J.C. Burns and D.S. Fisher. 1994. Preference of *Gliricidia sepium* fed to sheep at 3 different wilting levels. In: Proc. of 7th Annual Animal Science Congress. Austral-Asian Association for Animal Production. July 11-16, Bali, Indonesia.

Pond, K.R. 1994. La integración de sistemas de producción como una aproximación a la

problemática de la nutrición de ruminantes menores. En: L. Iniquez and E. Tejada (eds.). Producción de Ruminantes Monores en los Valles Interandinos de Sudamérica. Memorias de un Taller Sobne Metodologias de la Investigacion. Tarija, Bolivia. 16-21 de Agosto de 1993. 224 p. LaPaz, Bolivia.

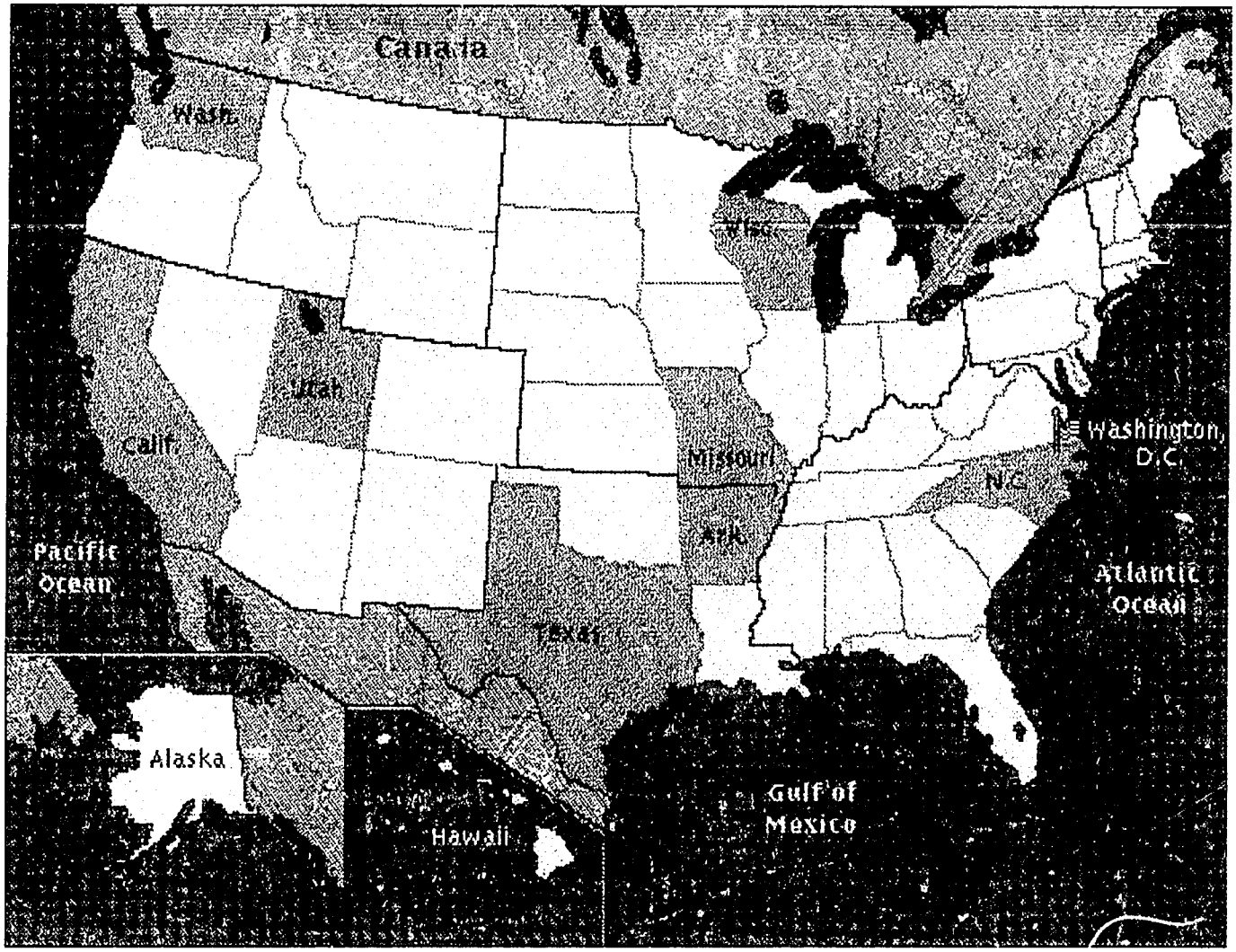
Pond, K.R., M.D. Sanchez, P.M. Horne, R.C. Merkel, L.P. Batabara, T. Ibrahim, S.P. Ginting, J.C. Burns and D.S. Fisher. 1994. Improving feeding strategies for small ruminants in the Asian region. In: Strategic Development for Small Ruminant Production in Asia and the Pacific, edited by Subandriyo and R.M. Gatenby. Small Ruminant Collaborative Research Support Program, University of California-Davis.

