# Small Ruminant CRSP

# Annual Report 1992

# Small Ruminant Collaborative Research Support Program

## Oversight Groups

Research and Development 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

Colorado State University, Ft. Collins

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) |
| **Morocco** | Institut Agronomique et Vétérinaire (IAV), Hassan II University |

# Small Ruminant CRSP
## Annual Report 1992


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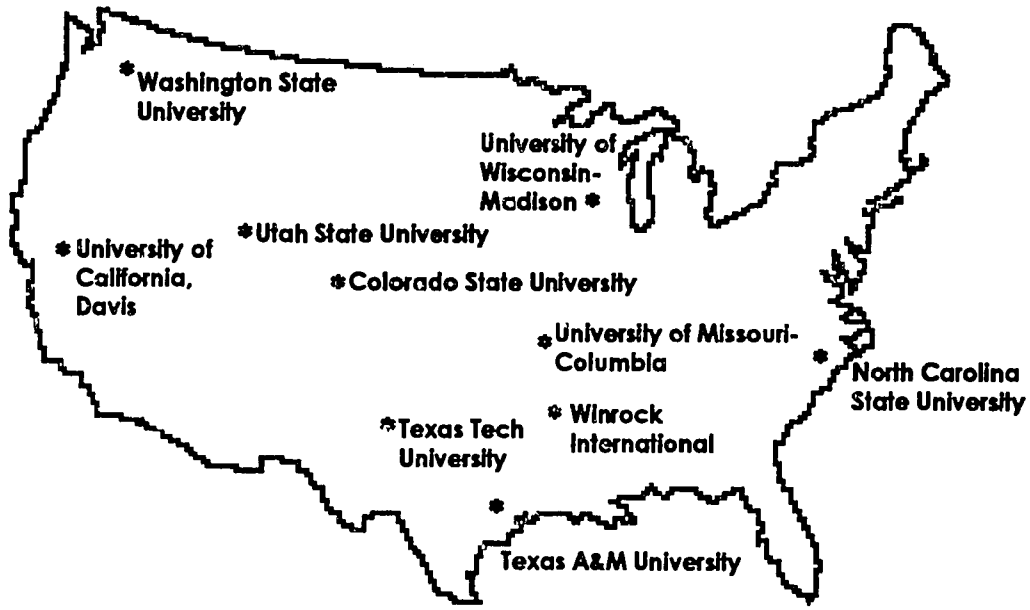



## Table of Contents

# Preface

The Small Ruminant Collaborative Research Support Program (SR-CRSP) produces an annual report each year, as required by the grant from the U.S. Agency for International Development. The annual report includes reports from each principal investigator on research conducted with funding from the SR-CRSP. In addition, project expenditures are listed at the end of each annual report.

Prior to 1991, the annual report covered research performed during the SR-CRSP's fiscal year, October 1 through September 30. However, in 1991 the principal investigators requested that the annual report follow the calendar year so as to avoid writing the past year's annual report at the same time that research for the fiscal year was beginning. As a result, the 1990-1991 Annual Report covered fifteen months (October 1, 1990, through December 31, 1991) in order to reflect this change. The 1992 Annual Report is the first report to cover fully the calendar year, January 1, 1992, through December 31, 1992.

The Annual Report is a compilation of research reports written by principal investigators. The Management Entity edits these reports to conform to standard grammar and format guidelines and to ensure the completeness and clarity of tables and graphics. Otherwise, each report is the expression of the principal investigator.

In addition to the research reports from SR-CRSP principal investigators, occasionally the editor includes a report on research funded by the SR-CRSP but not occurring under the auspices of a particular principal investigator. The 1990-91 Annual Report included a review of the Indonesia Small Grants. In this annual report, a summary of work performed by a consultant group (INI ANSREDEF) on sheep disease constraints in Indonesia is included with the Hair Sheep Production Systems Component.

Each year, more information is appended to the annual reports in an attempt to make the information more accessible to readers who are not intimately familiar with the SR-CRSP. Thus, the publication's front and back covers give information on SR-CRSP participants; each principal investigator's name, address, telephone, and fax number are listed at the beginning of their particular report; a glossary of terms, abbreviations, and acronyms is provided; and country maps are included with locations of major research indicated. Two items added this year are: a map of the United States with the locations marked of participating U.S. institutions, located above the Table of Contents, and an introduction, which details the history, structure, and goals of the SR-CRSP.

Acknowledgment is due to Jennifer Barber, who is responsible for the layout, design, and final production editing.

Mary R. Keane
Editor

# 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 (JCORD) 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 a 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 1993, ten U.S. institutions participate 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 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 are:

*Current*

- Instituto Boliviana de Tecnología Agropecuaria (IBTA), Bolivia
- Kenya Agricultural Research Institute (KARI), Kenya
- Agency for Agricultural Research and Development (AARD), Indonesia
- Institut Agronomique et Vétérinaire (IAV), Morocco

## The Achievements and Highlights

The Small Ruminant Collaborative Research Support Program (SR-CRSP) has carried out highly effective research successfully linking fourteen U.S. universities and institutions with institutions in six developing countries to improve the efficiency of small ruminant production. The SR-CRSP research has produced remarkable results: in Kenya and Brazil, cassava and sweet potato vines are now fed to young goats for earlier weaning, providing families with more milk; in Kenya, vaccines against several deadly livestock diseases have been developed; in Morocco, sheep are now grazed on cereal stubble, reducing the need for supplemental forage and decreasing pollution from burning stubble; in Morocco and Indonesia, breeding for prolificacy has substantially increased the number of lambs per ewe; in Peru and Bolivia, research on drought and its effects on alpacas, llamas, and sheep has led to interventions and strategies for sustainable agricultural practices; and in Indonesia, nutrition research has decreased the need for forages and herbicides by grazing sheep under rubber trees. The collaboration among U.S. and host country scientists has resulted in shared knowledge and technologies among scientists and countries. In addition, the SR-CRSP has enabled over three hundred scientists to obtain master's or doctoral degrees.

## 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 and 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 ten U.S. universities and research institutions:

| | |
|---|---|
| University of California, Davis | Breeding and Genetics |
| Colorado State University, Ft. Collins | Animal Health |
| 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 |

# Sustainable Agropastoral Systems on Marginal Lands

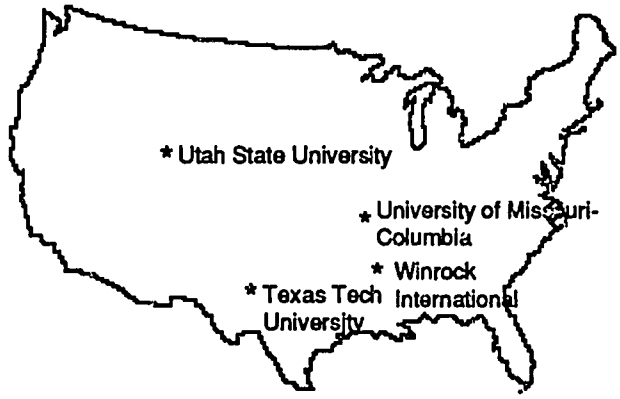
"Most of the world's small ruminants are produced in agropastoral systems on marginal and fragile lands. The key to development of sustainable agricultural systems in these regions depends on the implementation of suitable management strategies for the livestock sector. . . . The goal of this SR-CRSP 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*

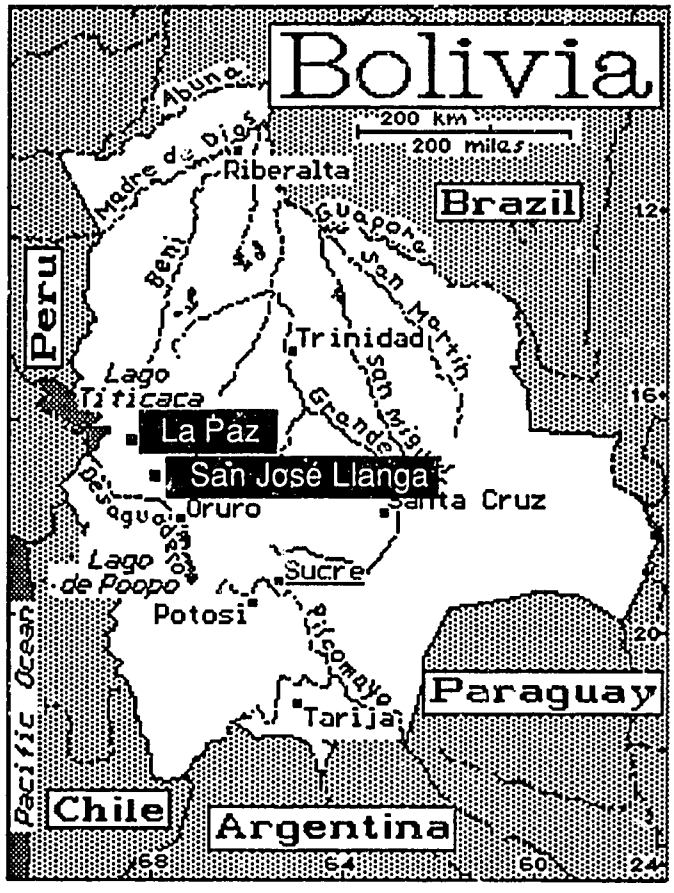
# Republic of Bolivia

Total area: 1,098,580 square km (424,165 square miles)
Geography: In central Andes Mountains, at an altitude of 12,000 feet.
Capitals: Sucre (legal) and La Paz (de facto).
Population(1991): 7,156,000
Languages: Spanish, Quechua, Aymara.
Labor force: 50% agriculture, 10% industry, 26% services.
% Females in labor force: 25.2%
Industries: Textiles, food processing, mining, clothing.
Chief crops: Potatoes, coffee, sugar, corn, coca.
Land in Agriculture: 27.4%
Agriculture of GNP: 24%
Sheep population: 9,600,000
Goat population: 2,350,000
Uses of sheeps and goats: Meat and milk.
Inflation rate: 15.5% (1989)
Monetary unit: Bolivianos.

## United States Sites




## Bolivian Flag



# *Range Ecology*
## Utah State University

Brien E. Norton, Department of Range Science, Utah State University, Logan, Utah, 84322-5230. Telephone (801) 750-2476, Fax (801) 750-3796.

## Narrative Summary

Livestock production in the semi-arid zone of developing countries is invariably constrained by recurring drought. It also tends to be part of an integrated production system in which livestock and crop agriculture are interdependent. The Small Ruminant CRSP agropastoral project on the altiplano of Bolivia has adopted a novel approach to research in this context. We propose that sustainability of the production system under severe periodic stress such as drought may be more important to the producers than achieving the production potential of favorable seasons. Furthermore, we recognize that the role of livestock within the overall production system must be understood before any technical intervention can be deemed appropriate.

The field site for the agropastoral project, established early in 1992, is the community of San José Llanga which encompasses about 7,000 hectares, of which approximately forty percent is farmed. Research during this first year focused on gathering baseline information which would lead to a quantitative characterization of the community's resources. The range ecology subproject conducted detailed on-ground surveys assisted by aerial photos to produce a "Land Use and Vegetation Map" of the community. Over 2,500 parcels of farmland were mapped and their current crop identified. Thirty-three vegetation types were distinguished on the community rangelands. In a companion study on the major vegetation types, species composition was determined by proportional plant cover and plant biomass was estimated at different seasons of the year. Specific vegetation types appear to be delineated by soil texture, degree of inundation during the rainy season, and salinity. The association between vegetation and soil properties, and the dynamics of vegetation change, are under investigation.

Land resources at San José were also examined through the analysis of satellite imagery. A 12-month time series beginning in August 1986 illustrated the seasonal behavior of different kinds of resources. A comparison of several Landsat images from 1972 to 1987 revealed the impact of the 1984 drought. Fluctuations in site productivity associated with the drought appear to be of far greater magnitude than the 15-year trend in ecological status. Land types defined by spectral signatures derived from satellite imagery and on-ground data may be characterized in terms of the dynamics of resource productivity in both short- and long-term perspectives. These signatures can form the basis for a GIS stratification of production system attributes and will also allow us to extrapolate the results of research at San José Llanga to comparable sites in the central altiplano.

The key to success of the Bolivian agropastoral project is the integration of information from different disciplines into a quantitative model of the production system. Manipulation of the model will identify the relative importance of production system

components in promoting sustainability under different scenarios of stress and opportunity, and also reveal the kinds of interventions which are technically, socially, and economically appropriate.

Conceptualization of a production system model has begun with the preliminary identification of system-level hypotheses and key system interactions. For example, we hypothesize that dairy enterprises in San José, which provide a substantial cash income for community households, would not be possible without the support of small ruminants as venture capital and as a contingency resource when dairy production is threatened by drought or other catastrophes.

## Research

As foreshadowed in the research proposal for 1991-92, the efforts of the range ecology program in 1992 were strongly focused on a resource inventory of the community lands of San José Llanga and the characterization of vegetation types. Utah State University (USU) was also engaged in a study of the utilization of rangelands from the livestock point of view. However, this project on the determination of diet preference was transferred to the aegis of Texas Tech University (TTU), and a soils study was transferred from Texas Tech to USU, following a meeting between the principal investigators of TTU and USU held in November, 1992. At that meeting it was agreed that, in order to enhance the efficiency of the overall agropastoral program, Utah State University should confine its involvement to soil and plant aspects of the production system, while Texas Tech would focus on the livestock side of research activities. The only exception to this division was USU's desire to evaluate the impact of cross-bred sheep present in some of the flocks at San José Llanga. The improved crossbred rams incorporating Corriedale and Targhee blood were originally introduced to the community, along with improved American varieties of alfalfa, as part of a USU/USAID project on the altiplano which concluded in 1975.

### *Inventory of resources: Land use and vegetation map.*

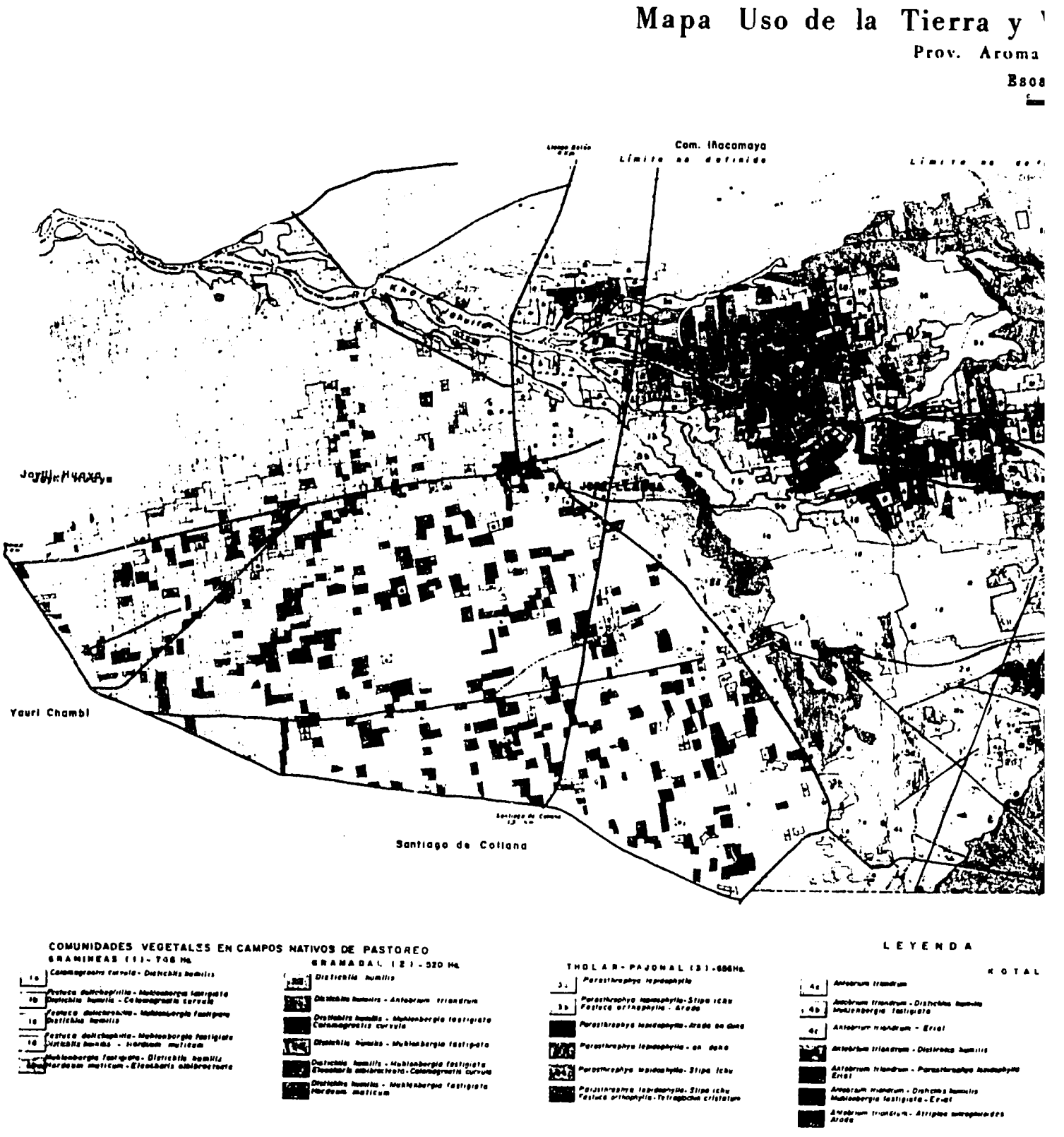
#### Problem statement and approach

The community lands of San José Llanga, where the SR-CRSP agropastoral project commenced field-work in March, 1992, comprise an area somewhere between 6,500 and 7,500 hectares depending on where one draws the boundary. In order to quantify the manner in which these lands are utilized for a variety of agricultural pursuits, and to acquire an understanding of changes in land use and resource condition through time, it was necessary to construct a resource map of the area. Although this inventory of resources was primarily intended to characterize the project site from an ecological point of view, it became apparent within the first few months of study that a resource map would be an asset to the sociological and economic components of the project as well.

Resource inventory activities proceeded on two fronts: the generation of a map based on extensive ground survey assisted by aerial photos and the analysis of satellite imagery (see next section). Both approaches depended on the acquisition of a fresh set of aerial photos of the community which were obtained in March, 1992. The Small Ruminant CRSP in Bolivia, and this range ecology subproject in particular, is indebted to the University of Missouri sociology subproject for providing the 1992 aerial photos.

The ground survey work to compile the land use and vegetation map was carried out in April and May, 1992, and required the combined effort of a large number of people. In addition to Bolivian range ecologists Humberto Alzérreca and Jaimé Valdivia, and Texas Tech resident scientist Morty Ortega, two key individuals were Maximo Liebermann of the Instituto de Ecología and Dean Treadwell, who

**Figure 1. Land use and vegetation map of San José Llanga.**



# getación en San José Llanga

)pto. La Paz - Bolivia

- 1: 20000


- 1344 Ha.

ERIALES (51-288 Ha.

USO DE LA TIERRA
2218 Ha

SIMBOLOGIA

- Río permanente
- Río temporal
- Canal de riego
- Pozo de agua
- Carretera
- Sendero
- Centro poblado
- Vivienda
- Muro perimetral
- Límite de Comunidad

FUENTES

Fotos aereas pancromaticas, Marzo de 1992
Esc. 1 20000
Carta topográfica Hoja 6044 IV, Esc. 1: 50 000
Mapa basado en interpretación de fotos aereas
Trabajo de campo: Marzo - Abril de 1992
Compilación y Diseño:
Uso de la tierra M. Libermann Cruz
Vegetación Dion Trawavet
Dibujo: J. Orihuela Juarez
Lab de Cartografía - I.E., UMSA
La Paz, Agosto de 1992

IBTA-CRAP - BOLIVIA

was seconded to the CRSP/USU as a volunteer under the USAID-supported Farmer-to-Farmer program. Nine senior students from the Instituto de Ecología worked on this assignment, concentrating on the farmland portion of the community; the range ecologists focused on the rangeland areas. Both teams included field technicians from all four disciplines employed under the SR-CRSP and based at San José Llanga, whose local knowledge of the community was invaluable.

## Progress

The land use and vegetation map of San José Llanga is presented in Figure 1. An estimated 5,772 hectares of the community lands are classified in the resource map. The area may be divided into three regions: cultivated farmland on the west; a strip of sub-irrigated meadows, alfalfa pastures, and cropped fields (mostly barley) in the center; and a zone of rangeland to the east, which includes an area of sandy soils in the southeast corner (map unit 3f) that is cultivated and, more recently, irrigated. A string of loosely-connected villages runs along the eastern edge of the cultivated farmland in a northwest to southeast orientation, utilizing wells which exploit the high water table in the vicinity. The largest, northernmost village, and administrative center of the community, is clearly marked on the map.

The western agricultural zone is at slightly higher elevation than the rest of the community lands and therefore less subject to salinization. The surface soils are sandy overlaying a clay horizon, with depth of the sandy layer varying from five cm to five meters. Past and current wind erosion is strongly in evidence, and stabilized sand dunes are prominent towards the northwest. Cultivated fields in this western zone were differentiated in terms of the three crops grown in 1991-92, or as fallow. For this initial survey no attempt was made to separate fallow fields according to age classes. Farmed fields in the northwest corner and along the northern boundary were not classified because of a border dispute with the neighboring community. The cropland comprises well over 2,500 different parcels of land privately owned. Of the fields cropped in 1991-92, and marked on the map, 43% were potatoes, 36% quinoa and 21% barley. For every field cultivated, four or five are in fallow which can last for up to 20 years; the fallow fields are grazed by sheep and cattle, especially at certain times of the year.

Most of the barley is grown not in the western, sandy agricultural land but on the alluvial flats by the Rio Khora Jahuira, among the alfalfa pastures. The alfalfa map unit is bright blue, revealing a concentration of alfalfa in the north-central portion of the community. The water table in this zone is two to five meters below the soil surface, well within the reach of alfalfa roots. The alfalfa is harvested for hay and grazed by sheep as well as cattle, although cattle have primary access. Some fields were established at least twenty years ago in connection with the USU/USAID/Bolivia project cited earlier and before dairy production became a major enterprise in the San José area. There is evidence of careful management of alfalfa fields in terms of temporal and spatial distribution of use.

The grassy meadows of the sub-irrigated zone, even those which may have been cultivated in the past, form an important component of pastoral forage resources, together with less productive rangelands to the east. Much of the grazing lands are subject to inundation in the rainy season and parts may remain flooded for months at a time. Salinity appears to be a major factor limiting productivity and determining species composition, and this hypothesis is being addressed. Thirty-two meadow and rangeland vegetation types have been mapped, plus a completely barren unit (erial). The most productive grassy meadows (gramineas) are dominated by *Calamagrostis curvula* and *Festuca dolichophylla* (misspelled Festuca dolichophilla in Figure 1). The low-growing grasses on the gramadal flood-plains include halophytic species such as *Distichlis humilis*, *Muhlenbergia fastigiata*, *Hordeum muticum*, and the sedge *Eleocharis albibraceata*. Several rangeland plant

communities on the sandier and loamier soils are dominated by the 'thola' shrub *Parastrephia lepidophylla* (misspelled Parasthrephya in Figure 1), a monospecific genus endemic to the altiplano which is often an indicator of soils suitable for farming and reappears on fallow fields. It tends to be associated with perennial grasses such as *Festuca orthophylla* and *Stipa ichu*. A halophytic cushion plant, *Anthobryum triandrum* (misspelled Antobrium in Figure 1), is a key species of limited forage value which dominates apparently degraded sites and appears to be actively invading gramadal communities. It is associated with thola shrubs and/or halophytic grasses.

Nearly ten percent of the rangeland is classified as more or less barren (erial). The sparse vegetation encountered in parts of the erial is of *Anthobryum* and the gramadal grasses, *Distichlis* and *Muhlenbergia*. The reason for this lack of vegetation is not yet clear, but it could be due to anoxia under seasonal flooding, high soil salinity, or man-induced degradation, or a combination of these factors.

## *Inventory of resources: Satellite image analysis.*

### Problem statement and approach

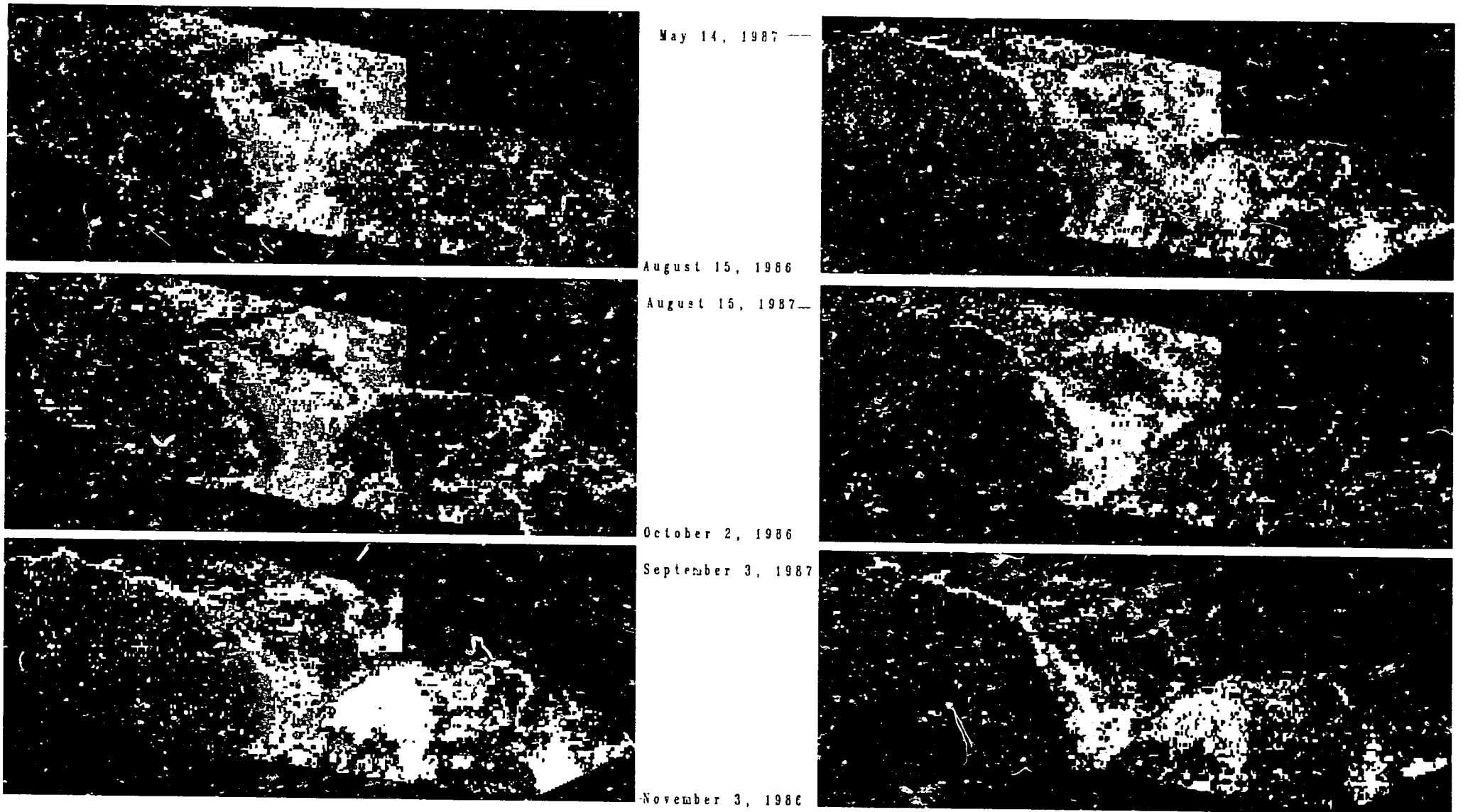
The resource map produced from 1992 aerial photos and extensive ground survey, as described above, provides a snapshot characterization of the lands managed by the community of San José Llanga. It cannot illustrate the seasonal or long-term dynamics of the farmland, pastures, and range vegetation, nor can the classification units be readily applied to other areas with similar ecological characteristics without further on-ground survey. From the point of view of extending the results of research conducted at San José Llanga to other communities within the central altiplano, it will be necessary to establish correspondence between San José and the potential expansion sites. For these objectives concerned with change dynamics and extrapolation of results, the analysis of remotely sensed images taken at different times is the appropriate methodology.

The satellite images acquired for the project were taken over a range of years (1972 to 1990) and seasons (six images from August 1986 to September 1987). The Landsat TM (Thematic Mapper) image from 1984 was used to generate a computerized classification of resources modified by subsequent ground observations. The series of six MSS (MultiSpectral Scanner) images from dry-season 1986 to dry-season 1987 was analyzed to show seasonal shifts in gross vegetation parameters. The description of long-term change utilized a series of dry-season Landsat images from 1972, 1984, 1986, and 1987. Subsequent work will examine a 1990 Spot image and sets of aerial photos from 1955 and 1992 for more detailed elucidation of long-term change in the community. Dry-season imagery was used for the chronological study because of the problem of cloud cover during the growing season. Furthermore, analysis of seasonal imagery indicated that flooding or wet soil conditions in the growing season could mask vegetation parameters.

The computer analysis of satellite imagery was conducted at the Remote Sensing and Geographic Information Systems Laboratory at Utah State University. Ground truth data were obtained on a field visit to the site in October, 1992, and from vegetation studies being carried out by Nelson Massy. Multispectral TM and MSS Landsat images were rectified, corrected for sun angle, calibrated, and converted to reflectance values and Normalized Difference Vegetation Index (NDVI) ratio images. Analysis involved image differencing and visual interpretation of multi-composite change images, with comparisons of mean-variance plots and density slice maps (spatial histograms) of ecosystem dynamics.

### Progress

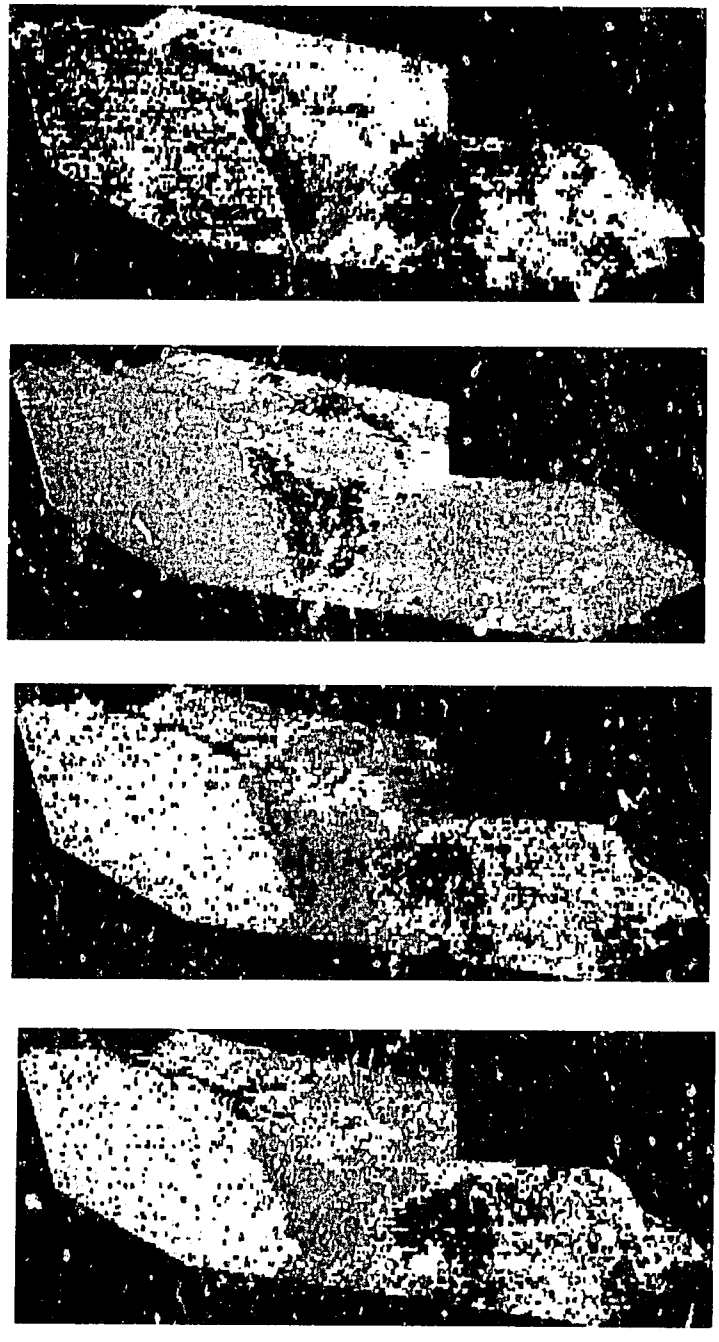
A sequence of seasonal change on community lands is illustrated in Figure 2. The first three images are on 15 August, 2 October, and 3 November 1986; the second three images




| TNDVI HISTOGRAM | LANDCOVER |
|---|---|
| 02 - 06 | water |
| 07 - 11 | water and soil |
| 12 - 16 | soil |
| 17 - 21 | soil and vegetation |
| 22 - 26 | vegetation |
| 27 - 31 | vegetation |
| 32 - 36 | tall grasses |
| 37 - 41 | tall grasses |
| 42 - 46 | sub-irrigation |
| 46 - 51 | sub-irrigation |

**Figure 2. A sequence of seasonal change on community lands.**

Figure 3. Interannual data record for 1972, 1984, 1986, and 1987.



were taken on 14 May, 2 August, and 3 September 1987. The long gap of six months (3 November to 14 May) during the growing season is due to lack of cloud-free images. The seasonality is most evident in the pulse of orange and yellow color on the sub-irrigated portion of the community, reflecting biomass trends in the tall grass meadows, alfalfa fields and associated crops. The farmland on sandy soils to the west exhibits remarkably little seasonality in this series. This may be explained by the prevalence of fallow lands and by the harvest of most cultivated crops before the 14 May image was taken. The decline in TNDVI (Transformed Normalized Difference Vegetation Index) on farmland from 2 October to 3 November 1986 may be due to the preparation of fallow fields for planting and an increase in soil moisture content.

The TNDVI index appears white on much of the rangeland on 3 November 1986 and 14 May 1987. Since the line of the Rio Khora Jahuira also shows a white TNDVI, we may assume that this signature is associated with water or damp, exposed clay soil. Detailed precipitation records for the period can elucidate this aspect. The production years of 1985-86 and 1986-87 are known to be similar in terms of precipitation received. It is evident in the imagery, however, that in August 1987 the plant communities at San José were at a much lower level of standing biomass than the previous August. We need to be sensitive, therefore, to annual variability which is not apparent from gross climatic data alone.

Figure 3 shows the interannual data record for 1972, 1984, 1986 and 1987. (The color coding of TNDVI classes in this figure differs from that used in Figure 2; the lowest index class in Figure 3 begins at the value range of 12-16, whereas the lowest TNDVI range in Figure 2 is 2-6. Therefore the colors used in Figure 3 do not correspond to the same TNDVI levels in Figure 2.) The most obvious feature of this series is the drought year of 1984 with much lower TNDVI values across the entire community. It also interesting to note the similarity between 1972 and 1986-87. Interannual differences were analyzed by differencing the TNDVI maps. Because the data is digital it can

**Table 1. Standing biomass of dry plant material (in kg per hectare) and percent plant cover for 16 major vegetation types on the rangeland.**

| Vegetation Type (codes refer to map units) | | Biomass (kg/ha) | Cover (%) |
|---|---|---|---|
| 1a | Calamagrostis curvula - Distichlis humilis | 3055 | 82 |
| 1d | Festuca dolichophylla - Muhlenbergia fastigiata | 2507 | 87 |
| 4f | Anthobryum triandrum - Distichlis - Muhlenbergia | 1630 | 42 |
| 2f | Distichlis - Muhlenbergia - Hordeum muticum | 1508 | 80 |
| 1e | Muhlenbergia - Distichlis - Hordeum - Eleocharis albibracteata | 1350 | 60 |
| 4k | Anthobryum - Distichlis - Muhlenbergia - Bouteloua simplex | 1332 | 78 |
| 2a | Distichlis humilis | 1264 | 82 |
| 2e | Distichlis - Muhlenbergia - Eleocharis - Calamagrostis | 1060 | 73 |
| 4a | Anthobryum triandrum | 1010 | 19 |
| 4j | Anthobryum - Distichlis - Muhlenbergia (saline erial) | 979 | 30 |
| 2b | Distichlis - Anthobryum | 948 | 69 |
| 2d | Distichlis - Muhlenbergia | 666 | 76 |
| 3b | Parastrephia lepidophylla - Stipa ichu - Festuca orthophylla | 570 | 52 |
| 4b | Anthobryum - Distichlis - Muhlenbergia | 448 | 34 |
| 5b | Distichlis - Eleocharis (erial) | 430 | 38 |
| 5c | Anthobryum triandrum (erial) | 127 | 8 |

be manipulated mathematically, i.e., image pixel values from one year can be subtracted from another year. The image differencing indicates that San José Llanga experiences oscillations in plant production (and perhaps other variables) associated with drought which are of far greater magnitude than the 15-year trend in ecological status.

## *Vegetation characterization.*

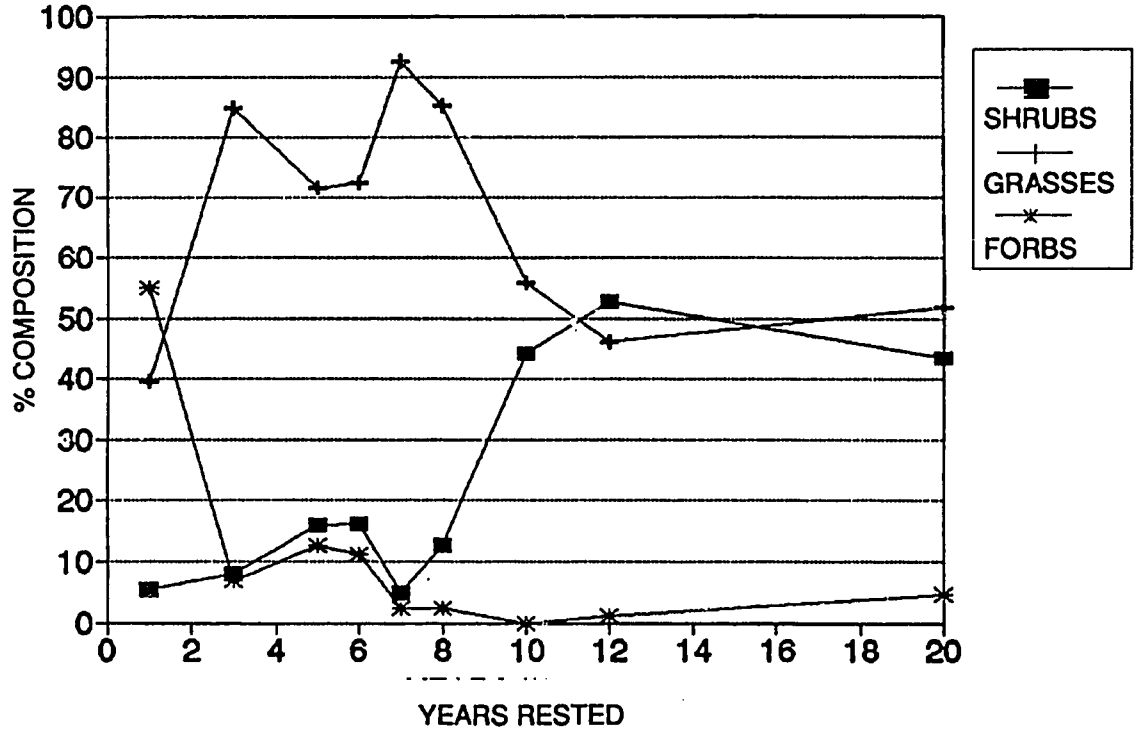
### Problem statement and approach

An objective of the range-ecology project is to know how various types of vegetation are being used by livestock and also to determine the trends in condition of rangeland vegetation. Answers to these questions require detailed characterization of the vegetation types identified in the land use and vegetation map (Figure 1). Every two or three months, Nelson Massy has collected information on species cover and biomass for 16 major vegetation types. Cover data were obtained by step-point and line intercept methods; biomass was estimated by the weight-estimate double-sampling technique utilizing linear regression for the correction of bias.

As part of the ground-truthing undertaken in October to assist in the computerized classification of spectral signatures on the satellite images, Robert Washington-Allen collected data on fallow fields of different ages. At least two fallow fields were sampled in each age class, and data were obtained on cover and perennial plant height using the step-point procedure.

Initial observations have linked soil salinity to the presence and distribution of halophytic species on the rangeland. The apparent increase of *Anthobryum triandrum*, an invader of

**Figure 4. Trend in composition of vegetation on fallow fields based on samples taken in October, 1992, on fields of different ages (space-for-time substitution).**



gramadal communities, could be related to salinization of those communities. In order to sort out some of the potential causal factors determining vegetation attributes, a study of soil properties was initiated by Roberto Miranda in late 1992. A number of soil pits have been dug and samples taken for analysis, but data are not yet available.

### Progress

The 16 vegetation types for which biomass and cover data have been obtained are listed in Table 1 in order of decreasing biomass. This representative set of data was obtained from the dry-season (July) sample. Each vegetation type has been identified with the map code used in Figure 1, so that it is possible to refer back to that figure to see its distribution on community lands. The most productive sites are the grassy meadows of the sub-irrigated zone with up to three metric tons dry weight of standing forage per hectare. The low-growing gramadal grasslands form the next most productive vegetation type, generally ranging from 1 to 1.5 tons per hectare. The standing biomass of *Anthobryum*-dominated and *Anthobryum*-gramadal mixed communities also fall within this range. The thola shrub *Parastrephia* tends to occur in areas that have been subjected to prior agricultural use; the relatively low productivity of these areas at San José (0.5 tons per hectare) is probably below potential. The semi-barren erial lands fall at the bottom of the list.

Using the technique of space-for-time substitution, the trend in species composition during the course of a 20-year fallow field on farmland is illustrated in Figure 4. The first three years of fallow witness dramatic changes as a large initial component of ephemeral forbs, chiefly wild *Chenopodium* spp., disappears. The rise in grasses in the first three years, complementing the decline in forbs, is composed mainly of the annual *Bouteloua simplex*. By the fourth or fifth year of the fallow the annual grasses are less obvious and perennial grasses such as *Festuca* spp. are becoming conspicuous. Thola shrubs begin to appear at the onset of the fallow period but remain insignificant for the first ten years. By then, however, they have approached mature height and along with the perennial grasses start to dominate the fallow-land vegetation. When the fallow lands are prepared for planting, the thola is harvested and used for firewood.

## *Utilization of rangeland by livestock.*

A study of the botanical composition of diets of sheep and cattle grazing rangeland vegetation, and thus the ranking of more palatable plant species in different seasons, has been in progress since February, 1992. This work has used the bite-count approach to quantify diet preference.

During the Program Advisory Committee meeting in Bolivia in early November, 1992, this study by Freddy Flores was transferred from the aegis of Utah State University to that of Texas Tech University. This move was consistent with the division of research responsibility which places animal studies under Texas Tech and plant and soil projects under Utah State.

## *Production systems analysis.*

### Problem statement and approach

An important objective of the Bolivian agropastoral project is to develop an interdisciplinary systems perspective that illuminates, in a semi-arid zone, the role of small ruminants in the promotion of ecologically sustainable agropastoralism, poverty alleviation, and economic growth of the community. Now that field activities are underway, the development of a conceptual ecosystem model is a high priority. Identification of system-level hypotheses and model building must be a team effort; efficient model integration, however, requires that disciplinary perspectives be subjected to some degree of coordination. Dr. Layne Coppock offered to act as coordinator for development of the system model during the Bolivia PAC meeting in November, 1992. He

recently completed a synthesis volume covering 11 years of inter-disciplinary research conducted by ILCA in the Ethiopian highlands which integrates the work of over 30 scientists from 10 disciplines. This synthesis, which has generated new perspectives for pastoral development in semi-arid Africa, provides Dr. Coppock with the intellectual experience to help the Bolivia SR-CRSP pull together a viable systems concept more quickly.

Model coordination will begin with preliminary lists of system-level hypotheses and key system interactions. These lists will be circulated among project staff and collaborators for comment and contributions early in 1993. This exercise must be an iterative process in which the final conceptual model is a team product. In addition to achieving a consensus among scientists regarding the prioritization and testing of system-level hypotheses, this activity will provide a rational framework for guiding future field work. Priority should be given to those major interactions and assumptions that are critical for addressing system-level hypotheses but are unobtainable from existing data or literature.

The conceptual model will need to be translated into a simulation model. This is because questions examining issues such as sustainability and drought impacts can only be addressed under different scenarios of climate, population pressure, economic policies, livestock and cropping parameters, etc. Not all model components need to be built from scratch. Submodels dealing with dryland cultivation (e.g., CENTURY), ruminant production, and use of landscapes by herbivores, already exist and may be adopted or adapted. The greater challenge for the Bolivia team probably lies in quantifying population dynamics, crop-livestock interactions, and human resource-allocation decisions, and sources of variation for some of these components. The system concept must also link the project at San José Llanga to broader development issues in Bolivia as well as other semi-arid regions of the developing world. While the community of San José Llanga is somewhat unusual on the altiplano in terms of uptake of production innovations and change taking place in the traditional system, it is precisely this unusual character that makes San José a "living laboratory" for studying issues such as the sustainability of induced change. There are also many similarities between the situation in San José and peri-urban locations elsewhere in developing countries.

## Progress

The systems analysis for San José Llanga has barely begun. Progress to date includes planning for compiling the first draft of system-level hypotheses and key system interactions. The systems concept will focus on the roles of small ruminants in promoting sustainability, economic growth, and the persistence of the agropastoral system at San José. The project thus emphasizes how small ruminants are used, whether these uses are changing, how current uses could be facilitated, and whether improved production of small ruminants is compatible within the dynamic constraints of the resources and changing priorities of the campesinos.

An initial proposition is that small ruminants may contribute to economic growth and change through their subsidization of dairy production, whose expansion at San José may be limited ultimately by the availability of alfalfa fields for high-quality forage. Dairy production is reportedly attractive to the campesinos because it provides more frequent income, and this income partially substitutes for sales of animals that campesinos prefer to hold as assets. (This is a common finding in Africa.) In contrast, sheep may have been sold traditionally to meet acute cash needs in addition to their role as a means to store wealth. In the San José context, sales of small ruminants may now be a critical source of funds to purchase cattle, feeds, and veterinary inputs for the cattle herd. It is in the national interest of Bolivia to promote peri-urban dairy production in the La Paz milkshed to reduce dependence on powdered milk imports, as these stocks are

declining globally. Peri-urban dairy production in dry environments is a major issue worldwide. In this broad national perspective for Bolivia, sheep on the altiplano could be the engine which allows small-holder dairy production to occur. Without cattle, such a scenario may never be realized. This is because the cattle represent one of the first outlets for income generation that justifies nontraditional use of sheep for economic growth in addition to wealth storage. Similar conceptual linkages of small ruminants to crop diversification also need to be explored.

The project can make a major contribution to how sustainability is defined, interpreted, and evaluated for this and similar ecosystems. An evaluation of sustainability should include social and economic as well as ecological aspects. Range trends and livestock population dynamics are critical in evaluating the equilibrial or non-equilibrial nature of the system and assessing the degree to which grazing pressure directs vegetation change. The influence of livestock may be species-specific; for example, substitution of sheep for camelids has been implicated in range deterioration in the altiplano. Cattle's role in land degradation, or as competitors to sheep or camelids, can only be interpreted at the system level. Finally, the role of livestock in transferring nutrients from rangelands in support of crop production is another crucial topic in sustainability. The principal fertilizer application at the beginning of a crop rotation is in the form of sheep manure.

The Community of San José Llanga has persisted for centuries through countless frosts and droughts. Persistence, however, does not necessarily equal sustainability. The role of small ruminants in promoting persistence and sustainability of the community can be addressed at the household level through studies of small ruminants' use as insurance and assets to enable recovery from perturbations. This is a major theme of the original project proposal.

## Training

*In progress*

Robert Washington-Allen, M.S. in Range Science, 1993, Utah State University, Logan

Lita Buttolph, Ph.D. in Range Science, 1995, Utah State University, Logan

Nelson Massy Quiroga, B.Sc. in Agronomy, 1993, Universidad Técnica de Oruro.

Freddy Flores Choque (until November 1992), B.Sc. in Agronomy, 1993, Universidad Mayor de San Andrés

Roberto Miranda Casas (since November 1992), B.Sc. in Agronomy, 1993, Universidad Mayor de San Andrés

*Partial support*

Humberto Alzérreca, Ph.D. in Range Science, 1995, Utah State University, Logan

Jorge Laura Camacho, B.Sc. in Agronomy, 1992, Universidad Técnica de Oruro

Juan Flores Rocabado, B.Sc. in Agronomy, 1992, Universidad Autonoma "Tomas Frias," Potosí

Erick Moron Rios, B.Sc. in Agronomy, 1992, Universidad Técnica de Oruro

Lino Fausto Torrez Ibieta, B.Sc. in Agronomy, 1992, Universidad Mayor de San Simón, Cochabamba

## Contributions

### *Environmental impact*

The characterization of resources begun in the first year of field research has identified wind erosion on farmland as a potentially important contributor to deterioration of the agricultural production base. Windblown sand drifts across fields and accumulates as sand dunes. A native shrub which invades readily on fallow fields will be harnessed in trials to establish windbreaks around parcels of cropland. Fallow-field management will be examined in terms of rate of revegetation to stabilize the soil. Salinity is a critical problem over approximately one-third of the central altiplano

and is manifest in the rangelands of the study site. Studies to better understand and monitor salinization are currently underway, and efforts to rehabilitate barren areas will begin in 1993.

### *Agricultural sustainability*

Agricultural production at the study site is diversified among a variety of livestock and crops and a mixture of range, pasture, and farmland resources. These components are integrated by the community into a system whose core is a subsistence strategy shaped by centuries of adaptation to uncertainty in climate and markets.

Subsistence production tends to be intrinsically sustainable because it maximizes self-reliance and minimizes risk and dependence on inputs beyond the community's control; instead, opportunism and versatility are emphasized. Our first year of study has shown, however, that (a) periodic drought can inject major perturbations into the dynamics of the system, and (b) the community is becoming entwined in an attractive commodity enterprise in the form of dairy production, in addition to other outside influences to which it was less accessible in the past. The goal of the project is to pinpoint the weaknesses in the production system which jeopardize its integrity in the face of adversity, either ecological or economic, and thus to suggest mechanisms to enhance the long-term well-being of the inhabitants.

### *Contributions to U.S. agriculture*

The Bolivian agropastoral project has adopted an integrated, interdisciplinary approach to understanding the biological and socio-economic dynamics of the production system. Although a systems perspective has frequently been applied to agriculture in developing countries, it is uncommon in the United States. Nevertheless, the amounts and kinds of livestock production in the U.S. are determined as much by the economic, social, and policy environment, including transport and marketing infrastructures, as by a collection of climatic and biological parameters. The production systems analysis for the agropastoral community in Bolivia will be the companion to a project funded by the Utah Agricultural Experiment Station to assess the adoption of technological innovation by livestock producers in Utah and should have a synergistic influence on the success of the American counterpart. In each case the study will attempt to clarify interactions among biological, technical, and socio-economic factors, embracing issues of land-use policy and practice as well as cultural dimensions. Both studies will attempt to explain why specific technical innovations which demonstrably have the potential to significantly improve livestock production are, or are not, adopted by the producers.

### *Contributions to host country*

1. USAID had expressed some concern that too much agricultural research in Bolivia has been confined to established research stations and few results were extended to, and adopted by, the campesinos nearby. From its inception, the agropastoral project has been located in an indigenous community. The benefit to the host country is expressed in a greater willingness on the part of agricultural scientists to work with the campesinos to identify priority problems for research programs to address. The SR-CRSP approach encourages scientists to think of on-station research as complementary to on-farm trials in a realistic production setting. The Bolivian students and technicians being trained by the project will be indoctrinated into the merits of on-farm research and this may be our most lasting legacy.

2. There is a clear differentiation of gender roles at San José Llanga. Women and children do almost all the herding of small ruminants. In view of the importance of women in the use of rangeland resources we have approached Ms. Sonia Aranibar who deals with Women in Development programs at the USAID Mission. The project will define the role of women in the management of the community's livestock and land resources and determine the nature of

their decision-making responsibilities for those resources. The range ecology project is a major contributor to the biological database which will be utilized by the sociologists and economists as they examine gender issues in the community.

3. Utah State University has explored opportunities for collaboration and data exchange with representatives of Bolivia's remote sensing organization ABTEMA (Asociacion Boliviana de Teledeteccion para el Medio Ambiente). These contacts were organized through Maximo Liebermann, USU's Co-Investigator at the Instituto de Ecología. At Maximo's behest, USU gave ABTEMA some copies of satellite imagery of Bolivia. The ABTEMA connection would link USU's Center for Remote Sensing, the remote sensing laboratory of the Instituto de Ecología in La Paz (University of San Andres), and ABTEMA in a three-way cooperative relationship. Information exchange and the prospects of collaboration are occurring also with the Canadian IDRC project, directed by Roberto Quiroz, which is working at the Community of Santiago de Collana, adjacent to San José de Llanga.

4. Dr. Layne Coppock, Co-principal investigator of the USU subproject, brings to the SR-CRSP ten years of experience with pastoral production systems in East Africa. He has recently completed a synthesis of interdisciplinary research conducted by ILCA in the Borana region of the Ethiopian highlands. At present this link with ILCA is principally an intellectual one in which the SR-CRSP has inherited the conceptual thinking and synthetic skills underlying the Boran production systems analysis. Subsistence agropastoralism has fundamental similarities no matter where it occurs, however, and it would be a logical development to pursue a more organic link to ILCA in the near future.

