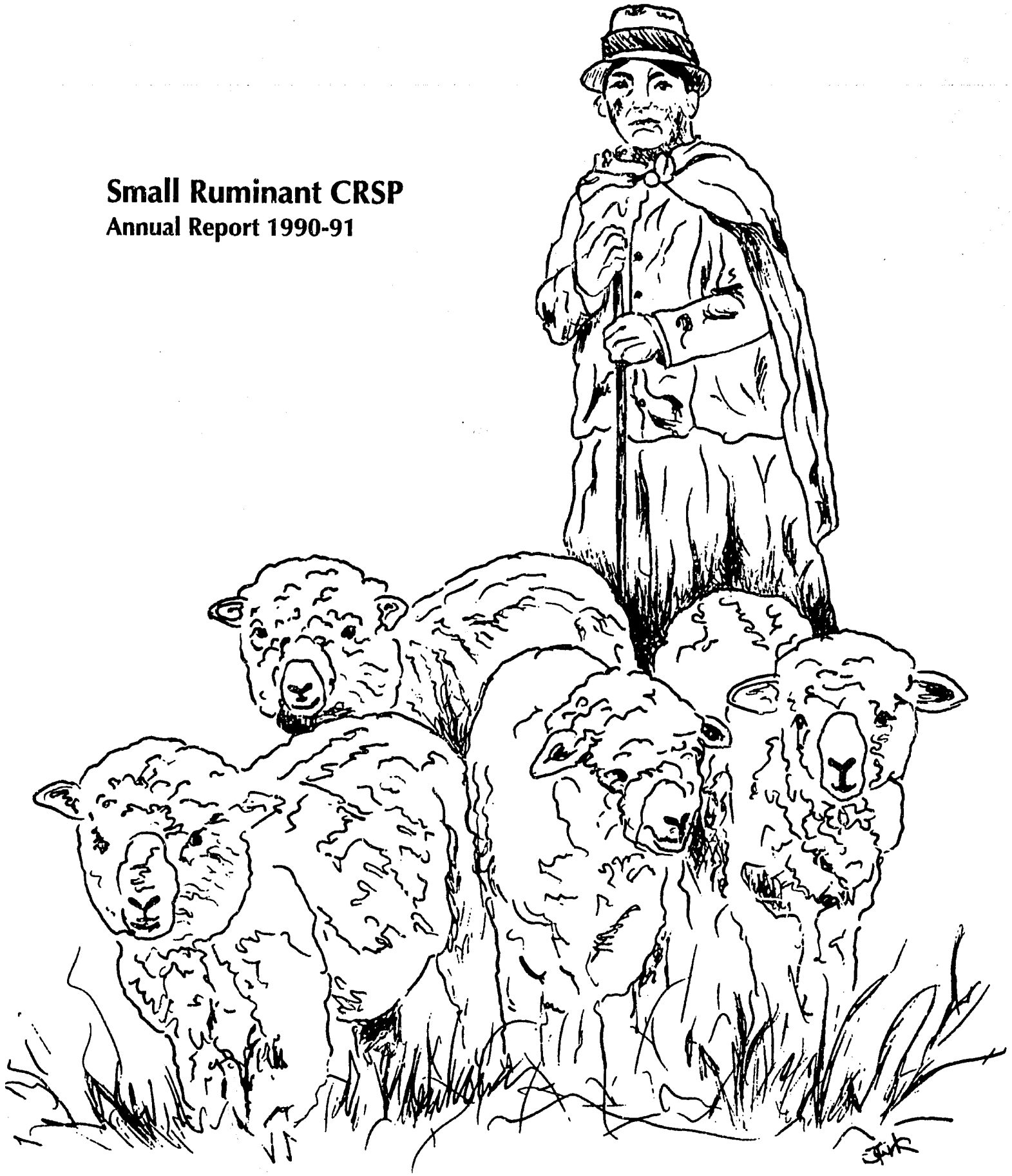
PN-ABM-925

Small Ruminant CRSP
Annual Report 1990-91



Collaborating Institutions

United States

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)

Overseas Collaborators

Bolivia	Instituto Boliviano de Tecnologia Agropecuaria (IBTA)
Indonesia	Agency for International Research and Development (AARD)
Kenya	Kenya Agricultural Research Institute (KARI)
Morocco	Institut Agronomique et Veterinaire (IAV), Hassan II University

Participating U.S. Institutions

University of California, Davis
Colorado State University, Ft. Collins
University of Missouri, Columbia
Montana State University, Bozeman
North Carolina State University, Raleigh
Texas A&M University, College Station
Texas Tech University, Lubbock
Utah State University, Logan
Washington State University, Pullman
Winrock International Institute for Agricultural Development, Morrilton, Arkansas

Small Ruminant CRSP

Annual Report 1990-91

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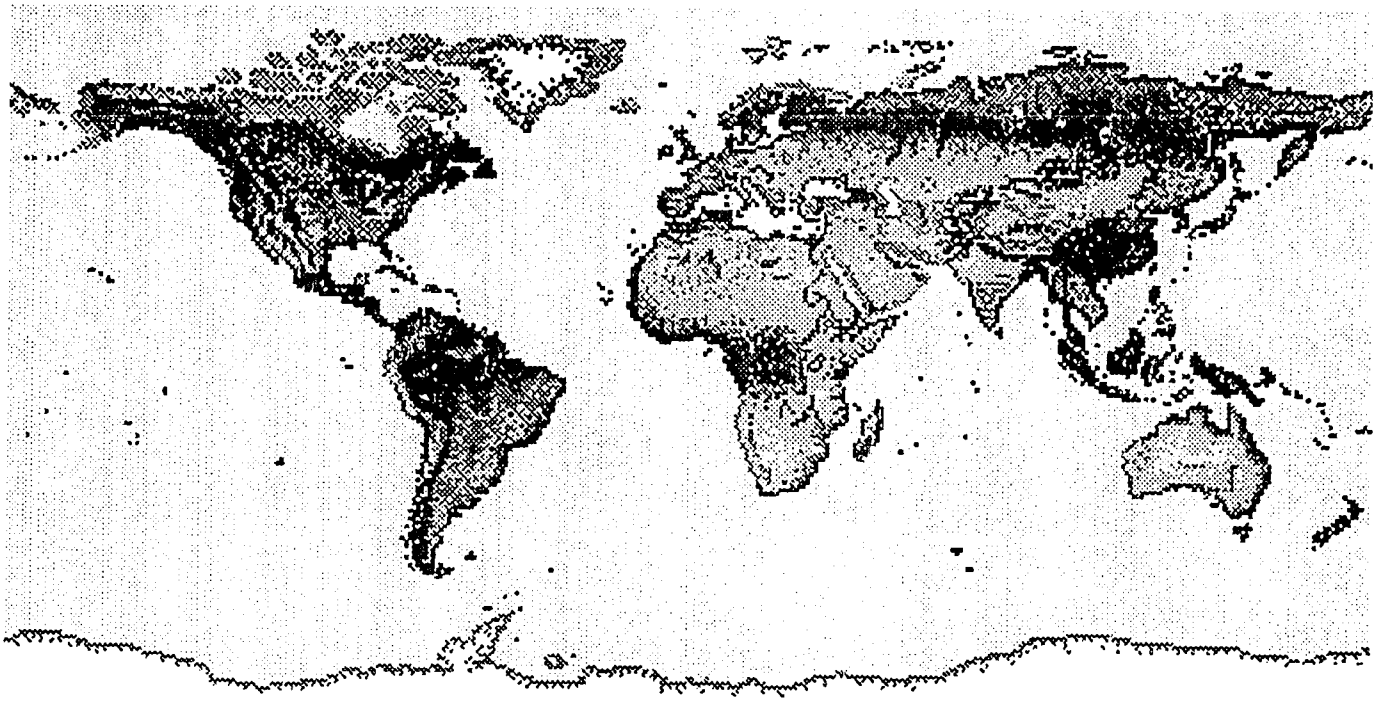


Table of Contents

Foreword

The Small Ruminant Collaborative Research Support Program is funded through a grant from the United States Agency for International Development. In 1990-91, the program collaborated with nine U.S. land-grant universities, a private voluntary organization based in Arkansas, and four host country institutions. The host country institutions are located in Bolivia, Indonesia, Kenya, and Morocco. In addition, the headquarters for the Andean Small Ruminant Network was located in Lima, Peru. The names and locations of all program collaborators are listed on the front and back covers of this publication.

This annual report covers the period of October 1, 1990, to December 31, 1991. This time period was the first fifteen months of the third five-year grant from the Agency for International Development to research global constraints affecting small ruminants (sheep, goats, llamas, and alpacas). Previous annual reports coincided with the fiscal year of the project, October 1 to September 30; however, in 1991, the decision was made to report on the calendar year. Therefore, this annual report covers fifteen months instead of the usual twelve. The change will integrate the annual report with the External Evaluation Panel report and the development and funding of workplans and budgets.

The report is organized under five major research objectives or "components." All the reports that pertain to a specific component are grouped together. The first page of each component has a brief excerpt from the five-year extension proposal. The extension proposal was written and submitted in 1989 and some of the specific plans have been modified since that time; however, these excerpts will provide a brief overview of the major objectives of each component. The five components are:

- Dual Purpose Goat
- Hair Sheep Production Systems
- Prolific Sheep
- Sustainable Agropastoral Systems on Marginal Lands
- Animal Health Through Biotechnology

In addition, the Small Ruminant CRSP funds the Andean Small Ruminant Network. This network, initiated on October 1, 1990, focuses on Andean zones and collaborates with Latin American countries such as Argentina, Bolivia, Chile, Ecuador, Peru, and Venezuela. The headquarters of the network were located in Lima, Peru, until 1992 when they were moved to La Paz, Bolivia. A report on the activities of the network begins on page 149.

Linkage grants were awarded competitively in 1990-91. These grants are intended to continue research activities and linkages with host country scientists where the Small Ruminant CRSP has phased-out. The program phased-out of Peru in 1990 and began a partial phase-out of Morocco in 1990; thus, scientists from both countries were eligible to apply for linkage grants. The linkage grants were submitted to a

panel of U.S. scientists who ranked them in order of priority and scientific merit. Five proposals from Peru and one from Morocco were awarded funds. The reports on these linkage grants begin on page 155.

In this annual report, all individual reports give the name, address, telephone number, and fax number of the principal investigator for that project. In addition, all collaborating personnel and institutions are listed at the back of each report. Inquiries are welcome; all participants of the program will gladly send more information, publications, etc. Correspondence can also be directed to the Management Entity (address on the back cover).

Two new items were added to this report: a glossary of terms (pages 176-177) and statistics on each country with which the program collaborates. These statistics are provided next to the maps of the appropriate country.

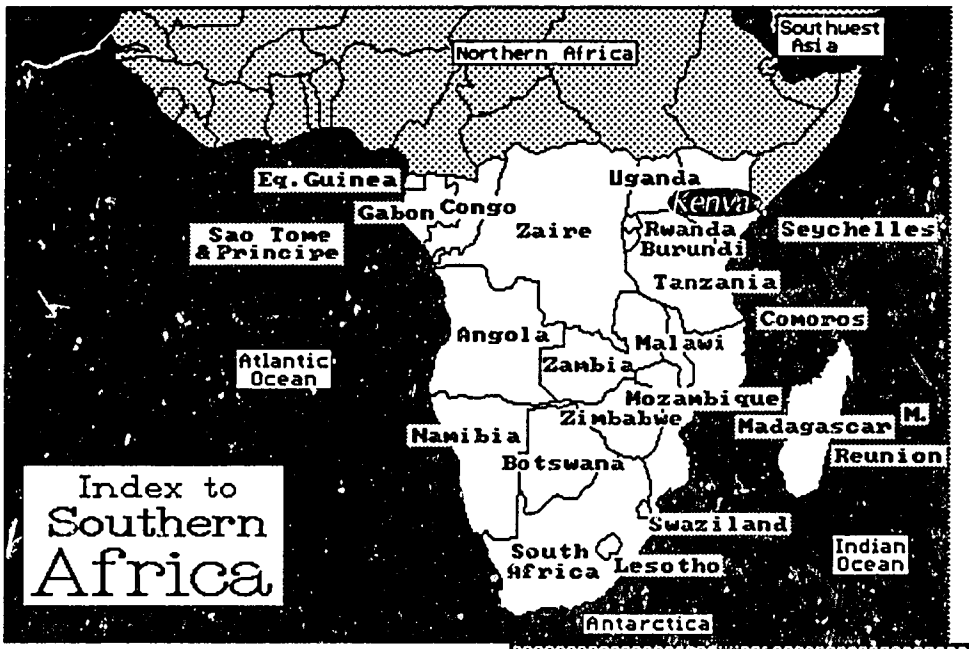
I welcome your comments and suggestions on the Small Ruminant CRSP and this annual report. My address, telephone number, and fax number are listed on the back cover.

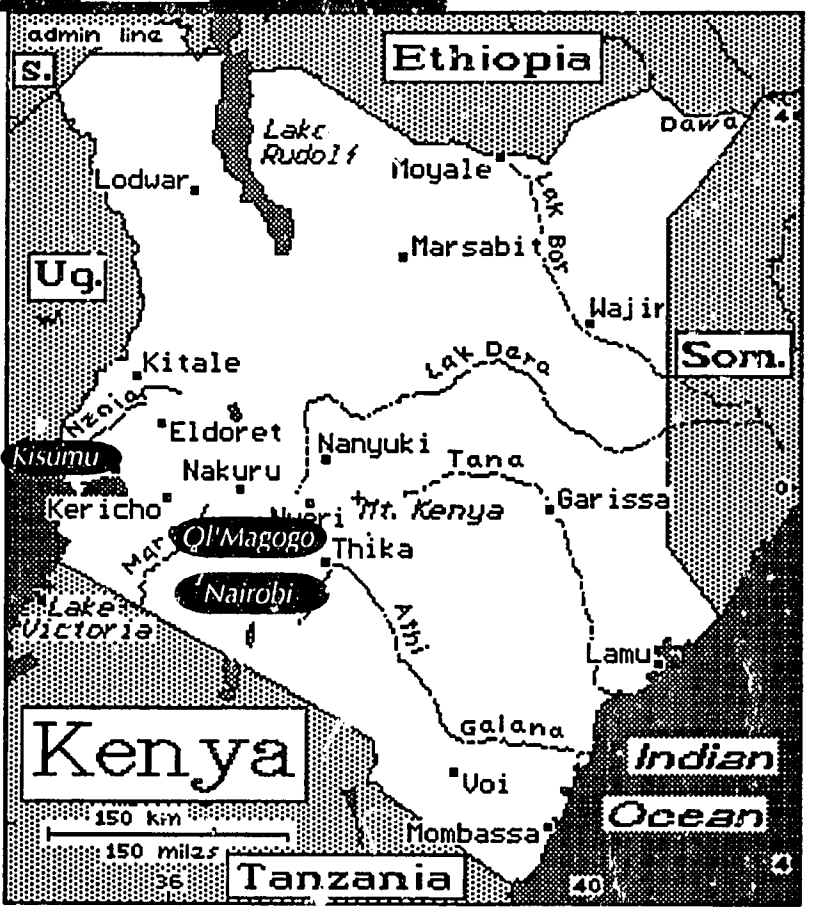
John S. Glenn, D.V.M., Ph.D.
Director
Small Ruminant CRSP

Dual Purpose Goat Component

"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 (224,961 square miles)
Land use: 3% arable land, 1% permanent crops, 7% meadows and pastures, 4% forest and woodland, 85% other.
Population (1990): 24.6 Million
Population growth: 3.8%
Agriculture accounts for 31% of GNP, 78.2% of workforce, and 50% of exports
Agricultural imports: $165,607,000
Agricultural exports: $908,915,000
Food and animals imported: $94,618,000
Food and animals exported: $827,878,000
Sheep: 7,300,000
Goats: 8,500,000
Mutton and lamb: 26,000 metric tons
Goat meat: 19,000 metric tons
Sheep milk: 29,000 metric tons
Goat milk: 82,000 metric tons
Wool: 1,150 metric tons

University of Missouri-Columbia

Sociological Analysis of Small Ruminant Production Systems

Project Number: 105-12

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
Six specific activities (one with three separate projects) were prepared for 1990-91. All involved support to the on-farm monitoring, evaluation, and modification of the Dual Purpose Goat Technology Package being developed for smallholder farmers in western Kenya. The activities given specific attention in 1990-91 were: how farmers managed the forage production package; breeding management; on-farm animal management with attention given to health issues; and utilization of goat manure in food crop/forage crop production. These activities are part of an ongoing effort to improve the DPG package and will continue through 1992.

Two other activities—monitoring of on-farm milk utilization and a study of factors involved in farmer withdrawal from the project—were postponed due to a lack of personnel. It is anticipated they will be completed in 1992.

Two special activities coordinated by the Sociology Project came to fruition in 1991. First, a comprehensive color brochure, *Kenya: Weaving Science with Tradition*, describing the decade-long involvement of the SR-CRSP in Kenya was published. This was made possible, in part, through a special allocation of SR-CRSP augmentation funds.

Second, a "video techpack" describing the Dual Purpose Goat Technology Package was completed. This four-part, two-hour set of teaching modules was produced in cooperation with a Missouri based NGO, Good News Production International. The University of Missouri served as the link between Good News, KARI, and the SR-CRSP resident scientists in western Kenya.

Research

Problem Statement and Approach
The DPG program in Kenya has advanced to the point where the basic elements of a technology package have been developed, and the primary efforts have turned to assessing the package as it is actually used by farmers. Primary responsibility for the on-farm monitoring and evaluation has fallen to the SR-CRSP Social Science Projects (Sociology and Economics) supported by the production system and feed resources components.

The approach followed is as follows. Six locally hired enumerators conduct regular visits to participating farm households. Enumerators complete a short questionnaire (checklist) to record animal performance measures on each visit. They are also trained to keep a journal where more qualitative observations are recorded.

Progress
During the period 1988-90, on-farm activities were coordinated by the sociology project resident scientist (RS). When he departed in December 1990, coordination shifted to the economics project RS. Sociology has continued to provide financial support for enumerators and technical backstopping. A major impact study is planned for 1992 which will provide a capstone to the entire DPG on-farm evaluation effort.

Key areas targeted in the monitoring and evaluation effort are: forage production; breeding management; animal management, especially flock health; and manure utilization. These are all well underway and data analysis and report writing will be undertaken in 1992. Studies on family milk utilization and farmer drop-outs had to be postponed due to a shortage of personnel. It is anticipated these will be completed in 1992.

Two special outputs were recorded for the SR-CRSP Sociology Project in 1991. First, with the assistance of a grant from SR-CRSP augmentation funds, a color brochure describing a decade of involvement of the SR-CRSP in Kenya was produced and distributed.

Second, a two-hour, four-part video describing each of the elements of the DPG Technology Package was completed. These teaching modules are meant to complement the written materials which have been prepared to instruct interested persons on the components of the DPG Techpack. The video and written materials form a comprehensive communication package meant to convey the information the SR-CRSP has accumulated relative to DPG production techniques to non-scientific audiences. The video modules were produced by Good News Productions International, a Missouri-based NGO. The University of Missouri coordinated the overall effort and linked Good News to KARI, the SR-CRSP resident scientists, and their KARI collaborators in western Kenya.

Training
M.S. thesis research of D. Sheikh and D. Ethuro which utilizes SR-CRSP social science data is near completion. Degrees are expected to be awarded in May 1992 (Clemson University, Agricultural Economics)

Other Contributions
Many farm households in Western Kenya are headed by women. In this sense a major focus of sociology (and economics) project activity is to see how DPG technology impacts female farmers and their families.

The Kenya video describing the DPG technology package was produced in collaboration with Good News Productions International--a Missouri-based NGO. Good News raised the funds to produce the video and handled all aspects of production and editing. The SR-CRSP provided in-kind support.

Collaborating Personnel
Kenya
- A. N. Mbabu, Resident Scientist (Sociology)
- F. Nyaribo, Resident Scientist (Economics)
- M. Onim, Resident Scientist (Feed Resources)
- P. Semenye, Resident Scientist (Nutrition/Management)

- D. Sheikh, KARI Counterpart
- D. Ethuro, KARI Counterpart

United States
- M.F. Nolan, Principal Investigator
- J. L. Gilles, Co-Principal Investigator
- Domingo Martinez, Collaborating Scientist
- Constance McCorkle, Collaborating Scientist
- Corinne Valdivia, Collaborating Scientist

Collaborating Institutions

University of Missouri
Winrock International
Kenya Agricultural Research Institute

Publications

Books and Chapters in Books

Conelly, W. Thomas. 1992. "Population pressure and changing agropastoral management strategies in Western Kenya" in McCorkle (ed.) *Plants, Animals, and People Agropastoral Systems Research.* Westview Press, Boulder Colorado.

Mbabu, Nkonge. 1992."The Transformation of the Kenyan Agrarian Sector: The Case of Western Kenya" in McCorkle (ed.) *Plants, Animals, and People Agropastoral Systems Research.* Westview Press, Boulder Colorado..

Noble, Amanda. 1992. "Women, men, goats, and bureaucrats: The Samia women's dairy goat project" in McCorkle (ed.) *Plants, Animals, and People Agropastoral Systems Research.* Westview Press, Boulder Colorado.

Kenya Brochure. 1991. *Kenya: Weaving Science with Tradition,* University of Missouri-Columbia, Missouri.

Video

"A Search for Improved Living." Two-hour four-part video Produced by Good News Productions International. Joplin, Missouri, in cooperation with the University of Missouri-Columbia.

Abstracts and Presentations

Abstracts

Chaiken, Miriam S. and W. Thomas Conelly. "Changing conditions of community welfare: Indigenous Perceptions vs. Anthropological Wisdom," presented in the session "Intergenerational Relations and Ecology in Western Province, Kenya" at the meetings of the American Anthropological Association New Orleans, Louisiana, November 1990.

Articles in Newspapers and Magazines

"MU Researchers aiding agriculture efforts in Kenya." *Mizzou Weekly.*

Curley, Jim. "Kenya: a country works together to feed its people" in *Focus 21* Missouri's College of Agriculture Magazine. Fall 1990.

Texas A&M University

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

Project Number: 109-12

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 animals increased to 326 (142 males, 184 females) and F1 to 363 (98 males, 265 females). A total of 60 F_1 and 25 KDPG bucks not required for breeding were sold to farmers for improving indigenous flocks. The demand for bucks is high, particularly with the NGOs, and the sale price was not subsidized at KSh 1000 per buck. Most of the indigenous G and E does were culled to provide room for the increased number of KDPG. Attempts were made to accelerate multiplication of the KDPG using multiple ovulation and embryo transfer (MOET). Preliminary results indicate that out of transferring two high quality embryos each into 144 recipients, only 29 kids were born. Considering the somewhat higher MOET success rates in the U.S. and New Zealand, there clearly exists problems that require further investigation for improving the efficiency of MOET before it can be usefully applied in Kenya. Considering that low AI success has been reported in indigenous zebu cattle breeds, it may be possible that similar problems exist with MOET in goats since the recipients used were primarily of indigenous breeds. Based on the estimates of returns to estrus conducted within 14 to 40 days after the transfers, 60% of the recipients should have kidded.

Production parameters and resistance to gastrointestinal helminths of the KDPG were assessed. Toggenburg (T) and Nubian (N) sire breeds and East African (E) and Galla (G) dam breeds were compared for body weights and carcass characteristics. The differences between T and N sire breeds were small for body weight; dressing percentage; and carcass lean, fat, and bone composition. Large differences between E and G dam breeds were observed for body weights, dressing percentage, total bone, and internal fat percent. Castration influenced accretion of fat. Castrated male goats had higher total fat, carcass fat, internal fat, and kidney fat, and less lean than intact males; however, the dressing percentage difference was small (0.1%). The results suggest that T and N sire breeds offer similar advantages in growth and carcass characteristics in crossbreeding for improving indigenous tropical goat breeds. For the indigenous Kenya breeds, the G is superior to the E.

Screening for *Haemonchus contortus* identified 11 kids with the phenotype of resistance. When the resistant kids and a group of controls were artificially challenged with 10,000 infective larvae and monitored for six weeks, the highest average eggs per gram (EPG) for resistant and susceptible (controls) goats were 591 and 4,018 respectively, in week six post-infection. Molecular

genetics attempts to identify genetic markers for resistance to *H. contortus* have identified a putative Random Amplified Polymorphic DNA (RAPD) marker for a quantitative trait locus (QTL) associated with packed cell volume. Individuals with the AP9:500 allele were significantly (P<.01) associated with Packed Cell Volume (PCV) and had 1.73 % PCV higher than goats with the alternate genotype. Recent emphasis in this research has been in the development of RAPD markers for the caprine to allow screening of the genome for genes associated with the phenotype of resistance. A total of 79 randomly synthesized 10 base oligonucleotide primers have been screened in the KDPG yielding a total of 24 polymorphic markers. Eighteen of these polymorphic markers have now been used to score genotype in 82 KDPG which comprise 8 sire families that appear to be segregating for the phenotype of resistance. Additional DNA will be gathered as kids are born within these families to provide data allowing statistical analyses of these marker/phenotype associations.

Research

The project focused on continued breed development, multiplication, and distribution and in the genetics of resistance to the gastro-intestinal tract parasite *H. contortus*.

Activity: Multiplication and Distribution

Problem Statement and Approach

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. Following this, a second phase was to utilize the results of the first phase to implement a transfer program involving as many as 300 recipient does. The current 4-way cross KDPG does were superovulated, embryos collected, and those of high quality were transferred into 144 indigenous East African (E) 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 *H. contortus*. Scientists from the International Dairy Goat Research Center at Prairie View A&M University and U.S. graduate students from the TAMU Reproductive Science Laboratory, all experienced in surgical and nonsurgical transfer procedures, collaborated on the project. The project was to involve two visits to Ol'Magogo to allow superovulation of donor animals and transfer into indigenous breed recipients. During each visit, a workshop in MOET techniques involving classroom instruction and practical experience was to be held to facilitate training of local scientists to bring about a more widespread transfer of this technology to Kenya. This strategy was designed so as not to 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). The existing F_1 animals continued to be mated appropriately to produce 4-way

KDPGs; whereas, the indigenous breeds acted as recipients to produce KDPGs instead of producing F_1s as genetic parents.

Goats which will form the initial flocks of collaborating breeders (core breeders) are not anticipated to have the genetic potential for milk yield that is the ultimate goal of 4.0 kg/day at peak lactation. The initial release of does should have a potential of about 3.5 kg/day. It is estimated that the foundation flock will require about six to eight years of selection to increase potential to 4.0 kg/day, while simultaneously holding mature size constant. Data collection by the collaborating breeders will be supervised by the SR-CRSP breeding project resident scientist and will be used for progeny testing sires in the environments in which their daughters are expected to produce. The proposed program would be a joint venture between the SR-CRSP, KARI, and the core private breeders, each providing incentive as well as checks and balances to the others, all to the betterment of the KDPG and farm families who will utilize this new breed. This strategy will not only provide the opportunity to examine the performance of selected animals "on-farm" for comparison with performance of relatives "on-station," it will allow the development of the infrastructure for the orderly transition of the project to the Kenyans once the SR-CRSP terminates its research work.