Comments

The small grants scheme was a highly effective means of involving more non SR-CRSP supported scientists from a variety of regions to conduct research on sheep and goats that otherwise could not be conducted by SR-CRSP scientists. The first round of small grants resulted in the August 3-4, 1993 workshop and the book "Advances in Small Ruminant Research in Indonesia." The second round of funded small grants resulted in research reports at a variety of technical and scientific meetings.

The premature ending of the SR-CRSP and unpredictability of USAID decisions resulted in discouragement of cooperating scientists and degradation of previously excellent working relationships. Unfortunately, it tarnished the previously brilliant glow associated with this highly successful USAID project. It was indeed unfortunate that grazing research that was the result of three years of field testing and development had to be abandoned. The loss of time, effort and money left cooperating scientists gun-shy of future collaboration with USAID. Training costs that were not covered by the SR-CRSP of graduate students had to be picked up by the host institutions, not a good way to end a successful partnership.

It is unfortunate that a major success (of a USAID program) had to end like this.



United States Participating Institutions

Department of Animal Science
University of California, Davis
Davis, California 95616

Department of Range Science
Utah State University
Logan, Utah 84322

Dept. of Vet. Micro. & Pathology
Washington State University
Pullman, Washington 99164-7040

Dept. of International Programs
University of Wisconsin
Madisin, Wisconsin 53706

Department of Animal Science
Texas A&M University
College Station, Texas 77843

International Agricultural Programs
University of Missouri
Columbia, Missouri 65211

Winrock International
Route 3, Box 376
Morrilton, Arkansas 72110

Office of Research Services
Texas Tech University
Lubbock, Texas 79409

Department of Animal Science
North Carolina State University
Raleigh, North Carolina 27695

SR-CRSP Management Entity
University of California, Davis
Davis, California 95616

Networks and Linkages

"The long-term success of SR-CRSP in aiding the producers of small ruminants throughout the world rests in the ability of participating institutions to establish and maintain a Small Ruminant Science Network (SRSN). Such a network would serve small ruminant scientists and specialists, in the United States and abroad, by providing for:

- *continuous professional development*
- *prompt flow and exchange of research results, experience, and methods*
- *mechanisms to facilitate collaboration and cooperation in planning and executing research on a multi-country, regional, or global basis*
- *identification of sources of funds to support research*
- *increased attention to issues involved in the rapid and efficient transfer of new technology from laboratories and research stations to application in farmers' flocks and fields."*

p. 44-45, Extension Proposal, 1990-1995

Latin American Network.....149
Jane Homan, University of Wisconsin-Madison

Latin American Network

University of Wisconsin-Madison

Jane Homan, Department of International Programs, Room 240, Ag. Hall, 1450 Linden Drive, University of Wisconsin, Madison, Wisconsin, 53706. Telephone (608) 262-4874, Fax (608) 262-885?, E-mail: ejhoman@calshp.cals.wisc.edu

Narrative Summary

The RERUMEN newsletter was published three times. Proceedings from the workshop on production of small ruminants in the interandean valleys were completed. An electronic list server and document source was set up but utilization has been slow to develop. Participants in the region are actively seeking ways to maintain network activities following the cessation of SRCRSP support.