### *Support for free markets*

The community of San José Llanga is in an economic transition marked by an emergent dairy industry which first appeared three or four years ago. Now about half the families in the community sell milk on a daily basis. We surmise that this shift in enterprise towards a readily marketable commodity is backed by flocks of small ruminants which provided the capital to enter the market and comprise a cash reserve if the dairy business runs into difficulties, such as the elimination of current subsidies. In this view the dairy marketing venture will be propped up by a diversified, sustainable, and robust livestock sector in the community, which is the goal of the SR-CRSP agropastoral project.

### *Compliance with Mission objectives*

The altiplano has the highest population density of any region in Bolivia. The rural population is vulnerable to vicissitudes such as drought and frost. Dislocated families drift to the urban fringe where they add to poverty and unemployment and become a drain on Bolivia's resources. The SR-CRSP agropastoral project is concerned with the integrity and resilience of rural communities in the face of adversity and with the ability of agricultural households to overcome the hardships of subsistence production and be able to purchase needed inputs with cash from commodity sales. To the extent that the Mission shares this desire for a stable economy in the rural sector of the altiplano, the SR-CRSP is making a contribution to Mission objectives. Furthermore, perturbations to the agricultural economy of the altiplano exacerbate the flow of labor to coca-growing regions of the country. If the SR-CRSP can incidentally reduce the need for such emigration, as it intends, then it indeed complies with Mission objectives.

### *Concern for individuals*

The SR-CRSP project is based within a rural community of 104 households. It works with family members in order to unravel the nature

of interdependent resources and management strategies that comprise the production system of San José Llanga. And it plans to work at the level of families and individuals in efforts to try out possible improvements to the productivity or sustainability of the system. In all aspects of its research the project operates at the denominator of individual herders or households and the resources they control.

### *Support for democracy*

The presence of SR-CRSP scientists in the community of San José Llanga is under the auspices of a contract signed with the elected leaders of the community. The project team respects this leadership, engages in activities only with the leadership's permission, and thus reinforces the democratic system of community administration.

### *Humanitarian assistance*

By its nature, the Small Ruminant SR-CRSP cannot engage directly in humanitarian assistance. Nevertheless, project staff provide informal assistance by giving advice to the people when asked and helping campesinos travel to and from town. The project generates income for the community through rent paid for accommodation for scientists who visit the site and technicians who live there. The SR-CRSP was pleased to be informed that the community welcomed the agropastoral project partly so that the rental income could help them build a new school. For its part, the Bolivian collaborating institution, IBTA, provided an architect for the new school free of charge. In the year since the SR-CRSP began work in San José the school has been built and is a fine structure indeed.

## Collaborating Personnel

*United States*

Brien E. Norton, P.I., Associate Professor, Utah State University

D. Layne Coppock, Co-P.I., Assistant Professor, Utah State University

R. Douglas Ramsey, Co-P.I., Assistant Professor, Utah State University

John C. Malechek, Co-P.I., Professor, Utah State University

Dean Treadwell, Farmer-to-Farmer Program, University of Arizona

*Bolivia*

Humberto Alzérreca, Co-I. (until August 1993), IBTA

Jaimé Valdivia, Co-I. (from August 1993), IBTA

Maximo Liebermann, Co-I., Instituto de Ecología, Universidad de San Andrés

*Collaborating scientist*

Jaimé Valdivia, IBTA

## Collaborating Institution

Instituto Boliviano de Tecnología Agropecuaria
Casilla Correo 5783, Plaza España Esq.
Mendez Arcos 710
La Paz, BOLIVIA

## Publications

None from SR-CRSP research during the reporting period

# *Sustaining Small Ruminant Production in the Andean Agropastoral Zone*

Texas Tech University

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## Narrative Summary

This report covers the period of activity from 1 January through 31 December 1992. Texas Tech University is actively involved with research, training, and administration of the Sustainable Agropastoral Systems in Marginal Lands component in Bolivia. Research focuses on the understanding of feed resources available to grazing animals, the nutritional contribution to their diets, and the role of small ruminants in the system. Research centers around drought and drought strategies for the Bolivian highlands (altiplano). Feeds resources under study are those present in the agricultural areas, those under various stages of fallow or deferment, and native prairies. We are also engaged in research leading to an understanding of the animal-plant interface in an arid Andean environment. Baseline studies include water availability and quality, as well as livestock production traits of the peasant community. Training of students is one of the most important tasks for Texas Tech University since human resources are among the most valuable impacts our program will leave behind. Eight Bolivian students are involved in the training process. Texas Tech University also has responsibility as the lead institution for the Agropastoral Component and is fully integrated into a multidisciplinary team of sociologists, economists, animal scientists and nutritionists, and range ecologists.

## Research

As part of the administration process, we participated in the selection of the Bolivian counterparts. An important effort was to establish a working relationships with the peasant community of San Jose Llanga. Once the agreement IBTA/SR-CRSP/San Jose Llanga was signed, the most critical problems affecting the peasants and their environment were identified. Detailed research planning in the area of animal nutrition and feed resources was conducted at the beginning of the reporting period. Research began in April 1992 and included four Bolivian students. Four more Bolivian students began research between June and August 1992.

Research activities covered during this period in Bolivia:

1. Weather analyses to establish drought periodicity.
2. Vegetation characterization on agricultural areas and fallow fields.
3. Sheep production traits.
4. Spatial and temporal distribution of peasant herds.
5. Use of feed resources by livestock.
6. Nutritional analysis of the livestock diets and feed resources.
7. Development of vegetation under grazing.
8. Water analyses for quality and quantity.

## *Activity 1*

### Problem statement and approach

Drought affects peasant communities. Analyses of climatological data may help extensionists understand when droughts occur and their relative severity.

With the help of SENAMI ("Servicio Nacional de Meteorologia de Bolivia") we obtained information on rainfall from 1943 to 1990 (Figures 1a and 1b). These data come from the town of Patacamaya, 16 km northeast of San Jose Llanga.

### Progress

Preliminary data shows that there is not a drought pattern for the area. However, ten years had a deficit rainfall of more than 50 mm below normal while only seven years received more rainfall than normal. About 14 years received the 427 mm annual average rainfall. An important aspect to consider is frost days, which have a major economic impact on the campesino communities in the Altiplano. Seven months of the year had an average of more than ten days of frost at Patacamaya. An in-depth study of the weather is currently being carried out by Oscar Peña.

## *Activity 2*

### Problem statement and approach

Fallow fields are an important feed resource for small ruminants and other community animals. No information is available on vegetation growing in fallow fields.

Biomass residues of fallow fields were obtained in May-June after harvest (Table 1). An assessment of vegetation cover, diversity, and density in the agricultural areas was conducted in December 1992.

### Progress

Vegetation basal cover varies little with years of rest (Figure 3a). However, shrubs increase and reach nearly 30% of basal cover by the sixth year after fallow. Forbs decreased from over 50% cover in the first and second years down to less than 5% in fields with more than six years of rest (Fig. 3b). Total density of plants was highest during the second year of rest of fallow fields (Fig. 4). The most important forbs found in December were *Malva silvestre, Paronichia chilensis, Chenopodium quinoa* and *Oenothera punae.* The most important grasses were *Distichlis humilis* and *Bouteloua simplex. Tetraglochis sp.* and *Parastrepia lephydophylla* were the most important shrub species.

**Table 1. Post-harvest biomass of crop residues found in different soil types in San Jose Llanga, Bolivia, May-June 1992.**

| Crops/soil type | Ton/ha | S.D. |
|---|---|---|
| Barley/sandy loam | 0.53 | 0.12 |
| Barley/clay loam | 1.19 | 0.23 |
| Oats/clay loam | 1.66 | 0.45 |

### *Activity 3*

#### Problem statement and approach

At least 53% of the campesinos in the Altiplano depend upon sheep production. However, they share many problems including commercialization, price regulations, and lack of organization. Campesinos are not adequately managing the sheep herd.

Sheep production traits are being quantified in terms of animal weights and lamb crops.

#### Progress

In San Jose Llanga, sheep weight gain is greater in improved male lambs and in Corriedale female lambs than in male or female "criollo" (young alpaca and llama). Within Sabilani, the zone with the greatest sheep weight gain, animals had better genetic and feed resources. Betty Villanueva is conducting in-depth studies on this area.

### *Activity 4*

#### Problem statement and approach

The use of the community lands by animals is not well defined, yet it is important in evaluating feed resources available to animals. Spatial distribution of certain flocks were plotted on a community map.

#### Progress

Agricultural fields most used for grazing are those just harvested and those fallowed for one year. Also highly used are those fields rested for more than six years. Cattle used mostly native prairies, where they are tethered in one place each day. In the agricultural areas, cattle are herded through the fields. Cattle are also herded to alfalfa fields. Donkeys are taken along as beasts of burden, so they are herded mostly to recently harvested fields and areas where the campesinos can harvest "thola" (*Parastrepia lepidophilla*). Sheep are grazed mostly on agricultural areas except for November and part of December (growing season) when agricultural areas are banned from grazing.

Campesinos graze their animals only about six hours in winter, increasing the grazing time up to nine hours in the summer. Zulma Victoria is conducting in depth studies on this area including behavioral patterns of livestock while grazing.

### *Activity 5*

#### Problem statement and approach

The competition for feed resources could limit production of small ruminants. Nutritional evaluation of diets is important to understand the relevance of diet overlap. Animal foraging habits were observed to determine diets and potential overlap.

#### Progress

Diet overlap is mostly between cattle and donkeys when data was pooled into forb, grass, and shrub categories. However, cattle and sheep diets overlap on fields rested one year. Overlap was greatest for *Chenopodium* spp. A highly used species, *Bouteloua simplex*, is preferred by donkeys. This study is being complemented by a nutritional analysis of diets. Magali Caceres and Ester Lopez are working in this project.

### *Activity 6*

#### Problem statement and approach

Environmental impact of grazing is manifested in its impact on feed resources. Enclosures were erected to protect plants from grazing. Vegetation development was compared to areas grazed by peasant livestock.

#### Progress

Maria Eugenia Jimenez is doing a study to consider this aspect. No analysis of the data has yet been conducted.

### *Activity 7*

#### Problem statement and approach

Water is a limiting factor in drought-prone environments. The availability of water is unknown for San Jose Llanga.

Quality water analyses are currently being conducted on wells found at San Jose Llanga in the prairie area. The superficial quantity of water is also being measured since July.

### Progress

Area rainfall and stream flow of the "Desaguadero" river will be analyzed for the past 25 years to determine the variation of quantity and possibilities of using this water for livestock and irrigation.

### Administrative duties and progress

Program Representative Morty Ortega was involved in or directed:

- The establishment and administration of the SR-CRSP office in La Paz, including supervision of the personnel.
- The liaison between the U.S. A.I.D. Mission, IBTA, World Bank, Instituto de Ecologia (Universidad Mayor de San Andres) and NGO's such as AIGACAA (Asociacion Integral de Ganaderos en Camelidos de los Andes Altos), CEPROMU (Centro de Promocion de la Mujer), and SEMTA (Servicios Multiples de Tecnologias Apropiadas).
- The establishment of an agreement between the peasant community of San Jose Llanga and IBTA/SR-CRSP. The agreement was signed in January 1992.
- The employ and training of Bolivian technicians for research at San Jose Llanga.
- The process of electricity installation at the Patacamaya Research Station
- The procurement of equipment and supplies, including a computer for field assistants to be installed at the Patacamaya Research Station, and the process of bringing four vehicles through customs to be used by the SR-CRSP team.
- Weekly meetings with the SR-CRSP team, monthly meetings with SR-CRSP personnel and field students, occasional meetings with San Jose Llanga authorities, and other meetings with IBTA managers, NGO's, and other institutions.
- The organization of a retreat of IBTA personnel held in April at Lake Titicaca. This was coordinated with Tom Yuill, World Bank Project Manager.

### United States

No research activities were conducted.

## Training

*Bolivian Trainees*

Cristian Garay, Post-Degree Fellow, SR-CRSP/ Bolivia, Animal Science

Magali Caceres, Thesis, Universidad Autonoma Tomas Frias, Potosi, Bolivia, Animal Science

Freddy Flores, Thesis, Universidad Mayor de San Andres, La Paz, Bolivia, Animal Science

Maria Jimenez, Thesis, Universidad Mayor de San Andres, La Paz, Bolivia, Range Science

Ester Lopez, Thesis, Universidad Tecnica de Oruro, Oruro, Bolivia, Animal Science

Oscar Peña, Thesis, Universidad Mayor de San Andres, La Paz, Bolivia, Range Science

Zulma Victoria, Thesis, Universidad Autonoma Tomas Frias, Potosi, Bolivia, Animal Science

Betty Villanueva, Thesis, Universidad Tecnica de Oruro, Oruro, Bolivia, Animal Science

*Short-Term*

A workshop for IBTA/SR-CRSP personnel in Bolivia was held in the city of Coroico. The workshop was organized in conjunction with Texas Tech University, University of Missouri, and Winrock International. During this workshop Texas Tech University and Winrock International held a symposium on systems research. Twenty-eight participants spent three days in formal discussions and presentations of research on Andean agropastoralism.

## Contributions

### *Environmental impact and relevance*

Rangeland environments are affected by grazing animals. Research is directed at understanding grazing impacts on the native vegetation in terms of plants and animal and the development of fallowed areas when grazing is excluded.

### *Agricultural sustainability*

Sustainability of agricultural systems depends upon an understanding of how animals use feed resources and their production traits. Interventions to sustain livestock production can only be developed after knowledge is obtained.

### *Contributions to U.S. agriculture*

Evaluating drought strategies could lead to improved sustainability in semiarid and arid regions of the United States. Faculty enrichment through international involvement helps U.S. researchers understand global problems and relevance of research and training. Such involvement can pay dividends to U.S. agriculture in the future.

### *Host country*

*Linkages and Networking:* Linkages have been established with several Bolivian institutions. A proposal was submitted to the U.S. Information Agency to create a faculty exchange program between the Instituto de Ecologia, Universidad Mayor de San Andres, and Texas Tech University.

*Gender Analysis:* At least five of the eight Bolivian students currently in training are women.

*Collaboration with International Research Centers (IARCS) and other CRSPs:* No contact has been made with other International Research Centers.

### *Support for free markets and broad-based economic growth*

Understanding the role of small ruminant production traits and production cycles and developing interventions will aid in improving the economic growth of peasant communities.

### *Contributions to and compliance with mission objectives*

Human resource development is the number one priority of the USAID Mission in Bolivia. Texas Tech University's efforts to train Bolivian students contributes to the Mission's overall objectives.

### *Concern for individuals*

Educational programs, short courses, and training demonstrates our concern for individuals.

### *Support for democracy*

Through improved enterprise development of peasant communities, democratic principles are encouraged and sustained.

### *Humanitarian assistance*

Some of the poorest people in developing countries are peasants who depend upon animals and subsistence farming. The community of San Jose Llanga is one such group of poor people. Our efforts are humanitarian because they assist the poorest of the poor.

## Collaborating Personnel

*Overseas*

Dr. Carlos Salinas, M.V., Instituto Boliviano de Tecnología Agropecuaria

Lic. John Vargas, Instituto Boliviano de Tecnología Agropecuaria

Lic. Christian Jette, Instituto Boliviano de Tecnología Agropecuaria

Ing. Jaime Valdivia, Instituto Boliviano de Tecnología Agropecuaria

Lic. Maximo Liberman, Instituto de Ecología, UMSA

*United States*

Drs. Michael Nolan and Jere Gilles, University of Missouri

Drs. Ben Norton and Layne Coppock, Utah State University

Dr. Enrique Ospina, Winrock International

### Collaborating Institutions

Instituto Boliviano de Tecnología Agropecuaria (IBTA)

Instituto de Ecologia, Universidad Mayor de San Andres

Asociacion Integral de Ganaderos en Camelidos de los Andes Altos (AIGACAA)

Utah State University

Winrock International

University of Missouri

### Publications

Bryant, F.C. 1992. Grazing Systems: Are They the Solution to Rangeland Deterioration? IN: Proceedings of the IV Mexican Society of Range Management. July 1992 . Guadalajara, Mexico. (In Press).

Bryant, F.C. and C.A. Taylor. 1992. Meat Goat/White-Tailed Deer Relationships on Rangelands. pp: 157-164. IN: J.C. Paschal and C.W. Hanselka (eds.) Proceedings of the International Conference on Meat Goat Production, Management and Marketing. July 1992. Laredo, TX. 236 pp.

Ortega, I. M., and S. Scholz. 1992. El Programa de Rumiantes Menores, Su Metodologia y Objetivos. IBTA 127/Boletin Tecnico 05/SR-CRSP 01/1992. 9p.

### Abstracts

Caceres, M, I.M. Ortega, and F.C. Bryant. 1992. Feeding Behavior and Diet Overlap of Three Domestic Species in the Central Altiplano of Bolivia. pp: 20. IN: D.B. Wester and R.S. Lutz (eds.) Research Highlights Noxious Brush and Weed Control Range and Wildlife Management 1992. Texas Tech University, Lubbock, Texas. 46 pp.

Victoria, Z.R., I.M. Ortega, and F.C. Bryant. 1992. Spatial and Temporal Distribution of Livestock in the Central Altiplano of Bolivia. pp: 19. IN: D.B. Wester and R.S. Lutz (eds.) Research Highlights Noxious Brush and Weed Control Range and Wildlife Management 1992. Texas Tech University, Lubbock, Texas. 46 pp.

### Presentations

Bryant, F.C. 1992. Grazing Systems: Are They The Solution To Rangeland Deterioration? IV Mexican Society of Range Management. July 1992. Guadalajara, Mexico.

Bryant, F.C. and C.A. Taylor. 1992. Meat Goat/White-Tailed Deer Relationships on Rangelands. International Conference on Meat Goat Production, Management and Marketing. July 1992. Laredo, TX.

Ortega, I.M. 1992. La Ecologia y la Produccion Ganadera. XI Reunion Nacional de la Asociacion Boliviana de Produccion Animal. October 1992. Oruro, Bolivia.

### Funding levels and Mission support

USAID Mission involvement has been essential to the progress of our project in Bolivia. Mr. Bill Baucum and Ing. Hernan Muñoz have fully supported our activities. They understand that training given to young researchers is the main impact the SR-CRSP is going to leave behind in Bolivia. The Mission has also cooperated in the search for a second research site, by initiating contact with the Asociacion Integral de Ganaderos en Camelidos de los Andes Altos.

Figure 1. Rainfall At Patacamaya, Aroma Province, La Paz Department, Bolivia. (a) Average annual rainfall 1943-1990 period, (b) Excess-deficit rainfall.

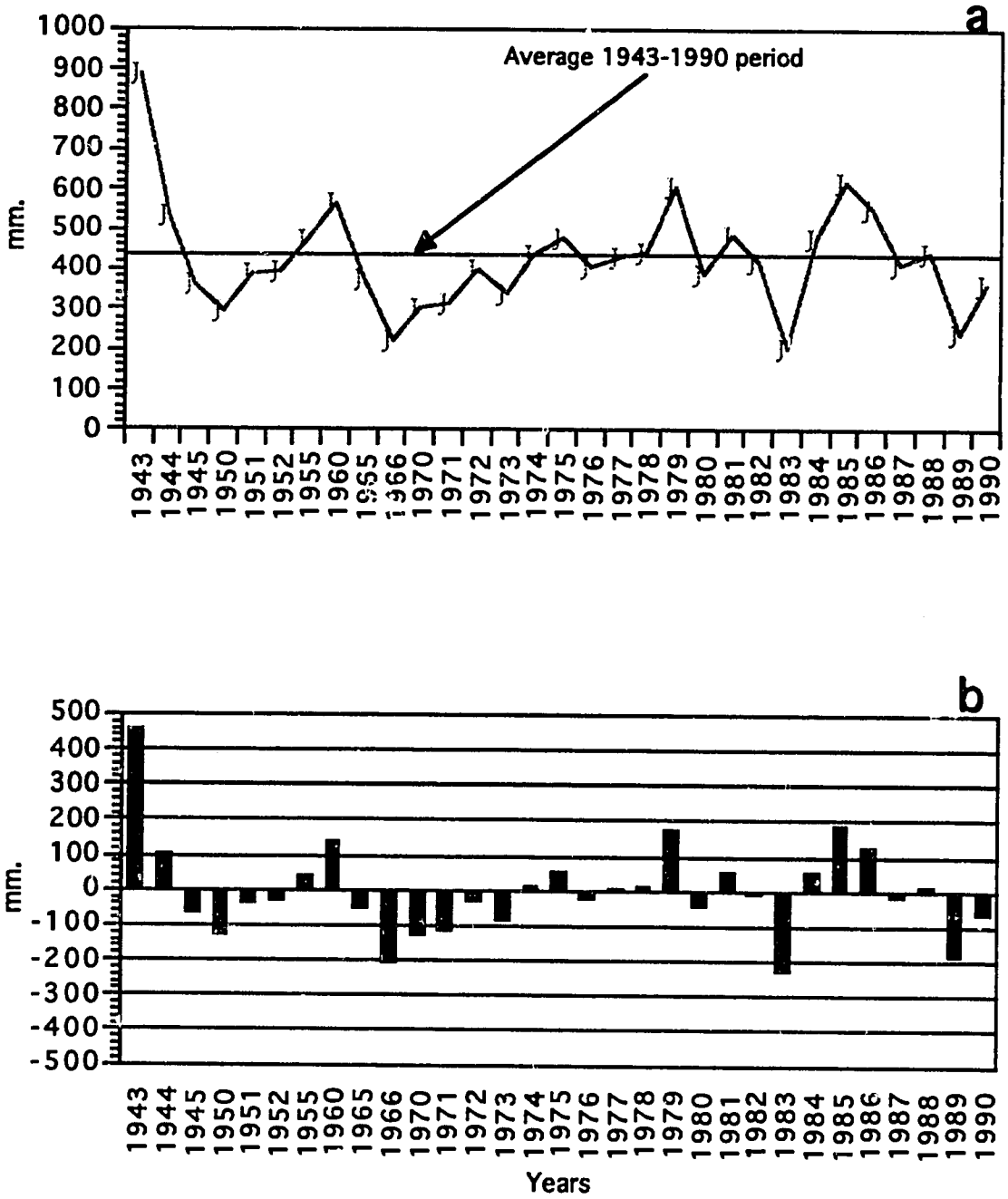


**Figure 2. Average number of frost days at Patacamaya, 1943-1990.**

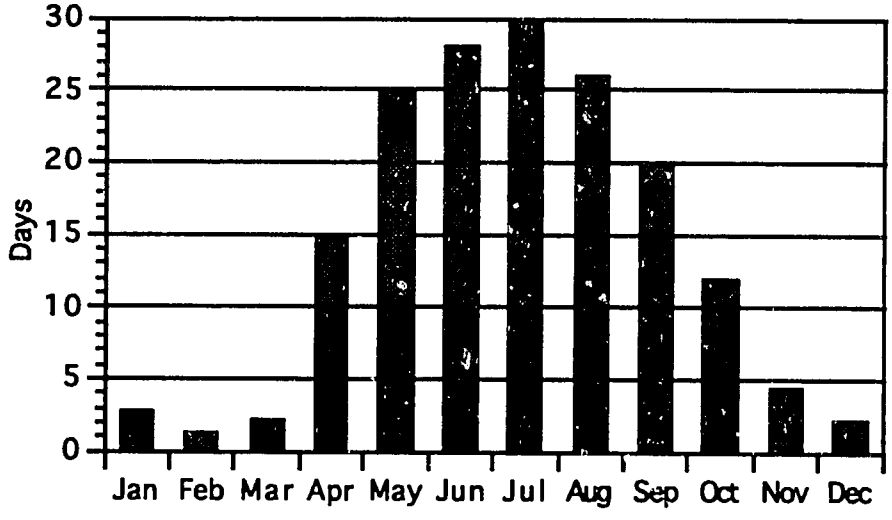


**Figure 3.** (a) Basal cover and (b) vegetation basal cover of fallow fields rested from 1 to over 6 years at San Jose Llanga.

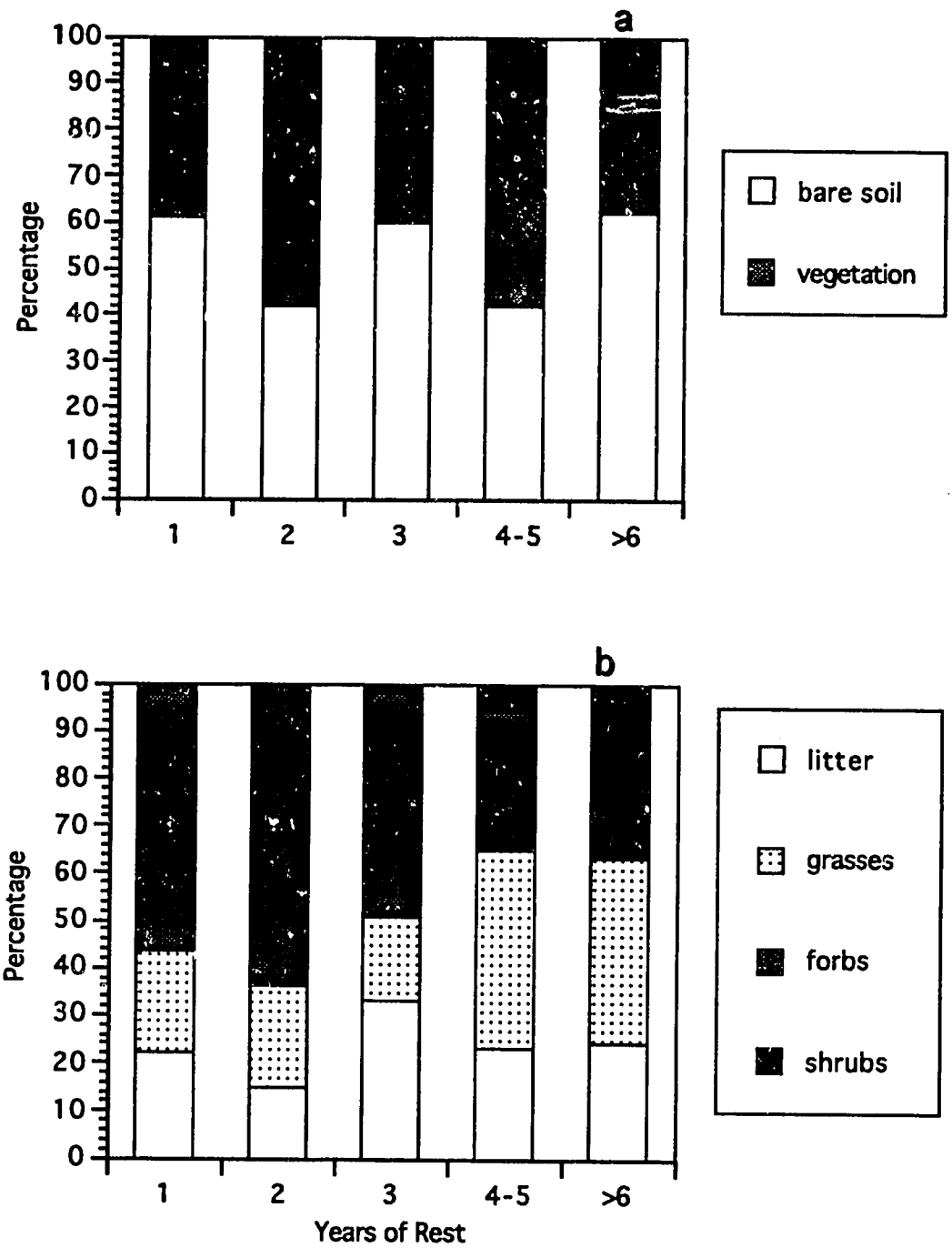
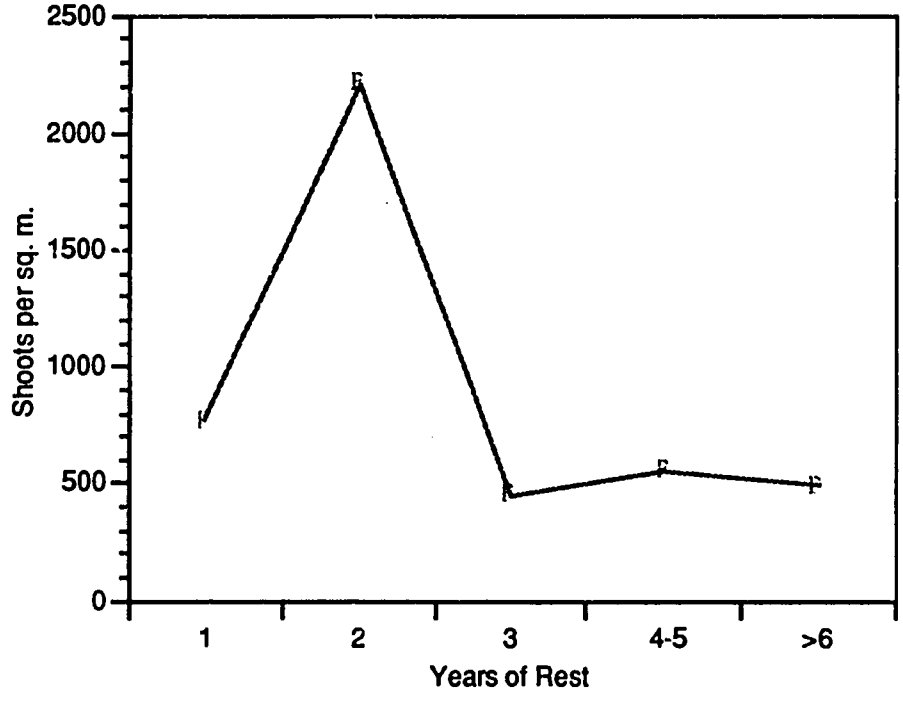


**Figure 4. Absolute density in fallow fields at San Jose Llanga.**



# *Economics of Small Ruminant Production Systems and Markets*

Winrock International

Enrique Ospina, Winrock International Institute for Agricultural Development, Petit Jean Mountain, Route 3, Morrilton, Arkansas, 72110. Telephone (501) 727-5435, ext.268, Fax (501) 727-5417.

## Narrative Summary

The primary field activity this year centered on conducting the survey in the San Jose de Llanga community. Preliminary results indicate there is strong outmigration of young men and, to a lesser extent, of young females. In the age group 16 to 20 years there are 3% males and 16% females; in the 21 to 25 year group the figures are 7% and 9% for males and females, respectively.

Survey results also indicate the average sheep flock size is 28 animals per family. Some families also own three to four cows. Preliminary regression results show no significant relationship between land (hectares) and number of animals owned. Of the 120 families, 69 owned cows and half of them sell the milk to a cooperative. On average, these families sell 1770 liters per year that yields US$500(milk prices are subsidized). Because a strong milk market exists, milk production is the most important animal product. The resulting revenue from milk was very important during the last drought. Survey results indicate local practices to cure common animal health problems are well understood. They include the use of petrol, oil, sodas, and other substances to treat problems such as goiter, bloat, internal parasites, and high temperature. A study on ethnoveterinary medicine is underway.

## Research

### Problem statement and approach

Over one-half of the world's small ruminants live in drought-prone, marginal lands where animals depend on rangelands and crop residues from dryland agriculture. Producers in these areas must deal with environmental market risks that can undermine the ecological and economic sustainability of agriculture. Small ruminants are well adapted to these regions and contribute to the sustainability of agriculture by reducing the risks involved in agricultural production and by providing soil nutrients and capital needed for agriculture.

At the present time population and market pressures are threatening the sustainability of drought-prone agropastoral zones. The sustainability of agriculture and livestock in these regions is very important to the survival of the people and the enhancement of the environment. Livestock, particularly small ruminants, play a major role in risk management strategies in the drought-prone areas.

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 constitute the focus of the economics program: assessing the resources available for small ruminant production, evaluating the institutional structure to identify major constraints and proposing changes, and analyzing

the economic implications of gender roles in production of small ruminants and of processing and marketing products.

Baseline analysis is the primary step in assessing resources and conducting impact analyses in the future. Establishing a baseline data on the production system and the resources available and identifying the potential to increase productivity and income in the community of the San Jose de Llanga has been a primary activity. This past year, three students have been gathering the necessary information. They have been living in the community to identify the relevant economic production and resource parameters and increase knowledge and understanding of these parameters' role in the local economy; a second community is currently being identified. The students' work will be presented as degree theses.

A second important activity has been to design and conduct structural and institutional analysis of small ruminant product processing and marketing activity to evaluate what occurs beyond the farm gate. The objective is to identify and evaluate existing institutional structures, including markets and government regulations (or lack of them) for the small ruminant product (meat, milk, hides, wool) markets; to identify ways to alleviate the negative effects of government policies and regulations; and to propose ways for the public sector to promote value-added activities and internal and external trade. One student has been working on gathering information in La Paz and in regional markets and is preparing a degree thesis on non-traditional exports, with emphasis on sheep hides.

Another important activity has been to conduct economic analysis of gender roles in production, processing, and marketing of small ruminant products. The ultimate objective is to identify program interventions and training needed to increase economic opportunities and incomes of the members of the communities. The gender role economic analyses are primarily descriptive, and guidelines for collecting information and for developing measurements and collecting information are being established. A workshop was conducted during the year to compare the experience of the different researchers working in this area, and three papers were prepared to increase gender awareness. One of the students is gathering information and identifying gender specific technologies while preparing a degree thesis.

Primary data for these analyses is currently being collected in the San Jose de Llanga community and in the livestock markets in La Paz and regional centers. Secondary data availability is currently being examined. All the data collected is being processed and stored in the project computers in the La Paz office in order to perform economic impact analyses for project evaluation. Students have entered and processed the data and will be performing the analyses in the coming months.

### Training

During the spring and summer of 1993, training activities have been organized to support five Bolivian students from different universities preparing B.A. theses while working on SR-CRSP-related problems. The students are:

Ximena Paredes
Rosa Lisarraga
Juan Jaillita
Beatriz Copa
Marcello Morales

In addition, a three-day seminar was offered on farming systems research, gender sensitivity, and problem solving to the students and to all staff. Students have also been offered training on computer software including work processing and spread sheets which is needed to conduct research. Two students are receiving training in statistical work and simulation. All the students are receiving editorial assistance to improve writing skills.

## Collaborating Personnel

*United States*
Enrique Ospina, Principal Investigator
Henk Knipscheer, Co-Investigator
Corinne Valdivia, University of Missouri

*Bolivia*
Sibylle Scholz, Resident Economist (since April 1992)
John Vargas, Bolivian Co-Investigator

## Collaborating Institution

Instituto Boliviano de Tecnología Agropecuaria (IBTA)
Plaza España esquina Méndez Arcos 710
La Paz, Bolivia
Tel. 011 591 239 2551

Strong relationships have been developed with several Bolivian NGOs. These are critical for future work, giving the strong role NGOs play in extension in Bolivia. Primary links have been established with CEPROMU (women issues in the altiplano), SEMTA (new appropriate technologies), and AIGACAA (camelids production and marketing).

## Publications

Ortega, Morty and Sibylle Scholz. El Programa de Rumiantes Menores: Su Metodologia y Objetivos. Boletin Tecnico 05, 1992.

## Abstracts and Presentations

Papers prepared for the International Telecomputer Conference on Perspectives on Livestock Research and Development in Lesser Development Countries, sponsored by IDRC:

Scholz, Sibylle, W.H.M. van Immerzeel, Juan V. Nunez del Prado. Culture and Sustainable Agriculture: An Example from the Andes.
Scholz, Sibylle, and Carmen Llanos de Vargas. Gender Consideration in Livestock Development.

Scholz, Sibylle, Roberto Quiroz, Carmen Llanos de Vargas, Anibal Castillo. The Role of NGOs in Development: The Case of Bolivia.

Quiroz, Roberto, and Sibylle Scholz. FSR/E and Livestock Research and Development Projects.

Scholz, Sibylle, and Florencio Zambrana. To What Extent does IBTA Conform to the Recommendations Suggested by the Expert Consultation on Minimal Critical Mass of Resources Required to Conduct Livestock Research.

Scholz, Sibylle and Carmen Llanos de Vargas. Demographic Changes, Technology Changes and the Role of Women in Agriculture.

Scholz, Sibylle. Policies, Politics and Projects.

Scholz, Sibylle. Gender Planning in Development Projects.

# *Sociological Analysis of Small Ruminant Production Systems*

University of Missouri-Columbia

Michael F. Nolan, International Agricultural Programs, 228 Gentry Hall, University of Missouri, Columbia, Missouri, 65211. Telephone (314) 882-6085, Fax (314) 882-5127.

## Narrative Summary

The sociology program serves two roles in the agropastoral component: a) providing services to the other disciplines through acting as the project's facilitator and official representative to the San José Llanga Peasant Community and b) conducting service and disciplinary research.

The research activities conducted during 1992 span both the 1991-1992 and 1992-1993 workplans. The activities planned for 1991-1992 were: site selection, including establishing the criteria to be used in defining an agropastoral community in semi-arid regions; development of a baseline questionnaire to be administered to households in the selected agropastoral communities; and publishing the proceedings of the workshop that took place in Lubbock, Texas, in 1991. This was co. ted in February of 1992.

The Bolivia counterpart for Sociology was hired by IBTA and started his work in January of 1992. His work as official liaison with San José Llanga Peasant Community, and guiding the basic data collection and training of students, was essential to the research during 1992. Service provided to the research program as official liaison between the community and the SR-CRSP takes approximately 25% of the sociology co-investigator's time. This includes coordinating all the students working in the community and guiding the collection of baseline information. In July, 1992, Missouri placed a resident scientist in Bolivia to complement the work carried out by the co-investigator.

The 1992-1993 workplan activities started in September. These activities were a continuation of the medium-term objectives of sociology and represented a focusing and greater refinement of the activities presented in the 1991-1992 workplan. Data collection for the assessment of community resources and patterns of interactions was initiated, first through a "ficha" (thematic index cards) system and then through a formal survey. This data is being checked against information obtained through in-depth interviews, gathered from ongoing projects. The social and environmental history of the community and region is being studied through archival research, interviews and cartographic aerial photo interpretation with the collaboration of Utah State University to determine the impact of institutional policies and environmental change on resource management.

A third research activity is the study of labor participation in agropastoral production by sex and by age. Structured, open-ended interviews and 24-hour activity recalls are being used to collect information. Access to key factors of production, land, and animals is the fourth research activity. Two students, both Aymara speakers, were selected and are being guided in their research in this area. Understanding of the social, cultural, and other means through which resources are obtained as well as its ease or difficulty have implications for the management strategies used and alternatives

that may be developed. A fifth activity was started in 1992 but will be completed around 1995. As part of an assessment of the impact on human capital development, a baseline profile of human resources in Bolivian research institutions, and current approach to research, was undertaken as part of activities for 1992-1993.

Budget limitations did not allow work to start in a second community during 1992. A special proposal has been developed and presented to the Management Entity to obtain research funds for a second site.

Two proposals submitted by University of Missouri to the New Initiatives Fund were funded and will start in 1993. The first is Gender and Livestock: Dairy Expansion and Traditional Agropastoral Systems in the Bolivian Highlands, and the second is Human Population and Environmental Degradation, the latter in collaboration with Utah State University.

## Research

### Objectives

Develop a practical methodology to assess resources, control and access, and the bio-social roles of livestock management in drought-prone agropastoral systems.

Identify and/or develop drought survival strategies of crop-livestock producers for semi-arid regions and the institutional, cultural, and social mechanisms used to reduce the risks posed by the environment and society.

Ensure that proposed interventions are viable and sound for the target groups, identifying the social, cultural and institutional constraints, and flexibilities of the production systems and the political systems in which these groups exist.

Strengthening the capacity of institutions in Bolivia and the U.S. to conduct research in social sciences.

### Problem statement and approach

The majority of small ruminants are in agropastoral semi-arid and arid zones with high climatic variability and periodic droughts. The ability to sustain a production systems in these conditions depends upon the integrated management of rangeland and croplands. A major role in the survival of households during drought is played by livestock, especially small ruminants. These animals, more than any other type of livestock, impact the welfare of women, children, and the elderly, who are segments of the population at greater risk during droughts and famine. The ability of agriculture to sustain human life and the environment depends on the way producers respond to climatic risk. Any proposed alternative to improve livestock production in these regions must be climate centered and, in the case of the Altiplano, must deal with droughts and frosts.

A systems approach is used to fulfill the goals of the agropastoral component. Within this component, sociology's activities consist in the short and medium term to provide baseline information on social control, access, and resource constraints. A gender sensitive approach in collecting survey data and interviewing is used in order to identify bio-social roles in the system. Differences in gender and age are believed to play a role in control and access to resources and income. Current and past notions and practices of conservation and survival strategies are being identified, as well as the effect of a changing environment on tenure. A historical approach, with review of literature, archives, and oral histories, is used to study past changes in the environment and its effect on the production systems. Interviews with researchers in Bolivia are the basis for future assessments on strengthening institutions on biological and social science research.

### Progress

Field and archival research undertaken in Bolivia during 1992 (activities 1-4 in the 1992-1993 workplan) represents a continuation and refinement of activities 2 and 3 presented in the 1991-92 workplan. A summary of each activity follows.

## *Assessment of resources and patterns of interactions.*

### Justification

One of the SR-CRSP's objectives as a multidisciplinary team is the development of a model that gives the best picture of all the interactions that take place between the natural, social, and economic factors important in an agropastoral production system. This model would provide a basis for evaluating the probable effects of modifications in this system.

### Progress

The first step in the elaboration of this model has involved collecting general data about human and animal populations and about agriculture and husbandry in San José Llanga (SJL). Toward this end, different types of methodologies have been employed. Initially, a system of "fichas" was used, comprised of thematic index cards (population, husbandry, agricultural production, land use, labor) on which each student living in San José was to record information acquired in the course of fieldwork. Assessment of the "fichas" in May and June showed that improvements needed to be done both to the "ficha" and the training and supervision of students collecting the information. In order to support this, Christian Jetté, sociology's co-investigator, came to Missouri for short-term training, research planning, and coordination. A formal survey with all the families of SJL, with questions taken from the "fichas," has been conducted. Finally, more precise and detailed data are now gathered from families included in samples selected for the different investigations underway in SJL. Lisa Markowitz, sociology's resident scientist, is coordinating the data collection.

Sociology researchers believe that data on SJL as a whole concerning human and animal population, and household composition, is reliable. In July 1992, the total human population was 421, 53% of which are women. There were 104 families, with an average number of 5.7 members, and 30% of the children of each household are living out of the community. It should be mentioned that preliminary analysis of more detailed demographic information (see activity 3) indicates an even higher out-migration rate among the parental generation. The migration pattern suggests a local preference for Cochabamba (although not the Chapare). The numbers for the total animal population are 4821 sheep, 467 cows, and 121 donkeys. It is difficult to have a clear idea of the distribution of these animals by family, given the complexity of animal management strategies (i.e., people often care for stock not belonging to their immediate family). Data collection from on-going projects, which should be completed by the end of the next budget year, will answer this question more definitely (as well as on land possession).

From the beginning, sociology has made understanding the communal organization a priority. Jetté's role as community liaison has greatly facilitated this aspect of research. His work requires constant interaction with community authorities, including the delegates of each of the six zones that comprise SJL. Closely related families live in these zones. Interestingly, it appears resource management practices in each reflect their spacial variation. However, the San José assembly, composed of representatives from all the families, defines general rules for adherence by all "comuneros."

### *Social and environmental history: Impact of institutional policies and environmental change on resources management.*

#### Justification

Much research on technological innovations is based on the assumption that increasing population and ignorance are the main causes of environmental degradation. These assumptions demand revision under the light of a better understanding, on one hand, of transformations occurring in the natural environment (those, for example, provoked by drought), and, on the other hand, of institutional changes (e.g., land reform). A realistic view of development possibilities requires an understanding of the relations between population increase, land erosion, introduction of new technologies, and national policies.

#### Progress

The work of reconstructing the logic of the historical transformations in the Llanga's region is based on several methodologies: interviews, archival research, and cartographic aerial photo interpretation. Christian Jetté is collaborating with Robert Washington Allen, from Utah State University, on the latter. To date, community documents from the 1960s have been analyzed; local historians have been consulted about archival sources; some literature on agrarian laws and proposed reforms has been reviewed; and a proposal seeking funds for historical demographic reconstruction was submitted to the Management Entity. Finally, the latest sociology "becaria" (Juan Huanca), hired in October, is investigating local perceptions of the natural world and tracking changing practices of natural resource use.

### *Labor: Participation in agropastoral production by age and sex.*

#### Justification

The availability of labor constitutes a key factor in the local acceptance of new technologies. Until the 1980's, work performed by women and children in agricultural production and social reproduction was neglected and under-reported, to the detriment of myriad development programs. Accurate information of this sort is particularly critical in the Andes, where women's involvement in cultivation is markedly greater than elsewhere in Latin America. In addition, young children assume major responsibility in the daily care of livestock, and, in this region, the variegated use of non-familial assistance (reciprocity and wage labor) is common.

#### Progress

To begin assessing individual roles in production, and the conditions influencing them, Sociology under the lead of Lisa Markowitz, has so far conducted structured open-ended interviews with 25 families in San José Llanga (out of a total sample of 33 [a third of those resident], selected to maximize demographic and socio-economic variation and ensure accessibility). The interviews cover household composition, family history, off-farm work, need for extra-familial assistance, and specify the daily tasks of each family member, including children as young as five. Additionally, 24-hour activity recalls have been collected from 31 junior high school students and 32 fourth and fifth graders.

### *Access to land and animals.*

#### Justification

Rural small-holders like those in San Jose obtain access to key factors of production through both commercial and non-monetized social relations. The relative ease or difficulty of acquiring land or livestock has many implications for yearly and seasonal management strategies, as well as the general economic well-being of a given family or individual. To understand local access to animals and access to plots and pastures clearer, two research projects are well underway. Two students from sociology at Universidad Mayor de San Andrés, both Aymara speakers, were selected to undertake

this area of research under the supervision of both Jetté and Markowitz.

### Progress

The first project (Edgar Cala) examines land tenure. Mr. Cala has nearly completed his collection of data from 25 families on the source, current tenure, and use of each of their parcels. His findings point to a divergence between ownership and actual use. Control of land, acquired through rent or non-cash arrangements, supersedes property as a critical element in household production strategies. Preliminary data analysis indicates an average total of 31 hectares of land per family, divided in an almost equal number of parcels (29). The second student (Rigoberto Espejo) explores the ways people acquire, maintain, and lose their herds. Research techniques include participant observation and structured interviews with some 25 families, coincident with the sample mentioned in the third activity. Since starting field work in August, Mr. Espejo has detailed acquisition practices, identified the variable economic and social roles of livestock, and enumerated holdings for about half his sample.

## *Baseline profile of human resources in Bolivian research institution and current approach to research.*

### Justification

The SR-CRSP and other CRSPs have always had problems assessing the impact of their programs in terms of human capital development. Number of trained personnel in host country institutions is the approach normally used to answer this question. The shifts in the quality and effectiveness of research cannot be assessed with this type of measure. Lags also exist between training and impact on productivity resulting in problems for impact assessment at the end of the program. In order to assess the impact on current research carried out by host country institutions, and how it may change as a result of the program, interviews will be carried out by Keith Jamtgaard at the beginning of the program, and a follow-up will be repeated hopefully in 1995. Interviews developed were concerned with the academic background, professional, and research experience of the Bolivian researchers. During the interviews, attention was given to how research problems were selected, the frequency with which research themes shifted, publication patterns, overseas contacts, and experience with researchers from other disciplines.

### Progress

The study design was a longitudinal panel study of professionals from two Bolivian institutions; a group of 12 researchers and administrators working with the Instituto Boliviano de Tecnología Agropecuaria (IBTA) at the La Paz headquarters and at the Patacamaya experiment station were interviewed. They were considered the experimental group as the expectation is that IBTA will be the closest institutional counterpart to the SR-CRSP.

Another research group was selected as a control group for the study. The inclusion of a control group was desirable because it would allow for identification of changes that could occur at the national level, affecting all researchers, and could be unrelated to the presence of the SR-CRSP. Five interviews were conducted with researchers and administrators working with CIF (Centro de Investigación en Forrajes) located at the University of Cochabamba.

### Training

Although long-term graduate degree training was not possible due to budget limitations, training constitutes an on-going component of the Bolivia project. This takes place in two forms.

1. Intensive supervision and advising of three sociology "becarios," as they develop skills in the following areas: qualitative social science research, word processing, manipulation of spreadsheets (both PC and Mac), and oral and

written presentations. These are:

Edgar Cala Chambi, B.A. (anticipated) 1993, Sociology, University Mayor of San Andrés, La Paz

Rigoberto Espejo Uscamayta, B.A. (anticipated) 1994, Sociology, University Mayor of San Andrés, La Paz

Juana Huanca Tarifa, B.A. (anticipated) 1994, Anthropology, University Mayor of San Andrés, La Paz

2. Short term workshops, or individual courses. These, listed in chronological order, all took place in 1992.

*Bolivia*

Patacamaya: Training workshop with first seven "becarios" and the whole IBTA/CRSP team; presentation on general history of the Altiplano and basics of Sociology by Jetté; January 27-31, five days.

Coroico: Project Retreat, systems research, examining gender (presented by Markowitz), August 4-6, attendance 30.

La Paz, IBTA: Carmen Vargas of CEPROMU, lecture/ discussion: Roles of Bolivian Women, August 19, attendance 15.

La Paz, Museo Etnografía: Student Prospectus Presentations, September 9, Attendance 40.

La Paz: Markowitz attended USAID workshop on incorporating gender into projects, October 6-7.

*United States*

Columbia, Missouri: C. Jetté, intensive computer, bibliographical research, and CRSP orientation, June 26-July 10.

Columbia, Missouri: L. Markowitz CRSP orientation, July 1-10

## Contributions

### *Environmental impact/agricultural sustainability*

One of our research projects (Juana Huanca's thesis) explores local or indigenous practices of natural resource conservation. Andean ethnographic accounts indicate considerable variability in both the knowledge and application of conservation technologies. Loss of information concerning the techniques, and the loss of time for their implementation, appear to limit sustainable production. The sociology household labor survey will contribute to our understanding of time constraints as criterion in resource management decisions (e.g., to use a tractor or plow). Ms. Huanca's research also concerns peoples' perceptions and understanding of the natural world as expressed through ritual and divination. This work can provide metaphors to serve important conceptual/methodological bridges between residents and researchers.

Flexible allocation of resources and diversification of production comprise two general strategies of agricultural sustainability in the Andes. Sociology research, with its concentration on access to factors of production, exposes this flexibility by documenting, for example, the conditions motivating people to switch forms of short-term land tenancy or initiate use of paid rather than reciprocal labor. Agropastoralists, of course, benefit from a varied source of income and foodstuffs. Jetté's analysis of regional institutions will clarify recent pressures mitigating against such diversification.

### *Contribution to the host country*

Sociology regularly and increasingly interacts with an array of NGOs, state agencies, and international research programs. These include: Center for Research and Support of the Peasantry (CIPCA)[Bolivia]; Alternative Technology [United States]; Appropriate Technology Multiple Services (SEMTA) [Bolivia];

Women's Support Center (CEPROMU) [Bolivia]; High Andean Camelids Integrated Association (AIGACAA) [Bolivia]; Taypikala [Bolivia]; Latin American Social Science Faculty (FLACSO) [Bolivia]; Bolivian Social History Institute (HISBOL) [Bolivia]; Andean Oral History Workshop (THOA) [Bolivia]; Economy and Rural Sociology Club [Bolivia]; The Norwegian Mission; the Dutch Mission; Peasant Self- Development Program II (PAC)[EEC]; IDRC: CIID [Canada]; ORSTOM [France].

Additionally, Markowitz and/or Jetté attended the following conferences which provided useful occasions for sharing ideas and information:

- New Agrarian Legislation, Santa Cruz, May 25-26;
- Indigenous Narrators Meeting, La Paz, August 12;
- Annual Ethnology Meetings, La Paz, August 25-28;
- Ethnic Economy Seminar, La Paz, September 11-12;
- Camelid Network, Oruro, November 29.

### *Gender*

Until the mid-seventies, social scientists tended to treat peasant households as undifferentiated units, with members sharing motivations and objectives. Since this time researchers have recognized the varying interests between individuals of different sex and age. Understanding the social dynamics of agricultural families and communities, and designing appropriate interventions, requires addressing variable concerns and aspirations. The sociology research design incorporates this awareness. While the household as a major unit of analysis is considered, the roles and perspectives of each person are identified. In forthcoming phases the six questions suggested by USAID (GENYSIS) will be evaluated: Who does what (household labor survey); who receives revenue [by Elizabeth Dunn and Corinne Valdivia (D-V)]; who spends what (D-V); who decides what (Markowitz); who controls essential resources (all student projects, Jetté's history, D-V). A particularly salient issue, outlined in Jetté and Markowitz, 1992, and addressed by Markowitz, forthcoming, is the impact of the transition to dairying on the status and well-being of women in SJL. This involves analysis of daily workloads, livestock ownership patterns, and control over milk revenues and the more amorphous valuation of technical knowledge and the comparative symbolic load of sheep and cattle.

### *Individuals and democracy*

Sociology does its best to demonstrate respect for the strong communitarian principles at play in San José and keep in the foreground that the campesinos, not the sheep or forage, are the intended beneficiaries of the project.

## Collaborating personnel

*Bolivia*

Christian Jetté, Co-Investigator Sociology, IBTA
Lisa Markowitz, Resident Scientist, Sociology, University of Missouri-Columbia
Robert Washington Allen, Graduate Student, Utah State
Edgar Cala, Field Assistant, Universidad Mayor de San Andrés
Rigoberto Espejo, Field Assistant, Universidad Mayor de San Andrés
Juana Huanca, Field Assistant, Universidad Mayor de San Andrés

*United States*

Michael F. Nolan, Principal Investigator, University of Missouri-Columbia
Jere L. Gilles, Co-Principal Investigator, University of Missouri-Columbia
Corinne Valdivia, Co-Principal Investigator, University of Missouri-Columbia
Keith Jamtgaard, Collaborating Scientist, Montana State University
Elizabeth Dunn, Collaborating Scientist, University of Missouri-Columbia
Domingo Martínez, Research Associate, University of Missouri-Columbia

## Publications

Jetté, Christian. 1992. "Relación de la historia con la investigación agropecuaria," INFO IBTA, no 4. La Paz.

