Small Ruminant Collaborative Support Program (SR-CRSP):

A Summary of Accomplishments and Impacts

1979-1993

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The SR-CRSP in Bolivia: Accomplishments and Impacts (1991-1993)

Summary of Accomplishments

- Interdisciplinary characterization of the Andean Highland resource base as it relates to small ruminant production and larger farming systems.
- Strengthening of Bolivian national agricultural research capacity through the Bolivian Institute for Agricultural Research (IBTA) by contributions to training of local scientists, socio-economic research, interdisciplinary methods, on-farm research and facilities development.

Feed and Nutrition

- **Land use and forage map.** Feed supply and its variation is the major constraint to increasing the productivity of camelids, sheep, and cattle raised in the Andean Highlands (*altiplano*). Through detailed on-ground surveys, aerial photos and satellite imagery analysis, a land use and vegetation map has been produced for San Jose Llanga which describes farm land use, range land vegetation distribution and species composition. This provides a detailed and quantitative characterization of the area's natural resource base, including a distribution of forage productivity and understanding of range land dynamics under changing climatic conditions. As part of the mapping process, trends in the condition and special composition of range land vegetation were revealed through the analysis of time series satellite imagery. Baseline land use and vegetation information will form the basis of a geographic information system (GIS) stratification of production attributes that can be used to assess comparable sites in the altiplano. A quantitative model of the San Jose production system can then be developed to identify the relative importance and interaction of various components in sustaining the system under stressful and favorable conditions.

- **Identification of constraining conditions on farm land.** The quality and quantity of native forage species, and livestock productivity, are severely affected by the following factors: high altitude, limited rainfall conditions with prolonged periods of drought, high radiation and irradiation losses, fragile soils susceptible to erosion, and large short-term temperature variations.

Economics

- **Assessment of resource use.** An assessment of people's means of securing access to primary factors of production (land, labor and animals) has guided research activities oriented towards gender specific analysis of production strategies. Important foci of research have been the conservation of pasture land in relation to total household resources, intra-household decision making and labor allocations, gender specific crop production technologies, interactions between crop-livestock production decisions and potato production.

- **Small ruminant commercialization on the altiplano.** It was revealed that commercial channels for small ruminant products occurs on three different levels. At the San Jose village level milk is the most important animal product sold, along with sheep hides and some cheese. At the provincial markets in Lahuachaca, Patacamaya, and Tablachaca live animals are sold, as are sheep hides which appear to constitute an important part of the trade. A study of the export market found that sheep hides are considered non-traditional exports, and are important cash crops at the local level.

- **A social and environmental history.** The environmental, demographic and institutional history of San Jose Llanga, Bolivia and the surrounding zone has been reconstructed to identify significant episodes of socio-economic and ecological change and their impacts on resource management.

- **Information management system established for socio-economic data.** A unifying data management system for all economic and sociological data has been established with the aim of enabling easy access for other researchers as well as to assure that data is analyzed to its fullest potential.

Training and Institution Building

- **Training.** Twenty six Bolivian students from five Bolivian universities have conducted their senior research theses for their B.S. degrees. Bolivian universities do not offer a Master's degree in agriculture, and several of these students are prospects for M.S. training in the U.S.

- **Strengthening Bolivian scientists' on-farm research capabilities.** The on-farm research approach of the SR-CRSP agropastoral project and its base in an indigenous

community has fostered a greater willingness on the part of Bolivian researchers to include farmers in setting research agendas. This mode of field-based research is directly addressing the concern expressed by many, including those in USAID, that too much agricultural research in Bolivia has been confined to established research stations with few results extended to the nearby campesinos.

- **Nutrition laboratory established.** With leadership and direction from SR-CRSP scientists, unused equipment was used to set up a functional nutrition lab at the Patacamaya research station.

- **Direct contributions to the community of San Jose Llanga.** While the SR-CRSP cannot provide humanitarian assistance, the project's community based research approach has generated direct benefits to the community of San Jose. In addition to informal technical assistance provided by project staff, community income has been increased from the rents and expenditures of scientists and technicians living there. This rental income has financed the construction of a new school in the first year of SR-CRSP work there. Bolivian collaborating institution, IBTA, provided an architect to design the building free of charge.

- **Benefits to the US.** The application of an interdisciplinary systems perspective to US agriculture is less common than it has been in developing countries. The production systems analysis for the agropastoral community in Bolivia will be the companion project funded by the Utah Agricultural Experiment Station to assess the adoption of technological innovation by livestock producers in Utah. The lessons and successes of the Bolivian agropastoral project will have a synergistic influence on this American counterpart and its ability to clarify complex interactions among biological, technical and socio-economic factors. The ultimate goal is a greater understanding of the reasons that specific technical innovations of great potential for improving productivity may or may not be adopted by farmers. Not only does the SR-CRSP systems approach in Bolivia have direct application to the livestock industry of the U.S. high plains inter-mountain states, but the program is developing forage seed markets for U.S. exports. Finally, the SR-CRSP is an important component of USAID's objective in Bolivia and therefore plays a potentially important role in the coming liberalization of economic relations between North and South America in the wake of the North American Free Trade Agreement (NAFTA).

The SR-CRSP in Brazil: Accomplishments and Impacts (1979-1987)

Summary of Accomplishments

- Joint collaborative research critical to the establishment of the Brazilian National Goat Research Center (CNPC), including development of human, scientific and laboratory resources.
- A multidisciplinary applied research approach produced a substantial amount of technologies and management practices for hair sheep and goats raised under semiarid conditions and applied in the so called drought polygon, considered one of the poorest regions of the world. Goats in the drier areas of Northeast Brazil comprise a large share of grazing animals, and represent 89.8 percent of the overall Brazilian goat population.
- Formal training of graduate students from the U.S., Brazil, and other developing countries.

Management

- **Importance of small ruminants.** In the overall production system in the semiarid Northeast Brazil, small ruminants provide not only meat and milk, even during the recurrent droughts which frequently hit the region, but they represent an immediate source of cash that the poor rural population may use to buy other subsistence food crops.

- **Meat production from goats and hair sheep.** Sheep were found to be better meat producers than goats except under complete browsing conditions. Goats appeared to produce milk more efficiently than cattle where browse (*caatinga)* was the primary feed source. Studies have shown a response to energy (molasses) and protein (urea and natural proteins) for lactating goats grazing *caatinga.* The percentage of goats increases as a part of the total livestock mix during dry periods. These results suggest approaches to species of choice under arid conditions.

- **Sheep productivity in Brazil.** Small or medium sized ewes with higher lambing rates are more efficient producers under Brazilian conditions than larger types of sheep. Utilization of this information by producers in Brazil and in similar environments would result in a significant contribution to meat production.

- **On farm technology trials.** These studies tested improved small ruminant technologies using regular research field hearings in which farmers participated jointly in selecting the technologies they were to receive.

- **Improved production parameters.** Even though there are several variables involved in the process of improving livestock production in any part of the world, generation and transfer of technology unquestionably play a major role in the process. The amount of information resultant of the cooperative efforts of CNPC and SR-CRSP have surely had an impact on the overall small ruminant production, even though this influence cannot be precisely measured. Some production parameters pre and post SR-CRSP activities in Northeast Brazil are shown below. The data demonstrate increases in terms of goat and sheep populations, as well as increases in off take and carcass weight, principally for goats. Those figures may be linked to research results and transfer of technology during SR-CRSP's presence in Brazil..

Selected comparative production parameters for small ruminants in Brazil.

Parameters	Year		
	1979 (A)	1989 (B)	Change (%)
Flock population (1,000 head)			
Sheep (Northeast)	6,117	7,577	23.9
Sheep (R. G. do Sul)	10,851	10,846	0
Sheep (Brazil)	17,806	20,041	12.6
Goats (Northeast)	7,429	10,477	41.0
Goats (Paraná)	181	273	50.8
Goats (Brazil)	8,070	11,669	44.6
Slaughters (1,000 head) [1]			
Sheep (Brazil)	730	871	19.3
Goats (Brazil)	368	773	100.5
Off take (%)			
Sheep (Brazil)	4.1	4.3	4.9
Goats (Brazil)	4.6	6.6	43.5
Carcass weight (kg)			
Sheep (Brazil)	13.67	14.04	2.7
Goats (Brazil)	12.80	14.04	9.7

[1]Data from official slaughterhouses. It is estimated that those numbers represent only 20-25% of the animals actually slaughtered.

Source: *Anuário Estatístico do Brasil*, 1980; 1991

- **Local breeds characterized.** In general, goats as well as sheep are described as "Sem Raça Definida" or "Crioulo." However, there are some local types or breeds in the region. These include "Moxotó," "Marota," "Canindé," and "Repartida" for goats, while "Morada Nova," "Santa Inés," and "Somalis" are the hair sheep breeds more commonly found.