Research Description

The Latin American network's activities have been concentrated mainly on strengthening communications at a regional level as a means to connect all research and training efforts concerning small ruminants. However, the focus has also involved other regions of Latin America such as Central America, Mexico, the Caribbean, USA and Canada; since the interest was to bring together isolated efforts and valuable information among those involved in work with small ruminants.

Workshop

In August 1993 the network hosted a workshop on research methodologies applicable to the production of small ruminants in interandean valleys of South America. Some of the linkages promoted by this encounter have continued to develop during the present year. FUNDEPAZ, an Argentinean NGO has maintained contact with IBTA and is sharing experience in goat production by small producers. Training opportunities for long term and short term training for small ruminants production were discussed in the workshop among participants from Chile, Argentina and Bolivia and continue to show promise. Opportunities for small ruminant germplasm exchange were established. The meeting was also one motivation for the present interest in seeking on-going support for the newsletter after the CRSP support dwindles. During 1994 the workshop proceedings were edited and translated and have now been distributed.

Links to other networks

In November 1993, a representative of RERUMEN participated in a Costa Rican meeting hosted by the Agropastoral Small Ruminant network. A component of this meeting was devoted to building links between networks several of which were represented, including the Caribbean based anglophone network.

Newsletter

RERUMEN published three editions of the newsletter; the first two were sent out in English and Spanish, the third in the latter language only. The newsletter has been well received throughout the region among people interested in small ruminant and motivated clear interest in exchanging information and publication; small ruminant production and associated research have historically had a very low profile in Latin America.

The newsletter was organized to address issues of general interest. For instance it provided information on dairy sheep production, which is now a focus of several sheep improvement programs in South America. Contributors were invited from US

scientists interested in dairy sheep production.

An opportunity for students to publish summaries of their research work and thesis was also provided. This has had an immediate response, especially noted during the production of the later issues of the newsletter. There are very few alternatives for young scientists to project themselves into the research community in Latin America.

The newsletter has also provided a means for the SR-CRSP/IBTA Program in Bolivia to publish and disseminate their research results within the region. This also has helped IBTA (our host institution) in its projection to the research community in the region.

After hearing word of funding termination, many requests for continuation of the newsletter were received. Participants in the region are actively looking now for ways to make this communication effort sustainable. There appears to be a good chance that the newsletter will continue in some form and a proposal for funding is circulating among potential donors. Such a response has been one of RERUMEN's objectives since its reactivation and reflects the impact it has had.

Electronic network

RERUMEN started an e-mail service this year to provide both a rapid communication and discussion forum for otherwise isolated individuals and to provide a means of exchange of documents of common interest. Due mainly to the fact that e-mail services are still in development in Latin America the use of the facility has not filled yet our expectations. US scientists have also been contacted to join the network but have shown a limited response. With the termination of funding, the e-mail network can continue to function and hopefully grow as electronic mail access expands.

Other contributions

The subject matter for the research workshop was selected specifically in response to concerns about degradation of lands in the interandean valleys and to promote research on the utilization of small ruminants in these areas in production systems compatible with the natural resource base. Such valleys have been the subject of significant human migration and developing stable and economically viable production systems are key to stabilizing the population movements.

Collaborating Personnel

Jane Homan, University of Wisconsin
Luis Iñiguez, University of Wisconsin

Collaborating Scientist

Ing. Einstein Tejada, Livestock Program IBTA

Collaborating Institution

Instituto Boliviano de Tecnología Agropecuaria
Edificio El Condor
Calle Batallon
Colorado, La Paz
Telephone & fax: 591-2-370883

Publications

Proceedings: Workshop on Production of Small Ruminants in the Intern Andean Valleys of South America, Tarija, Bolivia August 16-21, 1993, Eds: Luis Iñiguez and Einstein Tejada, 1994; 223 pp in Spanish

Rerumen Newsletter: - three editions published in 1993-94

Comments

With the conclusion of SR-CRSP activities in Bolivia RERUMEN participants in the region have started to explore ways to continue its newsletter, at least at a regional level, through e-mail. If this is so, it is very likely that the electronic mail facility will be utilized more than it is presently.