McCorkle, Constance M., ed. 1992. "Plants, Animals & People Agropastoral Systems Research." Westview Special Studies in Social, Political and Economic Development. Westview Press, Boulder.

McCorkle, Constance M. 1991. "Pooling labor and herds," ILEIA Newsletter. December. Reprinted in IFOAM Ecology + Farming 4(1992): 19-21.

McCorkle, Constance M. and Donald L. Esslinger. 1992. "Communicating Project Results: A Model From An International Agricultural R&D Programme," The Journal of Development Communication 1 (3). June.

Valdivia, Corinne ed. 1992."Sustainable Crop-Livestock Systems for the Bolivian Highlands Proceedings of an SR-CRSP Workshop." Published by the University of Missouri-Columbia Press, Columbia.

Valdivia, Corinne. 1992. "Assessing the Impact of Policy on Peruvian Small Ruminant Production Systems." Development Studies Paper Series. Winrock International Institute for Agricultural Development, Morrilton. July.

## Abstracts and presentations

Gilles, Jere L. 1992. "Social Sciences and Collaborative Research Towards an Agenda for Social Sciences Research in Agriculture." paper presented at The Workshop on Social Sciences Research in the CRSPs. Lexington, Kentucky. June 9-11.

Jetté, Christian, and Lisa Markowitz. 1992. "A la Búsqueda de un Desarrollo Sostenible en el Altiplano Central. Sociología y Antropología en el Estudio de Sistemas de Producción." Encuentro Anual de Etnología, Bolivia. August.

McCorkle, Constance M. 1991. "The Roles of Animals in Cultural, Social and Agroeconomic Systems," address to the USAID/ROCAP/ UGIAAG/CATIE Symposium on Strategies for Sustainable Animal Agriculture and Natural Resources in Central America. San José, Costa Rica. November.

# Dual Purpose Goat

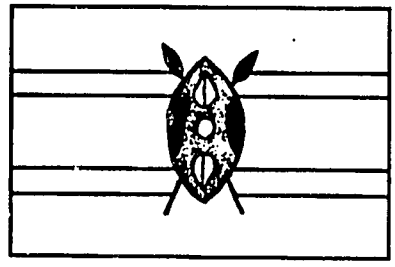
"Research in Kenya clearly shows that the dual purpose goat (DPG) has the potential for contributing significantly to the nutritional and economic welfare of households of small farmers. The milk-producing potential is the most important factor in the adoption of DPG by such farmers. . . .At the end 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*

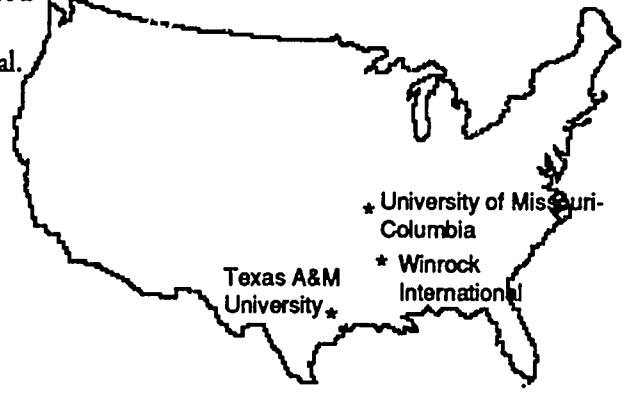
# Republic of Kenya

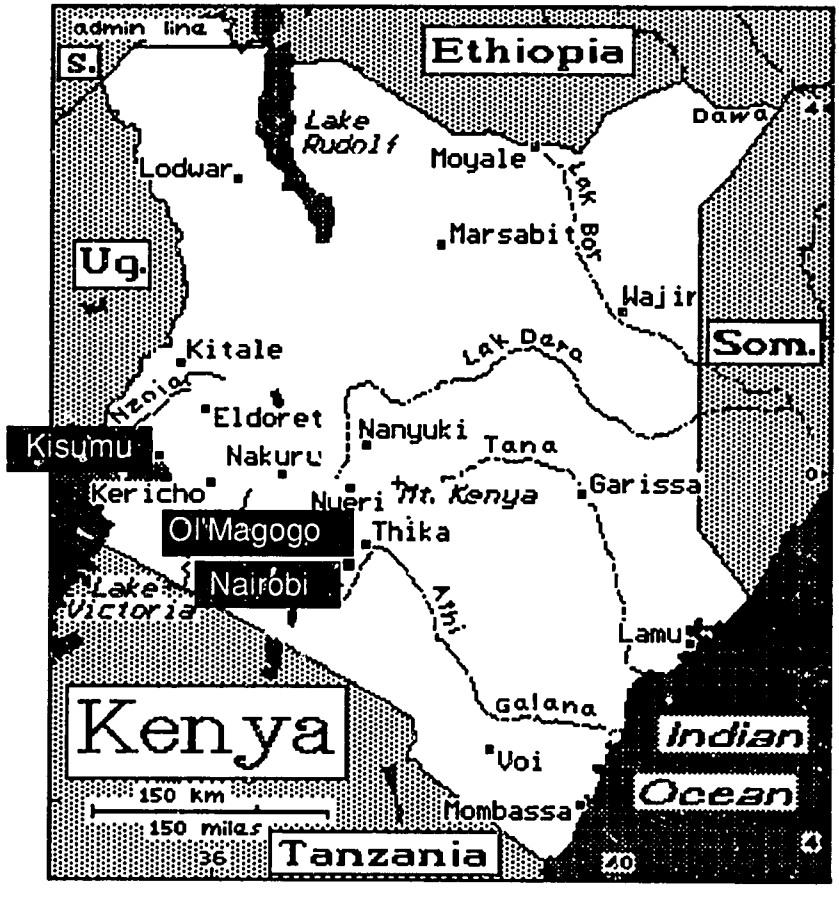
**Total area:** 582,650 square km (224,960 square miles)
**Geography:** Tropical along coast to arid in interior, low plains rise to central highlands bisected by Great Rift Valley; fertile plateau in west.
**Capital:** Nairobi.
**Population(1991):** 25,241,000
**Languages:** Swahili, Kikuyu, Luhya, Luo, Meru.
**Labor force:** 78% agriculture, 22% non-agriculture.
**% Females in labor force:** 40.3%
**Industries:** Tourism, light industry, petroleum products.
**Chief crops:** Coffee, corn, tea, cereals, cotton, sisal.
**Land in Agriculture:** 10.6%
**Agriculture of GNP:** 31%
**Sheep population:** 7,300,000
**Goat population:** 8,500,000
**Uses of sheeps and goats:** Meat and milk.
**Inflation rate:** 8.3% (1988)
**Monetary unit:** Shilling.

**Kenyan Flag**



**United States Sites**



# *Dual-Purpose Goat Production Systems for Smallholder Agriculturalists in Kenya*

Winrock International

Will R. Getz, Winrock International Institute for Agricultural Development, Petit Jean Mountain, Route 3, Morrilton, Arkansas, 72110. Telephone (501) 727-5435, ext.232, Fax (501) 727-5417.

## Narrative Summary

This has been a year of transition. A year in which the feed resources element was phased out as part of the master plan to transfer greater responsibility for on-going work to the Kenya Agricultural Research Institute (KARI). A year in which the model farm provided further evidence that crops and dual-purpose goats fit well together even on small land holdings. A year in which the first steps were taken to redirect production systems collaborative research through linkages with scientists in other locations in Kenya and eastern/southern Africa in order to expand the impact. The western Kenya DPG solidified through collaboration and support to local non-government organizations and their clientele. More attention was given explicitly to work with organizations composed of or targeting women directly. Direct contact was made with scientists participating in the ILCA-supported small ruminant network (SRNET) so that technical contributions the SR-CRSP makes to research enhancement will be synergistic and complimentary. The production systems group worked with KARI management to develop a national, cohesive small ruminant research program. Papers were presented at the annual SR-CRSP workshop in Nairobi. The resident scientist, Dr. Patterson Semenye, was invited to present papers on small ruminant research in Nigeria and Tanzania and at the All-Africa Conference on Animal Agriculture held in Nairobi, Kenya. He also conducted a two-week workshop on principles of livestock production and development for a non-governmental organization in Zimbabwe and was elected a committee member of the Small Ruminant Research Network. Focus has been on final data analyses and production of manuscripts for journals and meeting presentations. A highlight of the year was the printing and official presentation of the Kenya Dual-purpose Goat Technical Package. It has been well received, and the one thousand copies are being distributed in Africa and around the globe. Winrock International and our nutrition and management resident scientist had primary responsibility for this undertaking.

## Research

### *Feed resources.*

#### Problem statement and approach

On the very limited land holdings in western Kenya there is little latitude for animal feed production areas as differentiated from human food and cash crop production areas. The production systems group has had the challenge to identify feed resources which could serve multiple purposes. As well as to enhance the local soils and allow them to be more productive.

The approach was to work with farmers in identifying the constraints, then to test multiple interventions on-station and on farmers' holdings using traditional crops plus others which could contribute multiple outputs, e.g.,

multipurpose trees and forages for feed or sale.

The feed resources staff have worked closely with the animal nutritionist to create systems that result in year-round feeding systems which support continual production of milk for family needs and periodic sources of cash or meat or both as the need dictates.

### Progress

A comprehensive system has been developed using one-half hectare of land for all household needs such as crops, fuel wood, livestock feed, soil enhancement, and cash. The leafy parts of crops such as maize leaves and sweet potato vines are used for lactating does and young kids. By-products such as bean hulms and maize bran are used for maintenance. On the very acid red soils of western Kenya the use of even small amounts of goat manure result in markedly improved yields of maize. And tree species such as *Sesbania sesban* and *Leucaena leucocephala* provide high protein feeds, a source of wood, and nitrogen deposits in the soil. Forages such as *Pennisetum purpureum* provide good sources of energy to animals and a source of cash when sold. The system is explained in detail in the technology package, *On-farm Research and Technology for Dual-Purpose Goats*. Various aspects of this work will be submitted to appropriate journals and used in simplified form by nongovernment organizations.

## *Animal nutrition and management.*

### Problem statement and approach

While the theory of good feeding and management for dual-purpose goats in the tropics is known, there has been inadequate information about applying these principles in a cost-effective and locally acceptable manner. Limited-resource farmers have relatively few options in animal feeding and management. Therefore the goal of this component was to identify low-cost options including locally available materials, which would provide adequate dry matter, net energy, and crude protein for dual-purpose goats at various stages in their production cycle.

The approach was to listen to farmers, observe animals, and test locally-available feedstuffs, storage methods, processing options with the on-station herd and on farms of the client group. A range of more than 20 local feedstuffs including crop parts and residues, local grasses, herbs, woody plants, tree foliage, and processing by-products were studied. Results have been presented at workshops and other meetings and published.

### Progress

No new research was initiated in 1992. Results to date continue to be analyzed and written up as the production systems research initiative in western Kenya phased into more direct KARI responsibility. Much time has been invested in data entry, analysis and study as a prelude to preparing manuscripts for journal submission. Preliminary results have been presented at the annual workshop, meetings of the ILCA small ruminant network, small ruminant research meetings in Nigeria, and other less formal venues.

## *Technology package document.*

### Problem statement and approach

Although there are several good general reference works on small ruminant production in the tropics, there is a dearth of information based on research results from on-farm studies addressing specific constraints and presenting specific interventions. This is especially true for western Kenya and dual-purpose goat production systems. So three years ago it was determined that the time was right to compile in one document all of the practical information that had resulted from a number of years of SR-CRSP research on farms and in laboratories. The information was considered to be a package of technologies related to animal health, breeding and genetic resources, nutrition and management, economics, feed resources, and the social aspects of dual-purpose

goat production in areas of relatively high rainfall and land scarcity. In the publication, the methodologies used in obtaining the information, especially on-farm research methods, are presented as well as some of the historical background of agriculture and social structure in the western Kenya region.

Each of the principal investigators and resident scientists were responsible for preparing appropriate chapters. These were submitted to Patterson Semenye who served as chief coordinator for the endeavor. Editorial assistance was provided by Ted Hutchcroft from Winrock International headquarters. It was a major undertaking because each of the technologies included in the package had been tested and proven in the field in Kenya.

### Progress

After two years, the dual-purpose goat production systems technology package was completed in 1992, in spite of several major delays at the printers because of intermittent power cuts and the press of work. In November, Dr. Semenye officially presented Dr. Ndiritu, Director, KARI, with the first 500 copies of the document entitled *On-Farm Research and Technology for Dual-purpose Goats.* He, in turn, has forwarded copies to the Ministry of Livestock Development for distribution throughout the country. In addition, 500 copies will be distributed through the global SR-CRSP network.

The physical size of the manual will make it easy for people to use. It is an excellent research product and will go a long way toward bridging the gap between research and extension. It is a tangible result of collaborative research involving national and international institutions.

Through the courtesy of Good News Publishers and the University of Missouri-Columbia, a companion videotape was produced and released in 1992. The high quality videotape features most of the Kenya resident scientists who contributed to the writing of the Technology Package. The availability of these informational materials has potential for much positive impact.

## Training

*Degree*

The production systems component of the Kenya program did not directly support any degree training in 1992. However, two collaborating scientists were engaged in graduate studies. Kenneth Otieno was in the process of completing his Ph.D. at the University of Reading after completing field research with the Sesbania sesban collection at the SR-CRSP Maseno site. He is under sponsorship of IDRC, and his research related directly to the feed resources element of production systems. Dr. Siamba completed his M.S., taught courses, and conducted research at the School of Veterinary Medicine at the University of Nairobi during 1992. He is currently writing his thesis for submission and defense later this year. He was supported by the Kenya Agricultural Research Institute and the animal health and production systems component of the SR-CRSP. His research is on parasitology as related to animal nutrition and management.

*Nondegree and informal*

Over the year both resident scientists and collaborating KARI and MOLD personnel conducted numerous training sessions for school groups, farmers, and extension personnel. These sessions were very practical in orientation and addressed the role of dual-purpose goats in local agricultural systems.

First steps were taken to formalize a training and monitoring program for KARI regional scientists endeavoring to conduct on-farm research with livestock. It is recognized that if the methodologies that have been found to be successful by the SR-CRSP endeavor are to be applied more widely, it will be necessary to work more directly and frequently with other research staff at KARI regional stations. Dr. Semenye will lead this effort with support from Dr. Onim and others in 1993.

### Contributions to U.S. agriculture

There is evidence that the methodologies used in the on-farm research endeavors of the production systems group have application to research methodologies applied in the United States. This participatory approach treats the farmer as a part of the research team rather than simply an end-user of information developed by researchers on experiment stations.

The information included in the Kenya technology package will be useful to goat producers in the United States especially as they find it necessary to look at lower-cost options for feeding and daily care. There has been impact on the scientific community as well. For example, it has influenced feed resource use in a major space-related experiment in the U.S. by informing Space Biosphere Ventures of the successful use of sweet potato vines for weaning kid goats in self-contained agricultural systems.

There have been lessons learned by U.S.-based principal investigators regarding interdisciplinary teams and the relationships between technical competence and personality characteristics necessary for effective teams.

### Contributions to Kenya and African agriculture

The Kenya Agricultural Research Institute has taken steps to utilize production systems resident scientists and the principle investigator in the development of a national small ruminant research program. Emphasis is on the need to create a mechanism which will allow research on whole systems and the integration of various components.

SR-CRSP scientists have been intimately involved with several networks which include research workers from a number of other countries. The production systems research experience is, therefore, passed on through formal presentations and informal discussions among individual members of these networks. Further, this year the first steps have been taken for the production systems group to reach out beyond western Kenya and to create a mechanism whereby they can influence research in other parts of Kenya and other countries in the region. This influence will be in the form of technical assistance and small grants which will enable more research to be done which truly reflects farmer needs and farmer involvement.

African agriculture has been influenced by the SR-CRSP through participation in research meetings and in the conduct of short courses and seminars. There is more acceptance of the on-farm methods espoused by the scientific community, but there is little practical experience in implementing these methods. Our experience in Kenya allows SR-CRSP personnel to contribute to implementation elsewhere in Africa.

### Collaborating personnel

D. N. Siamba, Collaborating Scientist, KARI (on study leave)
K. Otieno, Collaborating Scientist, MOLD (on study leave)
H. Ingati, Office Administrator, Maseno SR-CRSP Office
N. Otiende, M. Shisya, Technical Assistants

### Collaborating institutions

Kenya Agriculture Research Institute
Ministry of Livestock Development, Kenya
Animal Production Society of Kenya
Washington State University
Colorado State University
Texas A&M University
University of Missouri - Columbia
International Center for Research in Agroforestry
International Livestock Center for Africa
International Development Research Centre

### Publications

Semenye, P.P. and T. Hutchcroft., eds On farm Research and Technology for Dual-purpose Goats. Small Ruminant Collaborative Research Support Program, Kenya. 1992.

## Abstracts and presentations

Semenye, P.P., D.N. Siamba, M. Shisya and W.R. Getz. 1992. Can fodder diets increase goat production by a quantum leap? Paper presented at the All African Conference on Animal Agriculture, 23-27 November, 1992. Nairobi, Kenya.

Semenye, P.P., M. Shisya and W.R. Getz. 1992. Overcoming dual-purpose goats production constraints of dry matter intake by feeding defoliated maize leaves. Paper presented at the Second Biennial Conference of the Small Ruminant Research Network, 7-11 December, 1992. Arusha, Tanzania.

Semenye, P.P., L. Musalia, and K. Otieno. 1992. Interaction of dual-purpose goats with subsistence crops and weeds. Paper presented at the International Workshop on Research and Development of Goat Production Systems in the Humid Tropics. 6-9 July, 1992. Ile-Ife, Nigeria.

Semenye, P.P. 1992. Techniques for measuring on-farm livestock research: problems and issues. Paper presented at the International Workshop on Research and Development of Goat Production Systems in the Humid Tropics. 6-9 July, 1992, Ile-Ife, Nigeria.

Semenye, P.P., D. N. Siamba, M. Shisya, and W. Getz. 1992. Nutritive Values of Pennisetum purpureum, mixed grasses, Cajanus cajan, Sesbania sesban and Tylossema spp. Paper presented at the 10th SR-CRSP Workshop, International Laboratory for Research in Animal Diseases, Nairobi, Kenya. February 26-27, 1992.

Onim, J.F.M., K. Otieno, M. Mathuva, and W. Getz. Adoption of feed resources improved technologies for dual-purpose goats by farmers in western Kenya. Paper presented at the 10th SR-CRSP Workshop, International Laboratory for Research in Animal Diseases, Nairobi, Kenya. February 26-27, 1992.

## Additional comments

As mentioned in the introduction, 1992 has been a year of reduced level of effort for on-farm activities. Focus has been on organizing existing data, analyzing data, preparing documents, hosting visitors, and interacting with local NGOs as steps are taken to enable them to promote dual-purpose goat production systems. There continues to be a need to provide technical support and services for collaborating farmers, but this function is being vested in local organizations which have a better chance for sustained involvement.

Support will continue to be given to KARI as they seriously address the opportunities for a coherent national small ruminant research program. The production systems resident scientist will perform services for KARI to the degree it agrees with the overall SR-CRSP mandate.

During 1992 the Kenya production systems principal investigator participated in a fact-finding mission to the Caribbean as part of the Board's desire to expand the impact of the SR-CRSP in regions where it has heretofore been absent. This mission identified limited areas where the SR-CRSP could enhance existing programs. One area was that of communications. As a result, an international conference will be held in Puerto Rico in 1993 to enhance interaction of SR-CRSP participants with research and development workers in the Caribbean.

# *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) 845-2695, Fax (409) 845-6970.

## Narrative Summary

Multiplication and stabilization of the Kenya Dual Purpose Goat (KDPG) was the major project research emphasis. The number of KDPG increased by 69% to 591 (262 males, 329 females) this year. A total of 65 $F_1$ and 4 KDPG surplus bucks were sold to farmers for improving indigenous flocks. Demand for bucks is high, and contacts with Food for the Hungry International, the GTZ, and Heifer Project International indicate interest in participating in the multiplication and distribution processes. A second attempt was made to identify constraints to the use of multiple ovulation and embryo transfer (MOET) to accelerate multiplication of the KDPG. In the first phase, a surfeit of embryos were collected and the limiting factor was the poor kidding rate from recipients. In the second phase, donor response to superovulation was much lower than in the first phase and only 55 high-quality embryos were transferred into 31 recipients. Two recipients returned to estrus and kids are due to be born in February-March, 1993.

In 101 lactations on composite KDPG dams, milk production averaged 1.35 kg/d while nursing a kid. Lactation length (112.7±71.6 d) had the greatest effect on average daily milk yield. Season of kidding had no effect on milk yield, but affected weaning weight, which was heaviest in kids born January-March and lightest in kids born October-December. There was no difference in milk yield of the $F_1$ and KDPG, and the KDPG retained the average heterosis of the $F_1$s. Lactation curves will be fitted to characterize peak and persistency characteristics of purebred, F1, and KDPG lactations. Associations between teat diameter and teat length were studied to identify a trait genetically correlated to milk production that could be more easily measured and selected than milk production. A sample of 2,300 records of udder size, collapsibility, teat diameter, teat length, and milk production indicated positive phenotypic correlations among all traits; however, associations between teat diameter and teat length with milk production were significant only in the Galla.

We have developed 24 polymorphic RAPD markers in the goat, and these data were used to develop a successful USAID PSTC proposal. However, limitations of RAPDs have caused us to focus attention on the development of goat specific microsatellites. Microsatellites are highly polymorphic, short, tandemly repeating sequences usually found in non-coding genomic regions. An example of a goat specific microsatellite (designated SR-CRSP91) is provided. We have identified over 20 goat specific microsatellites and have developed PCR primers that amplify 10. Of these, at least four are polymorphic; two have two alleles, and two have three alleles. We anticipate the generation of 40 microsatellites within a year, some of which will contribute to mapping the sheep and cattle genomes. Four manuscripts describing the microsatellites detected to date are in preparation. Polymor-

phic microsatellites will be screened in KDPG families derived from the 400+ goat DNAs currently available and will be statistically analyzed for associations with the phenotypes of resistance/resilience to *Haemonchus*.

## Research

The project focused on implementing improved management procedures to minimize kid losses to allow optimization of the rate of breed development, multiplication, and distribution. The project also concentrated on the development in the goat of a new class of molecular markers, microsatellites, which are highly polymorphic and which are inherited in a codominant manner. Emphasis in this area was to provide the initial data to allow the development of a USAID PSTC grant to leverage SR-CRSP funds in the study of the genetics of resistance to the gastro-intestinal tract parasite *Haemonchus contortus*. The proposal appears to have been successful (see page 63).

### *Multiplication and distribution.*

#### Problem statement and approach

Following the poor rate of increase in multiplication of the KDPG during 1991, a series of improved management and accounting practises were implemented by Dr. Mwandotto at Ol'Magogo. These included a reevaluation of animal health management resulting in a return to a more proactive vaccination schedule, improved nutrition in lactating does, and the extension of the system of fires to heat the bomas housing the kids overnight. Also a more detailed and verified method of accounting for animal losses was implemented.

A multiple ovulation and embryo transfer program was designed with the objective of accelerating the production of the KDPG. The first phase of this project was to examine alternative synchronization protocols (timing of PMSG injection and/or duration of CIDR implantation) resulting in the highest conception rates. A total of 267 fresh embryos transferred into 132 recipients resulted in only 29 kids born, with a higher kidding rate from embryos transferred laparascopically than from embryos transferred surgically. However, all kids produced were from embryos transferred soon after harvest, and the second phase of the project was designed to minimize the duration between harvest and transfer. Current four-way cross KDPG does were superovulated and embryos collected, and those of high quality were transferred into indigenous East African (EA) and Galla (G) recipient does at Ol'Magogo. Female donors were selected on the basis of milk production recorded in performance trials and from the line of animals identified as resistant to *Haemonchus contortus*. U.S. graduate students from the TAMU Reproductive Science Laboratory, experienced in surgical and nonsurgical transfer procedures, collaborated on the project. The strategy was designed so as to not affect the production of KDPG animals in the existing breeding program, except for the embryo collection interventions of the donor KDPGs which briefly delayed breeding of these animals (by one estrus cycle). Existing $F_1$ animals continued to be mated appropriately to produce four-way KDPGs, whereas the indigenous breeds acted as recipients to produce KDPGs instead of producing $F_1$s as genetic parents.

The multiplication and distribution phase of the KDPG project is expected to be facilitated with the cooperation of NGOs and private breeders. The philosophy of this approach is that these organizations will possess a vested interest in the multiplication of the KDPG and formation of a breed society to ensure the sustainability of the breed. The SR-CRSP and KARI would 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 contrib-

ute to the development of the nucleus flock gene pool at Ol'Magogo through artificial insemination.

## Progress

Table 1 gives the current inventory of the number of KDPG available. The table reflects the culling of purebred does, but does not include the 65 $F_1$ and 4 KDPG animals sold during the year. The table reveals a 69% increase in the number of KDPG animals produced over the last 12 months. The majority of this increase is due to the implementation of a series of improved management practises following the PAC meetings in Kenya in February.

**Table 1. Distribution of Genotypes at Ol'Magogo Research Station.**

| | December 1991 | | |
|---|---|---|---|
| | EAG/Galla | F1 | KDPG |
| Does | 148 | 261 | 201 |
| Bucks | 29 | 91 | 149 |
| Total | 177 | 352 | 350 |
| | **December 1992** | | |
| | EAG/Galla | F1 | KDPG |
| Does | 95 | 276 | 329 |
| Bucks | 24 | 72 | 262 |
| Total | 119 | 348 | 591 |

The protocol for the first phase of the MOET was to harvest embryos from donors in the morning and store the high quality embryos in a culture medium until about noon, when transfers began. Analysis of the results of the first round of MOET research indicated that all of the 29 kids that were born were from embryos that were transferred early in the afternoon. Hence, rather than any asynchrony between embryos and recipients, it appeared that a contributing factor to the low kidding rate was desiccation due to storage prior to transfer. Consequently, in phase two of the MOET program conducted in October through November, as embryos were harvested and graded, they were immediately transferred into recipients. Mr. Said Mkuu, the farm manager at Ol'Magogo, who had been brought to the U.S. for a six-week training program in MOET, and Dr. B.A.J. Mwandotto were responsible for implementing the synchronization and superovulation of animals before the arrival of the team comprising Drs. Bill and Gaby Foxworth from TAMU. Both Mr. Mkuu and Dr. Mwandotto received additional training in the laparascopic harvest and transfer of embryos during this period. While in phase one of this project, ample numbers of embryos were collected, however problems in shipping FSH to Kenya (FSH became a prohibited drug between phases one and two of this project) and in shipping CIDR-Gs from New Zealand (one shipment of 50 CIDRs never arrived) resulted in the harvest of only 55 embryos in the second phase which were transferred into 31 recipient animals. At this time, five animals have returned to estrus and kids are scheduled to be born from February through March. It is concluded that the technical backstopping to support MOET in Kenya is inadequate at this time to support the effective multiplication of the KDPG. Funds have been requested by KARI within NARP 2 to obtain the equipment necessary to allow research into MOET in Kenya to determine the protocols to optimize conception rates.

During the year correspondence was initiated between the Principal Investigator and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Food for the Hungry International (FHI), and Heifer Project International (HPI) to determine interest in collaborating with the SR-CRSP in multiplying and distributing the KDPG. All of these donors reacted positively, and, in December, the Principal Investigator visited representatives of FHI and HPI in Nairobi to evaluate these opportunities. FHI has an irrigation project in Garissa at the Tana river designed to settle nomadic peoples afflicted by drought to an

agrarian lifestyle. (The four KDPG bucks that were distributed were sent to this site). The model follows closely that of the demonstration farm developed by the SR-CRSP and KARI at Maseno, but with only minimal technical backstopping support for animal production provided by FHI. HPI has identified a number of women's collaboratives located towards the coast that merchandise cow milk but that would like to maintain goats for domestic milk production. Both of these potential collaborations would seem to fulfill the SR-CRSP mandate of assisting the small-holder, and, in particular, the FHI project at Garissa would seem to allow the opportunity to transfer and adapt the Techpack to a different region of Kenya. The USAID/KADO is supportive of efforts in this direction and suggested the opportunity for conducting impact assessment studies in each collaboration. These opportunities have been discussed with Farming System and Sociology projects of the KDPG component and arrangements are underway for these Principal Investigators to conduct site evaluations during the February 1993 Program Administrative Committee meetings and workshop meetings in Kenya–if safe to do so. The PI will also visit the GTZ en route to these meetings in Kenya to evaluate opportunities for collaboration with this agency in the multiplication and distribution of the KDPG.

Reflecting the change in direction of the KDPG Breeding project from that of being primarily research oriented to multiplication and distribution oriented, Dr. Mwandotto left the project at the end of December and will be replaced by Mr. Joseph King'oko. Mr. King'oko had previously managed the KARI Ngong Research Station and was recruited to the SR-CRSP from an NGO located on the Tana River Authority. His responsibilities will be to oversee the management of the Breeding program at Ol'Magogo and to collaborate and provide technical backstopping in management to the NGOs selected to collaborate in the multiplication and distribution of the KDPG. The reduced level of financial support by KARI has caused problems in program development considering that over 1,150 animals must be maintained. In particular, the KARI Landrover and tractor based at Ol'Magogo have been inoperable for over a year, and estimates for repairs are US $5,500. Further, several thousands of dollars urgently need to be devoted to rehabilitate the wooden bomas housing the goats. Needless to say, no additional funds were allocated to develop the alfalfa plot at Ol'Magogo, and the plot has been taken out of production. Funds and replacements for the Landrover and tractor have repeatedly been requested from KARI to meet these needs, but have not been received. Any reduction in funding of the Breeding project in an attempt to stimulate increased financial inputs from KARI will have disastrous consequences.

## *Development of the KDPG.*

### Problem statement and approach

The breeding program described in the 1989-90 Annual Report was designed and implemented 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 with a peak lactation milk production of 4.0 kg/d. Of importance to this genotype are carcass characteristics, particularly in comparison to $F_1$ and indigenous goats, and also total lactation milk yield as mediated through lactation length. Research in 1991 focused on carcass attributes, and hence research in 1992 was focused on milk production.

Sufficient numbers of KDPG bucks are now available to implement a selection program within the KDPG to enhance growth and milk production and reduce variation within the breed (breed stabilization). To accomplish this requires the development of a multiple trait genetic evaluation system using the statistical best linear unbiased prediction (BLUP) procedure. Further, sufficient females must be milk

recorded to allow the prediction of breeding values of related individuals (particularly the sires of these females) to allow selection. KDPG bucks that are not needed for the Ol'Magogo breeding program can now be distributed to farmers for improvement of indigenous flocks. While these bucks are below the average performance of the Ol'Magogo KDPG breeding flock, comparisons against $F_1$ and indigenous breeds maintained at Ol'Magogo indicates that, on average, these animals should be superior to the flocks in which they will be used.

## Progress

### Milk production

In an analysis of 101 lactations on composite KDPG dams, milk production averaged 1.35 kg/d while nursing a kid. Lactation length (112.7±71.6 d) had the greatest effect on average daily milk yield. Though season of kidding had no effect on milk yield, it did affect weaning weight which was heaviest in kids born January through March and lightest in kids born October through December. There was no difference in milk yield of the $F_1$ and KDPG animals, hence the KDPG retained the average heterosis of the $F_1$s as would be expected under a dominance model for heterosis.

Studies into the associations between teat diameter and teat length were initiated in an attempt to identify a trait genetically correlated to milk production that could be more easily measured and selected for than milk production. Preliminary analysis of a sample of 2,300 records of udder size, collapsibility, teat diameter, teat length, and milk production suggested the existence of positive phenotypic correlations for all traits, however, associations between teat diameter and teat length with milk production were significant only within the Galla breed. Studies in this area are continuing in an attempt to define a selection criteria more easily measurable than daily milk yield with twice daily milking.

Dr. Kogi scored daily milk production on an additional sample of animals during June through August and is in the process of fitting lactation curves to these data to characterize both peak and persistency characteristics of purebred, F1, and KDPG lactations. Preliminary results will be presented at the workshop to be held in Kenya in March 1993.

### Progeny testing

In order to implement the computer program Derivative Free Restricted Maximum Likelihood (DFREML) on a personal computer (PC), we needed to obtain SPARSPAK, a sparce matrix manipulation program from the University of Waterloo, Ontario. This has finally been accomplished and the program is now operational. The program allows the estimation of genetic parameters and the prediction of breeding values for multiple traits. Matt Jones has begun to use this program in his thesis research to estimate genetic parameters among KDPG growth traits, including breed additive direct, maternal direct, and heterotic components. Dr. Joseph Kogi has also begun to use this program to analyze milk weights. These analyses will provide estimates of breeding values for milk and weight in the KDPG that can be used for selection. Dr. Kogi will continue to run these analyses and will use the resulting estimates of breeding value to select the flock when he returns to Kenya later this year.

## *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 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. This collaboration has now identified a flock of 48 does and 44 bucks classified as resistant or resilient.
- 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 genetics 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.

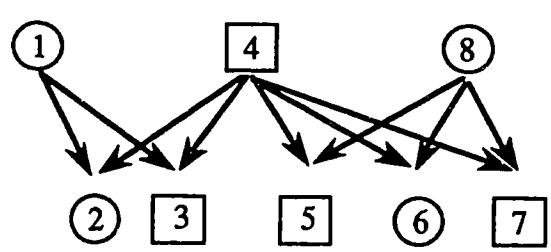
## Progress

The primary goal of the KDPG Breeding project is the multiplication, stabilization and subsequent distribution of the KDPG. The great majority of effort and project funds are devoted to these goals. Allocation of resources to *Haemonchus* research have been to support the research collaboration of Dr. Waruiru to sample animals and to provide limited laboratory supplies to allow Dr. Kogi to extract DNAs in Kenya, and to support screening of molecular markers by Mr. Bhebhe at TAMU. SR-CRSP resources are inadequate to support a research program committed to studying the genetics of *Haemonchus* resistance, although the Breeding program design has been ideal for this purpose. Consequently, the goals of research in this area have been to leverage SR-CRSP resources to obtain external funding to support a fully fledged research program involving the collaboration of TAMU, WSU, and KARI counterparts. In 1992, a USAID PSTC grant for US $150,000 over three years

was written based upon preliminary SR-CRSP results and subsequently submitted. The reviews of this proposal were excellent and it appears that the proposal will be funded (see pages 64-66). This area of research offers the SR-CRSP a great opportunity to capitalize on its investment in the KDPG.

Initially, efforts to develop molecular markers in the goat were focused on Random Amplified Polymorphic DNA (RAPD) systems because of the ease with which these can be developed in genetically uncharacterized species, and because they appear to be randomly distributed throughout the genome. We have developed 24 RAPD marker systems that are polymorphic in the goat (the work of Rohrer and Bhebhe, described in the 1991 annual report), and these data were used to develop the PSTC proposal. However, there are several limitations to the general utility of RAPDs as marker systems. First, these tend to be dominant markers (band present vs. band absent) which does not allow discrimination of homozygotes (with two copies of the band) and heterozygotes (with a single copy). Second, it seems that alternate DNA fragments may be preferentially amplified with varying DNA concentrations, hence repeatability of RAPDs is a problem where DNA concentrations cannot be standardized. These limitations have caused us to focus our attention on the development of another class of molecular marker, microsatellites, in the goat. Microsatellites are short, tandemly repeating elements that are primarily associated with non-coding regions of the genome, are randomly distributed throughout the genome, and tend to be highly polymorphic. We have focused on identifying goat microsatellites with at least 17 dinucleotide repeats so as to maximize the likelihood of detecting polymorphisms in the KDPG. Mr. Bhebhe has identified over 20 goat specific microsatellites to date, and we have developed PCR primers that amplify 10. Of these, at least four are polymorphic; two have two alleles, and two have three alleles. The process is sequential. As microsatellites are identified in goat DNA clones they are sequenced, PCR primers to amplify them are developed, and those that amplify are finally screened in KDPG families for polymorphism. Consequently all 20 goat specific microsatellites identified to date could result in polymorphic markers, and we will continue to identify new microsatellites. This research commenced in September and has progressed very rapidly. We anticipate the generation of 40 microsatellites within a year, some of which will be polymorphic in sheep and cattle and will contribute to mapping these genomes. Each of these will be published in Animal Genetics, and four manuscripts describing the polymorphisms detected to date are in preparation.

An example of a goat specific microsatellite (designated SR-CRSP91) is provided in Figures 1 and 2 (See pages 61 and 62). Figure 1 contains sequence data of a cloned genomic fragment from a *Sau* 3A size selected (< 800bp) pUC plasmid library that was hybridized to an end-labeled 30-mer of poly dG-dT. The sequence reveals a poly (AC) repeat half-way up the gel, for which PCR primers were designed from flanking regions. These primers were used to amplify SR-CRSP91 in two half-sib KDPG families in Figure 2 to demonstrate mendelian inheritance of the marker. The eight lanes in Figure 2 correspond to the pedigree below, in which the squares indicate males and circles females:




The fourth lane in Figure 2 indicates that sire 4 is homozygous for the slow allele, dam 1 is heterozygous for slow and fast alleles, and dam 8 is heterozygous for medium and fast alleles. Progeny 2 is a heterozygote that inherited a slow allele from sire 4 and fast allele from dam

1. Progeny 3 is a homozygote that inherited a slow allele from both sire 4 and dam 1. Progeny 5, 6, and 7 are all heterozygotes that inherited one slow allele from sire 4 and one medium allele from dam 8.

Polymorphic microsatellites (such as SR-CRSP91 segregating in informative families such as depicted in Figure 2) will be screened in KDPG families derived from the over 400 goat DNAs we currently have at TAMU and will be statistically analyzed for associations with the phenotypes of resistance/resilience to *Haemonchus.*

## Training

*In Progress*

Dr. J.N. Kogi successfully completed the course work requirement for an M.S. in Animal Breeding at Texas A&M University in the Fall semester of 1992. He spent the summer semester in Kenya gathering research data to characterize the milk production capability of the KDPG and assisting in the study of genetic resistance to *Haemonchus contortus.* Dr. Kogi is completely supported by the Breeding project and is expected to complete his research in summer 1993.

Mr. Evison Bhebhe, a TAMU Ph.D. candidate in Genetics has been provided DNA and phenotype data from project goats for screening microsatellites in the Haemonchus research. He has been partially supported by the Breeding Project through provision of laboratory supplies for this project. His completion date will be June 1993. Mr. Bhebhe has been training Dr. Kogi and Ms. Chen-Chen Yeh a M.S. candidate in Genetics in screening molecular genetics techniques using the KDPG DNAs.

Mr. Matt Jones, a TAMU M.S. candidate in Animal Science, initiated his research program to determine the estimability of direct, maternal and heterotic effects in unbalanced crossbreeding designs using KDPG data. This work continues the initial studies presented by Dr. Ruvuna at the SR-CRSP workshop in February and will be completed for a M.S. thesis and for publication by summer 1993.

Ms. Elizabeth McDonald commenced course work for a M.S. degree in Animal Science with an emphasis in small ruminant production in Fall 1992. She will participate in the analysis of KDPG production data to fulfill the research component of her program.

*Short-term*

The second phase of ET work was conducted in Kenya between October 15 and November 8 and provided additional training in ET for Mr. Said Mkuu and Dr. B.A.J. Mwandotto who had the responsibility of implementing the initial synchronization phase of the project.

## 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, to be 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.

### *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. The *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 United States due to the importance of parasite resistance to chemotherapy and due to the estimated annual $45 million cost due to losses in sheep and goat production.

Dr. F. Ruvuna was invited to present a paper at the International Conference on Meat Goat Production, Management and Marketing held in Laredo, Texas from July 8-10. There was great interest expressed by producer attendees in obtaining the KDPG! Unfortunately, quarantine restrictions will not allow us to pursue multiplication and distribution of the KDPG in the United States.

Dr. Ruvuna was Co-PI on a successful $500,000 five-yr grant to the USAID Linkages program 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 United States. This would not have been possible without Dr. Ruvuna's experience in SR-CRSP programs in Kenya.

### *Contributions to host country*

Dr. Joseph Kogi returned to Kenya for the summer to conduct research in the milking capacity of the KDPG and in the genetics of resistance to *Haemonchus contortus* in collaboration with Kenyan colleagues.

The KARI-Naivasha field day held in July featured the milking capacity of the KDPG at Ol'Magogo.

The second phase of ET work was conducted in Kenya between October 15 and November 8 and provided additional training in ET for Mr. Said Mkuu and Dr. B.A.J. Mwandotto who had the responsibility of implementing the initial synchronization phase of the project.

In both the Nakuru and Nairobi shows, the Breeding Project won the overall goat champion for the country the third year running. These activities continue to make a great impact on producers and stimulate interest in the KDPG and a demand for bucks.

A collaborative linkage was maintained with Dr. R.M. Waruiru of the Department of Veterinary Pathology and Microbiology of the University of Nairobi to conduct collaborative research into the genetics of resistance and resilience to infection by *Haemonchus contortus*. Publications from this collaboration have been submitted to refereed journals. The Resident Scientist, Dr. B.A.J. Mwandotto, also assisted the University's Department of Animal Production and executive of the Animal Production Society of Kenya with access to the Ol'Magogo flock for instructional purposes.

The Kenya Stud Book is prepared to register the KDPG as soon as the breed is declared, a society is formed, and its constitution is presented to the Stud Book.
In November, the Resident Scientist presented a paper on the genetic aspects of the KDPG breeding program to center directors at the request of KARI headquarters. The Resident

Scientist also presented a paper at this time on the breeding of multipurpose animals to the All Africa Conference in Animal Production.

Regional contact with Sokoine University's Department of Animal Science in Tanzania was maintained and an invitation for a second visit to the project was accepted.

*Gender analysis*

Ms. Elizabeth McDonald, a Jamaican national, has been recruited with the support of the Jamaica Agricultural Development Foundation to study towards an M.S. degree in small ruminant production at Texas A&M University.

Dr. Gabriella Foxworth, a veterinarian currently pursuing a Ph.D. degree in reproductive physiology at TAMU, was funded by the SR-CRSP Breeding project to participate in the Kenya ET work. This experience has led to the development of an interest in contributing to international agricultural development on the part of Dr. Foxworth.

Proposals for SR-CRSP matching training funds were developed and submitted to support the international program training for Ms. Marcia Walker and Ms. Barbara Walsh, both U.S. citizens, from Texas A&M University. The proposal to support Ms. Walsh's research in parasitology was successful and she will conduct this research in summer 1993. The proposal to support Ms. Walker will be rewritten to reflect the need for an impact assessment study in the collaborations with NGOs and will be resubmitted.

*Collaboration with IARCS and other CRSPs*

Following meetings with Dr. Leyden Baker at ILCA held during February concerning opportunities for collaborating in research involving the genetics of disease resistance, a letter was received (pages 67-68) indicating interest in such collaboration. A follow-up meeting was held between Dr. Baker and Dr. Taylor in December and the collaboration will eventuate. The degree of collaboration will be enhanced by the principal investigator's receipt of a USAID PSTC grant (see pages 67-68) to pursue this research.

Ms. Elizabeth McDonald, a Jamaican national has been provided support by the Jamaica Agricultural Development Foundation (JADF) to study towards a M.S. degree in small ruminant production at Texas A&M University. Ms. McDonald commenced her program in the Fall of 1992 and will collaborate in the analysis of KDPG Breeding project data.

*Support for free markets and broad based economic growth*

The project is moving rapidly towards a model of privatization and decentralization for the multiplication and distribution of the KDPG. Two NGOs with projects focused at private sector development have been identified as potential collaborators and modalities for collaboration between KARI, the SR-CRSP and each NGO are in development. Additionally, a total of 69 animals surplus to the project were sold to farmers. The demand for bucks has been high, and the sale prices have not been subsidized.

*Contributions to and compliance with mission objectives*

Consultations with the USAID/Nairobi Mission Agricultural Development Officer have greatly assisted with the design of the multiplication and distribution phase of the KDPG Breeding project to facilitate the incorporation of impact assessment studies.

*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 training towards a M.S. degree for Dr. Kogi, a Kenyan national, the Breeding project has provided resources to assist with the Ph.D. programs of Mr. Evison Bhebhe (Zimbabwe), Dr. Bill Foxworth (USA),

and Dr. Gaby Foxworth (Mexico); the M.S. training of Mr. Matt Jones (USA), Ms. Elizabeth McDonald (Jamaica), and Ms. Chen-Chen Yeh (Taiwan). The project has also supported the career 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*

Sales of 69 surplus animals to small-holders and NGOs at free-market prices 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 provides him with exposure to the principles of the U.S. democratic system.

### *Humanitarian assistance*

Linkages have been established with the GTZ, Food for the Hungry International (FHI), and Heifer Project International (HPI) to identify potential groups to assist with the multiplication and distribution of the KDPG. FHI has identified a project at Garissa involving the settlement to an agrarian lifestyle of nomadic peoples afflicted by drought, and HPI has identified a Women's Group in the Mombasa area as potential collaborators who will benefit from distribution of the KDPG.

## Collaborating Personnel

*United States*

Scott K. Davis, Associate Professor, TAES.
Francis Ruvuna, Research Scientist, TAES.
Lewis Nuti, Research Scientist, Prairie View A&M University.
Gary Newton, Research Scientist, Prairie View A&M University.
T.C. McGuire, Professor, Washington State University.
D. Jasmer, Professor, Washington State University.

*Kenya*

Bonfance Mwandotto, Research Scientist and Resident Scientist, TAES.
R.M. Waruiru, Lecturer, University of Nairobi.
A.M. Okeyo, Lecturer, University of Nairobi.
S.M. Mkuu, Technical Officer, KARI.
F. Rurangirwa, Associate Professor, Washington State University.

*Collaborating Scientist*

C.O. Ahuya, Research Officer, KARI.

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Ruvuna, F., J.F. Taylor, S.K. Davis, B.A.J. Mwandotto and C.O. Ahuya. 1992. Application of a nucleus breeding system in the development and improvement of the KDPG. Proc. 10th annual SR-CRSP workshop, Nairobi. Feb. 26-27, 1992.

Okeyo, A.M., B.A.J. Mwandotto, J.F. Taylor, F. Ruvuna, R.O. Mosi and C.O. Ahuya. 1992. Reproductive performance rating of indigenous goat genotypes and their crosses in Kenya. Proc. 10th annual SR-CRSP workshop, Nairobi. Feb. 26-27, 1992.

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Ahuya, C.O., F. Ruvuna, B.A.J. Mwandotto, J.F. Taylor, A.M. Okeyo and S.M. Mkuu. 1992. Teat size and udder conformation and their relationship to milking potential of East African and Galla goats. Proc. 10th annual SR-CRSP workshop, Nairobi. Feb. 26-27, 1992.

## Comments

Following the poor progress in multiplication of the KDPG last year, a review of management procedures was held with the Resident Scientist at the Workshop meetings in Nairobi in February. Following this meeting, a number of management changes were implemented that appear to be working-considering the 69% increase in KDPG numbers this year. However, this required a considerable amount of micro-management on the part of the principal investigator, which in conjunction with his serving as chair of the ETC this year, resulted in some loss in research productivity. However, the management changes implemented in Kenya now appear sustainable, and efforts devoted to research following relinquishment of the chair of the ETC have put the project's research back on line. Six manuscripts reflecting the research of our graduate students are currently in preparation and will be submitted within the next two months. Additionally, the project has assisted leverage of a $500,000 USAID Linkage grant between UNAM (Mexico) and Texas A&M University, and it also appears that the project will be successful in leveraging SR-CRSP funds with a USAID PSTC grant to study the genetics of *Haemonchus* resistance in the KDPG.

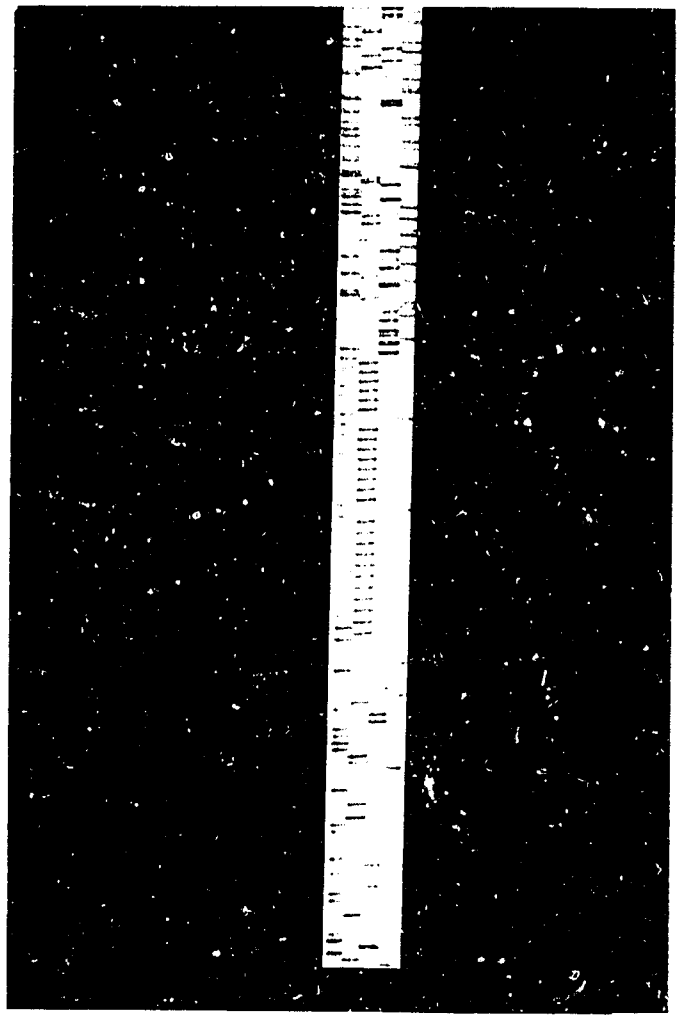

Figure 1. Sequence data of a cloned genomic fragment (designated SR-CRSP91) from a *Sau* 3A size selected (< 800bp) pUC plasmid library that was hybridized to an end-labeled 30-mer of poly dG-dT. The sequence reveals a poly (AC) repeat, for which PCR primers were designed from flanking regions.

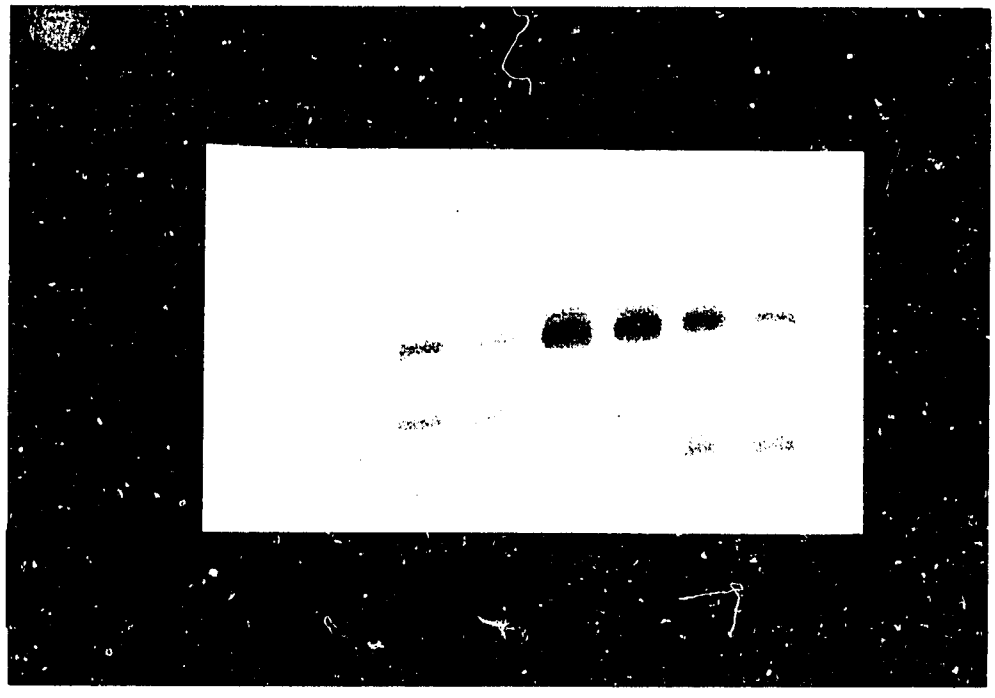

Figure 2. SR-CRSP91 scored in two half-sib KDPG families to demonstrate mendelian inheritance of the marker. The eight lanes correspond to eight animals with lane 1 the dam and lane 4 the sire genotypes corresponding to progeny genotypes in lanes 2 and 3. Lane 4 and lane 8 contain the sire and dam genotypes corresponding to progeny genotypes in lanes 5, 6, and 7. Sire 4 is homozygous for the slow allele, dam 1 is heterozygous for slow and fast alleles, and dam 8 is heterozygous for medium and fast alleles. Progeny 2 is a heterozygote that inherited a slow allele from sire 4 and fast allele from dam 1. Progeny 3 is a homozygote that inherited a slow allele from both sire 4 and dam 1. Progeny 5, 6, and 7 are all heterozygotes that inherited one slow allele from sire 4 and one medium allele from dam 8.

AGENCY FOR INTERNATIONAL DEVELOPMENT
OFFICE OF RESEARCH
ROOM 320 SA-18
WASHINGTON, D.C. 20523-1818 USA
TELEPHONE: (703) 875-4444
FAX: (703) 875-4157

7 December 1992

Dr. J.F. Taylor
Texas A&M University
Department of Animal Science
College Station, TX 77843

RE: "A Reverse Genetics Approach to Genetic Resistance to Helminths" (13.343)

Dear Dr. J. Taylor,

Congratulations. The review of your project by our peer review panel was positive. Moreover, your proposal was judged to be among the more highly ranked projects. Enclosed you will find the Decision Sheet and the specific critiques from the principal reviewers (A Forms). We will therefore continue with the processing of this proposal.