Feed and Nutrition

- **Demonstration that the use of *caatinga* forest in the Sertáo region of northeast Brazil could be an economically effective and sustainable enterprise for both animal and wood production.** By selectively harvesting certain species, ages, and growth forms of trees (rather than wholesale clearing), commercially valuable trees could be left in the stand to reach the size and age of maximum economic value with virtually no reduction, and perhaps even an increase, in forage potential for small ruminants.

- **Discovery that *caatinga* forest in Brazil has a rapid speed of recovery and high potential sustainability.** Virtually all trees and shrubs in this ecosystem possess the capacity for regenerating from dormant buds in the stump after cutting the adult plant. Further, seedlings of the important forage and timber species *sabia* were increased greatly. If protected from grazing for one growing season, *sabia* becomes well established in the forest plant community.

- **Establishment of the importance of several native tree and shrub species as valuable forage plants for sheep and goats.** For example, *sabia* produces a nutritious foliage that animals prefer either as green browse or as dry leaf litter. Research established the potential importance of coppice in the year-round forage balance for sheep and goats, and introduced the possibility of "coppice management" as a new principle in small ruminant production systems worldwide.

- **Goats as a "living bank account."** It was learned that farmers in northeast Brazil use goats mainly as "living bank account" and more of a form of drought insurance than as a market commodity. Goats, contrasted with cattle and sheep, provide a reasonably dependable animal resource that contributes to economic stability in an inherently variable and unpredictable environment. Money invested in goats will not depreciate with inflation, and goats require little maintenance expense. Goats, with high probability of surviving the extended droughts that often

grip the Sertáo region, can be used as an economic base to restock properties with cattle and sheep, the preferred animal species.

- **Development of a test in Brazil for identifying immune response to the bacterium that causes caseous lymphadenitis, a worldwide disease of sheep and goats.** The test then was used to help assess the immune response of goats vaccinated with an experimental toxoid vaccine, first experimentally and then later in naturally infected herds in Brazil. It also was demonstrated that transmission of internal parasites occurred primarily in the latter part of the wet season and the early part of the dry season.

- **Demonstration that forage production and goat nutrition in Brazil's semi-arid forest regions was enhanced through vegetal manipulation.** Thinning tree canopies resulted in significantly more production of forage biomass beneath the trees. A partial clearing of the canopy was just as effective as complete clearing. Increases of up to 600% in herbaceous vegetation on the ground were obtained by totally clearing the tree canopy.

- **Major nutritional constraint for small ruminants.** It was learned that the major nutritional constraint in Brazil was digestible energy from mid-September through December. Dietary protein was adequate to only marginally deficient. The energy deficit was resolved partly by careful timing of tree cutting thereby promoting growth of new coppice shoots arising from the stump. The subsequent browsing of forbs and coppice shoots by goats allows regulation of the amount and nutritive value of browse during the early to mid-dry season.

Institution Building

- **Initial collaborator of the Brazilian National Goat Research Center (CNPC).** The Brazilian Enterprise of Agricultural Research (EMBRAPA) was created by the Brazilian government in 1973, with the mission to generate and/or adopt adequate technologies for the agricultural development of Brazil. In 1975, EMBRAPA's executive board decided to create the Brazilian National Goat Research Center (CNPC) located in the Northeastern state of Ceará, in the town of Sobral. A young team of Brazilian scientists was then assigned to the new station with the mission to launch a strong research program and to build up the laboratory facilities. The identification of research partners to work in a cooperative fashion was facilitated when the Small Ruminant Collaborative Research Support Program was the first CRSP launched under the Title XII act. The beginning of a new research institution staffed by young and enthusiastic scientists was the key ingredient to start a mutually beneficial research joint venture.

- **Laboratory building.** In some cases, up to 20-25% of basic laboratory equipment was made possible through this partnership in a short period of time.

Training

- **Formal training.** This can be described as the most lasting influence of the SR-CRSP program in Brazil . Due to this, several Brazilians, Americans and other nations' graduate students were trained either in Brazil or in the U.S., utilizing data generated by this collaborative work. These well-trained professionals are now engaged in small ruminant research and related activities, and they are helping to multiply the body of knowledge actually available on those species.

Information Dissemination and Networking

- **International conferences.** A state of the art workshop involving Brazilian and U.S. counterparts was held in April 1986 at the CNPC. This included over forty presentations and a proceedings in English and Portuguese. In March 1987, CNPC/SR-CRSP results and recommendations were directly impressed upon a worldwide audience at the IV International Conference on Goats held in Brasilia. Over 651 goat specialists from 45 countries attended and SR-CRSP personnel figured prominently, delivering 18 of the invited papers and distributing 68 abstracts.

• **Publications.** New technologies and management practices were developed and transferred to producers through papers published either in Brazil or in the United States, in English as well as in Portuguese. These included two books, 30 chapters, 13 Masters theses, 15 Ph.D. dissertations, 79 scientific papers, 18 short courses, 95 abstracts, 85 technical communications. SR-CRSP research, findings and recommendations are summarized and disseminated via two books: "Improving Meat Goat Production in the Semi-arid Tropics" and "Hair Sheep Production in Tropical and Sub-tropical Regions."

The SR-CRSP in Indonesia: Accomplishments and Impacts (1980-1993)

Summary of Accomplishments

- Economic supplementation of small ruminant feed resources using locally available agricultural by-products.
- Developed nutrient requirements of Indonesian sheep and goats and identified forages appropriate for rubber plantations.
- Developed the technologies to enhance small ruminant production in villages;
- Trained scientists to improve research capabilities.
- Integrated sheep into rubber plantations benefiting the environment and farmers by reducing use of herbicides and increasing small holder incomes through relieving pressure on over-tapping and tree destruction.

outputs

actual impacts

Animal Breeding

- **Determined the mode of inheritance of prolificacy in Javanese sheep.** The mode of inheritance of prolificacy, breed characterization and estimation of production potential of Javanese sheep through on-station research on Javanese Thin-tail (JTT) and Fat-tail (JFT) sheep has been established. This breed is capable of reproducing year-round with high levels of prolificacy. Scientists determined that the prolificacy of Javanese sheep is affected by a major gene for which each incidence increases litter size by about 0.75 lambs. Determination of the mode of inheritance of prolificacy in Javanese sheep defines the basis for the development of breeding stock with optimal levels of prolificacy for a range of environments, and it contributes directly towards meeting the challenges imposed by the research goal of further intensifying an already intensive production system. This strategy complements new production schemes and specialized farms on Java which are beginning to raise weaned lambs or feedlot animals for market. The characterization and identification of valuable genetic material has direct implications for sheep production throughout the humid tropics. "The importation of the St. Croix breed into North Sumatra by the SR-CRSP will ultimately prove to be a major contribution to the sheep industry of Indonesia. This breed is clearly superior to any other breed in Indonesia in terms of lamb growth and pounds of lamb weaned per ewe." (External Evaluation Panel Report, 1993)

- **Sheep lines with known prolificacy.** These have been developed using knowledge of the mode of inheritance of prolificacy in Javanese sheep.

- **Sumatra sheep raised under rubber plantations.** Lambing and weaning data showed that Sumatra sheep possess exceptional potential for accelerated lambing in rubber plantation systems in humid tropical conditions. Sumatra sheep achieved 1.82 lambings per production year, and weaned 2.2 lambs per year weighing 21 kg per 22 kg ewe.

- **A new strain of productive hair sheep for the hot humid tropics.** A productive strain of hair sheep with superior genetic potential for resistance or tolerance to internal parasites was developed. This breed is well adapted to the climate and feed resources of the humid and sub-humid tropics and to a variety of management systems. Development of a productive strain of hair sheep in North Sumatra was initiated in 1986 when St. Croix sheep were imported from the Virgin Islands, USA. Woolless JTT were introduced from East Java, and Barbados Blackbelly imported from Barbados. In addition, a 50% hair sheep composite population is being produced. The crossbred ewes produced about 47% greater weight of lambs weaned (22.4 kg/yr) than Sumatra ewes (15.2 kg/yr). Productivity per unit weight of ewe and productivity per unit metabolic weight of ewe were 13 and 20% higher than for Sumatra ewes, respectively. There seem to be no disadvantages associated with crossbred sheep, and the crossbred of St. Croix with Sumatra sheep can be distributed in wider scale.

Feeding and Nutrition

- **Feeding technologies to overcome nutritional constraints due to shortage of high quality feed and land devoted to feed production.** An assessment of the feed used by small farmers in three locations in West Java revealed that feed mainly consists of native grasses, with some proportion of herbs, shrubs, tree legumes or other agricultural by-products. The amount of feed offered to animals depended on the season and the location, but was generally adequate. Crude protein levels of West Javanese village diets for small ruminants were adequate, but digestible energy intake was limiting. Supplementation with cassava leaves, tree legumes such as *Gliricidia, Sesbania, Leucaena,* and with concentrate supplements including rice bran, coconut meal, tofu waste, cottonseed, palm kernel cake, broken rice, molasses, rubber seed, and mixed concentrates improved feed intakes and increased growth by 50-100 grams/head/day.