Progress

The table gives the current inventory of the number of KDPG available. The table reflects the culling of purebred does, but it does not include the 60 F_1 and 25 KDPG bucks sold during the year. The table also reveals a very small increase in the number of KDPG animals produced over the last 12 months. No immediately apparent reason for this poor performance in the multiplication program is currently available.

The attempt to use MOET was not successful. Out of 144 transfers (two embryos into each recipient), only 29 recipients kidded (in November through December and hence are not included in the table above). While some difficulty was experienced in importing the drugs necessary for recipient synchronization (the airline lost the luggage containing—among other things—the PMSG for nearly one week), the reason for this low success rate is unknown. Since the majority of the work in Phase I was supported by alternate sources of funding, approximately 70% of the supplemental funds remain—these having been used primarily to support the short-term training of Mr. S.M. Mkuu and for supplies. Clearly, there is a need for research studies for improving MOET. In an environment with a poorly developed recording system, an open nucleus breeding system coupled with MOET offers the best approach for

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

	September 1990			October 1991		
	EAG/Galla	F_1	KDPG	EAG/Galla	F_1	KDPG
Does	303	316	171	163	265	184
Bucks	47	139	141	31	98	142
Total	350	455	312	194	363	326

breed multiplication and improving production. The same strategy is being recommended by FAO (1990) and is being implemented in several countries in Africa for cattle improvement.

The embryo transfer workshop was organized by the resident scientist and held in June 1991. The proceedings are in the process of being compiled by the resident scientist. Extensive video was shot of ET activities in Kenya, and some of this may be of a sufficiently high quality to allow some footage to be used for promotion of SR-CRSP activities.

Through the presentation of project bucks at the Nairobi and Nakuru annual shows, where project animals won national championships including six of the seven trophies at the Nairobi show, considerable interest has been generated in the KDPG. Accordingly, a total of 60 F_1 and 25 KDPG bucks not required for the project breeding program were produced for sale to farmers. These bucks were not subsidized at a sale price of KSh 1000 per buck. While a strong relationship has been developed with the Kenya Stud Book, KARI has not provided clearance for implementation of a strategy for the establishment of multiplier herds with private farmers. Further, the numbers of available KDPG does remain insufficient for the establishment of KDPG multiplier herds, and this strategy has been slow in developing.

One of the most considerable drains on project resources has been the high cost in purchasing alfalfa feed to support the large number of goats involved in the Breeding Project. This financial constraint has also been an important impediment to the ability of KARI to transfer SR-CRSP activities to its mandate. This problem has been partially alleviated this year and is projected to be eliminated within the next year for the following reasons:

- The present numbers of F1 and KDPG goats was sufficient to allow a reduction in herd size by culling purebred does thus reducing flock size and feed requirements.

- Through the support of KARI, an alfalfa plot has been developed at Ol'Magogo to sustain the KDPG project. The plot has now been partially fenced and is in production. Reticulation of irrigation water is being used. Irrigation is by gravity feed and goat manure is used to fertilize the plot.

Activity: 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 and with a peak lactation milk production of 4.0 kg/d. Of importance to this genotype are carcass characteristics, particularly in comparison to F1 and indigenous goats and also total lactation milk yield as mediated through lactation length. Accordingly, research in 1990-91 focused on these aspects of KDPG productivity.

Sufficient numbers of KDPG bucks are now available to implement a selection program within the KDPG to enhance growth and milk production and to 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 F1 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

A study was initiated in 1989 to investigate differences in potential milk yield of the KDPG, F_1s, and indigenous East African (E) and Galla (G) does. Seventy does were used to estimate once daily milking yields under conditions of intensive nutrition. The animals comprised eight E, 17 G, 32 F1s, and 13 KDPG. The F_1s comprised Toggenburg and Anglo Nubian crosses with E and G. In 1990-91, data on milk production continued to be collected to allow characterization for milk potential. Analyses of these data indicated that total lactation yields were influenced mainly by lactation length, doe breed, and season of kidding—the latter two influencing daily yield. Linear and quadratic partial regression coefficients of milk yield on lactation length were 1022.97± 117.28 g/d and -.83 ±.54 g2/d^2 across breedtypes. Compared with kid growth, results indicate, that through the development of the KDPG by crossbreeding the milk, the growth potential of indigenous goats has been greatly improved. Most of the improvement in milk production has been achieved through an increase in lactation length. These data and those from 1990-91 will be used in 1992 for ranking and selection of bucks and does for milk potential. A BLUP procedure suitable for use on the personal computer in Kenya is being developed for use in the KDPG breed improvement.

Growth and Carcass Traits

Effects of Toggenburg (T) and Anglo Nubian (N) sire breeds, East African (E) and Galla (G) dam breeds, and castration on body weight and carcass characteristics were assessed. Breed crosses represented were TxE, TxG, NxE, and NxG. The animals were in three age groups averaging 7.2, 14.7, and 23.9 months at slaughter. The differences between T and N sire breeds were small for body weight; dressing percentage; and carcass lean, fat, and bone composition. Large differences between E and G dam breeds were observed for body weights, dressing percentage, total bone, and internal fat percent. Generally, TxE crossbreds ranked lowest and TxG ranked highest for slaughter weight and dressing percent and vice versa for total bone percent; this reflects the breed of dam differences. The results suggest that Toggenburg and Anglo Nubian sire breeds offer similar advantages in growth and carcass characteristics in

crossbreeding for improving indigenous tropical goat breeds. For the indigenous Kenya breeds as dams, the Galla goat is superior to the East African. Choice of the breeds or breed crosses for commercial use should be based on the production system to complement existing biological and economic environments to maximize yield, which may also include reproduction and milk production or edible product relative to input cost.

Dressing percentage increased with age. The intact and castrated males averaged similar dressing percentages, but castrated males averaged 1.9 kg lighter at 24 months of age. The dressing percentages were 48%, 52%, and 58% at 7, 15, and 24 months, respectively. Castration influenced accretion of fat. Castrated male goats had higher total fat, carcass fat, internal fat, and kidney fat, and less lean than intact males. The total fat, carcass fat, internal fat, and kidney fat percentages of castrated males were, respectively, 5%, 4%, 3%, and 0.5% higher than those of intact males. The lean percentage of castrated males was 7% less than intact males. This result may have implications for the utilization of differences in carcass fat and lean composition of castrated and intact males when carcass quality is a major goal. It would appear that castration, as a routine management practice, could be used in goats when carcass quality, determined by fat composition, is the major goal. The declining demand for animal fat and the increased emphasis on more efficient red meat production suggests a greater need for meat production from intact male goats.

Progeny Testing

A computer program (DFREML) has been adapted to a PC to allow the estimation of genetic parameters for multiple traits. These parameters are necessary for the development of models for the prediction of breeding values using Best Linear Unbiased Prediction (BLUP). The process of adapting this software to the PC has proven to be extremely difficult considering the architectural limitations of the MS-DOS operating system. To overcome this, a Fortran compiler for the WINDOWS operating system was purchased, and DFREML is being adapted to this environment. This will allow the analysis of the complete KDPG data set this year for publication and the production of predicted breeding values of project goats for a more efficient selection program. At this stage the software will be transferred to Kenya to the project computer for routine breeding value analysis.

Activity: Genetics of Disease Resistance

Problem Statement and Approach

A major production constraint of cattle, sheep, and goats in tropical and subtropical areas is the detrimental effect of the stomach worm *H. 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/resiliance to *H. contortus* in the genetically segregating KDPG population, and that various measures of the phenotype of resistance (EPG and PCV)

have a genetic basis. Since drugs have been only marginally effective for control in LDCs, and there is evidence that parasites may develop resistance to these drugs, development of genetically mediated resistance or resilience in small ruminants has been recommended. If strains of resistant/resiliant 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 three 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 have been 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.

• This flock has also been used in the ET program to develop goat families that should segregate for the phenotype 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. The 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 *H. 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

This work was in collaboration with Washington State University and University of Nairobi. Kids born in

1990-91 were screened for resistance to *H. contortus*. One hundred and one three-month-old kids were artificially challenged with 10,000 infective larvae of *H. contortus* and monitored for strongyle egg output. Eleven (10%) of the kids showed resistance to *H. contortus* with a mean EPG of 512.5±59.9 with a maximum of 1,000 while 90 (78%) had a mean EPG of 2,731.3±375.7 with a maximum of 6,000. The mean EPG of "Resistant" and "Susceptible" groups against sampling day showed a gradual increase in EPG over the experimental period. The mean EPG of the "Susceptible" group was consistently higher than that of the "Resistant" group. On each sampling day, the "Resistant" group averaged a significantly lower EPG than the "Susceptible" group. The lowest mean EPG was 118 and 833 at day 21 for the "Resistant" and "Susceptible" groups, respectively. The highest mean EPG was 591 and 4,018 at day 39 for "Resistant" and "Susceptible" groups, respectively. If average EPG reflects total worm burden (Albers et al., 1984), the results show that individual kids in the "Resistant" group had significantly lower worm burden than kids in the "Susceptible" group, suggesting that resistance or susceptibility to *H. contortus* is genetically mediated.

Molecular genetics techniques were employed to determine if genes are segregating within this breed that can be selected to enhance specific genetic immunity to the common stomach worm *H. contortus* (Rohrer et al., 1991) using the randomly amplified polymorphic DNA (RAPD) technique. Molecular genetics attempts to identify genetic markers for resistance to *H. contortus* suggested a quantitative trait locus (QTL) associated with packed cell volume. Individuals with the AP9:500 allele were significantly ($P<.01$) associated with PCV and had 1.73 % PCV higher than goats without this allele. Presently, the population of resistant goats is being built up to provide large enough families for detailed molecular approaches. The current inventory of resistant goats is 95 animals.

Genetic RAPD polymorphisms were detected using 10 base oligonucleotide primers and amplified using the polymerase chain reaction. To date 79 randomly synthesized primers have been screened yielding a total of 24 polymorphic markers. Eighteen of these have been used to score a total of 82 goats defining eight sire families. Genotype scoring was based on the presence or absence of an amplification product. Available field data include packed cell volumes, strongyle eggs per gram of feces, and coccidia oocytes all sampled at two week intervals. An animal model with fixed effects of month of measurement, family, and marker genotype was fitted to determine the level of association between marker loci and Haemonchus susceptibility. Month of measurement was a significant source of variation for all variables, whereas no marker effect was detected for any of the 18 scored loci for any trait.

Several attempts have been made at modifying PCR reaction conditions to allow differentiation of individuals that are homozygous from those heterozygous for a particular marker. To date this has not proven to be possible. Further, research has examined the effects of variation in DNA concentration on the repeatability of PCR amplifi-

cation products. 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. We are pursuing research to identify those markers that are readily reproducible and also to identify alternate markers using PCR based approaches.

Training

• In August, 1991 Mr. J.N. Kogi commenced coursework for an M.S. in Animal Breeding at Texas A&M University. Mr. Kogi is completely supported by the Breeding Project. He is expected to complete his studies in May, 1993.

• Mr. Evison Bhebe, a TAMU Ph.D. candidate in Genetics has been provided DNA from project goats for screening RAPDs in the *H. contortus* research. He has been partially supported by the Breeding Project through provision of laboratory supplies for this project. His anticipated completion date is 1993.

Table 2. Marker Frequency in Families Segregating for Resistance

RAPD Marker	Frequency of +/+ and +/-	No. Animals Scored
A5	.244	82
A7	.585	82
A10	.667	12
A11(a)	.085	82
A11(b)	.415	82
A12(a)	.329	82
A12(b)	.573	82
A16(a)	.250	12
A16(b)	.167	12
A16(c)	.333	12
B01	.829	82
B03	.134	82
B04	.073	82
B08	.049	82
B09	.720	82
B20	.098	82
C01	.475	82
C07	.463	82
C11	.329	82
C14	.512	82
C17	.083	82
D02	.333	12
D04	.917	12
D10	.146	82

Short-Term

• Mr. S.M. Mkuu (Ol'Magogo farm manager) was completely supported by the Breeding Project to participate in a six-week training program in embryo transfer at Texas A&M and Prairie View A&M Universities in October and November, 1991. During this period, he was involved in experimental synchronization and surgical transfer procedures.

• During the period May-July, 1991 Dr. J. Derr, a postdoctoral researcher with the TAMU Animal Genetics group, and Drs. G. Foxworth and W. Foxworth, D.V.M.s and Ph.D. candidates with the Reproductive Sciences Laboratory at TAMU, travelled to Kenya to participate in the ET research program. This experience provided valuable short-term training for U.S. students in international program activities.

• In March 1991, the resident scientist, Bonfance Mwandotto, the collaborating scientist, C.O. Ahuya, and farm manager, S.M. Mkuu, attended the SR-CRSP workshop in Nairobi.

• In December 1990, Dr. Mwandotto and Mr. C.O. Ahuya participated in the annual symposium of the Kenya Agricultural Production Society at Egerton University. At this meeting, Dr. Mwandotto relinquished the chairmanship of the society to Mr. O. Mwai of the University of Nairobi.

Other Contributions

U.S. Agriculture

• The genetic studies on *H. contortus* are of importance to the U.S. since losses in sheep and goat production in the U.S. were estimated at $45 million annually (Drummond et al., 1981).

• Because of the experience in developing the KDPG, a collaborative project has been discussed with Prairie View A&M to develop a goat meat industry for Texas due to increased demand by ethnic groups in Texas for goat meat.

Host Country

Linkage and Networking

• A one day workshop on embryo transfer (ET) techniques in goats was organized by Dr. Mwandotto and the Principal Investigator in June, 1991, to sensitize the Kenyan community to the technology. Participation was limited to 25 but was open to the KARI, University, and IARC communities. Proceedings are being compiled and distributed.

• In December 1990, Dr. Mwandotto participated in the first biannual conference of the African Small Ruminant Research Network in Nairobi where he presented a keynote paper on small ruminant research in Kenya on behalf of KARI. The proceedings are being compiled by ILCA. During this conference, the SR-CRSP Ol'Magogo site was selected as the field visit site by the conference participants with the RS and and Center Director receiving the delegates on site.

• A collaborative linkage was established with Dr. R.M. Waruiru of the Department of Parasitology of the University of Nairobi to conduct collaborative research into the genetics of resistance and resilience to infection by *H. contortus*. Linkages with the

Departments of Animal Production and Clinical Studies were formed to collaborate in research in fertility and to facilitate extension of SR-CRSP research via seminars the Animal Production Society of Kenya. Efforts to initiate collaboration with the Department of Animal Physiology regarding embryo transfer research were not successful.

• The Ol'Magogo SR-CRSP Breeding Project has now been integrated as a component of the overall breeding program of the NAHRC, Naivasha, along the lines of the dual purpose Sahiwal breeding project. The resident scientist, Mr. Mwandotto, assists with the coordination of other breeding projects on KARI centers.

• In both the Nakuru and Nairobi shows, the Breeding Project won the overall goat champion for the country taking six of the seven trophies for the Nairobi show. Mr. Ahuya represented the project and KARI at both shows and KARI supported both shows financially. These activities are making a great impact on producers in stimulating interest in the KDPG and in stimulating demand for bucks.

• The ET work was videotaped while in Kenya, and the potential exists for developing a SR-CRSP educational documentary of these activities.

• In January 1991, Mr. Mwandotto and Mr. S.M. Mkuu participated in the shooting of the SR-CRSP "Good News" video at Ol'Magogo.

• Collaboration with the Kenya Stud Book and Central Artificial Insemination Station was satisfactorily maintained.

• Regional contact with Sokoine University's Department of Animal Science in Tanzania was maintained with the invitation extended for a visit by Dr. Mwandotto.

• KARI's special interest in extending SR-CRSP research to the coastal zone prompted contact with the Mtwapa research Center and a revival of interest in the Ukunda Station. The December, 1991, resident scientists meeting was scheduled to be held at Ukunda.

Women in Development

• Ms. Elizabeth McDonald, from Jamaica and funded by the Jamaica Agricultural Development Foundation, has been recruited to TAMU to study towards a M.S. degree in small ruminant production commencing in the Fall of 1992.

• 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.

• Between October 12 and 18, 1990, Mr. Mwandotto, resident scientist, organized an itinerary and hosted the visit of Ms. Gretcha Flynn and Ms. Colleen McGarrity of Texas A&M University to visit the SR-CRSP program in Kenya. Ms. Flynn and McGarrity were the recipients of a grant to research the involvement of women in international agriculture. Ms. Flynn recently graduated with a Ph.D. in sociology from TAMU.

Collaboration with IARCS and other CRSPs

• A meeting was held during a visit to TAMU with Dr. Hank Fitzhugh, Director of Research for ILCA based in Addis Ababa, Ethiopia, concerning opportunities for extending SR-CRSP Kenya research technology through collaboration with ILCA. Areas of potential collaboration indicated by Dr. Fitzhugh included systems analysis of small ruminant production systems, genetics of disease resistance, and germ plasm conservation utilizing molecular approaches for distinguishing genotypic diversity.

• A meeting was held with Dr. Tony Juo of the Soil and Crop Sciences Department at Texas A&M University regarding integrating SR-CRSP and TropSoils CRSP technologies into sustainable agricultural systems. Dr. Juo expressed considerable interest in developing a joint program researching hill-side farming systems. Such joint ventures should be considered if the SR-CRSP were to become involved in Honduras.

• Dr. Francis Ruvuna visited Jamaica at the expense of the Jamaica Agricultural Development Foundation (JADF) to explore the possibility of joint research into small ruminants with Dr. McLaren, Assistant Director Research Program of JADF. The degree of interest is extremely high on the part of the Jamaican government into a buy-in on the SR-CRSP. To evidence this, JADF will fund a Jamaican graduate student to attend TAMU to study towards a M.S. degree in small ruminant production commencing in the Fall of 1992.

Support for Free Markets and Broad Based Economic Growth

• A total of 60 F1 and 25 KDPG bucks were produced for sale to farmers. The demand for bucks is high, particularly with the NGOs, and the sale price was not subsidized at KSh 1000 per buck.

Responsible Environmental Policies

• In order to facilitate the transfer of the SR-CRSP KDPG Breeding Project to KARI, it has been critical to develop a sustainable, low input, and low cost system for the provision of high quality feed to support the flock of 1,000 goats maintained at the Ol'Magogo Research Station. To achieve this, a fenced alfalfa plot has been developed which is now in production. Primary irrigation is by gravity feed with reticulation of water, and goat manure is used to fertilize the plot.

Collaborating Personnel

Kenya

•Bonfance Mwandotto, Research Scientist and Resident Scientist, TAES.
•R.M. Waruiru, Professor, University of Nairobi.
•C.O. Ahuya, Research Officer, KARI.
•S.M. Mkuu, Technical Officer, KARI.
•R.M. Waruiru, Professor, University of Nairobi.

United States

•Scott K. Davis, 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.
•F. Rurangirwa, Professor, Washington State University.

•T.C. McGuire, Professor, Washington State University.
•D. Jasmer, Professor, Washington State University.

Collaborating Institutions

•Kenya Agricultural Research Institute
•University of Nairobi
•Washington State University
•Prairie View A&M University

Publications

Refereed Journal Articles

Blackburn, H.D. and C.R. Field.1990. Performance of Somali Blackhead sheep and Galla goats in northern Kenya. Small Rum. Res. 3:539-549.

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marker (RAPD) in an analysis of susceptibility to Haemonchus and Coccidia infestation in goats. J. Anim. Sci. (Suppl.1) 69:2.

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Comments

I am extremely concerned by the limited progress of the project this year in producing sufficient numbers of KDPG does. The reason for the poor progress will be scrutinized in depth by a thorough examination of flock breeding, kidding, mortality, and culling records maintained at Naivasha when the PI is in Kenya for the PAC and workshop meetings planned for February, 1992. If an ET program cannot be made to work, I have great doubts as to the ability of the project to be able to develop a herd of 600-1,000 KDPG does in Kenya by the time of the planned phase out.

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Winrock International

Economic Analysis of Small Ruminant Production and Marketing Systems

Project Number: 116-12

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Narrative Summary
The economics project has analyzed several forage packages that have been developed to balance food crops with forages. Benefit cost rations were used to rank the various packages. Several studies were undertaken during the past year: a case study on DPG technology development; a comparison of data collected in 1986, 1988, and 1991 on trends in the numbers of livestock; and a study on cash income from the sales of DPGs.

Research

Problem Statement and Approach
Population pressure in much of Africa's highland and sub-humid zones is reducing average landholdings to a size where many farmers can no longer have sufficient land to support cattle herds which formerly provided rural residents with meat and milk. It is desirable to improve goat production to utilize the feed resources available to smallholder farmers and to contribute to family income and nutrition.

There are two promising strategies for the improvement of goat production in these areas:
- To develop a dual purpose goat as an improved source of milk and meat.
- To improve animal health by developing vaccines against contagious diseases.

To achieve these objectives, there must be an understanding of how small ruminants fit into smallholder farmer production systems so that appropriate technologies might be developed for them.

The development of a dual-purpose goat requires understanding the factors that determine farmer production strategies and the factors influencing businesses and government agencies which serve the producer. This requires investigation of animal health and management issues. Over 12 years of past research and interventions need to be assessed. In the area of animal health, economic constraints to the development of small ruminant vaccines are identified while herd management are carried out in western Kenya to identify the basis of goat farmer management decisions. The following activities were planned:

- Conduct an ex-post economic impact analysis of the project under alternative sets of assumptions in terms of inputs and time periods. Rank different production strategies and evaluate their viability.

- Using the linear programming model already developed, conduct input-output analyses based on alternative output and input mixes to assist in prioritizing research activities and

identifying the limits of production strategies.

• Conduct market analysis on small ruminants and products, gather information to establish a data bank, identify institutional and policy constraints, and prioritize research needs.

• Conduct gender analysis to identify constraints in production and marketing strategies. Insights from this research will be communicated to other disciplines in the project for incorporation in their agenda.

• Analysis of social and economic constraints to the development, production, and marketing of vaccines and identification of institutional support needs for successful incorporation of vaccination practices in production management.

Economic significance of crop residues and sesbania in support of dual purpose goat (DPG) production

Crop residues such as maize and finger millet stovers and bean haulms make significant contributions to animal diets on subsistence farms in western Kenya. The feeds need to ensure maximum milk and meat production while forages must be grown without reducing food crop yields. Over the years several forage packages have been developed by the feed resources team to alleviate the feed deficit. The economics project has analyzed some of these interventions using partial budgeting to evaluate their economic validity. Results were reported in papers presented in Africa and in Costa Rica.

In the past year, interventions subjected to economic analysis involved comparing forage yield from maize grown in monoculture versus intercropping maize with beans, finger millet, sesbania and pigeon peas in Masumbi village. Benefit cost ratios (BCR) were used to rank food crops and their residues as sources of feed for the DPG. Increased (or reduced) grain yields were also incorporated into the evaluation.

The maize/beans intercrop yielded the highest economic returns with a BCR of 21.2 followed by maize/finger millet with a BCR of 8.12; maize/pigeon peas ranked third with a BCR of 2.39, and maize/sesbania ranked fourth with a negative BCR of -0.84. These results confirm the farmers' practice of intercropping maize/beans as the most preferred (profitable) crop association in the village. Results also indicate that it costs Ksh 0.56, 0.65, 5.73, and 8.46 to produce an additional kg of dry matter of maize and finger millet stovers, sesbania, and pigeon peas with added returns per kg DM of Ksh 6.16, 5.91, 0.90, and 0.90 for each of the cropping regimes.

A reduction of establishment costs and a higher cutting frequency is likely to improve returns from the maize/sesbania intercrop. Establishment costs can be reduced by direct seeding without using polythene bags. Sesbania and pigeon peas forages should only be used as protein supplements in the DPG's diet due to the high crude protein content. Further analysis will be done to determine their profitability as protein supplements. The high economic returns from the maize/beans and maize/finger millet associations support the need for increased integration of these enterprises with DPG rearing.

Case study on DPG technology development and potential impact and adoption

As part of an on-going impact and adoption assessment study, a mid-year (July 1991) survey was conducted to collect data on key variables that could serve as indicators of impact and adoption. The survey elicited data on livestock species and numbers kept per farm, including the DPG, sales and value by species, marketing decisions and criteria for sale, home use of DPG products and other means of disposal. Data were also collected on purchases and(or) sales of manure and forages. Collection of data on manure use was motivated by several reports from participant farmers about its frequent use.

Trends in livestock numbers

Livestock data collected before distribution of the DPG to participant farmers (Rapid Rural Appraisal 1986 and 1988) represent major categories of livestock reared, including sheep, local goats, and cattle. The second period (July 1991) shows the most recent data for the same species including the DPG. A comparison of the two data sets suggest that, except for Rabuor village, all other villages registered declining livestock numbers per farm. Declining livestock numbers are possibly an indication of an increasing population which needs more land for food crop production at the expense of livestock. Further analysis is being carried out to verify the observed trend and to determine what role and to what extent the DPG has impacted observed variations.

Cash income from DPG sales

Small ruminants can be viewed as a "checking account" for smallholders in Western Kenya while large stock take on the role of a "savings account." DPG sales data from participant farmers indicate that the rate of sales is more than twice that of large stock. For the years 1989, 1990, and the first half of 1991, a total of 218 DPGs and 95 cattle were sold. In Hamisi and Masumbi, DPG sales contributed an average of 27% of revenues from livestock sales over the three-year period; in Muhanda, Rabuor and Lela, 31% of revenues from livestock sales came from DPGs. Thus, the DPG enterprise continues to make a significant contribution to the farm families' economic welfare. The most common reasons for selling an animal was to meet family living expenses (45%), or because the animal was unproductive (38%), old (36%), or sick (16%). Sales of animals for breeding were 21% of the total.

Due to small numbers of DPGs per household, not enough manure is generated to cater to home use and for sale although an insignificant proportion (5%) of farmers reported sale of a mixture of goat and cow manure. Some 10% of farmers reported buying manure and(or) compost.

Forage sales and purchases

About 18% of the farmers reported purchases of forages, mostly napier grass. Most purchases occur during the months of December to February, a period which coincides with the dry season. In Hamisi purchases occur for most of the year, that is February to July. Only 5% of the respondents reported selling forages from January to August.

Training

Short term

Dr. Nyaribo received a grant from IDRC to conduct a case study on farm level impact and adoption of the DPG and supporting technologies. The study served as one of three case studies from Africa that contributed to assessing animal production systems research. Results of the study were presented at the Global Animal Production Systems symposium held in San Jose, Costa Rica, September 15-22, 1991.