You should understand that the final decision to fund your project will depend on the overall ranking of your proposal in comparison with other projects, and the availability of funds. Concurrence of other A.I.D. units is also required. Funding cannot be assumed at this time.

Whenever communicating with us, please always refer to your proposal by its A.I.D.-assigned number -- 13.343. Note that the following person in the Office of Research will be your contact person -- Dr. Nancy Johnson. Communications should be addressed to this individual. Thank you for your cooperation.

Sincerely,

Miloslav Rechcigl, Jr., Ph.D.
Research Review Director

Enclosures: Decision Sheet; Substantive Critiques

cc: Drs. J.Kogi & B.A.J.Mwandotto

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

SEP 29 1992

Mr. Robert Smith
Vice President for Finance and
Administration
Texas A&M University
College Station, TX 77843-3121

Subject: Cooperative Agreement No. PCE-5063-A-00-2045-00

Dear Mr. Smith:

Pursuant to the authority contained in the Foreign Assistance Act of 1961 and the Federal Grant and Cooperative Agreement Act of 1982, as amended, the Agency for International Development (hereinafter referred to as "A.I.D.") hereby provides to Texas A&M University (hereinafter referred to as "Texas A&M" or "Recipient") the sum set forth in Section 1C.2. of Attachment 1 of this Cooperative Agreement to provide financial support for the program described in Attachment 2 of this Cooperative Agreement entitled "Program Description."

This Cooperative Agreement is effective as of the date of this letter and funds obligated hereunder shall be used to reimburse the Recipient for allowable program expenditures for the period set forth in Section 1B. of Attachment 1 of this Cooperative Agreement.

The total estimated amount of this Cooperative Agreement is the amount set forth in Section 1C.1. of Attachment 1, of which the amount set forth in Section 1C.2. is hereby obligated. A.I.D. shall not be liable for reimbursing the Recipient for any costs in excess of the obligated amount. However, subject to Section 1C.4. of Attachment 1, additional funds may be obligated by A.I.D. until such time as the obligated amount may equal the total estimated amount of this Cooperative Agreement.

This Cooperative Agreement is made to the Recipient on the condition that the funds will be administered in accordance with the terms and conditions as set forth in the attachments listed under my signature below, which together constitute the entire Cooperative Agreement document and have been agreed to by your organization.

320 TWENTY-FIRST STREET, N.W., WASHINGTON, D.C. 20523

- 2 -

Please acknowledge receipt and acceptance of this Cooperative Agreement by signing all copies of this Cover Letter, retaining one copy for your files, and returning the remaining copies to the undersigned.

Sincerely,

Thomas M. Stephens
Agreement Officer
Chief, FA/OP/B/PCE Branch
Office of Procurement

Attachments:

1. Schedule
2. Program Description
3. Standard Provisions
4. Special Provision entitled "Restrictions on Lobbying"

ACKNOWLEDGED:

TEXAS A&M UNIVERSITY

BY: _____

TYPED NAME: Robert Smith

TITLE: Vice President for Finance and Administration

DATE: December 10, 1992

## FISCAL DATA

**A. GENERAL**

A.1. Total Estimated A.I.D. Amount: $500,000
A.2. Total Obligated A.I.D. Amount: $100,000
A.3. Cost-Sharing Amount: $1,105,693
A.4. Other Federal (non-A.I.D.) Amount: $ N/A
A.5. Project No.: 936-5063
A.6. A.I.D. Project Office: R&D/UC, R. Frischer
A.7. Funding Source: A.I.D./W
A.8. Tax I.D. No.: 74-6000531-A1
A.9. DUNS No.: 04-291-5991
A.10. LOC No.: 72-00-1359

**B. SPECIFIC**

B.1.(a) PIO/T No.: 936-5063-2691866
B.1.(b) Appropriation: 72-112/31021.3
B.1.(c) Allotment: 263-36-099-00-20-21
B.1.(d) BPC: DDNA-92-16900-KG11
B.1.(e) Amount: $100,000

**INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA**
**ILCA**

**CENTRE INTERNATIONAL POUR L'ELEVAGE EN AFRIQUE**
**CIPEA**

P.O. Box 46847
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E-MAIL CGI 358

29th September 1992

Dr. J.F. Taylor
Dept. of Animal Science
Texas A & M University
432 Kleberg Center
College Station
Texas 77843-2471
U.S.A.

Dear Jerry

This letter is to acquaint you with current developments in the research ILCA has initiated to investigate the genetic basis of resistance to endoparasites in indigenous sheep and goat populations in Africa. Since we are also in the process of developing our next 5-year medium term plan this is a chance to consider potential collaborators in the research we are developing. While our research has a strong quantitative genetics component we are very interested to investigate the possibilities of collaborative research in the molecular genetics area. We have initiated this by talking to both Alan Teale and Steve Kemp here at ILRAD.

ILCA does not have any expertise in molecular biology at present, but as you know ILRAD does, and I am sure that collaboration between ILCA and ILRAD can and should be developed. ILRAD's major programme, however, is to carry out bovine genome analysis to ultimately identify markers and/or genes associated with trypanotolerance. Alan Teale is very interested in our endoparasite research programme, and earlier this year Steve Kemp ran a battery of his RAPD probes across some pooled DNA samples from some of our Red Maasai and Dorper rams and obtained some interesting results. I will send you a copy of the manuscript when it is completed.

I think that what ILCA has to offer would be DNA from pedigreed populations of sheep and goats which have been recorded for most production traits of economic importance, including resistance to endoparasites. I enclose some further details of our research protocols for your information.

The research site that is furthest down the track at present is that here in Kenya on the coast near Mombasa (i.e. Diani Estate).

In the 1990 and 1991 matings the following experimental design was followed:

| | | Sire breed | |
|---|---|---|---|
| | | Dorper | Red Maasai |
| Ewe Breed | Dorper | ✓ | ✓ |
| | Red Maasai x Dorper | ✓ | ✓ |

At each mating 12 rams of each breed was used each mated to 15-20 ewes.

I modified this design in 1992 to include a group of Red Maasai ewes as follows:-

| | | Sire breed | |
|---|---|---|---|
| | | Dorper | Red Maasai |
| Ewe Breed | Dorper | DxD | RMxD |
| | Red Maasai x Dorper | Dx(RMxD) | RMx(RMxD) |
| | Red Maasai | DxRM | RMxRM |

The first crop of lambs from the above mating design were weaned about a month ago, but unfortunately very few Red Maasai ewes were mated. This is about to be rectified in the next mating which will take place in a few weeks time when 100 Red Maasai ewes will be mated (i.e. half to each sire breed).

It seems to me that this mating design may be informative for genetic marker research as well as the quantitative genetics objectives (i.e. $F_1$'s and backcrosses available). We are not producing any $F_2$'s but this could be arranged if it was deemed useful. Our family structure, number of sires, etc has been designed with the objective of detecting breed differences and estimating heritabilities, etc reasonably precisely. Our family sizes may be too small for genetic marker studies and are half sib families rather than full-sib families. Again we would be prepared to think about alternative family structures.

There were not any very exciting breed differences in the 1990 and 1991 lamb crops, but the 1992 lamb crop looks more interesting (summary enclosed).

Research funds within ILCA and ILRAD from the CGIAR core funding are very tight at present and projections for future funding does not look much better. We are not, therefore, in a position to offer funds to carry out the sort of collaborative research I have suggested here. However, we are in the process of seeking external funding sources, and we would be very interested in any sources of funding you are aware of (e.g. USAID?). If you think there might be possibilities of collaboration please let me know how you would like to see this developed. I would also be interested to hear how your current research thrusts are progressing.

Kind regards,

Ray

R. L. Baker

P.S. Hope you had a good leave in Australia. Did you get to NZ?

PPS. We have now got DFREML Version 2.0 running here in Nairobi. The dimensions are very constrained by computer memory, but we hope to get a 486 with more memory to rectify that.

# *Economics of Small Ruminant Production Systems and Markets*

## Winrock International

Enrique Ospina, Winrock International Institute for Agricultural Development, Petit Jean Mountain, Route 3, Morrilton, Arkansas, 72110. Telephone (501) 727-5435, ext.268, Fax (501) 727-5417.

### Narrative Summary

In 1992, the SR-CRSP initiated a policy change that stated no principal investigator could have active programs in more than two sites. The economics program chose to concentrate on the Bolivia and Indonesia sites. As a result, the Kenya economics program was phased out on 30 September 1992. During its last year the program focused on livestock marketing in western Kenya. Main issues included the factors that influence small-holder farmers' decisions to sell animals and the contribution of those sales to the economic welfare of the families. The economics program also directed attention to an ex-post characterization survey and to gathering information in support of the SR-CRSP economic impact in Kenya in collaboration with the University of Missouri. Finally, the economics program collaborated with the Task Force on Donor PVO Perspectives on Livestock funded by the International Development Research Centre (IDRC) to review bibliography related to livestock research and development funding.

## Research

### Problem statement and approach

Population pressure in most of Africa's highland and subhumid zones is reducing average landholdings to a size where many farmers cannot support cattle herds which formerly provided rural residents with meat and milk. Thius the SR-CRSP is working to improve goat production and utilize the feed resources available to small-holder farmers and contribute to family income and nutrition. There are two promising strategies for the improvement of goat production in these areas: developing a dual purpose goat as an improved source of milk and meat and improving animal health by developing vaccines against contagious diseases.

These objectives can only be achieved if there is an understanding of how small ruminants fit into small-holder farmer production systems so that appropriate technologies might be developed for them. Five activities were planned,but due to the phase-out work concentrated on two activities, the ex-post economic impact analysis and the market analysis.

The livestock market analysis in western Kenya concentrated on identifying factors influencing livestock sales by small-holder farmers. Data from a 1991 survey conducted by the economics project in five villages of western Kenya indicate that small ruminant sales contribute about 24% of livestock revenues. Table 1 displays a summary of data indicating factors that influence sales decisions. The sales data cover the 1989-1991 period and show that a large proportion of DPG (54%) and other livestock sales (43%) take place in order to meet family financial needs.

**Table 1. Factors influencing sale decisions (%).**

| Item | DPG | Other Livestock |
|---|---|---|
| Financial need | 54 | 43 |
| School fees | 18 | 32 |
| Medical expenses | 12 | 9 |
| Sick animal | 9 | 3 |
| Poor condition | 3 | - |
| Unproductive | 3 | 2 |
| Land purchase | - | 4 |
| Cultural/festival needs | - | 6 |

Some 18% of DPG sales versus 32% of other livestock sales were made in order to raise cash for school fees. Farmers also often sell their animals due to medical emergencies (12% of DPG sales versus 9% of other livestock). Survey data in table 2 shows the value of livestock sold in the five villages over a period of three years. DPGs contributed an average of 20% of livestock revenues compared to 4% for local goats and sheep and 76% for cattle. The proportion of revenue contribution by cattle was high due to their larger body size; however, the frequency of small ruminant sales (298) was about two times as high as that of cattle (127).

**Table 2. Value (Ksh) of livestock sold in five villages.**

| Year | DPG | Sheep/ Goats | Cattle | Total |
|---|---|---|---|---|
| 1989 | 18265 | 3400 | 54825 | 76490 |
| 1990 | 14885 | 2270 | 77805 | 94960 |
| 1991(half) | 24825 | 5865 | 92185 | 122875 |
| Total | 57975 (20%) | 11535 (4%) | 224815 (76%) | 294325 (100%) |

Combined sales data for Hamisi, Rabuor, and Muhanda indicate that mean sales age for female DPGs was 2.83 years with a mean price of Ksh 224. Mean figures for male DPGs were 1.35 years and Ksh 205. While these prices exclude DPGs bought back by the project, the buy-back price of Ksh 200 per weaned female influenced the prices at which farmers sold the remainder of their DPGs. Depending on time of sale, mature local female goats in the area can be sold for as much as two to three times the prices reported here for DPGs. Also, these prices are far below those paid by well-to-do farmers who have purchased DPGs for breeding purposes from the breeding station at Ol Magogo in Naivasha.

### Activities

Those carried out as part of a collaborative effort between Winrock (economics project) and the University of Missouri (sociology project) included:

- Expost characterization survey.
  - Field work: identifying and making contact with non-participant farmers to be included in the survey and preparation of survey instrument (December 1991-January 1992).
  - Enumerator training and pre-testing survey instrument (January-February 1992)
  - Conducting the survey and the start of data coding (March-April 1992)
- Collaboration on the preparation of the economic impact study of the Kenya SR-CRSP. The study will look at the estimated potential macro effects of the Kenya SR-CRSP project.
  - Among other activities were the collaboration on the "Task Force on Donor and PVO Perspectives on Livestock" funded by IDRC. With SR-CRSP expertise in the area of livestock research major, assistance was provided in reviewing bibliography related to livestock funding, research, and development.
  - Winrock leaves the economics program in Kenya with the sense of having contributed to the sustainability of agriculture in western Kenya as a participant in developing profitable and environmentally benign dual purpose goat production practices and increasing marketability of its products.

## Training

Dr. Nyaribo participated in the one week course in Developing, Marketing, and Writing Research Project Grant Proposals, July 27-31, 1992, offered at Winrock International headquarters in Petit Jean Mountain. Dr. Nyaribo attended the annual American Agricultural Economics Association meetings, August 9-11, Baltimore, Maryland.

## Collaborating Personnel

*United States*
Enrique Ospina, Principal Investigator
Henk Knipscheer, Co-Investigator
Domingo Martinez, University of Missouri

*Kenya*
Fanny Nyaribo-Roberts, Resident Economist (to September 1992)
A. Nyongesa, Farm manager, Maseno Veterinary Farm, P.O. Box 25, Maseno, Kenya

*Enumerators*
T. Otana, B. Amwai, J. Atichi, C. Ominde, J. Chweya, I. Airo, B. Okumu, N. Omondi (Field assistant), P. Kwoba ( technical assistant).

## Collaborating Institution

Kenya Agricultural Research Institute (KARI)
P.O. Box 57811, Nairobi, Kenya

## Publications

Nyaribo, F.B. and D.L. Young. 1992. The Impacts of Capital and Land Constraints on the Economics of New Livestock Technology in Western Kenya. Agricultural Economics 6(4):353-364 March/April

## Abstracts and presentations

Nyaribo, F. and E. Ospina. 1992. Smallholder Livestock Marketing Patterns in Western Kenya. Proceedings of the 10th Small Ruminant CRSP Workshop, February 27-28, 1992, ILRAD, Kabete, Kenya.

Nyaribo, F. and E. Ospina. 1992. Dual Purpose Goat Technology Development in Western Kenya: Potential Farm Level Impact and Adoption. Paper presented at a Workshop on Social Science Research and the CRSPs, June 9-11, 1992, University of Kentucky, Lexington, Kentucky, sponsored by USAID and the CRSP Council.

# *Sociological Analysis of Small Ruminant Production Systems*

University of Missouri-Columbia

Michael F. Nolan, International Agriculture Programs, 228 Gentry Hall, University of Missouri, Columbia, Missouri, 65211. Telephone (314) 882-6085, Fax (314) 882-5127.

## Narrative Summary

Sociology concentrated its efforts this year on the study of adoptive behaviors of smallholder farmers that were involved with the Dual Purpose Goat component in western Kenya and on the ex-post assessment of the changes brought about by the SR-CRSP during its decade-long intervention in western Kenya's farming systems.

An aggregate adoptive behavior study was completed based on information from 1990 surveys. This study showed that the probabilities of adopting practices that require high capital outlays or human capital were relatively low, while those practices requiring low human capital and investment capital had relatively high probabilities of adoption. A 1992 follow-up survey sought to determine adoption behavior after the phase-out of technical assistance and to obtain a greater understanding of gender differences in the adoption process, as well as reasons for adoption of specific techniques.

The second area of emphasis was the ex-post evaluation study. The need to evaluate the research program and its impact on the participant and non-participant farmers resulted in the ex-post study, a joint effort between sociology at University of Missouri and economics from Winrock International. A specially-developed questionnaire was used to survey 220 farmers, including 63 who had not participated directly in the DPG on-farm program, to compare changes between participant and non-participant farmers. Comparative analyses of this and three prior surveys are under way, and preliminary results will be available in March 1993. Methodologically, the more complex issue is to factor out exogenous changes from the overall changes occurred among participant farmers due to dual purpose goats.

A third area, supported by University of Missouri-Columbia (sociology) and Winrock International is an economic impact assessment study of the Dual Purpose Goat Component. This study is being carried out at two different levels: impacts at the micro level (the household) and at the aggregate level (western Kenya and other regions where DPG and or supporting technologies can be introduced). The aggregate analysis will indicate the potential impacts of the component and the returns to research. Macro-data collection and the ex-post survey provide information needed for both the micro and aggregate analyses.

## Research

### Objectives

- To monitor and identify recent trends on adoption among cluster participants at a reduced level of intensity of technical assistance, and to identify factors influencing current patterns of adoption of technological packages.

- To determine the impact of the Dual Purpose Goat Component on the participant and non-participant farmers in western Kenya.

### Problem statement and approach

Land scarcity as a result of population pressure, and the traditional transfer of land from fathers to sons in much of Africa's highlands and sub-humid zones, is reducing the average landholding to a size where farmers can no longer have sufficient land to support cattle herds, which formerly provided rural residents with meat and milk. This is why goat production that provides both milk and meat using available feed resources has been viewed as a promising alternative to improve family income and nutrition.

The SR-CRSP has been working in western Kenya for more than ten years. One of the most recent achievements of the SR-CRSP in Kenya was the development and distribution of a technological package to support the Kenyan Dual Purpose Goat. In the past decade, changes have taken place in the farming systems project; the activities of the project were phased out during 1992, and farmers raising goats will continue production without technical assistance from the SR-CRSP. Analysis of the factors constraining or facilitating adoption of the DPG and supporting technologies is essential to an effective extension phase, which is beyond the mandate of the program. But if positive social and economic impacts are expected from the SR-CRSP's research in Kenya, this information is essential. Assessment of micro and macro impacts will provide information for the next phase to be carried out by the Government of Kenya: extension and adoption of technologies.

## *Study of adoption behavior of farm households with the DPG technology in Western Kenya.*

### Justification

The DPG and its technological package is suitable for the small farm units and unreliable rainfall conditions faced in western Kenya. To assess suitability of the dual purpose goat to the farming community, the socio-economics project studied acceptability and adoption of the goat and the recommended packages in selected regions of western Kenya.

### Progress

Two research activities were undertaken by Dekha Sheikh, sociology's co-investigator, to study factors affecting the adoption of technological packages by farmers. The first was to investigate the differences in probabilities of adopting specific dual purpose technology items across demographic, farm, and household characteristics. Data for this study were collected from a 1990 survey of sixty-six farm households in western Kenya. A multinomial logit model was utilized to categorize the farmers on the basis of demographic, farm, and household characteristics, and probabilities of adopting specific dual purpose goat technology items were estimated.

The aggregate adoptive behavior represents the estimates of the whole sample (e.g., of all households in western Kenya using dual purpose goat technology, the probability is 11.36 percent that a random household will grow napier grass). Estimates of aggregate adoptive behavior of farm households are presented in Table 1 in descending order of probability of adoption. Results indicate that probabilities of adopting items that require high capital outlays or relatively higher human capital are low. On the other hand, items that require relatively low capital investment as well as low human capital have higher probabilities of adoption. The first six items with highest probability of adoption pertain to feeding and nutrition. The research results also indicate that adoption rates are lower for items that require high capital outlays or relatively higher human capital in the case of female farm operators as compared to male farm operators (Table 2). The results suggest that high human capital and capital investments may be major contributors to low adoption rates of certain technological items. Economics (Winrock International) and sociology (University of Missouri-Columbia) provided resources for data collection in western Kenya.

As a co-investigator from KARI, Sheikh continued the evaluation of adoption practices. The items studied in the first research activity were reviewed in 1992 to compare adoption patterns with declining technical support received by farmers from the project. Data was also gathered to assess further the differential adoptive behavior of male and female decision makers within the farm households. A survey of seventy farm households (including all sixty-six surveyed in 1990) was conducted July to August 1992 to gather data for this study. Tentative results indicate that the level of utilization of some of the techpacks has gone down due to the absence of the dual purpose goats on 50% of the farms. Reasons for this decline include deaths of dual purpose goats or sale of the goats to provide emergency cash for needs including funeral expenses, hospital expenses, food purchases, etc. Analyses of the data to elicit reasons why farmers are utilizing or not utilizing some of the technological items, and to examine gender roles in the production of the dual purpose goat, are on going. This activity corresponds to the 1992-1993 workplan, and its conclusion is expected to be on time.

**Table 1: Aggregate adoptive behavior of farm households.**

| Innovations | Probabilities(%) |
|---|---|
| Growing napier grass | 11.36 |
| Tethering | 10.73 |
| Growing *Sesbania spp.* | 10.56 |
| Sweet potato vines | 9.37 |
| Growing *Leucaena spp.* | 9.29 |
| Hanging vines | 8.35 |
| Milking DPGs | 8.26 |
| Feed supplements | 7.63 |
| Model farm | 6.44 |
| Production records | 5.52 |
| Steaming up | 4.79 |
| Flushing | 4.57 |
| Housing | 1.54 |
| Health records | 1.52 |

Note: The probabilities do not add up to 100 percent due to rounding errors.

**Table 2. Adoptive Behavior of Male and Female Farm Decision Makers: DPG Technology in Western Kenya, 1990**

| Male Farm Decision Makers | | Female Farm Decision Makers | |
|---|---|---|---|
| Innovations | Prob(%) | Innovations | Prob(%) |
| Tethering | 10.22 | Growing napier grass | 12.41 |
| Growing napier grass | 10.21 | Growing *Sesbania spp.* | 11.49 |
| Growing *Sesbania spp.* | 9.54 | Tethering | 10.28 |
| Milking DPGs | 9.02 | Growing *Leucaena spp* | 10.08 |
| Feed supplements | 8.71 | Sweet potato vines | 10.04 |
| Sweet potato vines | 8.64 | Hanging vines | 8.56 |
| Growing *Leucaena spp* | 8.42 | Model farms | 8.02 |
| Hanging vines | 8.13 | Milking DPGs | 7.57 |
| Production records | 7.24 | Feed supplements | 6.65 |
| Flushing | 7.05 | Steaming up | 4.64 |
| Seaming up | 4.95 | Production record | 3.95 |
| Model farms | 4.70 | Flushing | 2.31 |
| Housing | 2.42 | Health records | 2.28 |
| Health records | 0.69 | Housing | 0.74 |

## *Ex-post study of the Dual Purpose Goat in Western Kenya.*

### Justification

Several changes have taken place due to the introduction of innovations by the SR-CRSP, as well as due to changes occurring outside the program, such as the dissemination of string or French beans (a new cash crop) and other adjustments induced more subtly by modifications in the macroeconomic environment. However, no systematic study exists on the nature, origin, and extent of those changes, and therefore it is not yet possible to measure the actual and the potential impact of the SR-CRSP. The general objective of the ex-post study is to measure the impact of the SR-CRSP at the farm level, not only with regards to the economic changes (which will be the main concern of the economic impact study), but to the various components of the farming system, such as crops, livestock, markets, and labor utilization. This activity is carried out by Domingo Martínez, research associate from University of Missouri, collaborating with Fanny Nyaribo, resident scientist from economics at Winrock International.

The SR-CRSP farming systems program in western Kenya has collected family-farm information since its inception in 1980, but no comparative analyses have been made across time. Since 1986, follow-up information was collected only from the farmers participating in the DPG on-farm trials. To factor out the effects of the SR-CRSP, it is necessary to measure first the changes brought about by the evolution of technology, economics, and social environment. These measurements are obtained from so-called control subjects that, in projects like this one, cannot be effectively sustained in the long term due to interviewee fatigue, unwilling interventions, etc. It is then necessary to examine changes between pairs of static observations, as opposed to the dynamic observations pursued with the participant farmers.

The research in western Kenya has resorted to several questionnaires to collect farm and farmer data, such as:

1. Baseline survey (1980-81); a static survey that, because of its length, was administered in two modules, 14 days apart, to eighty farms in two clusters of households (in Kakamega and Siaya districts);
2. Extension Survey (1984); multi-stage interviews of one hundred and four farmers in thirteen villages in Kisumu, Siaya, and Kakamega districts (demographics, education, land, and other socioeconomic data, as well as aspects of crops and livestock enterprises);
3. Rapid Appraisal I (1986); on-farm evaluation of F1 goats provided by the Ol Magogo DPG breeding center (twenty-four farmers were selected in each of Hamisi, Kaimosi, and Masumbi clusters);
4. Rapid Appraisal II (1988); similar to the first, eighty-two farmers were interviewed in three new clusters, namely Muhanda (36 farmers), Rabuor (35), and Lela (11).

The ex-post study will be carried out through a comparison of farms in western Kenya. It will use the available information of all SR-CRSP data sources described above, plus a specific survey applied in March and April 1992. Several types of comparisons will be made:

a) Aggregate comparisons, based on statistics for the samples available at each period in which information was gathered;
b) Over-time comparisons by cluster;
c) In-depth case studies of some families for which information exists covering several years.

## Progress

An initial quantitative comparison is being made between the current and the 1980's farming systems in each of the clusters. Subsequently, the data base will be used for in-depth comparisons of specific analytical topics, with special consideration as to persistence of introduced technologies, long-term bio-economic impact, and market issues. The first report will be an overall assessment of changes in land use, livestock (species mix and breeds), crop yields and varieties, and income sources.

To begin, two types of questionnaires (for participant and non-participant farms, respectively) were tested and applied in western Kenya. The survey included most of the households that participated in the on-farm trials of dual-purpose goats and a sample of non-participant households drawn from the farmers interviewed in the 1984 Extension survey. In total, 221 farmers were interviewed (157 participant, 64 non-participant). To avoid interviewee fatigue, an effort was made not to address inquiries on information readily available elsewhere and/or being collected as part of the Nutrition and Management dynamic data collection. For the participant farmers, this includes most data on goats, crops, inputs, production, etc. The basis for the questionnaires was the Rapid Appraisal instruments of 1986 and 1988.

Non-Participant Farmer Questionnaire: This questionnaire consisted of four pages of information on demographics, capital goods, crops, livestock inventory, perceptions about the DPG, and off-farm activities; additional livestock information was collected.

Participant Farmer Questionnaire: Similar to the non-participant questionnaire with the exception of the additional details referring to DPG-keeping. Care was employed not to include queries asked by other projects. The purpose of the questions referred to changes occurred in the household and/or the farm.

The ex-post questionnaire was tested in February 1992 and applied during March and April. Data bases for Rapid Appraisals I and II were identified in computer files at Maseno, and most have been translated into a common format. The Extension questionnaires, also available at Missouri, needed to be re-entered completely. The ex-post questionnaires have been coded, and data entry for the non-participant farmers has been completed. Data entry for the participant farmers will be resumed in January.

There is some delay with respect to the completion of these tasks because of the unexpected difficulties found in the old data bases, the need to re-enter completely the Extension questionnaire of 1984, and the lack of funds from October 1992 to January 1993. A preliminary report with general statistics will be submitted to the workshop on March 1993.

### *Economic impact assessment of the Dual Purpose Goat and supporting technological packages.*

#### Justification

This assessment is part of a larger study that looks at economic impacts of the SR-CRSP research and training programs on the farmers and consumers of host countries. There is currently a movement by donor agencies to determine the returns to investment in research. Africa is no exception to this, and the CRSPs are being urged to show their impacts. The greater part of the effort of 1992 was concentrated in the study of the Indonesia program, though data collection went on in western Kenya and Nairobi. The objective is to determine the returns to research and the benefits to producer and consumers at the micro and macro level.

#### Progress

A review of methodologies showed the economic surplus model as a feasible tool to measure returns to research. In order to accomplish this, information on the technological alternatives and their impact on yield and costs need to be determined. Dr. Fanny Nyaribo-Roberts is collaborating in this effort, looking at introducing technologies preferred by the farmers and estimating the yields and costs of these activities. Knowledge of adoption is required to predict probable patterns in the future. This is necessary because research, development, and adoption lags exist in agriculture. An ex-ante evaluation or estimation of potential impacts requires this information. Ms. Dekha Sheikh, collaborating scientist of socio-economics, has provided information that will be used in estimating adoption levels. The collaboration of Domingo Martínez through the ex-post study will provide information at the micro level as to the impact of users and non-users of the DPG technologies. A research assistant, Mr. Charles Kenyanito, gathered macro statistics on livestock production, prices, and trade that will be used in the evaluation. Interviews were carried out with biological scientists on the yields and performance of F1s and their multiplication efforts. Dr. Corinne Valdivia is leading the economic impact study. Information at the micro level (budgets and yields) is expected sometime in Spring 1993. Estimation of the returns are expected around May 1993.

#### Training

Dekha Sheikh completed her M.S at Clemson University in Economics in May 1992. The title of her research is "A Study of the Adoption of Dual Purpose Goat Technology By Small-Scale Farmers: A Case Study of Western Kenya." Support for her thesis research was provided by University of Missouri-Sociology and Winrock International-Economics, and the USAID Kenya National Agricultural Research Project (KARI and UM).

David Ekwee Ethuro from Kenya obtained his Master's degree in economics from Clemson University in May of 1992. His Masters Thesis, "A Socio-Economic Analysis of Household Expenditures in Rural Western Kenya," focused on the study of household consumption and expenditure behavior to evaluate the demographic and economic determinants of household expenditures. Age of respondent, education, income levels of the household, and employment status of the family were found to be key determinants of the expenditures. Support from Sociology (University of Missouri-Columbia) and Economics (Winrock International), and the USAID Kenya National Agricultural Research Project, was provided for his research in Kenya.

## Contributions

### *Sustainability*

The Dual Purpose Goat Technological Package is fairly comprehensive, developed through an approach that considers the system in which animal production is being introduced, and the impact it will have in resource use and production substitution. The monitoring of farmers allows us to determine the socio-economic conditions in which technologies are introduced and the impact it has in the farming system. Appropriate technologies to the land; capital and labor resources; and environmental, social, and economic conditions of household farmers are developed through contributing to a sustainable production system. Sociology contributes to developing sustainable systems by identifying the social and cultural constraints to access land, labor, and other productive resources, and it works with biological scientists in the development of techniques that are sound.

### *Gender*

Factors conditioning adoption of technological practices are being analyzed by gender to establish the conditions under which differences in adoption exist. This information is necessary for the Government of Kenya and non-governmental organizations to develop an effective extension program in the future.

### *People impact*

Although a commodity mandate exists, small ruminants, the ultimate beneficiaries of the technologies developed with the Kenyan Dual Purpose Goat are the household producers that own small ruminants and consumers of milk and meat in Kenya.

## Collaborating personnel

*Kenya*

Dekha Sheikh, Host Country Socio-economics Co-investigator, KARI

A. Nkonge Mbabu, Sociology Collaborating Scientist, KARI and ISNAR

Fanny Nyaribo-Roberts, Economics Resident Scientist, Winrock International

Patterson Semenye, Nutrition and Management Resident Scientist, Winrock International

*United States*

Michael F. Nolan, Principal Investigator, University of Missouri-Columbia

Jere L. Gilles, Co-Principal Investigator, University of Missouri-Columbia

Corinne Valdivia, Co-Principal Investigator, University of Missouri-Columbia

Domingo Martínez, Research Associate, University of Missouri-Columbia and collaborator Winrock International

Ralph Brown, Research Associate, University of Missouri-Columbia

## Collaborating Institution

Kenyan Agricultural Research Institute (KARI)

## Publications

Ethuro, David Edwee. "A Socio-Economic Analysis of Household Expenditures in Rural Western Kenya," Unpublished Masters Thesis, Clemson University, Clemson, South Carolina. May, 1992.

McCorkle, Constance M. and E. Mathias-Mundy. "Ethnoveterinary Medicine in Africa," Africa: Journal of International African Institute 62(1):59-93. 1992.

Sheikh, Dekha. "A Study of the Adoption of Dual Purpose Goat Technology By Small-Scale Farmers: A Case Study of Western Kenya," unpublished Masters Thesis, Clemson University, Clemson, South Carolina. May, 1992.

## Presentations

Dekha Sheikh presented the paper "Aggregate Adoptive Behavior of Farm Households: Dual Purpose Goat Technology in Western Kenya" Seminar KARI/SR-CRSP. Nairobi. Nov. 23, 1992.

# Animal Health Management through Biotechnology

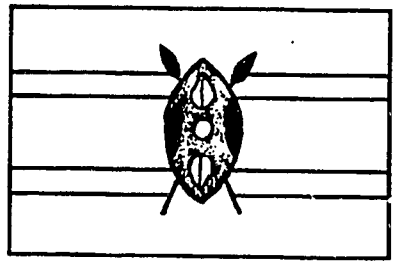
"Mortality and morbidity rates at SR-CRSP worksites show that infectious diseases continue as an important constraint to sheep and goat production. Because of the difficulty of obtaining and applying local reliable, economical univalent (single disease) vaccines, few farmers vaccinate their animals. 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*

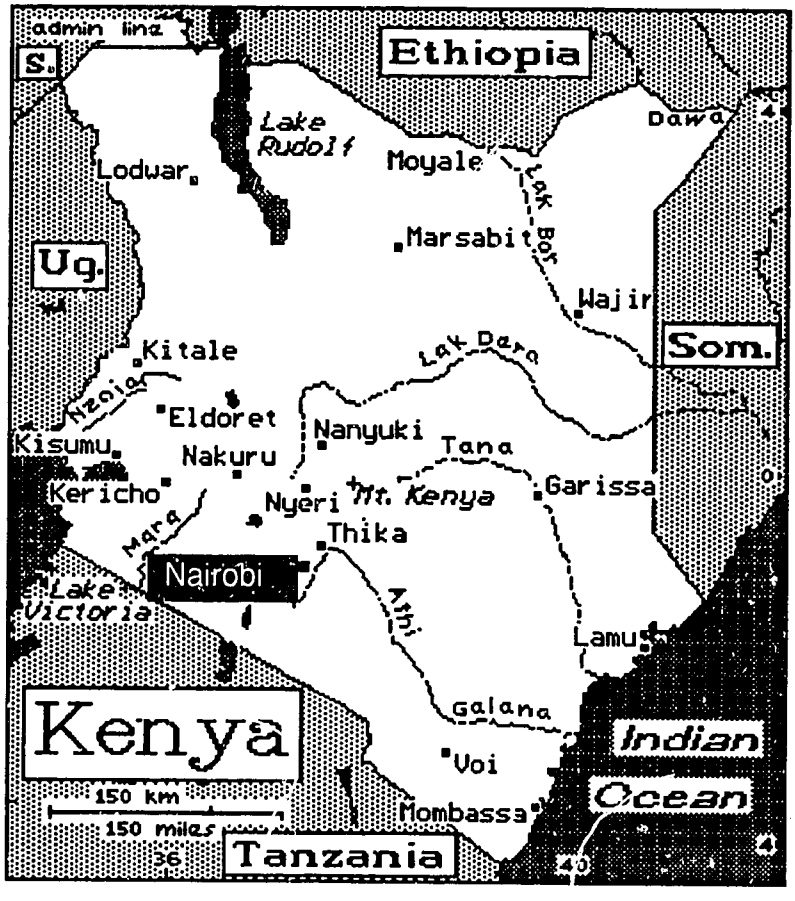
# Republic of Kenya

**Total area:** 582,650 square km (224,960 square miles)
**Geography:** Tropical along coast to arid in interior, low plains rise to central highlands bisected by Great Rift Valley; fertile plateau in west.
**Capital:** Nairobi.
**Population(1991):** 25,241,000
**Languages:** Swahili, Kikuyu, Luhya, Luo, Meru.
**Labor force:** 78% agriculture, 22% non-agriculture.
**% Females in labor force:** 40.3%
**Industries:** Tourism, light industry, petroleum products.
**Chief crops:** Coffee, corn, tea, cereals, cotton, sisal.
**Land in Agriculture:** 10.6%
**Agriculture of GNP:** 31%
**Sheep population:** 7,300,000
**Goat population:** 8,500,000
**Uses of sheeps and goats:** Meat and milk.
**Inflation rate:** 8.3% (1988)
**Monetary un.:** Shilling.

**Kenyan Flag**



**United States Sites**

# *Multivalent Virus-Vectored Vaccine for Goats*

## Washington State University

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## Narrative Summary

The Washington State University (WSU) project is part of a biotechnology component that includes a focused research goal, strong inter-institutional collaboration, and limitation to one primary site, Kenya. Investigators from WSU and Colorado State University (CSU) work with resident scientists and Kenya Agricultural Research Institute (KARI) collaborators to develop multivalent virus-vectored vaccines for selected infectious and parasitic diseases of sheep and goats in Africa and other parts of the world. SR-CRSP investigators from the University of Missouri (UM) are engaged in assessing the capacity of African countries to produce and apply the vaccines and assessing their social acceptability and potential economic impact.

One major activity for which the WSU project has the lead is the development of a safe and reliable virus vector to deliver the multivalent vaccines to goats and sheep. The primary goal is to evaluate attenuated capripoxvirus as a virus vector. Major progress was made by constructing and isolating a recombinant capripoxvirus (rCPV-RVFg) which appears to express a foreign gene encoding a protective glycoprotein from Rift Valley fever virus. Since both wild type capripoxvirus and Rift Valley fever virus cause disease in goats and sheep, the rCPV-RVFg may induce protection from both viruses. If protection occurs, we would then have a bivalent virus-vectored vaccine to which other genes encoding protective proteins could be added.

Previous reports described that goats immunized with isolated whole gut preparations from *Haemonchus contortus* were significantly protected against challenge with $10^4$ *H. contortus* larvae. Gut antigens isolated by affinity chromatography with a monoclonal antibody also induced significant protective immunity. This result identifies protective gut antigens and provides a polyclonal antiserum to screen *H. contortus* mRNA libraries to identify an mRNA clone expressing the protein. This is an important step to obtaining a *H. contortus* gene to insert into the virus vector. In addition, one gene encoding an immunodominant protein of *Cowdria ruminantium*, the cause of heartwater, was cloned and expressed in bacteria.

Training activities were also successful with the completion of an M.S. degree by Francis Karanu, a trainee from Kenya and Stanley Kihara, another trainee very close to completion of his M.S. Karanu will continue to work on a Ph.D. Leah Ndung'u, another trainee, continued her M.S. thesis research.

## Research

The general problem addressed by this project is that infectious diseases, including internal parasites, continue to constrain efficient goat raising and to limit the introduction of improved goat breeds. One method of control for infectious diseases is vaccination. However, current univalent vaccines derived from attenuated or inactivated organisms are

expensive to produce one-by-one and the distribution of several individual vaccines is difficult. The goal of the project on multivalent virus-vectored vaccines for goats is to use biotechnology to develop a single vaccine that is economical and will protect animals against several infectious diseases. This goal is shared by other projects focused on the development of a similar vaccine for sheep and on the evaluation of the acceptance and utility of new vaccines. In fact, the same virus vector may be used for both goat and sheep vaccines and may include some similar components since some of the diseases needing vaccines occur in both species.

One specific problem addressed by the WSU subcomponent is 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 multivalent. Other specific problems are identifying vaccine genes from organisms causing goat diseases. The primary targets for 1992 were heartwater and haemonchosis.

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. Heartwater is a problem in Africa below the Sahara and in the Caribbean. Haemonchosis is a parasitic disease of small ruminants that occurs in most countries of the world, including the United States.

## *Evaluate attenuated capripoxvirus (CPV) as a virus-vector for foreign genes.*

### Problem statement and approach

The problem is to find a safe virus vector that will express foreign genes in goats and sheep while inducing immune responses to the expressed proteins. One possibility is CPV, which causes goat and sheep pox. These are economically important diseases in countries throughout Africa and Asia. Attenuated CPV has been used as a successful vaccine in Kenya for many years and is an excellent starting point for development of a virus vector. CPV has been partially characterized molecularly and gene insertion sites have been described.

The first objective was to construct an attenuated capripoxvirus (CPV)-Rift valley fever glycoprotein gene recombinant. The proposal was to use a recombinant plasmid that contained a gene from a pathogenic virus of goats and sheep. The plasmid, pSCRV-6, was made by inserting the Rift valley fever glycoprotein gene into pSC11. When others used pRVF to make a recombinant vaccinia virus that expressed the glycoprotein gene, the recombinant vaccinia virus induced a protective immune response against RVF virus challenge. The plan was to use pSCRV-6 to insert the glycoprotein gene into CPV since we did not want to use a recombinant vaccinia virus. Homologous recombination between the attenuated Kenya strain of CPV and pSCRV-6 occurred in cell cultures evidenced by the cells expressing the ß-galactosidase gene carried by pRVF. However, the recombinant CPV could not be isolated away from wild type CPV.

Another strategy was tried using a new recombination plasmid. This plasmid, p1114, contained the *E. coli* xanthine-guanine phosphoribosyl transferase gene (*gpt*) which is a dominant selectable marker for the construction of recombinant poxviruses. Mycophenolic acid inhibits the growth of poxviruses, including CPV. When the *gpt* gene is inserted with the foreign gene of interest into CPV, the recombinant poxvirus will grow in the presence of mycophenolic acid and can be selected from non-recombinant CPV. Therefore, the gene encoding RVF glycoprotein was removed from pSCRV-6 and inserted into the cloning site of p1114. The p1114/RVF was used in homologous recombination experiments with attenuated CPV (KS-1). A recombinant CPV was isolated which grew in the presence of mycophenolic acid. This recombinant, rCPV-

RVFg, was biologically cloned three times and evaluated for expression of RVF glycoprotein.

The second objective was to demonstrate that the recombinant CPV expresses the RVF glycoprotein gene. Western blots were done on rCPV-RVFg infected cells using a monoclonal antibody to the RVF glycoprotein to show that the rCPV-RVFg construct makes RVF glycoprotein *in vitro*. The western blot allows evaluation of the glycoprotein size, which should be the same as reported for the vaccinia virus expressing the same gene. Preliminary data indicated that rCPV-RVFg infected cells were making RVF glycoprotein.

### Progress

The criteria for evaluation of attenuated capripoxvirus (CPV) as a virus-vector for foreign genes is as follows. A recombinant virus will be made from CPV that contains the Rift valley fever virus glycoprotein gene. Evidence also will be available that this recombinant CPV will express the glycoprotein.

Both these criteria were met. However, the recombinant capripoxvirus expressing the rift valley fever virus glycoprotein needs additional characterization. Completing this activity is a major achievement for this component that will allow animal testing of the virus vector and a foreign gene from a disease causing virus.

## *Identify vaccine genes from the heartwater agent,* ***Cowdria ruminantium.***

### Problem statement and approach

Heartwater was chosen for inclusion in a multivalent vaccine for goats because of its widespread occurrence in Africa and the Caribbean. In the absence of a practical vaccine, this tick-transmitted rickettsial disease causes high morbidity and mortality in both goats and sheep. To include *C. ruminantium* genes in a virus-vectored multivalent vaccine for goats, a gene encoding a protein that will induce a protective immune response must be identified.

The first objective was to clone at least two genes expressing *C. ruminantium* surface proteins. In collaboration with Dr. Tony Barbet at the University of Florida and Dr. Frans Jongejan at the Utrecht Faculty of Veterinary Medicine, immunoscreens of genomic DNA libraries were done with dilutions of a serum from a heartwater-infected goat that survived infection and was rechallenged. A recombinant *E. coli* colony, F5.2, was identified from a pUC13 library of *C. ruminantium* genomic DNA by immunoscreening with hyperimmune sheep serum. The F5.2 plasmid insert DNA programmed *in vitro* synthesis of a protein of approximately 21 kDa that was immunoprecipitated by immune sheep serum. Sera from rabbits immunized with recombinant F5.2 *E. coli* recognized a 21 kDa protein in all seven strains of *C. ruminantium* tested. By immunoblotting, the 21 kDa protein was immunodominant and consistently recognized by sera from infected sheep, goats, and cattle.

The 2773 bp cloned DNA insert contained two long open reading frames (ORF's) of 627 bp and 831 bp, both potentially encoding proteins containing an N-terminal signal peptide. The 627 bp ORF encoded a 23.6 kDa polypeptide or a mature protein of 21.4 kDa. The 831 bp ORF was incomplete, being interrupted at the 3' end by plasmid vector sequences. Deletion experiments suggested that the 627 bp ORF encoded the immunodominant 21kDa *C. ruminantium* protein. A 2125 bp EcoRI fragment of the cloned DNA hybridized to genomic DNA prepared from *C. ruminantium* strains from Zimbabwe, South Africa, Nigeria, and the Caribbean island of Guadeloupe did not hybridize to *Anaplasma marginale*, *Babesia bigemina*, *Babesia bovis*, *Trypanosoma brucei*, bovine, ovine, or caprine DNA.

The immuno-dominant nature of the 21kDa protein and its consistent recognition by sera from heartwater-infected animals are reasons for further testing of this recombinant protein in subunit vaccines and diagnostic tests.

The second objective was to determine if antibody to outer membrane epitopes will

block infection by *C. ruminantium*. This objective was pursued by Leah Ndung'u, a KARI employee and WSU graduate student funded by SR-CRSP. She completed her M.S. coursework at WSU and returned to Kenya to do her thesis research. Her advisor at WSU is Dr. Guy Palmer and her advisor in Kenya is Dr. Fred Rurangirwa. The strategy is to test the ability of antibody to outer membrane epitopes of the heartwater organism to block infection of endothelial cells *in vitro*. Antibody that blocks cell infection by the organism can be used to identify the proteins being recognized, which will lead to specific antibody reagents for screening genomic DNA libraries.

The progress on this objective has been delayed by technical problems involved in growing enough *C. ruminantium* organisms in *in vitro* endothelial cell cultures. The organisms are needed to isolate outer membranes for use in immunizing goats. The major advisor, Dr. Palmer, will visit Kenya in early February to discuss these problems with Ndung'u and Dr. Rurangirwa. A solution or alternate strategy will be devised to enable Ndung'u to finish her M.S. thesis research.

### Progress

The criteria for evaluation, for identifying vaccine genes from the heartwater agent *Cowdria ruminantium*, is as follows. Two genes expressing *C. ruminantium* surface proteins will be cloned and characterized. In addition, antisera to outer membrane proteins will be made and evaluated for its ability to block infection of endothelial cells.

The part of these criteria that was completed was the cloning, expression, and sequencing of one *C. ruminantium* gene expressing an immunodominant protein. This recombinant protein will be evaluated to determine if it will induce a protective immune response in goats. Another gene will be cloned before the end of the 1992/93 grant year. Production of the antisera to outer membrane proteins was delayed because of problems in growing the organism *in vitro*. This problem is being assessed to determine if a change in the objective is needed to finish a M.S. thesis project.

## *Identify 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. Recent immunization trials using parasite gut homogenate induced a significant protective immune response. It is hypothesized that the parasite ingests antibody and immune cells as it feeds on blood, and these immune components kill or injure the worm. The current problem is to identify the active component in the homogenate. Since sera from protected animals react with only a few homogenate proteins, it seems feasible to isolate the major proteins and to test their immunoprotective potential individually. Monoclonal antibodies are particularly effective for isolation of proteins from complex mixtures.

The objective was to immunize groups of goats with two different *H. contortus* gut surface proteins isolated by monoclonal antibody affinity chromatography. One group of six monoclonal antibodies had similar reactivity on tissue and western blots and were represented by one designated 42/10.6.1. This monoclonal antibody reacted with several worm tissues, including the gut surface and body wall, and weakly to cuticular regions. On western blots of whole worm extracts, it reacted with at least 18 protein bands ranging in size from about 175 to 18 kDa. Thirteen comigrating proteins were identified in isolated gut samples. Another monoclonal antibody designated 42/53.3.5 reacted exclusively with the microvilli of adult *H. contortus* gut in fixed cryosections and to the surface of the gut of fresh samples. This

monoclonal antibody recognized a 46 kDa protein, although occasionally a band was also observed at about 100 kDa. The 46 kDa protein was also enriched in the crude membrane and excretory/secretory fractions of adult worms. The epitope recognized by each monoclonal antibody was destroyed by periodate treatment, indicating that these epitopes were carbohydrates. We currently consider the epitopes recognized by both mAb 42/10.6.1 and 42/53.3.5 as presumptive carbohydrates.

Both 42/10.6.1 and 42/53.3.5 were used to immunoaffinity isolate antigens from adult *H. contortus* worms. Numerous proteins were isolated from the 42/10.6.1 antibody column, and, without obvious exception, all isolated antigens reacted with this monoclonal antibody on subsequent western blot. In contrast, three dominant proteins of 52, 46, and 30 kDa were repeatedly isolated from the 42/53.3.5 antibody column. Two of these proteins (46 and 30 kDa) demonstrated significant binding of this anti-body on western blots of the isolated proteins.

Antigen preparations isolated from the 42/10.6.1 and the 42/53.3.5 immunoaffinity columns were each used to immunize groups of goats. Both preparations induced immunity that resulted in significant reductions of mean total worms (45% and 60%, respectively) in the immunized group compared to the control group ($p<0.05$). Numerically lower mean fecal egg counts were observed for the immunized compared to control groups in both trials; at all time points tested, but differences were not statistically significant ($p>0.05$). We consider this level of immunity to be moderate, although very significant because the results identify specific gut surface antigens that induced protection against a blood-sucking nematode parasite. To improve on the level of protection may require either different antigen presentations and/or additional protective antigens presented in combination with those already identified. The polyclonal antisera from immunized goats can be used to screen *H. contortus* mRNA libraries for genes expressing these protective antigens.

### Progress

The criteria for evaluating the activity identifying vaccine genes from *Haemonchus contortus* is as follows. Two immunization experiments will be completed evaluating two different *H. contortus* gut surface proteins isolated from gut homogenate by immunoaffinity chromatography.

The criteria for completion of objective 1 of this activity have been met. Importantly, the antigens identified by monoclonal antibody 42/53.3.5 produced the best protection in goats and were identified for further study.

## *Search for vaccine genes identified from our other projects and other scientists.*

### Problem statement and approach

We and others doing research on different infectious diseases of goats might identify vaccine genes that could be included in the virus-vectored multivalent vaccine for goats. In particular, Dr. Don Knowles and others at WSU are evaluating the ability of genes from caprine arthritis encephalitis virus to make proteins that will induce a protective immune response. The plan for this activity is to monitor progress of this and other research and, if such genes are identified, to negotiate for their use in the SR-CRSP sponsored effort to develop a virus-vectored multivalent vaccine for goats.

Dr. Donald Black (Pirbright, England) has developed a recombinant capripox-rinderpest virus vaccine that might induce a cross-protective immune response in sheep and goats against peste des petits ruminants (PPR). If additional funds were identified, he might be willing to work with SR-CRSP to test the construct in West Africa.

## Progress

The criteria for evaluating the search for vaccine genes identified from other projects and scientists is as follows. Even though no SR-CRSP funds will be used for this activity, we expect to identify or negotiate for one gene that can be evaluated as a component of the virus-vectored multivalent vaccine for goats.

The goal of identifying at least one gene that could be evaluated as a vaccine component was met; we will, however, continue to pursue this activity.

## Training

All training involves degree candidates in the WSU Department of Veterinary Microbiology and Pathology; we have no non-degree training. All students are natives of Kenya. They 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.

Stanley Kihara was a master's degree student who finished in early 1993. His salary was paid by KARI, but SR-CRSP paid all other costs of research. His research was on identification of surface antigens of contagious caprine pleuropneumonia that might provide the basis for subunit vaccines or diagnostic tests.

Francis Karanu, a KARI employee and a WSU graduate student funded by SR-CRSP, has completed his M.S and is at WSU completing his coursework for a Ph.D. 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 will be in the area of identifying *H. contortus* genes that encode proteins that induce a protective immune response in animals.

Leah Ndung'u recently returned to Kenya to begin her master's degree research. She started studying at WSU in January 1991; her anticipated completion date is December 1993. KARI is now paying her salary while SR-CRSP continues to pay all her research costs. Her research is on *Cowdria ruminantium*.

Reuben Soi is now doing doctoral research in Kenya. His studies on the WSU campus began in June 1988. His projected completion date is May 1993. SR-CRSP is now paying about 25% of his research costs.

Donald Siamba is a KARI employee who is also a University of Nairobi graduate student in veterinary parasitology. His research is supported by the WSU SR-CRSP project with tuition support from Kenya SR-CRSP matching funds. The SR-CRSP contact is Fred Rurangirwa. He expects to complete his M.S. in the spring of 1993.

## Contributions

### *Environmental impact*

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*

Small ruminant deaths and production losses due to diseases interfere greatly with the sustainability of enterprises depending on these animals for income.

### *Contributions to U.S. agriculture*

Research on vaccines for *H. contortus* has as much benefit for U.S. producers as it does for other countries. In addition, multivalent virus-vectored vaccines would be modified with regard to vector and used in the U.S., if they prove effective.

### *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 their scientists have been collaborating with us on the CPV vector development.

### *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 are integrating women in our project through recruiting women graduate students from Kenya (one for SR-CRSP and one for a related project) and to involve women faculty from WSU (she is scheduled to visit the project this semester to develop collaborative research).

### *Support for democracy*

I try to contribute to this issue by example.

### *Humanitarian assistance*

I believe that training host country people is the best long term contribution we can make to humanitarian assistance.

## Collaborating Personnel

*United States*

James C. DeMartini (Animal Health)
Colorado State University
Michael Nolan (Sociology and Economics)
University of Missouri-Columbia
Anthony F. Barbet
University of Florida
Timothy B. Crawford
Washington State University
Douglas P. Jasmer
Washington State University
Donald P. Knowles
Washington State University
Guy H. Palmer
Washington State University

*The Netherlands*

Frans Jongejan
Utrecht Faculty of Veterinary Medicine

*Kenya*

Fred Rurangirwa
Associate Professor, WSU
Resident Scientist in Nairobi
Paul Rwambo
CSU Resident Scientist in Nairobi
Cyrus Ndiritu
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## Publications

Mahan, S.M., Waghela, S.D., McGuire, T.C., Rurangirwa, F.R., Wassink, L. and Barbet, A.F. A cloned DNA probe for *Cowdria ruminantium* hybridizes with eight heartwater strains and detects infected sheep. Journal of Clinical Microbiology. 30:981-986, 1992.