Project Expenditures

Management Entity

University of California - Davis

Expenditures by Program 153
Approved Program Budgets 155
Matching Contributions from U.S. Institutions 157
Summary of Host Country Contributions 159

Small Ruminant CRSP
USAID Grant No. DAN-1328-G-0046-00
Expenditures by Program

Institution	Disciplines	Year 12 90/91	Year 13 91/92	Year 14 92/93	Year 15 93/94	Total
Univ. of California, Davis	Genetics	$331,324.81	$321,288.16	$253,754.04	$178,367.45	$1,084,734.46
Colorado State	Animal Health	$179,497.99	$195,474.36	$137,000.00	$0.00	$511,972.35
Univ. of Missouri	Sociology	$201,575.76	$353,614.61	$345,687.42	$217,925.32	$1,118,803.11
Montana State Univ.	Breeding	$110,568.80	$105,196.99	$0.00	$0.00	$215,765.79
North Carolina State Univ.	Nutrition	$383,672.90	$337,642.00	$303,258.17	$305,833.06	$1,330,406.13
Texas A&M Univ.	Breeding	$141,524.58	$194,460.00	$165,750.00	$150,321.83	$652,056.41
Texas Tech. Univ.	Range-Nutrition	$84,122.34	$191,010.28	$168,446.05	$132,179.41	$575,758.08
Utah State Univ.	Range-Ecology	$91,342.42	$133,195.00	$142,270.00	$165,870.00	$532,677.42
Washington State Univ.	Health	$160,000.00	$175,000.00	$146,000.00	$197,061.34	$678,061.34
Winrock Int'l.	Dairy Mgmt.	$233,000.00	$186,690.00	$126,318.17	$78,290.76	$624,298.93
Winrock Int'l.	Economics	$212,325.07	$246,906.00	$187,000.00	$173,095.25	$819,380.32
Univ. of Wisconsin	Networking	$0.00	$0.00	$28,779.79	$13,829.53	$42,609.32
	Subtotal	$2,128,954.67	$2,440,531.40	$2,004,263.64	$1,612,773.95	$8,186,523.66
HOST COUNTRIES*						
Indonesia		$0.00	$0.00	$7,099.00	$0.00	$7,099.00
Kenya		$0.00	$0.00	$0.00	$0.00	$0.00
Morocco		$14,609.18	$10,756.76	$0.00	$0.00	$25,365.94
Bolivia		$42,656.96	$147,330.90	$46,241.74	$34,656.64	$270,886.24
	Subtotal	$57,266.14	$158,087.66	$53,340.74	$34,656.64	$303,351.18
Management Entity**		$439,035.03	$498,501.98	$658,193.61	$422,137.36	$2,017,867.98
	Subtotal	$439,035.03	$498,501.98	$658,193.61	$422,137.36	$2,017,867.98
	TOTALS	$2,567,989.70	$2,939,033.28	$2,662,457.25	$2,034,911.31	$10,204,391.98

Most Host Country Expenses are reflected in the expenditures for the participating U.S. institutions.