Dr. Nyaribo attended and presented a talk entitled "The Role of Social Scientists in a Multidisciplinary Research Team" at a training seminar for provincial and district livestock extension officers for Western and Nyanza Provinces. The seminar was held at Mabanga Farmers' Training Center, Bungoma, May 30-31, 1991. Dr. Nyaribo attended the Eastern and Southern Africa Pegional Workshop on Assessment of Animal Agriculture in Sub-Saharan Africa, November 28-30, 1990, ILRAD, Nairobi, Kenya.

Dr. Nyaribo attended the Annual Symposium of the Animal Production Society of Kenya (APSK) and presented a talk on Dual Purpose Goat Technology Development in Kenya, October 31-November 1, 1991, Kenya Science Teachers' Training College, Nairobi, Kenya.

Dr. Nyaribo participated in the annual field day for farmers and school children held at Maseno Veterinary Farm in June, 1991.

Collaborating Personnel

Kenya

- Dr. Fanny Nyaribo, Winrock resident economist posted at Maseno
- A. Nyongesa, KARI, Maseno
- N. Omondi, KARI, Maseno
- P. Kwoba, KARI, Maseno

United States

- Henk Knipscheer, Co-Principal Investigator, Winrock International
- Dr. Corinne Valdivia, University of Missouri
- Domingo Martinez, University of Missouri

Collaborating Institutions

Kenya Agricultural Research Institute (KARI), Kenya

Publications

Refereed Journal Articles

Nyaribo, F. B. and D. L. Young. 1991. The impacts of capital and land constraints on the economics of new livestock technology in Western Kenya. (Accepted for publication in the International Journal of Agricultural Economics.)

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Budget and General Comments

For the 1990/91 fiscal year, the economics program total subgrant funding amounted to $211,434 ($219,000 was budgeted). Winrock contributed $73,820 ($73,000 was budgeted). These resources proved insufficient to maintain a well-organized program in three sites and fund a resident scientist in each site. The amount of work and administration for the PIs makes it difficult to administer three sites.

In general, relations with the USAID Missions were good. Collaboration with host country organizations has been excellent.

Winrock International

Dual Purpose Goat Production Systems for Smallholder Agriculturalists in Kenya

Project Number: 117-12

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

Dual-purpose goat production systems in western Kenya must fit within the existing agricultural system and household unit. The environment includes relatively high rainfall, high population density, small land holdings, and the presence of other livestock, especially cattle. Early survey and on-farm research identified major constraints in the areas of feed resources; nutrition, especially insufficient dry matter intake; and management, especially internal parasite control. Because of the small land holdings and intensive land use, and the early rejection of introduced and more conventional technologies, it was determined that interventions associated with animal feed supply would necessarily need to be incorporated with human food production. Animal management options were identified which could be implemented in the face of shortages of cash available for supplies and equipment. On-station and on-farm research has now led to production packages which allow dual-purpose goats to be a viable part of agricultural systems in many parts of western Kenya. The production packages include the use of multipurpose tree species, suitable forage species in combination with food crops, exploiting the availability of a maize cultivar with a high frequency of double cobs, utilizing goat manure in the cropping system, cost-effective conservation of excess feed materials, exploiting sweet potato vines for kids, and strategic deworming and feed harvesting procedures to control internal parasites, especially Haemoncus contortus. Each of these packages has required several years of exploration, testing, and monitoring to reach the point where they can now be part of the overall system. Several interventions or materials which conventional wisdom suggested would work have been rejected for biological, economic, or social reasons. For example, the Multipurpose Tree (MPT) species *Calliandra calothyrus* comes highly recommended by many forestry and agroforestry specialists, and yet in whole-farm research conducted by the production system resident scientists it has had definite detrimental yield effects on adjacent rows of maize as compared to other MPT species.

Another example is the many forage grass and legume species that were rejected because of low dry matter yields or the requirement that they be grown as a separate crop on land being used to grow food crops.

And, a final example relates to the wisdom of using certain formulations of inorganic fertilizer for maize in the very acid soils in western Kenya. Normally

thought to be part of improved farming practices, the economic benefits were calculated to be marginal at best. Yet use of small amounts of goat manure proved to be very beneficial when used alone or in combination with the locally recommended inorganic fertilizer.

A model 0.5ha farm has been established by the scientists on the Maseno station, and several farmers have followed suit on their farms in the districts surrounding the station. These farms allow for continued on-farm research and observations of the results of whole packages of technologies which have as a major component the dual-purpose goat. Data are now being gathered to determine the degree to which these goat technologies are being applied to other farm livestock in western Kenya.

Research

Feed Resources

Problem Statement and Approach
The feed resources group has been challenged by the need to identify suitable feedstuffs for dual-purpose goats and to deal with the agronomic constraints of growing them as a part of the overall agricultural system. They have also had to do this on land areas which are small and intensively farmed with food and cash crops. The approach has been to look at the following: crops which can be used as a feed resource and human food crop and crops and plants which can be used as a feed resource and are beneficial in some way to food crops as well. Finally, we sought to identify forage crops which maximize yield per unit of area so little land is required.

This has been accomplished by working with farmers in identifying preferred crops, testing local germplasm in maize and sweet potatoes, introducing and testing several species of new feed resources, e.g., multipurpose trees and pigeon pea, and developing technologies for making use of advantageous species and cultivars easier at the farm level, e.g., planting techniques and seed bulking. All these things make it more feasible for farmers to accept the use of dual-purpose goats and to benefit from their outputs.

Progress
An agronomic system has been devised which enhances food crop yields and provides more than enough feed for four mature does and their offspring on an annual basis from only 0.5ha. When mated at appropriate intervals, four does can provide milk for the household on a continual basis. Numerous research papers have been presented and published which document the details of the results and make the information available to numerous others in Kenya and Africa with similar circumstances. The crops include maize, beans, sweet potatoes, elephant grass, and *Sesbania* or *Leuceana*. Goat manure is used as a source of soil nutrients and as a buffering agent for the acid soils.

Animal Nutrition and Management

Problem Statement and Approach
It was determined during the early stages of on-farm research that to allow goats to be more productive, it would be necessary to increase daily dry matter intake. Because most parts of western Kenya have relatively high rainfall and moisture during much of the year, most plant materials and

potential feedstuffs carry high moisture contents and low digestible energy levels. Energy levels were too low to support the potential rapid growth and higher levels of milk production in dual-purpose goats. In young animals the level of protein intake was also frequently below requirements, especially when part of the doe milk was taken for household use.

The energy situation was made even worse by the constant challenge from internal parasites for what energy was available. It was not economically feasible to increase energy levels by feeding large amounts of concentrates. Nor was much money available in local households to frequently purchase anthelmentics for use against the parasites. Therefore a feeding and management system had to be created to enhance economically intake of digestible dry matter and to establish a strategic plan for reducing parasite load.

Progress

A feeding and management system has been developed and tested through on-farm and on-station research in collaboration with several other resident scientists. It has been determined that kids can be weaned onto sweet potato vines as early as two weeks of age. These vines are very palatable and nutritious, and the tubers are an important food for humans.

Wilting of forages increases the relative energy value and also has the effect of reducing the number of live parasite larvae which are ingested by goats. Protein intake is enhanced by the use of leguminous tree leaves, either in the form of hanging branches or as dry leaf meal. These trees also provide fuel wood and soil nitrogen for crops grown near by. The feeding system includes several feed legumes since goats seem to do better on diets with variety.

The strategic use of maize parts during the growing season, e.g. leaves and tops, has also increased the availability of higher levels energy and protein from a forage source. Because the flush of growth in plants creates a surplus of feed during the rainy season, methods for conserving the excess have been identified and recommended to farmers. Progress has been made in developing a protein/mineral block using molasses, leaf meal, and other materials. Problems continue to be encountered because of the variation in the consistency of the molasses coming from the sugar processing plant.

Technology Package (Techpack)

Problem Statement and Approach

While many of the research results have been published in journals and presented at workshops, invitational meetings, or network meetings it remained problematic for the extension and outreach community to have easy access to the information in a usable form. Following numerous meetings and discussions it was decided that the best approach to getting the information out where it could be used and applied was to develop a series of informational and instructional packages with included useful information on ways to successfully keep goats in environments like many parts of Kenya. Patterson Semenye was designated coordinator of this effort which has involved all resident scientists and principle investigators.

Progress

This undertaking was more intense and time consuming than originally presumed. Nearly all work was done in Kenya; only final editing was done at Winrock International headquarters. By the end of 1991 the manuscript was complete and ready to go to the printers in Kisumu. The final product should be available by the end of February 1992 in time for the annual planning meeting. All technologies recommended by this Techpack have been developed and tested through the on-farm research conducted in Kenya. Information is available on breeding and development of the dual-purpose goat, feed resources, nutrition and management, health, economics, and social acceptance.

Training

In Progress

No degree training is being supported with S-CRSP funds allocated for production systems research. However, two collaborating scientists are studying for graduate degrees, through scholarships provided from other sources. Mr. Kenneth Otieno is working on a Ph.D. at Reading University, and Dr. Siamba is working on an M.S. at the University of Nairobi.

Short Term

No members of the production systems team attended short term training as participants. There were several short term training sessions that were given by the staff at Maseno. Most of these were for farmer groups.

Kenneth Otieno did attend (with Fanny Nyaribo) and participate in a week-long workshop in Botswana which included participants from several networks operating in Africa. The workshop was supported by IDRC. Otieno presented a paper on his work and experience at Maseno.

Contributions to U.S. Agriculture

The methods used and refined in the Kenya work can be just as effectively used in the U.S by agricultural researchers. These methods include on-farm research, farmer participation in research, and use of interdisciplinary research teams composed of biological and social scientists.

Successful development and acceptance of the dual-purpose goat as a critical component of new production systems suggests potential for export of high quality and healthy breeding stock from the U.S. for use in developing countries with large populations of local goats.

Several American graduate students and young professionals have been involved with the production systems research in Kenya. This experience in dealing with basic needs of the target audience has had the effect of creating U.S. scientists who know how to focus on real needs and to conduct animal research for the benefit of people. In 1991 the production systems group hosted and supervised for six weeks an intern from the Cornell University, College of Veterinary Medicine. She worked most closely with Dr. Semenye and stayed at the guest house maintained by such purposes at Maseno.

To Kenya and African Agriculture

The production system resident scientists participate in several networks,

including the African small ruminant network and AFRENA—an African network of agroforestry and development forestry practitioners. They maintain linkages with several other networks and individual scientists in the area of sustainable land use, feed utilization and pastures, and professional organizations. The principle investigator regularly interacts with researchers and development organizations with an interest in more efficient use of small ruminants in eastern and southern Africa.

The on-farm research and short-term training for farmers has had direct positive impact on women. SR-CRSP sociology research confirms that women are the gender most frequently involved with small ruminants. This involvement suggests that the financial benefits from sale of animal products as well as surplus feed supplies will accrue to women in western Kenya.

The production systems staff have regular communication and interaction with colleagues at international research centers such as ILCA, ILRAD, and ICRAF. Research conducted through the SR-CRSP has also had the effect of drawing additional funding from, for example, IDRC for the support of research with *Sesbania* spp. Much of the results and research techniques also have application to other SR-CRSP sites, and the principal investigator has made the point to offer assistance. For example, the emerging efforts to evaluate several MPT species in Indonesia have the potential to be guided by resident scientists from the Kenya site who are highly experienced in the matter.

On several occasions the resident scientists have served as resource persons at workshops or symposia. For example both Dr. Onim and Dr. Semenye participated as resource persons in a two-week farming systems research/livestock workshop held in Tanzania and contributed to the leadership of that workshop; they also served as resource-persons and coordinated selected field activities for a symposium on NGO involvement in agricultural research held in Kisumu. Dr. Onim served on a panel at a discussion session at the annual farming systems research and extension symposium in the U.S., and Dr. Semenye presented at paper at a colloquium held at Wye College in the U.K. Dr. Onim serves on the governing board of the International Association for Sustainable Land Use and invested about six weeks of time producing a reference chapter and serving as a resource person on the expert panel for the Africa portion of a global animal agriculture study funded by several international donor agencies. The title of his chapter was "Promising Interventions in Animal Agriculture to Improve Feed Supply and Quality."

Collaborating Personnel

Kenya

- Dr. Moses Onim, Agronomist, Feed Resources, Resident Scientist
- Dr. Patterson Semenye, Animal Scientist, Nutrition and Management, Resident Scientist
- D. N. Siamba, Collaborating Scientist, KARI (on study leave)
- K. Otieno, Collaborating Scientist, MOLD (on study leave)
- H. Ingati, Office Administrator, Maseno office

•M. Shisya, J. Kahumbe, and N. Otiende Technical Assistants
•F. Ochieng, Laboratory Technician

Collaborating Institutions

- Kenya Agriculture Research Institute
- International Center for Research in Agroforestry
- International Livestock Center for Africa
- International Development Research Centre

Publications

Mannasmith, C.H., M. J. Keens-Dumas, W.R. Getz, H.A. Fitzhugh, and A.E. Wilhelm. 1991. Comparative ewe productivity among selected hair sheep genotypes in the Caribbean: Preliminary assessments. In: Stephan Wildeus (Ed.) Proc. Symp. Hair Sheep Research, June 28-29, 1991, Hotel on the Cay, St. Croix. Agric. Exp. Sta., Univ. Virgin Islands, Kingshill, St. Croix, U.S.V.I.

Getz, W.R. and G.H. Mannasmith. 1991. Reproductive performance in a small flock of sheep grading up to Katahdin hair sheep in Arkansas. In: Stephan Wildeus (Ed.) Proc. Symp. Hair Sheep Research, June 28-29, 1991, Hotel on the Cay, St. Croix. Agric. Exp. Sta., Univ. Virgin Islands, Kingshill, St. Croix, U.S.V.I.

Abstracts and Presentations

Annual Small Ruminant Workshop, Feb 27-28, KETRI, Maguga, Kenya.

Onim, J.F.M., K. Otieno, and W. Getz. Border effects on maize grain yields by Leucaena, Sesbania, and Calliandra in alley cropping systems. Presentation at 8th Annual Small Ruminant Workshop. KETRI, Maguga, Kenya. Feb. 27-28.

Onim, J.F.M., K. Otieno, and W. Getz. Development of Maseno Double Cobber maize cultivar for high forage and grain yield. Presentation at 8th Annual Small Ruminant Workshop. KETRI, Maguga, Kenya. Feb. 27-28.

Semenye, P.P., D. Otieno, and W. Getz. Integration of dual-purpose goats with maize production. Presentation at 8th Annual Small Ruminant Workshop. KETRI, Maguga, Kenya. Feb. 27-28.

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Semenye, P.P, A.N. Mbabu, B. Mwandotto, F.B. Nyaribo, J.M. Onim, F. Rurangirwa. 1990. Research Highlights - Small Ruminant Collaborative Research Support Program: The Dual-Purpose Goat. First Biennial Conference, African Small Ruminant Research Network. ILCA, Kabete, Kenya. December 10-15.

Otieno, K., M.J. Bryant, J.F.M. Onim and J.A. Kategile. 1991. The effect of site and cutting frequency on forage yield from Sesbania sesban in western Kenya. Presentation at AFRNET Sesbania

Network Workshop. Jacaranda Hotel, Nairobi, Kenya. September 9-14.

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Onim, J.F.M. 1991. Sustainable agricultural production in crop-livestock system in western Kenya. Presentation at Farming Systems Research and Extension Symposium. Michigan State University, East Lansing, MI. October 7-12.

Additional Comments

This year has included activities aimed at reducing the level of effort of the production systems component of the Kenya SR-CRSP program. This has included a major reduction in support staff and casual workers, curtailment of on-farm activities, and increased efforts to analyze existing data and write-up results. Much of the effort has focused on finalizing data collection, organizing existing data, hosting visitors, analyzing data, and preparing documents and manuscripts. This trend will continue into 1992 when the research activities of the feed resources group at Maseno will cease completely.

Significant efforts have been made to work more aggressively with KARI in developing an on-going program for small ruminant research within the Institute. The resident scientists have participated in numerous meetings where this topic was on the agenda. They have worked most directly with the office of the KARI Deputy Director - Livestock Production.

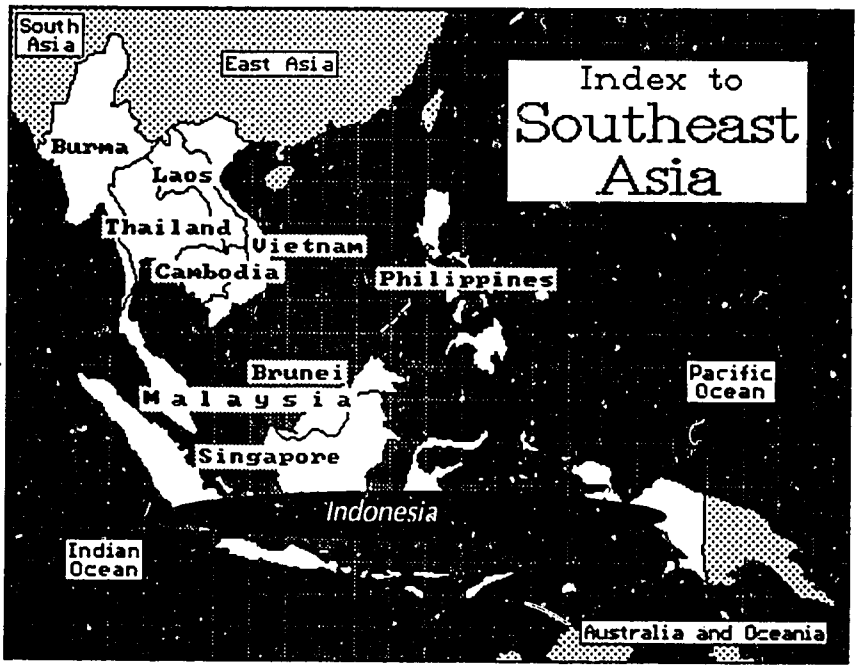
Hair Sheep Production Systems Component

"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)
Land use: 8% arable land, 3% permanent crops, 7% meadows and pastures, 67% forest and woodland, 15% other.
Population (1990): 189.4 Million
Population growth: 1.8%
Agriculture accounts for 26% of GNP, and 55% of workforce
Agricultural imports: $934,720,000
Agricultural exports: $2,528,270,000
Food and animals imported: $586,170,000
Food and animals exported: $1,439,250,000
Sheep: 5,415,000
Goats: 12,700,000
Mutton and lamb: 45,000 metric tons
Goat meat: 53,000 metric tons



University of California, Davis

Genetic Improvement of Sheep and Goats

Project Number: 101-12

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Narrative Summary

Research on hair sheep production under rubber plantations continued to focus on genetically removing wool produced by Indonesia sheep breeds by crossing with strains of hair sheep. In addition, special emphasis was given to the understanding and eradication of internal parasite problems.

Because internal parasites are an especially serious problem in warm, humid environments such as tree crop plantation areas of the tropics, a health component was added to the project investigating sheep grazing under rubber trees. Preliminary findings suggested that pure St. Croix animals have higher mortality rates than the local breed sheep due to the pancreatic fluke *E. pancreaticum*. The Tettigonidae family of grasshoppers was confirmed as a second intermediate host of this fluke, and a method was developed to count fluke eggs in feces. Studies are being implemented to devise means of overcoming this problem.

Research

Problem Statement and Approach

Because the wool produced by Indonesian sheep breeds is of poor quality and causes heat stress, the aim of this project was to genetically remove the wool by crossing with strains of hair sheep, such as the St. Croix (SC) sheep imported in 1985. Evaluation of the crosses among SC, North Sumatran Thin-tail (NS) and Javanese Thin-tail X NS animals continued, with plans to add the Barbados Blackbelly (BB), a hair sheep breed imported from Barbados, and Javanese Fat Tail (JFT) sheep from East Java to the project. In addition, a 50% hair sheep composite population is being produced by intermating SC X NS, F1's, and a pure SC population by mating the pure SC, 3/4 and 7/8 SC females to SC rams. The mating plan is shown in table 1.

Table 1. Mating Plan

	Ewes				
Rams	NS	JTT x NS[1]	SC x NS	"SC"[2]	Total
NS	100[3]	30			130
SC x NS			100[3]		100
SC	70	30		30	130
BB[4]	70	30			100
JFT	70	30			100
Total	310	120	100	30	560

[1] *Daughters of JTT rams from Cicadas involved in progeny test for F gene.*
[2] *All available pure, 7/8 and 3/4 SC ewes.*
[3] *As availability of animals and barn space permits, these groups should be increased in number to provide animals for nutrition and grazing trials.*
[4] *Artificial insemination.*

The NS X NS group will serve as a control, with which all of the other groups will be compared. The JTT x NS ewes are included because of availability. They are fairly similar to the NS ewes and will not be needed in the original project once they have been laparascoped twice. Weight will be recorded on lambs at birth and at monthly intervals up to six months, and it will be recorded on all other animals at three-month intervals except breeding ewes which will be weighed at each mating.

Earlier problems with low viability rates of pure SC ewes due to internal parasites prompted modifications in the breeding plans, resulting in the addition of a health monitoring and control program to the project. A collaborative agreement was signed with veterinarians at BALITVET and the James Cook University project in Bogor for development of a helminth control protocol for the Sei Putih Flock.

Progress

A flock of Javanese Fat Tail (JFT) sheep was purchased in East Java and taken to Sei Putih to be included in breed comparisons. Semen from Barbados Blackbelly sheep in Barbados was collected and frozen by USDA scientists. Mr. Martin Dally of UC Davis took this semen to Sei Putih and performed laparascopic inseminations on a total of 95 ewes. Lambing will begin in early March. These crossbred lambs, and lambs obtained from the other breeding groups, will then be compared for various traits, including their resistance tolerance to internal parasites, both helminths and flukes.

Due to the internal parasite problems encountered in the imported St. Croix breed and its crosses with the local sheep, an animal health component was added to the project. A study conducted by Dr. Prema Arasu of Cornell University on the pancreatic fluke infections was completed during the summer of 1991. The aims of this study were to determine if the local sheep were more resistant to *Eurytrema pancreaticum* than St. Croix sheep and to develop a method for counting fluke eggs in feces. Preliminary results suggest that St. Croix sheep and its F1 crosses may be more susceptible to the fluke infections than the local sheep. An examination by Dr. Ruth Gatenby, resident scientist in Indonesia, of approximately 80 grasshoppers from 12-15 species revealed that the long-horned green grasshoppers of the family Tettigonidae serve as intermediate host for the infection. A method was developed to count fluke eggs in feces. Based on these findings, the use of chemotherapeutic agents such as praziquantel or nitroxynil was suggested. These findings, as well as other alternatives, were discussed at the PAC meeting in Sei Putih. Studies on this issue continue under an agreement signed with the Indonesia International Animal Science Research and Development Foundation (INI ANSREDEF), headed by Dr. Alan Wilson.

Training

- Ismeth Inounu and Bambang Setiadi are enrolled in the Ph.D. program at Institute Pertanian Bogor.
- Natalie Bogui of Ivory Coast is continuing the analyses of sheep reproduction data at UC Davis. She is a candidate for an M.S. degree.

• Ismeth Inounu completed his M.S. studies at Institute Pertanian Bogor.
• Subandriyo completed his Ph.D. studies at the University of Missouri and returned to Bogor.
• Sagari Ramdas of India completed her M.S. studies at UC Davis and returned to India. Her studies were partially funded by the SR-CRSP.
• Raphael Sitomorang attended a course entitled "International Sheep and Lamb Management Course" held in Kuala Lumpur, Malaysia, July 1-14, 1991.
• Lahsen Derquoui of IAV, Rabat, is completing his doctoral dissertation using SR-CRSP data.

Other Contributions

To U.S. Agriculture

The SR-CRSP continues its significant contributions to research on small ruminants through the training of graduate students from the U.S. and the participating countries, as well as students from other non-participating countries.

To Host Country

The SR-CRSP research on hair sheep in North Sumatra is helping the U.S. and Indonesian scientists to understand better the constraints on introduction of new breeds. Work to date on the internal parasite problem in Sei Putih has attracted interest from other organizations for collaborative research.

During the 1990-91 project year, communication with the Malaysian Agricultural Research and Development Institute (MARDI) has continued, and the importation of Barbados Blackbelly (BB) semen from Barbados was realized. Technical assistance was provided to MARDI by UC Davis for the artificial insemination of Malaysian sheep using frozen BB semen.

A request for collaboration was received from the Prince Leopold Institute of Tropical Medicine in Belgium to submit a joint proposal to the EEC for the funding of a project to study the internal parasite problem in the Sei Putih flock.

Collaborating Personnel

Indonesia
Ruth Gatenby, Ph.D., Sei Putih
Luis Iniguez, Ph.D., Bogor
Subandriyo, Ph.D., BPT, Bogor
Ketut Sutama, Ph.D., BPT, Bogor
Ismeth Inounu, M.S., BPT, Bogor
Bambang Setiadi, M.S., BPT, Bogor
Bess Tiesnamurti, M.S., BPT, Bogor
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Endang Romjali, B.S., BPT, Sei Putih
Simon Sinulingga, B.S., BPT, Sei Putih

United States
Thomas R. Famula, Ph.D., UCD
Hakan Sakul, Ph.D., UCD
Nathalie Bogui, M.S., UCD
William Cushwa, M.S., UCD
Martin Dally, M.S., UCD
Curtis M. Finley, M.S., UCD
Dana Van Liew, M.S., UCD
Sagari Ramdas, M.S., UCD

Collaborating Institutions

Balai Penelitian Ternak, Bogor, Indonesia (BPT)

Publications

Papers Published

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Ginting, S.P., M.D. Sanchez, E. Romjali, R.M. Gatenby, and K.R. Pond. 1991. Supplementation of ewes in late pregnancy and early lactation. In: Annual Report, SR-CRSP Sungai Putih, North Sumatra, Indonesia. pp. 5-7.

Iniguez, L., G.E. Bradford, M.D. Sanchez, D.L. Thomas, E. Romjali, S.E. Sinulingga, and R.M. Gatenby. 1991. Productivity of Sumatra Thin-tail, Virgin Island and crossbred ewes. In: Annual Report, SR-CRSP Sungai Putih, North Sumatra, Indonesia. pp. 17-19.

Romjali, E., and R.M. Gatenby. 1991. What is the best litter size? In: Annual Report, SR-CRSP Sungai Putih, North Sumatra, Indonesia. pp. 23-27.

Romjali, E., I. Inounu, and R.M. Gatenby. 1991. Synchronisation of oestrus in ewes using progesterone-impregnated sponges. In: Annual Report, SR-CRSP Sungai Putih, North Sumatra, Indonesia. pp. 41-43.

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Wilson, A.J., I. Carmichael, R M. Gatenby, M. Hutauruk, and E. Romjali. 1991. Helminth parasitism in sheep grazing in rubber plantation in North Sumatra. In: Annual Report, SR-CRSP Sungai Putih, North Sumatra, Indonesia. pp. 47-49.

Theses

Ramdas, S. 1991. Lamb and wool production of Targhee and prolific breed crossbred ewes. M.S. Thesis. University of California, Davis.