Karanu, F.N. Identification of proteases with diverse characteristics in adult *Haemonchus contortus* excretory-secretory products. M.S. Thesis. Washington State University. Pullman, Washington, 1992.

## Abstracts and Presentations

Rurangirwa, F.R., McGuire, T.C., Wambugu, A.N. and Kihara, S.M. Identification and characterization of a target antigen of a monoclonal antibody (WM-25) which inhibits the growth of mycoplasma strain F38. Ninth International Congress of the International Organization for Mycoplasmology (IOM), Ames, Iowa, August 2-7, 1992.

## Comments

The attention on the vaccine project the last two years has been intense. It is now time to agree on a plan and move forward.

# *Multivalent Virus-Vectored Vaccines for Sheep*

## Colorado State University

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## Narrative Summary

The Animal Health Management through Biotechnology component of SR-CRSP includes scientists from Colorado State University (CSU) and Washington State University (WSU) working with resident scientists and Kenya Agricultural Research Institute (KARI) collaborators in Kenya to develop multivalent virus-vectored vaccines for certain diseases of sheep and goats. Sociologists from the University of Missouri-Columbia are assessing vaccine production capacity and potential economic impact of these vaccines in African countries. The CSU and WSU integrated research planned for 1990-92 was directed toward (1) development and characterization of suitable virus vectors and (2) identification and cloning of genes of infectious agents that encode immunoprotective proteins. The following summary pertains to work undertaken by the CSU project at the Kenya National Veterinary Center at Kabete and the basic supporting research performed at CSU.

The vaccine project in Kenya focused on identification and cloning of genes encoding proteins that elicit protective immune responses against Nairobi sheep disease virus (NSDV). NSDV causes heavy economic losses resulting from a high mortality in susceptible sheep and abortion in ewes. Presently, prevention against NSDV depends on control of the principal vector tick, *Rhipicephalus appendiculatus*. Tick control programs are prone to failure and, besides their negative environmental impact, are not sustainable especially with the dwindling economies of the developing world. Thus, an effective vaccine against NSDV remains a major developmental concern for Eastern Africa. In pursuing this goal, representative isolates of NSDV were identified and used in determining how the virus replicates in infected cells. This study formed the basis upon which molecular characterization of NSDV depended. Using a combination of immunochemical techniques, the major immunogenic proteins of NSDV were identified. The NSDV genes encoding these proteins are targeted for insertion into capripoxvirus as part of the multivalent virus-vectored vaccine for sheep. Because the segmented genome of NSDV lacks a poly-A tail that is traditionally exploited in generation of cDNA libraries, the viral RNA was isolated and modified to facilitate cloning. This strategy is being pursued to enhance cloning of the NSDV M segment for vaccine development. Another anticipated outcome of research on NSDV is the development of new diagnostic tests based on monoclonal antibodies and recombinant antigens.

In vector development, we have embarked on identifying a site alternative to the thymidine kinase locus of capripoxvirus (CPV) for insertion of vaccine genes. To this end, a plasmid containing the sequences of cowpox virus serpin gene was obtained and has been used to identify a homologous locus in CPV DNA. This work is in progress, and it is anticipated that the serpin locus will allow the insertion of vaccine genes in tandem in the

CPV genome for development of multivalent vaccines.

Our work on sheep retrovirus infections–ovine lentivirus (OvLV) and ovine pulmonary carcinoma (OPC)–mainly involves identification of genes useful in vaccines or diagnostic reagents. The critical *env* gene of one OvLV strain has been cloned, and immunologically relevant proteins encoded by this gene are being studied. A segment of the OPC virus also has been cloned, permitting future studies funded by non-CRSP sources to characterize the viral cause of this disease and develop new means for detection of infected carrier sheep. Evidence was obtained that OvLV and OPC are common in sheep flocks in Kenya and six OvLV isolates were made from clinically affected sheep of one farm. One OvLV isolate has been characterized by Western blotting and shown to be related to North American OvLV strains.

## Research

*Component Objective 1:* Develop virus vectors for multivalent vaccines for sheep.

The development of multivalent vaccines requires use of a vector system for insertion and expression of genes of disease agents. Among many alternatives, we have chosen to use poxvirus vectors because of their large genome and available data concerning their molecular structure and immunogenicity and because vaccinia poxvirus has been shown to be a highly effective vector for recombinant virus-vectored vaccines. Most of the recombinant virus-vectored vaccines developed to date, including a very effective vaccine for rinderpest in cattle, use vaccinia virus as a vector. Rabies has been eradicated in Southern Belgium using a field-bait delivery system employing a recombinant vaccinia-rabies vaccine. However, many strains of vaccinia virus are pathogenic for humans, especially immunocompromised people, and there may be problems associated with recombination of vaccine viruses with wild vaccinia viruses present in the environment. In this project, we are developing two poxviruses for use as vaccine virus vectors, raccoon poxvirus and capripoxvirus.

### *Evaluation of raccoon poxvirus as a vector for multivalent vaccines in sheep.*

#### Problem statement and approach

Raccoon poxvirus (RCNV), an indigenous virus of raccoons in North America which is apparently apathogenic for humans, may be useful as a virus vector for sheep in countries in which sheeppox does not occur. We decided to evaluate the use of RCNV as a virus vector in sheep by evaluating the immunogenicity and safety of a rabies G protein gene RPV construct (rRCNV-G) produced by Dr. J. Esposito of the Centers for Disease Control, Atlanta. This vaccine has been shown to be capable of inducing neutralizing antibody and protection against a rabies challenge in dogs, raccoons, and other non-livestock animals after oral immunization.

#### Progress

Preliminary results for this experiment were reported in last year's annual report. Twenty adult sheep were exposed to rRCNV-G or to wild type RCNV (wt-RCNV) by intradermal, intramuscular, and oral routes. In-contact (sentinel) animals were included with each group. Sheep were re-inoculated with rRCNV-G 7 weeks after the primary exposure. High titers of neutralizing antibody to rabies virus developed within four weeks following primary intradermal inoculation with rRCNV-G; markedly lower titers of antibody resulted from intramuscular or oral routes of exposure. Re-immunization increased the rabies neutralizing antibody titers 5 to 50 fold in the intradermal and intramuscular groups, but not in the oral group. Development of neutralizing antibody to RCNV generally paralleled neutralizing antibody to rabies virus. Prior exposure to wt-RCNV apparently inhibited the neutralizing antibody response to rabies virus in sheep exposed to rRCNV-G by the intradermal route.

There was no evidence for horizontal transmission of rRCNV-G or wt-RCNV in sentinel sheep. The histological severity of local skin inflammation generally correlated with dose of rRCNV-G or wt-RCNV. These results suggest that the RCNV vector is a safe and effective means of immunizing sheep to a recombinant expressed rabies protein by the intradermal and intramuscular routes and that wt-RCNV is relatively innocuous in sheep.

### *Develop capripoxvirus as a vector for multivalent vaccines of sheep.*

#### Problem statement and approach

Capripoxvirus (CPV) is the cause of sheep and goatpox in many African, Middle Eastern, and Asian countries. It is an especially attractive candidate for use as a vaccine vector in these parts of the world because attenuated strains of the virus are already in widespread use as vaccines. One gene insertion site, the thymidine kinase gene, is already developed for use, but alternative sites must be identified if CPV is to be used as a virus vector for a multivalent vaccine. This is one of our objectives in the present work. Another objective is to work collaboratively with WSU scientists in developing and evaluating a Rift Valley fever-CPV construct for protection against a bunyavirus disease in sheep.

A plasmid containing a portion of the cowpox virus 38Kd serpin gene and B-gal selectable marker (pGP1.7) has been obtained from Dr. Mark Buller of National Institutes of Health. This plasmid, which has been used successfully as a co-insertion plasmid for vaccinia virus, will be tested to determine whether the cowpox serpin gene sequences are sufficiently homologous with CPV serpin gene sequences to undergo homologous recombination with CPV. To construct a transfer vector plasmid, either the pGP1.7 cowpox virus serpin plasmid or a plasmid constructed with the homologous CPV serpin gene insert will be ligated to a selection cassette containing gpt flanked by vaccinia virus early and late promoters and a cloning site for insertion of foreign vaccine genes. The coding sequence of the CPV serpin gene will be interrupted by the NSDV cDNA by insertion into a unique cloning site. The constructed plasmid will be transfected into cells infected with CPV for homologous recombination. The rCPV eventually will be used for immunogenicity studies in naive sheep. Drs. Mercedes Juarrero of International Laboratory for Research on Animal Diseases, Don Black of Pirbright, United Kingdom, and Drs. Crawford and McGuire of WSU serve as consultants in this work.

#### Progress

In pursuing identification of an alternative locus for cloning vaccines genes in the CPV DNA genome we obtained a plasmid, pGP1.7, containing the 38 kDa serpin gene of cowpox virus interrupted by a B-gal and neomycin selection cassette. MAX Efficiency DH5-a cells were transformed with pGP1.7 and grown in the presence of neomycin. The plasmid DNA was purified and analyzed with Not-1 and Sal-1 restriction enzymes. Two fragments have been generated and are being characterized in Southern blots. We have titrated CPV in Vero cells under varying concentrations of G418 sulfate. If homologous recombination of CPV with the recombinant cowpox virus serpin gene occurs, transfection of Vero cells with pGP1.7 will confer the ability of the cells to grow in the presence of G418 sulfate. Results indicate that at two mg/ml of G418, the virus titer was the lowest; concentrations above two mg/ml led to rapid cell degeneration. Work on isolating recombinant CPV under neomycin selection is in progress. To exploit this plasmid fully for our vaccine work we plan to insert a multiple cloning site within the selection cassette. This work is in progress in collaboration with Dr. Mercedes Juarrero at International Laboratory for Research on Animal Diseases.

*Component Objective 2.* Identification of Vaccine Genes for Sheep Diseases.

## *Identify vaccine genes for Nairobi sheep disease virus (NSDV).*

### Problem Statement and Approach

Nairobi sheep disease virus (NSDV) infection of susceptible sheep and goat flocks causes heavy losses due to its high mortality and abortion in ewes. Presently, the only method of prevention against NSD is by control of the vector tick, *Rhipicephalus appendiculatus,* which also transmits East Coast fever, a devastating disease of cattle in Eastern Africa. This method is not only too expensive, but also leads to environmental degradation and is prone to failure, because ticks develop resistance to acaricides. NSDV, as do all members of the virus family Bunyaviridae, has a segmented RNA genome of negative polarity. 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 (RVF). Thus, we planned to purify the three RNA segments of NSDV and prepare a cDNA library. Using an expression vector system, clones that contain the protein encoded by the M segment were to be selected, analyzed, and used in preparation of a recombinant capripoxvirus (rCPV). The immunoprotective capacity of the rCPV constructs is to be evaluated in parallel with the Rift Valley Fever rCPV constructs prepared collaboratively with the WSU subcomponent. Since NSDV and RVF 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.

### Progress

*Objective 1:* Structural and antigenic analysis of recombinant NSDV proteins expressed in *E. coli*

We have been successful in characterizing the structural proteins of NSDV by radioimmunoprecipitation and by Western blotting using convalescent sheep sera. Analysis of $^{35}$Smethionine labeled lysates of virus infected cells of SDS-PAGE identified 11.0 KDa, 45 kDa, and 29 kDa proteins. The 30 kDa protein was the most abundantly expressed protein. In radioimmunoprecipitations, all of these proteins were recognized by antibodies in the sera of sheep infected with NSDV. Having identified the authentic proteins of NSDV we embarked on identifying the genes of the virus in order to prepare a cDNA library. We have successfully isolated the viral RNA from low melting point agarose using the RNaid kit. Recent efforts to add poly-A tails on the 3'-end of viral RNA using cordycepin triphosphate did not yield the optimum length required for oligo-dT priming. Consequently, we have used ATP and the *E. coli* poly-A synthetase to optimize the M segment for oligo-dT priming. Our urgent efforts are directed at cloning the M segment of NSDV. We anticipate that, having successfully added the poly-A tails, the current strategy should facilitate in the attainment of this major objective.

*Objective 2:* Identification and cloning of NSDV cDNA fragments

We planned to identify *E. coli* transformed with plasmid containing cDNA inserts that encode for proteins that are recognized by antivirus antibodies. Work in this activity is ongoing, but has been hampered by the problems we have experienced in the successful priming of the M segment for cDNA synthesis. We expect that identification of the NSDV cDNA fragments will be readily accomplished, especially with the new strategy for optimizing the RNA for priming.

*Objective 3:* Identification of cDNA clones encoding immunoreactive antigens of NSDV

We planned to identify cDNA clones encoding proteins that can protect sheep against NSDV. One of the problems encountered in expressing recombinant proteins in *E. coli* is the inability of *E. coli* to modify the translated products such the addition of oligosaccharides. Considering that the protective responses are directed to the glycoproteins of NSDV, we now plan to utilize expression plasmid that can replicate in the mammalian cell systems. One such plasmid is pSV-SPORT-1 which allows for transient expression of cloned genes in mammalian cells. We anticipate that this method will allow addition of oligosaccharides and thus be more relevant to our identification of cloned protective antigens of NSDV.

## *Identify vaccine genes from ovine lentivirus (OvLV).*

### Problem statement and approach

In the absence of vaccines, ovine lentivirus-induced diseases continue to cause substantial losses in productivity of sheep enterprises in countries throughout the world, including Kenya. With a background of knowledge of immunology and pathogenesis of OvLV-induced diseases, new diagnostic tools for detection of infected animals, and availability of molecular clones of OvLV, it is our goal to develop protective immunogens for OvLV based on application of techniques of biotechnology. Data from other lentivirus systems indicate that viral surface glycoproteins contain antigenic epitopes that induce anti-viral antibody and cell mediated immune responses. However, because of low titers of neutralizing antibody in OvLV-infected animals and a marked tendency for antigenic variation of viral neutralizing epitopes, epitopes important in cell-mediated immunity are the target of our approach. Defining these epitopes in OvLV surface glycoproteins is expected to provide the basis for development of protective immunogens for OvLV infection in sheep. This activity will constitute the Ph.D. thesis research for Dufton Mwaengo, a Kenyan graduate student at CSU fully supported by the SR-CRSP. Mr. Mwaengo has completed his coursework and began to devote full time to this research beginning summer, 1992.

### Progress

From early last year, our efforts have been to clone segments of our OvLV laboratory strains. Of the four extensively studied strains, two (namely 84RS28 and 85RS34) have been earmarked for further characterization as representatives of the slow/low and rapid/high strains respectively. Restriction maps for both viruses have been generated and DNA sequence comparisons (from parts of the LTR and *env* regions) made with the prototype OvLV, visna virus. Generation of full-length molecular clones of both viruses was the subject of a former graduate student's research.

In an attempt to clone the *env* gene of one of the viruses, we chose to isolate the gene using PCR technology. First, goat synovial membrane cells were infected with purified virions (85RS34) and extra-chromosomal low molecular weight DNA made using the Hirt protocol. By combining the LTR (1098) and *env*1 (upstream of the open reading frame for *env* gene) primers, we demonstrated that we could PCR-amplify the desired predicted product of about 3.5 Kb. This strategy gave the entire *env* gene but with about 150 bp 5' of the initiation site, ATG. To remove this unimportant sequence 5' of ATG, we first PCR amplified a small fragment of 342 bp flanking the ATG (called *env* 1 PCR product) and cloned and sequenced it in a pTA cloning vector (Invitrogen). This initial sequence not only served to confirm that the viral DNA we had was indeed not contaminating visna virus, but it also helped in the construction of a new 30 mer primer with the first ATG included and an EcoRI site just 5' to it. There was good homology between this sequence and the published

visna sequence but it was nonetheless different. The new primer, together with the LTR, were used to amplify the entire, clonable, *env* gene of about 3.1 Kb, which was to be cloned as an EcoRI/SacI fragment. Our initial efforts to clone this fragment in pBluescript, which we constantly use in our laboratory, were fruitless. This frustration led us to obtain a low copy number plasmid from Dr. Keith Rushlow of University of Pittsburg Medical School. The vector, pLG338-SPORT, has a pSC101 origin of replication and a proven capability of maintaining lentivirus sequences. Incidentally, our inability to clone our lentiviruses in high copy number plasmids is not new because recent literature reports seem to suggest that various groups have successes and failures with these. pSC11, a pBR322-derived shuttle vector that we had hoped would deliver our *env* gene into target cells for our proposed CMI studies, failed to accept the gene. We are currently in possession of another low copy number plasmid with a pSC101 origin namely pLG338-191 that has the P7.5 promoter engineered and flanked by the TK gene segments of vaccinia virus, courtesy of Dr. Rushlow, that we hope will solve this problem. We will then be able to proceed with preparation of vaccinia recombinants, analysis of OvLV protein expression, preparation of deletion mutants, and studies of cell-mediated immune responses in infected sheep.

Ovine lentivirus for a long time has been suspected to exist in sheep flocks in Kenya. The virus has finally been isolated from sheep with clinical signs of OvLV infection. Among nine sheep from one farm (in Laikipia district) that were necropsied, lesions of OvLV-associated lymphoid interstitial pneumonia were found in seven animals and lesions of ovine pulmonary carcinoma (OPC) were found in two animals. Six OvLV virus isolates were obtained from these animals by their capacity to induce syncytia in lamb testis (LT) cells. One virus that replicates rapidly in LT cells was purified and used in Western blot analysis of sheep sera from different parts of Kenya and North America. Reactivities to p15, p27, and gp105 were detected for a number of sera. Preliminary results indicate that the Kenyan isolates are serologically related to the North American isolates particularly in relation to p27. In addition, a diagnostic test that is more sensitive than AGID needs to be developed for accurately detecting infected sheep. Ongoing work will lead to a better understanding of OvLV antigens, especially the gp105, and development of a sensitive diagnostic test for OvLV infection in sheep flocks in Kenya.

## *Cloning and characterization of a type D retrovirus associates with ovine pulmonary carcinoma.*

### Problem statement and approach

Ovine pulmonary carcinoma (OPC) is a contagious lung tumor of adult sheep. The disease is identified as an important economic factor in South and East Africa, South America (Peru), southern Europe, the British Isles, Asia, and the Middle East. Since there are no diagnostic tests or vaccines for the OPC, there are no effective means for controlling this disease. The infectious agent has been identified as a type D retrovirus, based on ultrastructural, enzymatic, and immunological studies. Lung fluid and tumor material from infected animals can transmit the disease experimentally, with the time of onset proportional to viral titer.

SR-CRSP research on OPC over the past few years has been directed toward studies of its etiology and pathogenesis in order to develop improved methods of diagnosis and control in the numerous countries in which OPC is a major economic problem. Although progress is being made, a decision was reached to terminate funding for this project after the 1992-93 budget year. In the 1991-92 workplan, we proposed to identify and characterize the retroviral etiology of OPC using a molecular approach to the problem. Once the putative type D retrovirus is linked to the disease, it will be possible to develop serological or other diagnostic assays to detect and remove infected

carriers from the flock. Such applied research can proceed using non-SR-CRSP funds.

### Progress

In the previous year, we succeeded in cloning a portion of the OPC virus. Further analysis has shown our sequences to be highly related to other known retroviruses found in primates. As the eventual goal in this research is to develop diagnostic test and vaccines, we also have cloned the capsid gene of OPC virus into a high expression vector. Production of the viral protein in *E. coli* cells has been obtained, and we have begun optimizing production parameters. The viral product will then be used to screen sheep sera and to immunize rabbits to make polyclonal sera. Since these will result in diagnostic tools as well as an understanding of the sheep immune response to OPC infection, we are pursuing this approach. Use of the viral sequences to probe sheep DNA has shown that most, if not all, sheep carry virus-related nucleotide sequences in their genome. This observation may be important in understanding the disease course and transmission and in design of a vaccine. SR-CRSP support for this project was terminated in September, 1992.

## Training

*Long-term*

Dufton Mwaengo (Kenyan), Ph.D. expected 1994, Virology, Colorado State University.

Scott J. Brodie (U.S.), Ph.D. received Sept. 1992, Microbiology, Colorado State University

*Short-term*

F. Mbithi (Kenyan), short-term training in virology, immunology, and molecular biology, 1992 at the SR-CRSP laboratories in Kenya. (Mr. Mbithi is awaiting funding for training at the M.S. level at CSU.)

## Contributions

The SR-CRSP has continued to serve as a model laboratory for molecular biology in KARI and has contributed in dissemination of relevant knowledge in vaccine development and diagnosis of infectious diseases of small ruminants. In particular, the project, in collaboration with KARI, participated in the annual Nairobi International Agricultural Show in October, 1992, where it exhibited the dual purpose goat and educated farmers on animal health problems affecting sheep and goats. Our close collaboration with diagnostic laboratories of the Kenyan Ministry of Livestock Development, the International Laboratory for Research on Animal Diseases (ILRAD), and the University of Nairobi Veterinary School has provided a synergistic service to agricultural development in Kenya. Because of these linkages, we have managed to determine the maturation pathway of NSDV using an electron microscope at ILRAD. In addition, using the project's experience in virology, we have been able to assist the Kenya Veterinary Vaccine Production Institute in assessing the purity of their virus vaccine seeds. It is hoped that with time, the project's impact on agricultural development will be enormous. Enhancing these linkages even further, Dr. Rwambo attended a meeting on Conservation of Biodiversity in Africa organized by the National Museums of Kenya from August 31-September 3, 1992. Conservation of biodiversity and the environment in East Africa, as in many developing countries of the world, is an essential component of sustainable agriculture. With respect to improvement of livestock health, indigenous wild and domestic animals and their disease agents will provide important genetic material for elucidating mechanisms of natural resistance to infectious and parasitic disease. Newly identified strains of viruses or other microbes may be useful as biological vectors or components of multivalent recombinant vaccines for livestock. These developments in biotechnology also may serve as models for new methods for disease

control in the United States.

The USAID Mission in Kenya has indicated its interest in livestock disease research. Its willingness to provide funding and administrative support for our PSTC grant on improving diagnostic tests for Nairobi sheep disease is further evidence for this commitment.

## Collaborating Personnel

*Host Country*

Paul M. Rwambo, Resident Scientist, KARI, Kenya, SR-CRSP Collaborating Scientist
Fred Rurangirwa, SR-CRSP Resident Scientist, KARI, Kenya
Flora Mbithi, KARI, Kenya
R. Soi, KARI, Kenya
M. Shaw, Scientist, ILRAD, Kenya

*United States*

S. Hecht, Post-doctoral fellow, Dept. of Pathology, CSU
Y. He, Post-doctoral fellow, Dept. of Pathology, CSU
Joseph Esposito, Scientist, Centers for Disease Control, Atlanta, GA
Travis McGuire, Professor, Veterinary Microbiology and Pathology, WSU
W. Cheevers and D. Knowles, Professors, Vet. Microbiology and Pathology, WSU
J. Dalrymple and J. Smith, Scientists, USAMRID, Frederick, MD

## Collaborating Institutions

*Primary*

Kenya Agricultural Research Institute, Nairobi, Kenya

*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
Dept. of Microbiology and Pathology, Washington State University, Pullman, WA
Institute of Virology and Environmental Microbiology, Oxford University, UK

## Publications

### Refereed Journals

Brodie, S.J., K.A. Marcom, L.D. Pearson, B.C. Anderson, A. de la Concha-Bermijillo, J.A. Ellis, and J.C. DeMartini. 1992. Effects of virus load in the pathogenesis of lentivirus-induced lymphoid interstitial pneumonia. J. Infect. Dis. 166:531-541.

He, Y., S.J. Hecht, and J.C. DeMartini. 1992. Evidence for retroviral capsid and nucleocapsid antigens in ovine pulmonary carcinoma. Virus Res. 25:159-167.

Marcom, K.A., S.J. Brodie, L.D. Pearson, and J.C. DeMartini. 1992. Analysis of ovine lentivirus infectivity and replication using a focal immunoassay and an antigen-capture ELISA. J. Clin. Micro. 30:2852-2858.

### Technical Communications (SR-CRSP)

Brodie, S.J., G.D. Snowder, and J.C. DeMartini. 1992. Ovine progressive pneumonia: Advances and prospects for control. Sheep Res. J. 8:116-126.

### Abstracts and Presentations

DeMartini, J.C., H. Bickle, and S.J. Brodie. Immunogenicity of a raccoon poxvirus rabies-glycoprotein recombinant vaccine in sheep. 10th Scientific Workshop, SR-CRSP, ILRAD, Nairobi, Kenya, February 26-27, 1992.

DeMartini, J.C., S.J. Hecht, and Y. He. Characterization of a type D retrovirus associated with ovine pulmonary carcinoma. 10th Scientific Workshop, SR-CRSP, ILRAD, Nairobi, Kenya, February 26-27, 1992.

Brodie, S.J, and J.C. DeMartini. The pathogenesis of ovine lentivirus infection in lymphoproliferative lung disorders. 10th Scientific Workshop, SR-CRSP, ILRAD, Nairobi, Kenya, February 26-27, 1992.

Brodie, S.J., J.C. DeMartini, L.D. Pearson, K.A. Marcom, A. de la Concha-Bermejillo, and B.C. Anderson. Ovine lentivirus expression in alveolar macrophages correlates with antigenemia and clinicopathological manifestations of disease. Abstract No. 754. 1992 Meeting of the Federation of American Societies for Experimental Biology, Anaheim, CA, April 5-9, 1992.

Pearson, L.D., S.J. Brodie and J.C. DeMartini. Comparison of methods for diagnosis of ovine lentivirus infection. 4th AASRP Symposium on the Health and Disease of Small Ruminants, Fort Collins, CO, June 10-12, 1992.

DeMartini, J.C., H. Bickle, and S.J. Brodie. Immunogenicity of a raccoon poxvirus rabies-glycoprotein recombinant vaccine in sheep. 4th AASRP Symposium on the Health and Disease of Small Ruminants, Fort Collins, CO, June 10-12, 1992.

Brodie, S.J., L.D. Pearson, B. Anderson, and J.C. DeMartini. Detection of ovine lentivirus and localization of viral proteins in tissues and fluids of infected sheep. 4th AASRP Symposium on the Health and Disease of Small Ruminants, Fort Collins, CO, June 10-12, 1992.

Rwambo, P., M. Shaw, and J. DeMartini. Studies on the morphogenesis of Nairobi sheep disease virus, a nairovirus. 11th Annual Meeting of the American Society for Virology, Ithaca, New York, July 11-15, 1992.

DeMartini, J.C. and S.J. Hecht. Antigenic and molecular characterization of a type D retrovirus associated with ovine pulmonary carcinoma. 12th International Symposium of the World Association of Veterinary Microbiologist, Immunologists, and Specialists in Infectious Diseases, Davis, California, September 8-12, 1992.

DeMartini, J.C., S.J. Hecht, and J.M. Sharp. Genetic and immunological analysis of a type D retrovirus associated with ovine pulmonary carcinoma. 1992 Workshop on the Pathogenesis by Non-Acute Retroviruses, Newport Beach, California, December 2-3, 1992.

## Comments on funding

Our research on Nairobi sheep disease has been enhanced by a three year USAID PSTC grant of $150,000 for development of a diagnostic test based on monoclonal antibodies and recombinant antigens. The funding for this project is provided through the USAID Mission in Kenya, and the project is administered by KARI.

# *Sociological Analysis of Small Ruminant Production*

## University of Missouri-Columbia

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## Narrative Summary

The research presented in this annual report covers the 1991-1992 workplan and part of the 1992-1993 workplan. Sociology concentrated its efforts in describing and analyzing the process and institutions through which manufactured vaccines are delivered to small-holders farmers. The locus of most of this research is presently in Kenya, but its objectives are global. The international community has invested considerable resources in the development of veterinary vaccines over the past few decades, but the benefits of these investments can only be obtained if means are found to organize the development, production, and utilization of vaccines on a sustained basis. These are organizational and resource mobilization issues that can be addressed by social science research.

Efforts fall into two categories: studies of the institutional barriers to the development of vaccines and studies of the actual production and distribution of vaccines. The first is a study primarily conducted through archival research methods and with key informant interviews, with the goal of identifying any institutional barriers that might inhibit the development of vaccines using biotechnology. Contagious Caprine Pleuro-pneumonia (CCPP) is an excellent case study because it represents one of the few vaccines developed specifically for a developing world disease of small ruminants. This is especially important because the CCPP vaccine is much less expensive than the treatment for CCPP-infected animals.

The fact that a vaccine against CCPP is available in Kenya provides an excellent opportunity to look at the actual process of producing and distributing vaccines to small ruminants. Although the technical requirements for producing a virus vectored vaccine are different from those for producing the CCPP vaccine, they have a similar institutional context. Two researchers from the University of Missouri worked at different times in Kenya on a detailed case study of the production and distribution experience of CCPP, covering activities from workplan 1991-1992 and the first two activities from workplan 1992-1993. This case study was developed to obtain an understanding of the milieu that any multivalent vaccine developed by the SR-CRSP will enter.

The study identified barriers presented by institutional and governmental policies in the development, production, distribution, and use of the CCPP vaccine. In addition, constraints to the integration of the CCPP vaccine into Kenya's animal health delivery system were studied. The study was conducted by holding informal and formal interviews with over fifty individuals, including farmers, scientists, government veterinary services representatives, business managers, and veterinarians; a review was also made of government reports and associated literature.

The study found that 70% of Kenya's goats are located in areas where CCPP is endemic. A number of factors affect the delivery of CCPP vaccine as well as the general

animal health care system; these factors can result in limited adoption of the vaccine. Among these factors are constraints of supply, production, lack of operating funds, and constraints to access capital by parastatals, as well as sustainability of a vaccination campaign without donor funding. An important constraint is the lack of funds by the Department of Veterinary Services to carry out effective disease surveillance and control programs. In the case of the CCPP vaccine there is also lack of communication and information, and no solid linkages are in place to integrate research output, production, and delivery. A technical report of this study is expected in April, 1993.

Further information about small ruminant diseases will help researchers, production managers and decision makers create policies and plans that lead to more effective disease control. Such work will, in the longer term, move activities away from disease control and more towards prevention.

## Research

### Objectives

Identify the socio-economic barriers or constraints to vaccine development production and distribution, as well as utilization by small ruminant producers.

### Problem statement and approach

Whether used for cash exchange or subsistence purposes, to many people in developing countries small ruminants represent a significant portion of their economic livelihoods. A very real problem is the loss of animals through disease. Left unchecked, highly contagious diseases can devastate not only family and local economies, but national economies as well. However, in developing countries, a persistent problem has been finding an economical and efficient way to control small ruminant diseases. Creating and producing a relatively inexpensive vaccine through recombinant technology capable of protecting animals from many diseases is envisioned as one possible solution.

However, the existence of a vaccine will not by itself assure its use. There must be a system in place to produce and distribute vaccines and institutional policies in place that assure that vaccines are produced in an efficient and timely manner. Vaccines must also be available at a price that is attractive to producers.

A CGIAR-sponsored study on the future of animal agriculture in Africa gave special attention to small ruminants. These are now believed to be the animals with the greatest potential to increase production. Increases in productivity of small ruminants could be achieved through current efforts to produce multivalent vaccines through biotechnology. The development of these vaccines is predicated on the idea that the means exist to produce, distribute, and utilize vaccines effectively. Unfortunately, this does not seem to be the case in most countries as the recent resurgence of rinderpest in Africa indicates.

In order to address this question, University of Missouri concentrated its efforts in studies of the institutional barriers to the development of vaccines and studies of the actual distribution and production of vaccines.

### *Activity 1. Vaccine development.*

#### Justification

This study is primarily conducted through archival research methods and with key informant interviews. The purpose of this study is to identify any institutional barriers that might inhibit the development of vaccines using biotechnology. The work is being carried out by an M.Sc. student at Missouri, Courtney Daniels.

#### Progress

The first step in the study was to identify the regulations surrounding the development of vaccines using recombinant techniques and to see what challenges they pose to the development and testing of new vaccines. The second step is to examine the links between researchers,

corporations, and vaccine institutes that would actually commercialize and/or distribute vaccines. Telephone interviews were done with persons involved in using new genetic techniques to develop such vaccines. There appear to be no private industry incentives for the development of these drugs, and this fact appears to inhibit the testing and development of vaccines that have shown potential in laboratories and in limited trials. National Regulations on the testing of drugs based upon recombinant technologies also appear to limit the development of such vaccines. In addition, lack of epidemiological data is an issue. Preliminary results were presented in a paper given at the conference on Agriculture and Human Values in Lansing, Michigan, in June 1992.

### *Activity 2. Barriers to the development, production, distribution, and use of small ruminant vaccines: Constraints to the integration of CCPP into Kenya's Animal Health Delivery System.*

#### Justification

Contagious Caprine Pleuropneumonia (CCPP) is a fatal small ruminant disease. In recent years, outbreaks of the disease pose a serious threat to goats in Kenya, the Horn of Africa, the Arabian Peninsula, and Turkey. This disease has also been reported in West Africa, Syria, and Sudan. A viable vaccine against CCPP has been available in Kenya since 1987. However, its integration into the system of disease prevention and control has met with limited success. The vaccine has not been widely distributed (Table 1) and its impact is unclear. Michele Lipner and Ralph Brown, research associates from the University of Missouri-Columbia, carried out a socio-economic study from March through November 1992 to identify constraints to the production and delivery of CCPP vaccine in Kenya. Ralph Brown, with the collaboration of Adrian Mukhebi (ILRAD), Fred Rurangirwa (WSU), and others, started gathering data on the production and distribution of vaccines. As a follow-up of the activities started in March, an in-depth study was carried out by Michele Lipner. Informal and formal interviews were held with over 50 individuals, including farmers, scientists, veterinary service personnel, Ministry (MOLD, MORST) and KARI representatives, business men and women, and veterinarians. Information was also gathered from the Department of Veterinary Services (DVS) annual reports for 1989-1991, Ministry reports, other consultancy reports, and associated literature.

#### Progress

CCPP is reported as the most serious infectious disease of goats in Kenya, and it is also serious in the Horn of Africa, the Arabian Peninsula, and perhaps the Middle East. Yet, conflicting reports are received from interviews with administrators responsible for vaccine production delivery, policy, and implementation regarding the scope of the problem, the economic impact of CCPP on farmers and farmers' herds, and disease incidence. Implicit in these reports is the notion that production of the vaccine has been relatively low because demand has been limited and economic losses resulting from CCPP are not significant.

**Table 1. Total CCPP vaccinations by province in Kenya, 1989-1991.**

| Province | 1989 | 1990 | 1991 |
|---|---|---|---|
| Central | 700 | - | 2489 |
| Eastern | 8000 | 20458 | 63430 |
| Northeastern | - | - | - |
| Nyanza | - | - | - |
| Western | - | - | - |
| Coast | 10786 | 3596 | 199 |
| Rift Valley | 218760 | 150969 | 159004 |
| Total | 238246 | 173023 | 225122 |

In order to gain a more accurate profile on CCPP and its importance in Kenya, DVS annual reports from all districts/provinces from 1989-1991 were examined. Information gathered included: number of cases of CCPP reported/treated per year, number of animals vaccinated, trends in livestock movement for slaughter, and breeding and disease prevalence (endemic, outbreaks, isolated cases, no incidence). Information was plotted using GIS (Table 1).

As Table 1 indicates, over a three-year period the disease was reported in all Kenyan provinces with the exception of Western and Nyanza. CCPP was recorded as endemic in Northeastern, Eastern, and most of Rift Valley provinces as well as in Tana River District in Coast Province. In addition to areas that are endemic with CCPP, outbreaks have been reported in Coast Province (Taita Taveta District), Central Province (Kiambu District), and Nairobi.

The number of actual CCPP cases reported, treated, and/or suspected for 1989-1991 are reported in Table 2. The number of CCPP cases reported almost doubled from 1989 to 1991 (from 14,225 to 27,940). In general, numbers of deaths from an outbreak were not reported, suggesting that animal loss from CCPP is much higher than that provided above. However, from personal interviews with field staff and private veterinarians, it was suggested that thousands of animals per month are lost on average from CCPP infection.

From this information, it appears that the disease is more widespread than suggested and that risk to the national goat herd is substantial. Given that over 70% of the 10.5 million goat population in Kenya is located in areas where CCPP is endemic, animals at risk of infection is high. It is true that the actual number of goats susceptible to CCPP would not reach the percentage noted above; outbreaks are affected by grazing patterns, production systems, level of animal stress, livestock movement, etc. Still, in order to estimate need, these general figures suggest that the prevalence of CCPP has been underestimated, and that vaccine supply has not kept pace with actual need.

There are a number of factors specific to CCPP and those relevant to the more general system of animal health care delivery that limit the adoption and diffusion of the vaccine. These are briefly discussed below.

### *Supply*

Only 60,000 doses of the CCPP vaccine can be produced by KEVEVAPI at any one time and the production process is lengthy (one month). Inoperative or inadequate equipment has limited production potential. It has been suggested that if the vaccine currently in use were replaced by the lyophilized form instead, larger quantities could be produced (more cheaply) and kept on the shelf for longer time periods.

**Table 2. CCPP cases reported by province in Kenya, 1989-1991.[a]**

| Province | 1989 | 1990 | 1991 |
|---|---|---|---|
| Nyanza Province | 0 | 0 | 0 |
| Coast Province | 68 | 34 | 588 |
| Northeastern Province[b] | 21 | 0 | 13 |
| Eastern Province | 6800 | 2300 | 3145 |
| Central Province | 4 | 3 | 7 |
| Rift Valley | 7332 | 19646 | 24188 |
| Western Province | 0 | 0 | 0 |
| Total | 14225 | 21983 | 27941 |

[a]Numbers should generally be seen as an underestimation of actual cases. Annual reports often did not provide numbers or information was lacking and/or inconsistent.

[b]No actual numbers of reported cases provided except that 13 cases of CCPP suspected in Garissa.

### *Production*

The production unit for the vaccine, KEVEVAPI, has been operating for less than two years. While charged with production and marketing of vaccines, the parastatal is still a relatively new venture. Profitable enterprises within the Institute are yet to be fully defined and promoted. Production costs have not been determined and actual need, in terms of domestic and foreign demand, has not been established.

### *Lack of operating funds*

Lack of operating funds impacts on both production levels and delivery. In terms of production, although KEVEVAPI is expected to generate profits that will be fed back into the parastatal for facility development and vaccine improvement, its primary customer is the Government of Kenya. Financial constraints of the Government limit KEVEVAPI's ability to access capital for its own use. Thus, breakdowns in the vaccine production process are not unusual.

Lack of funds also constrains delivery of vaccine. Given the extensive services DVS provides and the limited funds that are available, it becomes difficult to carry out effective disease control activities (i.e., diagnostic services, disease surveillance, control of livestock movement). Given that CCPP is highly contagious, spreads quickly, and can result in major animal losses in a short time frame, the lack of these services can be devastating to farmers and goat herds.

### *Sustainability*

As a number of respondents suggested, vaccination campaigns are not sustainable activities without donor funding. Based on a review of the vaccination campaigns carried out from 1989 to 1991, the data tends to support this position. The only major governmental-sponsored vaccination campaign was held in Baringo District in 1989; 41,508 goats were vaccinated. By 1991, this number increased to 148,397 (representing 66% of the total vaccines administered in 1991).

Actual costs of vaccine production have not been determined. Initial and very rough estimates from KEVEVAPI suggest a production cost of Ksh 1.00 to Ksh 1.50 per dose for CCPP vaccine (compared to Ksh 10-40 per animal for treatment). This is the price charged per dose. If, for instance, a longer lasting vaccine, produced in larger supplies, could be generated, production costs could conceivably decrease.

Preliminary pricing of vaccine delivery (including per diem, transport, fuel, supplies etc.) from the present study generated a ceiling figure of Ksh .75 per dose (Ksh .50/dose if supplies are excluded). These figures indicate that CCPP can be produced relatively inexpensively at minimal cost to farmers. Without the assurance of future donor funding, it becomes more important to find alternative avenues for sustaining production and delivery of vaccine.

### *Disease surveillance and control*

The lack of funds impacts directly on the ability of DVS to carry out effective disease surveillance and control programs. Without an effective tracking system, disease outbreaks are more likely to occur. Given the shortage of funds, lack of transport, inaccessibility to CCPP-infected areas because of weather or roads, and other concerns, animal movement is difficult to restrict and control even harder to attain. Without adequate surveillance, information on animal deaths, outbreaks, patterns of outbreaks, effectiveness of vaccination, etc. are not well recorded.

Reports have suggested that the problem is in part related to the expanded mandate that presently guides DVS activities. Charged with disease control and prevention, provision of clinical services, and the sale of drugs, the Department simply does not have the resources to provide all services to all constituents. Efforts to privatize aspects of veterinary services (e.g., provision of clinical services, sale of drugs) may help the DVS focus more attention on those aspects of its mandate that originally were identified as priority areas—specifically, disease prevention, control, and surveillance.

### *Lack of communication and information*

With CCPP, there appears to be no solid linkages in place to integrate research output, production, and delivery. For example, while there is a vaccine on the shelf that shows potential as a more viable product than that which is presently being marketed, little attempt has been made to field-test the vaccine or integrate it into the production process. Information at the farmer-level regarding the efficacy of the vaccine presently in use is not fed back into the research or production cycle for examination. Different sources stated that the length of immunity provided by the liquid form of the CCPP vaccine is either six, nine, or twelve months. One veterinary officer in the field claimed an immunity of only four months. Some have reported that the vaccine did not provide any immunity against CCPP. To date, these claims have neither been confirmed nor proven false.

## Contributions

- Collaboration with International Agricultural Research Centers.
- Adrian Mukhebi, Economist, ILRAD provided considerable assistance with the gathering both of sociological and economic data on the production and distribution of vaccines.
- The French tropical veterinary institute, IEMVT, through its director Georges Tacher, has supported the project by providing us with information about the incidence of CCPP outside of Kenya.

### *Contribution to host country*

Controlling livestock disease is seen as crucial to Africa and especially by the Government of Kenya in the development of arid and semi-arid lands. Disease control and prevention was recognized as a priority in the *National Livestock Policy* of 1980 (MOLD 1980), and research aimed at improving animal health has been initiated. With scarce economic resources, most of the attention has been directed to the cattle industry. Socio-economic research through the SR-CRSP will contribute to identify the bottlenecks faced in the development, production, distribution and use of vaccines and will provide for a methodology that will be relevant globally.

### *Privatization*

USAID is also interested in the study of vaccine development, production, and distribution as a potential for private sector assistance.

### *Agricultural sustainability*

Appropriate alternatives for disease prevention at the farm level will allow for an efficient use of scarce resources, such as land and feed, therefore contributing to the sustainability of household producers that raise small ruminants.

## Collaborating personnel

*Kenya*

Dekha Sheikh, Co-investigator, KARI
A. Nkonge Mbabu, Collaborating Scientist, KARI and ISNAR
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Paul Rwambo, Resident Scientist, Colorado State University

*United States (University of Missouri)*

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Jere L. Gilles, Co-Principal Investigator
Corinne Valdivia, Co-Principal Investigator
Ralph B. Brown, Research Associate (now Asst. Professor at Mississippi State Univ.)
Michele Lipner, Research Associate
Domingo Martínez, Research Associate

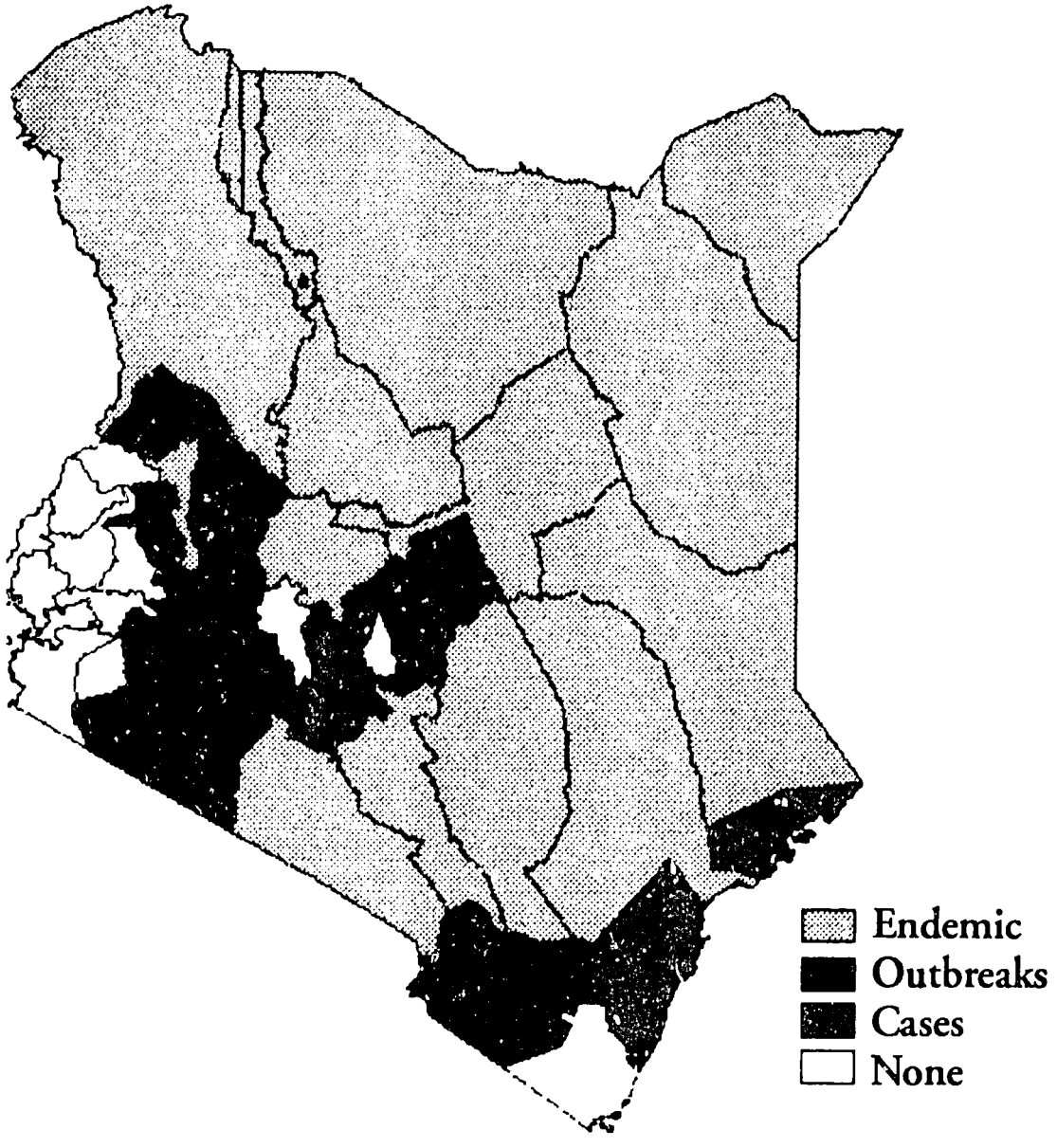
## Collaborating Institutions

Kenyan Agricultural Research Institute (KARI)

## Presentations

- Michele Lipner presented the paper "Constraints to the Integration of the CCPP Vaccine into Kenya's Animal Health Delivery System" at a SR-CRSP/KARI seminar. Nairobi. Nov. 23, 1992. Michele Lipner also presented this paper at a seminar at ILCA, Addis Ababa, Dec. 22, 1992.
- Courtney Daniels presented a paper on vaccine development at the conference on Agriculture and Human Values in East Lansing, Michigan in June 1992.

# Figure 1. Occurrence of CCPP, 1989-1991.



# Hair Sheep Production Systems

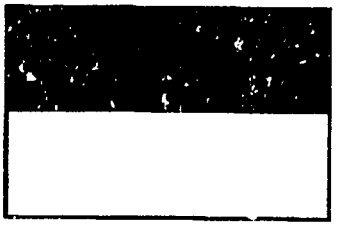
"Results of SR-CRSP research in Brazil and Indonesia suggest that by improving feed supplies, health practices, management techniques, and genetic potential, the productivity of hair sheep can be increased and made more cost-effective. Widely distributed in the tropics, hair sheep are important sources 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*

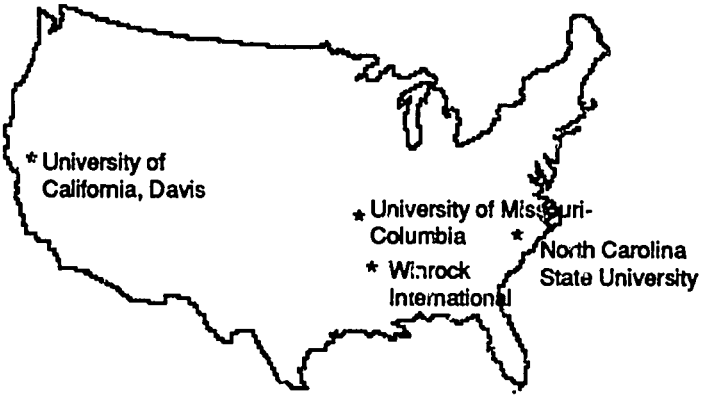
# Republic of Indonesia

**Total area:** 1,919,440 square km (741,096 square miles)
**Geography:** Indonesia comprises some 17,000 islands.
**Capital:** Jakarta.
**Population(1991):** 193,000,000
**Languages:** Bahasa Indonesia, Javanese, other Austronesian languages.
**Labor force:** 56% agriculture, 23% industry, 16% services.
**% Females in labor force:** 31.2%
**Industries:** Food processing, textiles, light industry.
**Chief crops:** Rice, coffee, sugar.
**Land in Agriculture:** 17.3%
**Agriculture of GNP:** 26%
**Sheep population:** 5,415,000
**Goat population:** 12,700,000
**Uses of sheeps and goats:** Meat.
**Inflation rate:** 5.5% (1989)
**Monetary unit:** Rupiah.

**Indonesian Flag**



**United States Sites**




# *Genetic Improvement of Sheep and Goats*
University of California, Davis

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## Narrative Summary

The Hair Sheep Component looks at breeding sheep to eliminate wool ( unnecessary and unproductive in the tropics). In addition, the Breeding project has been selecting breeds for rapid growth for higher productivity. The two hair-breed crosses surpassed the two native breeds for all weights (birth, weaning, six-month, and nine-month).

## Research

### Problem statement and approach

The wool produced by the local North Sumatran sheep is of low quality and causes heat stress. Shearing these animals every few months represents significant labor cost. Thus, the possibility of genetically removing the wool by crossing the local animals to hair sheep breeds is being explored. Besides removing the wool, crossing these breeds was expected to result in more rapid growth that might lead to higher productivity of the hair sheep crosses.

To accomplish these objectives, a group of St. Croix (SC) hair sheep originally from the Virgin Islands was imported to North Sumatra and crossed with the local North Sumatran (S) sheep. The crossbred lambs from these matings grew more rapidly than S and some did not require shearing. SC x S and S had similar reproductive performance measured as fertility, lambing interval, and prolificacy. However, it was observed that the pure SC animals were not doing particularly well, possibly due to internal parasites. As part of the expanded program on hair sheep production systems, we decided to add two other breeds to the study, the Barbados Blackbelly (BB), a hair sheep breed from the Caribbean, and the Javanese Fat Tail (JFT), a breed in which some individuals have little or no wool. Matings/inseminations were initiated in October 1991 according to the following mating plan, see table 1. All ewes were given a second chance to mate again in January-February and April-May 1992.

The plan was to compare the crosses produced by the above matings, starting with the birth of the first lamb crop in early 1992. These comparisons will continue through 1995. Additionally, a 50% hair sheep composite population is being produced by intermating the H1 animals. Selection in this group will be based on a productivity index for ewes and on individual growth rate, dam's performance, and lack of wool for rams. The composite population will be compared to the local S breed for prolificacy, viability, lambing interval, growth, incidence of disease, and parasite problems.

### Progress

First lambing from this mating plan took place in March and April 1992. Fifty-two percent of the ewes, which were artificially inseminated, lambed with an average litter size of 1.69. Average birth, weaning, six-month, and nine-month weights for the crossbred lambs are given in Table 2. A second lambing took place in June.

**Table 1. Mating plan.**

| Rams | Ewes | | | |
|---|---|---|---|---|
| | S | SC x S (H1) | SC (H) | JFT (E) |
| S | 100[1] (S) | | | |
| SC x S (H1) | - | 100[1] (HC) | | |
| SC (H) | 100 (H1) | | 35[2,3] | |
| BB | 100[4](B1) | | | |
| JFT (E) | 100 (E1) | | | 35[3] |

[1]As availability of animals and barn space permits, this group should be increased to provide animals for nutrition and grazing trials.
[2]All available pure, 7/8, and 3/4 SC ewes.
[3]Matings to maintain these breeds; SC includes pure SC (H), 3/4 SC (H2), and 7/8 SC (H3).
[4]Artificial insemination with frozen semen.

**Table 2. Weights of crossbred lambs born March-April 1992 (kg).[1]**

| | Birth Wt. | Weaning Wt. 90 days | 6-mo Wt. | 9-mo Wt. | | 9-mo Wool Score | |
|---|---|---|---|---|---|---|---|
| | | | | F | M | F | M |
| B1 | 1.84 (79) | 10.1 (67) | 16.4 (58) | 20.0 | 29.1 | 5.6 | 4.9 |
| E1 | 1.74 (147) | 8.3 (122) | 14.2 (101) | 16.8 | 23.8 | 7.8 | 7.6 |
| H1 | 1.92 (135) | 9.3 (107) | 15.4 (93) | 19.0 | 27.5 | 6.6 | 8.0 |
| S | 1.75 (123) | 8.0 (96) | 12.7 (76) | 16.4 | 24.3 | 7.7 | 8.4 |

[1]Number of animals in each group is shown in parentheses.