***Expenditure for ME includes expenses for EEP, Board Meetings, Technical Committee and other meetings.*

Small Ruminant CRSP
USAID Grant No. DAN-1328-G-0046-00
Approved Program Budgets

Institution	Disciplines	Year 12 90/91	Year 13 91/92	Year 14 92/93	Year 15 93/94	Total
Univ. of California, Davis	Genetics	$281,246.00	$233,000.00	$185,000.00	$223,167.00	$922,413.00
Colorado State	Animal Health	$201,570.00	$175,000.00	$137,000.00	$0.00	$513,570.00
Univ. of Missouri	Sociology	$313,500.00	$202,442.00	$210,000.00	$266,780.00	$992,722.00
Montana State Univ.	Breeding	$113,025.00	$106,412.00	$0.00	$0.00	$219,437.00
N. Carolina State Univ.	Nutrition	$295,000.00	$227,000.00	$195,00.00	$352,100.00	$1,069,100.00
Texas A&M Univ.	Breeding	$210,659.00	$140,000.00	$129,000.00	$167,000.00	$646,659.00
Texas Tech. Univ.	Range-Nutrition	$180,000.00	$115,000.00	$118,000.00	$170,000.00	$583,000.00
Utah State Univ.	Range-Ecology	$120,000.00	$115,000.00	$115,000.00	$165,870.00	$515,870.00
Washington State Univ.	Health	$160,000.00	$175,000.00	$146,000.00	$304,327.00	$785,327.00
Winrock Int'l.	Dairy Mgmt.	$200,000.00	$150,000.00	$107,000.00	$82,500.00	$539,500.00
Winrock Int'l.	Economics	$255,000.00	$202,558.00	$177,000.00	$205,000.00	$839,558.00
Univ. of Wisconsin	Networking	$0.00	$0.00	$40,000.00	$55,000.00	$95,000.00
	Subtotal	$2,330,000.00	$1,841,412.00	$1,559,000.00	$1,991,744.00	$7,722,156.00
Management Entity*		$600,000.00	$610,000.00	$610,000.00	$524,275.00	$2,344,275.00
Program Enhancement Funds		$0.00	$43,588.00	$40,000.00	$15,000.00	$98,588.00
Host Countries		$310,000.00	$305,000.00	$206,500.00	$41,620.00	$863,120.00
Linkages		$65,000.00	$0.00	$70,000.00	$0.00	$135,000.00
Impact Assessment					$3,133.00	$3,133.00
Networks				$14,700.00	$0.00	$14,700.00
Funds for Student Training					$20,000.00	$20,000.00
New Site/Activity/Grant Renew.				$459,800.00	$19,000.00	$478,800.00
	Subtotal	$975,000.00	$958,588.00	$1,401,000.00	$623,028.00	$3,957,616.00
	TOTAL	$3,305,000.00	$2,800,000.00	$,960,000.00	$2,614,722.00	$11,679,772.00

**Allocation for ME includes funding for External Evaluation Panel, Board Meetings, Technical Committee, and other meetings.*

Small Ruminant CRSP
USAID Grant No. DAN-1328-G-0046-00
Matching Contributions from U.S. Institutions

Institution	Disciplines	Year 12 90/91	Year 13 91/92	Year 14 92/93	Year 15 93/94	Total
Univ. of California, Davis	Genetics	$118,292.08	$122,877.02	$103,056.00	$92,682.00	$436,907.10
Colorado State	Animal Health	$53,333.04	$87,499.62	$41,861.38	$0.00	$182,694.04
Univ. of Missouri	Sociology	$66,184.42	$81,894.67	$121,900.45	$91,115.58	$361,095.12
Montana State Univ.	Breeding	$60,734.04	$52,668.00	$0.00	$0.00	$113,402.04
North Carolina State Univ.	Nutrition	$64,731.14	$55,975.10	$53,631.00	$55,192.79	$229,530.03
Texas A&M Univ.	Breeding	$46,289.63	$53,757.88	$63,822.49	$63,704.89	$227,574.89
Texas Tech. Univ.	Range-Nutrition	$51,422.63	$68,212.94	$49,900.38	$45,924.26	$215,460.21
Utah State Univ.	Range Ecology	$46,379.09	$84,756.83	$52,639.90	$54,737.10	$238,512.92
Washington State Univ.	Health	$53,333.00	$81,373.76	$48,180.00	$120,470.61	$303,357.37
Winrock Int'l.	Economics	$75,406.90	$83,273.79	$102,045.27	$92,258.89	$352,984.85
Winrock Int'l.	Dairy Mgmt.	$68,022.61	$56,749.01	$26,262.35	$47,138.48	$198,172.45
Univ. of Wisconsin	Networking		New	$0.00	$11,795.61	$11,795.61
	TOTAL	$704,128.58	$829,038.62	$663,299.22	$675,020.21	$2,871,486.63
	Percentage*	32.18%	$34.43%	$33.09%	37.57%	34.20%

**Cost sharing is based on expenditures incurred at the participating institutions and overseas sites.*

Small Ruminant CRSP
USAID Grant No. DAN-1328-G-0046-00
Summary of Host Country Contributions