- **Computerized database.** This includes composition of feedstuffs utilized in all of the nutrition feeding studies in three locations in West Java. The database is being maintained at the Research Institute for Animal Production (RIAP), Bogor.

- **Protein and energy requirements of growing sheep and goats.** This information, for animals less than 20 kg weight, has been estimated and published for use in Indonesia. Nutrient requirements and productivity responses of pregnant and lactating ewes/does to dietary treatment and on strategic supplementation of prolific sheep have also been determined.

- **Improvements in basal forage resource for sheep in villages and on large plantations.** Shaded forage decreases in quantity with tree growth. Forage quality declines as grasses under shade become dominant. Shade tolerant forages with potential to triple productivity during the first five to seven years of a plantation have been evaluated. Promising species have been identified and carried forward into larger scale trials to assess their persistence and yield when grazed or cut. Tree legumes and locally available by-products of agriculture and plantations are being evaluated as potential feed supplements.

- **Species evaluation of forage trees.** SR-CRSP has collaborated on the evaluation of forage tree species with the Nitrogen Fixing Tree Association (NFTA), the International Centre for Research in Agroforestry (ICRAF), the Indonesian Biotechnology Research Institute, International Center for Tropical Agriculture (CIAT), and the Australian Center for International Agricultural Research (ACIAR).

Socio-Economics

- **Sheep grazing in rubber plantations.** The development of sustainable and economically workable techniques for integrating of sheep grazing with rubber plantations can help to reduce environmental contamination by herbicide, saving nationally approximately U.S. $51 million per year. Approximately ten sheep can control weeds in one hectare of rubber plantation, reducing the labor needed for weeding by 18-31%. Small farmers raising sheep have an average 33% higher profit and return for labor–almost three times higher than those without sheep. Increasing small holder incomes can reduce pressure for over-tapping of rubber trees and subsequent tree destruction.

data & calculations ?

- **Economics of commercial systems.** Considerable variation in economic returns per animal unit were found in the local commercial system, however the system was highly profitable because of high rates of compensatory gain made by small ruminants purchased from villages and because of a regular and low cost protein feed supply.

- **Economics of feed supplementation.** Small amounts of cheap feed supplements provided over the critical lambing period were found to have more economic benefits than general supplementation. Using cheap available supplementary feeds for a few weeks after lambing will yield a 40% increase in productivity and a more than 200% gain in net benefit.

- **Profile of the small ruminant marketing system .** In West Java and North Sumatra, the marketing system has been characterized as to the participants are, the general marketing channel, and how prices are formed. The middleman is present in most small ruminant market transactions as a broker or village collector with farmers selling mostly to brokers and village collectors (67-90%). Only a small portion (10-33%) of livestock are sold directly in livestock markets by farmers. Animals sold in local markets are bought by local farmers as stock replacements or for fattening, and the rest supply the provincial and regional needs for slaughter. Among the economic reasons choosing to sell to local brokers and village collectors over other buyers are high transportation costs and the risk of not selling the animal at all or accepting an even lower price.

- **Central role of the village collector.** The village collector's role in the small ruminant marketing system in Java was a key finding. A stable relationship seems to exist between trader and farmer, which is characterized by a traditional market system with cash/credit payment. A similar system was found in Aceh, but in North Sumatra no credit system seems to exist between producer and trader. The selling price generally is set by the middlemen at the time of selling based on exterior looks, live weight, and age. This price is accepted as fair by indicating the farmer's relatively weaker bargaining position and poor knowledge of pricing.

- **Role of women.** While the importance of small ruminants among farmers is clearly exemplified by the central role of male heads of household in making nearly all the major management decisions, women play a central role in the farm enterprise. Sociological studies indicated that husbands and wives have very different perceptions of the wife's participation in the management of sheep and goats. Men engage in small ruminant activities more frequently than do women, although women realize the economic value of small ruminants and contribute

an average of 1.8 hours per day in their raising. Women assume males' work if the latter cannot perform such activities, and they can contribute up to 40% of total labor input.

Animal Health and Management

- **Parasitic constraints to sheep production in plantations.** Gastro-intestinal worms and pancreatic fluke were identified as the most serious constraints to production of sheep in rubber plantation. While gastro-intestinal worms have demonstrated no resistance to anthelmentic drugs - which have demonstrated large economical benefits - an effort has been made to avoid reliance solely on the use of the drugs for control. Based on SR-CRSP research in North Sumatra showing that three months after grazing the pasture is free of all larvae, a system of grazing management has been introduced in which the sheep are given anthelmintic every three months then moved to pasture which has been fallow for three months. Some animals appear to have genetic resistance to worms.

- **Existence of the pancreatic fluke (*Eurytrema pancreaticum*) first recorded in Indonesia.** First identified in 1985 by SR-CRSP, little is known about the biology of this fluke in contrast to gastro-intestinal worms. The fluke has two intermediate hosts, land snails and grasshoppers and almost all sheep are infected with *E. pancreaticum*.. Three potential drugs, nitroxynil, praziquantel, and albendazole have been tested but none reduced infections to negligible levels. More frequent doses of the drugs or higher dose rates may be more effective but would almost certainly not give an economic response.

- **On-farm research and development of technology packages.** The successful testing and adoption of technology packages introduced to farmers on farms via the Outreach Pilot Project (OPP) in Bogor (1984-1990) and the Outreach Research Project (ORP) in Sungai Putih since 1988. The objectives of the OPP and ORP are to establish a dialogue with groups of farmers and developing appropriate small ruminant management and technologies, and evaluate crossbred sheep in integrated tree cropping and sheep production systems. These new technologies increase farmer incomes from small ruminant production.

  A marked impact on flock productivity has been achieved through the OPP with an emphasis on shortening lambing interval, reducing lamb mortality, increasing weaning weights, improving marketing information for farmers, improving feeding management, and improving barn design. Instead of lambing once-a-year, now farmers can achieve three lambings in two

where is writeup

years, a net annual increase of 50%. Additionally, pre-weaning mortality has been reduced from 27% to less than 12%. This means that more lambs are weaned per ewe and farmers' income is improved.

Since the completion of the OPP in October 1990, new research to strengthen the already intensive production system has been conducted in four villages of Bogor district. This on-farm research effort tests the feasibility of changing the traditional small-scale system of raising small ruminants to a system that will provide substantial income to farmers evenly distributed throughout the year. This effort is known as the Village Intensive Production Scheme (VIPS). The concept of VIPS is an integrative one. It integrates available information about biological and economic variables into a management package for intensive production. The long-term aim of VIP is to boost the capability of local production to supply domestic and external demand while improving farm income. In the ORP in North Sumatra similar achievements were quantified. Growth rates of pre-weaning sheep raised by ORP farmers averaged 79 g/d; pre-weaning mortality was relatively low (8%), and lambing interval was only 217 days on average. The ORP farmers started with only four ewes, and flock size has increased over the years. The increases in productivity level and farmer incomes.

Training and Institution Building

- **Training.** SR-CRSP has played a central role in the development of research capabilities of government institutional staff through training and collaborative research. Short or long-term training has been provided in Indonesia, U.S., and other countries with either full supported from SR-CRSP or funded in collaboration with the National Agricultural Research II project which is funded by the World Bank and managed by Winrock International. Over ten years, SR-CRSP has fully supported six people to pursue B.S. degrees, five people to pursue M.S. degrees, and three people to pursue Ph.D. degrees in Indonesia. SR-CRSP has fully supported six people for M.S. degrees and three people for Ph.D. degrees in U.S. universities. Additionally, one person is supported for a Ph.D. degree in the Philippines. Approximately eight people have been supported partially by SR-CRSP in Indonesia or in the U.S. toward advanced degrees. Partial support includes placement, use of data collected by SR-CRSP, and funding of research. Short-term, non-degree technical training either in Indonesia, U.S., or a third country has been provided to scientists and technicians, and scientists have been supported to attend national or international conferences. Many Indonesian scientists trained through the SR-CRSP now hold important positions in government institutions.

- **Development of Indonesia research capacity.** "The project is clearly supported by the Indonesian research community as important to their future development plans." (External Evaluation Report, 1993) Collaborative work between SR-CRSP and Indonesian scientists to identify the economic potential for improvement of small ruminant production systems and develop technology packages to improve the income-generating capacity of rural families has been recognized by the Indonesian government. Small ruminants are now used as a major component of technological packages for the Upland Agriculture and Conservation Project in Central and East Java, and the "Banpres" (Presidential Aid) program provides sheep for farmers. An increased willingness by producers to pursue information related to agribusiness in small ruminants has also been witnessed. This is especially crucial given the challenges facing Indonesia in capitalizing on small ruminant export opportunities to middle-eastern countries. Commercial sheep and goat breeding is starting and an Open Nucleus Breeding Scheme in East Java is now getting support from the Food and Agricultural Organization (FAO).