Other Comments

The most important issues relate to continuity of the research programs. Termination of the Indonesian hair sheep program at this stage, as has been recommended by AID/Jakarta, would have represented a very serious loss; Indonesian scientists developing their research skills at SBPT/Sei Putih would have been left with totally inadequate support, and investment in importation of animals and semen would have been lost, as would a great deal of potential information of value related to grazing of sheep under tree crops. Expatriate scientist contracts wouldhave been terminated prematurely. It is fortunate that early termination of this project has been avoided.

University of Missouri-Columbia

Sociological Analysis of Small Ruminant Production Systems

Project Number: 105-12

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Narrative Summary

Due to difficulty placing a resident scientist in North Sumatra, the majority of work for the sociological analysis of small ruminant production systems continued in West Java through the efforts of collaborating scientists. However, projects undertaken by them dealt with larger issues applicable to the Sei Putih area. Previous research conducted by collaborating scientists in Indonesia emphasized the importance of women in small ruminant production (see Sabrani et al., 1981; Wahyuni and Gaylord, 1985; Priyanto, et al., 1989; Suradisastra and Wahyuni, 1990; Indonesian Technical Report #121). Other research has shown linkages to extension and found that other sources of information for improved small ruminant production are lacking (Hussein, 1986; Cernea et al., 1985, 1990-1991 workplan). Two separate work projects dealt with one or both of these issues in conjunction.

Extension information and services, when utilized at all, have traditionally been consumed by men. It has been recognized that women play an important role in small ruminant production, as well as having "different" networks than men, studying these networks as possible information transfer linkages was considered. The idea, though straight forward, has large implications. Because women play a large role in small ruminant production, they can perform an important role in providing information linkage to a traditionally underutilized area. In a baseline data collection, Wahyuni, et al., (1990), took the first steps in systematically evaluating the potential of these linkages as small ruminant information transfer mechanisms. This work is just beginning, and preliminary findings have been reported in the above working paper. Other efforts have been made to identify and organize potential groups of women for more detailed study.

Paul Mundy also began data collection for a Ph.D. His dissertation examines extension linkages in Indonesia and is funded by Iowa State University and sponsored by the SR-CRSP. His research is currently underway.

Another important aspect of the Hair Sheep component was the evaluation of traditional veterinary practices of small ruminant holders. This project was originally headed by Constance McCorkle. McCorkle consequently accepted a position with the Institute for International Research in Arlington, Virginia . The research from that time has been carried on by Evelyn Mathias-Mundy and others (Wahyuni, et al., 1991; Priyanto, et al., 1991). From March to November, 1991, Mathias-Mundy, a

veterinarian with some anthropological training, worked with the SR-CRSP sociology group in Bogor. She formed and coordinated a multidisciplinary team, which is necessary for ethnoveterinary research. Between May and October, 1991, the team studied ethnoveterinary practices of small ruminant holders in three villages around Bogor, West Java. The team examined how farmers prevent and treat livestock diseases; who holds information on animal health care; who treats animals; and which remedies are used.

An on-farm research site examining small ruminant production on nuclear estates was an important part of the sociology agenda for the Hair Sheep Component. Unfortunately many difficulties were experienced in establishing a site. With the rubber research institute taking the lead, a site was established in Ache District in Sumatra and work begun. However, due to civil unrest in the area, the site was abandoned in early 1991. A new site has been selected and preliminary work begun. An important component of this research was carried out, however, by Sri Wening Handayani (1991) in her Master's thesis. Sri examined peasant production systems in plantation areas in North Sumatra identifying key differences between different types of systems.

Research

Evaluation of Non-traditional Methods of Disseminating Small Ruminant Technology

Problem statement and approach
"To assess the potentials of rural women's groups for acting as an small ruminant technology transfer mechanism."

Progress
Women's need for better access to small ruminant production information is necessitated by the large role they play in small ruminant production. Yet information seems to bypass women in the information exchange linkages of current extension practices. Because women have different networks than men, they may prove to be a valuable source of information transfer. An evaluation of this potential was the focus of this activity. Information of small ruminant production techniques was to be made available to certain groups of women. Using a control group, the analysis was to evaluate if the information was transferred to other groups of women. To date, baseline data has been gathered to identify potential sample groups for the study. Preliminary baseline data showed women were aware of several breeding aspects of small ruminants like assisting in delivery and giving special treatment to post partum ewes and newborns. Yet, indicating the importance of getting small ruminant production knowledge to women, they showed relatively little knowledge in recognizing the signs of estrus, estrus cycles, gestation periods, pregnancy, and parturition. The report

also examined the demographic composition of three areas to see if they could serve as a potential study area.

Support for Sheep under Rubber on Nuclear Estates in North Sumatra

Problem statement and approach
"Via on-farm trials, to design and validate technology for raising sheep under rubber trees on nuclear estates."

Progress
Work started in the Ache District on Sumatra with the Rubber Research Institute taking the lead in the project. Facilities were already available in the Ache District. These were utilized by the project. However, the advantage of established facilities proved to be a disadvantage in their location as the Ache area experienced civil unrest. To protect the safety of those working on the project, the site was abandoned in early 1991. We are expecting some work reports from this abbreviated Ache experience to be forth coming. In the meantime, a new site has been selected south of the Sei Putih area and preparations are continuing to establish the on-farm research site there.

Small Ruminant Production Potentials in Plantation Systems of North Sumatra

Problem statement and approach
To identify the organization of labor within peasant households with regard to labor processes in housework and on-farm activities, differential participation in the labor market, the division of labor within the peasant household, and household constraints (e.g., land, labor, capital, and information) to increasing agricultural productivity.

Progress
Three villages were identified in the sub-district Galang in North Sumatra. Each village represents a different type of peasant household production system: landless households; subsistence households; and semi-commercial households. A random sample procedure was used to select households in the three villages. Interviews were then conducted with male and female heads of households. Findings show landless heads of households have a higher percentage of nuclear family members compared to the other two types. Larger/extended families in semi-commercial households create greater household production potential. This is because they own land that can be worked by the family and profits directed back to the family. For landless and subsistence families, lack of land ownership means household production is increasingly dependent on selling their labor to estate companies. In all three types of household production systems, women play key roles. In subsistence and landless households, women's activities often take them from the farm to seek income. In semi-commercial households, women are engaged in more on-farm activities. Children also play an important role in all three production systems. In landless and subsistence systems children often sell their labor or even migrate to help the family. In semi-commercial systems, children engage in more on-farm activities, relieving their parents from more menial tasks. This allows the adults to work at more productive tasks. In essence, access to the means of production (land, labor, and capital) greatly determines labor allocation for peasant household production.

Wening's thesis is being used as a baseline to further the on-farm research studies in the new site.

Information Needs of Extension Agents in Indonesia

Problem statement and approach
"To detail the information needs of extension specialists in Indonesia and to design and evaluate a program to fulfill those needs."

Progress
Paul Mundy has finished gathering data for his dissertation. He is still in the process of analyzing the data. We are expecting some working papers and the final dissertation to be completed later this year. Paul has interviewed extension specialists to determine their information sources, their reasons for using those sources, their information needs, and the best way to meet those needs. In addition to these interviews, he used a mail questionnaire which he sent to a larger sample of extension specialists to confirm leads from the interviews. The questionnaire itself was constructed from information obtained in the interviews.

Ethnoveterinary Research in the SR-CRSP/Indonesia

Problem statement and approach
1) To complete an annotated bibliography on ethnoveterinary medicine pertaining to herd animals in southeast Asia generally.

2) To identify promising local methods of treating and preventing livestock disease—in particular, ectoparasitism of Indonesia's small ruminants based on information gleaned from the annotated bibliography and from interviews with experienced researchers plus field work with expert farmer informants. In the process, the Sociology Project will train SR-CRSP scientists and researchers in techniques of ethnoveterinary field research.

3) To critically analyze these findings in terms of their technological validity, socioeconomic feasibility, and ecological sustainability so as to generate recommendations for further research into specific therapies, prophylaxes, and animal health practices via, e.g., laboratory analysis of the action and efficacy of indigenous botanical, clinical trials on-station, and adaptive trials on-farm of actual or improved local techniques and treatments.

Progress
To date, one annotated bibliography has been completed by Evelyn Mathias-Mundy and Constance McCorkle. This was published in 1989. During the Indonesian phase of the project Constance received an offer to work for the Institute for International Research in Arlington, Virginia. She accepted the position and has consequently left the SR-CRSP. However, work continues in Indonesia conducted by Mundy and other collaborating scientists. In a study in Cinangka, a village close to Bogor, Wahyuni et al. found farmers relied more on traditional veterinary practices than modern drugs and services. This was the case even though they were very close to modern veterinary facilities and information in Bogor. Men appeared to be more knowledgeable about traditional treatments and cures than women. Often, actual practice did not coincide with stated practices in animal health activities. Finally, in

conjunction with veterinarians and biologists, the research team documented several cases of disease in the sheep population of Cinangka. They asked farmers about these diseases and how they were treating them.

A study of three villages revealed that most animals were in sufficient to good condition, although differences between villages were observed. Sheep and goats which were kept totally confined in raised slatted floor barns had lower mortality rates of newborns than did those which were permitted to graze. The main diseases observed by the team were diarrhea, scabies, and eye diseases like pink eye. Most farmers considered their animals to be relatively healthy. Collectively, the farmers distinguished at least 20 different disease conditions. These were treated with a wide range of drenches, ointments, and other medications derived from at least 50 plants, including trees, vegetables, and grasses as well as other ingredients. Farmers often did not treat sick animals but sold or slaughtered them instead. Their decision seemed to be based on whether the disease was acute and directly life-threatening or chronic. Results of the study showed traditional health practices could be effective in reducing parasitic burdens and preventing certain diseases such as maggot infestation of wounds. Infectious diseases seemed to be less important constraints than nutritional factors.

Training

In progress

Sri Wening Handayani, Ph.D. Rural Sociology. Anticipated, December 1994. University of Missouri-Columbia.

Completed

Sri Wening Handayani, MS. Rural Sociology, University of Missouri-Columbia, May 1991.

Short-term

Evelyn Mathias-Mundy, Ethnoveterinary studies in Indonesia. Together with Dr. Tri Budhi Murdaiti from RIAP, Mathias-Mundy edited the proceedings of an Ethnoveterinary Seminar presented at the Faculty of Animal Science, Bogor Agricultural University, April, 1991. She also assisted the sociology group in writing up the data from the ethnoveterinary research. Much of this research concentrated on the role of women in livestock production. Paul Mundy, a specialist in development communication and temporarily associated with the SR-CRSP, assisted in this. He taught the sociologist team some basic skills in research design, data analysis, and the use of the SPSS computer statistics program.

Other Contributions

Women in Development

Working paper No. 121 by Wahyuni et al., 1990.

Suradisastra, K. and Sri Wahyuni. 1990. "The Significance of women in small scale sheep farming activities in West Java." *Proceedings of the First National Workshop on Women in Rice Farming System in Indonesia.* April 6, 1989. Central Research Institute for Food Crops and International Rice Research Institute, Agency for Agricultural Research and Development, Bogor Indonesia. AARD, CRIFC, IRRI.

Wahyuni, Sri and Agus Suparyanto. 1991. "Changes in women's Small Ruminant Management and Impact on family labor patterns." Paper presented at the International Seminar on Livestock and Feed Development in the Tropics, Brawijaya University Malang, 21-25 October, 1991.

Wahyuni, Sri. 1990. "Sociological variables influencing women's roles in smallholder farming systems." Paper presented at the Asian Farming System Research/Extension Symposium, Bangkok Thailand, November 1990.

Collaborating Personnel

Indonesia
Sri Wening Handayani, Collaborating Scientist
Tri Budhi Murdiati, Collaborating Scientist
Sri Wahyuni, Collaborating Scientist
Dwi Priyanto, Collaborating Scientist
Agus Suparyanto, Collaborating Scientist
Isbandi, Collaborating Scientist
Beriajaya, Collaborating Scientist
Harini Sangat-Roemantyo, Collaborating Scientist

United States
Michael F. Nolan, Principal Investigator
Constance M. McCorkle, Collaborating Scientist
Evelyn Mathias-Mundy, Collaborating Scientist
Paul Mundy, Collaborating Scientist
Sibylle Scholz, Resident Scientist (Economics)

Collaborating Institutions

- University of Missouri-Columbia
- Coordinating Research Institute for Animal Science (CRIAS)
- Research Institute for Animal Production (RIAP)
- Winrock International

Publications

Books and Book Chapters

Suradisastra, K. and Sri Wahyuni. 1990. "The Significance of women in small scale sheep farming activities in West Java." *Proceedings of the First national Workshop on Women in Rice Farming System in Indonesia.* April 6, 1989. Central Research Institute for Food Crops and International Rice Research Institute, Agency for Agricultural Research and Development, Bogor Indonesia. AARD, CRIFC, IRRI.

Theses and Dissertations

Handayani, Sri Wening. 1991. *Peasant Household Systems in North Sumatra Plantation Areas.* Masters Thesis. Rural Sociology, University of Missouri-Columbia, May, 1991.

Manuscripts Submitted or in Press

Wahyuni, Sri. 1991. "Social structure of small ruminant farm families." in SR-CRSP Indonesia Tech Pak, 1991. *Current Issues in Sheep Production and Management in West Java, Indonesia.*

Wahyuni, Sri, Patrick J. Ludgate, and Michael F. Nolan. 1991. "Dissemination of small ruminant production information." in SR-CRSP Indonesia Tech Pak, 1991. *Current Issues in Sheep Production and Management in West Java, Indonesia.*

Mathias-Mundy, Evelyn, and T.B. Murdiati (eds.) 1991. *Traditional Veterinary Medicine for Small Ruminants in Java.* Indonesian Small Ruminant Network and Small Ruminant-Collaborative Research Support Program, Balai Penelitian Ternak, Bogor, Indonesia.

Technical Communications/Working Papers/Project Reports

Wahyuni, Sri, Tri Budhi Murdiati, Beriajaya, Harini Sangat-Roemantyo, Agus Suparyanto, Dwi Priyanto, Isbandi, and Evelyn Mathias-Mundy. 1991. "The Sociology of Animal Health: Traditional Veterinary Knowledge in Cinangka, West Java, Indonesia. A Case Study." Project Final Report, Bogor Indonesia.

Priyanto, Dwi, Agus Suparyanto, Isbandi, Sri Wahyuni, Tri Budhi Murdiati, Evelyn Mathias Mundy. (eds.) 1991. [Traditional Veterinary Knowledge of Small Ruminants and its Applications. (A Case Study of Two Villages in Bogor District.)] *Pengetahuan Veteniner Tradisional Peternak Domba/ Kambing dan Aplikasinya. (Studi Kasus Dua Desa di Kabupaten Bogor).* Ciawi, Bogor.

Wahyuni, Sri, D. Priyanto, A. Suparyanto, P.J. Ludgate, and T.D. Soedjana. 1990. "Baseline data for research regarding the sociological impact of women focused strategies for improving small ruminant production." Working Paper No. 121 (November) 1990. UMC-Rural Sociology

Wahyuni, Sri, P.J. Ludgate, and Michael F. Nolan. 1990. "Dissemination of small ruminant production information in OPP villages in the Bogor district of West Java." Project Paper 1990. UMC-Rural Sociology

Joint UMC/Winrock Working Papers

Tjeppy D. Soedjana, Elianor Sembring, and Manuel Sanchez. 1990. "The Outreach Project (ORP) Evaluation in Sei Putih, North Sumatra." Working Paper No. 119 (October) 1990. UMC-Rural Sociology/ Winrock International.

Ludgate, Patrick J. Tjeppy D. Soedjana, Atien Priyanti, and Henk C. Knipscheer. 1990. "Farmer Oriented Research Yield Innovative Communication Technologies for On-Farm Research in West Java." Working Paper No. 120 (October) 1990. UMC-Rural Sociology/Winrock International.

Abstracts and Presentations

Wahyuni, Sri and Agus Suparyanto. 1991. "Changes in women's small ruminant management and impact on family labor patterns." Paper presented at the International Seminar on Livestock and Feed Development in the Tropics, Brawijaya University Malang, 21-25 October, 1991.

Paul Mundy. 1991. "The Role of indigenous knowledge and indigenous communication in development." Ethnoveterinary Seminar presented at the faculty of Animal Science, Bogor Agricultural University, April 1991.

Wahyuni, Sri, Patrick Ludgate, and Kedi Suradisastra. 1990. "Group dynamics study with outreach pilot project farmers in the Bogor District of West Java." Paper presented at the Asian Farming System Research/ Extension Symposium, Bangkok Thailand, November 1990.

Wahyuni, Sri. 1990. "Sociological variables influencing women's roles in smallholder farming systems." Paper presented at the Asian Farming System Research/Extension Symposium, Bangkok Thailand, November 1990.

Comments

A resident scientist was identified for long term location in North Sumatra (Ralph Brown). To date, the project has been relying on collaborative help from the economics portion in Sei Putih. The presence of a resident scientist was crucial to the carrying out of work plans and agendas. However, due to an attempt by the USAID Mission Director in Jakarta to terminate the SR-CRSP project in Indonesia, we were unable to place Ralph and his family there. This has severely hampered our efforts in Indonesia. We are waiting for a resolution to the problem before we can proceed with placing a resident scientist there. Additionally, due to the extended delays, Ralph is pursuing other job opportunities. Even if the Indonesian situation does clear up, we may have to conduct another search for a resident scientist if Ralph finds other employment before then.

North Carolina State University

Feed Resources and Nutrition of Small Ruminants

Project Number: 107-12

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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 and supplementary feeding. Complementary work in the United States focused on evaluation of extremely shade-tolerant forage species and evaluation of hair sheep breeds for use in the Southeastern United States.

The evaluation of grasses and legumes that are shade tolerant and capable of surviving and providing good quality forage for sheep grazing under plantation tree crops completed its second year. These promising grasses and legumes planted in monoculture or in association have all persisted in spite of 30-40% reduction in light penetration caused by the rubber tree growth. Highest yields continue to be from *Panicum maximum, Setaria splendida* and *Paspalum dilatatum*. The legume *Stylosanthes guianensis* competes well and successfully grows in association with grass.

Computers that measure the grazing behavior of sheep were used to examine traditional grazing management. Sheep generally are allowed to graze between 8:30 and 15:30 and then placed back in the barn. Other farmers may only graze sheep for part of the afternoon. It was determined that either system did not allow sufficient time for adequate intake of forage. These systems also force animals to graze during the hottest part of the day. Alterations in total grazing time and/or time of day that grazing occurs will be researched.

The herbaceous dicot *Asystacia intrusa* was identified as the most shade tolerant and highest quality forage available for growing under rubber trees. However, because of its rapid spread, all work involving *Asystacia intrusa* at the research station in Sei Putih was eliminated. Work in the greenhouses at North Carolina State University indicate that *Asystacia* is extremely shade tolerant. The physiological mechanisms for shade tolerance have been identified. The quality of the forage is extremely high (Crude Protein >19%) and in many respects is higher quality than alfalfa.

Evaluation of the breeds of hair sheep for use in the Southeastern US indicate that they are able to breed in the spring for fall lambing. The reproductive performance of the Barbados Blackbelly and the Dorset, Blackbelly cross are consistently the most prolific sheep in the Southeastern U.S. environment.

Research

Objectives

1. To characterize the nutritional value of locally available feedstuffs for small ruminants
2. To develop guidelines for formulation of nutritionally and economically optimum diets, especially at critical stages of the production cycle
3. To develop forages and strategies for grazing sheep under plantation tree crops.

Problem Statement and Approach

Sheep in Indonesia are integrated into farming systems of small holders and integrated into plantation cropping. In highly populated and in many village areas, sheep are kept by small farmers. In some cases they 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 into tree crop plantations to utilize the forage under the tree canopy thereby reducing mowing and herbicide costs. Lack of quantity and quality of feed is the major problem in both systems. Recent research in North Sumatra has focused on the problems associated with grazing, and it has concentrated on the agronomic and chemical evaluation of native and introduced forage grass and legume species, while also investigating the nutritive value of locally available supplemental feed and supplementation strategies for productive sheep. New technologies have been developed and tested with on-farm evaluations.

Progress

Introduction of forage species and their persistence in new rubber plantations.

Justification

The introduction and evaluation of forage grasses and legumes for eventual use under rubber trees began in January 1988. More than 50 accessions from Indonesian, Malaysian, and Australian sources were planted in replicated plots and their performance compared in full sunlight. Observations were made on growth, recovery after harvest by hand cutting or grazing, persistence, nutritional quality, resistance to diseases, and insects. The best of these introductions were established under new rubber trees and are being evaluated by cutting and grazing. The objective of this long term study is to access the productivity and persistence of these forage species under increasing levels of shade.

Progress

In 1988, several species of grasses and legumes were planted in either monoculture or in combination in three blocks. Of the original species established all continue to persist. In October 1990, *Asystacia intrusa*, a herbaceous dicot, was removed from the study and exterminated from the neighboring area. A local variety of Asystacia was planted in its place.

Asystacia, a very shade tolerant and highly reproductive specie, has been eliminated to avoid the introduction to neighboring fields and to avoid the harvesting by locals farmers and transport outside of the study area.

Monthly, five 1M² quadrats were harvested from each plot. Samples were dried and weighed, and yield (tons DM/ha) was computed. The average production per month of the forage grasses and legumes growing in monoculture (table 1) indicated that the highest yields were from *Panicum maximum, Setaria splendida,* and *Paspalum dilatatum.* The lowest yields were from *Cyrtococcum acreascens, Setaria palmifolia,* and *Brachiaria mutica.*

Yield of the grasses and legumes grown in association (table 2) indicated that *Stylosanthes guianensis* was the most competitive legume but still only contributed 24% of the total DM production. The average yield of *Pueraria javanica, Stylosanthes guianensis,* and *Cetrosema pubescens* in association averaged .35, 172 and .25 ton/ha/month, respectively.

Table 1. Dry matter production of grasses and legumes grown in monoculture (Averages t/ha/month).

Grass	Yield	Legume	Yield
Brachiaria decumbens	2.44^{bcd}	Calopogonium muconoides	1.19^{ab}
Brachiaria humidicola	2.09^{abc}	Centrosema plumieri	1.32^{ab}
Brachiaria mutica	1.44^{a}	Centrosema pubescens	1.26^{ab}
Cynodon plectostachyus	1.52^{a}	Clitoria ternatea	0.94^{a}
Cyrtococcum acrescens	1.33^{a}	Pueraria javanica	1.34^{ab}
Ottochloa nodosa	2.39^{bcd}	Stylosanthes guianensis	2.47^{c}
Panicum maximum (var Hamil)	3.00^{d}	Stylosanthes hamata	1.59^{b}
Panicum maximum (var Tricogylum)	3.21^{d}		
Paspalum conjugatum	1.54^{a}		
Paspalum dilatatum	2.92^{cd}		
Setaria palmifolia	1.44^{a}	*Values with different letters*	
Setaria sphachelata	2.05^{ab}	*within each column are*	
Setaria splendida	2.53^{cd}	*different (P<.05).*	

Table 2. Production of grasses and legumes grown in association (t DM /ha/month)

Legume	Grass	Grass	Legume	Total
Pueraria javanica	Paspalum dilatatum	2.91^{bc}	0.13^{a}	3.04^{b}
	Panicum maximum	2.00^{ab}	0.46^{abc}	2.46^{ab}
	Ottochloa nodosa	2.03^{ab}	0.32^{ab}	2.35^{ab}
	Setaria splendida	2.20^{ab}	0.50^{abc}	2.70^{ab}
Stylosanthes guianensis	Paspalum dilatatum	3.01^{c}	1.04^{d}	4.05^{c}
	Panicum maximum	2.62^{b}	0.70^{cd}	3.32^{bc}
	Ottochloa nodosa	2.08^{ab}	0.55^{bc}	2.63^{ab}
	Setaria splendida	1.64^{a}	0.60^{bc}	2.24^{a}
Centrosema pubescens	Paspalum dilatatum	2.48^{b}	0.25^{ab}	2.73^{ab}
	Panicum maximum	3.35^{c}	0.20^{ab}	3.55^{bc}
	Ottochloa nodosa	1.96^{a}	0.25^{ab}	2.21^{a}
	Setaria splendida	2.10^{ab}	0.30^{abc}	2.40^{ab}

Values with different letters within a column are different (P<.05).

Light measurements were taken in full sun and under the tree canopy to give an indication of the photosynthetic active radiation (PAR) that is available to the forages under the rubber trees. Stylosanthese guianensis was the highest yielding legume.

The PAR values for full sun and under the tree canopy of the three blocks (table 3) indicate 38 to 57% of the sun's PAR was intercepted by the rubber tree canopy. This increased shading occurs more rapidly than originally anticipated.

Table 3. Penetration of sunlight through the rubber tree canopy at two years of age (June 1991).

	Light intensity (µmol quanta s^{-1} m^{-2})		
Block	Full sun	Shade	Ratio (%)
A	1250±187	780±500	62
B	1320±235	760±370	58
C	1160±255	495±154	43

It is expected that persistence of the forage species will reduce rapidly as the rubber tree canopy increases thereby reducing the radiation reaching the forage.

Asystacia intrusa: A Very Shade-Tolerant Species

Justification

Asystacia 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). Several things need to be learned about *Asystacia* before it is evaluated on a large scale. The existence of other *Asystacia* species in North Sumatra needs to be investigated.

- Botanical survey of varieties in North Sumatra, including location and types, should be completed. To control its growth, it is important to know how to kill it (herbicides to use, seed hardness, and vigor).

- Spreading potential, length of time to seed set, quantity of seeds produced/area, longevity in soil, spread by the animal through feces, etc. are all questions to consider. There is also concern that it may be a nitrate accumulator.

With answers to these questions we will be able to evaluate its potential benefit/hazard more effectively.

Progress

Asystacia intrusa was the most shade tolerant forage evaluated in North Sumatra. However, its potential problems as a noxious weed led to the decision to eliminate it from the research site and shift work to North Carolina State University greenhouse and phytotron.

A botanical survey identified three species of *Asystacia* (including *intrusa*) that were found in a 50 km radius of the research station. These have been collected by Tuti Kuslyanti and are being cultivated in the green house and experimental plots at the Rubber Research Institute.

Asystacia intrusa is a fast growing plant with high seed production and ability to vegetatively propagate. The seed coat is

very hard and longevity of survival in the soil is high. The herbicide glyphosate is effective in control but residual seed requires persistent control measures to kill new seedlings.

Although an effort to kill out all stands of *Asystacia* on the station has been in effect since October 1990, isolated plants are still killed weekly.

A yellow flowering *Asystacia* has been identified in a stand of new rubber trees at PTPV and it is the dominant forage in that area.

Work at NCSU is continuing on *Asystacia intrusa*. See section on supporting work in the United States.

Grazing Sheep Under Plantation Crops

Justification
Traditional grazing management utilizes sheep with a shepherd for 4-8 h/d 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 the optimal combination of grazing and cut and carry is. By logging grazing/biting with computers, this information will be collected and used to determine relationships of grazing time and need for cut and carry forage.