Host Country	Year 12 90/91	Year 13 91/92	Year 14 92/93	Year 15 93/94	Total
Bolivia	$809.00	$164,787.00	$81,230.00	$117,013.48	$363,839.48
Indonesia	$1,428,400.00	$3,691,400.00	$4,692,840.00	$5,004,400.00	$14,817,040.00
Kenya	$213,771.00	$216,284.00	$127,919.00	$56,489.00	$619,463.00
Morocco	$1,044,000.00	$826,000.00	$811,000.00	$0.00	$2,681,000.00
Peru	$6,845.00	$6,500.00	$0.00	$0.00	$13,345.00
TOTAL	$2,698,825.00	$4,904,971.00	$5,712,989.00	$5,177,902.48	$18,494,687.48
Non-CRSP Support	$46,615.00	$120,962.00	$166,259.00	$340,472.00	$674,308.00
TOTAL	$2,745,440.00	$5,025,933.00	$5,879,248.00	$5,518,374.48	$19,168,995.48

Glossary

AARD	Agency for International Research and Development, Indonesia
ABTEMA	Asociacion Boliviano de Teledecteccion para el Medio Anbiente
ADF	Acid detergent
AGRIS	International Information System for the Agricultural Sciences and Technology, FAO
AID	Agency for International Development, Washington, D.C., U.S.A.
AIGACAA	Asociacion Integral de Ganadevos en Camelidos de los Andes Altos
BIFADEC	Board for International Food and Agriculture Development and Economic Cooperation
BPP	National Rubber Research Institute, Indonesia
BPT	Balai Penelitian Ternak, Bogor, Indonesia (Animal Husbandry Research Institute)
B W	Body weight
CCPP	Contagious Caprine Pleuropneumonia
CELL	Cellulose
CP	Crude protein
CEPROMU	Centro de Promocian de la Mujer
CGIAR	Consultative Group on International Agricultural Research
CIDR	Controlled Internal Drug Release dispensers
CPV	Capripox virus
CRIAS	Coordinating Research Institute for Animal Science, Indonesia
CRSP	Collaborative Research Support Program
CSU	Colorado State University
d	day
DM	Dry Matter
DPG	Dual Purpose Goat
EEC	European Economic Community
EEP	External Evaluation Panel

EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria, Brazil
ENA	National School of Agriculture, Meknes, Morocco
EPG	Eggs per Gram
FAO	Food and Agriculture Organization, United Nations
FD	Full-day
GOI	Government of Indonesia
GTZ	German Aid Development
ha	Hectare
HEM	Hemicellulose
IARC	International Agricultural Research Center
IAV	Institut Agronomique et Veterinaire, Morocco
IBTA	Instituto Boliviano de Technologia Agropecuaria
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICRISTAT	International Crops Research Institute for the Semiarid Tropics
IDRC	International Development Research Centre (Canada)
IEMUT	French Tropical Veterinary Institute
IICA	Interamerican Institute for Cooperation in Agriculture
ILCA	International Livestock Center for Africa, Addis Ababa, Ethiopia
ILRAD	International Laboratory for Research on Animal Diseases
INIAA	Instituto Nacional de Investigaccion Agraria y Agroindustrial, Peru
INI ANSREDEF	Indonesia International Animal Science Research and Development Foundation
ISAPLAAC	Information System on Animal Production in Latin America and the Caribbean, IICA and IDRC
IVDMD	In vitro dry matter disappearance
JCARD	Joint Committee on Agricultural Research and Development
KARI	Kenya Agricultural Research Institute

KDPG	Kenya Dual Purpose Goat
KEVEVAPI	Kenya Veterinarian Vaccine Production Institute
kg	kilogram
Ksh	Kenya Shilling
LDC	Lesser Developed Country
LIG	Lignin
MARDI	Malaysian Agricultural Research and Development Institute
ME	Management Entity
MIAC	MidAmerica International Agricultural Consortium
MOET	Multiple Ovulation and Embryo Transfer
MOU	Memorandum of Understanding
MSS	Multi Spectral Scanner
MUCIA	Midwest Universities Consortium for International Agriculture
N	Nitrogen
NARP	National Agricultural Research Project
NARS	National Agricultural Research System
NCSU	North Carolina State University
NDF	Neutral detergent fiber
NGO	Non-Government Organization
NSDV	Nairobi Sheep Disease Virus
NSF	National Science Foundation
OPC	Ovine pulmonary carcinoma
OvLV	Ovine lentivirus
PAC	Program Advisory Committee
PAR	Photosynthetic Active Radiation
PI	Principal Investigator
PL480	Public Law No. 480
PMSG	Pregnant Mare Serum Gonadotropin
PVO	Public Volunteer Organization