Information Dissemination and Networking

- **Publications.** SR-CRSP has published more than 140 papers describing research findings in Indonesian and international journals.

- **Sheep and goat production handbook.** "A Collection of Training Materials Within the Framework of Goat and Sheep Research in the Village" has been published by SR-CRSP in Indonesia. Written for farmers and extension personnel using pictures and limited text, the handbook was produced in Indonesian, Sundanese, Javanese, and English language editions.

- **Publication on small ruminant research in the tropics.** "New Technologies for Small Ruminant Production in Indonesia" has been published. This publication presents a summary of many findings of research on small ruminants in the tropics, and it provides a valuable source of information for other researchers as well as agribusiness enterprises.

- **International workshops.** Two international workshops have been supported by the SR-CRSP in collaboration with international donor agencies and the host country. The first workshop entitled "Small Ruminant Production Systems in South and Southeast Asia" was co-sponsored by International Development Research Centre (IDRC), SR-CRSP, and AARD. This workshop was held in Bogor, 6-10 October, 1986 with a proceedings published as Proceeding Series of IDRC-256e. The second international workshop entitled "Integrated Tree Cropping and Small Ruminant Production System" was co-sponsored by SR-CRSP, AARD, and IDRC. This workshop was held in Medan, North Sumatra, on September 9-14, 1990.

- **Small grants program.** Initiated in 1991, the program made ten grants to recipients throughout Indonesia in 1991 with an additional nine in 1993. The small grants have enabled Indonesian scientists in locations other than West Java and North Sumatra to undertake research into sheep and goat production.

- **The Indonesian Small Ruminant Network (ISRN).** Launched in 1989, the ISRN now is part of the Coordinating Research Institute for Animal Science (CRIAS) and SR-CRSP. With direct financial support from SR-CRSP Management Entity, this communication effort has: published an inventory of human resources and centers involved in production, education, research, and development of small ruminants; established a literature database; supported events of national interest such as a workshops on Production Aspects of Javanese Fat-Tail Sheep, traditional veterinary medicine for small ruminants in Java, role and potential of small ruminants in Eastern Indonesia, and research and development of goats in Eastern Indonesia; and published a biannual newsletter.

- **The Small Ruminant Production System Network for Asia (SRUPNA).** The SR-CRSP Management Entity partially supports SRUPNA, as does Canada's International Development Research Centre (IDRC). The coordinating unit of SRUPNA is located in Bogor, Indonesia.

- **Recognition of small ruminants in agricultural development.** Ten years of small ruminant technologies and networking in Indonesia generated by the SR-CRSP has played a direct role in the increased attention paid by government, donor agency and private sectors to the importance of small ruminant production to small farmers and their role in the local and national economy.

- **Government investment in sheep production.** Indonesian government plantations have started investing in sheep production units as part of their mandated 5% expenditures on social development using advice and technology from the SR-CRSP. As part of the government-sponsored transmigration program, the government has started buying sheep and establishing sheep husbandry for small holder farmers.

The SR-CRSP in Kenya: Accomplishments (1980-1993)

Summary of Accomplishments

- Significant training program in SR-CRSP projects.
- Important programs of development of physical facilities for research.
- Development of the Kenya Dual Purpose Goat (KDPG).
- Development of vaccines and diagnostic tools.
- Development of appropriate technology packages for KDPG production under small holder management systems.
- Pioneering role of institutionalizing multidisciplinary research and on-farm trials in applied agricultural research.

Breeding

- **The development of a synthetic breed of Kenyan dual-purpose goat (KDPG).** To meet the requirements of small-scale farm families, a dual-purpose goat, composed of equal proportions of two local goats and two exotic dairy breeds, has been developed. The KDPG possesses acceptable milk yield, a fast growth rate, high fertility, and is highly adaptable to the various agro-ecological zones of small-holder farms. The KDPG can also be bred and adapted to low-production potential areas by varying the proportions of exotic and local genes. Introduction of KDPGs and improved forage production practices has resulted in a 66% increase in food yield from goats for small holder families. Each DPG generates an average of US$52 additional income per hectare. Assuming that only about 10% of the humid and subhumid zone in Kenya would be available for food crops and fallow, the potential annual benefits to farmers would amount to $2,500,000.

- **Over 50,000 people have been directly exposed to the KDPG technology package.** On-farm research activities among 150 small-holder farmers in western Kenya leave farmers well acquainted with the dual purpose goat technology. In collaboration with the breeding project, nucleus KDPG herds have been established at Bukura Institute of Agriculture, Lumigo Women Group, Government Prison farm at Kibos, and Siaya Livestock Multiplication Center. Furthermore, in collaboration with the Ministry of Agriculture, Livestock Development and Marketing, the program has conducted field days. KDPGs and the supporting management package has been exhibited at the Nairobi International Show

annually and at the local agricultural shows since 1985. Given the importance of small-holder agricultural production systems are in Kenya, and the prevalence of small-ruminant stock among this sector of farmers, the dissemination of the SR-CRSP KDPG technology has far-reaching effects on Kenyan agriculture.

- **Established and maintains a nucleus flock for upgrading goats to the synthetic KDPG.** The breeding project has provided F1 crosses for on-farm trials in western Kenya. A total of 206 KDPGs (F1 proxies) have been transferred to the Maseno farm since 1986. Some of these goats were distributed among the 150 small-holder farmers who participated in on-farm trials in western Kenya. Other goats remain on-station for controlled experiments in nutritional requirements. Having developed and tested the KDPG technology package on farms in western Kenya, plans are underway to conduct similar on-farm trials in other ecological zones of Kenya.

Feed and Nutrition

- **The development and preservation of suitable feed resources for small ruminant livestock under small-holder farmer management in Kenya.** Accomplishments include:
    - screening forage crops from various parts of Kenya and other tropical countries to determine their suitability for western Kenya conditions;
    - determination of production and utilization potentials of *Sesbania sesban* as a forage for small-ruminants;
    - selection of sweet potato cultivars best suited for fodder and food production;
    - development of appropriate silage and hay baling techniques for resource poor farmers;
    - evaluation of one fertilizer value of goat manure for food and feed crops under small-holder conditions.

- **Improved nutrition and management of small ruminants in small-holder production systems.** Accomplishments include:
    - conducted palatability ranking and nutritive analysis of commonly used forages in western Kenya;
    - quantification of feed resources available for livestock throughout the year;
    - evaluation of the effect of wilting grass on helminth larvae infestation and dry matter intake among KDPGs;

- development of appropriate nursing regimes for KDPGs;
- refinement of appropriated tethering management techniques .

Animal Health

- **Development of highly sensitive and specific reagents for detection of animals infected with contagious caprine pleuropneumonia (CCPP), heartwater, and anaplasmosis.** The disease detection techniques include: a rapid diagnostic kit for CCPP using purified antigens; a monoclonal antibody highly specific for F38, the mycoplasma that causes CCPP; a DNA probe for detecting *Cowdria ruminantium* in ticks and infected goats; and a DNA probe for detection of *Anaplasma ovis* in goats in Kenya. These highly specific and sensitive diagnostic reagents allow for the unequivocal identification and characterization of highly infectious agents of small ruminants worldwide. A number of these products have the potential for use in many parts of the world, including the U.S.

- **Disease control methods for the safe introduction of goats into Kenya and more healthy flock management.** Using the animal health facilities developed at Kenya Agricultural Research Institute (KARI) in collaboration with the SR-CRSP, disease control methods for caprine arthritis encephalitis virus in goats imported to Kenya has been devised. Selected studies have identified management practices that allow the introduction of goats to areas infested with trypanosomiasis and into areas that require feed supplementation with selenium.

- **Identification and control of caprine arthritis encephalitis viral infection in Kenya, Peru, and other parts of the world.** It was determined that viral transmission of this disease occurs through colostrum and milk, and methods were developed to prevent its spread. These control methods are important for the United States, where about 80% of dairy goats are affected. The control of this disease represents a US$20,000,000 savings for goat producers worldwide.

- **Animal health research in Kenya at the forefront of conventional and contemporary strategies for vaccine development.** A new vaccine against contagious caprine pleuropneumonia (CCPP) in Kenya has been developed and shown to be efficacious in on-farm trials. This epidemic disease affects at least 48,000,000 goats in Africa and Asia and, if untreated, has a mortality rate greater than 80%. This vaccine has an extended shelf life and

when properly used at the recommended regimen, is highly effective. The vaccine is safe, easily stored, economical to produce, and highly efficacious. If this vaccine were available widely it would prevent an average of 82 annual local outbreaks involving an estimated 300,000 goats in Kenya alone. One million doses have been produced already and vaccine production has been fully transferred to the Kenya Veterinarian Vaccine Production Institute.