The two hair-breed crosses surpassed the two native breeds for all weights with the B1 cross ranking the heaviest at each age. More growth data are being collected from these four groups. Of the March-April born ewes, a random 50% will be mated in January 1993 and the other half in April 1993. Reproduction data from these groups will be collected through 1995. A high proportion of adult H and E ewes have shed their wool and now appear as hair sheep. However, as shown in Table 2, lambs at nine months carry substantial wool cover, with only the Barbados crosses being significantly less wooly.

Intermating of H1 animals to create a composite population (HC) continued. SC animals were also mated inter se to maintain this breed. Currently we have pure SC (H), H x H1 (H2), and H x H2 (H3) animals that are kept as a single group. A comparison of weaning weights of lambs born between January 1991 and March 1992 in various genetic groups is given in Table 3.

**Table 3. Means for weaning weights for various genetic groups.**

| Genotype | n | Weaning weight (kg)[1] |
|---|---|---|
| S | 161 | 8.56 ± .19[a] |
| E (JFT) | 23 | 8.69 ± .42[a] |
| G1(Garut x S) | 8 | 8.99 ± .72[a] |
| H, H2 and H3 | 59 | 10.75 ± .27[b] |
| HC | 119 | 11.37 ± .21[b] |

[1] Means without a common superscript differ significantly (P<.05)

Mean weaning weight was significantly higher for St. Croix and its crosses than from pure North Sumatran Thin-Tail, Javanese Fat-Tail, or Garut x North Sumatran F1 crosses. Breed of ewe or sire did not significantly affect perinatal mortality of these lambs, suggesting that the hair sheep (St. Croix) x local breed cross is reasonably well-adapted to this environment. A regression coefficient of perinatal mortality on birth weight of -.12 was calculated from these data, indicating that every kg increase in birth weight would be expected to result in a 12% decrease in perinatal mortality.

Studies on parasite problems in the Sei Putih flock continued. Mr. Ari Zabell, a third-year veterinary student from Cornell University, spent about two months in Sei Putih to study different treatments of forage to reduce transmission of strongyle parasites in sheep. The conclusions from this study were that washing the forage, using forage from unsprayed fields, and allowing animals to graze in rotational grazing systems all resulted in slower transmission of strongyles than feeding fresh or dried contaminated forage.

Study of pancreatic flukes was continued during 1991-92. Dr. Alan Wilson performed necropsy on 41 animals which died during this period and found that 80% (n=33) of these animals died from fluke-related causes. Various drugs are being used in the flock to study further their effectiveness in reducing fluke infestation.

A proposal submitted the European Economic Community jointly with the Prince Leopold Insitute of Tropical Medicine in Belgium to study the internal parasite problem in the Sei Putih flock was approved for funding by the European Economic Community. This work will be initiated later in 1993.

The Breeding project routinely provides rams to Outreach Pilot Project (OPP) farmers, and project personnel are actively participating in discussions on development of a multiplication program for sheep with PTP4, one of the large rubber plantations in North Sumatra. This program is expected to be initiated in the near future with St. Croix-Sumatran crossbred ewes from the SR-CRSP breeding project.

## Training

Torop Sialagan, one of the barn managers at Sei Putih, attended a short course on sheep husbandry and management in Malaysia (funded in part by SR-CRSP)

Endang Romjali is enrolled in an M.S. program at Gaja Madah University in Yogjakarta, Java, supported by project funds.

Djoko Pitono is enrolled in a Ph.D. program at the University of New South Wales in Australia. He is supported by Australian funds, but is using project data from Sei Putih for his research.

## Contributions

The SR-CRSP research in Sei Putih has made significant contributions to our understanding of the constraints on introduction of new breeds. The Sei Putih flock is a valuable source for the study of parasite problems and genetic resistance to parasites, and as such it has received attention from other institutes for collaborative research. The request for collaboration from the Prince Leopold Institute of Tropical Medicine in Belgium has resulted in a joint research proposal to the EEC, and the proposal was approved for funding to study the internal parasite problem at Sei Putih. Also, several graduate students from the U.S. and Europe, funded by non-CRSP money, have completed internships at Sei Putih to study the parasite problem.

The SR-CRSP project continued its support for the training of graduate students from the U.S. and Indonesia.

During the 1991-92 project year, collaboration with the Malaysian Agricultural Research and Development Institute (MARDI) has continued for the importation of Barbados Blackbelly (BB) semen. Technical assistance was provided to MARDI by UC Davis for the artificial insemination of Malaysian sheep using frozen BB semen, which took place in October 1991.

The SR-CRSP Breeding project in Sei Putih has been providing breeding animals for distribution to farmers through the Outreach Research Project (ORP). This contributes to increased overall output from small-scale farms, economically benefiting these farms.

The Sei Putih flock is grazed on forage areas under rubber trees which traditionally are not utilized. This not only provides the necessary forage intake for these sheep but also potentially saves other pasture areas from overgrazing. Thus it can contribute to sustainability of agriculture of the region as well as to increasing small-holder income. The use of sheep to control weeds under rubber trees also reduces herbicide use, contributing to a cleaner environment.

## Collaborating personnel

*United States*

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Endang Romjali, B.S., SBPT/SP
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## Abstracts

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# *Feed Resources and Nutrition of Small Ruminants*

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## Narrative Summary

The Feed Resource and Nutrition research of the Hair Sheep Production Systems component concentrated on forage evaluation, grazing systems, supplementary feeding, and feed requirements for growth of hairsheep-cross lambs. Complementary work in the United States focussed on the evaluation of extremely shade tolerant forage species including arachis (forage peanut obtained from the Peanut CRSP) and the evaluation of hair sheep breeds for use in the southeastern United States.

Evaluation of forages that are shade tolerant and capable of providing high quality forage for sheep grazing under plantation tree crops completed a third year. Not all of the promising forages have survived under the 75% light reduction occurring under the rubber tree canopy. Rest periods between grazing or cutting must be increased from one month to three months in most cases due to slow growth in low light under the canopy.

The use of tree legumes as a source of protein for growing lambs indicates that growth rates of over 150 grams per day are possible and that acceptance of *Paraserianthes falcataria* is excellent. This tree legume offers the farmer an alternative to feeding concentrate feeds with similar average daily gains. Other tree legume species as *Gliricidia sepium* and *Calliandra calothyrsus* are also of great potential value as a protein supplement.

The herbaceous dicot *Asystasia intrusa* was identified as most shade tolerant and of high quality in work conducted at the North Carolina State University greenhouse. The chemical composition did not change with shading or with level of fertilizer. Shade tolerant studies evaluating 16 lines of forage peanuts are under way. Forage production, persistence, and chemical composition will be determined.

Evaluation of the breeds of hair sheep for use in the Southeastern United States indicate that they may have superior tolerance to internal parasites and better reproductive performance but generally slower growth rate.

## Research

### Problem statement and approach

Sheep in Indonesia are integrated into farming systems of small-holders and integrated into plantation cropping. In highly populated areas and in many villages, sheep are kept by small-holder farmers. In some cases the sheep are allowed limited grazing and in some cases are confinement-fed in a cut and carry system. In tree crop plantations, sheep are becoming integrated to utilize the forage under the tree canopy thereby reducing mowing and herbicide costs. The critical need is to develop systems of management which will improve productivity and sustainability. Lack in quantity and quality of feed is the major problem in all systems. The introduction of hair sheep germplasm may change the level of production and, therefore, the feeding management systems required. Potential feed resources need to be identified and developed if sheep production is to be sustainable and economical.

## Objectives

- To characterize the nutritional value of locally available feedstuffs for small ruminants.
- To develop guidelines for formulation of nutritionally and economically optimum diets, especially at critical stages of the production cycle.
- To develop strategies for more efficient use of the feed resources available within intensive small farming systems.
- To develop small ruminant production systems integrated with plantation tree cropping.
- To develop hair sheep production systems.

### *Forage introduction and evaluation*

The introduction and evaluation of forage grasses and legumes for use under plantation crops began in January 1988. Over 50 accessions obtained from Indonesia, Australia, Colombia, and Malaysia were planted in replicated plots and their performance (growth, persistence, nutritional quality, etc.) evaluated in full sunlight. Subsequently evaluations began on the performance in shaded areas. Evaluation to identify forages that are shade tolerant and that persist additional cutting and/or grazing continued during 1992 to identify the accessions with highest potential that warrant evaluation on a large scale.

*Asystasia intrusa* is a herbaceous dicot that is the most shade tolerant of all species evaluated thus far. However, it is considered to be a noxious weed in Malaysia because of its rapid growth and reproduction (both from seeds and vegetatively). In September 1990, the decision was made to eliminate *Asystasia intrusa* from the site. In 1991, a botanical survey of North Sumatra identified two additional *Asystasia* species that were evaluated for production and shade tolerance.

There was also concern that *Asystasia* may compete for nutrients and thereby reduce growth of rubber trees. A greenhouse study to determine the effects of competition for nutrients on growth of rubber planted with *Asystasia* was deemed necessary.

### *Grazing sheep under rubber plantation crops*

A shepherd usually allows sheep four to eight hours of grazing/day prior to placing the animals in a raised barn with access to cut forage. Little is known about the length of time required to satisfy total voluntary intake by grazing or what is the optimal combination of grazing and cut and carry. With the use of computers for logging grazing/biting and markers for estimation of intake, information will be collected and used to refine the relationships of grazing time and need for cut and carry forage.

Allowing sheep to graze on a 24-hour basis (not corralled in a barn at night) has not been attempted because of thievery. On large plantations, the construction of barns is expensive and barns cannot be moved. Utilizing shepherds 24 hours/day and allowing sheep to have access to grazing for longer times may result in improved performance. Plots fenced with electric fencing were to be used with shepherds to determine the feasibility of this proposal and to develop a system for keeping sheep without barns.

Long-term studies with three to four of the most promising forages (pure stands or combinations) need to be conducted and evaluated as the tree canopy and resulting shade increases. Depending on land area available, a replicated trial with each forage as a treatment will be established. Measurements of per animal and per hectare gains, herbage mass, canopy structure, leaf area and quality of the canopy constituents are important indicators to determine relative value of these promising forages.

### *Outreach pilot program*

Outreach research with local villages has been an important way to increase collaboration between all scientists of the SR-CRSP. It has also been quite effective in increasing communication between scientists and allowing field testing of new technologies. Close monitoring of existing farmers and expansion to other farmers is desirable.

### *By-product feeding to maximize lamb growth*

During the last three years, several feed by-products have been evaluated as potential feed sources for lambs fed to market weight. Daily rates of gain of most lambs has been less than 50 grams/day. With supplementation of energy, protein, and/or minerals, growth rates two to three times the average are possible. From experience with feeding palm kernel cake, broken rice, rice bran, rubber seed, molasses, urea, and minerals, rations were developed with the objective to maximize lamb growth with economically affordable feedstuffs. In addition, rations were developed to maximize growth to determine biological potential for growth of the Sumatra Thin Tail and the hairsheep crosses of the local Sumatran Thin Tail with the Barbados Blackbelly, St. Croix, and Fat Tail.

### *Raleigh: Forage quality, selection, and evaluation*

Shade tolerance of *Asystasia intrusa, Calopogonium caeroleum, Pueraria javanica,* and *Arachys Spp.* Research from 1990 in Sei Putih, Indonesia, has shown that the weedy herbaceous dicot *Asystasia intrusa* has an unusual tolerance for low light. This species has shown promise as a forage crop and would persist in plantation crops longer than other available species because of its tolerance for shading. Research continued on the mechanism of shade adaptation in *Asystasia intrusa* as compared with the two tropical legumes, *Calopogonium caeroleum* and *Pueraria javanica.* The *C. caerolenum* and *P. javanica* were chosen because they are commonly used as ground cover forages under plantation crops. However, they have not shown as great an ability to adapt to shade. Seeds for each of these forages were collected at Sei Putih and planted in the greenhouse at NCSU. In addition, work on the shade tolerance of the germplasm of ten seeded and ten vegetatively reproduced lines of *Arachis spp.* (perennial peanut) obtained through linkage with the Peanut CRSP continued. These potentially valuable lines have been screened for shade tolerance, and lines with greatest shade tolerance were examined to determine the mechanism of tolerance as well as the physiological and production consequences of the trait.

### *Quality of tropical grasses grown under rubber plantations*

A second year of data on the quality of the tropical grass and legume germplasm that have potential for use in rubber tree plantations by either grazing or harvested as "cut and carry" will be completed. The quality of these forages at a specific maturity and over a range of maturities needs to be determined. Quality must be considered along with persistence and productivity when selecting the germplasm with the most potential. An additional year of forage samples will be taken at specific physiological stages, dried, ground and sent to NCSU for analysis of fiber factions, nitrogen and in vitro dry matter disappearance.

### *Evaluation of the reproductive cycling activity of Hair sheep and Hair sheep crosses*

Since the mid 1960's, North Carolina State University has maintained a flock of Barbados Blackbelly sheep. Extensive crosses were made primarily with Dorset to produce a ewe with more heat tolerance and parasite resistance. In 1983, St. Croix sheep were obtained from Ohio State University, and, in 1987, Katahdin sheep were obtained from Heifer Project International. Preliminary data of the ability of hairsheep to initiate cycling for spring breeding look promising. In addition, some breeds appear to initiate cycling activity while lactating. Progesterone was monitored weekly to determine differences in cycling activity of hairsheep and F1 wool crosses during spring and summer and while lactating. Samples were taken from 8-12 ewes of purebred Barbados, St. Croix, Katahdin, Suffolk, Dorset, and various wool-hairsheep crosses. Developing a ewe that is capable of cycling year round would be a boon to the sheep industry in the Southeastern United States.

### *Maintenance and finishing rations utilizing by-products*

By-product feeds offer a great potential for utilizing materials that are not consumed by people, and, in addition, these by-products can be processed into a nutritive fertilizer. By-products of peanut and cotton production will be evaluated to develop rations for feeding small ruminants. Cotton by-products from ginning and textile mills are currently being disposed of in landfills. A feeding strategy to utilize these by-products will reduce cost of feed and reduce reliance on landfills for disposal.

## Progress

### *Forage introduction and evaluation*

Light transmission is now less than 30% as the tree canopy is closing. Cutting frequency of the forages was maintained at monthly intervals until July 1992. As shaded forages tend to partition a larger portion of photosynthate to shoots, they become less persistent under frequent (monthly) cuttings. Therefore, after July the cutting frequency was linked to physiological stage of regrowth rather than the calendar. This has changed harvest interval to approximately every three months. All species are now moderately to severely limited by shade.

Chemical composition of each forage from four harvests are currently being determined at NCSU. This experiment will be terminated in 1993.

*Asystasia intrusa* can be used as a high quality feed for sheep. It has a high protein content (24%) compared to other common plantation weeds such as *Mikania micrantha*, *Ottochloa nodosa*, and *Paspalum conjugatum*. Given this potential and the lack of information about the competitive effects of *Asystasia* on rubber, this experiment was designed to determine the effects of competition for nutrients on growth of rubber underplanted with *Asystasia* in polybags.

The experiment began in June 1992 and will be conducted for one year at the experiment station of Puslitbun Sungai Putih, North Sumatra. A completely randomized design with five treatments and three replications was used (each replication consisting of five polybags). The treatments in which *Asystasia* and rubber were grown in single- and mixed-species were as follows: a) *A. intrusa* alone; b) *A. gangetica* alone; c) rubber alone; d) rubber + *A. intrusa; and* e) rubber + *A. gangetica*.

The soil used was an ultisol with a pH of 5.4. No fertilizer was added. The rubber planting material used was budded stumps of clone RRIM 600. The *Asystasia* planting material used was two-node cuttings planted when the first whorl of the rubber leaves was almost mature. The polybags used were filled with 16 kg of air- dried soil. To prevent leaf disease, 0.2% Daconil 75 SP (chlorothalynyl) was applied once every two weeks.

During the experiment, regular measurements were made on: the height of *Asystasia;* leaf color of *Asystasia* (using a score/rating from 1=very green to 5=yellow); number of flowers and pods of *Asystasia*, fresh and dry weight (harvest timed to occur when the *Asystasia* is about to produce mature seeds); height and diameter of rubber; number of fully expanded leaves and number of expanding leaves of rubber; and leaf color of rubber.

At the end of the experiment, root yields will be measured. Soil mineral content, particularly nitrogen, phosphorus, potassium, calcium, and magnesium were analyzed before the experiment and will be measured again at the end of one year.

**Table 1. Rubber height (cm) and diameter (mm) at zero, two, and four months after planting *Asystasia*.[a]**

| Treatments | Rubber height (cm) | | | Rubber diameter (mm) | | |
|---|---|---|---|---|---|---|
| | At planting | 2 mo | 4 mo | At planting | 2 mo | 4 mo |
| Rubber alone | 26.4 | 34.8 | 46.4 | 5.7 | 7.5 | 9.4 |
| Rubber with *A. intrusa* | 25.2 | 33.6 | 44.3 | 5.7 | 7.1 | 8.6 |
| Rubber with *A. gangetia* | 25.5 | 32.9 | 42.1 | 5.5 | 7.1 | 8.3 |

[a]Measurements mean of three reps with five polybags per rep.

**Table 2. *Asystasia* height (cm) one and two months after planting.[a]**

| | 1 month | 2 months |
|---|---|---|
| *A. intrusa* alone | 39.8 | 63.9 |
| *A. gangetia* alone | 18.2 | 46.7 |
| *A. intrusa* with *gangetia* | 20.7 | 40.7 |
| *A. gangetia* with *intrusa* | 19.2 | 27.7 |

[a]Measurements mean of three reps with five polybags per rep.

### *Preliminary results*

The experiment is still at an early stage. Rubber tree heights and diameter measurements before *Asystasia* was planted and after two and four months are presented in table 1. Heights of *Asystasia* one month and two months after planting are presented in table 2. Although numerically reduced, there has been no effect (P>.1) of *Asystasia* on reducing height or diameter of the rubber trees. These effects are cumulative with time so there may be effects seen before one year. *Asystasia intrusa* clearly grows more rapidly and was taller at two months than *Asystasia gangetia*. This method of experimentation allows for strict control of the *Asystasia* and also is a very sensitive test for negative effects on rubber growth.

### *Grazing sheep under rubber plantation crops*

Effect of duration and time of grazing on intake of sheep grazing under rubber in North Sumatra, Indonesia.

Time spent grazing by sheep under plantation crops such as rubber and oil palm varies according to management and available labor for shepherding. Grazing periods reported typically range from 7.5 to 9.5 hours per day. Present management at the Sei Putih research site allows seven grazing hours each day. Smallholder farmers who participate in a sheep extension/research project at Sei Putih generally graze their sheep for roughly four hours in the afternoon. Most farmers also provide cut and carry forages in the early morning although others do not provide any additional forage. The present study was designed to evaluate the effect on forage intake of ewes grazing half-day

(four hours) versus full-day (seven hours) and to compare morning versus afternoon grazing.

Sumatra Thin-tail ewes, one to two years of age, were selected from a large group of ewes purchased from local farmers. In the first of two replicates ewes grazed under 20-year-old rubber trees in an area that had been previously grazed by sheep for six years. The second replicate was on a new grazing area under three-year-old rubber trees. All animals had access to drinking water, a molasses/urea mixture, and mineral block.

A total of 33 ewes in replicate one and 47 ewes in replicate two were divided into three groups and randomly assigned to one of three treatments: AM (grazing 8 a.m. - noon), PM (grazing noon- 4 p.m.), and FD (grazing 9 a.m. - 4 p.m.). After a seven-day adaptation period, 10 animals per group in replicate one and 12 in replicate two received chromic oxide marker (500 mg/day for 14 days) to determine fecal output. The chromic oxide was given at 7 a.m. (300 mg) and at 7 p.m. (200 mg). During the last seven days, rectal grab fecal samples were taken, dried, composited by day for each animal and analyzed for chromium. Digestibility of grazed vegetation was determined and intake calculated by ratio. Analysis of variance for the randomized complete block design was conducted, and, due to unequal group numbers, least square means were calculated and used in the analysis. In replicate one three ewes lambed and one aborted and in replicate two a single ewe lambed; this necessitated their removal from the trial.

There was significant replicate treatment interaction for both intake ($P<.04$) and intake as percentage of body weight ($P<.02$). Replicates were therefore analyzed separately. In both replicates, intake and intake as percentage of body weight was higher for full day than half day ($P<.0001$). Intake in both replicates was not different in replicate two, although in replicate one AM ewes had a higher ($P<.03$) intake as percentage of body weight. Intake data are summarized (table 3) with AM and PM values given as percentages of FD values. Intake as percentage of body weight was significantly higher ($P<.02$) in the AM versus PM group in replicate one and tended to be higher in replicate two. In replicate one AM ewes weighed slightly less than PM ewes, and this, combined with slightly higher intakes, resulted in a higher intake as percentage of body weight.

These results suggest that four hours grazing is not sufficient to allow for adequate intake and therefore longer grazing times are recommended. The practice followed by most farmers of providing supplemental forage to their sheep will help to compensate for the reduction in intake caused by short grazing times. Whether longer grazing times of 10 to 11 hours would be beneficial needs further investigation. Cooler morning temperatures may also pay a role in intake by resulting in less heat stress on grazing animals. Thus an earlier grazing time such as 7 a.m. could be beneficial. The effect of forage supplementation on intake of sheep grazed for half days in order to maximize intake should be studied in future trials. Allowing sheep to graze on a twenty-four hour basis has not been accomplished. Permanent electric fencing in the rubber plantation was not permitted by the rubber plantation because it limited access for rubber tappers to tap trees. In addition, hiring a shepherd to stay alone with the sheep at night was not possible. Therefore, we elected not to pursue twenty-four hour grazing as an alternative to housing sheep at night. Although possible on large integrated plantations, there seems to be little application to the small-scale producer.

Two areas of new rubber have been allocated by the rubber research institute to establish large areas of improved forage. In addition, PTPV has also provided land, currently being renovated, for new planting that can be used for evaluating the most promising forages on a large scale. PTPV prefers that the forage be removed by cutting rather than by grazing. Therefore, forages planting will begin in April 1993.

**Table 3. Intake, and intake as percent body weight, of ewes grazing under rubber plantation for four hours in the morning (AM), four hours in the afternoon (PM), or seven hours full-day (FD), expressed as percent FD values.**

| | Intake (% of FD) | | | Intake %BW (% of FD) | | |
|---|---|---|---|---|---|---|
| | FD | AM | PM | FD | AM | PM |
| Rep 1 | 100 | 80.8 | 76.7 | 100 | 87.0[a] | 78.2[b] |
| Rep 2 | 100 | 80.4 | 80.1 | 100 | 84.6 | 82.8 |

[a,b]Differ P<.02; in both replicates AM, PM<FD P<.0001.

### *Outreach pilot programs*

In 1988, the SR-CRSP in collaboration with SPBT and Puslitbun initiated the Outreach Research Project (ORP). Eight farmers began the project. The objectives were to 1) extend production methods that would help small-scale farmers improve their standard living by incorporating and increasing productivity of small ruminants and 2) allow field testing of new technologies.

Currently, twenty-six farmers are involved with the ORP. Evaluation of the productivity of the ORP indicated that production levels of the farmers are equal to or greater than production on the research station. Survival rates (92.5%) are higher and litter size (1.33 kg) and weaning weight (9.2 kg) are similar to on-station results. Incorporating sheep into farms has increased farm income by 40% compared to income before sheep were part of the farming system.

Another outreach program is now underway in Membang Muda, North Sumatra. This area is much different than the ORP in that farmers own two hectares planted with rubber trees. Income diversification of is desired because many of the farmers are overtapping the trees (which reduces tree longevity) to obtain sufficient income to survive. Income from sheep consuming forages grown under the rubber trees may help reduce overtapping. Basic socioeconomic survey data have been taken and reported in working paper No. 128, and good collaboration between researchers, extension personal, and farmers has been developed. This project should provide an excellent opportunity to test technology packages for sheep under rubber for small-holder farmers and specifically evaluate new and alternative forages.

## *By-product feeding to maximize lamb growth*

### *Comparative growth responses of four genotypes of sheep on a high energy/protein concentrate and a plantation-forage diet.*

The main aim of the hair sheep breeding program at Sungei Putih is to combine the high reproductive potential of the local Sumatra Thin Tail sheep (STT) with the larger body size and lack of wool of exotic hairsheep breeds. Three genotypes have been produced by crossing STT ewes with St. Croix, Barbados Blackbelly, and East Java Fat Tail sheep. The objective of this study was to determine the maximum growth rates of the four genotypes and compare these with the growth rates

obtained under conventional barn management. To achieve this, ten ram lambs of each of the four genotypes were fed a high protein energy/diet (15.3% CP and 3.22 MCal ME/kg) or fed a diet based on ad libitum plantation grass with 400 g/day of concentrate (11.8% CP and 2.77 MCal ME/kg).

Average daily gains through eight weeks for each genotype and diet (table 4) indicate that traditional feeding management will not allow the animals to exhibit their true genetic potential for growth. With a set feeding of 400 g/day concentrate, the larger animals are at a big disadvantage as compared to the smaller animals. The mean weight of the lambs after the eight-week study for the traditional and concentration treatments were 21.9 vs 23.4 (S), 27.8 vs 31.7 (SxSC), 31.2 vs 38.8 (SxB), and 24.2 vs 27.4 (SxFT). There was no difference in average daily gain due to breed or the traditional diet.

The traditional feeding management needs to be modified to increase supplementation based on body size. The concentrate treatment averaged over 100 g/day for all breed groups and exceeded 200 g/day for the SxB. When not limited by nutrient intake, the SxB gained the most (201 g/day) followed by the SxSC and SxFT (175 g/day) and S (108 g/day). The combination of improved genetics and nutrition has increased growth rate to the target level proposed in the five-year extension document.

***Comparative growth responses of five genotypes of sheep on a high energy/protein diet and a diet based on tree legume leaf.***

One of the disadvantages of many agro-industrial by-products for supplementary feeding of sheep in smallholder farms is that they are not easily obtained. Molasses must be transported by tanker and products such as palm kernel cake are only available at the factory gate. Supply problems, combined with cost, push these products beyond the reach of smallholder producers. The ideal feed supplement will be cheap and available locally. Several species of locally-adapted leguminous trees offer promise because they are persistent, easy to manage, can be planted in corners of field or on boundaries, and have a relatively high feeding value.

**Table 4. Average daily gain of ram lambs of purebred Sumatra Thin-tail (S) and S crosses with St. Croix (SxSC), Barbados blackbelly (SxB), and East Java Fat-tail (SxFT) fed traditional or concentrate diets.**

| Diet | S | SxSC | SxB | SxFT |
|---|---|---|---|---|
| Traditional[a] | 85 | 79 | 49 | 83 |
| Concentrate[b] | 108[c] | 177[d] | 201[d] | 173[d] |

[a]Diet consisted of ad libitum plantation forage with 400 g/head/day of concentration (11.8% CP, 2.77 MCal ME/kg).
[b]Ad libitum concentrate (15.3% CP, 3.22 MCal ME/kg).
[cd]Means with different superscripts are different (P<.05).

The growth rates of five genotypes of sheep (East Java Fat Tail (FT), Sumatra Thin Tail (STT), and three crosses - FT x STT, Virgin Island x STT (H1), and H1 x H1) are being compared between a high energy/protein diet (15.3% CP and 3.22 MCal ME/kg) and a diet in which 50% of the protein is provided by leaf of the tree legume, *Paraserianthes falcataria.*

Preliminary results indicate that *Paraserian-theses falcataria* is well accepted by the animals. This experiment will continue through April 1993.

***Growth rate of four genotypes fed concentrates of three energy levels.***

Average daily gains of each genotype [Sumatra Thin-tail (S) and S crosses with St. Croix (SxSC), Barbados blackbelly (SxB), and East Java Fat-tail (SxFT)] were determined with three diets . Five lambs of each genotype were fed either: high energy (3.45 MCal ME/kg), medium energy (3.16 MCal ME/kg), or low energy (2.84 MCal ME/kg). All diets contained

15% crude protein (higher than requirement). Following a two-week adjustment period, lambs were fed experimental diets for 14 weeks. Average daily gains (table 5) were highest for the high energy (152 g/day) followed by the medium energy (118 g/day) and low energy diets (105 g/day). Overall the SxB had the highest average daily gain. On the low energy diet there was no difference due to breed, on the medium energy diet the S was highest, and on the high energy diet the S was lower than the crosses. It appears that maximum growth for the S was obtained at approximately 3.3 Mcal ME/kg diet. The other genotypes had not reached their maximum growth rate even on the high energy diet. Energy requirements for these genotypes needs further investigation.

radiation) to determine N and shade influences of fiber fractions and crude protein concentrations.

Twenty-four single-row 0.5 x 1.5 m plots were established to *Asystasia intrusa* in glasshouse beds from seed collected in North Sumatra, Indonesia. The plots were arranged in a randomized complete block design with six treatments in four replicates. The treatments consisted of 0 and 80 kg/ha of nitrogen each at three levels of photosynthetically active radiation (PAR). Levels, as a percent of natural PAR, were 63, 32, and 16. Plots were permitted to become well established with several defoliations occurring prior to initiation of the treatments. Fertilization with granular ammonium nitrate occurred at each defoliation. At

**Table 5. The average daily gain of ram lambs of the breeds Sumatra Thin-tail (S) and S crosses with St. Croix (SxSC), Barbados blackbelly (SxB), and East Java Fat-tail (SxFT) fed concentrate diets of three energy levels.**

| | Breed | | | |
|---|---|---|---|---|
| | S | SxSC | SxB | SxFT |
| | g/d | | | |
| High energy | 134a | 158b | 164b | 153b |
| Medium energy | 131[a] | 108[b] | 122[b] | 111[b] |
| Low energy | 97[a] | 111[a] | 116[a] | 97[a] |

[ab]Means with different superscripts are different (P<.05).

## *Supporting research in Raleigh, NC forage quality, selection, and evaluation*

### *Quality of Asystasia intrusa as influenced by shade and nitrogen fertilization.*

The herbaceous dicot, *Asystasia intrusa*, was grown in a Raleigh, North Carolina, glasshouse using two nitrogen rates (0 and 80 kg nitrogen/hectare) each at three levels of shade (63, 32, and 16% of natural photosynthetically active

initiation of the study all plots were defoliated and shades were placed over the appropriate plots. Shades consisted of a PVC frame (0.5-m wide, 1.5-m long, and 0.5-m high) over which either one or two layers of shade cloth were placed and attached to obtain 32 PAR and 16 PAR, respectively. *Asystasia intrusa* was harvested at eight weeks by clipping to a 50-mm stubble. The herbage was weighed and subsampled. One subsample was used for dry

matter determination. A second subsample was hand-separated into leaf and stem fractions, quick frozen in liquid nitrogen, freeze dried, ground in a Udy mill to pass a 1.0 mm screen, and stored at 15°C until chemically analyzed. Herbage was analyzed for neutral detergent fiber, acid detergent fiber and lignin. Hemicellulose and cellulose were determined by difference. Crude protein was estimated by multiplying nitrogen by 6.25.

Neither nitrogen fertilization nor shade altering (P≤0.05) affected the fiber fraction concentrations or the crude protein concentrations of *Asystasia intrusa*. This plant has a high concentration of cell solubles as indicated by the low neutral detergent fiber. Also the other fiber fractions, including lignin, were low, reflecting a composition that would favor high daily animal performance. Concentrations of crude protein were high and in the range of immature temperate legumes. These data agree with previous findings that *Asystasia intrusa* is a potentially high quality feed.

Leaf and stem tissue differed (P≤0.05) in all fractions analyzed except neutral detergent fiber (table 6). The estimation of neutral detergent fiber was somewhat variable (note magnitude of the SE) because of difficulty in filtration, especially of stems. Pretreatment with cellulase, amylase or the use of filter aid was not consistently effective in improving filtration. Leaf tissue had greater concentrations of acid detergent fiber, hemicellulose, ash, and crude protein. Composition of plant parts did not interact with either nitrogen or shade treatments. The reference to health problems with sheep that consume herbage consisting of more than 60% *Asystasia intrusa* warrants further, careful examination. Work continues on examining the nature of the crude protein fraction relative to concentrations of soluble nitrogen.

**Table 6. Fiber, ash and crude protein composition of *Asystasia intrusa*.**

| Item | NDF | ADF | CELL | HEM | LIG | ASH | CP |
|---|---|---|---|---|---|---|---|
| Light level (percent of natural PAR)[a] | | | | % | | | |
| 63 | 39.7 | 24.0 | 18.2 | 15.6 | 5.2 | .5 | 24.3 |
| 32 | 39.2 | 24.3 | 19.5 | 14.9 | 4.7 | .5 | 24.5 |
| 16 | 40.3 | 24.7 | 18.9 | 15.7 | 5.3 | .5 | 25.5 |
| Mean | 39.7 | 24.3 | 18.9 | 15.4 | 5.1 | .5 | 24.8 |
| Plant parts[b] | | | | | | | |
| Leaf | 39.1 | 16.0 | 11.7 | 23.1 | 3.3 | .9 | 30.5 |
| Stem | 40.3 | 33.0 | 25.7 | 7.6 | 6.9 | .1 | 19.0 |
| P≤0.05 NS | * | * | * | * | * | * | * |
| SE | 1.8 | .7 | .6 | 2.0 | .4 | .2 | .5 |

[a]Each value is the mean of two nitrogen levels, two plant parts and four replicates; PAR = photosynthetically active radiation.
[b]Each value is the mean of six treatments and four replicates.

***Examination of perennial Arachis for variation in forage quality and response to shading.***
There is a need for perennial ground covers in plantation crops such as rubber and oil palm in the tropics. The ground covers reduce soil erosion and leguminous ground covers are desirable because of nitrogen fixation. Because of the expense of mowing, there is interest in grazing. Perennial Arachis has already been shown to have potential as a forage crop, and germplasm with shade tolerance may provide both ground cover and forage of high quality.

The objective of this study was to examine *Arachis* germplasm for variation in dry matter production potential and forage quality.

The plant material utilized included 16 *Arachis* (obtained from N.T. Stalker of the Peanut CRSP) *Peuraria* and *Calopogonium*. Each plot consisted of two plants transplanted 30 cm apart with rows made up to 18 plots spaced 40 cm apart. The design was a randomized complete block with four replications. Shade was applied as a striped effect. The main plot was the germplasm (18 treatments). The subplot was the shade or no shade treatment, but it was striped across germplasm because all the plots in a replication must be with or without shade. The order in which plots of the four replications received shade was randomized.

In December 1992, two arachis lines were eliminated because of poor growth and persistence. *Peuraria* and *Calopogonium* out-yielded all arachis lines.

The following procedure will be followed to complete the study. The yield of each plot will be estimated by sowing a quadrat 20-cm wide and 40-cm long. All plant material within the quadrat to within approximately 3 cm of the soil surface will be harvested. After the quadrat has been harvested, the remainder of the plant material should be cut to 3 cm and discarded. Leaflets will be removed from the quadrat samples to determine the leaf area in vitro dry matter disappearance, neutral detergent fiber, and crude protein.

***Evaluation of the reproductive cycling activity of Hair sheep and Hair sheep crosses***
Sheep breeds vary in the length of the anestrus period and in the ability to breed in the spring for production of vigorous lambs in the fall. Ewes of the wool breeds, hair breeds, and DxB crosses were exposed to rams from mid-May to mid-June (34 days) from 1987 through 1992 [wool breeds are Suffolk (S) and Polled Dorset (D); the hair breeds are Barbados blackbelly (B), St. Croix (SC), and Kataahdin (K); and the cross is Dorset x Barbados blackbelly]. Rams were switched after 17 days and, each breeding group was exposed to at least one fertile ram. After breeding, ewes were kept as one flock. Fertility for each year and breed was calculated (number of ewes lambing/ number of ewes exposed), and the number of lambs born and weaned recorded. Differences due to year and breed were determined by analysis of variance. There was no effect ($P>0.1$) of year on any of the parameters measured. S ewes had the lowest fertility ($P<.001$) and the B, SC and DxB the highest ($P<.001$)[see table 7]. Because of low fertility, S ewes were removed from the study after 1990. SC and K ewes began the studying 1990. The number of lambs/ewe lambing was highest ($P<.05$) for SC, B, S, and DxB and lowest for the D and K. The number of lambs weaned/ ewe lambing was highest ($P<.05$) for B, SC, and DxB and lowest for the D, S, and K. The B, SC, and DxB ewes were the best fall lambing ewes and are most appropriate for accelerating lambing sc,hemes. Although low overall, high fertility and productivity of individuals within the D, S and K breeds indicate that selection for fall lambing may be possible.

To determine initiation of estrous cycling following fall, winter, and spring lambing, ovarian activity (serum progesterone) was monitored weekly in ewes from the week after lambing through two weeks post weaning. A rise in progesterone above 1 ng/ml was considered representative of luteal function. The number of ewes cycling was determined and

summarized for cycling activity during lactation and weaning (table 8).

The return to estrous after lambing in January indicated very few ewes of any breed initiated cycling before weaning with the exception of D ewes. Ninety-percent of the D ewes cycled before weaning. Accelerated lambing by breeding during lactation may be most likely with the D. There was variation within breed in that there were individuals within the BB, K, and S breeds that did cycle before weaning. All ewes were handled together and were fed nutritionally adequate free choice diets. After weaning, more ewes quickly exhibited cycling activity. The D, BB, and DxBB ewes had the highest number returning to estrous, while nearly 50% of the K and S ewes initiated cycling. There may be possibilities of selection for cycling activity within breed.

None of the ewes that lambed in March exhibited estrous activity while lactating. This is the normal seasonally anestrous period; so to cycle, ewes would have to overcome both lactational and seasonal anestrous. However, when these ewes were exposed to rams for breeding in May and early June, only crossbred ewes (DxBB and SxSC) conceived and lambed. All ewes lambing in October and November initiated cycling after weaning with the exception of one S. January would be during the normal cycling period. Accelerated lambing would be possible for these ewes.

During lactation the D, DxBB, and DxSC ewes that lambed in January-February all cycled. However, only three out of five of the S and only one out of six of the K ewes cycled. There appears to be a breed effect on cycling during this time.

**Table 7. Fall reproductive performance of wool and hair breeds 1987-1992.**

| | S | D | B | SC | K | DxB |
|---|---|---|---|---|---|---|
| Total # ewes | 108 | 115 | 108 | 35 | 63 | 110 |
| Years represented | 4 | 6 | 6 | 3 | 3 | 6 |
| Fertility | 13.9$^{c}$ | 42.6$^{b}$ | 81.5$^{a}$ | 74.3$^{a}$ | 46.0$^{b}$ | 80.9$^{a}$ |
| # lambs born/ewe | 1.78$^{a}$ | 1.61$^{ab}$ | 1.79$^{a}$ | 2.08$^{a}$ | 1.40$^{c}$ | 1.61b |
| # lambs weaned/ewe | 1.27$^{b}$ | 1.09$^{b}$ | 1.78$^{a}$ | 1.77$^{a}$ | 1.17$^{b}$ | 1.55$^{a}$ |

$^{abc}$Values within a row with different superscripts are different (P<.05).

**Table 8. Cycling activity after lambing for Barbados blackbelly, St. Croix, Katahdin, Dorset, Suffolk and Crossbred ewes.**

| Ewe breed | while lactating | after weaning |
|---|---|---|
| | # cycling/total | |
| Ewes lambing in January | | |
| Barbados blackbelly | 1/8 | 6/8 |
| St. Croix | 0/5 | 0/5 |
| Katahdin | 1/5 | 2/5 |
| Dorset | 9/10 | 8/9[a] |
| Suffolk | 3/10 | 5/10 |
| DxBB | 0/2 | 2/2 |
| Ewes lambing in March | | |
| Dorset | 0/8 | 0/8 |
| Suffolk | 0/5 | 0/5 |
| DxBB | 0/9 | 5/9 |
| SxBB | 0/3 | 0/3 |
| SxSC | 0/10 | 3/10 |
| Ewes lambing in October-November | | |
| Barbados blackbelly | | 7/7 |
| St. Croix | | 8/8 |
| Katahdin | | 3/3 |
| Suffolk | | 3/4 |
| DxBB | | 8/8 |
| SxSC | | 3/3 |
| Ewes lambing in January-February | | |
| Katahdin | 1/6 | |
| Dorset | 6/6 | |
| Suffolk | 3/5 | |
| DxBB | 7/7 | |
| DxSC | 4/4 | |

[a]One Dorset ewe died just before weaning.

## *Additional work not in work plan*

***Effect of high environmental temperature on respiration rate, rectal temperature, and plasma concentration of thyroid hormones of wool and hair sheep.***

Six Katahdin (hair) and six Dorset (wool) sheep were utilized to determine the effect of high environmental temperature on respiration rate, rectal temperature, and plasma concentration of triiodothyronine (T3) and thyroxine ($T_4$). Three animals of each breed were individually penned and kept in either a thermoneutral chamber (20.8°C and 61% RH) or in a hot chamber (29.9°C and 56% RH) for a 35-day period and then were switched for a second 35 day period. The animals were fed chopped coastal bermudagrass hay twice a day. Rectal temperature and respiration rate were recorded on the last eight days of each period. Blood samples to measure percentage of $T_3$ and $T_4$ were taken four times a day, just before feeding and three hours after feeding time on the days 30, 33, and 35 of each period. Analysis of variance for a Cross-over design was performed on the data.

The daily average of dry matter intake was 41.6 g/kg$^{.75}$ in both chambers. The Dorset showed higher (P<0.01) rectal temperature and respiration rate than the Katahdin sheep in both the thermoneutral chamber and hot chamber (table 9). The Katahdin had a higher plasma level of T3 than the dorset sheep in both chambers. The Katahdin in the thermoneutral chamber had the highest (P<0.01) and Dorset had the lowest plasma concentration of $\%_4$ in the thermoneutral chamber. Both breeds had equal plasma concentration in the hot chamber. No difference in plasma levels of $T_3$ and $T_4$ was detected among sampling hours, suggesting a rather steady hormone secretion by the Thyroid gland. It is concluded that animals of both breeds were negatively affected by heat stress. It is unknown if the increase of $T_4$ in the hot chamber may be the reason why the Dorset is less adaptable to hot weather.

***Tolerance to internal parasites: Is there a difference among breeds?***

Internal parasites are one of the major limitations to sheep production. Internal parasites can limit growth, reproduction, and cause death. Anthelmintics are available but are costly. Genetic variation in tolerance to internal parasites has been reported for many breeds. The Barbados blackbelly is reported to have a higher tolerance to internal parasites as compared to Dorsets. Little is known about the tolerance to internal parasites of other hairsheep (St. Croix and Katahdin) or hairsheep crosses.

Two experiments were conducted. In the first experiment, representative (five or six) mature ewes representing the Dorset, Barbados blackbelly, St. Croix, Katahdin, and Dorset x Barbados blackbelly, Suffolk x St. Croix, Dorset x St. Croix were orally administered about 500 larva/day for 10 days (Monday-Friday over two weeks). Ewes were housed on expanded metal

**Table 9. Effect of temperature on rectal temperature, respiration rate, and plasma $T_3$ and $T_4$ of Katahdin (KTDN) and Dorset (DRST) sheep.**

| | Thermoneutral Chamber | | Hot Chamber | | |
|---|---|---|---|---|---|
| | Katahdin | Dorset | Katahdin | Dorset | SEM |
| Rectal Temp. (C) | 38.9$^a$ | 39.3$^b$ | 39.5$^b$ | 39.9$^c$ | 0.102 |
| Respiration Rate (breaths/min) | 22.1$^a$ | 77.1$^b$ | 83.6$^b$ | 151.0$^c$ | 9.689 |
| Plasma $T_3$ (ng/ml) | 0.85$^b$ | 0.68$^a$ | 0.81$^b$ | 0.68$^a$ | 0.017 |
| Plasma $T_4$ (ng/ml) | 36.3$^c$ | 30.8$^a$ | 33.9$^b$ | 33.9$^b$ | 0.750 |

$^{a,b,c}$Values in a row not followed by a common superscript are different (P<0.01)

flooring and fed pelleted forage ad libitum. Fecal grab samples were taken from each ewe before dosing (initial sample), at four weeks and then weekly for eight weeks following initial larva dose. Fecal egg counts (number of eggs/gm fecal DM) were determined.

In the second experiment, eight-month-old wether lambs (five each) representing Dorset, Barbados blackbelly, St. Croix, Katahdin, and Suffolk breeds were given 6,000 larva in one dose. Fecal samples were taken as with the ewes 0, 3, 5, and 8 weeks post dosing.

There were no differences in egg counts due to breed of sheep in experiment one (with mature ewes). In the second experiment, there were differences in egg counts with time due to breed (figure 1). Blackbelly sheep had the lowest counts and Dorset and Suffolk the highest. The other hair breeds were intermediate. This experiment is now being repeated with weaned lambs of the same breeds and the Dorset x Barbados blackbelly.

### *Maintenance and finishing rations utilizing by-products.*

***Waste cotton as a feed resource for ruminants.*** Short-fiber cotton that is not suitable for textile use is currently being disposed of in solid-waste landfills, and approximately 150 million pounds per year are disposed of in North Carolina. Experiments were conducted to determine if this textile by-product (4% crude protein, 81% acid detergent fiber) is suitable as a feedstuff for ruminants. Cotton motes (10% crude protein, 68% acid detergent fiber) is another cotton by-product that originates at the gin and is composed of short-fiber cotton and immature cotton seeds. Four steers (325 kg) were fed alfalfa pellets (17% crude protein, 38% acid detergent fiber) or alfalfa pellets with 25% of the diet as textile by-product, cotton motes, or fescue hay (10% crude protein, 42% acid detergent fiber) in a 4 x 4 Latin Square design. There were no differences in gain (.98 kg/day; P=.96) for the four treatments with the steers consuming 3% body weight. In a second experiment, 28 lambs (30 kg) were fed 55% concentrate diets with either 45% fescue hay (8% crude protein, 49% TDN) or 0, 15, 30 or 45% textile by-product (replacing hay). Diets were isonitrogenous (15.4% crude protein) and isocaloric (65% TDN). Performance was measured for seven weeks, then digestibility was determined. Intake decreased linearly (P<.01) with increasing textile by-product from 1.20 kg to .95 kg/day (4.2 to 3.4% of body weight; P<.01). Gain also decreased linearly (P<.01) with increasing textile by-product from 171 g/day to 111 g/day. Dry matter digestibility did not differ (P=.26) and averaged 74.8% despite the decrease in intake, which indicates that textile by-product was less digestible than the hay for sheep. When means were compared by the least significant difference method, there were no differences for intake or gain for the 0 and 15% diets, indicating that this level of textile by-product can be incorporated into diets for sheep. In conclusion, steers performed satisfactorily and readily consumed diets containing 25% cotton. Sheep were more selective and decreased intake when cotton was increased from 15 to 30% of the diet, indicating that sheep have a lower tolerance for the by-product in the loose form. The value of the cotton appears to be similar to low quality hay, but other factors, such as ease of handling and relative costs, need to be considered when incorporating cotton into ruminant diets.

## Training

*In Progress*

Wayan Mathius, Ph.D., December 1993, Nutrition, IPB, Bogor, Indonesia (100% funded by SR-CRSP).

Simon Ginting, Ph.D., September 1995, Nutrition, North Carolina State University, Raleigh, NC (100% funded by SR-CRSP).

Roger Merkel, Ph.D., January 1994, Nutrition, North Carolina State University, Raleigh, NC (Research work completed in Indonesia and supported by SR-CRSP).

Jose Luis Romano, Ph.D., December 1993, Nutrition, North Carolina State University, Raleigh, NC (Research supported by SR-CRSP).

Silvia Buntinx, Ph.D., May 1994, Nutrition, North Carolina State University, Raleigh, NC (Research supported by SR-CRSP).

Oneas Mufandaedza, Ph.D., August 1993, Animal Science and Crop Science, North Carolina State University, Raleigh, NC (50% of assistantship and part of research funded by SR-CRSP).

*Short Term*

Pungu Nababan, barn manager at Sei Putih, attended a short course on sheep husbandry and management in Malaysia (funded by SR-CRSP and NCSU).

Simon Ginting, SBPT scientist attended tour of sheep production and integration into tree crop plantations in Malaysia (funded by SR-CRSP).

## Contributions

*Environmental impact and relevance*

The grazing of sheep under plantation tree crops reduces the need and use of herbicides, improves soil characteristics, and increases nutrient recycling. The fragile soils are more stable and use of legume forages improves fertility through nitrogen fixation.

Through use of agri-industrial by-products as feedstuffs, small ruminants transform waste to high quality protein. In the United States, textile waste and gin by-products are now used as animal feed rather than being deposited in the land-fill. In North Carolina alone, 150 million pounds are available.

Sheep grazing is used to remove forage in Caribbean aloe plantations; this technology was first exploited by the SR-CRSP in Indonesia with rubber plantations This has reduced the need for herbicides, diversified income, and stabilized the soil.

*Agricultural sustainability*

The incorporation of improved legumes into the forage growing under the tree-crops reduces need for fertilization and stabilizes the system.

Use of manure collected under barns adds nutrients and organic matter to cropping area and is a "free" source of fertilizer.

Use of legume trees planted in hedgerows and areas not used for cropping allows farmers to have high quality protein supplement that is available to the farmer and cannot be eaten by neighbors, livestock (cannot reach the leaves). This low cost, high quality protein source can be regularly cut and sustained.

*Contributions to U.S. agriculture*

*Asystasia intrusa*, a non-leguminous dicot, has been brought to and evaluated in the United States. Its high quality and vigor may be important as a potential annual forage with the quality of alfalfa.

The work with hair sheep has identified breeds that are more resistant to internal parasites, more tolerant of heat, and the ability to breed out of season. These characteristics are important in developing a ewe that is capable of reproducing and thriving year-round in the Southeastern United States.

A Ph.D. student, Roger Merkel, conducted research in Indonesia and therefore has a better understanding of international agriculture and differences in sociological and cultural practices.

*Contributions to Indonesia*

The Indonesian Small Ruminant Network has improved communications among scientists and sponsorship of training and conferences has been effective in technology transfer. The network is supported by the SR-CRSP. To further this work, scientists are being trained: Wayan Mathius at IPB and Simon Ginting (NCSU).

Collaboration with the Soils Management CRSP (formerly TropSoils CRSP) has continued. The Soils Management CRSP is beginning another project in Indonesia and the Mission has requested that the SR-CRSP work with the project. In addition, germplasm from the Peanut CRSP has been evaluated for shade tolerance and forage germplasm has been obtained from CIAT and the Tree Legume Center.

### *Support for free markets and economic growth*

Development of a feeding management scheme for growing lambs on large scale has been adapted to commercial practices. These larger scale farms have the volume to supply the lambs needed for the larger cities. Economy of scale allows many alternatives to be used.

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# *Economics of Small Ruminant Production Systems and Markets*

## Winrock International

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### Narrative Summary

The economics program in Indonesia focuses on research, technology transfer, and institution building. The program works with farmers who raise sheep in conjunction with rubber plantations in the humid tropical lowlands through the Outreach Research Project (ORP) which covers an area near the Sungai Putih rubber plantations and involves 27 farmers who have received in-kind credit. Technical assistance is provided and technologies are tested. Preliminary results indicate sheep production provides 25% of income for farmers with average flock size of 20 animals. Their profits are 30% higher and their return to labor 300% higher compared to farmers without sheep.

## 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 small-holder farmers. Cash flow is a barrier to successful small-holder 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. Although governments have promoted small-holder production for many years, tree crop production has not always been successful. The government recognizes the value of integrated tree production systems in small-scale farming which would provide additional income. However, constraints faced by small producers must be identified because there is concern that current sheep production systems only benefit the larger commercial producers.

The long-term goal is to contribute to the development of an integrated production system to benefit sheep producers whose animals graze under plantation crops. Included in this goal are health and grazing management aspects of production and analysis of marketing and agribusiness opportunities. The economics program focuses research on three main analytical activities: integrated production systems, animal health, and marketing.

The economic analysis of integrated production systems concentrated on evaluating and designing integrated production systems studies involving economics, nutrition and forage at Puslitbun and SBPT. The main focus is a comparison of the economics of sheep grazing under rubber trees with alternative crops such as rattan, bananas, or other shade-tolerant crops; a cost-benefit analysis of shade-tolerant forage species; and developing guidelines for sheep production in rubber plantations as an agribusiness enterprise. This comparison includes labor cost and household labor availability. The working hypothesis is that integrating sheep with rubber trees has higher returns than alternative products. Preliminary results seem to support such an hypothesis.

## Results

Results indicate that animal health is crucial to future research. An animal health care delivery system is being designed using recommendations from traders and merchants in the area to establish a free-market system of the most important sheep medicines. Preliminary analysis indicates DINAS Peternakan is a feasible animal health care provider. When its health care delivery systems are compared to others, the rating is favorable in terms of efficiency, costs, and farmers' satisfaction. Further analysis is being conducted and the different possibilities evaluated. DINAS Peternakan's contribution to animal health research is crucial not only to evaluate future research priorities, but also to complete a feasibility assessment of the animal health care delivery system design.

Market analysis to compare systems and assess comparative advantages have been conducted for sheep and products at two levels of trade–local and provincial. The comparative advantage of sheep in North Sumatra is being established and evaluated using data collected by Setel Karo Karo. This will help evaluate the effects of increased supply on producer and consumer prices. At the same time, guidelines are being developed for an agribusiness enterprise–sheep in rubber tree plantations. This includes developing a comprehensive commercial scheme with spreadsheets using different price assumptions.

Marketing studies concentrated on local and provincial trade. A market analysis will be conducted using traders in Medan. This is an extension of the marketing study conducted at the local level in 1991 using the same variables and estimation procedures to enable comparison and estimation of price differentials. A sample size should probably be extended to 500 observations.