RAPD	Random Amplified Polymorphic DNA
RFP	Request for Proposals
RCNV	Racoon poxvirus
REPAAN	Pastures Andean Network
RERUMEN	Andean Small Ruminant Research Network
RIAP	Research Institute for Animal Production, Bogor, Indonesia
RISPAL	Latin American Network for animal Production Systems Research, IDRC
RS	Resident Scientist
SBPT	Balai Penelitian Ternak, Sei Putih, Indonesia (Animal Husbandry Research Institute)
SEMTA	Servicios Multiples de Technologies Agropiadas
SFM	Sunflower meal
SLJ	San José Llanga, Bolivia
SR-CRSP	Small Ruminant Collaborative Research Support Program
SRNET	Pan-African Small Ruminant Research Network
SRUPNA	Small Ruminant Production Systems Network for Asia
TAMU	Texas A&M University
TC	Technical Committee
TDN	Total digestible nutrients
Techpack	Technology Package
TM	Thematic Mapper

Country	Project	U.S. Principal Investigator	Resident Scientists	International Collaborator
Bolivia	Economics	E. Ospina	M. Cuesta	J. Cespedes
	Range Ecology	B. Norton	J. Queiroz	G. Prieto
	Range Management	F. Bryant	J. Yazman	X. Sandy
	Sociology	C. Valdivia	L. Markowitz	C. Jetté
Indonesia	Animal Nutrition	K. Pond	P. Horne	L. Batubara
	Breeding	E. Bradford	R. Gatenby	Subandriyo
	Economics	H. Knipscheer	A. Mulyadi	S. Karo Karo
Kenya	Animal Health	T. McGuire	F. Rurangirwa	S. Shompole
			P. Rwambo	R. Soi
	Breeding	J. Taylor	J. Kogi	J. Kogi
	Production Systems	W. Getz	P. Semenye	M. Wanyama
	Sociology	M. Nolan	N. Mbabu	D. Sheikh
Latin America	Network	J. Homan	L. Iniguez	R. Peña
				E. Tejada

Technical Committee
1994

Eric Bradford	University of California, Davis
Fred Bryant	Texas Tech University
Edmundo Espinoza	IBTA, Bolivia
James Fitzgerald	USDA Sheep Experiment Station, Idaho
Will R. Getz	Winrock International
Jane Homan	University of Wisconsin, Madison
Travis C. McGuire	Washington State University
Michael F. Nolan	University of Missouri-Columbia
Brien E. Norton	Utah State University
Enrique Ospina/H. Knipscheer	Winrock International
Kevin Pond	North Carolina State University
Jeremy F. Taylor, Chair	Texas A&M University
Open	AARD Indonesia
Open	KARI, Kenya

Administrative Council
1994

Robert C. Albin, Chair	Texas Tech University
Leonard Bull	North Carolina State University
James B. Henson	Washington State University
Earl Kellogg	Winrock International
Carl Menzies	Texas A&M University
Cyrus Ndiritu	KARI, Kenya
Gordon Niswender	Colorado State University
Paul Rasmussen	Utah State University
Jack Rutledge	University of Wisconsin, Madison
Rafael Vera	IBTA, Bolivia
Kenneth C. Schneeberger	University of Missouri-Columbia
Marwan Rangkuti	CRIAS, Indonesia
Robert Shelton	University of California, Davis

External Evaluation Panel
1994

S. Gordon Campbell, Chair	Cornell University
Thadis Box	New Mexico State University
Hudson Glimp	University of Nevada, Reno
Edna McBreen	West Virginia University
Glen Vollmar	University of Nebraska, Lincoln

Management Entity

Montague Demment	Program Director
James W. Scott	Assistant Program Director

Mailing Address
Small Ruminant CRSP
University of California, Davis
Davis, California 95616-8700

Telephone
(916) 752-1721

Fax
(916) 752-7523

E-mail
srcrsp@ucdavis.edu