Allowing sheep to graze on a 24 h basis (not corralled in a barn at night) has not been attempted because of theft. On large plantations, the construction of barns is expensive, and barns cannot be moved. Utilizing shepherds 24 h/d and allowing sheep to have access to grazing for longer times may result in improved performance. Plots fenced with electric fencing will be used with shepherds to determine the feasibility, and, if feasible, a system will be developed 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 increases (shade increases). Depending on land area available, a replicated trial with each forage as a treatment will be established. Measurements will consist of per animal and per hectare gains, herbage mass, canopy structure, leaf area, and quality of the canopy constituents.

Progress
The grazing behavior of sheep was monitored by specialized computers that sense the jaw movements of sheep. These computers were modified to be used on the Sumatra thin-tail. The active grazing time was determined while ewes were feeding under rubber trees during the whole day (8:30 - 15:30) or only in the afternoon (12:30 - 15:30). Eight Sumatra thin-tail ewes (~23 kg) grazed under the same trees for either all day or only in the afternoon. Halters and computers were fit to sheep and utilized to measure feeding time. Results indicated that the active feeding time for ewes grazing the whole day averaged 3 h 11 min (45% of the time) and averaged 2 h 10 min (72% of the time) for the ewes grazing in the afternoon only.

The current system for grazing is for shepherds to allow sheep to graze between 8:30 and 15:30. There are several problems with such a system. The time allowed for grazing is not sufficient for adequate feed intake and

the forage available is generally medium to poor quality. Shepherds follow the sheep in the general area rather than control where the sheep graze. Sheep also are forced to graze during the hottest part of the day, whereas if they were allowed to graze full time, the peak time of grazing would occur shortly after daybreak and close to sundown.

From these grazing time measurements it is clear that intake is being restricted to less than ad libitum. Therefore, positive response to concentrate supplementation would be expected.

Allowing the sheep to graze 24 h/d should be advantageous to increasing the time available for eating and thereby improving intake. Construction of a portable barn to be used by sheep grazing 24 h/d was in the work plan. However, it proved to be too expensive. In addition, another permanent barn was needed to house the increasing number of sheep involved in the hair sheep work. Therefore, experiments on grazing 24 h/d were delayed until pasture and barn facilities were available.

Larger long-term studies with the most promising forages need to be completed on areas of new rubber establishments. Areas for establishing new forage species with new rubber have not yet been assigned by the Rubber Research Institute. This experiment will be initiated when the Rubber Research Institute identifies the appropriate area.

Outreach Pilot Project

Justification

Outreach research collaboration with local villagers and all the scientists of the SR-CRSP has been quite effective in increasing communication between scientists and allowing field testing of new technologies. The collaborative research projects remain very cost effective.

Progress

The Outreach Pilot Project has continued in the Galang district of North Sumatra. Support for continued interaction among scientists and for continued monitoring has been provided. This project allows the scientists to try to adopt new technologies for incorporation at the farm level and also allows the scientists to stay current with problems in the field and with innovations made by the farmers. It is also helpful for visitors to the SR-CRSP to view how relevant our work is to people's needs in the field and allows cooperators to have a farmer group to discuss ideas and monitor progress of individual flocks.

By-product Feeding to Maximize Lamb Growth

Justification

During the last several years, many feed by-products have been evaluated as potential feed sources for lambs fed to market weight. Daily rates of gain of most lambs is less than 30 g/d. With supplementation of energy, protein and/or minerals growth rates of 2-3 times the average are possible. From experience with feeding palm kernel cake, broken rice, rice bran, rubber seed, molasses, urea, and minerals, rations

can be developed that maximize lamb growth with economically affordable feedstuffs. Such rations need developing and testing to improve performance and reduce cost of gain.

Progress

The most sustainable and economically viable alternative feedstuffs for lamb feeding appears to be legume trees. In preliminary studies, weight gain improvement has been highest utilizing the tree legume *Gliricidia.* Other tree legumes offer potential as a high quality protein source. Initial work with farmers associated with the Outreach Pilot Project indicate farmers are willing to plant, cultivate, and utilize tree legumes. Therefore, the tree legumes *Gliricidia sepium, Calliandra callothyrsus, Albizia falcataria,* and a local variety of *Acacia* have been planted in a one-hectare plot. Production from this planting will be utilized for lamb growth trails and a nursery will be maintained. Promising legume trees will be supplied to the Outreach Pilot Project participants as appropriate. Planting occurred in September and harvesting should begin in March 1992. With this large tree legume base, sufficient quantities will be available for thorough testing.

Supporting Research in the United States

Justification

- Shade tolerance and quality of *Asystacia intrusa:* Research in Sei Putih, Indonesia, has shown that the weedy herbaceous dicot *Asystacia intrusa* has an unusual tolerance for low light. This species has shown promise as a forage crop that persists in plantation crops longer than other available species because of its tolerance for shading. The NCSU greenhouses and Phytotron offer a controlled environment to study the mechanism of shade adaptation in *Asystacia intrusa.*

- Shade tolerance of *Arachis* supp: The perennial peanut is a valuable forage legume in some subtropical and tropical agricultural systems, but it is not currently in use in the rubber plantations of Indonesia. Forage species used in the rubber plantations persist as the trees mature if they are shade-tolerant. Germplasm of ten seeded and ten vegetatively reproduced lines of *Arachis* spp. were obtained through linkage with the Peanut CRSP. These potentially valuable lines can be effectively screened in the NCSU facilities for shade tolerance. Lines with greater shade tolerance will be 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: Tropical grass and legume germplasm are being evaluated for use in rubber tree plantations by either grazing or harvesting as "cut and carry." 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. Forage samples will be taken at specific physiological stages, dried, ground, and sent to NCSU for fiber fractions and nitrogen determinations and assayed for in vitro dry matter disappearance.

Progress

Asystacia intrusa - a potential forage under plantation tree crops. Asystacia intrusa is a herbaceous dicot that was the most shade tolerant and had the highest quality of all the species evaluated in Indonesia. However, it is considered to be a noxious weed in Malaysia because of its rapid growth and reproduction (from seed and vegetatively). *Asystacia intrusa* is a unique plant species that could be an important source of protein for ruminants. However, to avoid the uncontrollable spread of this plant, the decision was made to kill the experimental plots in Sei Putih and shift the evaluation of *Asystacia intrusa* to the greenhouse and phytotron at North Carolina State University. Detailed characterization of its shade tolerance, physiology, and chemical composition were completed.

Shade tolerance and plant physiology of Asystacia intrusa. To conduct physiological studies of shade adaptation, nitrogen, and temperature response, approximately 750 m^2 of greenhouse ground beds were utilized to establish 24 plots of *Asystacia intrusa*. Two levels of shade (50% and 30% of full sun) were combined with a full sun control treatment to study the effects of shade adaptation. In addition, each of the shade treatments were tested with and without nitrogen fertilizer. Measurements of photosynthesis, respiration, and leaf fluorescence were made in vitro using an oxygen probe. Oxygen probe estimates were made at 4 temperatures (15, 20, 25, and 30°C). Estimates of yield, percent leaf, and specific leaf weight were also determined. The physiological data have been collected twice. Each period of data collection requires approximately four weeks with samples processed four days in each week.

Preliminary in situ studies of CO2 compensation point confirmed that *Asystacia intrusa* is a plant species with C3 carbon metabolism. As shade was decreased, the number of leaves per stem decreased from a mean of 4.9 to 4.1 leaves/stem. Consequently, the percent dry matter in the leaf fraction declined with increasing shade from 50% to 46%. This was associated with an overall decrease in dry matter yield. There were no significant effects of nitrogen detected on these variables.

On a dry weight basis, photosynthesis decreased from .17 to .16 μmol/g/s as shade increased. Due to the reduced specific leaf area, photosynthesis on a leaf area basis was affected to a larger degree and declined from 22 to 14 μmol/m^2/s. Nitrogen effects were not significant ($p>.05$) and indicate that *Asystacia intrusa* has a high level of nitrogen use efficiency. The primary adaptation to shade has been the typical reduction in specific leaf weight, but the fairly small decrease in photosynthesis on a dry weight basis shows that adaptation to low light is very efficient.

The temperature at which *Asystacia intrusa* leaf photosynthesis is measured was shown to have a large effect on the photosynthetic rate. Rates of net photosynthesis continued to increase up to 30°C. Measurements of photosynthesis, respiration and fluorescence made in vitro showed that temperatures below 20°C were damaging to the leaves. This has increased the expense of conducting research with this species because greenhouse temperatures have been increased to maintain the *Asystacia*

intrusa. It is also interesting to note that short day lengths (<12 h) are required for flowering of this species.

Quality of Asystacia intrusa. Low light intensities that occur under tree plantation crops create an environment that is not tolerated by many plant species. *Asystacia intrusa* is one of the few herbaceous plants that has reasonable growth at less than half sunlight. In studies in Malaysia and Indonesia this plant has been found to be readily consumed by sheep. One of its important characteristics has been its inherent high concentrations of crude protein relative to most forage legumes. A greenhouse study was conducted to examine the in vitro digestibility, fiber constituents, and nitrogen fractions of Asystacia intrusa grown with no supplemental nitrogen (N0) or 80 kg of nitrogen/ha (N80) at 50% shade (S3), 25% shade (S2), and no shade (S0).

The results (table 4) show a rather unusual composition. Forage neutral detergent fiber (NDF) concentrations are very low, especially in stems. Also low is the hemicellulose in the stems, but nitrogen is extremely high in both the leaves and stems. The addition of shade and fertilizer nitrogen tended to increase the concentration of nitrogen in the stems and leaves even higher. *Asystacia intrusa* has quality attributes that resemble or are better than most legumes (including alfalfa) and warrants further characterization and assessment as a forage for use under plantation tree crops.

Table 4. Fiber and total nitrogen concentrations of greenhouse-grown Asystacia intrusa as altered by nitrogen fertilization and shade

	Nitrogen (none)			Nitrogen (80 kg ha-1)		
Item	So[a]	S_1	S_2	S_o	S_1	S_2
Stem:	%	%	%	%	%	%
NDF	40.2[b]	41.3	42.2	40.9	42.8	40.0
ADF	29.2	31.4	32.5	30.0	30.9	28.6
Hemi	8.8	8.5	8.9	8.1	8.8	8.2
Cell.	22.0	24.5	25.6	23.3	24.8	22.3
Lignin	6.9	6.7	6.6	6.5	6.0	6.2
CP	20.1	19.8	19.2	20.1	19.7	22.3
Leaf:	%	%	%	%	%	%
NDF	39.4	40.0	42.3	41.4	41.2	40.8
ADF	16.2	15.7	16.8	16.3	15.9	15.4
Hemi	22.4	24.2	25.5	24.5	25.0	24.9
Cell.	11.0	9.9	11.8	10.5	11.4	11.4
Lignin	3.2	4.0	3.5	3.2	3.1	2.9
CP	30.6	31.1	30.3	29.9	31.1	32.9

[a] S=Shade and So=normal light (greenhouse) S1=25% shade and S2=50% shade.
[b] Values are the mean of three to eight observations.

Development of methodology to determine *in vitro* digestibility is currently underway. Traditional methods have been unsuccessful because of difficulty in filtering sample after digestion. In addition procedures for analyzing the nitrate level in the leaves and stems has been developed. Preliminary analysis indicates that the stems of *Asystacia intrusa* accumulate nitrate. Spot checks of the nitrate concentration in the stems have been as high as 7%. This level could be a serious health hazard to livestock.

Supporting Research in the United States: Evaluation of Breeds of Hair Sheep

Justification

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 (another breed of hair sheep) were obtained from Ohio State, and, in 1987, Katahdin hair sheep were obtained from Heifer Project International. Data on reproductive performance (conception rate, lambing rate, survival, lambing, and weaning percentages) and growth (rate of gain) have been collected but not quantitatively evaluated. Summarizing this data may yield excellent information as we determine which breeds of hair sheep are to be placed in Indonesia. These hair sheep or hair sheep crosses may be extremely appropriate for adoption in the Southeastern United States because of their reported heat and parasite tolerance.

Progress

Reproductive performance of hair sheep. In the Southeastern United States, one of the major problems in market lamb production is the difficulty of producing lambs ready to market in early spring, when lamb prices are high. In order to produce a breeding ewe that is heat tolerant and can breed out of season, three breeds of hair sheep have been incorporated in a crossbreeding program with Polled Dorset (D) and Suffolk (S).

The Barbados Blackbelly (BB) and St. Croix (SC) are two breeds of hair sheep that originated in West Africa and have been improved in the tropics, and the Katahdin (K) is a hair sheep breed developed in the United States.

The following summarizes the reproductive performance of ewes exposed in North Carolina to rams in early summer for fall lambing.

Available ewes were exposed to rams in May and early June. Ewes were placed in separate pastures with a maximum of 25 ewes/ram. After 17 d, rams were changed so that each pasture group was exposed to a wool and a hair breed for 17 d each. After breeding, ewes were managed together as one group. Lambing records for 1987-91 were summarized by ewe breed for percent of ewes lambing, number of lambs born/ewe lambing, and number of lambs raised/ewe lambing (table 5). The performance data for ewes exposed to rams in late May and June are presented in table 2. No data was available for SC or K ewes until 1990 because these ewes were involved in experiment 1 in 1988 and 1989.

Table 5. Performance of fall lambing ewes of the Barbados Blackbelly (BB), Dorset (D), Suffolk (S), Katadhin (K) and St. Croix (SC) breeds and their crosses (1987-1991)

Year	BB	D	S	DxBB	K	SC	DxSC	SxSC
No. Ewes exposed:								
1987	22	22	32	16				
1988	11	18	11	5				
1989	10	12	37	18				
1990	29	21	28	36	11	11	10	8
1991	15	19	-	12	18	16	6	7
Mean	17	18	28	18	15	14	8	8
% ewes lambing:								
1987	63.6	45.5	12.5	87.5				
1988	72.7	61.1	9.1	100.0				
1989	90.0	16.6	10.8	88.9				
1990	89.7	14.3	21.2	55.6	27.2	90.9	20.0	50.0
1991	93.3	31.6	-	100.0	44.4	62.5	66.6	100.0
Mean	82.0	34.8	14.2	78.6	35.8	76.3	43.2	75.0
No. lambs born/ewe lambing:								
1987	1.96	2.00	1.86	1.78				
1988	1.63	1.36	2.00	1.60				
1989	1.89	1.00	1.75	1.44				
1990	1.81	1.33	1.71	1.45	1.67	2.10	1.50	2.00
1991	1.93	1.33	-	1.66	1.75	2.0	1.75	2.00
Mean	1.85	1.53	1.78	1.56	1.71	2.05	1.63	
No. lambs raised/ewe lambing:								
1987	1.38	0.66	1.57	1.78				
1988	1.38	1.09	1.00	1.40				
1989	1.78	1.00	1.50	1.38				
1990	1.77	0.67	1.00	1.40	1.33	1.60	1.50	1.75
1991	1.86	1.33	-	1.5	1.75	1.90	1.75	2.00
Mean	1.76	.90	1.27	1.49	1.54	1.75	1.63	1.88

The percent of ewes lambing was consistently highest for BB (82.0%) and D x B (78.6%) ewes. The D ewes had a high percent lambing in 1988 (61.1%) and 1987 (45.5%), but they were comparable to the Suffolk ewes during the rest of the years. Although the percent of Suffolk ewes lambing was low (9-21%), it is encouraging that some individuals did lamb in the fall. The number of lambs born per ewe that lambed were acceptable for all breeds and averaged >1.5 for each breed. The high death loss (50% of fall born D lambs) has previously been observed in the NCSU flock. The BB and D x BB lamb survival was high.

Evaluation of the ewe performance of K, SC, D x SC and S x SC, is limited to two years with limited numbers of ewes. From this limited database it appears that the SC may be more similar to the BB than is the K. Number of lambs born and raised/ewe lambing was acceptable for each of these breeds. The S x SC has been utilized as a breeding ewe for several years. As part of the flock used to supply experimental animals for other projects, the S x SC has produced excellent quality lambs and has been desired by commercial sheep producers.

Digesta kinetics of hair sheep breeds fed hay or pelleted diets.

This study was initiated to compare differences between breeds of tropical (hair) sheep for digestion and passage when they were fed a concentrate diet. Twelve yearling rams [5 Barbados blackbelly (43 kg), 4 St. Croix (55 kg) and 3 Katahdin (64 kg)] were fed either fescue hay (9% crude protein, 41 ADF) or a commercial pelleted diet (18% crude protein, 31% ADF) ad libitum in a crossover design. Total fecal collection was employed to measure diet digestibility and feeds were mordanted with Chromium to evaluate kinetics of digesta kinetics. In addition, the rare earths ytterbium, erbium, and dysprosium were used to mark the diets by the emersion and rinse technique.

Rams ate less of the hay diet (386 vs 948 g/d; $p<.01$), and the pelleted diet was more digestible (73.2 vs 44.6%; $p<.01$). There were no breed by diet interactions ($p>.2$). Although the rams were the same age, the Katahdins were 50% heavier ($p<.01$) than the Blackbellies; however, Katahdins did not eat more than the Blackbellies when fed the hay diet (.36 vs .33 kg), and the St. Croix ate the most (.47 kg; $p<.01$). Rate of passage of the feed through the digestive tract was higher for the pelleted diet (.1027/h) as compared to the hay diet (.0537/h). Passage rates were not affected by the marker used indicating that markers behaved similarly. This offers the possibility of simultaneous multiple use for marking different components of the diets.

Retention time in the rumen and in the total tract did not differ for the Katahdin and St Croix when fed hay, while the Blackbelly had the longest retention times. When sheep consumed the pelleted diet, intake was lowest ($p<.05$) for the Blackbelly (.67 vs 1.11 kg), but intakes were not different when expressed as a percentage of body weight (1.80%). Digestibility and kinetics of digesta passage were also unaffected by breed when consuming the pelleted diet. Although ruminal retention times were similar for the two diets, the hay remained in the digestive tract longer ($p<.01$) than did the pellets (59.7 vs 46.5).

When fed a low or high quality diet, no difference in digestibility was found for the three breeds of hair sheep. Intake as a percent of body weight did not appear to be related to ruminal or total tract retention times.

Supporting work in the United States: Maintenance and finishing rations using by-products

By-product feeds offer a great potential for utilizing materials that are not consumed by people and processing of material into a nutritive fertilizer. By-products of peanut and cotton are agricultural by-products that are under-

utilized in the Southeastern U.S. In order to develop feeding strategies for small ruminants, these waste by-products will be used in feeding trials. These comparisons should include evaluation of the hair sheep breeds and their crosses. Farmers would readily adopt inexpensive by-product feeds as long as the animal production and economic returns remain high.

Anti-quality determination in forages and leguminous trees
Tannins, phenolic, soluble lignin, and core lignin are anti-quality factors in forages and tree legumes that reduce the digestion intake factors. Procedures for isolating identifying and overcoming these anti-quality factors are not widely understood and many procedures require equipment such as gas chromatographs and high pressure liquid chromatographs. Plant samples of suspect forage and tree legumes will be collected for analysis to identify potential problems with the plants and to develop methods for quantifying or at least qualitatively measuring anti-quality factors in the field.

Training

Oneas Mufandaezda, from Zimbabwe, is working on a Ph.D. in Animal and Crop Science at NCSU and is supported (50%) by the SR-CRSP. He should complete his degree December 1993.

Silvia Buntinx, from Mexico, is working on a Ph.D. in nutrition at NCSU. She will complete her degree in May 1994.

Roger Merkel, from USA, is working on a Ph.D. in Nutrition at NCSU. He completed a preliminary trial in Indonesia during the summer of 1991 and will return in 1992 to complete his research at Sei Putih.

Jose Luis Romano-Munoz, from Mexico, is working on a Ph.D. in Nutrition at NCSU. He is working with the physiological differences in digestive function of hair and wool sheep. He plans to complete his degree in May 1994.

Kathy Dugan, from the USA, is working on a Master of Science in Nutrition at NCSU. She should complete her degree in December 1992.

Kelly Jo Driggins, from the USA, completed a M.S. in Nutrition at North Carolina State University. Her research evaluated the use of peanut hulls and bread as a feed source for sheep.

Contributions To U.S. Agriculture

Through the SR-CRSP, the training of several graduate students in small ruminant nutrition has been achieved. One student spent the summer doing research in North Sumatra. He will now be better prepared for a career in international agriculture.

Our understanding of the biology and potential of sheep production in the Southeastern United States has increased. Many of the hair breeds (Barbados Blackbelly, St. Croix, or Katahdin) and crosses appear to be adapted to the climatic conditions of the Southeast. They also are appropriate for accelerated lambing.

The plant germplasm *Asystacia intrusa* has many quality characteristics that are better than alfalfa. This germplasm is being evaluated at NCSU. It may have

applications as an annual forage in the United States.

Collaboration with other CRSP's

Collaboration with the TropSoils CRSP was in process in Indonesia. Unfortunately, the USAID Mission in Jakarta has forced the phase-out of TropSoils CRSP activities in Indonesia.

Currently, the germplasm of the most promising lines of forage peanuts have been under shade tolerance testing at NCSU. These lines have been provided by the Peanut CRSP. Continued collaboration is anticipated.

Collaborating Personnel

Indonesia

- Dr. Budi Tagenjaga, Animal Nutritionist, BPT
- Dr. Ruth Gatenby, Site Coordinator, UCD
- Dr. Sibylle Scholz, Economist, Winrock
- Leo Batubara, station chief, SBPT

Mursal Boer, Animal Production, SBPT (on Study Leave)

- Simon Ginting, Animal Nutritionist, SBPT
- Tatang Ibrahim, Forage Agronomist, SBPT (on Study Leave)
- Setel Karo-karo, Socio-Economist, SBPT
- Pius Ketaren, Animal Scientist, SBPT
- Endang Romjali, Breeding, SBPT
- Eleanor Simbiring, Animal Production, SBPT

Rubber Institute, Sei Putih, Indonesia

- Basuki, Director, BPP
- Dr. Nong Alwi, Statistician, BPP
- Dr. Asril Darussamin, BPP
- Asmar Arsjad
- Tuti Kustiyanti, Botanist, BPP

Raleigh Campus, North Carolina State University

- Dr. Joseph C. Burns, Agronomist, USDA (Co- Investigator)
- Dr. Dwight S. Fisher, Plant Physiologist, USDA (Co-Investigator)
- Dr. Jeannette Moore, Research Associate, Nutrition
- Dr. Jerry W. Spears, Animal Nutritionist
- J. Vann Cooper, Research Technician
- Tina Goodwin, Research Technician
- Elizabeth Kegley, Research Technician
- Silvia Buntinx, Ph.D. Candidate in Nutrition from Mexico
- Roger Merkel, Ph.D. candidate in Nutrition
- Oneas Mufandaedza, Ph.D. Candidate in Animal and Crop Science from Zimbabwe
- Jose Luis Romano-Munoz, Ph.D candidate from Mexico
- Kathy Dugan, M.S. candidate in Nutrition

Collaborating Institutions

- Animal Husbandry Research Institute (BPT), Bogor, West Java, and Sungai Putih, North Sumatra
- National Rubber Research Institute (BPP), Sungai Putih, North Sumatra

Publications

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Winrock International

Economic Analysis of Small Ruminant Production and Marketing Systems

Project Number: 116-12

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Narrative Summary

The focus of this project during the past 15 months was research and technology transfer and institution building. Unfortunately, due to travel restrictions imposed during the Gulf War, the resident scientist for economics, Dr. Sibylle Scholz, did not arrive in Sei Putih until April, 1991. She capitalized on the delay by reviewing and finalizing the Indonesia techpacks. Upon arriving in Indonesia, Scholz initiated a new outreach project with 12 farmers in conjunction with a semi-private rubber estate. In addition, Scholz assisted in institution building by helping AARD write research proposals on sheep under rubber.

Problem Statement and Approach

The world's humid tropical lowlands contain a large amount of underutilized feed resources. Agricultural development in these regions has emphasized the monoculture of commercial tree crops such as rubber, oil palm, cocoa, and coconuts. These crops are produced by commercial estates and by smallholders. Although governments have promoted smallholder production for many years, tree crop production has not always been successful. Cash flow is a barrier to successful smallholder production of tree crops during the period between the establishment of trees and their maturity. Small ruminants are one means of increasing cash flow and reducing risk. One way to benefit smallholder producers is to develop a production system for sheep under plantation crops. Constraints faced by smallholder producers must be identified because there is a danger that sheep production will only benefit the larger commercial producers.

In order for the program on sheep production under plantation crops to be successful, areas must be identified where smallholder tree crop production is important and where there is a potential for small ruminants. The resource endowments and constraints of these production systems must be described in order to assure that on-station research will address the needs of smallholder producers. To accomplish this the following activities were planned:

- Conduct an economic impact study using cost-benefit analysis. The analysis uses several sets of assumptions in terms of inputs and time period. This allows us to rank different production strategies, while viability of particular production strategies can be evaluated.

- Conduct an input-output analysis with the help of linear and non-linear programming. Using several sets of input mixes allows us to prioritize research activities in other disciplines

(breeding and nutrition). The study will identify limits in production strategies.

• Conduct market analysis as ongoing research and information dissemination. Initially, research is descriptive to identify key variables which will be tracked over time to establish a continuous bank. Training local staff in conducting this analysis will be crucial. Information transfer has priority.

• Conduct research in management strategies which specifically incorporate veterinary knowledge and costs in the following areas: losses due to disease, profitability of preventive measures, and replacement decision of affected animals. A simulation model will aid in finding optimal strategies.

• Conduct study on ownership and property rights in Sei Putih area, considered crucial in identifying production strategies that are self-sustaining. The initial study will be descriptive; data will be incorporated into analysis of production strategies.

• Conduct gender analysis to identify constraints in small ruminant production strategies. Insights from this research will feed back into a research agenda for other disciplines.

• Set up the network in conjunction with other research staff and SRUPNA, as well as other local and regional organizations. Conduct training in research and methodology.

Research

Although the resident economist, Dr. Sibylle Scholz, was hired in December, 1990, she only arrived at the post in Sei Putih in April, 1991, because the Gulf War prevented travel. Her main activities while waiting for travel clearance included visits to Indonesia PIs at the Universities of California-Davis, Missouri-Columbia, and North Carolina State to review and finalize the Indonesian "techpacks." The documents have also been reviewed by Indonesian scientists. Final language editing is taking place at Winrock headquarters.

Research and Technology Transfer

In September 1991 a new outreach project was started in a semi-private rubber estate, 200 km from Sei Putih in Membang Muda. Extension services are provided for 700 smallholders who received two ha of rubber plantation from the Indonesian government. Twelve sheep farmers were selected in October. Also, in October we trained an extension agent for sheep. In November 72 sheep were delivered and 1,200 Gliricidia trees were planted mostly around the farmers' houses in erosion prone zones. Farmers are visited four days each month to monitor their progress, hold meetings, and collect data on performance both of sheep and rubber. The objective is to help the farmers reduce "overtapping" in the rubber plantations by supplementing their income from sheep production.