- **A multivalent virus-vectored vaccine for small ruminants using the sheep and goat pox virus as the carrier.** Such vaccines will be endowed with the thermostability of the pox virus thus eliminating the need for a cold-chain which is costly and difficult to maintain in developing country settings. In collaboration with ILRAD, a recombinant capripox virus has been developed carrying the Rift valley fever virus (RVFV) gene that encodes for antigens important in protection against infection with RVFV. The protective efficacy of this recombinant vaccine will be tested in animals under a controlled environment. Similar work on Nairobi sheep disease virus is underway with a complementary deoxyribonucleic acid (cDNA) library having been constructed to identify the genes relevant for incorporation into a capripox virus vector. In addition, collaborative research with U.S. universities has led to the isolation of ovine lentivirus and demonstrated that it is economically important in wool sheep production in parts of Kenya.

- **KDPGs resistance to the stomach worm, *Haemonchus contortus*.** It has been demonstrated in the early generations of the composite dual purpose goat population in Kenya that some individual animals display more tolerance to the common stomach worm, *Haemonchus contortus,* which is a worldwide problem in both sheep and goats. This research has been carried out in cooperation with researchers from the University of Nairobi.

Sociology

- **A baseline survey conducted to identify the role of the goat in the farming systems of western Kenya.** In general, the study indicated that farmers were familiar with the goat, but that it was neither a preferred source of meat, as compared with sheep, nor a conspicuous source of milk. However, it was recognized that food habits are never constant. Thus, given the population pressure in the study area, it was hypothesized that the cow would slowly be phased out and market studies showed that alternative sources of milk would be acceptable and welcome. The KDPG was considered an invaluable alternative for the study area.

- **An historical study of the character of the agrarian social structure and the circumstances of regional integration into the national political economy.** The findings of this study indicated that little capital investment has been made in the study area over time, and thus the agrarian social structure has not consolidated itself adequately to influence agricultural policy in their favor. Under these circumstances, the agricultural sector has not been able to retain labor in the region, hence the historical male out-migration from the region. As a result, women farmers have been a focus of SR-CRSP research and should be targeted by future research and extension.

- **Assessment of the capacity and capability of the existing agricultural extension system to deliver newly developed SR-CRSP technology.** This indicated that extension officer awareness in the study area was scanty. In addition to being hampered by significant logistical problems, many of the extension service's staff were not familiar with dairy goats. In recognition of this problem, SR-CRSP developed an approach that was as "user friendly" as possible. Local extension staff in the project area was involved in program outreach activities through farmers' workshops, field days and other learning fora to familiarize them with the emerging technology.

- **Study of dietary patterns .** This study of farm families participating in the KDPG program highlighted the specific role that milk played in nourishment. Findings revealed that for all households surveyed, milk was the major source of dietary protein. For example, in the Hamisi cluster, milk was found to be the only source of animal protein consumed on 50% of the survey days based on 24-hour dietary recall. Many households were found to purchase Kenya Creameries Cooperative milk to meet these needs. In this context, the importance of goats as a source of milk and the KDPGs potential role in the nutrition of communities in the project area was clearly demonstrated.

- **Anticipated and evaluated potential labor shortage constraints to the adoption and management of the KDPG by small-holder farmers.** This concern arose from several factors identified in the study area including the intensive management techniques recommended for the KDPG; the out migration men from the area in pursuit of wage labor; and the absence of school-going children from on-farm activities. Labor requirements for livestock rearing and for the KDPG in particular indicated that, in addition to an increase in the overall labor requirements for livestock, the adoption of intensive management techniques required by KDPG increased women's share of work. In the existing situation

however, women still retained reasonable amounts of leisure time, part of which was allocated to KDPG management if they attributed were assured of its value.

- **Evaluation studies of KDPG viability and the supporting production package in western Kenya.** Findings indicate that the KDPG technology and production package are particularly attractive to farmers in the higher elevation sites, areas of intense population pressure and reliable rainfall. In the lower elevation areas, where average household farm sizes are still large and rainfall more scarce, the technology packages have been received very reluctantly. This finding suggests current KDPG technologies are most likely to be accepted in areas where intensification of agriculture is already underway or is a viable proposition. Also, given the current production figures, the KDPG may be acceptable in areas where farmers are not particularly commoditized. ?

- **Follow-up study to withdrawal of SR-CRSP support in the study area.** While recommended small ruminant production practices were retained in high altitude areas, the KDPG itself appears to have been retained more in lower elevation areas. This double-edged finding supports pilot trials for the KDPG package in both humid and dry-land farming areas. In this spirit, KARI in collaboration with the SR-CRSP is establishing two new sites for the KDPG introduction in Kenya: a dry-land farming setting in Katumani and a humid coastal environment at Mtwapa centers. In both sites, the socio-economics project will assess the viability of the KDPG, its production systems and health intervention strategies.

- **Study to identify constraints to production and delivery of the Contagious Caprine Pleuropneumonia (CCPP) vaccine.** Although the CCPP vaccine has been available since 1987, it has seen limited integration into the disease prevention and control system, indicating shortfalls in the production process. This is attributed partially to the relatively low value given to small ruminant production, as compared to cattle production in Kenya. IMPORTANT Studies are planned to assess the socio-economic value of small ruminants at both the macro and micro levels in Kenya to inform policy makers and address this apparent policy bias. With regard to distribution of the vaccine, the findings indicate that certain endemic areas are not receiving enough of the vaccine, even when outbreaks are reported. Problems in vaccine production and distribution emanate from the complex institutional arrangements and authorities involved in vaccine research, production, and delivery. The involved institutions have collaborated to streamline vaccine production and delivery, and production technology has been transferred to the Kenyan Veterinary Vaccine Production Insitute.

Economics

- **Assessment of the KDPG technology's economic viability.** This challenge was met using methodologies such as partial budgeting analysis, enterprise budgets, gross margin analysis, and whole farm modeling.

- **An economic analysis of forage production.** Forage production strategies developed to support KDPG production in small-holder farm situations yielded the following, directly applicable, recommendations :
    - Always inter-crop maize with forages or dual-purpose crops.
    - Farmers who do not use fertilizers should inter-crop maize with leguminous forages such as sesbania or pigeon peas.
    - Maize-Sudan grass and pigeon pea inter-crops should be used by farmers who apply fertilizer.

- **Economic analysis of kid feeding practices.** This analysis resulted in the following findings:
    - When a forage supplement is not available, feeding only the dam's milk generates the highest economic returns.
    - When forage supplement is available, feeding one-half of the doe's milk is the superior practice.
    - Feeding kids with one-half the doe's milk provides the second best return.

- **Linear programming models evaluated the economic feasibility of the KDPG technologies and assessed its impacts on existing farming systems.** Considering small-holder farmers in western Kenya, this analysis concluded that the most profitable food-forage associations included: maize, beans, pigeon peas, and maize intercropped with sudan grass. The model assumed that all male kids and females not retained as flock replacements would be sold in order to maximize farm cash income. In order to sustain the high management levels required to make the KDPG enterprise profitable, credit facilities were considered necessary.

- **Determination of adoption rates of the various elements of the recommended KDPG technology using a multinomial logit model.** The results of this analysis indicated that adoption rates were higher for the elements of the technology packages requiring low capital investment and/or low human capital. This finding corroborates the previous study which

underscored the need for credit facilities if the high management levels required to make the KDPG enterprise profitable were to be attained.

Training and Institution Building

- **All SR-CRSP projects have incorporated significant training programs for Kenyan scientists - and provided training to local and foreign students.** The SR-CRSP Kenya program has supported two KARI research officers for B.S. degrees, eighteen for M.S. degrees and six for Ph.D. studies. Currently, there are three researchers in M.S. and three in Ph.D. programs, respectively. All the scientists trained in this program are involved in gainful research and one M.S. graduate is not working for UNESCO in Kenya. In addition, two KARI officers have had their field work supported for M.S. theses. One such student supported through the economics project is currently engaged in strengthening the socio-economics research program at KARI. In collaboration with ILCA, the production systems project has supported one KARI officer for a short course in forage agronomy, and another for small-stock production. In addition, the project hosted undergraduate students from various universities for internships (four from Egerton University; two from University of Eastern Africa, Baraton; and one from Cornell University). In the last two years, primary and secondary school students have visited Maseno at the average rate of one school per month, to learn about goat production and related aspects.

- **Institution building.** The impact of the CRSP's human resource development can be identified not only within KARI, but also in other institutions of higher learning in Kenya and elsewhere. The SR-CRSP has played a pioneering role of institutionalizing multi-disciplinary research and on-farm trials is also an important contribution to applied agricultural research. The program has also made significant contributions to the development of physical facilities for research. The current capacity in the Kabete veterinary laboratories speaks well on this point, as do the facilities at Ol'Magogo and Maseno.

Information Dissemination and Networking

- **Publications.** The numerous publications produced by SR-CRSP/Kenya include workshop proceedings, journal articles, management handbooks, book chapters, and even a video recording of the research highlights. The dissemination SR-CRSP findings and knowledge to

scientific, policy and agricultural production audiences all contribute to the wealth of knowledge in small-ruminant production.