## Training

Atien Priyanti, a graduate student from Indonesia in the department of Agricultural Economics and Rural Sociology at the University of Arkansas, Fayetteville, since July 1990, completed requirements for the M.Sc. in Agricultural Economics in December, 1992. She participated in the one week course in Developing, Marketing, and Writing Research Project Grant Proposals, July 27-31, 1992, offered at Winrock International headquarters in Petit Jean Mountain. Ms. Priyanti attended the annual American Agricultural Economics Association meetings, August 9-11, Baltimore, Maryland. All her funding was provided by SR-CRSP. She has returned to Indonesia.

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# *Sociological Analysis of Small Ruminant Production Systems*

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## Narrative Summary

The Sociology Project in Indonesia concentrated its efforts during 1992 in four distinct areas. In support of the Bogor (Prolific Sheep) program, from which the social science projects had begun to phase down a year earlier, efforts were directed toward completing studies which had been initiated in 1991 and assessing the impacts of SR-CRSP research. Completed studies included earlier undertakings which looked at indigenous systems of animal health management and further examinations of the role of women in small ruminant production. Impact assessment efforts included a reevaluation of the OPP (Outreach Pilot Project) program which had introduced a number of changes at the village level and a major effort to assess the rates of return to the investments the SR-CRSP has made in Indonesia since 1980. The latter was part of a world-wide effort to identify the impacts the SR-CRSP has had in the countries in which it has worked. Research in West Java showed that identifying and releasing the bottlenecks to the adoption process will have a great positive impact on the returns to research.

In North Sumatra, a three-month study looking at the role of women and potential organizational barriers to the adoption of technology was undertaken. Three areas were emphasized. The first was identifying and analyzing labor constraints faced by six different types of producers linked to rubber plantations in North Sumatra. A second study looked at the role of women and children in small ruminant production and at the differing results obtained when participant observation was used as opposed to formal surveys. A third area of analysis was the organizational barriers to diffusion of technologies. Analysis of the cooperative structure and relationships between farmers, the PTP, and the KUD (Koperasi Unit Desa) is analyzed. Some constraints that require further study, if the mechanisms for on-farm testing and technological adoption presently used are to continue and be effective, are presented. As seen in West Java, it is important to identify the audience for small ruminant technologies and the means through which these will be transferred, so bottlenecks are identified and eliminated.

Early in 1992, the decision was reached to allow projects to work in a maximum of two sites. As a result, the Sociology Project, which had active programs in three sites, elected to terminate its Indonesia activities (except for a continuing training commitment) in September, 1992. Future annual reports for Indonesia will be limited to activities related to training and the publication of data resulting from earlier data collection efforts.

# Research

## Objectives

Identification and general description of areas in Indonesia where small-holder production of tree crops occurs.

Conduct surveys to identify potential constraints to small ruminant production in one or two of the production systems identified above.

Support the completion of social science research and analyses begun in 1990-1991, including ethno-veterinary research.

### Problem statement and approach

The humid tropical lowlands of the world contain a large number of feed resources that are underutilized. The monoculture of tree crops such as rubber, oil palm, and other has been emphasized to date. These crops are produced by different types of producers, such as commercial states and small-holder farmers. Small-holder tree production has not been very successful, measured in productivity terms, although the government has tried for many years to promote and support it. A barrier to successful small-holder production of tree crops is cash flow during the period of establishment to the maturity of the trees. Small ruminants are seen as a means to alleviate this constraint and reducing the risks faced by producers. One benefit to producers is to develop a sheep production system before trees mature production. Constraints faced by small producers must be identified in order to develop production strategies to introduce small ruminants.

Technologies were developed in West Java to increase productivity of small-holder producers in intensive production systems. A technological package was developed and tested through the Outreach Pilot Project. Ten years of research in nutrition, breeding, management, and social sciences, and the development of human capital through training took place in West Java. Concerns about the cost of the program and contributions to the host country were among the reasons to study the potential impacts to the people of Indonesia.

### North Sumatra

Research activities in North Sumatra were carried out by Ralph B. Brown, research associate from University of Missouri-Columbia, and Sri Wening Handayani, host country co-investigator. Their work concentrated on identifying different types of households linked to rubber production in plantation areas and focused on the use of labor and existing labor constraints.

### *Social and economic assessment of six types of households in North Sumatra's plantation areas.*

#### Justification

The primary purpose of this research was to examine the attitudes and labor allocation of farmers with very different circumstances and characteristics within the plantation. Results are intended to help determine the most appropriate target population for SR-CRSP technology.

Introduction of SR-CRSP technology has and will continue to create adjustments by households to previous labor practices. Analyzing what some of those adjustments have been was the purpose of the research. Additionally, since major changes in farming practices often require significant adjustments in the amount of labor and the times when it is required and by whom, examining a wide spectrum of household types within the plantation to see how each has or may adjust was necessary.

#### Progress

Four different surveys were administered to six different household types. Those groups which had received SR-CRSP or SBPT sheep were given the same survey as those which had their own animals (one survey for Nucleus Estates Small-holders and one for permanent labor respectively). Each household type was represented by 12 respondent households. The number of respondent households was limited

by the number of farmers who had received sheep from the project—twelve. The six survey groups are as follows:

1. Nucleus Estates Small-holders with SR-CRSP sheep—Out-Reach Project Membang Muda (OPMM).
2. Nucleus Estates Small-holders without SR-CRSP sheep or other animals—Membang Muda.
3. Nucleus Estates Small-holders without SR-CRSP sheep but with their own animals (sheep, goats, or cows)—Membang Muda.
4. Permanent laborers which received SR-CRSP sheep in 1988.
5. Permanent laborers with no animals.
6. Permanent laborers with their own animals.

The first three survey groups were Nucleus Estates Small-holders (NES). NES is a project through the Indonesian Government and the World Bank. The NES provides two hectares of land for trees, new high yielding rubber clones, land and materials for housing, credit, and extension services to its participants. A major goal of NES is land reform. Participants—most often from the poorest economic strata of Indonesian society—are to receive a certificate of ownership after a specified period of time working the rubber trees. Although the NES is composed primarily of the "economically weak" it includes many different types of people—from those with no previous rubber experience to former plantation laborers. In October, 1991, the SR-CRSP and SBPT made a commitment to test an "out-reach project" in a NES area—Gunung Lonceng, Membang Muda. To date, twelve participants have received sheep from the project. The Sociology program monitored the participants to determine how the project was running in terms of social adjustments to the sheep and the technology associated with them. Additionally, the unique project structure and mix of human capital provided an opportunity wherein different household types (i.e., different asset structures, social positions, and cultivating experiences) could be studied effectively to determine their impact(s) on sheep production and sheep production's impact(s) on the participants.

The last three survey groups concentrated on permanent laborers of the rubber estate. These are people who are provided housing and wages by the plantation. Their main livelihood and potential pension comes from a monthly salary from the rubber estate and not from ownership of land. In 1988, twelve permanent

**Table 1. Time allocation of household members on domestic and non-domestic activities, in minutes/day (means & %)**

| Household Members | Overall | OPMM | NES SR | NES woSR | Labor Proj | Labor SR | Labor woSR |
|---|---|---|---|---|---|---|---|
| Father*** | 516 | 465 | 520 | 510 | 540 | 540 | 480 |
| | (98) | (92) | (100) | (100) | (100) | (100) | (92) |
| Mother*** | 487 | 430 | 515 | 520 | 495 | 509 | 570 |
| | (100) | (100) | (100) | (100) | (100) | (100) | (100) |
| Sons** | 105 | 68 | 87 | 135* | 130* | 134 | 180* |
| | (88) | (83) | (91) | (91) | (91) | (83) | (83) |
| Daughters** | 175 | 109 | 153 | 210* | 254* | 182 | 235* |
| | (92) | (92) | (100) | (83) | (83) | (100) | (92) |

** Sons' and Daughters' activities are only for household activities such as washing dishes, cleaning houses, sweeping floor, washing cloths. Schooling and small ruminant activities are not included in this category.

*** Domestic and non-domestic activities for father and mother include working in the plantation.

**Table 2. Time allocation of household members on small ruminant activities, in minutes/day (Means & %)**

| Household Members | Overall | OPMM | NES with SR | Labor in Project | Labor outside Project |
|---|---|---|---|---|---|
| Father | 74 (52) | 78 (92) | 67 (58) | 78 (33) | 70 (25) |
| Mother | 38 (46) | 36 (83) | 30 (50) | 65 (33) | 26 (33) |
| Sons | 252 (88) | 282 (83) | 248 (92) | 278 (92) | 203 (83) |
| Daughters | 156 (38) | 131 (33) | 240 (17) | 96 (42) | 157 (75) |

laborer households received sheep from the SBPT. Although the SBPT has maintained extension links with these households through an estate extension worker, direct linkages have not been maintained. In all six survey groups, the issues of land ownership, additional income generating activities or plans for such, household labor activities, and household expenses were examined. Additionally, labor allocation and various problems associated with the maintenance of animals were explored for those households who had animals. Analysis of this data is in progress and will appear in a technical paper entitled "Social and Economic Assessment of Outreach Project Membang Muda (OPMM)," by Sri Wening Handayani and Ralph B. Brown.

Tables 1 and 2 show some of the findings of these surveys. As can be seen in Table 1, for children in households were small ruminants are kept, minutes spent doing other chores are reduced. This is particularly true for female children. Table 1 shows that small ruminant care and production is primarily the responsibility of children, not the female head of household as was previously reported in other SR-CRSP reports. These findings were studied in greater detail and are reported in the next section (Women's and Children's labor roles and allocations).

### *Women's and children's labor roles and allocations.*

#### Justification

Existing research from Indonesia on women's and children's labor roles in household sheep production is confusing and inconsistent. A possible reason for this mixed bag of results is the choice of research methodology—it has relied heavily on survey techniques. However, in a culture which strongly sanctions personal assertiveness, the likelihood of a person accurately reporting the type and extent of labor he/she performs is minimal. In such a cultural environment one would expect personal reports of labor to be consistently underestimated and/or credited to the male head of the household.

#### Progress

To test these hypotheses, labor allocation questions were built into the surveys for a comparison base. The findings from the survey data were compared to findings from the same population using observational data. While administering the survey, commitment to the observational approach was continually reaffirmed as respondents would consistently report virtual inactivity from household tasks in the evening hours even though they were folding clothes, bathing children, and other chores.

**Table 3. Observational results for OPMM household labor and time allocation by age and gender. Reported in hours and minutes per day (N).**

| ACTIVITY | (male)Head | Wife | Less than 14 | | More than 14 | |
|---|---|---|---|---|---|---|
| | | | Male | Female | Male | Female |
| Maintain Home | .54(4) | 5.02(12) | — | 1.31(10) | 1.15(1) | 2.56(6) |
| Farming/On-Off Farm Job | 6.49(11) | 4.25(8) | — | — | 5.34(4) | 3.15(1) |
| Social Activity | 2.04(11) | 2.28(10) | 7.15(12) | 6.18(10) | 6.07(8) | 7.03(6) |
| Small Ruminant Care | .50(6) | .25(6) | 3.45(11) | 1.45(2) | 3.04(4) | — |
| Resting | 2.24(12) | 1.55(12) | 1.55(12) | 2.38(10) | 1.38(7) | 1.24(6) |

Sri Wening Handayani and Ralph B. Brown prepared a methodological approach which would allow Ms. Handayani and another researcher to "live" with a family for a day and document the tasks performed. They did this with several families in the project areas covered by the surveys. This data will serve two purposes for the SR-CRSP: first, it should give a much clearer picture of actual labor allocation within the household. This should help in determining the relative ability of different types of families to adopt the SR-CRSP technology. Second, it should show why, on a comparative basis, the survey research which has been done in this area is not an appropriate way to address this issue. This should clear the way for more accurate and usable research results in the future.

Research got underway on 10 July and continued until the end of the month. The results of this research will appear in a technical report by Ralph B. Brown and Sri Wening Handayani entitled "Bio-social roles in peasant small-ruminant production: the importance of children versus gender in secondary economic activities." Tables 3 and 4 are drawn from this report. As can be seen by a comparison of the two tables, male head-of-household's labor allocations are consistently overestimated by survey data as was suspected. The rest of the data is much closer to the observational data.

**Table 4. Survey results for OPMM household labor and time allocation by age and gender. Reported in hours and minutes (N).**

| ACTIVITY | (male)Head | Wife | Male(Child) | Female(Child) |
|---|---|---|---|---|
| Maintain Home | 1.42(4) | 6.48(12) | 1.15(6) | 5.24(10) |
| Farming/On-Off Farm Job | 8.30(11) | 5.35(9) | 6.35(6) | 5.15(5) |
| Social Activity | 3.05(11) | 1.55(12) | 7.30(12) | 7.49(12) |
| Small Ruminant Care | 1.11(11) | .24(8) | 3.55(10) | .44(14) |
| Resting | 1.15(11) | 1.35(12) | 2.48(12) | 2.05(12) |

### *Organizational issues.*

#### Justification

Present mechanisms to introduce and test small ruminants through the outreach program need to be analyzed to determine viability of the system for future extension efforts. The means of targeting the audience for technology is just as important to determine as the audience in order to provide positive impacts. Through intensive interviews and archival research of existing documents, organizational aspects of the NES project were examined.

#### Progress

Several factors associated with its organization directly affect the current SR-CRSP/SBPT project and could potentially affect others. As stipulated by the Indonesian Government, all economic development activities will occur through cooperatives. The intent of this cooperative organization is to safe-guard the concerns of those on or near the bottom of the economic hierarchy. SR-CRSP in cooperation with Puslitbun and SBPT has given sheep to 12 families in the NES of PTP III. The understanding is that PTP III will arrange for credit for the farmers to build a barn for the animals before the program is completed. However, the present system creates confusion for the farmers and opportunity for mismanagement. Farmers are uncertain as to the receiving and paying back of credit from PTP through KUD (Koperasi Unit Desa—The Farmer's Cooperative). The opportunity for mismanagement comes through the unique position the cooperative plays and in particular the role of the secretary.

All economic activities from the PTP with the farmers must pass through the cooperative. This includes the granting and paying back of credit as well as moneys from the sale of latex to the PTP III. By agreement, all latex from NES participants must be sold to PTP III. These sales must also go through the KUD. Within KUD itself one position holds all the keys—the secretary. All relationships between the two sides must pass through him.

This is the same organizational scheme which exists in all the PTP's and thus at all the NES sites. If the project is to benefit the small-holder, it must deal with this system. To date no access to the KUD secretary has been found. For the benefit of the project and particularly for the eventual benefit of the small-holder—whom the project will hopefully benefit—this issue must be explored in further detail. One possible access that needs further exploration is the power of other organizations involved with the NES (Internal Affairs, Bank Rakyat Indonesia, The Director General of Estates, The Department of Cooperatives, World Bank, etc.) over the existing KUD organizations.

## Progress Report Prolific Sheep: West Java

### *Ethnoveterinary research in the SR-CRSP/Indonesia.*

#### Progress

Work in this area was limited to the publication of results reported in last year's annual report. One working paper was published and two others are due out early in 1993.

A major book-length publication detailing the work of a number of scientists from around the world in this area is in preparation and is expected to be completed in 1993. A second annotated bibliography on ethnoveterinary medicine (see 1991 annual report for reference on the first publication) is also in preparation and is likely to be published in 1993 as well. Evelyn Mathias-Mundy and Constance McCorkle, sociology collaborating scientists, are leading this effort.

### *Women and small ruminant production (West Java).*

#### Justification

The SR-CRSP has supported several studies which have examined the role of women in the production of small ruminants. These were summarized by Sri Wahyuni Malole (1992), sociology co-investigator, in the paper she

presented at the Asian Association of Animal Production. Wahyuni also reported on her 1990-1991 study which looked at the influence of small ruminant training programs on women's knowledge and production practices.

### Progress

Over the course of the year in which the study/training was conducted, women's management scores increased significantly, especially in the areas of salt supplementation and cleanliness of the barn. In addition, the women increased their ability to recognize signs of estrous and pregnancy. However, these improvements could not be specifically linked to attendance at meetings (there were only small differences in test scores between frequent attendees and irregular attendees). Further, it was not clear that knowledge necessarily translated into better quality animals as a qualitative assessment of flocks did not reveal differences between those with high management knowledge scores and those with lower scores. In general, Wahyuni noted, women have lower management knowledge scores than men.

## *Reevaluation of Outreach Pilot Project.*

### Justification

This study was undertaken by Wahyuni in 1991. The Outreach Pilot Project (OPP) was initiated by the SR-CRSP in 1984 as an attempt to study and improve village level production systems in West Java. Formal activities ceased in 1989 and it was considered important to assess those villages two years later to determine which of the technologies introduced by the SR-CRSP had been maintained in the intervening time.

### Progress

Most of the analysis and writing from this undertaking are yet to be completed, but preliminary data indicate the following:

Forty-one percent of the farmers who were raising small ruminants in 1989 were no longer doing so in 1991. The two main reasons for this were increased off-farm employment and expanded food crops production. The quality and quantity of feed provided to animals seemed to have improved. Water and salt availability were about the same. Reports of the incidence of health problems showed an improvement, and the cleanliness of barns index was largely unchanged. Overall, the condition of animals was judged to be lower in 1991 than it was in 1989.

While overall conclusions are inappropriate, this study raises enough questions that a more intensive evaluation effort is appropriate. Learning more about the dynamics of why farmers decide to start and stop raising small ruminants and which management practices are likely to firmly take hold will provide all researchers with better information.

## *Returns to research: Economic impacts of small ruminant technologies in West Java Indonesia.*

### Justification

In a region where small ruminants are raised by every fifth farmer, and where this activity contributes between 15 and 25 percent to household income, increases in productivity have an important impact on the welfare of rural families, consumers, and the economy of Indonesia. Sheep act as a savings account and the source of accumulation of capital. In Indonesia, approximately 64 percent of sheep farmers, and 45 percent of the sheep, are in West Java. Of the 62.5 million people employed, 35 million are in agriculture. Meat accounts for 25 percent of the protein consumption from non-plant sources. With positive growth in per capita income and population, red meat demand is expected to increase. Commercial fattening operations are starting to develop in the region, increasing further the demand for sheep.

Small ruminants are raised in marginal areas of the developing world where subsistence living conditions and high levels of risk persist.

Development of basic research, technology, and human capital institutions can contribute to the economic welfare of smallholder families that raise sheep, specially women and children. This is essential to the development of an economic and social base that can sustain democratic transformations in the developing world, specially today when most countries are going through a process of structural adjustment, market oriented policies, and free trade. Donor agencies expect research to have immediate impacts and result in long-run sustainable systems for the people and the environment. Assessing the SR-CRSP is a difficult task because of lags between research and development, traditional tools that are not suitable to assess basic and development research, as well as human capital and institutional developments, which are important products of this program. When short-term impacts are expected, products of long-term research such as breeding are in question. The approach taken in this evaluation is to determine if the products of short and medium-term research, such as management nutrition and reproduction, can finance basic research, genetics, and training, which have long development and adoption lags, and therefore may have impacts in the long-term.

## Progress

The Highly Prolific Sheep Component of the SR-CRSP was assessed using information from the Outreach Pilot Project. Goals of the program concentrate on technological development that will increase the welfare of families that raise small ruminants and human capital development through training and research. The program concentrated on station and on-farm research and training between 1981 and 1990 in West Java. Breed characterization and mode of inheritance of the prolific gene were determined in Javanese Thin Tail Sheep. Nutrition research focused on the development of feeding technologies, such as supplementation with tree legumes, agricultural by-products and minerals, and testing feed sources available to the farmer. The characterization of production systems, bio-social roles, marketing channels, and farmer strategies, as well as adoption and willingness to pay for technologies, were areas of research for economics and sociology.

On-farm testing through the Outreach Pilot Project (OPP) of management, reproduction, nutrition, and marketing techniques, and the analysis of producer responses, resulted in a technological package for small producers in a cut-and-carry system that has been published in Indonesian, Javanese, Sundanese, and English. Production techniques increased yield by fifty percent. An economic surplus model was used to evaluated the OPP and the SR-CRSP in West Java. Besides calculating the internal rate of return, this model yields information about the total surplus generated through the development of technologies that improve productivity. It also allows measurement of the distribution of the gains from research between producers and consumers. In this evaluation all the costs of the Indonesian Prolific Sheep Component were considered. These included training of Indonesian and U.S. students, as well as research and travel costs in Indonesia and the U.S. These costs were discounted against the net benefits of the OPP technological package evaluated for West Java. A twenty-five percent shift of the supply function was calculated after considering the yield increases of the technology and the additional inputs required to obtain this productivity level.

The results presented are preliminary; the benefits of the breeding and training programs developed by the SR-CRSP are not included. A very conservative adoption rate (20 percent), with peak adoption reached in 12 years for West Java, gave an internal rate of return of 19.24 percent. A faster adoption rate (peak adoption of 20 percent in ten years) resulted in a 22.9 percent internal rate of return. If research spillovers of 19 percent to other provinces are considered, the return is 24.8 percent. The distribution of the gains from research, given the market conditions (i.e., a responsive demand for meat), resulted in producers

capturing a greater proportion of the surplus generated (77 percent).

Costs considered included graduate training. Indonesian researchers involved with the SR-CRSP received 23 graduate degrees, 12 at the M.S. level and 11 at the Ph.D. level. Of these, 19 were funded by the SR-CRSP. The four U.S. institutions of the Highly Prolific Sheep Component funded training and/or graduate research for eleven U.S. doctoral students and fourteen U.S. master students. Research installations constructed with SR-CRSP funding are being used by undergraduate students in the United States every year. Faculty experienced in research in developing countries prepare U.S. students for the global economy. Farmers in North Carolina are benefiting from hair breeds and crosses that are adapted to the climatic conditions of the southeastern United States. Seven producers have purchased 250 hair sheep for breeding stock and resistance to internal parasites. All these benefits were not included in the rates of return calculation. This evaluation shows that the returns to management nutrition and reproduction package finances the costs of basic research and human capital development, and that the technology will benefit both producers and consumers. This research was carried out by Corinne Valdivia at University of Missouri-Columbia, with the support of economics at Winrock International and with collaborating scientists in Indonesia and the U.S.

## Training

Ms. Sri Wening Handayani, Ph.D. student in the Department of Rural Sociology at the University of Missouri-Columbia. Expected completion 1994.

## Contributions

The sociology research group has always carried out gender sensitive research, where appropriate, to establish if differences exist in management, labor, and control over resources by gender and age. The latest contribution of the group is a look at differences in methodologies used to gather information to explain labor allocation by family member by age and gender. This is an important contribution that points to cultural differences and the need to utilize techniques that will eliminate biased responses due to culture. See especially the results obtained by Handayani and Brown in their study of North Sumatra families in rubber plantation areas.

The organization study in North Sumatra contributes to the understanding of the bottlenecks that exist in the current system. Alternatives developed will undoubtedly contribute to enhancing democratic institutions and become means for adoption of technological innovations.

## Collaborating personnel

*Indonesia*

Sri Wahyuni Malole, Sociology Co-Investigator, RIAP

Sri Wening Handayani, Sociology Co-Investigator, RIAP

Tjeppy Soedjana, Economics Co-Investigator, AARD

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*United States*

Michael F. Nolan, Principal Investigator, University of Missouri-Columbia

Jere L. Gilles, Co-Principal Investigator, University of Missouri-Columbia

Corinne Valdivia, Co-Principal Investigator, University of Missouri-Columbia

Ralph B. Brown, Research Associate, University of Missouri-Columbia

Constance McCorkle, Collaborating Scientist, The Futures Group

Evelyn Mathias-Mundy, Collaborating Scientist, University of Missouri-Columbia

## Collaborating institutions

Research Institute for Animal Production (BPT), Bogor West Java, and SBPT Sungai Putih, North Sumatra.

National Rubber Research Institute (BPP), Sungai Putih, North Sumatra

## Publications

Mathias-Mundy, Evelyn, Sri Wahyuni, Tri Budhi Murdiati, Agus Suparyanto, Dwi Priyanto, Isbandi, Beriajaya and Harini Sangat-Roemantyo, "Traditional Animal Health Care For Goats and Sheep in West Java: A Comparison of Three Villages," Small Ruminant Collaboration Research Support Program, Balai Penelitian Ternak Pusat Penelitian dan Pengembangan Peternakan, Bogor. 1992.

McCorkle, Constance M., "An Introduction to the Ethnoveterinary Research and Development," Journal of Ethnobiology 6(1)129-149, 1986 reprinted III Jornada sobre Herbolaria Medicinal en Veterinaria — Parte 2: Curso de Etnobotánica para Veterinarios. A. Aguilar Contreras and M.A. Martínez Alfaro, eds. México, DF: Universidad nacional Autónoma de México. 1991.

Valdivia, Corinne. Assessment of The Small Ruminant Collaborative Research Support Program and the Economic Impacts of Small Ruminant Technologies in West Java Indonesia. Final Report. September, 1992.

Wayhuni, Sri, Agus Suparyanto, I.W. Mathius, and Dwi Priyanto, "Social Structure of Small-Ruminant Farm Families and Production Techniques in Java," in Technologies for Small Ruminant Production in Indonesia, Ludgate, Patrick and Sibylle Scholz (eds.), Winrock International Institute for Agricultural Development. Morrilton, Arkansas. September, 1992.

Wayhuni, Sri, Patrick J. Ludgate and Michael F. Nolan, "Dissemination of Information About Small-Ruminant Production," in New Technologies for Small Ruminant Production in Indonesia, Ludgate, Patrick, Sibylle Scholz (eds.), Winrock International Institute for Agricultural Development. Morrilton, Arkansas. September, 1992.

Wahyuni, Sri, Tri Budhi Murdiati, Beriajaya, Harini Sangat-Roemantyo, Agus Suparyanto, Dwi Priyanto, Isbandi, and Evelyn Mathias-Mundy, "The Sociology of Animal Health: Traditional Veterinary Knowledge in Cinangka, West Java, Indonesia - A Case Study," Small Ruminant Collaborative Research Support Program Working Paper No. 127, Balai Penelitian Ternak Pusat Penelitian Dan Pengembangan Peternakan, Bogor. February, 1992.

## Abstracts and presentations

Handayani, Sri Wening, Ralph B. Brown and Jere L. Gilles, "Differential Access to the Factors of Production and its Consequences in Three Peasant Household Production Systems in North Sumatra's Rubber Plantations," presented at the Annual Meetings of the Rural Sociological Society, State College, Pennsylvania. August, 1992.

Handayani, Sri Wening and Ralph B. Brown. Differential Access to Land and its Consequences in Three Peasant Household Production Systems in North Sumatra's Plantation Periphery. Paper presented at the Rural Sociology Society Meetings, Penn State. August, 1992.

Mathias-Mundy, Evelyn and Constance McCorkle, "Ethonoveterinary Research: Lessons for Development," paper presented at the International Symposium on Indigenous Knowledge, International Institute for Rural Reconstruction, Silang, Cavite, Philippines. September, 1992.

Valdivia, Corinne and Michael F. Nolan, "Fighting and Prolific Sheep: Returns to Research in Indonesia." Presentation. Seminar Series of the Department of Agricultural Economics, University of Missouri-Columbia. Dec. 1, 1992.

Wahyuni, Sri, "The Sociology of Animal Health: A Comparison of Knowledge Between Women and Men; Recent Advances in Animal Production," Proceedings of the Sixth AAAP Animal Science Congress, Vol. III, AHAT, Bangkok. November 23-28, 1992.

Wahyuni, Sri, "Women Focused Strategy in Increasing Small Ruminant Production," Proceedings of the Sixth AAAP Animal Science Congress, Vol. III, AHAT, Bangkok. November 23-28, 1992.

## Awards

Sri Wahyuni Malole received "Best Presenter" award at the Sixth AAAP Animal Science Congress, at Bangkok. November 23-28, 1992.

# *Epidemiology and Control of Important Disease Constraints of Sheep*

## INI ANSREDEF

Alan Wilson and Gatot Adiwinata, INI ANSREDEF and RIVS, P.O. Box 1093, Boo 16010, Bogor, Indonesia.

*Editor's note: This report was excerpted from the midterm report by Wilson and Adiwinata. INI ANSREDEF began a consulting project on parasitology with the hairsheep component in 1992.*

### Narrative Summary

This report summarizes work conducted on Protocols 4, 5, 6, 7, and 8 during the period July to December 1992.

The continuous monitoring of five breeds of sheep maintained under the herd management system (Protocol 4) indicated that the pure St. Croix (H) had consistently lower egg counts than the other groups. There was no evidence for Benzimidazol resistance, and uptake of worms after treatment remains very rapid. There is large individual variation in all groups, and animals with low egg counts over time should be studied more carefully.

Around ten percent of the population of weaned sheep show reduced nematode egg counts. These results need to be quantified more accurately so that breeding for possible resistance to helminths can commence.
The main diseases of importance diagnosed during the period continue to emphasize the importance of internal parasitism and pneumonia. A nutritional disorder associated with Ca/P imbalance was also diagnosed.

The first of a series of experiments in Protocol 8 designed to test for breed effect on nematode and trematode uptake and establishment in six-month-old sheep indicated no obvious breed effect for *Haemonchus contortus*. However, the Javanese Fat Tail (E) had significantly less *Eurytrema pancreaticum* than any of the other breeds tested (S, H, HC, H1). This should be examined further.

### Background and introduction

Traditionally, small ruminants in Indonesia are housed in raised barns and remain indoors, either continuously or at least every night and part of the day. Animals are fed either entirely by a cut and carry system or are allowed limited periods of grazing.

At Sungei Putih, this traditional system has been modified by SR-CRSP to raise sheep for mutton production in large numbers using forage from rubber plantations. The animals are housed at night in raised barns with slatted floors where breeding, lambing, and supplementary feeding occur. During the day the sheep graze under rubber trees from around 0800 to 1600 hours.

Nutrition and genetics studies are well advanced at Sungei Putih and data on production parameters of at least six breeds of sheep (including crosses of Virgin Island and Barbados Blackbelly) are available.

The main aim of the Animal Health program is to identify and, if possible, control the main disease constraints which hinder the beneficial effects of nutrition and genetic potential in these studies.

The most important results in the first two years of this program are as follows:

•Nematode parasitism is a potentially serious constraint to sheep production under any management system developed at Sungei Putih. The climate is conducive for parasite development with high attack rates year round (see Table 1 in Wilson and Beriajaya 1992).

• The parasites are highly susceptible to Benzimidazol anthelmintics over a period of two years. However, there is now evidence that some Benzimidazol resistance is present in the *Haemonchus* population in the flock (reports from Sungei Putih).

• *Haemonchus* is by far the most pathogenic species all year round. While *Haemonchus* is the most important species, *Trichostrongylus* is also important at specific times of the year (Carmichael et. al 1992).

• Maximum larval survival on pasture is around three months (Carmichael et. al 1992). This result is of great significance and is now the basis of the grazing management system used at Sungei Putih where a three-month rotational grazing system is now standard practice.

• Some monitored sheep showed lower egg counts than others. This led to the initiation of Protocol 5, an in-depth study on the possibility of the development of genetic resistance in individuals in the sheep population at Sungei Putih. It has also stimulated international interest from The Prince Leopold University, Belgium, which will assist in the funding of this Protocol.

• A further helminth problem was identified, namely the trematode *Eurytrema pancreaticm* (pancreatic fluke). Preliminary studies showed that this trematode was common in sheep, from one year of age and older at Sungei Putih (flukes commonly being found at postmortem). Many of the infected sheep of two years and older showed ill thrift (Arasu et. al 1991; Graydon et. al 1992). A drug trial using Nitroxynil, Praziquantel, and Albendazol showed that none of these drugs were effective in the control of the parasite at the dose rates tested (Gatenby et. al 1992).These results were used as a basis for continued work in the Animal Health sector.

## Results

The results will be described according to Protocol number. Some of the results of Protocols 1-7 have already been reported (Carmichael et. al 1992; Wilson and Beriajaya 1992).

*Protocol 4.1. A study to examine the effect of breed on the levels of helminth parasitism in the sheep at Sungei Putih.*

The details of the animals used in this protocol are shown in Table 1. Four groups of animals of the Sumatra Thin-tail (S), East Java Fat-tail (E), St. Croix (H), and St. Croix-Sumatran cross (H1 and HC) breeds were monitored for nematode fecal egg count from August 1992-January 1993. Mean counts by group with standard deviations and standard errors are also shown in this table.

The results showed that:

• Although only one treatment of anthelmintic was monitored, the drug used (Rintal) still remains effective in clearing the gastrointestinal nematodes from sheep used in this experiment. There is thus no evidence of any Benzimidazol resistance in these sheep.

• The rapid uptake of worms as judged by fecal egg count levels after treatment was similar to that described in previous studies. High nematode egg levels were observed 21 days after treatment in some of the animals in groups S, E, and HC.

• The nematode egg levels of the St. Croix (H) group were consistently and significantly lower over time (154 days) than the other groups. This characteristic seemed to be present in some individuals in the St. Croix X Sumatran group indicating some possible heritability.

• The uptake of worms after treatment was very rapid in some animals being back to pathogenic levels within 20 days. Uptake was slower in groups H and E.

• There was great individual variation in nematode egg levels in all the groups in animals with both consistently low levels (e.g., 12001-E, 01065-S, 10368-H, 10385-HC) and high levels (e.g., 12850-E, 7104-S, 00412-HC) throughout the study period.

**Table 1. Means, standard deviations, and standard errors of fecal egg counts from groups of sheep maintained under the standard management system of pasture spelling every three months after anthelmintic treatment. The study commenced on August 3 (day 0) with one anthelmintic treatment (on day 62) over 154 day study period.**

| Breed | Animal # | DAYS AFTER START OF STUDY | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 14 | 28 | 42 | 56 | 62 | 70 | 84 | 98 | 112 | 126 | 140 | 154 |
| S | 00389 | 120 | 240 | 60 | 30 | 90 | ** | 30 | 120 | 210 | 490 | 840 | 17250 | 18570 |
| S | 01065 | 30 | 0 | | 120 | | ** | 0 | 84 | 120 | 390 | 0 | | |
| S | 01129 | 90 | 150 | 60 | 210 | 120 | ** | 0 | 0 | 0 | 120 | 60 | 4980 | 7080 |
| S | 7054 | 120 | 420 | 510 | 1290 | 2490 | ** | 0 | 540 | 1290 | 2610 | 2070 | 420 | 2820 |
| S | 7104 | 570 | 1740 | 0 | 280 | 630 | ** | 0 | 6990 | 7440 | 420 | 160 | 330 | 1260 |
| S | 8901 | 2130 | 3990 | 540 | 1110 | | ** | 0 | 0 | 390 | 1470 | 180 | | 6060 |
| | mean | 510 | 1090 | 234 | 507 | 832 | | 5 | 1289 | 1575 | 917 | 551 | 5745 | 7158 |
| | sd | 745 | 1418 | 238 | 499 | 980 | | 11 | 2556 | 2656 | 867 | 733 | 6903 | 6083 |
| | se | 298 | 567 | 107 | 200 | 490 | | 4 | 1022 | 1062 | 346 | 293 | 3451 | 2727 |
| E | 11098 | 60 | 30 | 0 | 0 | | ** | 0 | 0 | 90 | 240 | 0 | 450 | 240 |
| E | 11100 | 30 | 180 | 210 | 0 | | ** | 30 | 0 | 270 | 240 | 30 | 300 | 1290 |
| E | 12001 | 90 | | 0 | | | ** | | 0 | 120 | 30 | 360 | | 480 |
| E | 12820 | 0 | 0 | 150 | 260 | | ** | 0 | 0 | 0 | 30 | 0 | 90 | 30 |
| E | 12833 | 1050 | 2190 | 1470 | 720 | | ** | 0 | 60 | 120 | 510 | 90 | | 330 |
| E | 12850 | 60 | 8400 | 1950 | | | ** | 0 | 420 | 4440 | 210 | 1170 | 8010 | 3990 |
| | mean | 215 | 600 | 1705 | 586 | | | 6 | 80 | 840 | 210 | 275 | 2212 | 1060 |
| | sd | 374 | 920 | 3037 | 730 | | | 12 | 153 | 1611 | 161 | 419 | 3349 | 1369 |
| | se | 298 | 460 | 1215 | 327 | | | 5 | 61 | 644 | 64 | 168 | 1674 | 548 |
| H | 10198 | 0 | 0 | 0 | 0 | 60 | ** | 0 | 0 | 0 | 60 | 150 | 0 | 690 |
| H | 10274 | 90 | 30 | 150 | 120 | 1140 | ** | 0 | 30 | 90 | 270 | 180 | 270 | 270 |
| H | 10368 | 30 | 30 | 0 | 60 | | ** | 0 | 0 | 0 | 0 | 30 | | 180 |
| H | 9246 | 0 | 30 | 0 | 0 | 60 | ** | 0 | 0 | 270 | 420 | 0 | 660 | 780 |
| H3 | 00177 | 0 | 0 | 0 | 0 | 0 | ** | 0 | 420 | 180 | 0 | 60 | | |
| H3 | 00325 | 0 | 0 | 0 | 120 | | ** | 0 | 0 | 0 | 450 | 120 | | 3690 |
| | mean | 20 | 15 | 25 | 50 | 210 | | 0 | 75 | 90 | 205 | 90 | 310 | 1122 |
| | sd | 33 | 15 | 55 | 54 | 416 | | 0 | 154 | 104 | 186 | 65 | 270 | 1262 |
| | se | 16 | 7 | 27 | 27 | 208 | | 0 | 77 | 52 | 93 | 32 | 135 | 631 |
| HC | 00412 | 270 | 30 | 60 | 480 | 540 | ** | 0 | 6720 | 8760 | 1320 | 1470 | 2280 | 960 |
| HC | 00463 | 90 | 3990 | 750 | 1500 | 2580 | ** | 0 | 60 | 270 | 420 | 150 | 840 | 2430 |
| HC | 10222 | 180 | 660 | 4560 | 630 | 570 | ** | 30 | 0 | 30 | 90 | 900 | 330 | 180 |
| HC | 10385 | 120 | 0 | 0 | 30 | | ** | 0 | 0 | 90 | 0 | 30 | 240 | 570 |
| H1 | 6025 | 1650 | 3570 | 570 | 180 | 660 | ** | 0 | 0 | 0 | 120 | 0 | 60 | 120 |
| H1 | 7072 | 60 | 840 | 210 | 630 | 330 | ** | 0 | 60 | 1410 | 210 | 120 | 690 | 420 |
| | mean | 395 | 1515 | 1025 | 575 | 936 | | 5 | 1140 | 1760 | 360 | 445 | 740 | 780 |
| | sd | 565 | 1635 | 1604 | 470 | 833 | | 11 | 2495 | 3168 | 448 | 550 | 738 | 788 |
| | se | 282 | 817 | 802 | 235 | 417 | | 5 | 1247 | 1584 | 224 | 275 | 369 | 394 |

**Treatment with anthelmintic.

*Protocol 5.1. Monitoring for possible traits of helminth resistance in lambs maintained under a defined management system at Sungei Putih.*
A preliminary report on this protocol has been given by Gatenby et al. (1991).

All lambs of the SR-CRSP flock are being monitored (at 3, 9, and 12 months of age) prior to any herd anthelmintic treatment. The following have been recorded:
•breed and birth date of the animals monitored;
•fecal nematode egg counts at the above age groups;
•and growth rates.

All data will be handled through the data base a Sungei Putih. At present the data has only been entered. Detailed analysis will be undertaken in the future. It is hoped that this data will be used for a postgraduate degree by Endang Romjali.

*Protocol 6.1. To monitor for disease through gross pathology and histopathology of all sheep which are postmortemed at Sungei Putih.*
(i) Histopathology:
Lesions consistent with established causes of death were confirmed in 11 cases considered to be: acute *Pasteurella* pneumonia (1), acute parasitic gastroenteritis (2), nutritional disorder associated with Ca/P imbalance (3), and pancreatic fluke (5).
(ii) Lamb mortality:
The lamb mortality rates for 1992 cannot be calculated until March 1993 and will be reported in the final report. Comparisons with lamb mortality rates for 1990 and 1991 will also be reported.

*Protocol 7.1. Further studies on the chemotherapy of pancreatic fluke in sheep.*
The results from section (iii) of Protocol 7 have been reported in detail by Gatenby et al. (1992). These results showed none of the three drugs tested for efficacy against *Eurytrema pancreaticum* (Nitroxynil, Praziquantel, and Albendazol) were of value in the economical control of this parasite at the dose rates used. No further work has been conducted on this Protocol during the reporting period. The following is planned:
i) Further flukicides will be procured, namely Chlorsulon, Rafoxanide, and Fasinex. Some of these have to be purchased from outside Indonesia.
ii) The development of simpler and cheaper experimental techniques to test efficacy of drugs against the pancreatic fluke.

*Protocol 8. To examine the effect of sheep breed on levels of gastrointestinal nematodes and pancreatic trematodes in sheep at Sungei Putih.*
Four breeds of four-month-old sheep were grazed for a month with the main herd and then maintained indoors for a further month to allow maturation of any worms taken up. The animals were then killed and total gastrointestinal and pancreatic worm counts were conducted.

The results summarized in Table 2 indicate that:
(a) There were no differences in the mean abomasal *Haemonchus* counts between groups.
(b) There were also no differences in the growth rates between and within groups over the periods 0-56, 0-14, 14-56, and 28-56 days. These growth rates were low and showed no obvious worm effect.
(c) No pancreatic fluke were detected in the Fat Tails (E) though levels of pancreatic fluke were similar in the other groups. It is of interest that the pancreatic fluke is common in six-month-old animals.
This experiment will be repeated twice more. It is hoped that any breed differences may be detected in these subsequent studies.

**Table 2. Summary of results obtained from the 16 sheep of Experiment 1, Protocol 8, (a) at slaughter (total worm counts and fecal egg counts) and (b) during the two-month experiment (growth rates).**

(a) Results obtained at slaughter.

| Sheep No Breed (date of birth) | Pancreas wt(gm) | No flukes | Abomasum Haem | Abomasum Trich | Small Int Trich | Small Int Coop | Lar Int Oesop | FEC Nem | FEC Trem |
|---|---|---|---|---|---|---|---|---|---|
| S | | | | | | | | | |
| 22199(21/3/92) | 15.26 | 0 | 1060 | 25 | 195 | 250 | 0 | 17400 | 0 |
| 20213(19/3/92) | 17.35 | 0 | 1455 | 5 | 75 | 315 | 0 | 15960 | 0 |
| 20200(18/3/92) | 27.95 | 71 | 760 | 0 | 50 | 95 | 0 | 6480 | 0 |
| 20157(15/3/92) | 30.25 | 136 | 570 | 0 | 30 | 35 | 0 | 6600 | 0 |
| mean | 22.7 | 52 | 961 | 7.5 | | | 0 | 11610 | 0 |
| std | | 57 | 334 | | | | | 5095 | |
| se | | 28 | 167 | | | | | 2547 | |
| E1 | | | | | | | | | |
| 22072(14/3/92) | 26.16 | 0 | 840 | 0 | 60 | 85 | 1 | 3180 | 0 |
| 22173(27/3/92) | 22.27 | 0 | 885 | 0 | 35 | 180 | | 12060 | 0 |
| 22064(13/3/92) | 26.62 | 0 | 975 | 80 | 90 | 5 | 0 | 8040 | 0 |
| 20122(11/3/92) | 24.46 | 0 | 790 | 0 | 25 | 255 | 0 | 11520 | 0 |
| mean | 24.90 | 0 | 872 | 20 | | | | 8700 | 0 |
| std | | 0 | 68 | | | | | 3540 | |
| se | | 0 | 34 | | | | | 1770 | |
| H1 | | | | | | | | | |
| 22129(24/3/92) | 22.88 | 0 | 515 | 15 | 30 | 75 | 0 | 7140 | 0 |
| 20180(16/3/92) | nd | 20 | 1070 | 0 | 75 | 110 | 0 | 7080 | 0 |
| 20239(20/3/92) | 25.93 | 60 | 585 | 0 | 15 | 95 | 1 | 6460 | 0 |
| 22141(25/3/92) | 22.07 | 0 | 1070 | 5 | 135 | 375 | 7 | 12300 | 0 |
| mean | 23.60 | 20 | 810 | 5 | | | 2 | 8245 | 0 |
| std | | 25 | 261 | | | | | 2356 | |
| se | | 12 | 130 | | | | | 1178 | |
| B1 | | | | | | | | | |
| 20130(11/3/92) | nd | 27 | 1080 | 0 | 70 | 190 | 1 | 3300 | 0 |
| 20095(9/3/92) | nd | 121 | 1260 | 0 | 65 | 35 | 0 | 7440 | 0 |
| 22022(8/3/92) | nd | 21 | 150 | 0 | 35 | 50 | 0 | 2760 | 0 |
| 20066(7/3/92) | 21.20 | 101 | 395 | 0 | 60 | 220 | 0 | 5400 | 0 |
| mean | | 68 | 721 | 0 | | | .25 | 4725 | 0 |
| std | | 44 | 461 | | | | | 1852 | |
| se | | 22 | 230 | | | | | 926 | |

(b)Body Weights (kg) of the animals over the period.

| Breed | | D | A | T | E | S | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. | 4/8 | 18/8 | 1/9 | 15/9 | 28/9 | mean | growth | rates | (gm/day) |
| | days | 0 | 14 | 28 | 42 | 56 | 0-56 | 0-14 | 14-56 | 28-56 |
| S | | | | | | | | | | |
| 22199 | | 9.4 | 10.0 | 12.0 | 12.8 | 14.0 | 88 | 107 | 80 | 86 |
| 20213 | | 9.2 | 9.8 | 11.2 | 12.0 | 14.1 | 100 | 114 | 94 | 128 |
| 20200 | | 15.0 | 15.9 | 17.9 | 18.8 | 20.4 | 110 | 157 | 120 | 95 |
| 20157 | | 14.5 | 15.5 | 16.9 | 18.6 | 21.7 | 147 | 136 | 149 | 186 |
| mean | | | | | | | 111 | 129 | 111 | 124 |
| std | | | | | | | 22 | 19 | 26 | 39 |
| se | | | | | | | 11 | 9 | 13 | 19 |
| E1 | | | | | | | | | | |
| 22072 | | 14.3 | 14.5 | 17.8 | 18.2 | 20.8 | 116 | 143 | 129 | 129 |
| 22173 | | 10.0 | 10.7 | 12.4 | 13.4 | 15.3 | 104 | 86 | 110 | 104 |
| 22064 | | 9.0 | 9.2 | 10.0 | 11.4 | 13.1 | 84 | 57 | 93 | 110 |
| 20122 | | 15.7 | 16.6 | 18.4 | 19.8 | 22.0 | 132 | 143 | 129 | 129 |
| mean | | | | | | | 109 | 107 | 115 | 118 |
| std | | | | | | | 17 | 37 | 15 | 11 |
| se | | | | | | | 8 | 18 | 7 | 5 |
| H1 | | | | | | | | | | |
| 22129 | | 8.4 | 9.0 | 11.0 | 11.8 | 14.0 | 114 | 143 | 103 | 124 |
| 20180 | | 15.0 | 15.3 | 17.6 | 19.5 | 22.4 | 151 | 157 | 143 | 181 |
| 20239 | | 16.4 | 17.0 | 19.0 | 20.8 | 23.3 | 141 | 143 | 140 | 157 |
| 22141 | | 10.6 | 11.2 | 13.6 | 14.1 | 16.3 | 116 | 129 | 111 | 110 |
| mean | | | | | | | 131 | 143 | 124 | 143 |
| std | | | | | | | 16 | 10 | 17 | 28 |
| se | | | | | | | 8 | 5 | 8 | 14 |
| B1 | | | | | | | | | | |
| 20066 | | 10.0 | 10.5 | 12.9 | 14.4 | 16.1 | 124 | 136 | 120 | 114 |
| 20130 | | 16.0 | 16.7 | 19.6 | 21.2 | 23.9 | 161 | 164 | 160 | 186 |
| 20095 | | 15.0 | 15.8 | 17.6 | 18.2 | 20.1 | 104 | 114 | 100 | 86 |
| 22022 | | 9.2 | 9.4 | 11.0 | 12.4 | 14.9 | 118 | 129 | 140 | 110 |
| mean | | | | | | | 127 | 136 | 130 | 124 |
| std | | | | | | | 21 | 18 | 22 | 37 |
| se | | | | | | | 10 | 9 | 11 | 18 |

## Conclusions

i) The research program is proceeding well but the main constraints continue to be funding, as inadequate professional time inputs were included in the budget.
ii) The attack rates of *Haemonchus* continue at the high levels measured during the previous two years.
iii) Pasture spelling every three months after anthelmintic treatment is now standard management practice. The availability of suitable pasture is, however, a constraint to this approach.
iv) Some breed effects on parasite levels are becoming manifest; however, more studies must be conducted before definite statements can be made.
v) Pancreatic fluke continues to be a major threat to the development of economic production systems. Deaths in animals over two years old are common, and, as shown in Protocol 8, the parasite is common in six-month-old animals.
vi) While there is no definite evidence for Benzimidazol resistance in the animals of Protocol 4, a chemical switch has been recommended to Ivermectin. This is a safety procedure and should eliminate any Benzimidazol resistant strains in the pasture within a six month period.

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Special thanks are due to Dr. Ruth Gatenby and the staff at Sungei Putih for their help and enthusiasm.

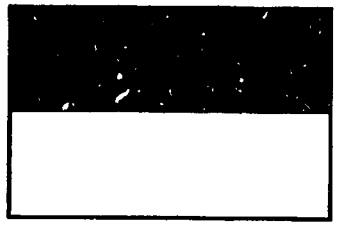
# Prolific Sheep

"Research on prolificacy in sheep (number of lambs born per female per unit of time) has anticipated further commercialization and intensification of small ruminant production in many areas. Such intensification will enable many small farmers to derive a major part of their income by specializing in livestock. . . Work will continue for 3 years in both Morocco and Indonesia with emphasis in both countries on development, testing, and release of technological packages for farmer flocks with increased prolificacy. While work in Morocco will focus on development of a new breed based on crossing with the D'Man and Sardi breed, activities in Indonesia will concentrate on selection criteria for prolificacy among existing breeds, progeny testing of rams, and release of performance data on animals of known prolificacy genotype under farm conditions.. . . Because more prolific sheep will increase the pressure on feed supplies and overall management systems, the collaborative research will include attention to nutritional and socioeconomic factors."

*p. 36-7, Extension Proposal, 1990-1995*

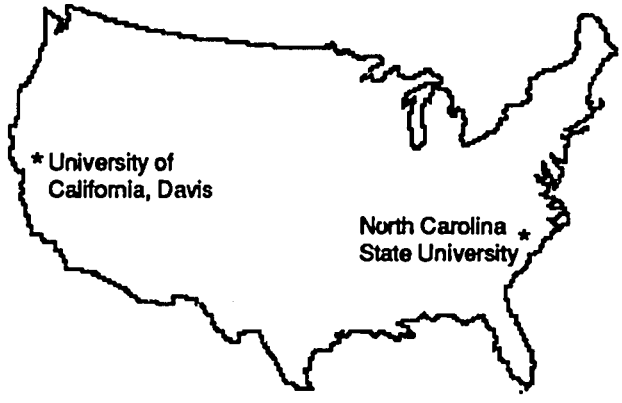
# Republic of Indonesia

**Indonesian Flag**



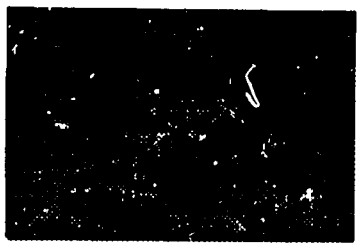
**Total area:** 1,919,440 square km (741,096 square miles)
**Geography:** Indonesia comprises some 17,000 islands.
**Capital:** Jakarta.
**Population(1991):** 193,000,000
**Languages:** Bahasa Indonesia, Javanese, other Austronesian languages.
**Labor force:** 56% agriculture, 23% industry, 16% services.
**% Females in labor force:** 31.2%
**Industries:** Food processing, textiles, light industry.
**Chief crops:** Rice, coffee, sugar.
**Land in Agriculture:** 17.3%
**Agriculture of GNP:** 26%
**Sheep population:** 5,415,000
**Goat population:** 12,700,000
**Uses of sheeps and goats:** Meat.
**Inflation rate:** 5.5% (1989)
**Monetary unit:** Rupiah.