Data from two outreach projects which were started in 1988 and 1990 is currently being analyzed.

Institution Building

The regional office of transmigration is not directly involved in these two activities; however, Dr. Scholz helped to write the proposals, and she presented the package of sheep under rubber developed for the Membang Muda

farmers during BPT's initial involvement with these institutions.

Dr. Scholz also assisted in the preparation of this package for presentation by the Director of SBPT, at a regional meeting held in October in Lombok. Also, for the Field Day in Puslitbun, Dr. Scholz helped the economist, Pak Uhendi, prepare a contribution in the pamphlet entitled, "The Economics of Sheep in Commercial Estates." Dr. Scholz collaborated with the revitalization of VIPS (Very Intensive Production Systems) in Bogor with Tjeppy Soedjana.

Training

The economics program has resources for long-term training of only one student. Ms. Atien Priyanti from Indonesia is currently on her second year of training in pursuit of an M.Sc. degree in agricultural economics at the University of Arkansas at Fayetteville. Her expected date of graduation is December, 1992.

Much time and effort has been dedicated to management of computer hardware and software. SBPT scientists are instructed in software application such as Lotus, WordPerfect, and Freelance. Hardware problems due to unreliable supply of electricity has been overcome by using battery operated laptops. Virus problems continue, but have been greatly reduced by assigning computers to scientists and restricting use of unauthorized software.

Other Contributions

Dr. Scholz prepared and distributed "A Call for Research on Small Ruminants in Southeast Asia." From the 11 selected candidates, Dr. Scholz oversees three researchers who received U.S. $1,500 to 2,000 each. One of these researchers is in Medan; the other two are in Bandung and Lombok.

Dr. Scholz coordinated activities of three students on internships with SR-CRSP. Craig Carlson, a U.S. graduate student from Purdue University, spent three months in the summer on an MUCIA scholarship and wrote two papers. Two Dutch students, Ton van Schie and Joost Verwilghen, from Wageningen are spending six months. They became involved in the preparation of extension materials for Membang Muda and are working on two research papers entitled, "The Economics of Indonesian and Cross-bred Sheep" and "Survey of Indonesian Local Livestock Extension Services" with particular emphasis on health care delivery systems.

Collaboration with SBPT and Puslitbun is excellent. SR-CRSP works closely with all aspects of research and assists in program planning and implementation. At Puslitbun, the directors of research and administration continue to be extremely helpful and forthcoming in all aspects of CRSP work. Both institutes have been instrumental in making our collaboration a success.

Collaborating Personnel

Indonesia

- Dr. Sibylle Scholz, Winrock resident economist posted at Sei Putih
- Setel Karo Karo, BPT, Sei Putih
- Elianor Sembiring, BPT, Sei Putih
- Craig Carlson (U.S. summer intern posted at Sei Putih)
- Ton van Schie and Joost Verwilghen (Dutch interns posted at Sei Putih)

United States
- Co-Principal Investigator: Henk Knipscheer, Winrock International
- Dr. Corinne Valdivia, University of Missouri
- Domingo Martinez, University of Missouri

Collaborating Institutions
- Balai Penelitian Ternak (BPT), Indonesia

Publications
Carlson, Craig, Sibylle Scholz, Elianor Sembiring and Setel Karo Karo. 1991. Goat and sheep trade data from North Sumatra's Deli Garang district: A preliminary analysis of price data. Annual report, Sungei Putih.

Carlson, Craig and Sibylle Scholz. 1991. The effect of increased supply of sheep on producer revenues. SR-CRSP Indonesia Working paper no. 126, December.

Karo Karo, Setel and Sibylle Scholz. 1991. Partial budget analysis of feeding supplements to sheep. Annual report, Sungei Putih.

Karo Karo, Setel and Sibylle Scholz. 1991. Partial budget analysis of feeding supplements. Working paper no. 125, December.

Scholz, Sibylle. 1991. Potential and actual income generated from sheep by small farmers in North Sumatra. Annual report, Sungei Putih.

Sembiring, Elianor and Sibylle Scholz. 1991. Socioeconomic survey of farmers in Membang Muda Outreach Project. Working paper no. 127, December.

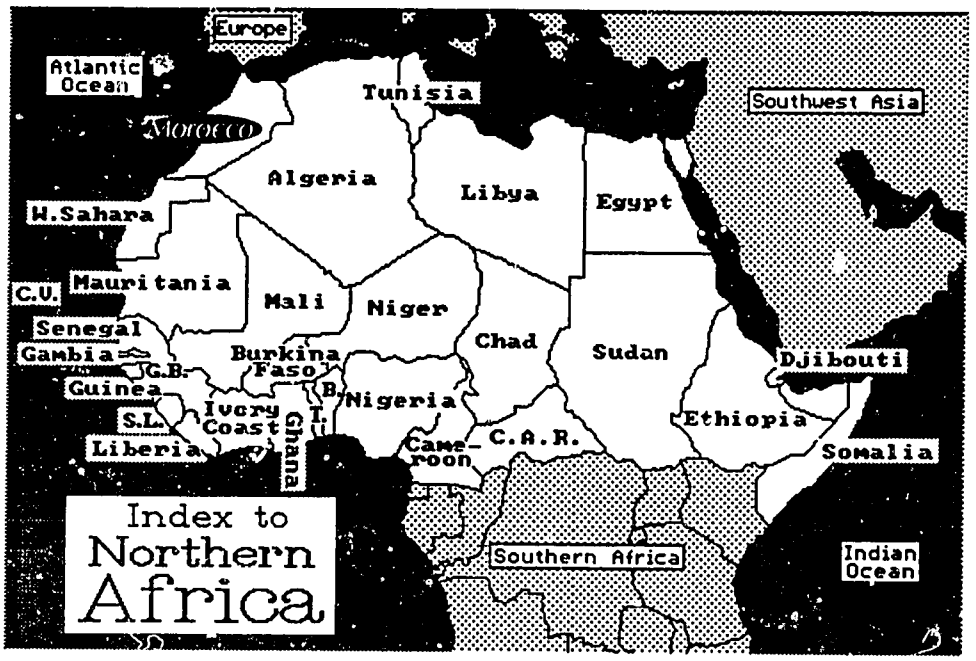
Budget and General Comments
For the 1990/91 fiscal year, the economics program total subgrant funding amounted to $211,434 ($219,000 was budgeted). Winrock contributed $73,820 ($73,000 was budgeted). These resources proved insufficient to maintain a well-organized program in three sites and fund a resident scientist in each site. The amount of work and administration for the PIs makes it difficult to administer three sites.

Collaboration with host country organizations has been excellent.

Prolific Sheep Component

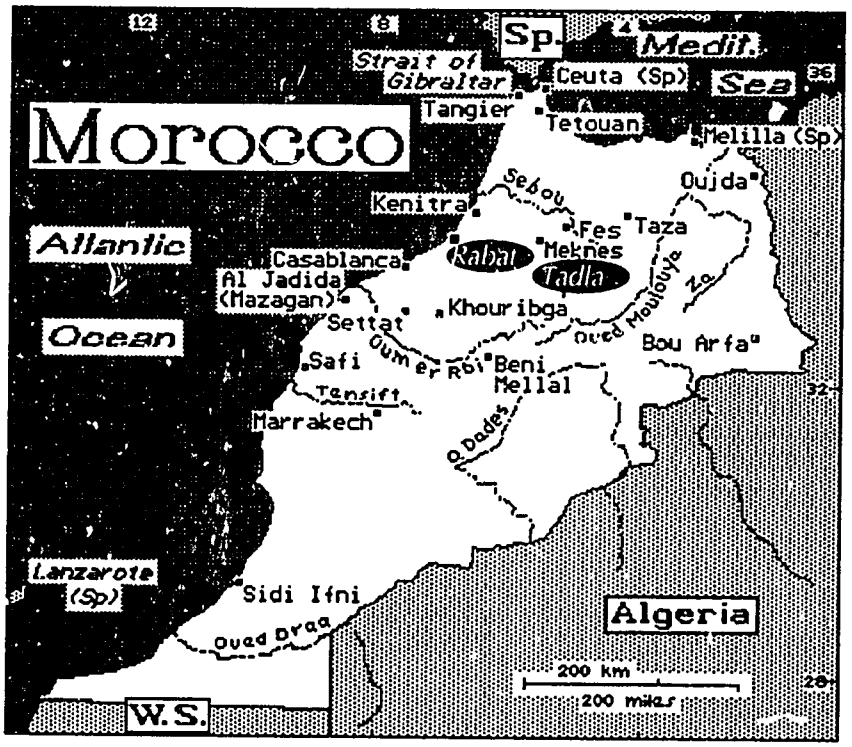
"Research on prolificacy in sheep (number of lambs born per female per unit of time) has anticipated further commercialization and intensification of small ruminant production in many areas. Such intensification will enable many small farmers to derive a major part of their income by specializing in 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



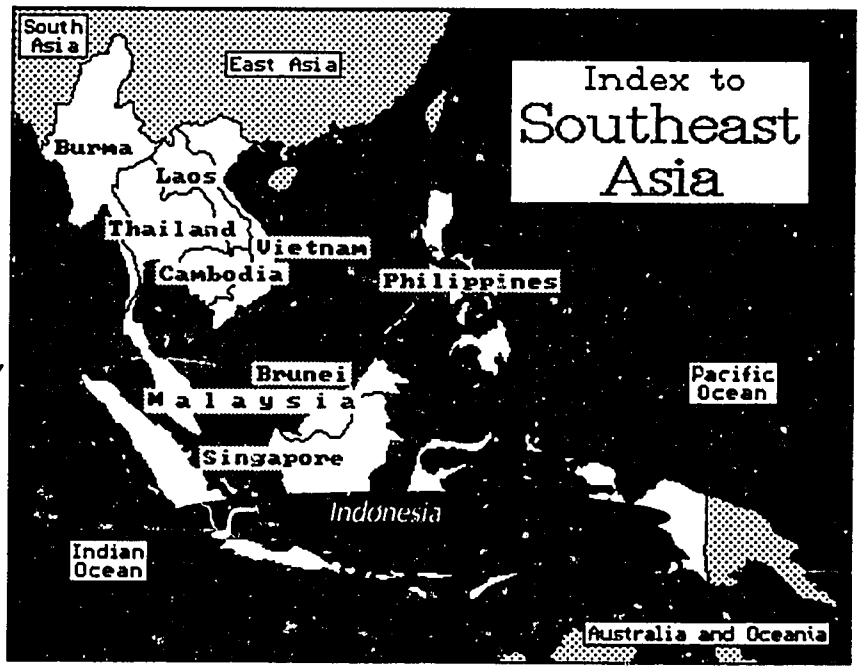
Kingdom of Morocco

Total area: 446,550 square km (172,413 square miles)
Land use: 18% arable land, 1% permanent crops, 28% meadows and pastures, 12% forest and woodland, 41% other.
Population (1990): 25.6 Million
Population growth: 2.6%
Agriculture accounts for 19% of GNP, 50% of workforce, and 30% of exports
Agricultural imports: $702,297,000
Agricultural exports: $455,973,000
Food and animals imported: $432,914,000
Food and animals exported: $413,035,000
Sheep: 15,700,000
Goats: 5,800,000
Mutton and lamb: 48,000 metric tons
Goat meat: 17,000 metric tons
Sheep milk: 26,000 metric tons
Goat milk: 37,000 metric tons
Wool: 8,000 metric tons



Republic of Indonesia

Total area: 1,919,440 square km (741,096 square miles)
Land use: 8% arable land, 3% permanent crops, 7% meadows and pastures, 67% forest and woodland, 15% other.
Population (1990): 189.4 Million
Population growth: 1.8%
Agriculture accounts for 26% of GNP, and 55% of workforce
Agricultural imports: $934,720,000
Agricultural exports: $2,528,270,000
Food and animals imported: $586,170,000
Food and animals exported: $1,439,250,000
Sheep: 5,415,000
Goats: 12,700,000
Mutton and lamb: 45,000 metric tons
Goat meat: 53,000 metric tons



University of California, Davis

Genetic Improvement of Sheep and Goats

Project Number: 101-12

Eric Bradford, Department of Animal Science, University of California, Davis, CA, 95616. Telephone (916) 752-1250, Fax (916) 752-0175.

Narrative Summary

Based on findings from previous research on the identification of the underlying genetic basis of prolificacy in Moroccan and Indonesian sheep breeds, breeding programs were developed for the control and optimum utilization of genetic variation in prolificacy in these sheep populations.

Indonesian sheep flocks contain a mixture of highly prolific and non-prolific ewes, due to segregation of a gene (F^J) with large effect on prolificacy. Development of animals with (F^JF^J) and without (++) this gene continued, with the aim of implementing a program to commercially produce F^J + animals. Due to the very high prolificacy of F^JF^J animals and varying levels of management conditions, F^J + and ++ animals would be more beneficial to farmers with good and average levels of feeding and management, respectively. Projects for the identification of the different genotypes, using DNA analysis or hormone assays, were initiated for earlier and more accurate determination of animals with and without the F^J gene.

Based on previous research findings on the Moroccan sheep breeds, studies currently continue for the formation of a composite breed (DS) using D'Man and Sardi stocks. Project re-search has shown that the DS stock effectively combines the superior growth rate of the Sardi l reed and earlier puberty and longer breeding season of the D'Man with an intermediate level of prolificacy. This combination results in overall performance of the DS superior to that of either parent breed. Physiology and nutrition studies continued to provide more information about the nutritional requirements of the different genotypes.

Research

Problem Statement and Approach: Indonesia

Research in previous years on Indonesian sheep breeds has revealed the existence of a major gene affecting litter size. In an effort to understand more completely the effects of this gene on litter size, the plan is to develop lines homozygous for the prolificacy gene (F^JF^J) and its normal allele (++), increase numbers in each group, and compare performance under farm conditions. Results obtained would be used to develop strategies for optimum utilization of the prolificacy gene by farmers with varying levels of management and feeding conditions, and in collaboration with Nutrition project personnel, to develop feeding and management systems to improve the survival and growth of lambs born as twins or higher multiples. Data collected so far in this project allow classification of ewes as F^JF^J, F^J + or ++ based on their own performance records. Rams in the flock are classified based on their pedigrees and progeny test result, which is time-

consuming. Currently, we are exploring possibilities for genotype identification by means of DNA analysis and by a study of various hormone levels in lambs and adult ewes. Success in proper identification of genotypes by either or both methods would substantially reduce the time taken to determine the genotype of an animal accurately. This would not only save time and money but also enable a better controlled dissemination of the F^{I} gene to farmers and their effective utilization of it.

Problem Statement and Approach: Morocco

Research findings on the D'Man breed have indicated that the high prolificacy of this breed is inherited quantitatively. In the first phase of the project, D'Man (D), Sardi (S) and their crosses were evaluated for prolificacy. In the second phase, backcrosses and F2's were also included in evaluations. Results have indicated a linear increase in litter size as percent D'Man inheritance increased from zero to 100. Based on the information obtained from F_1, F_2, and backcrosses, it was decided that the creation of DS "composite" breed would provide a stock of wide general utility, to use as a pure stock in the best agricultural areas, or as crossing sires on non-prolific ewes when a lesser increase in prolificacy was desired. Matings to create such a composite were initiated in 1989. During the remaining period of the Morocco project, it is proposed to expand the DS population, define selection criteria for long-term improvement of the new breed, and initiate selection. A minimum of 300 DS ewes and a Sardi flock of 200 is planned to provide up to 100 animals of each group for collaborative trials with nutrition and physiology and enough DS animals for expanded on-farm testing. In addition to the development of the DS composite, we have proposed the establishment of a multiplication center by a Moroccan agency or enterprise to expand the DS population and enhance selection, to compare nutritional requirements of DS and S ewes (in collaboration with the nutrition project), and to carry out on-farm evaluation of DS sheep in comparison to the local breeds. To help identify any potential problems in adaptability of the DS, and to develop better selection criteria to improve their performance, some funding of studies in animal physiology has been continued. Work to date has shown differences in heat tolerance and response to other stresses between D'Man and Sardi, with D'Man animals being more sensitive to stress than Sardi.

Progress

Indonesia

Animals in the Bogor flock were reclassified for the F^{I} gene based on ovulation rate (OR) or litter size (LS) records using the criteria shown in table 1.

Matings to increase numbers in $F^{I}F^{I}$ and ++ groups have been carried out based on this classification. Based on the data collected to date on this project, average litter size of ewes from each group is shown in table 2.

Although there is variation among individual ewes within each group due to nutrition and ewe age, differences in average prolificacy among the three genotype groups are large. These results indicate that one copy of the F^{I} gene increases the litter size by nearly one

Table 1. Criteria for reclassification.

Classification	Number of Records	OR or LS
FF	≥	4
F+	≥	3
	2 or 3	2
	≥	avg. ≥1.7

Table 2. Average litter size of ewes.

	Genotype					
	++		F+		FF	
	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

lamb. These results were presented at a meeting with the breeding project participants at BPT, Bogor, where a controlled breeding program to produce F + ewes for commercial production was discussed. It was stressed that the F + and FF ewes may be desirable or undesirable depending on the level of nutrition and management of the flock. Host country participants were cautioned that for farmers with limited feed resources and average management conditions, the use of ++ rather than F + may be more beneficial since higher lamb mortality is associated with the F gene under average management conditions.

For the study to identify possible DNA polymorphic differences that can be used as markers associated with the F gene, Mr. William Cushwa, a Ph.D. student in Genetics at UC Davis, traveled to Bogor and collected blood samples from 137 animals whose genotypes were presumed to be ++ or FF based on pedigree and individual performance records when available. DNA's extracted from the samples were brought into the U.S. under a permit from USDA and are being analyzed by family groups using RAPD (Randomly Amplified Polymorphic DNA) markers. The RAPD approach consists of using single oligonucleotide primers for PCR (polymerase chain reaction) amplification and scoring the presence or absence of amplified bands separated by electrophoresis. This work is being carried out in the lab of Dr. Juan Medrano at UC Davis.

Blood samples were also collected from animals with presumed genotypes of FF, F + and ++ to study various hormone profiles. The samples col-

lected from animals in the Bogor flock were then transferred to Singapore where they are being analyzed at the lab of Dr. Victor Goh of the University of Singapore for FSH, LH, and testosterone hormone levels.

Morocco

The field testing of D X S crosses at small-farm level is being conducted in the High Atlas region. Data on reproduction and production have been collected since February 1989. The analysis of puberty and seasonality data of various DXS crosses is in progress. A trial on the use of Melatonin implants for early breeding season in 90 Sardi ewes is underway. All of the ewes on this trial were mated in May 1991.

Studies with growing D'Man and Sardi lambs, fed a diet consisting of barley and alfalfa, have revealed better relative feed intake and feed efficiency and higher relative growth rate for the D'Man lambs. Research done in 1990-91 showed the presence of genotype by nutrition interaction for post-weaning growth. Furthermore, D'Man lambs had a faster rate of passage in the rumen; higher levels of plasma insulin, T3 and T_4; a higher sensitivity to insulin; and a faster rate of glucose metabolization than the Sardi lambs. As a result, feed intake, feed efficiency, and growth rate are better in D'Man when nutrition plane is high. However, this situation is reversed in favor of Sardi when feed is primarily composed of hay, not a surprising result since Sardi has evolved under conditions of frequent feed scarcity or poor feed quality.

Training

- Ismeth Inounu and Bambang Setiadi are enrolled in the Ph.D. program at IPB, Bogor.
- Natalie Bogui of Ivory Coast is continuing the analyses of sheep reproduction data at UC Davis. She is a candidate for an M.S. degree.
- Ismeth Inounu completed his M.S. studies at IPB.
- Subandriyo completed his Ph.D. studies at the University of Missouri and returned to Bogor.
- Sagari Ramdas of India completed her M.S. studies at UC Davis and returned to India. Her studies were partially funded by the SR-CRSP.
- Raphael Sitomorang attended a course entitled "International Sheep and Lamb Management Course" held in Kuala Lumpur, Malaysia, July 1-14, 1991.
- Lahsen Derquoui of IAV, Rabat, is completing his doctoral dissertation using SR-CRSP data.

Other Contributions

To U.S. Agriculture

The SR-CRSP continues its significant contributions to research on small ruminants through the training of graduate students from the U.S. and the participating countries, as well as students from other non-participating countries. The diversity of the underlying genetic basis of prolificacy in sheep breeds of Morocco and Indonesia has contributed importantly to knowledge of the genetics of prolificacy in sheep and has received attention from the scientific community.

To Host Country
In Indonesia, the Outreach Pilot Project (OPP) continues its positive impact on incomes of smallholder farmers. The breeding program developed for the control and optimum utilization of the prolificacy gene existing in the Indonesian sheep breeds is expected to make a significant contribution to the economics of small-holder farms.

In Morocco, the SR-CRSP program has made significant contributions to the implementation of the Tadla Farm Project. The DS synthetic breed has received much interest from local farmers. As the Moroccan portion of the CRSP program will be phased out earlier than originally scheduled, the Moroccan scientists are using the Tadla Research Station to get grants from other international agencies.

Collaborating Personnel

Indonesia
Ruth Gatenby, Ph.D., UCD (posted to SBPT)
Luis Iniguez, Ph.D., UCD (posted to BPT)
Ismeth Inounu, M.S., BPT, Bogor
Endang Romjali, B.S., BPT, Sei Putih
Elianor Semirang, B.S., BPT, Sei Putih
Bambang Setiadi, M.S., BPT, Bogor
Simon Sinulingga, B.S., BPT, Sei Putih
Subandriyo, Ph.D., BPT, Bogor
Ketut Sutama, Ph.D., BPT, Bogor
Bess Tiesnamurti, M.S., BPT, Bogor

Morocco
Said Benlamlih, Ph.D., IAV
Ismail Boujenane, Ph.D., IAV
Lahsen Derqaoui, M.S., IAV
A. Guerouali, Ph.D., IAV
A. Lahlou-Kassi, Ph.D., IAV, Co-PI
A. Sghiri, M.S., IAV
Francois Toe, M.S., IAV
R. Zinefilali, Ph.D., IAV

United States
Nathalie Bogui, M.S., UCD
William Cushwa, M.S., UCD
Martin Dally, M.S., UCD
Thomas R. Famula, Ph.D., UCD
Curtis M. Finley, M.S., UCD
Dana Van Liew, M.S., UCD
Sagari Ramdas, M.S., UCD
Hakan Sakul, Ph.D., UCD

Collaborating Institutions

- Balai Penelitian Ternak (BPT), Bogor, Indonesia
- Institute Agronomique et Vétérinaire (IAV), Hassan II, Rabat, Morocco

Publications

Papers Published

Benlamlih, S. 1991. Relationship between food intake, growth, blood hormones and body composition in Sardi and D'Man lambs. Proc. Intern. Symp. Nuclear and Related Techniques in Animal Production and Health. International Atomic Energy Agency, Vienna.

Boujenane, I. 1990. Methods of estimation of genetic effects from two breeds crossing system with an application to litter size in sheep. J. Anim. Breed. Genet. 107:431-436.

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Derqaoui, L., A. Sghiri, Y. Haj Hamou, and A. Lahlou-Kassi. 1991. Synchronisation des chaleurs at production d'agneaux á contresaison chez la race Sardi: Effet bélier. Conférence Internationale sur la maitrise de la Reproduction Animale. INRA, Tours, France, 29-31 Mai.

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Iniguez, L., G.E. Bradford, and I. Inounu. 1991. Sheep breeding plans for integrated tree cropping and sheep production systems Proc., Workshop on Integrated Tree Cropping and Small Ruminant Production Systems (IPS), Medan, North Sumatra, September 1990.

Technical Publications

Arasu, P., M. Hutauruk, and R.M. Gatenby. 1991. Studies of pancreatic fluke infections in sheep. In: Annual Report, SR-CRSP Sungai Putih, North Sumatra, Indonesia. pp. 50-57.

Gatenby, R.M., M. Hutauruk, A.J. Wilson, and E. Romjali. 1991. Identification of worm resistance in sheep. In: Annual Report, SR-CRSP Sungai Putih, North Sumatra, Indonesia. pp. 58-59.

Ginting, S.P., M.D. Sanchez, E. Romjali, R.M. Gatenby, and K.R. Pond. 1991. Supplementation of ewes in late pregnancy and early lactation. In: Annual Report, SR-CRSP Sungai Putih, North Sumatra, Indonesia. pp. 5-7.

Romjali, E., and R.M. Gatenby. 1991. What is the best litter size? In: Annual Report, SR-CRSP Sungai Putih, North Sumatra, Indonesia. pp. 23-27.

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Sghiri, A. 1991. Synchronization of oestrus and out-of-season lamb production: ram effect. Proc., Maitrise de la reproduction. May 29-30, 1991. CRITT, France.

Other Comments

The most important issues relate to continuity of the research programs. Termination of the Indonesian hair sheep program at this stage, as has been recommended by AID/Jakarta, would represent a very serious loss; Indonesian scientists developing their research skills at SBPT/Sei Putih would be left with totally inadequate support, and investment in importation of animals and semen would be lost, as would a great deal of potential information of value related to grazing of sheep under tree crops. Expatriate scientist contracts would be terminated prematurely. For all of these reasons, this early termination should be avoided if at all possible.

The early termination of the Morocco project also carries a high price. The point has been made that the participating scientists can continue the project on their own; that is true only if they have at least some external support, which is very uncertain without the SR-CRSP. Maintaining some SR-CRSP input via linkage arrangements is therefore judged to be critical to achievement of objectives of this long-term project.

North Carolina State University

Feed Resources and Nutrition of Small Ruminants in Morocco

Project Number: 107-12

Kevin R. Pond, Department of Animal Science, Box 7621, North Carolina State University, Raleigh, North Carolina, 27695-7621. Telephone (919) 515-4009; Telex 49-96937 NC STATE; Fax (919) 515-7780.

Narrative Summary

Sheep in Morocco are integrated into the total farming system. In the dryland cereal producing areas, sheep utilize the crop residue left behind after grain harvest.

To determine the quantity of residues available for sheep, a survey of 60 farms was conducted in the rainfed and irrigated regions near the Tadla Experiment Station. Grain, straw, and stubble yields indicated that irrigated farms had higher production, but even in the non-irrigated rainfed areas, available straw averaged approximately 1 ton/ha. The quantity of grain, stubble, and weeds left behind after harvesting accounted for another 1.8 tons/ha in the rainfed and over 3.5 ton/ha in the irrigated areas. Grazed stubble and harvested straw can provide feed for ewes during much of the summer, fall, and early winter.