- **Contribution of the program to the welfare of the small holder farming community.** Since the early 1980s, the program has worked with a total of 150 farm families in western Kenya. These farmers were allocated dual purpose goats and the supporting production technology to facilitate on-farm, farmer-managed trials. In the final analysis, besides assisting in fine-tuning the KDPG tech pack, these farmers also became acquainted with, and enjoyed the benefits of the new technology. Through various out-reach activities, the program also distributed KDPGs and the supporting production packages on a trial basis. In this vein, KARI is now in the process of establishing two new sites for more expanded trials to assess the impact of the KDPG technology.

The SR-CRSP in Morocco: Accomplishments and Impacts (1981-1992)

Summary of Accomplishments

- Genetic evaluation of a crossbreeding program between a non-prolific breed (Sardi) and a highly prolific breed (D'man).
- Nutritive assessment of the value of cereal and agro- industrial by-products for feed.
- Environmental physiology of the Sardi, D'man, and their crosses.
- Advances in the understanding of the ecology, nutritive value, and utilization of range land feed resources.
- Studies of the range land and human groups in the High Altas.
- Epidemiology of parasites in sheep.
- Significant contributions to improving Moroccan human resources in the field of sheep and goat production.
- Numerous scientific publications.
- Contributed to outreach and development of small ruminant production improvements mainly through a "technological package" publication on sheep.

Breeding

- **Sheep prolificacy.** It was demonstrated that the Moroccan D'Man breed of sheep transmits its high prolificacy additively to first cross and backcross progeny. This makes it possible to use local genetic resources to increase prolificacy in Moroccan sheep to different degrees, in accord with requirements of management and feeding systems. If 10% of Morocco's 10,000,000 ewes were replaced with D'Man crosses, this would generate an estimated US$5,000,000 in additional gross annual income to producers.

- **Cross breeding program established.** In 1982, two basic flocks of D'man (D) and Sardi (S) breeds were purchased from the Ziz and Draa Valleys and Marrakech, respectively, where these native breeds are normally raised. A crossbreeding program was then started. In 1988, a program for the development of a synthetic breed called DS involving 50% D and 50% S was initiated.

- **Identification of nutritional myopathy among sheep.** In Morocco it was determined that this condition, previously unrecognized in the region, resulted from a dietary deficiency in

selenium. Methods for correcting the deficiency previously developed in the United States were tested and found completely effective in Morocco.

Institution Building

- **Established a sheep station.** This 265 hectare farm is located in the central part of Morocco in the Tadla area within the largest irrigated district of the country. Since the farm is located at the edge of irrigated and rainfed zones, research conducted can simulate both the intensive irrigated mixed crop-livestock system and the extensive dryland system. Sheep facilities developed since 1982 include housing pens for more than 1,000 head of sheep, individual pens for nutrition and physiology studies, and a laboratory for reproductive physiology. The project also provided some support to improve forage production and farm management.

- **Improved facilities.** In addition to the Tadla farm, research facilities at the ENA experimental farm at Meknes and the range research station at Timahdit (Middle Atlas) were improved. Several pieces of equipment for laboratories at IAV and ENA were also purchased through the project.

- **Unique opportunity to build a comprehensive research program that addresses some of the main issues for improving small ruminant production.** The SR-CRSP attracted scientists from different but complementary disciplines who established collaborative work with their U.S. counterparts. More than 30 faculty members from seven departments of IAV and ENA were involved in the project.

Training

- **Significant contributions to training.** Because both IAV and ENA are teaching and research institutions, the number of students that took benefit from the project was high. Indeed, 12 faculty members were able to complete their doctoral theses (Ph.D.) in areas such as nutrition, physiology, and genetics between 1981 and 1992. During the same period, an average of eight students per year completed their M.S., DVM, or B.S. degrees in disciplines related to small ruminants (54 M.S. and DVM and 34 B.S. degrees). At least 10% of these students were from other North African and sub-Saharan countries. Consequently, the project

has contributed significantly to improving Moroccan human resources in the field of sheep and goat production. Several trainees have been hired by extension services, professional associations, research institutions and have become major actors in agricultural development.

Information Dissemination and Networking

- **Publicly available information on Moroccan small ruminants.** SR-CRSP has generated a considerable amount of basic information related to different Moroccan breeds of sheep and goats in terms of physiology, nutrient requirements, feeding behavior, breeding, and growth. Most of these data have been published in 111 articles in national and international scientific journals.

- **Data collection.** The project has also collected considerable data related to sheep production, management, marketing, and farmers decisions. Surveys conducted by students generated an important body of knowledge on sheep and goat production systems in different areas of the country. The resulting information has been used subsequently, to initiate development actions adapted for different zones.

- **Extending research.** Outreach has also been an important objective of the SR-CRSP in Morocco. The program maintained close relationships with the departments in charge of extension at the national and regional levels. Joint meetings were regularly organized to share results from research and discuss plans for the future. Seminars, field days, and demonstrations also were organized in the Tadla and Middle Atlas areas. Several faculty members were invited to give talks to sheep and goat producers.

- **Technology package for Mediterranean climate sheep production.** SR-CRSP/Morocco prepared a "technological package" publication that can be used by extension agents and advanced farmers. The comprehensive publication simply presents the issues related to management and health with very practical information concerning better management of cereal-sheep agricultural systems in Mediterranean countries. In 1989 an English version entitled Sheep Production and Management in a Mediterranean Climate: The Agropastoral System of Morocco was published by the University of California, Davis. One year later, the French version of this book was issued by IAV, L'elevage du Mouton dans un Pays a Climat Mediterranéen. This document has been extensively distributed throughout Morocco and also in North African, the Middle East and sub-Saharan zones with similar conditions.

The SR-CRSP in Peru: Accomplishments and Impacts (1980-1992)

Summary of Accomplishments

- Identification and control of important diseases of the goats, sheep, and alpacas.
- Identification and revaluation of the productive and adaptative qualities of the native Criollo sheep and appropriate selection methods are being tested for its genetic improvement.
- Acquired important knowledge about alpaca reproductive behavior and genetic characteristics as a necessary precursor for improving alpaca production.
- Validated technology for livestock production with the participation of the small peasant producer in communities.
- Assessment of indigenous and introduced small ruminants in terms of their ecological impacts, nutritional constraints and efficiencies, and proper stocking rates and animal mixes under range conditions.
- Enlarged the pool of skilled Peruvian scientists continuing research on small ruminant production as a result of collaborative relations between Peruvian and U.S. scientists and the training of many Peruvian professionals.
- Dissemination of research results and new management techniques achieved through scientific and technical publications, conferences, technical training courses and the Rerumen Network.
- Impacated the course of agricultural development strategies in Peru and other Andean countries through the finding that the dominant proportion of the livestock produced by highland peasant communities is raised in agropastoral communities, not exclusively by pastoral communities, as previously thought. The research also established that livestock in highland Peruvian agropastoral communities are valued most for the dung they provide (for use as fertilizer) rather than for their meat, fiber, or cash value.

Breeding

- **Established improvement efforts for 80% of the sheep population, native sheep in small holder hands.** Until the SR-CRSP program began in Peru, efforts at improvement of wool and meat production through breeding was restricted to just 20% of improved sheep on large commercial enterprises. The remaining 80% of native or Criollo type sheep in the hands of primarily of small holders had received very little attention in terms of breed characterization and breed improvement programs.

- **Productivity of the existing sheep breeds have been characterized.** The Junín and the Corriedale breeds have been characterized in productive and reproductive terms at two sites in the Central Sierra. Likewise, the productive parameters of the Criollo sheep have been defined. This has allowed SR-CRSP to quantify the degree of differences and comparative advantages that each of the evaluated groups possess under the same environmental conditions. Because of their adaptation to the highland rangelands, Criollo ewes should be used in the development of plans for improving sheep in the country.

- **Key genetic parameters for selection estimated in Junín and Corriedale sheep.** The selection of Junín rams by individual weight at 16 months helped produce better fertility rates and ewe productivity in terms of weight of progeny. Likewise, selection based on scrotal circumference produced very similar responses. The use of the estimated parameters, independently or in combination in the elaboration of selection indices can be applied to yield significant responses to the selection of sheep (especially with an emphasis on meat production) in the Peruvian Central Sierra.

- **Breeding at the Sociodad Agricola Interes Social (SAIS) Tupac Amaru.** The introduction of Targhee-Finn rams did not contribute to the improvement of the Junín sheep production, indicating it will be more efficient to exploit the pure Junín sheep. While Targhee-Finn rams and Junin ewes produced progenies with higher weight gains and staple lengths, in terms of kilogram of weaned lamb per ewe exposed, the breeding of Junín x Junín produced the highest yield. In SAIS Tupac Amaru, the progenies of Criollo ewes bred to Junín, Targhee, and Targhee-Finn rams were superior in live weight until second shearing than the pure Criollo progeny. The Junín breed will be the best crossing alternative to improve the productivity of the Criollo sheep under the conditions of SAIS Tupac Amaru.