**United States Sites**



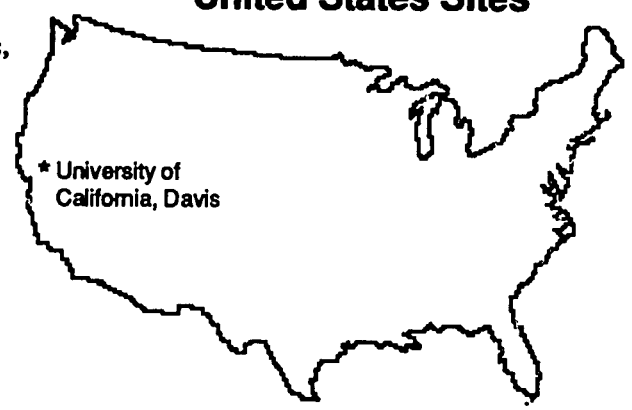

# Kingdom of Morocco

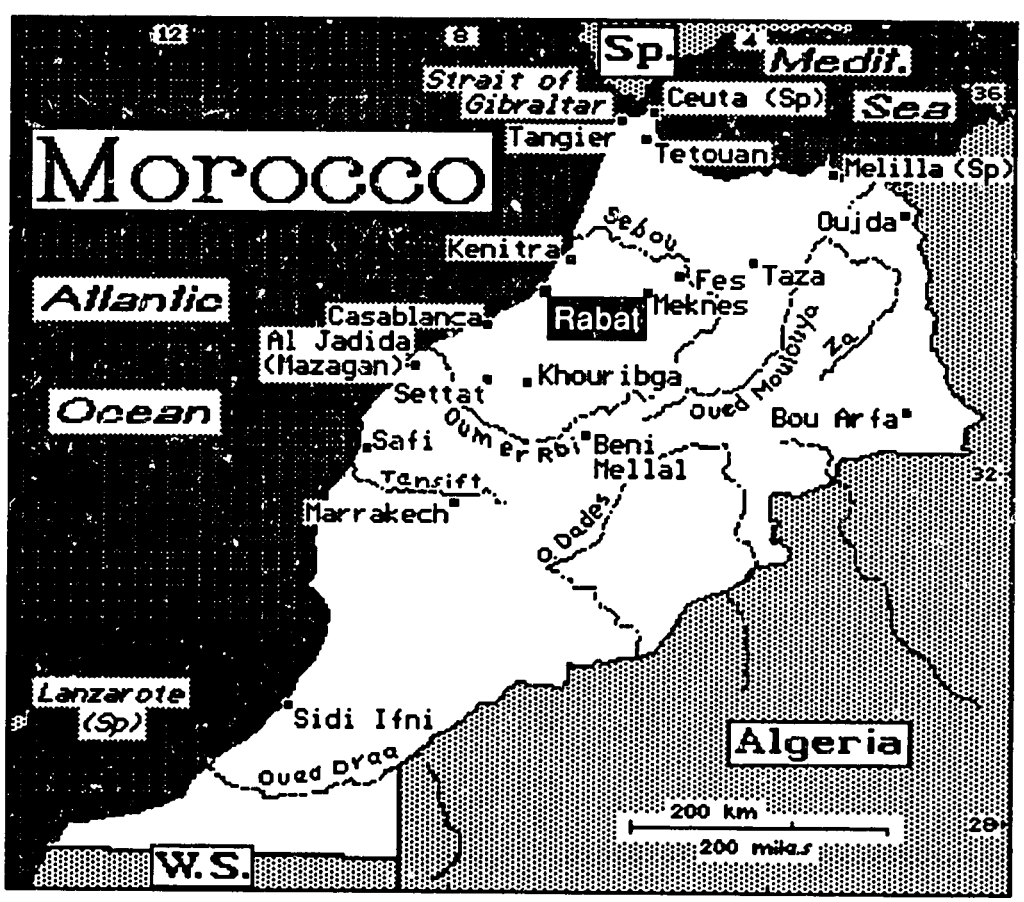
**Moroccan Flag**



**Total area:** 446,550 square km (172,413 square miles)
**Topography:** Mountain ranges, rich plains, alluvial plains, plateaus, and pre-Sahara arid zone.
**Capital:** Rabat.
**Population(1991):** 26,181,000
**Languages:** Arabic, Berber.
**Labor force:** 50% agriculture, 15% industry, 26% services.
**% Females in labor force:** 20.3%
**Industries:** Carpets, clothing, leather goods, mining, tourism.
**Chief crops:** Grain, fruits, dates, grapes.
**Land in Agriculture:** 65.8%
**Agriculture of GNP:** 19%
**Sheep population:** 15,700,000
**Goat population:** 5,800,000
**Uses of sheeps and goats:** Meat and milk.
**Inflation rate:** 8.3% (1988)
**Monetary unit:** Dirham.

**United States Sites**



# *Genetic Improvement of Sheep and Goats*
University of California, Davis

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## Narrative Summary

Since locating the $F^J$ gene the prolific sheep component has been studying the gene's affect on litter size. At present, the $F^J$ gene can only be classified in females; molecular biology and physiology methods are being used to extend the classification to males. In Morocco, the prolific sheep component was phased-down and put into linkage status.

## Research

### *Indonesia*

#### Problem statement and approach

The existence of a major gene affecting litter size in Indonesian sheep population has been confirmed by research in previous years. This major gene, denoted as the $F^J$ gene, is currently segregating in sheep flocks in Indonesia, with each copy contributing approximately .8 additional lambs. Due to varying levels of feeding and management conditions in Indonesia, a high proportion of these additional lambs die before reaching weaning age. To understand more completely the effects of this gene on litter size, the plan is to develop lines homozygous for this gene ($F^JF^J$) and its normal allele (++), increase numbers in each group, and compare performance under farm conditions. This will also allow controlled dissemination of the $F^J$ gene to farmers. We plan to develop feeding and management systems, in collaboration with the Nutrition project, to improve lamb survival and growth under farmers' conditions and to optimize the utilization of the prolificacy gene by farmers with varying levels of feeding and management conditions. At present, classification of animals for the $F^J$ gene is possible only for females, based on ovulation rate and litter size records. Rams in the flock are classified based on their daughters, if available, and pedigree records. To increase accuracy in genotype determination and to decrease the time taken for genotype classification, we are exploring ways to classify animals of either sex using molecular biology and physiology methods. The plan is to search for DNA differences among animals of different genotypes. A study of various hormone levels in lambs and adult ewes is also planned as a way to identify different genotypes. Success in proper identification will not only save time and money but also enable a controlled dissemination of the $F^J$ gene to farmers. One of the priorities for this project is the identification of private enterprises willing to keep flocks of $F^JF^J$ or ++ animals.

### *Morocco*

#### Problem statement and approach

Previous research on the native D'Man (D) breed has shown that the high prolificacy of this breed is inherited in a quantitative manner. During earlier phases of this project, D and Sardi (S) breeds and their $F_1$, $F_2$ and backcrosses were evaluated. Results indicate that litter size increases linearly as percent D'Man inheritance

increases from 0 to 100. Considering this information and the needs of farmers, a DS "composite" population was created, that could be used in various mating schemes depending on the level of prolificacy desired. Matings to obtain the DS stock were initiated in 1989, and selection criteria for the long-term improvement of the breed were defined. It is planned to continue on-farm testing of this breed in comparison to the local breeds, to support the establishment of a multiplication center by a Moroccan agency or enterprise to expand the DS population and enhance selection, and to compare nutritional requirements to DS and S ewes (in collaboration with the Nutrition project). Funding for the animal physiology studies was continued to identify any potential adaptability problems associated with the DS stock.

## Progress

### *Indonesia*

Matings to increase numbers of $F^JF^J$ and ++ groups have been continued based on available genotype classification data. Based on the data collected to date on this project, average litter size of ewes from each group is shown below. Although there is within-group variation due to ewe age and nutrition, differences in average prolificacy among these groups are large. Given these averages, $F^J+$ and $F^JF^J$ ewes may be desirable or undesirable depending on the level of feeding and management. Presently, all three genotype groups are managed as a single flock while the search continues for private enterprises or government agencies interested in maintaining $F^JF^J$ or ++ flocks. Some interest has been expressed, but nothing has yet been finalized. Ewe performance recorded during 1991-92 is summarized in Table 1.

| | Genotype | | | | | |
|---|---|---|---|---|---|---|
| | ++ | | $F^J+$ | | $F^JF^J$ | |
| | Mean | Range | Mean | Range | Mean | Range |
| Young ewes | 1.2 | 1-2 | 1.9 | 1-3 | 2.4 | 1-4 |
| Adult ewes | 1.3 | 1-2 | 2.1 | 1-3 | 2.8 | 1-5 |

**Table 1. Performance of ewes by genotype group during 1991-92.**

| Genotype | n | TB[1] | TBW[2] | TWW[3] | Lamb Survival(%) |
|---|---|---|---|---|---|
| ++ | 83 | 1.26 | 3.19 | 14.1 | 90.5 |
| $F^J+$ | 70 | 2.05 | 3.96 | 17.5 | 85.1 |
| $F^JF^J$ | 50 | 2.32 | 3.99 | 18.6 | 80.6 |

[1] TB = Number of lambs born per ewe
[2] TBW = Total litter birth weight per ewe (kg)
[3] TWW = Total litter weaning weight per ewe (kg)

The number of lambs born per ewe (2.32) in the $F^JF^J$ groups is lower than usually observed for this genotype. However, incomplete lambing data for the next lambing (January 1993) gave a value (2.76) very similar to that reported earlier. The most striking aspect of the current data is that ewes classified as ++ and $F^J+$ on the basis of previous records had litter sizes of only one and two and of only two and three, respectively, confirming the remarkably high repeatability of performance of these genotypes. Birth and weaning weights of lambs born during 1991-92 are given in Table 2 by litter size.

**Table 2. Lamb weights by litter size during 1991-92 (kg).**

| Litter size | Birth weight | Weaning wt. |
|---|---|---|
| 1 | 2.8 | 11.6 |
| 2 | 2.4 | 9.3 |
| 3 | 1.8 | 8.8 |
| 4 | 1.6 | 5.7 |

The much lower weaning weight of lambs born in large litters, combined with their higher mortality as reported previously, raises questions about total productivity of the different prolificacy genotypes. The answer is that the more prolific genotypes ($F^J+$ and $F^JF^J$) are much more productive under good feeding and management, but not so under less favorable conditions (Inounu et al., Small Ruminant Research, submitted). The more critical question is whether the extra inputs required to realize the higher productivity potential of ewes carrying the $F^J$ gene are economically justified. This question is currently under investigation in Inounu's Ph.D. studies at IPB, Bogor.

Regardless of the answer to the last question, above, utilization of the information on mode of inheritance of prolificacy in these sheep will increase the efficiency of sheep production in Indonesia. If genetically higher prolificacy is economically advantageous in defined environments, flocks carrying the gene can be produced for these environments; a systematic plan has been outlined to produce heterozygous ewes for such flocks. For environments where the gene is economically or biologically deleterious, utilization of ++ breeding stock is clearly indicated. However, it appears that general utilization of the information on mode of inheritance may not occur until an accurate method of identifying genotype for the $F^J$ gene, applicable early in life to animals of both sexes, is available.

For the study of DNA polymorphic differences, 100 more DNA samples were collected from the Bogor flock in addition to 137 samples collected last year. These additional samples were collected to extend the existing pedigrees. Some assay conditions have already been developed and tested using the DNA samples from the Bogor flock. More laboratory assays are underway using RAPD (Randomly Amplified Polymorphic DNA) markers in the laboratory of Dr. Juan Medrano at UC Davis. Blood samples collected last year from animals with presumed genotypes of $F^JF^J$, $F^J+$ and ++ to study FSH, LH, and testosterone hormone profiles have been assayed at the laboratory of Dr. Victor Goh at the National University of Singapore. Final results from this project are expected to be available next year.

### *Morocco*

On-farm testing of the DS composite breed was continued during this last year of the SR-CRSP breeding research in Morocco. Nutrition trials to compare nutritional requirements of DS and S breeds also continued in collaboration with the Nutrition project. Linkage funds to be used for completion of specific phases of the work at Tadla during 1992-93 period were well-received by the host institution. Meetings were held with the host country scientists during the principal investigator's visit to discuss future plans for the SR-CRSP flock following the termination of active SR-CRSP involvement in Morocco.

## Training

Ismeth Inounu is enrolled in the Ph.D. program in animal breeding at IPB, Bogor. Funds will be needed for another 2 years for Mr. Inounu.

Bess Tiesnamurti attended a short course on DNA technology in Australia. Her expenses were paid using non-CRSP money.

Lahsen Derqaoui of IAV, Rabat, has completed his doctoral dissertation at IAV using SR-CRSP data. He is conducting an additional project, involving response of ovariectomized D and S ewe lambs to exogenous estrogen, for inclusion in a Ph.D. dissertation to be submitted to University of California, Davis.

## Contributions

The SR-CRSP research in Bogor has made significant contributions to our understanding of the underlying genetic mechanism of prolificacy in sheep. The major gene for prolificacy detected in the Bogor flock has received recognition and much interest from the scientific community around the globe. The program developed for the control and utilization of the prolificacy gene is expected to make significant contributions to the economics of small-holder farms through distribution of animals of appropriate genotype to farmers, based on their level of management.

The SR-CRSP project continued its support for the training of graduate students from the U.S. and Indonesia. This was especially beneficial to the host institution in Bogor as the SR-CRSP responsibilities for this site was transferred from an expatriate scientist to an Indonesian counterpart.

## Collaborating Personnel

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# *Feed Resources and Nutrition of Small Ruminants in Morocco*

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## Narrative Summary

Sheep in Morocco are integrated into the total farming system. In the dryland cereal-producing areas, sheep graze the crop residue from the grain and straw harvest. Straw is stored, and the sheep are fed with agro-industrial by-products during periods of feed scarcity that generally correspond to the end of gestation and the beginning of lactation of the ewes.

A cereal stubble grazing trial using Sardi and first and second generation D'man x Sardi ewes was completed. Ninety-six ewes were placed on two treatments (16 ewes/hectare) and were either supplemented with energy and protein after eight weeks of stubble grazing or not supplemented. Mating started after two weeks of stubble grazing and lasted eight weeks. Ewes grazed the stubble for 16 weeks and then were pen-fed a similar diet through lambing and lactation. Residual grain available at the beginning of the stubble grazing period was low compared to previous years. On the other hand, stubble biomass was very high. Approximately half of the initial biomass had disappeared after 12 weeks of grazing. Concentrate supplementation did not affect ewe reproductive performance. On the other hand, the supplemented ewe group gained more weight during gestation and the daily gain of lambs from that group was higher. Supplementation with energy and protein during stubble grazing improved ewe body condition and lamb performance.

Cereal straw has many nutritional limitations and must be supplemented with both energy and protein to meet nutritional requirements. Fifteen Timahdit lambs were fed diets containing 63% wheat straw, barley, molasses, and various proportions of urea or sunflower meal to achieve two levels of protein (eight or ten percent). Increasing protein levels decreased dry matter and fiber digestibility whereas intake was not affected. Substituting dietary sunflower meal with urea increased crude protein digestibility but decreased straw and total intake.

The development of the synthetic D'man x Sardi breed requires knowledge of the nutritional requirements of these animals, particularly in terms of protein. Determining the minimum dietary protein level required by lambs will reduce feed costs and increase the economic return of growing and fattening operations. Thirty-two D'man x Sardi lambs were fed diets consisting of alfalfa hay, oat-vetch hay, citrus pulp, and sugar beet pulp. In addition, various proportions of wheat bran and sunflower meal were used to achieve four dietary protein levels (10 to 16%). Dry matter intake and digestibility, daily gain, feed efficiency, and dressing percentage were not affected by protein level. Native Moroccan breeds of sheep may have lower protein requirements and a better ability to utilize diets containing moderate levels of protein than breeds from temperate regions.

Information on developing a complete feeding system, utilizing cereal by-products and grazed stubble along with agro-industrial by-products or urea for ewes and growing lambs, is becoming more complete.

## Research

Sheep in Morocco are fully integrated into the total farming system, especially in the dryland cereal production areas. Farmers depend on their sheep for cash income. Thus it is important to sheep producers to maintain good productivity (growth and reproduction) for their flocks. Feed resources, however, may be a serious limiting factor. In order to make maximum use of cereal by-products (stubble and straw) while maintaining good production from the sheep, more information is needed on how to effectively use other locally available by-products (such as sugar beet and citrus pulps, carob meal, almond hulls, and waste palm dates). Determining the right amount to supplement at critical times during the animal production cycle is critical to optimize economic efficiency. In addition, the highly prolific D'man (D) and the crossbred D'man x Sardi (DxS) breeds of sheep require a higher plane of nutrition than less productive sheep. Therefore, adequate nutrition of these animals is essential, especially if they are to be integrated into the traditional sheep production systems.

### Objectives

To characterize the nutritional value of locally available feedstuffs for small ruminants.

To develop guidelines for formulation of nutritionally and economically optimum diets, especially at critical stages of the production cycle.

To develop strategies for more efficient use of the feed resources available within intensive small farming systems.

### *Stubble grazing trials.*

#### Problem statement and approach

After grain harvest and until the onset of the rainy season, cereal stubble (the material remaining after harvest) represent the main feed available for sheep raised in a mixed crop-livestock system in Morocco. Previous work has attempted to characterize stubble utilization in terms of collected diet nutritive value, level of intake, and animal performance. Different strategies for energy and/or protein supplementation in relation to body weight performance have been tested. However, since the mating period and early gestation usually take place during the first part of the stubble grazing period, more attention is now given to reproductive performance and its relationship to supplementation programs.

#### Progress

The effect of protein and energy supplementation of ewes grazing soft wheat stubble on their body weight and reproductive performance was evaluated in a trial using 48 Sardi, 12 F1 (DxS) and 36 F2 (DxS) mature ewes randomly assigned to two treatments, with three replicates per treatment. Stocking rate was set at 16 ewe/ha. Mating started after two weeks of stubble grazing and lasted eight weeks. Rams of the same breeding as the ewes were used. During the 16-week trial, ewes in treatment A were supplemented with minerals and vitamins only. Ewes in treatment B received daily, in addition to minerals and vitamins, 200 g sunflower meal from week 5 to 8 and 200 g of sunflower meal plus 200 g barley from week 9 to 16 of grazing. At the end of the stubble grazing period, all ewes were pen-fed the same diet based on alfalfa hay, wheat straw, barley, and sunflower meal. Diets were formulated to meet energy and protein requirements of ewes at the end of gestation and during lactation.

Biomass measurements indicated that amount of residual grain available at the beginning of the stubble grazing period was low compared to previous years (table 1). On the

other hand, stubble biomass was very high. Approximately half of the initial biomass had disappeared after 12 weeks of grazing. Preliminary results suggest that concentrate supplementation during stubble grazing did not affect ewe reproductive performance such as ovulation rate, fertility, and prolificacy (table 2). On the other hand, energy and protein supplementation had a significant impact on ewe live weight changes during the stubble grazing phase. Consequently, average live weight at lambing was greater for ewes on treatment C ($P < .01$). Lamb birth weight was similar for both treatments. However, average daily gain to 30 days was higher ($P < .05$) for lambs on treatment C. Although these results are preliminary, they suggest that energy and protein supplementation during the stubble grazing period has a positive affect on ewe performance at lambing and lamb daily gain in early life.

**Table 1. Biomass of wheat stubble, weeds and wheat grain.**

| Sampling date | Sampling week | Stubble (Kg DM/ha) | Weeds (Kg DM/ha) | Residual grain (Kg/ha) |
|---|---|---|---|---|
| 7/20/91 | 0 | 6,963 | 183 | 24.4 |
| 8/17/91 | 4 | 5,106 | 253 | 11.2 |
| 9/14/91 | 8 | 4,241 | 236 | 0 |
| 10/12/91 | 12 | 3,396 | 36 | 0 |

**Table 2. Reproductive performance, ewe live weight changes and lamb average daily gain.**

| Item | Treatment A | Treatment C |
|---|---|---|
| Reproductive performance[1], (%) | | |
| Ovulation rate | 169 | 166 |
| Fertility | 100 | 97.5 |
| Prolificacy | 137 | 140 |
| Ewe weight changes | | |
| 16-0 weeks, kg | -2.5 | 5.0 |
| weight at lambing, kg | 40.1 | 44.1 |
| Lamb birth weight, kg | 3.41 | 3.37 |
| Lamb daily gain to 30 days, g/day | 94 | 116 |

[1]Fertility, number of ewes pregnant per number of ewes mated; prolificacy, number of lambs born per number of ewe lambed.

## Stubble utilization.

### Problem statement and approach

During the past years, all data collected on stubble composition and production originated from the Tadla experimental station. An attempt was made to estimate these parameters in private farms. Comparison of these two sets of information is essential to adapt the recommendations that came out of the stubble utilization trials conducted at the Tadla station to actual field conditions.

### Progress

This study is part of the 1991-1992 workplan but was initiated early due to student interest and availability. During the months of May and June 1991 a survey was conducted in Dar Ouled Zidouh, district of Tadla, to evaluate cereal stubble biomass in rainfed and irrigated areas. Sixty farms were selected, representing different farm sizes existing in the district: 41 were in the dry area whereas 19 were in the irrigated perimeter. Results from the study were presented in the 1990-91 annual report.

## Protein requirements for growth and fattening of lambs.

### Problem statement and approach

The development of the synthetic D'man x Sardi breed requires knowledge of the nutritional requirements of these animals, particularly in terms of protein. In Morocco, conventional protein sources are costly and in short supply. Therefore, determining the minimum dietary protein level required by lambs will reduce feed costs and increase the economic return of growing and fattening operations.

### Progress

The response of D'man x Sardi lambs to several dietary protein levels was evaluated in terms of nitrogen utilization and growth performance. Thirty-two lambs (initial weight 20 kg and 4 months of age), divided into four balanced groups of eight animals, were used in a 105-day feeding trial. Each group was randomly assigned to four diets having crude protein levels of 10 (A), 12 (B), 14 (C), and 16% (D). Diets contained dry matter. 13% alfalfa hay, 12% oat-vetch hay, 20% citrus pulp, 25% sugar beet pulp, 2% mineral-vitamin mix, and various proportions of wheat bran and sunflower meal to achieve the four dietary crude protein levels. Lambs were individually fed, and intake was monitored daily. Lambs were weighed on three consecutive days at the initiation and completion of the trial and on two consecutive days at three-week intervals during the course of the trial. At the start of the ninth week of the trial, four lambs were randomly selected from each treatment group to measure diet digestibility and nitrogen balance by total collection of urine and feces during a seven-day period. All lambs were slaughtered at the end of the trial, and carcass data were collected.

Dry matter and energy digestibility averaged 68.5 and 69.7%, respectively, and were not affected by treatment ($P > .10$), whereas acid detergent fiber digestibility decreased ($P < .04$) and crude protein digestibility increased linearly ($P < .001$) with increasing dietary crude protein level. Values were 61.7, 59.6, 56.9, and 55.1% for acid detergent fiber and 61.3, 67.3, 72.5, and 75.6% for crude protein. Nitrogen intake was 14.9, 18.9, 22.1, and 25.6 g/d for diets A, B, C, and D, respectively. Fecal nitrogen excretion (5.9 to 6.3 g/day) and nitrogen retention (4.8 to 6.6 g/day) were unaffected by treatment ($P > .10$). Urinary nitrogen increased linearly ($P < .001$) from 3.8 to 14.0 g/day, and nitrogen retained as a percentage of nitrogen intake decreased ($P < .03$) from 34.9 to 20.7% with increasing crude protein level in the diet. There was no treatment effect ($P > .10$) on feed intake (92.3 to 98.4 g DM/kg.75/day), daily gain (202 to 228 g/day), feed efficiency (6.4 to 7.3 kg DM/kg gain), or dressing percentage (48.8 to 50.0%). It was concluded that D'man x Sardi lambs do not respond to increasing levels of

crude protein similar to dietary levels recommended for western breeds of sheep. Native Moroccan breeds of sheep may have lower nitrogen requirements and a better ability to utilize diets containing moderate nitrogen content.

### *Supplementation of wheat straw diets.*

#### Problem statement and approach

Wheat straw is an important crop residue in the cereal producing regions of Morocco that is harvested and stored until it is fed to ewes during late gestation and lactation. However, cereal straw has many nutritional limitations and must be supplemented with both energy and nitrogen to prevent abortion, ensure normal fetus development, lamb birth weight, and adequate milk production by the ewe to insure rapid lamb growth. Improving cereal straw-based diets by supplementation with energy and nitrogen sources from locally available sources is important to improve the biological and economic viability of Moroccan sheep production.

#### Progress

The effects of nitrogen level (8 and 10% N) and source (sunflower meal and urea) on intake and digestibility of wheat straw-based diets were evaluated with 15 lambs in a two-period digestion trial. Each period consisted of 22 days, divided into the first 17 days for adjustment to diets and measurement of intake and the last 5 days for total fecal collection. Four diets, arranged in a 2 x 2 factorial arrangement of treatments and a control, were formulated to contain 63% straw and 37% supplement. The supplements of the four experimental diets contained varying amounts of sunflower meal, urea, barley, and molasses. The control diet contained only barley and molasses as supplement.

Increasing nitrogen level decreased dry matter ($P < .03$) and neutral detergent fiber ($P < .07$) digestibility, whereas crude protein and acid detergent fiber digestibility were not affected (Table 1). Lambs fed urea had higher ($P < .01$) crude protein and lower ($P < .09$) ADF digestibility than those fed sunflower meal. Straw and total dry matter intakes were higher ($P < .05$) in lambs fed sunflower meal. No nitrogen level X nitrogen source interaction was observed. Compared to the control, dry matter intake of lambs fed the 8% sunflower meal diet was higher, and increasing nitrogen level increased crude protein digestibility. Substituting dietary sunflower meal by urea increased crude protein digestibility and decreased intake of straw.

**Table 1. Intake and digestibility of straw-based diets.**

| Item | CP 8 | level (%) 10 | P Value | Urea | SFM | P Value |
|---|---|---|---|---|---|---|
| Digestibility, % | | | | | | |
| DM | 54.6[a] | 50.5[b] | .02 | 52.4 | 52.7 | |
| NDF | 50.5[a] | 43.2[b] | .07 | 47.5 | 45.6 | |
| ADF | 32.7 | 29.3 | | 28.2[a] | 33.7[b] | .09 |
| CP | 72.2 | 73.3 | | 77.9[a] | 67.6[b] | .01 |
| Intake, $g/kg^{.75}$ | | | | | | |
| Total DM | 42.6 | 40.9 | | 40.3[a] | 43.2[b] | .06 |
| Straw DM | 68.3 | 64.4 | | 63.9[a] | 68.8[b] | .05 |

Another study investigating the effects of dietary protein levels on straw degradability in the reticulorumen had to be terminated because of unexpected mortality of fistulated rams. This second study was not included in the 1991-92 workplan.

## Training

*In Progress*

J. Benjhelloun, IAV Hassan II Rabat. MS Nutrition. Expected graduation: February 1993. MS research focuses on stubble grazing by pregnant ewes.

M. Tazi, IAV Hassan II Rabat. MS Nutrition. Expected graduation: February 1993. MS research focuses on protein levels in diets for growing lambs.

A. Mendili, ENA Meknes. MS Nutrition. Effective graduation: January 1993. MS thesis title: Effets de la supplementation energetique et azotee sur l'utilisation de rations a base de paille de ble par les ovins.

## Contributions

*Environmental impact - Agricultural sustainability*

SR-CRSP nutrition research in Morocco has enhanced scientific understanding of the sustainability of existing cereal/livestock production systems. The development of improved management practices such as strategic nutrition supplementation according to cereal stubble biomass and(or) its quality, and animals' physiological stage, enhances the sustainability of the existing production systems. Consequently, adoption of these practices has considerable impact on small ruminant production efficiency, expansion of markets, and farmers' disposable income. In addition, the knowledge acquired in Morocco with sheep grazed on cereal stubble is applicable to the entire Mediterranean basin and other regions of the world with similar mixed production systems and climate.

Evaluation of locally available feedstuffs and industrial by-products unfit for human consumption and their incorporation in sheep diets for the production of meat, hide, and wool add other dimensions to the sustainability of the existing production systems.

*Contributions to U.S. agriculture*

Research on grazed cereal stubble coupled with strategic feeding of supplements or incorporation of by-products such as almond hulls and waste palm dates in sheep diets has important implications for cereal-producing and semi-arid regions of the Western United States, as producers move toward more sustainable agricultural systems.

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Guessous., F. 1992. Utilization des chaumes de cereales par les ruminants. In "Livestock in the Mediterranean cereal production systems." Proc. Int. Symp. ANPA-EAAP-ICAMAE. October 7-10, 1990. Rabat. EAAP Publication No 49. pp 82-88. Pudoc Scientific Publishers, Wageningen.

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Rihani, N., R.A. Zinn and W.N. Garrett. Influence of urea level and method of supplementation on characteristics of digestion of citrus pulp based diets by sheep. 43rd Annual meeting of the EAAP. Sept. 14-17, 1992. Madrid, Spain.

Kabbali, A. Nutritional requirements of pregnant ewes fed wheat straw-based diets. 43rd Annual meeting of the EAAP. Sept. 14-17, 1992. Madrid, Spain.

Rihani, N. and F. Guessous. Improving feeding systems for sheep in the agro-pastoral areas of Morocco. Workshop on the strategies for the development of fat-tail sheep in the near-East. FAO-ICARDA-ICAMAS-EAAP-CUZF. October 509, 1992. Adana, Turkey.

## Comments

Achievements by the SR-CRSP in Morocco would not have been possible without the sustained cooperation and assistance from the USAID-Minnesota project.

# 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:

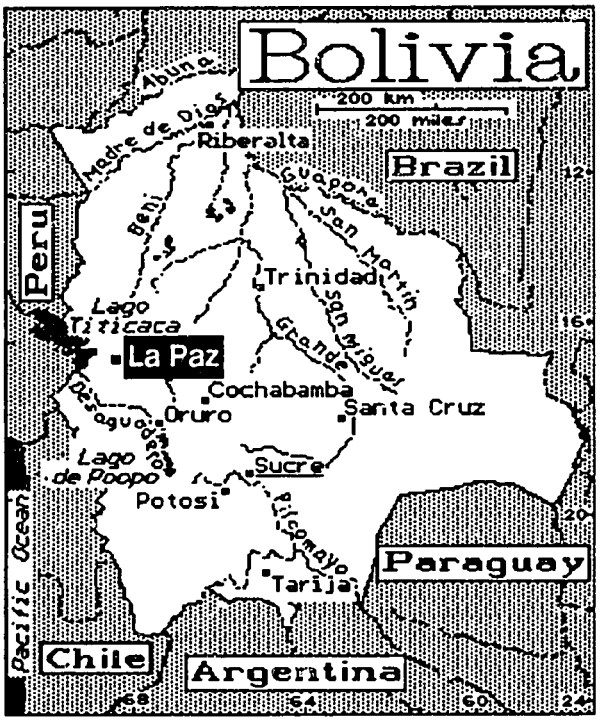
- continuous professional development
- prompt flow and exchange of research results, experience, and methods
- mechanisms to facilitate collaboration and cooperation in planning and executing research on a multi-country, regional, or global basis
- identification of sources of funds to support research
- 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 America Network

## Republic of Bolivia

**Total area:** 1,098,580 square km (424,165 square miles)
**Geography:** In central Andes Mountains, at an altitude of 12,000 feet.
**Capitals:** Sucre (legal) and La Paz (de facto).
**Population(1991):** 7,156,000
**Languages:** Spanish, Quechua, Aymara.
**Labor force:** 50% agriculture, 10% industry, 26% services.
**% Females in labor force:** 25.2%
**Industries:** Textiles, food processing, mining, clothing.
**Chief crops:** Potatoes, coffee, sugar, corn, coca.
**Land in Agriculture:** 27.4%
**Agriculture of GNP:** 24%
**Sheep population:** 9,600,000
**Goat population:** 2,350,000
**Uses of sheeps and goats:** Meat and milk.
**Inflation rate:** 15.5% (1989)
**Monetary unit:** Bolivianos.


# Networking in Latin America

University of Wisconsin-Madison

Jane Homan, Department of International Programs, Rm. 240, Ag. Hall, 1450 Linden Drive, University of Wisconsin, Madison, Wisconsin 53706. Telephone (608) 262-4874, Fax (608) 262-8852.

## Narrative Summary

1992 marked a year of transition for the RERUMEN (Andean Small Ruminant Network). With the withdrawal of the SR-CRSP from Peru, a decision was made to relocate the Network in Bolivia, based within the Instituto Boliviano de Tecnología Agropecuaria (IBTA) in La Paz, Bolivia. Efforts thus focused on organization and distribution of data to participants prior to the transition and subsequently on the establishment of operations in Bolivia. Copies of the bibliography files were submitted to RISPAL for review and inclusion in the AGRIS database. An agreement was drafted to establish a formal relationship with the Pastures Andean Network, but was put on hold pending the relocation. The RERUMEN participants are Argentina, Chile, Bolivia, Peru, Ecuador, and Venezuela.

## Research

*Conduct and sponsor workshops on small ruminant production and provide a forum for development of collaborative proposals to send to funding organizations.*

Given the transition status, no workshops were conducted in 1992. As an outcome of workshops conducted in Lima, Peru, on grantsmanship in 1990 (co-sponsored by Winrock International) and in Santiago, Chile, on technology transfer to small farmers in 1991, efforts continue to develop multinational collaborative research projects on common problems in small ruminant production. This is a thrust which will be re-emphasized in the future.

*Publish a newsletter regularly on research topics and technology transfer and other items of interest to small ruminant scientists.*

The RERUMEN Newsletters were published in 1992; Volume 2 No. 2 appeared in August 1992 with a circulation of approximately 550. Increasing interest has been noted with each publication and continued growth of the data base. Through the newsletter the network is overcoming the professional isolation of researchers in the different Andean countries, permitting continuous growth and professional development. The challenge in the coming year is to re-establish the publication of the newsletter in a similar format to avoid loss of this momentum.

*Inventory, develop, and maintain a data base of scientists with common interests in small ruminant research and extension in the Andean region.*

This data base, which has now been corrected in each country, contains the names, addresses, and areas of interest of researchers and extensionists in each Andean country. A directory of small ruminant researchers from this data base has been published and has been distributed in each country.

*Develop a bibliographical data base for small ruminants in the Andean region.*
With the help of Ing. Rioja, students from UNA-La Molina, and groups guided by the national coordinators in each country, eight thousand bibliographical entries were compiled addressing research and technological transfer related to small ruminants in South America. Part of this data base (7,000 registers and a manual of instructions) was given to each National Coordinator of RERUMEN (Argentina, Chile, Bolivia, Peru, Ecuador, and Venezuela) in Santiago, Chile, in November 1991. They have initiated a RERUMEN information service in each of their countries. The service has already begun in Peru and has been managed by Instituto Nacional de Investigaccion Agraria y Agroindustrial (INIAA) with great success. This data base has also been the subject of an agreement with RISPAL.

*Establish linkages with other Andean Networks and other regional small ruminant networks.*
An agreement is in place with ISAPLAC (Organization of American States-RISPAL) to share and collaborate with the data bases. A similar agreement was drafted and discussed with the Pastures Andean Network (REPAAN) funded by the International Development Research Centre (Canada) which has operated in South America in the Andean region since 1988. Likewise, INIAA-Peru has formed the Information System on Animal Production (SIOA) which has also expressed interest in signing an agreement with RERUMEN. Given the decision to transfer the RERUMEN operational base, these agreements were put on hold and communications will be reinitiated from the Bolivian base.

*Establishment of RERUMEN in Bolivia.*
In early December 1992, an initial visit to Bolivia was made by incoming University of Wisconsin principal investigator Jane Homan to initiate activities in collaboration with IBTA. Co-principal investigator Dr. Luis Iñiguez, also of UW, is based in Bolivia. Arrangements for fiscal and logistical management in Bolivia were made. IBTA counterparts Rommy Peña and Einstein Tejada worked with the UW team, and plans for RERUMEN activities in 1993 were drafted, including an early resumption of the newsletter distribution. The communications will be reinitiated early in 1993 with the transfer of the data bases to Bolivia from Peru.

## Training

Ph.D. program at Montana State University: Miguel Paz (Peru), major in Statistics.

## Contributions

The RERUMEN network has made significant progress in technology transfer and communication within the Andean countries of the research carried out under the SR-CRSP. It works to support individual scientists in the Andean countries, enhancing their access to research information, encouraging intra-regional collaboration, and optimizing use of research resources in the participant countries by reducing duplication of research effort.

## Collaborating Personnel

*1 January - 30 September 1992:*
Dr. Arturo Florez

*1 October -31 December 1992:*
Dr. Edmundo Espinoza
Ing. Rommy Peña
Ing. Einstein Tejada
Lic. Carmen de Sotelo

## Collaborating Institutions

*1 January - 30 September 1992:*
Instituto Nacional de Investigaccion Agraria y Agroindustrial, Lima, Peru

*1 October -31 December 1992:*
Instituto Boliviano de Tecnología Agropecuaria, La Paz

## Publications

### Referred Journals

Burfening, P.J. and D.D. Kress. 1992. Early growth traits related to subsequent most probable producing ability. Small Rumin Res. 7:67-74.

Burfening, P.J. and Rossi, D. 1992. Serving capacity and scrotal circumference of ram lambs as affected by selection for reproductive rate. Small Rumin. Res. (In Press).

Burfening, P.J. and Kress, D.D. 1992. Direct and Maternal effects on birth and weaning weights in sheep. Small Rumin. Res. (In Press).

Burfening, P.J., Kachman, S.D., Hanford, K.J. and Rossi, D. 1992. Selection for reproductive rate in Rambouillet sheep: Estimated genetic change in reproductive rate. Small Rumin. Res. (In Press).

Curry, K.C., Berardinelli, J.G., Burfening, P.J. and Adair, R. 1992. Effect of selection for reproductive rate in females and feeding regimen on testicular characteristics and epididymal sperm reserve in Rambouillet rams. Small Rumin. Res. (In Press).

Burfening, P.J. and Carpio, M. 1992. Genetic and environmental factors affecting growth and survival of Junin sheep in the central highlands of Peru. Small Rumin Res. (In Press).

### Submitted for Publication

Cardenas, H., Berardinelli, J.B., Burfening, P.J. and Lane, M.A. 1992. Testicular characteristics of rams from lines selected for high or low reproductive rate: I. Gross anatomy and histomorphology. J. Reprod. Fertil. (Submitted for Publication).

Cardenas, H., Berardinelli, J.B., Burfening, P.J., and Adair, R. 1992. Testicular characteristics of rams from lines selected for high or low reproductive rate: II. oLh/hCG receptors and in vitro testosterone secretion. J. Reprod. Fertil (Submitted for publication).

Burfening, P.J. and Caprio, M. 1992. Improving Criollo sheep in Peru through crossbreeding with improved breeds. Small Ruminant Res (Submitted for Publication).

Smith, V.R., Burfening, P.J. and Berardinelli, J.G. 1992. Follicular numbers in Rambouillet ewes selected for high and low reproductive rate. Small Rumin. Res. (Submitted for Publication).

### Miscellaneous publications

Florez, A. 1992. Directorio de Profesionales. Red De Rumiantes Menores. Ed. A. Florez. Lima, Peru. pp 111.

Burfening, P.J. 1992. Direct and maternal genetic effects on lamb survival. MSU. Sheep Reports. Miscellaneous Publications-Animal and Range Sciences Department. pp 57.

Burfening , P.J. and Kress, D.D. 1992. Direct and maternal effects on birth and weaning weight in sheep. MSU. Sheep Reports. Miscellaneous Publications-Animal and Range Sciences Department. pp 58.

Burfening, P.J., Kachman, S.D., Hanford, K.J. and Rossi, D. 1992. Selection for reproductive rate in Rambouillet sheep: estimated genetic change in reproductive rate. MSU. Sheep Reports. Miscellaneous Publications-Animal and Range Sciences Department. pp 59-60.

Chavez, J.C.,Vyse, E.R.,Cameron, D.G.,Blackwell, R.L. and Burfening, P.J. 1992. Interrelationship between plasma transferrins and some reproductive traits in Rambouillet, Targhee and Columbia sheep under montana range conditions. MSU. Sheep Reports. Miscellaneous Publications-Animal and Range Sciences Department. pp 61-62.

Burfening, P.J. 1992. Selection for scrotal circumference and its relationship to female reproductive traits in Columbia sheep. MSU. Sheep Reports. Miscellaneous Publications-Animal and Range Sciences Department. pp 63.

Burfening, P.J. and Caprio, M. 1992. Genetic and environmental factors affecting growth rate and survival of Junin sheep in the central highlands of Peru. MSU. Sheep Reports. Miscellaneous Publications-Animal and Range Sciences Department. pp 64-65.

Burfening, P.J. and Caprio, M. 1992. Improving Criollo sheep in Peru through crossbreeding with improved breeds. MSU. Sheep Reports. Miscellaneous Publications-Animal and Range Sciences Department. pp 66-67.

Cardenas, H., Berardinelli, J.G., Burfening, P.J. and Lane, M.A. 1992. Testicular characteristics of rams from lines selected for high or low reproductive rates: i. Gross anatomy and histomorphology. MSU. Sheep Reports. Miscellaneous Publications-Animal and Range Sciences Department. pp 68.

Cardenas, H., Berardinelli, J.G., Burfening, P.J., Lane, M.A. and Adair, R.A. 1992. Testicular Characteristics of Rams from Lines Selected for High or Low Reproductive Rates: II. oLH/hCG Receptors and In Vitro Testosterone Secretion. MSU. Sheep Reports. Miscellaneous Publications-Animal and Range Sciences Department. pp 69.

Lane, M.A.,Berardinelli, J.G., Cardenas, H. and Staigmiller, R.B.,1992. Sperm transport and distribution during the puberal transition in ewe lambs. MSU. Sheep Reports. Miscellaneous Publications-Animal and Range Sciences Department. pp 70.

Curry, K.C., Berardinelli, J.G., Burfening, P.J. and Adair, R.A. 1992. Selection for Reproductive Rate in Females and Feeding Regimen on Testicular Traits and Epididymal Sperm Reserves in Rambouillet Rams. MSU. Sheep Reports. Miscellaneous Publications-Animal and Range Sciences Department. pp 71.

Burfening, P.J. and Rossi, D. 1992. Serving capacity and scrotal circumference of ram lambs as affected by selection for reproductive rate. MSU. Sheep Reports. Miscellaneous Publications-Animal and Range Sciences Department. pp 72.

### Publications from Past SR-CRSP Work

Florez, A., Malpartida, E. and San Martin, F. 1992. Manual de forrajes. Para zonas aridas y semiaridas andinas. Red de Rumiantes Menores. Lima, Peru. pp 280.

### Comments

During its two years of operation in Peru, RERUMEN has begun to generate a strong network in Latin America and make significant inroads by building a viable network to the isolation and lack of communication experienced participating scientists. This is a reflection of the effort and dedication of the Peruvian Site Coordinator and his staff and colleagues working with the support of counterparts at Montana State University. We are now committed to work from the new Bolivian base to enable RERUMEN to build effectively on the foundations laid in Peru and respond to the growing interest in the network expressed in the many letters sent to Peru.

# Project Expenditures

# SMALL RUMINANT CRSP

## USAID GRANT NO. DAN-1328-G-00-0046-00
## EXPENDITURES BY PROGRAM

| INSTITUTION | DISCIPLINES | YEAR 12 90/91 | YEAR 13 91/92 | TOTAL |
|---|---|---|---|---|
| UCD Genetics | Genetics | $331,324.81 | $321,288.16 | $652,612.97 |
| Colorado State Univ. | Animal Health | $179,497.99 | $195,474.36 | $374,972.35 |
| Univ. of Missouri | Sociology | $201,575.76 | $353,614.61 | $555,190.37 |
| Montana State Univ. | Breeding | $110,568.80 | $105,196.99 | $215,765.79 |
| North Carolina State Univ. | Nutrition | $383,672.90 | $337,642.00 | $721,314.90 |
| Texas A&M | Breeding | $141,524.58 | $194,460.00 | $335,984.58 |
| Texas Tech | Range–Nutrition | $84,122.34 | $191,010.28 | $275,132.62 |
| Utah State Univ. | Range Ecology | $91,342.42 | $133,195.00 | $224,537.42 |
| Washington State Univ. | Health | $160,000.00 | $175,000.00 | $335,000.00 |
| Winrock Int'l–Econ. | Economics | $212,325.07 | $246,960.00 | $459,285.07 |
| Winrock Int'l–DPG | Dairy Mgmt. | $233,000.00 | $186,690.00 | $419,690.00 |
| | Subtotal: | $2,128,954.67 | $2,440,531.40 | $4,569,486.07 |
| HOST COUNTRIES: | | | | |
| Indonesia | | $0.00 | $0.00 | $0.00 |
| Kenya | | $0.00 | $0.00 | $0.00 |
| Morocco | | $14,609.18 | $10,756.76 | $25,365.94 |
| Bolivia | | $42,656.96 | $147,330.90 | $189,987.86 |
| | Sutotal: | $57,266.14 | $158,087.66 | $215,353.80 |
| Management Entity* | | $439,035.03 | $498,501.98 | $937,537.01 |
| | Subtotal: | $439,035.03 | $498,501.98 | $937,537.01 |
| | TOTALS: | $2,625,255.84 | $3,097,121.04 | $5,722,376.88 |

*Expenditure for ME includes expenses for the External Evaluation Panel, Board Meetings, Technical Committee and other meetings.

# SMALL RUMINANT CRSP

## USAID GRANT NO. DAN-1328-G-00-0046-00
## APPROVED PROGRAM BUDGETS

| INSTITUTION | DISCIPLINES | YEAR 12 90/91 | YEAR 13 91/92 | TOTAL |
|---|---|---|---|---|
| UCD | Genetics | $281,246.00 | $233,000.00 | $514,246.00 |
| Colorado State | Animal Health | $201,570.00 | $175,000.00 | $376,570.00 |
| University of Missouri | Sociology | $313,500.00 | $202,442.00 | $515,942.00 |
| Montana State | Breeding | $113,025.00 | $106,412.00 | $219,437.00 |
| North Carolina State | Nutrition | $295,000.00 | $227,000.00 | $522,000.00 |
| Texas A&M | Breeding | $210,659.00 | $140,000.00 | $350,659.00 |
| Texas Tech | Range–Nutrition | $180,000.00 | $115,000.00 | $295,000.00 |
| Utah State | Range–Ecology | $120,000.00 | $115,000.00 | $235,000.00 |
| Washington State | Health | $160,000.00 | $175,000.00 | $335,000.00 |
| Winrock Int'l | Dairy Mgmt. | $200,000.00 | $150,000.00 | $350,000.00 |
| Winrock Int'l | Economics | $255,000.00 | $202,558.00 | $457,558.00 |
| Undesignated | Indo/Kenya | $0.00 | $0.00 | $0.00 |
| | Subtotal: | $2,330,000.00 | $1,841,412.00 | $4,171,412.00 |
| Management Entity* | | $600,000.00 | $610,000.00 | $1,210,000.00 |
| Program Enhancement Funds | | $0.00 | $43,588.00 | $43,588.00 |
| Host Countries | | $310,000.00 | $305,000.00 | $615,000.00 |
| Linkages | | $65,000.00 | $0.00 | $65,000.00 |
| Networks | | | | $0.00 |
| New Program Initiatives | | | | $0.00 |
| | Subtotal: | $975,000.00 | $958,588.00 | $1,933,588.00 |
| | TOTAL: | $3,305,000.00 | $2,800,000.00 | $6,105,000.00 |

*Allocation for ME includes funding for the External Evaluation Panel, Board Meetings, Technical Committee, and other meetings.

# SMALL RUMINANT CRSP

## USAID GRANT NO. DAN-1328-G-00-0046-00

## MATCHING CONTRIBUTIONS FROM U.S. INSTITUTIONS

| INSTITUTION | DISCIPLINES | YEAR 12 90/91 | YEAR 13 91/92 | TOTAL |
|---|---|---|---|---|
| UCD Genetics | Genetics | $118,292.08 | $122,877.02 | $241,169.10 |
| Colorado State Univ. | Animal Health | $53,333.04 | $87,499.62 | $140,832.66 |
| Univ. of Missouri | Sociology | $66,184.42 | $81,894.67 | $148,079.09 |
| Montana State Univ. | Breeding | $60,734.04 | $52,668.00 | $113,402.04 |
| North Carolina State Univ. | Nutrition | $64,731.14 | $55,975.10 | $120,706.24 |
| Texas A&M | Breeding | $46,289.63 | $53,757.88 | $100,047.51 |
| Texas Tech | Range–Nutrition | $51,422.63 | $68,212.94 | $119,635.57 |
| Utah State Univ. | Range Ecology | $46,379.09 | $84,756.83 | $131,135.92 |
| Washington State Univ. | Health | $53,333.00 | $81,373.76 | $134,706.76 |
| Winrock Int'l–Econ. | Economics | $75,406.90 | $83,273.79 | $158,680.69 |
| Winrock Int'l–DPG | Dairy Mgmt. | $68,022.61 | $56,749.01 | $124,771.62 |
| | TOTAL: | $704,128.58 | $829,038.62 | $1,533,167.20 |
| | *Percentage: | 32.18% | 34.43% | 33.36% |

*Cost sharing is based on expenditures incurred at the participating institutions and overseas sites.

# SMALL RUMINANT CRSP

## USAID GRANT NO. DAN-1328-G-00-0046-00

## SUMMARY OF HOST COUNTRY CONTRIBUTIONS

| COUNTRY | 1990 | 1991 | 1992 | TOTAL |
|---|---|---|---|---|
| Bolivia | $0.00 | $809.00 | $164,787.00 | $165,596.00 |
| Indonesia | $1,420,400.00 | $1,428,400.00 | $3,691,400.00 | $6,540,200.00 |
| Kenya | $317,081.00 | $218,771.00 | $216,284.00 | $752,136.00 |
| Morocco | None Reported | $1,044,000.00 | $826,000.00 | $1,870,000.00 |
| Peru | $118,695.00 | $6,845.00 | $6,500.00 | $132,040.00 |
| TOTAL: | $1,856,176.00 | $2,698,825.00 | $4,904,971.00 | $9,459,972.00 |
| Non-CRSP Support | | $46,615.00 | $120,962.00 | $167,577.00 |
| | TOTALS: | $2,745,440.00 | $5,025,933.00 | $9,627,549.00 |

# 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 |
| BPP | National Rubber Research Institute, Indonesia |
| BPT | Balai Penelitian Ternak, Bogor, Indonesia (Animal Husbandry Research Institute) |
| BW | Body weight |
| CCPP | Contagious Caprine Pleuropneumonia |
| CELL | Cellulose |
| CP | Crude protein |
| CEPROMU | Centro de Promocian de la Mujer |
| CIDR | Controlled Internal Drug Release dispensers |
| CPV | Capripox virus |
| CRIAS | Coordinating Research Institute for Animal Science, Indonesia |
| CSU | Colorado State University |
| d | day |
| DM | Dry Matter |
| DPG | Dual Purpose Goat |
| ENA | National School of Agriculture, Meknes, Morocco |
| EPG | Eggs per Gram |
| FAO | Food and Agriculture Organization, United Nations |
| FD | Full-day |

| | |
|---|---|
| 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 |
| 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 |
| 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 |
| MOET | Multiple Ovulation and Embryo Transfer |
| MSS | Multi Spectral Scanner |
| MUCIA | Midwest Universities Consortium for International Agriculture |

| | |
|---|---|
| N | Nitrogen |
| NCSU | North Carolina State University |
| NDF | Neutral detergent fiber |
| NGO | Non-Government Organization |
| NSDV | Nairobi Sheep Disease Virus |
| OPC | Ovine pulmonary carcinoma |
| OvLV | Ovine lentivirus |
| PAC | Program Advisory Committee |
| PAR | Photosynthetic Active Radiation |
| PI | Principal Investigator |
| PMSG | Pregnant Mare Serum Gonadotropin |
| RAPD | Random Amplified Polymorphic DNA |
| 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 |
| SR-CRSP | Small Ruminant Collaborative Research Support Program |
| SRUPNA | Small Ruminant Production Systems Network for Asia |
| TAMU | Texas A&M University |
| TDN | Total digestible nutrients |
| Techpack | Technology Package |
| TM | Thematic Mapper |

| | |
|---|---|
| TNDVI | Transformed Normalized Difference Vegetation Index |
| TTU | Texas Tech University |
| UCD | University of California, Davis |
| UMC | University of Missouri-Columbia |
| USAID | United States Agency for International Development |
| USDA | United States Department of Agriculture |
| USU | Utah State University |
| UW | University of Wisconsin, Madison |
| WSU | Washington State University |
| WI | Winrock International Institute for Agricultural Development |

| Country | Project | U.S. Principal Investigator | Resident Scientists | International Collaborator |
|---|---|---|---|---|
| Bolivia | Economics | E. Ospina | S. Scholz | J. Vargas |
| | Range Ecology | B. Norton | open | J. Valdivia |
| | Range Management | F. Bryant | M. Ortega | C. Salinas |
| | Sociology | M. Nolan | L. Markowitz | C. Jetté |
| Indonesia | Animal Nutrition | K. Pond | P. Horne | L. Batubara |
| | Breeding | E. Bradford | R. Gatenby | Subandriyo |
| | Economics | E. Ospina | I. Kartamulia | S. Karo Karo |
| Kenya | Animal Health | T. McGuire<br>J. DeMartini | F. Rurangirwa<br>P. Rwambo | F. Karanu, R. Soi<br>S. Shompole |
| | Breeding | J. Taylor | B. Mwandotto | C.O. Ahuya |
| | Production Systems | W. Getz | P. Semenye | D. Siamba, M. Onim |
| | Sociology | M. Nolan | N. Mbabu | D. Sheikh |
| | Economics | E. Ospina | F. Nyaribo-Roberts | |
| Latin America | Network | J. Homan | | R. Peña<br>E. Tejada |
| Morocco | Genetics | E. Bradford | | A. Lahlou-Kassi |
| | Nutrition | K. Pond | | F. Guessous |

## Technical Committee
## 1992

| | |
|---|---|
| Eric Bradford | University of California, Davis |
| Fred Bryant | Texas Tech University |
| James G. DeMartini | Colorado State 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, Chair | Washington State University |
| Michael F. Nolan | University of Missouri-Columbia |
| Brien E. Norton | Utah State University |
| Enrique Ospina | Winrock International |
| Kevin Pond | North Carolina State University |
| Marwan Rangkuti | CRIAS, Indonesia |
| Jeremy F. Taylor | Texas A&M University |
| | KARI, Kenya |

## Administrative Council
### 1992

| | |
|---|---|
| Robert C. Albin | Texas Tech University |
| Leonard Bull | North Carolina State University |
| James B. Henson, Chair | Washington State University |
| Carl Menzies | Texas A&M University |
| Cyrus Ndiritu | KARI, Kenya |
| Gordon Niswender | Colorado State University |
| Paul Rasmussen | Utah State University |
| Ned S. Raun | Winrock International |
| Jack Rutledge | University of Wisconsin, Madison |
| José Salinas C. | IBTA, Bolivia |
| Kenneth C. Schneeberger | University of Missouri-Columbia |
| P. Sitorus | CRIAS, Indonesia |
| Barbara D. Webster | University of California, Davis |

## External Evaluation Panel
### 1992

| | |
|---|---|
| S. Gordon Campbell, Chair | Cornell University |
| Cornelia Flora-Butler | Virginia Polytechnic Institute |
| Hudson Glimp | University of Nevada, Reno |
| Martin Gonzalez | Mexico |
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