A stubble grazing trial using highly prolific D'man x Sardi (DxS) and 3/4 D'Man, 1/4 Sardi ewes was completed. Forty-eight ewes were placed on two treatments (16 ewes/ha) and were either supplemented with protein and energy or not supplemented. Ewes grazed the stubble for 16 weeks and then were pen fed a similar diet through lambing and lactation. The supplemented ewe group gained more weight during gestation and had more lambs born per ewe, while lambs were heavier than the nonsupplemented group. Supplementation with energy and protein during stubble grazing improves performance of highly prolific ewes.

The growth of lambs is highly dependent on the feeds and feeding strategy utilized. To improve the economic returns, emphasis has been placed on evaluating low cost by-product feeds that are available in the region. This year included the evaluation of ammoniated citrus pulp and by-products of almonds. Prolific D'man x Sardi lambs were utilized in digestion trials. Ammoniation of citrus pulp using urea was a safe and practical method of improving the nutritional value of citrus pulp. The chemical composition of almond hulls indicated that although low in protein (3 to 7% crude protein), it is a high energy feed. Feeding studies indicated that it is very palatable and can be fed at levels up to 40% of the diet for growing lambs provided it is supplemented with protein.

Information on developing a complete feeding system utilizing cereal by-

products and grazed stubble along with agricultural by-products for growing lambs is becoming more complete.

Research Results

Objectives

- To characterize and evaluate 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 feeding strategies for prolific ewes and their lambs.

Problem Statement and Approach

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 for sheep producers to maintain good productivity (growth and reproduction) in 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 feedstuffs of high quality (such as sugar beet, citrus pulp, 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.

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 prolific sheep is essential, especially if they are to be integrated into the traditional sheep production systems.

Stubble Grazing Trials

After cereal grain harvest, cereal stubble (the material remaining after harvest) represents the main feed available (during the summer) 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 performances. 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.

The effects of protein and energy supplementation of ewes grazing soft wheat stubble on their body weight and reproductive performance were evaluated in a trial using 24 F1 (D x S) and 24 (3/4 D x 1/4 S) mature ewes randomly assigned to two treatments, with two replicates per treatment. All animals were put on cereal stubble on July 16. Stocking rate was set at 16 ewes/ha (3/4 ha of stubble per treatment/rep). Mating started after two weeks of grazing and lasted eight weeks. During the 16-week trial, ewes in treatment A were supplemented with minerals and vitamins only. Ewes in treatment B received, in addition to minerals and vitamins, 200 g sunflower meal from week 5 to 10 and 200 g sunflower meal plus 200 g barley from week 11 to 16 of

grazing. At the end of the stubble grazing period (November 5, 1990), all ewes were pen-fed the same diet based on alfalfa hay, straw, sugar beet pulp, and sunflower meal.

Initial biomass averaged 5.74 tons DM/ha for stubble, 210 kg DM/ha for weeds, and 122 kg DM/ha for residual grain. Stubble biomass decreased cubically ($P < .01$) with time of grazing. Among the 48 initial ewes (from the breeding project), 14 were later found to have been gestating since before the start of the trial; they were removed at the end of the grazing phase. For the remaining F1 ewes, prolificacy was 125 and 183% for treatments A and B, respectively, versus 170 and 175% for the 3/4 D x 1/4 S ewes. Total number of lambs born reached 21 in treatment A and 23 in treatment B. Among these lambs, 9 and 5, respectively, died during the first week following birth. Ewe weight change during the stubble grazing period was lower in treatment A (+ .2 kg/ewe/period) than in treatment B (+ 7.2 kg/ewe/period). These differences were partially reduced during the last part of gestation. Average ewe weight at lambing was 40.6 and 43.3 kg for treatments A and B, respectively. No differences in ewe weight were found after 13 weeks of lactation.

Lambs born in treatment A had a lower ($P < .05$) birth weight than those of treatment B (2.9 vs 3.6 kg). At 3 months of age, differences between the two groups were not significant (14.5 vs 15.6 kg). Although these results were obtained with a limited number of animals, they suggest that protein and energy supplementation during the stubble grazing period has a positive effect on ewe performance at lambing and on lamb viability.

Grazed Stubble Utilization

During the past four years, all data collected on stubble composition and production originated from the Tadla experiment station. This year, an attempt was made to estimate these parameters on 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 experiment station to actual field conditions.

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. Average flock sizes for sheep, goats, cattle and equines were respectively 65.3, 2.9, 3.4, and 1.4 head per farm in the rainfed area versus 120, .4, 11.2, and 1.5 in the irrigated perimeter. Grain, straw, and stubble yields were determined immediately following the harvest of hard wheat, soft wheat, and barley. The latter was only cultivated in the rainfed zone. On the rainfed farms, average grain yield was about the same among the three cereal species: 1.5 to 1.6 tons/ha (table 1). Straw production averaged between .8 to 1.0 ton/ha. For the irrigated farms, grain and straw yields were three times higher than those of non-irrigated ones. Large variation existed within each group for each cereal specie.

Table 1. Grain and straw production in the rainfed and irrigated farms in Dar Ouled Zidouh area of Tadla (Ton/hectare).

Item	Grain Yield			Straw Yield		
	Wheat	Hard Wheat	Soft Barley	Hard Wheat	Soft Wheat	Barley
Rainfed						
No. of observations	8	18	15	8	17	15
Average	1.66	1.64	1.55	1.04	0.84	0.97
Standard Deviation	0.65	0.53	0.45	0.23	0.29	0.30
Irrigated						
No. of observations	7	12	—	7	11	—
Average	4.81	4.24	—	3.18	2.54	—
Standard Deviation	1.43	0.97	—	1.23	1.21	—

Table 2. Estimated amounts of stubble, weeds and residual grain left after harvest of cereals.

	Hard Wheat		Soft Wheat		Barley	
	Avg.	S.D.	Avg.	S.D.	Avg.	S.D.
Rainfed						
Stubble (T DM/ha)	1.57	.56	1.42	.48	1.50	.46
Weeds (Kg DM/ha)	120	61	326	372	389	454
Residual grain (Kg DM/ha)	34	20	21	19	45	43
Irrigated						
Stubble (T DM/ha)	3.37	.81	3.62	.88	—	—
Weeds (Kg DM/ha)	185	222	126	150	—	—
Residual grain (Kg DM/ha)	28	23	60	46	—	—

Immediately after harvest, stubble biomass in the rainfed farms was about 1.5 ton/ha regardless of cereal specie (table 2). Quantities of weeds per hectare were variable and average residual grain was low (20 to 45 kg/ha). On the other hand, stubble biomass in the irrigated farms was high (3.4 to 3.6 ton DM/ha); small quantities of weeds were found, while average residual grain did not exceed 60 kg/ha.

By-Product Evaluation and Utilization for Fattening Lambs

Growth and fattening of lambs for market is an important phase that has great impact on the overall productivity of sheep. The objective is to achieve normal growth after weaning and to increase carcass weight of slaughtered lambs. The primary goal of this part of the CRSP feed resource and nutrition program is to establish feeding systems for growing and fattening lambs based on locally available and economical feed resources. Several byproducts have been tested, such as waste palm dates, beet pulp, citrus pulp, carob pulp and almond hulls. These feeds are adequate as energy sources but need to be supplemented with protein (nitrogen). Under Moroccan conditions, urea is the cheapest source of nitrogen; however, sunflower meal as a source of true protein is becoming increasingly available at a competitive price. Ammoniation of feeds may also have potential as a method of nitrogen enrichment of some of these low protein by-products. The evaluation of these alternatives has been the main focus of recently conducted trials.

1. Ammoniated Citrus Pulp versus Urea or True Protein as Sources of Supplemental Nitrogen in Dried Citrus Pulp-based Diets for Sheep: Metabolism study. This metabolism study was conducted on the same diets previously used in a feeding trial which was summarized in the 1989-90 annual report. However, this study was not included in the 1990-91 workplan.

Citrus pulp was either ammoniated with ammonium hydroxide (CP-A), ammoniated with urea (CP-U), supplemented with urea, or supplemented with horse beans (HB). Citrus pulp was incorporated at a level of 45% in all diets. A low nitrogen grass hay (.96% N) was used as the forage component in these diets which also contained 10% molasses, 2% mineral-vitamin mix, and .5% chromic oxide as a digesta marker. Diets were isonitrogenous (1.8% N) and were fed at a rate of .8 kg/animal/day. Treatment effects on characteristics of digestion and nitrogen utilization were evaluated in a 4 x 4 Latin square using four crossbred (D'Man x Sardi) young rams with ruminal and proximal duodenum cannulas.

Peak and average ruminal ammonia concentrations were 25 to 47% lower ($P < .01$) for CP-A and CP-U versus the urea supplemented diet. However, ammoniation was not very effective in achieving sustained nitrogen release in the rumen. Ruminal pH values ranged from 6.7 to 7.0 across treatments and tended to be lower with HB versus non protein nitrogen-(NPN) containing diets. Source of supplemental NPN had no effect ($P > .10$) on ruminal volatile fatty acids (VFA) concentration or VFA profiles. Peak and average values were 93 to 107 and 73 to 84 mmoles/liter, respectively. As with previous studies

with citrus pulp-based diets, acetate:propionate ratio was high, with average values of 4.2 to 4.6. There was no treatment effect (P > .10) on ruminal digestion of organic matter (OM) and cell wall constituents. However, total tract digestion coefficients were 7 to 8% lower (P < .05) for NPN-supplemented diets, compared to HB diets. Net microbial N synthesis and microbial efficiency were greater (P < .05) for the CP-U and HB versus CP-A or urea diets, with no significant differences between CP-U and HB. The poorer N utilization in the CP-A diet is partly attributable to a higher (P < .05) fecal N excretion observed with that diet. It was concluded that ammoniation of citrus pulp using urea is a safe and practical method of NPN enrichment and that there are potential nutritional benefits of ammoniation of citrus pulp versus direct urea addition to the diet.

2. *Chemical Composition, Nutritive Value and Utilization of Almond Hulls in Diets for Growing-fattening Lambs.*
Chemical composition of almond by-products was evaluated. Samples representing different varieties were collected in several areas of Morocco. Hulls and shells were analyzed separately. Almond hulls are high in soluble carbohydrates (25 to 27%) and pectin (7 to 10%). Neutral detergent fiber and lignin values averaged 20 and 7%, respectively. Crude protein (CP) is low and variable (3 to 7%). The shell fraction is particularly high in cell wall constituents (90% NDF) and lignin (25%) and extremely low in crude protein (less than 1%). Thus, the shell has little value as a ruminant feedstuff and may be a source of contamination if not completely separated from the hulls.

In vivo digestibility of the hulls was determined in a trial involving six young Sardi rams. Three alfalfa hay-based diets containing 0, 25, or 50% almond hulls were used in a duplicated 3 x 3 Latin square. Urea was added to almond hull-containing diets to equalize the CP content of all three diets (17% CP). Rams were fed at maintenance level. Each experimental period consisted of 15 days for adaptation and 7 days for total fecal collection. Digestibility coefficients were 64.0, 66.4, 42.5, 59.6, and 3.1% for dry matter (DM), organic matter, NDF, energy, and CP, respectively. Energy value was calculated as .69 feed units/kg DM for maintenance and .63 feed units/kg DM for growth.

In another trial, three isonitrogenous (14% CP) diets containing 0, 20, or 40% almond hulls (T1, T2, and T3, respectively) were used in a 90-day feeding trial involving 30 lambs (initial weight 22 kg and 4 months of age). Three balanced groups of 10 lambs (five Sardi and five D'Man x Sardi) were randomly assigned to one of the three diets. All diets contained, in addition to almond hulls, 25% alfalfa hay, 2% mineral-vitamin mix, and various proportions of barley grain and sunflower meal. Sugar beet pulp was included in T1, T2, and T3 at levels of 40, 20, and 0%, respectively (substituting for almond hulls). 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. All lambs were slaughtered at the end of the trial and carcass data were collected. Feed intake was higher (P < .05) for almond hull-containing diets. Values were 85, 97, and 94 g DM/

kg .75/day, respectively, for T1, T2, and T3. There was no treatment effect (P > .10) on feed efficiency (5.6 to 6.3 kg Dm/kg gain), daily gain (217 to 233 g/day), carcass weight (20.7 to 21.6 kg), or dressing percentage (47.8 to 50.2%). Daily gain and dressing percentage of Sardi lambs (236 g/d; 49.9%) were higher (P < .05) than those of the crossbred lambs (208 g/d; 48.0%). It was concluded that almond hulls, a by-product which remains unknown and largely under utilized in Morocco, is a good energy feed. It is very palatable and can be adequately used at levels up to 40% in diets for growing-finishing lambs, provided it is supplemented with nitrogen and minerals.

Supplementation of Wheat Straw Diets

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 and to ensure normal fetal development, lamb birth weight, and adequate milk production by the ewe for rapid lamb growth. Improving cereal straw-based diets by supplementation with energy and nitrogen from locally available sources is important to improve the biological and economic viability of Moroccan sheep production.

Effects of Energy and Protein Levels and Protein Source on Intake and Digestibility of Straw Diets Fed to Pregnant Ewes

Fifty-six Timahdit ewes were used to determine the effects of protein source, crude protein (CP), and energy intake during the last month of pregnancy on ewe weight change, lamb birth weight, and lamb growth during the first month after lambing. Treatment consisted of two protein sources (urea and sunflower meal), two CP levels (9 and 11% CP), and two energy levels (80 and 120% energy requirement). The design was a 2 x 2 x 2 factorial arrangement. Preliminary data on the weight changes of ewes and lambs are presented in table 3.

Table 3. Weight changes (Kg) of Timahdit ewes and their lambs at different protein and energy supplementation level.

Energy level, %		80				120			
CP level, %		9		11		9		11	
Source of CP		Urea	SF	Urea	SF	Urea	SF	Urea	SF
Initial wt	avg	32.3	33.3	32.9	33.5	32.8	28.6	28.1	30.7
	sd	4.4	2.4	3.9	4.5	3.8	2.6	5.1	2.5
Final wt	avg	38.6	36.8	37.6	37.0	37.6	35.6	37.7	37.1
	sd	4.4	3.1	3.7	4.8	4.2	2.2	3.7	2.4
Wt at lambing	avg	31.4	31.8	29.5	31.1	32.3	29.6	30.1	33.0
	sd	3.8	1.5	4.7	4.8	2.9	2.2	3.0	2.7
Ewes wt at 30 d	avg	31.6	29.5	31.3	26.7	32.0	30.8	32.0	32.8
	sd	4.2	2.6	5.4	5.4	2.4	2.2	4.4	1.3
Lamb Birth wt	avg	3.1	3.2	2.6	3.1	3.1	3.2	3.4	3.0
	sd	.6	.3	.4	.5	.9	2.2	.6	.6
Lambs wt at 30 d	avg	8.1	8.3	7.6	7.7	9.1	8.7	8.9	7.9
	sd	1.2	.9	.9	1.1	1.4	2.2	.6	.8

Changes in 1990-1991 work plans and reason(s)

Difficulty in obtaining ewes from the breeding project for use in nutrition studies again necessitated modification in plans. There was no work completed on the influence of nutritional flushing on ovulation rates because no animals were released for such work. The direct comparison of supplementing Sardi and Sardi x D'Man F1 ewes grazing wheat stubble was not completed as planned because few animals were available. Instead of 48 Sardi and 48 D'Man x Sardi (DxS), the nutrition group was provided with no Sardi, 24 DxS, and 24 (3/4 D x 1/4 S) ewes. Unfortunately, 14 of the ewes were pregnant before the trial began. Difficulty in cooperative studies continues to be a major limitation in the prolific sheep work.

Training

In Progress

A. Fares, IAV Hassan II Rabat. MS. Nutrition. Expected graduation: 1991. MS research focuses on stubble grazing by pregnant ewes.

Abdellah Mendili, ENA Meknes. MS. Nutrition. Expected graduation: 1992. MS research focuses on effects of energy and protein supplementation on intake and digestibility of straw diets for pregnant ewes.

Malika Elhata, IAV Hassan II Rabat. MS in Nutrition. Expected graduation: 1992. MS research focuses on chemical composition, nutritive value and utilization of almond hulls in diets for growing sheep.

Completed
Nacif Rihani, IAV Rabat. 1992. PhD Nutrition. Univ. of California, Davis. Dissertation Title: Non-protein nitrogen supplementation of citrus pulp based diets for sheep.

Collaborating Personnel

Morocco
- Fouad Guessous, Co-PI, Nutritionist, IAV
- Nacif Rihani, Animal Nutritionist, IAV
- Ahmed Kabbali, Animal Nutritionist, ENA

United States
- Jean Marie Luginbuhl, Animal Nutritionist (Morocco Coordinator), NCSU

Collaborating Institutions

- Hassan II Institute for Agronomy and Veterinary Medicine (IAV), Rabat
- National School of Agriculture (ENA), Meknes

Publications

Kabbali, A., W. L. Johnson, D. W. Johnson, R. D. Goodrich and E. C. Allen. 1991. Effects of undernutrition and refeeding on weights of body parts and chemical composition of growing Moroccan lambs. J. Anim. Sci. (In Press).

Kabbali, A., W. L. Johnson, D. W. Johnson, R. D. Goodrich and E. C. Allen. 1991. Effects of compensatory growth on some body component weights and on carcass and non-carcass composition of growing lambs. J. Anim. Sci. (In Press).

Guessous, F., J-M. Luginbuhl, N. Rihani and K. R. Pond. 1991. Influence of supplementation on the performance of gestating ewes grazing wheat stubble pastures. Anim. Feed. Sci. Technol. 35:95-103.

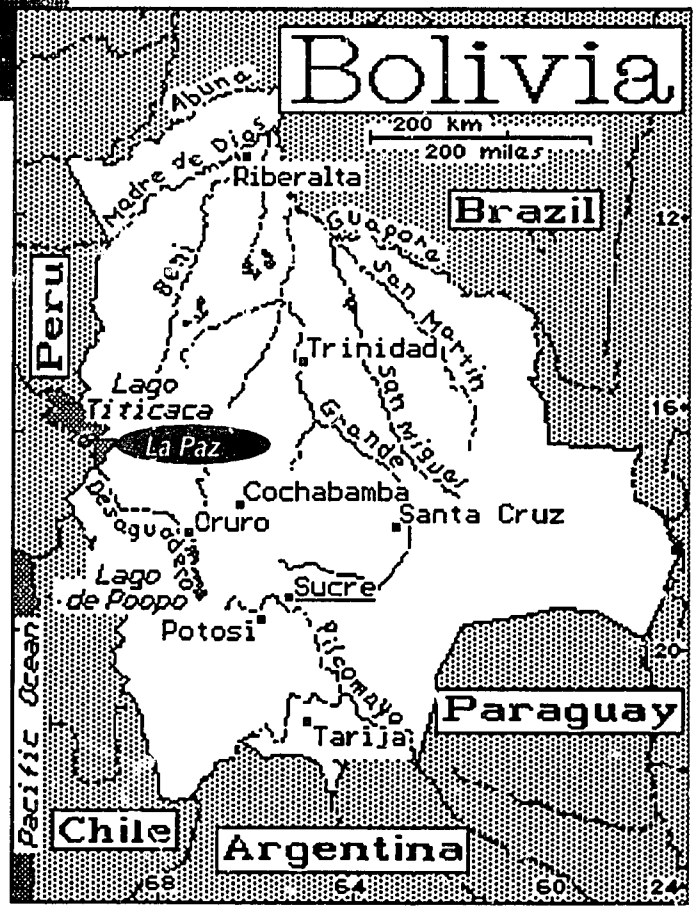
Guessous, F. Utilisation des chaumes de cereales par les ruminants. 1991. In: Livestock in the Mediterranean Cereal Production Systems. Proc. Int. Symp. ANPA - EAAP -ICAMAS. (In Press).

Rihani, N. Citrus fruit by-product nutritive value and utilization. 1991. In: J. L. Tisserand and X. Alibes (Ed.) Mediterranean Forages and By-Products. Options Mediterranennes. Serie A, No. 16. CIHEAM.

Sustainable Agropastoral Systems on Marginal Lands Component

"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 (424,162 square miles)
Land use: 3% arable land, 25% meadows and pastures, 52% forest and woodland, 20% other
Population (1990): 7.3 Million
Population growth: 2.6%
Agriculture accounts for 20% of GNP (including forestry and fisheries) and 43% of workforce
Agricultural imports: $90,828,000
Agricultural exports: $36,307,000
Food and animals imported: $86,738,000
Food and animals exported: $28,564,000
Sheep: 9,600,000
Goats: 2,350,000
Mutton and lamb: 23,000 metric tons
Goat meat: 5,000 metric tons
Sheep milk: 31,000 metric tons
Goat milk: 11,000 metric tons
Wool: 5,100 metric tons

University of Missouri-Columbia

Sociological Analysis of Small Ruminant Production Systems

Project Number: 105-12

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
Papers were commissioned as part of the baseline research on Agropastoral Systems in Bolivia, following the stated strategy of the 1990-1991 workplan. This consisted of first holding a workshop, planned and organized by the Sociology component of the SR-CRSP. The presenters selected prepared papers on topics that fall in the objectives of the proposed research. Topics pertaining to Bolivian agropastoral production and the ecology were presented, combined with the latest theoretical views on arid land ecology, agro-ecology, household production, and farming systems research. The role played by small ruminants was emphasized. The following topic was analyzed: semi-arid, drought prone environments with high variability of rainfall, with both livestock (sheep and South American camelids) and crop production as requirements of the site. A review of the following was presented: previous small ruminant research in Bolivia (Alzerreca); a general description of the Altiplano ecology (Quiroga); and comparisons of three different small ruminant production systems (Caro) in the Bolivian Altiplano and how production systems evolved historically and geographically to face labor and other constraints (Painter). This was necessary to plan the interdisciplinary research agenda of the SR-CRSP in Bolivia.

This integrated research program was developed for Bolivia in June of 1991, and the factors to be considered for site selection were narrowed.

As part of the site and counterpart selection process Keith Jamtgaard went to Bolivia in June of 1991. He found that it was difficult to locate a site where sheep, camelids, and crops were equally important. In that sense the region of the Patacamaya Station seemed to be most appropriate, though llamas are out-numbered by sheep and cattle.

In December, 1991, Jere Gilles went to Bolivia and participated in a planning activity; subsequently, a sociologist has been hired by IBTA as a counterpart to the Sociology project.

Research

Problem statement and approach
"To gather background data on the complex human-animal-environment interactions to be studied in the new SR-CRSP site, which focuses on sustainable agropastoral systems on marginal land."

The first means to accomplishing this objective was the workshop "Sustaining Agropastoral Systems in the Bolivian Altiplano: SR-CRSP Research Priorities for the Next Decade." This research

symposium took place May 14-17 in Lubbock, Texas. Both the theoretical and Bolivia background papers were important to define and develop a multidisciplinary and integrated research agenda (a list of the papers is provided in section 10).

This activity was to be followed by a baseline study to be carried out in Bolivia. Difficulties were encountered in carrying out this activity due to several delays: signing the memorandum of understanding, selecting resident scientists, and finding Bolivian counterparts for the sociology component. The base line study has been scheduled for the first semester of 1992.

The second activity was the initial site and counterpart selection for the base line survey. Jamtgaard found that the latest survey in rural areas was the census conducted in 1976. A rural household survey is being prepared with the support of AID. At the time of Jamtgaard's visit, no counterparts had yet been selected as there were problems in finding scientists that would be willing to participate in the SR-CRSP mode. This was solved when IBTA, with PL 480 funds, hired a sociologist.

Planning activities were carried out by Jere Gilles in his December trip to Bolivia. The community of San Jose de Llangas was the first chosen for the research. The activities have been planned, and the baseline survey will be carried out in the first six months of 1992.

Training

No training was budgeted in this fiscal year.

Other contributions

IBTA is also working with ORSTOM and IRDC and is coordinating efforts to study agropastoral systems in the Altiplano. Currently we are in the process of developing procedures for data processing, methods, and findings.

The whole purpose of the research on sustainable agropastoral systems in the Bolivian Altiplano is to develop responsible policies for the environment that are feasible for the small ruminant producers of this region.

Collaborating Personnel

Bolivia

- Christian Jette, IBTA

United States

- Michael F. Nolan, Principal Investigator
- Jere L. Gilles, Co-Principal Investigator
- Corinne Valdivia Ph.D. University of Missouri-Columbia
- Keith Jamtgaard Ph.D. Montana State University
- Constance McCorkle Ph.D. University of Missouri-Columbia

Collaborating Institutions

- Utah State University
- University of Missouri-Columbia
- Winrock International
- Instituto Boliviano de Tecnología Agropecuaria (IBTA)
- Texas Tech University

Publications

Papers Published

Constance, Douglas H., Jere L. Gilles and William A. Heffernan. 1990.

"Agrarian policies and agricultural systems in the United States." pp 9-75 in A. Bonanno (ed) *Agrarian Policies and Agricultural Systems* Boulder, Westview Press.

Gefu, Jerome and Jere L. Gilles. 1991. "Pastoralist, ranchers and the state in Nigeria and North America," *Nomadic People* 27:34-50.

Gilles, Jere L. 1990. "The Social context for rangeland improvement" pp. 38-53 in BOSTID National Research Council *The Improvement of Tropical and Sub-Tropical Rangelands*, Washington, D.C., National Academy Press.

Gilles, Jere L. and Jerome Gefu. 1990. "Nomads, Ranchers and the State: The socio-cultural aspects of pastoralism" pp. 99-118 in J. Galaty and D. Johnson (eds) *The World of Pastoralism*, N.Y. Guilford Press.

Commissioned Papers for the Bolivia Workshop Lubbock Texas May, 1991

Painter, Michael "Changes in Highland Land Use Patterns and the Implications for Agropastoral Research in Bolivia."

Quiroga, Juan Carlos "Agro-ecological Characterization of the Bolivian Altiplano."

Ellis, James E. "New Perspectives of Arid-Lands Ecology and Implications for SR-CRSP Agropastoral Research."

Grove, Thurman L. "Agro-Ecological Perspective on Small Ruminant Research and Development."

Caro, Deborah A. "The Socio-Economic and Cultural Context of Andean Pastoralism: Constraints and Potential for Biological Research and Interventions."

Norman, David W. "Household Economics and Community Dynamics."

Alzerreca, Humberto "Overview of Small Ruminant Research in Bolivia."

Books and Chapters in Books

McCorkle, Constance M. (ed). 1990. *Improving Andean Sheep and Alpaca Production: Recommendation from a Decade of Research in Peru* published in Spanish and English. UMC, Missouri.

Bilinsky, Paula and Mark Gaylord. 1992. "Outreach pilot project: Small Ruminant Research and Extension in West Java" in McCorkle (ed.) *Plants, Animals, and People Agropastoral Systems Research* Westview Press, Boulder Colorado.

Fernández, María E. 1992. "The Social organization of production in community-based agropastoralism in the andes" in McCorkle (ed.) *Plants, Animals, and People Agropastoral Systems Research* Westview Press, Boulder Colorado.

Guillet, David W. 1992. "The Impact of alfalfa introduction on common field agropastoral regimes: Quechua Villagers in Southwestern Peru" in McCorkle (ed.) *Plants, Animals, and People Agropastoral Systems Research* Westview Press, Boulder Colorado.