- **Small ruminant production improvements in the Southern Sierra.** SR-CRSP implemented production recording in commercial sheep herds of the zone, facilitating the selection process by performance and progeny, without affecting the production systems. In addition, a quantification of the impact of climatic variation on the production of the Corriedale breed in the highlands was achieved. Researchers found that the Criollo sheep in the highlands present better reproductive characteristics (i.e. an early age of reproduction and fertility) and better carcass yields at 18 months than the improved breeds of the zone.

- **Genetic characterization of alpaca.** The herd of the La Raya Experimental Center (in Puno) has been implemented and within this herd a "nucleus of genetic studies for alpacas"

was formed. This herd has permitted the generation of a database (1982-1989) for the development of studies in the area of genetic improvement. The alpaca fleece has been characterized in terms of its physical aspect and match fiber length. The yields of herds located at different altitudes has been determined. The different types of congenital malformations have been recorded in Puno herds, and the frequency of presentation of each of them has been determined.

Feed and Nutrition -- Range Improvement

- **Characterized grazing on Peru's highland ranges.** Competitive and interactive grazing behavior of sheep, alpacas, and llamas on Peruvian highland ranges has been characterized. Research demonstrated that camelids are better adapted to the ecosystem than sheep in Peru, yet sheep are the dominant herbivore raised by peasants and on social cooperatives. Overgrazing, primarily by sheep, has led to severe deterioration in the productivity of these grazing lands Alpacas, having the most opportunistic feeding strategy, compete directly with llamas and sheep when range conditions vary; llamas and sheep can be grazed together, while alpacas are best managed alone. Research also has shown that rotational grazing systems are important in the recovery of these lands and vegetation. Moreover, research demonstrated that properly used, cultivated forages could boost animal production by 15 to 20%.

- **Agro-edaphologic maps.** Scientists have devised a practical method for elaborating agro-edaphologic maps that permit differentiation of range sites according to their suitability for grazing.

- **Native forage species characterized.** The effect of climatic patterns on the growth cycle and nutritive value of the principal native grasses has been established. Predominant plant associations have been characterized, using a cover, biomass production, and nutritive quality as criteria.

- **Stocking rates calculated.** Appropriate range site stocking rates have been established according to range condition and animal species.

- **Range land improvement.** Procedures for the improvement and recuperation of range land from various adverse environmental conditions have been introduced. Effective methods for

flat and gently sloping overgrazed range lands include applying phosphate at the beginning of the rainy season, scarifying the overgrazed area with a drill and then broadcasting orchard grass-clover seed, and, finally, covering the seed by using herds of camelids or sheep to trample it into the earth. With the foregoing techniques, it is possible improve initial stocking rates of 0.5 sheep units/ha/year on the overgrazed range to four or five sheep units/ha/year.

- **Pastures established to supplement native range.** Native range land in highland Peru is deficient in nutrient quality and quantity, especially in the dry season. Under these conditions, available supplies of nutrients do not meet the major demand by animals. Areas with topographic characteristics and water availability exist that allow the establishment of high-production pastures using species of grasses and legumes. The different soil and altitude level requirements of various forage species are known, as are their productive yields. The pastures can carry between 20 and 40 sheep units /ha/year depending on altitude. In addition to contributing to range recovery, pastures are economically productive and sustainable when used only during critical periods of the animal production cycle (i.e. growth, lactation, and last third of gestation).

- **Agricultural plots and soil fertility in peasant communities.** In many peasant communities cropping is carried out in small plots, but due to the poor soil fertility, cultivation periods of two to three years are alternated with one to seven years of rest. The proven benefits of seeding nitrogen fixing legumes at the beginning of the fallow period to recover soil fertility has been demonstrated locally. This allows a shortening of the fallow period while simultaneously providing additional forage for livestock and, overall, it gives a better use intensification of scarce soil.

- **Use of shrubs for fuel and forage.** In most peasant communities, the manure "bosta" is used as fuel in the family kitchen. The use of adapted shrubs, preferably legumes, seeded in the borders of plots permits replacing "bosta" fuel and improving the structure and fertility of the soil, with a resulting increase in production of Andean crops.

Animal Nutrition

- **Adaptive advantages of South American camelids.** Studies of range and concentrate fed small ruminants have documented the adaptive advantages of South American camelids (SAC) over other sheep and goals, including range utilization, digestive efficiency and water

stress tolerance. In native range the llama selects a major proportion of tall growing grasses in both the dry and rainy seasons while alpacas and sheep preferentially select the short grasses and herbs. In mixed grass-legume pastures, SAC consume less legumes than sheep. The quality of the selected diet, in terms of protein and digestibility, is highest for sheep, intermediate for alpacas, and lowest for llamas. In general, they also consume 30% less than sheep and are adapted for low quality feeding as they possess a greater digestive capacity than sheep due principally to the greater retention time of feed in the digestive tract. Under concentrate feeding conditions, SAC consume up to 50% less than sheep, although sheep have a greater feed conversion than camelids due to their greater relative feed intake and rate of weight gain. It has been estimated that the potential consumption is 4.6, 2.3, and 2.6% of the live weight for sheep, alpacas, and llamas, respectively. he SAC, compared with sheep, are more resistant to water deficit. The llama is more resistant to water stress than the alpaca, requiring less water ingestion per kilogram of dry matter consumed.

Reproduction

- **Achievements in sheep reproduction.** Researchers have characterized the presentation of estrus and ovulation in the Breeds Junín, Corriedale, and Criollo under natural range conditions.

- **Feed availability and reproduction.** Under irrigated pasture conditions at the IVITA Station in the Mantaro Valley, it has been demonstrated that with mixed pastures (rye grass and clover) one can obtain three parturitions in two years in Junín, Criollo, and Corriedale breeds, with no major differences among the three. This corroborates the finding that seasonal differences in reproduction in natural range lands are due principally to feed availability. In rainfed conditions, it was found that the highest concentration of parturitions occurred in April to July indicating that most of the fertile services occur in the rainy season, a time of high feed availability. Variation among herds is attributable to management differences among producers, which should be considered for extension purposes in communities

- **Achievements in alpaca reproduction:** The reproductive cycles and behavior of alpacas have been studied and well documented. They have continuous estrus and ovulation induced by copulation. The one-year-old females show sexual activity similar to adults, but only the ones that reach 35 Kg of body weight reproduce successfully. In La Raya conditions, 50% of females reach that weight at one year of age. Where males and females are herded together all

year, parturition is seasonal (January-March), although if females and males are separated and joined periodically, they produce kids year-round. Males lose sexual interest when they are with the same females for more than 15 days so changing females periodically is required to maintain sexual activity.

These alpaca reproductive characteristics, have practical applications for increasing the number of females bred/females exposed and also for the survival of the newborns. Under natural range land, it is important to adjust reproduction to the best season of the year in order to obtain maximum levels of estrus, ovulation, and survival of embryos and fetus, as well as to insure favorable conditions for the survival of lambs. The ewe needs a high nutrition level during the two last pregnant months; inadequate nutrition results in premature parturitions, low birth weights, reduction in ewe energy reserves, and poor milk production, and, as a result of all of this, low survival. A simple management system of males has been developed during breeding which increases the number of females bred/females exposed from 55% to 85%.

Animal Health

- **Identification of an ovine pulmonary carcinoma (OPC) virus-specific antigen.** This antigen that will be useful in isolating the causative virus, in developing a serological test for carrier animals, and eventually in developing a vaccine. This disease is responsible for severe losses of adult sheep in Peru.

- **Achievements in diagnosis and control of sheep pulmonary adenomatosis (SPA) and ovine progressive pneumonia (OPP).** Clinical and pathological criteria have been established for diagnosis of sheep pulmonary adenomatosis (SPA) and ovine progressive pneumonia (OPP). The distribution of this respiratory complex has been determined by scientists in two livestock enterprises, in which the disease constitutes the principal cause of losses. Based on these findings, a program to control of the OPP has been introduced consisting of systematic culling of all sheep with clinical manifestations of the disease and with sheep lentivirus as a result of annual testing. After working for five years, the morbidity and mortality due to OPP in herds under the indicated management diminished compared to the control herds. These results permit extending the OPP control program to other herds.

- **Perinatal mortality in lambs.** The microorganism *Clostridium perfringens* Type A which causes lamb enterotoxemia was isolated for the first time in Peru by SR-CRSP scientists. The microorganism has been used in preparation of a commercial biologic product which will aid in control of the disease.

- **Reducing lamb mortality through improved preventative care training.** Pneumonia is a significant cause of neonatal mortality among lambs. Enteric infections in lambs are usually prevented by administering oral medication to newborns. Researchers found that in 40% of the cases in which lambs died of pneumonia in the first four days of life, false deglutition (oral medication forced into the lungs rather than the stomach) was in fact the cause of death. These results highlight the need for improved training and preventative care management to reduce unnecessary lamb mortality.

- **Efficacy trials for sheep Brucellosis vaccination .** The semen quality and other aspects of rams of SAIS submitted to a vaccination program with REV 1 (*Brucellosis melitensis*) for 10 years and without epididymitis, were compared to rams without a vaccination program and with presence of epididymitis in males. The semen quality was classified as excellent for 97% of vaccinated rams versus 77% for the control group, indicating that vaccination of young rams should be extended to similar SAIS enterprises.

- **Pollution effects of La Oroya on the health of sheep.** It was determined that there was no relationship between concentration of heavy metals (arsenic, cadmium, copper, manganese, lead and zinc) in the liver and mortality due to the SPA/OPP complex, coenurosis, and pneumonias. However, it was established that the sheep population is acting as a sentinel species for contamination of the atmosphere in the neighborhood of the La Oroya melting plant. These results have important implications for public health.

- **Assays of medicinal plants for control of parasitic infections in sheep.** SR-CRSP animal health research included efficacy trials of medicinal plants believed to control parasitic infections in sheep. These include: the use of "utashayli" for control of *Melophagus ovinus*, the efficiency of the artichoke (*Cynara scolymus)* and "jayashipita" against *Fasciola hepatica* in sheep of Central Sierra, and the antihelmintic efficiency of squash seeds (*Curcubita maxima Duch*). These medicinal plants, now proven to be effective, constitute an accessible resource to small producer for treatment of some parasitic diseases.

- **Perinatal mortality in alpacas.** An SR-CRSP study that related field (clinic and pathological) and laboratory findings (bacteriological, parasitological, and histopathological studies) with samples of dead newborn alpacas during parturition of 1987, 1988, and 1989 at SAIS Aricoma, Picotani, CAT Santa Lucía (Puno), and SAIS Pachacutec (Junín) yielded important findings that made real contributions to better knowledge of mortality causes in newborn alpacas. For example, there is now a better understanding of etiopathogeny. In addition, there is a classification proposal for mortality causes, which is already being used in Puno. This will allow standardization of criteria used in the designation of such causes of death.

- **Alpaca neonatal mortality.** Demonstration that the high incidence of neonatal mortality in alpaca in Peru was related to *Clostridium perfringens* type A (CPA), enterotoxigenic *Escherichia coli* (EEC), and an increased susceptibility to infectious diseases because of failure of passive transfer of the maternal antibody. To improve the methods for diagnosis and prevention of CPA, an enterotoxin produced by the bacterium was purified using monoclonal antibodies, characterized its *in vitro* and *in vivo* pathogenicity and developed an ELISA assay to detect its presence.

- **Determination of the presence of infectious agents in alpacas.** Serologic findings indicate that Peruvian alpacas are infected with a variety of viral, mycoplasma and toxoplasma infectious agents. Studies to correlate these findings with the clinical and histopathological manifestations indicate infections in alpacas are likely due to the fact that these camelids live together with other species of domestic animals, such as sheep and cattle. These findings in alpacas are valuable contributions to understanding infectious diseases of these animals. The existence of infections that were not even suspected in this species has been demonstrated. These diseases are not new or exotic diseases, but their identification paves the way for addressing those with which may have affected alpaca production for a long time. For example, SR-CRSP scientists have already characterized the pathology of the parasitic infection Sarcocistiosis (*Sarcocystis aucheniae*) in alpacas and a partial characterization of its antigenic compounds has been achieved.

- **Determination of the presence of infectious agents in vicuñas.** Because vicuñas do not share their habitat with other domestic animals, analysis of blood samples from semi-confined vicuñas tested negative for the presence of viral agents which occur in alpacas and llamas.

- **Determination of the presence of infectious agents in goats.** Serological identification has been made for various infectious agents detected for the first time in Peru. These include Influenza A Virus, Parainfluenza 3 Virus, Bovine Syncytial Respiratory Virus, Bovine Infectious Rinotraqueitis Virus, Border Disease Virus. The Caprine Arthritic-Encephalitis (CAE) disease was first reported in Peru in 1983. This infection, caused by a retrovirus, is prevalent in goat farms where husbandry is intensive, e.g., in Lima (56.5% of serum-reactors), Trujillo (62.6%), and Piura (58.5%). The disease probably entered through animals imported from the U.S. and Europe. In addition, goat mycoplasmosis was reported for the first time in Peru in 1985. This disease is caused by *Mycoplasma mycoides subsp. mycoides*. *These* findings constitute an important contribution for a better knowledge of health problems in goats.

Socio-Economics

- **Highland production systems characterized.** Detailed knowledge of the production systems that comprise small ruminants has been achieved in associative enterprises and rural communities of the highland region and in small goat herds in the Northern Coast of Peru. It has been established that in the agropastoral communities more than 60% of family hand labor is used in livestock activities versus 25% in agricultural work. In addition, it was found that women's roles are predominant in livestock production, which should be taken into account for research-extension purposes in communities. SR-CRSP findings indicate that institutional forms of credit and technical assistance do not yet serve the existing system of alpaca fiber production and marketing. Currently, middlemen provide advances of money and other assistance to the producer. This factor determines that producers stay in the system in spite of the low prices received for the product.

- **Benefits of supplementation.** It has been established that pasture feeding supplementation during the last third of gestation in sheep and during growth and reproduction of female alpacas is an economically advantageous practice.

- **Comparative sheep productivity in cooperative enterprises.** The comparison of the growth, capital reproduction, capital accumulation and worker participation in small cooperative enterprises (10,000 animals) and big cooperatives (around 200,000 animals) demonstrated that the principal variables that affect yields are the participation of workers and their productive organization.

- **Computer data analysis.** Tools have been developed for data processing by computer. From a simple herd model programs have been prepared for the recording of quantitative and qualitative data which facilitates their analysis.

Training and Institution Building

- **Training of Peruvian scientists.** This has been developed in close collaboration with INIAA and universities. The types of training sponsored by the program have covered a wide spectrum, from informal, on-the-job training of technicians at one extreme to training of research scientists through overseas doctoral programs at the other. With an objective of producing graduates with research capability, the training of Peruvian students at the doctoral and masters levels has been emphasized. 19 M.S. and 17 Ph.D. degrees have been obtained by Peruvian students at U.S. universities under SR-CRSP auspices. A total of 67 Peruvian students have received B.S. (45) or M.S. (22) degrees. In this process, 41 B.S. theses, 51 M.S. theses and 15 Ph.D. theses have been produced directly as a result of SR-CRSP support. Peruvian scientists trained by SR-CRSP are currently working in their respective institutions, both in research and teaching. An SR-CRSP trained scientist working in Peru was appointed the Dean of Veterinary Science at the National Veterinary Institute. In addition, eighteen training courses intended to train technical support staff have been offered and supported the SR-CRSP in Peru.

- **Peruvian graduate training program in animal production and health.** The contributions of SR-CRSP funding, research capability and training of Peruvian scientists was instrumental in the establishment of post-graduate programs in the Veterinarian Faculty at San Marcos and Puno Universities. The graduate school in the veterinary faculty of the San Marcos University confers the M.S. degree in Animal Production and Animal Health. Also important is the development of research facilities in Peruvian institutions

- **Demonstration of a successful, large-scale research effort.** The success of the SR-CRSP's holistic, multidisciplinary, and collaborative approach to understanding and solving the complex problems of sheep, alpaca, and goat production in Perú has had a significant impact on the country's research and development capability. This major systematic research effort has demonstrated to many researchers and development workers in Perú the importance

of coordination and administration that is not unduly bureaucratic and funding that is flexible and opportune.

Information Dissemination and Networking

- **Information dissemination.** Publications by the SR-CRSP in Peru include 62 journal articles, 103 conferences attended, 170 technical reports, 9 books or book chapters, 203 summaries.

- **The Andean Small Ruminant Science Network.** Since 1991, the SR-CRSP developed a leading role in establishment of the Small Ruminant Network (RERUMEN) in South America, with focus on the Andean region. RERUMEN made an excellent start in networking in a large region of the world, especially in Argentina, Chile, Bolivia, Ecuador, Venezuela and Perú. In October, 1992 by decision of the SR-CRSP the network was moved to Bolivia. Since 1991, the RERUMEN newsletter has been published several times a year and distributed to over 500 professionals. A bibliography database of 8500 entries related to small ruminants now exists as does a database of 581 professionals dedicated to small ruminant research and production in the Andean countries of South America. In addition, RERUMEN has elaborated collaborative research projects in topics of common interest to the South American countries to present to financial institutions. RERUMEN's role in information exchange has created great interest and a growing demand in the South American region for increased coordination in small ruminant activities and information exchange; and has contributed significantly to scientists' abilities in Latin America to conduct their research programs.

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A complete listing of publications which detail the work of the SR-CRSP can be found in the 1994 Publications document available from the Management Entity.