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McCorkle, Constance M. 1992. "Introduction. Agropastoral systems research in the SR-CRSP Sociology Project" in McCorkle (ed.) *Plants, Animals, and People Agropastoral Systems Research* Westview Press, Boulder Colorado.

Perevolotsky, Avi. 1992. "Integration versus conflict: Crops and Goats in Piura, Peru" in McCorkle (ed.) *Plants, Animals, and People Agropastoral Systems Research* Westview Press, Boulder Colorado.

McCorkle, Constance M. 1992. "The Agropastoral dialectic and the organization of labor in a Quechua Community" in McCorkle (ed.) *Plants, Animals, and People Agropastoral Systems Research* Westview Press, Boulder Colorado.

Mendes, Lloyd and Hamid Narjisse. 1992. "Range-Animal ecology and agropastoralism in Morocco's Western High Atlas Mountains" in McCorkle (ed.) *Plants, Animals, and People Agropastoral Systems Research* Westview Press, Boulder Colorado.

Primov, George. 1992. "The Role of Goats in Agropastoral Production Systems of the Brazilian Sertao" in McCorkle (ed.) *Plants, Animals, and People Agropastoral Systems Research* Westview Press, Boulder Colorado.

Abstracts and Presentations

Abstracts

McCorkle, Constance M. "Principles and Praxis in Ethnoveterinary R & D." American Anthropological Association. 90th Annual Meeting Chicago, Illinois. November 1991.

Mathias-Mundy, Evelyn. "Paraveterinary Health Care: A Review if the Literature" American Anthropological Association. 90th Annual Meeting Chicago, Illinois. November 1991.

Valdivia, Corinne. "The Impact of Exchange Rate Policy on Producers of Tradable Goods: Sheep Meat and Wool in Peru" Southern Agricultural Economics Association. Fort Worth Texas. Feb. 1991.

Presentations

McCorkle, Constance M. (Chair/Organizer) Ethnoveterinary Research and Development: Applications for Theory and Practice at the American Anthropological Association Annual Meeting Nov. 1991, Chicago.

McCorkle, Constance M. "Ethnoveterinary Research and Development" lecture to Seminar on International Veterinary Medicine. Purdue 4 April 1991.

McCorkle, Constance M. "The Roles of Animals in Social, Cultural, and Agroeconomic Systems" Purdue University 5 April, 1991.

Nolan, Michael F. "Perspectives on the Sheep and Goat Industry in Indonesia" at Global Animal Agriculture Animal Science Center UMC Nov, 1990.

Articles in Newsletters and Magazines

McCorkle, Constance M. "Pooling labor and herds" in *ILEIA* Newsletter for Low External Input and Sustainable Agriculture 4/91 December Volume 7, 1991 The Netherlands

McCorkle, Constance M. et al. "Social Research in International Agricultural R & D: Lessons from the Small Ruminant CRSP" *Agriculture and Human Values* Vol.VI No.3 pp.42-51 reviewed in The Heifer Project exchange Appropriate Technology for a Developing World No. 57 November/December 1990.

Awards

Honorable mention winner of the 1991 Oberly Award for Bibliography in the Agricultural Sciences to Dr. Constance McCorkle and Dr. Evelyn Mathias-Mundy, authors of *Ethnoveterinary Medicine: An annotated bibliography* by Science and Technology Section, Association of College and Research Libraries of the American Library Association

Other Comments

Through IBTA, linkages are being made with a World Bank research support program and UNPP program targeted at alpaca and llama producers.

Texas Tech University

Sustaining Small Ruminant Production in the Andean Agropastoral Zone

Project Number: 111-12

Fred C. Bryant, Department of Range & Wildlife Management, Texas Tech University, Lubbock, Texas 79409-2125. Telephone (806) 742-1983, Fax (806) 742-2280.

Narrative Summary

This report covers the period of activity from October 1, 1990, through December 31, 1991. Primary activities focused on intensive and detailed research planning in order to implement properly a comprehensive, multi-disciplinary program. Major benchmarks for the period include (1) a three-day symposium on Andean agropastoralism in Lubbock, Texas, involving key scientists from the U.S. and Bolivia and (2) two trips to Bolivia which laid the groundwork for a long-term working relationship with USAID/La Paz and collaborating Bolivian institutions. Two scientists supported by the SR-CRSP graduated from Texas Tech University with Ph.D.s in Range Science. Through supplementary funding, a resident scientist, Morty Ortega, was employed and placed in Bolivia in October, 1991. Dr. Ortega became the first SR-CRSP Resident Scientist placed in Bolivia and temporarily assumed the role of Acting Site Coordinator. Dr. Ortega's activities include directing the SR-CRSP office in La Paz, identifying co-investigators and potential research sites, and providing liaison with USAID La Paz.

Research

Problem Statement and Approach

Bolivia

During this reporting period, the SR-CRSP was authorized to undertake a new component: Sustaining agropastoralism on Marginal and Fragile Lands. Bolivia was identified as the Host Country for this component. Detailed planning workshops were conducted in the U.S. and Bolivia to identify production constraints, explore new socio-economic and biological theories and paradigms, solicit ideas and input from scientists with Andean agropastoralist experience, and receive counsel from Bolivian scientists.

United States

A major research effort supported by the SR-CRSP was brought to fruition during 1991. Research was launched four years ago in the Texas Coastal Bend to understand the dynamics of herbivory by livestock under different grazing practices and stocking rates. Impacts on rangeland phytomass, floral composition, domestic livestock, and native ungulates, were studied. Two Ph.D. students, Sergio Soltero-Gardea (full SR-CRSP support) and Morty Ortega (partial SR-CRSP support), conducted research using conventional methods of vegetation sampling, esophageally fistulated livestock, and semi-domesticated white-tailed deer on native rangeland grazed under a short-duration grazing system and continuous year-long grazing at two different stocking rates. Data were collected on herbage biomass and floral composition, ruminant nutrition, and foraging behavior.

Progress

Bolivia

Collaborators in the SR-CRSP identified drought as the most devastating, natural-occurring phenomenon affecting agropastoralists in arid and semi-arid environments. Drought causes extreme hardship on small ruminant producers because it affects animals, destroys crops, reduces household income, causes peasant migration and relocation, and damages natural resources. Research was designed to not only understand how campesinos deal with drought, but to study methods and strategies which produce interventions that help agropastoralists ameliorate its devastating impacts. The following series of workshops and meetings permitted the development of a long-term research plan.

A symposium, "Sustaining Agropastoral Systems in the Bolivian Altiplano," was held in Lubbock, Texas, May 1991. Papers from leading scientists were given on topics such as ecology of the Bolivian Altiplano, social constraints of agropastoralists, economic and marketing alternatives, and new paradigms in natural resource management in developing countries. Symposium participants also conducted planning sessions in which small, multi-disciplinary work groups debated and discussed potential researchable topics that could be addressed by the SR-CRSP. Proceedings of this symposium is being prepared and will be available in 1992.

In June, 1991, a detailed planning workshop involving all the principal investigators working in Bolivia was held in Kansas City to finalize the long-term research agenda.

In July, 1991, Principal Investigators (PIs) traveled to Bolivia to present the research plans and agendas to USAID and Bolivian counterparts for input and approval. Further, Bolivian institutions were visited to understand the level of technical, laboratory, and scientific support available. Research budgets were developed to justify additional financial support from PL-480.

In December, 1991, PIs returned to Bolivia to cement collaborative relationships and identify worksites. In addition, a workshop was held in La Paz with representatives from several Bolivian universities and institutions and international donor agencies. Representatives from USAID, France, Canada, World Bank, and Bolivian institutions presented individual workplans and work sites to identify areas of overlap and commonality with the SR-CRSP. A field excursion identified a worksite near Patacamaya where research would be implemented. U.S. PIs and Bolivian co-investigators identified research projects to be implemented early in 1992.

Scientists working with Texas Tech University were targeted to address problems and constraints dealing with Nutrition and Feed Resources.

United States

Highlights from the impact study on of livestock herbivory include the following findings.

Over the two-year study period, phytomass of forbs was not affected by grazing system or stocking rate (tables 1 and 2). Desirable grass phytomass was negatively affected by short duration grazing and heavy stocking rates (tables

1 and 2). Litter accumulated more under short duration grazing and under moderate stocking rates than continuous grazing and heavy stocking rates (tables 1 and 2).

Table 1. Phytomass of plant groups (g/sq m) under continuous yearlong grazing (CYG) and short duration grazing (SDG) across seasons in the Texas Coastal Bend.

	Grazing System			
Plant Groups	CYG	SD[1]	SDG	SD
Desirable forbs	27.5[a2]	23.3	23.1[a]	22.8
Undesirable forbs	22.4[a]	48.9	20.8[a]	56.0
Desirable grasses	58.5[a]	39.8	50.6[b]	36.7
Undesirable grasses	0.8[a]	1.5	0.4[a]	1.5
Desirable grass-like	3.7[a]	3.6	1.6[b]	1.7
Undesirable grass-like	0.2[a]	0.4	0.2[a]	1.0
Litter	112.7[b]	46.0	133.1[a]	73.0
Total	224.5[a]	101.7	231.1[a]	97.1

[1] Standard deviation
[2] Means with the same superscript in rows are not significant different (P<0.05).

Table 2. Phytomass of plant groups (g/sq m) under heavy (HE) and moderate (MO) stocking rates across seasons in the Texas Coastal Bend.

	Stocking Rate			
Plant Groups	HE	SD[1]	MO	SD
Desirable forbs	26.4[a2]	23.9	24.1[a]	22.1
Undesirable forbs	22.1[a]	49.6	21.1[a]	55.3
Desirable grasses	45.7[a]	33.3	63.8[b]	43.2
Undesirable grasses	0.4[a]	1.1	0.7[a]	2.0
Desirable grass-like	2.0[a]	2.0	3.3[b]	3.3
Undesirable grass-like	0.1[a]	0.3	0.2[a]	1.0
Litter	102.6[b]	62.7	143.3[a]	56.3
Total	198.0[a]	105.7	257.6[a]	93.7

[1] Standard deviation
[2] Means with the same superscript in rows are not significant different (P<0.05).

Table 3. Crude protein (%) and digestible organic matter (%) of deer and cattle diets under two grazing systems continuous yearlong (CYG) and short duration grazing (SDG), and two stocking rates, heavy and moderate in the Texas Coastal Bend.

	Deer				Cattle			
Grazing Strategy	CP[1]	SD[2]	IVDOM	SD	CP	SD	IVDOM	SD
Grazing System								
CYG	11.1	1.9	47.5	7.8	8.0	2.1	39.1	7.6
SDG	10.6	1.9	44.6	8.3	7.4	1.9	38.6	7.8
Stocking Rate								
HE	10.9	1.9	46.6	8.0	8.2	2.0	39.7	8.0
MO	10.8	1.9	45.4	8.1	7.3	2.0	37.9	7.4

[1] CP = Crude protein
IVDOM = *In vitro* digestible organic matter
[2] Standard deviation

Domestic ruminants and deer selected diets higher in crude protein and digestibility under continuous yearlong grazing than short duration grazing (table 3). Deer nutrition was unaffected by stocking rate, while domestic ruminants selected higher quality diets under heavy stocking rates than moderate stocking rates (table 3). This was attributed to nutritious regrowth grazed by cattle under heavy stocking. However, phytomass was lower under heavy grazing (tables 1 and 2) which implies that while quality of forage was enhanced, quantity of forage was depressed making the relative value of heaving stocking questionable to maintaining good livestock production.

Training

In Progress

Morty Ortega, Post-Doctoral Fellow, Range Science, Texas Tech University

Completed

Morty Ortega, Ph.D., 1991, Range Science, Texas Tech University

Sergio Soltero-Gardea, Ph.D., 1991, Range Science, Texas Tech University

Short Term

Texas Tech University hosted the symposium, "Sustaining Agropastoral Systems in the Bolivian Altiplano." Over 30 participants spent three days in formal presentations, formal discussions, and group planning.

Contributions to U.S. Agriculture

Two Ph.D. students, Sergio Soltero-Gardea and Morty Ortega, completed dissertations of relevance to U.S. agriculture. The dissertations focused on livestock grazing systems and stocking rate impacts on (1) floral composition and biomass of native pastures, (2) nutrition of domestic livestock utilizing native rangeland, and (3) nutrition and grazing behavior of wild ungulates. Results documented that stocking rate and grazing systems both impact natural resources and livestock nutrition. Information gained will be used to better manage livestock on native rangelands of the southwest United States.

Collaborating Personnel

Bolivia

- Ing. Humberto Alzerreca, Instituto Boliviano de Tecnologia Agropecuaria
- Dr. Maximo Lieberman, San Andres University, La Paz
- Ing. Carlos Salinas, Instituto Boliviano de Tecnologia Agropecuaria

United States

Drs. Mike Nolan and Jere Gilles, University of Missouri
Dr. Enrique Ospina, Winrock International
Dr. Ben Norton, Utah State University
Dr. Bill Dahl, Texas Tech University
Dr. Rod Preston, Texas Tech University
Dr. Carlton Britton, Texas Tech University

Collaborating Institutions

Instituto Boliviano de Tecnologia Agropecuaria
Utah State University
Winrock International
University of Missouri

Publications

Dissertations

Soltero-Gardea, Sergio. 1991. Phytomass dynamics and deer and cattle nutrition under different grazing practices in the Texas Coastal Bend. Ph.D. Diss. Texas Tech University, Lubbock.

Ortega, Isaac Morty. 1991. Deer and cattle foraging strategies under different grazing practices and stocking rates. Ph.D. Diss. Texas Tech University, Lubbock.

Publications

Bryant, Fred C. 1990. Facts about short-duration grazing. Pages 89-112. In: D. Herd and W.M. Warren (Eds.) Beef Cattle Sci. Handbook Vol. 24. International Stockmans School.

San Martin, F. and F.C. Bryant. 1991. Investigaciones sobre pastos y forrajes de Texas Tech University en El Peru. Texas Tech University. Volume VI.

Abstracts and Presentations

Abstracts

Soltero, S., F. C. Bryant, and I. M. Ortega. 1990. Herbage dynamics as affected by two stocking rates and two grazing systems. Abstr. No. 94. Abstracts of Papers, 43rd Annual Meeting, Soc. for Range Manage., Reno, NV.

Ortega, I. M., F. C. Bryant, and S. Soltero. 1990. White-tailed deer diets under short duration and continuous grazing. Abstr. No. 307. Abstracts of Papers, 43rd Annual Meeting, Soc. for Range Manage., Reno, NV.

Soltero, S., F. C. Bryant, and I. M. Ortega. 1990. Quality of deer and cattle diets under two grazing systems and two stocking rates. Abstr. No. 309. Abstracts of Papers, 43rd Annual Meeting, Soc. for Range Mange., Reno, NV.

Presentations

San Martin, F., F. C. Bryant, and J. Pfister. 1990. Selectividad, consumo, y importamiento alimenticional pastoreo le llama, alpaca y ovinos en los Andes del Peru. XII Mtg. Latin Amer. Anim. Prod. Asociacion. Sao Paulo, Brazil.

Soltero, S., F. C. Bryant, and I. M. Ortega. 1990. Herbage dynamics as affected by two stocking rates and two

grazing systems. 43rd Annual Meeting, Society for Range Manage., Reno, NV. Feb. 13-15.

Ortega, I. M., F. C. Bryant, and S. Soltero. 1990. White-tailed deer diets under short-duration and continuous grazing. 43rd Annual Meeting, Society for Range Manage., Reno, NV. Feb. 13-15.

Soltero, S., F. C. Bryant, I. M. Ortega. 1990. Quality of deer and cattle diets under two grazing systems and two stocking rates. 43rd Annual Meeting, Society for Range Manage., Reno, NV. Feb. 13-15.

Bryant, F. C. 1990. Facts about short duration grazing. International Stockmans School. Houston, TX Feb. 15-17.

Other Comments

Funding levels from Supplemental Funds greatly boosted our ability to launch a research program and place a Resident Scientist in Bolivia after the MOU was signed in September. Funding levels from the subgrant were sufficient to cover travel, completion of training obligations, publications, and U.S. core support. Because the Agropastoral Program was to be phased in slowly, funding levels in the original subgrant were not adequate to support anything but a minor research effort.

USAID Mission involvement has been more than adequate. A major plus for the SR-CRSP was the steadfast support by USAID Mission in La Paz for PL-480 funds directed to the SR-CRSP. These funds will support four Bolivian Scientists from IBTA who are assigned to the SR-CRSP. In addition, PL-480 funds will support six technicians to work with SR-CRSP research projects.

Utah State University

Range Ecology

Project Number: 114-12

Brien E. Norton, Department of Range Science, Utah State University, Logan, Utah, 34322-5230. Telephone 801-750-2476, Fax 801-750-3796.

Narrative Summary

The Agropastoral Systems project in Bolivia was initiated in 1991. Humberto Alzerreca was identified as the IBTA counterpart for the range ecology section. The community of San Jose de Llanga was selected as the field site for an interdisciplinary research program. Attention in 1991 focused on research design and planning. The first step is a land-use survey of San Jose, which will complement analysis of satellite imagery underway at Utah State University. The remote sensing study will also include a general resource inventory of the central altiplano and a retrospective review of land use and productivity over the past ten years. Sheep flocks in San Jose will be monitored in order to describe the relative importance of their feed and forage resources, thus placing the grazing land in perspective. Much of the community's lands are characterized by saline soils, which have potential for increased productivity. The first experimental trial at the site is testing the suitability of several indigenous perennial species for rehabilitating saline areas. On the Logan campus of Utah State University, documents from range and/or livestock development projects have been cataloged and are being scrutinized to ascertain procedures for evaluating such projects, particularly the assumptions upon which the procedures are based. This last study will create a reference point for exploring improved methodologies for assessing resources and livestock management in drought-prone areas.

Research

The Sustaining Agropastoral Systems project was initiated in Bolivia during the past year. Final approval for a project in Bolivia was finally granted by the SR-CRSP Board on August 13, and the Memorandum of Understanding authorizing the Small Ruminant CRSP to operate in Bolivia was not signed until September. A final project proposal was adopted by the four participating U.S. institutions in June 1991. That proposal forms the basis for this report of research.

Most of the work in the reporting period focused on start-up activities. Humberto Alzerreca, an IBTA range scientist, was appointed counterpart to the Range Ecology project in July. The Principal Investigator made three site visits to Bolivia, largely concerned with project planning and initiation. In early December, 1991, the group of U.S. P.I.'s and their Bolivian counterparts chose the campesino community of San Jose de Llanga to become the field site for the integrated agropastoral project. A cooperative agreement with San Jose will be signed in January, 1992. A second field site will be selected some time in 1992.

Six students conducting research projects for their B.S. theses at San Andreas University in La Paz were identified to receive support from the SR-CRSP. These thesis projects will be included in the next annual report.

Inventory and utilization of feed resources

The selection of a field site (the community of San Jose de Llanga) for this activity occurred in the last month of the reporting period. Initial studies were outlined and plans laid for obtaining a vehicle, purchasing equipment, hiring field technicians, and providing training for the technicians.

Land-use survey of the community of San Jose de Llanga. The first priority of the range ecology project is to conduct a land-use survey of the area managed by the community, of which about 40 percent is farmland in small parcels and the remainder rangeland. The product generated by this survey will be a map showing each farmed field, the crop grown in 1991-92 or fallow status, and the rangelands mapped according to ecological type and condition class. A fresh set of aerial photos (1:10,000) will be taken in Spring, 1992, to assist with the survey.

Remote sensing. Satellite imagery is being analyzed to conduct resource surveys of the central region of the altiplano. (This work is being funded by the SR-CRSP supplementary funds received in 1991.) The remote sensing work has several thrusts. The specific community of San Jose de Llanga will be studied with Thematic Mapper imagery and the map units related to the on-ground land-use survey. On a smaller scale, a strip of the central altiplano will be mapped, covering an area of about 5,000 km^2. If funds permit, Landsat imagery will also be used to look at land use and resource productivity going back over the last ten years, which embraces the drought of 1983-84 and will assist the project in defining drought on the altiplano. Finally, AVHR data will be utilized to develop a picture of phenological change on the altiplano.

Partitioning of forage resources utilized by sheep herds in the community of San Jose de Llanga. Concurrently with the land-use survey, work will begin on the study to determine how the feed resources of sheep herds are partitioned. The methodology will require the monitoring of sheep flock movements and recording where they graze and for how long, determining the relative contribution of feeds and forages to sheep diets, and interviewing sheep herders to discover the owner's or herder's rationale for specific flock management activities. This study will be carried out for at least one complete cycle of seasons, beginning in Spring, 1992.

Field evaluation of halophytic species with potential for vegetation improvement on saline rangelands. The community of San Jose de Llanga includes an extensive area of sandy saline soils. For some time IBTA has been collecting germplasm of halohytic species and conducting preliminary species evaluation studies at the Patacamaya Research Station. The more promising species need to be examined under natural conditions and subjected to sheep grazing pressures. To this end, some saline land has been set aside in San Jose for halophyte trials. Plots of 20 to 25 m^2 have been planted with three indigenous halophytes: *Atriplex cristata, Sueda foliosa,* and a

halophytic *Poa* species. More species will be established in 1992. The halophytes will be evaluated for ease of establishment, adaptation to the environment, forage production, and persistence under grazing. An estimated 30 percent of the altiplano has saline soil.

Livestock production
No research could be initiated for this activity in 1991-92 due to the delay in identifying the field work site.

Traditional methodology used for planning and justifying livestock development projects
A collection of development project documents was compiled and catalogued. The documents are drawn from about three dozen projects, most of them funded by USAID, designed to improve productivity of rangeland and/or the livestock sector in developing countries. The documents include project papers, implementation plans, reports, and project evaluations. Work has begun to sift through these materials initially focusing on the rationale proposed at the project design stage to justify the projects.

This screening process is identifying methods used to present an economic argument which justifies project implementation. Assumptions explicit in the economic analysis are noted, and an attempt is made to discover and define implicit, non-stated assumptions critical to the economic justification. These assumptions generally include some estimation or presumption of carrying capacity of rangeland. The concept of carrying capacity, as developed in the U.S., may be inappropriate to subsistence production systems and traditional pastoralism, especially in semi-arid ecosystems (see papers listed under publications). We are interested in how figures of carrying capacity are derived as well as in the way in which estimates of carrying capacity are used in the economic analysis, including the sensitivity of the economic justification to specific carrying capacity values.

A secondary enquiry of this USAID project document review is to understand the basis for predicting an increase in off-take or other market activity in response to project inputs. In this case also, the assumptions underlying the economic arguments are often implicit. By reviewing a large number of projects in the range/livestock area we hope to discover patterns of methodological approach.

An understanding of agropastoral systems in a global setting
One of the objectives of this activity is to establish linkages with IARC's and other organizations concerned with small ruminant production systems in a global context.

The Principal Investigator is the leader of a project funded by the World Bank to develop a strategy for the development of the range/livestock sector in Morocco. This work will examine sheep production in Morocco in an agropastoral context and consider the effects of periodic droughts which have proven to have a major impact on the livestock sector. Despite conspicuous differences in environment and culture, there are many parallels between livestock production on the Bolivian altiplano and in semi-arid Morocco. The primary similarity is the interdependence of livestock and farming, both

biologically and economically. Incidence of drought is a critical feature of both production systems.

The World Bank is about to implement a project of technical assistance to IBTA with a livestock component focusing on the Bolivian altiplano. This World Bank project is under the leadership of the University of Wisconsin with Utah State University as a partner. In 1991 the SR-CRSP Principal Investigator contributed material towards proposal development showing how the two projects could interact for mutual benefit.

Concepts of sustainability developed in 1989-90 to provide a theoretical basis for the SR-CRSP Agropastoral project were a key ingredient to the generation of a proposal in 1991 for the SANREM CRSP (Sustainable Agriculture and Natural Resources Management CRSP) involving Utah State University in a consortium of institutions led by Michigan State University. The proposal from this consortium successfully passed the initial screening process.

Training

- Robert Washington-Allen, M.S. to be completed in 1992, in Range Science (remote sensing), Utah State University.
- Abdinasir Abdulle, Ph.D. to be completed in 1994, in Agricultural Economics, Utah State University.

Collaborating Personnel

Bolivia

- Humberto Alzerreca, Instituto Boliviano Tecnologia Agropecuaria

United States

- John C. Malechek, co-investigator, Utah State University.
- D. Layne Coppock, co-investigator, Utah State University.
- R. Douglas Ramsey, Dept. of Geography and Earth Resources, Utah State University

Collaborating Institution

Instituto Boliviano Tecnologia Agropecuaria (IBTA), La Paz, Bolivia

Publications

Bartels, G.B., G.K. Perrier and B.E. Norton. 1990. The applicability of the carrying capacity concept to Africa: comment on a paper by de Leeuw and Tothill (PDN 29b). Pastoral Development Network 29d. Overseas Development Institute, London.

Bartels, G.B., B.E. Norton and G.K. Perrier. An examination of the carrying capacity concept. Proceedings of the Technical Meeting on Savanna Development and Pasture Production. Woburn, U.K., Nov 19-21 1990. Overseas Development Institute, London. (in press)

Winrock International

Economic Analysis of Small Ruminant Production and Marketing Systems

Project Number: 116-12

Enrique Ospina, Winrock International, Route 3, Morrilton, Arkansas, 72110. Telephone (501) 727-5435, Fax (501) 727-5417.

Narrative Summary

Due to delays on the commencement of research in Bolivia, most of the work during the past 15 months has focused on planning and organization. Several meetings were held in Bolivia and the U.S. with collaborators to plan and initiate research on the altiplano. The Economics Project completed a PL-480 proposal that was approved for funding by IBTA for January, 1992. The economics counterpart, John Vargas, has begun a descriptive analysis of livestock and a production survey; the resident scientist for economics is expected to be in Bolivia by April, 1992.

Problem Statement and Justification

More than 50% 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. It is necessary to develop sustainable crop-livestock production systems which are compatible with the needs and risks faced by small producers.

Economics will focus this year's research on the identification of areas where the program is most likely to contribute to smallholder welfare and to identify the mechanisms used by producers to cope with environmental and market risks. The following activities will be performed:

- Characterize the livestock production systems and the main economic constraints to production in the altiplano of Bolivia.

- Complete a baseline characterization for impact analysis of market, policy, and institutional constraints to small ruminant production in Bolivia.

- Identify labor, land, and capital sources, uses, and constraints.

- Describe policies of government and donors and assess impact on production and marketing.

- Assess impact of small ruminants in the household economy and gender roles.

Research

Work in the Agropastoral component in Bolivia during 1991 was focused on planning and organization. There were delays in signing project official documentation. Two planning meetings were held, one at Texas Tech in May and one in Kansas City in June.

There were two trips to Bolivia (July and December) by the principal investigators, to get work underway with IBTA, to visit the possible field stations and work sites, and to touch base with all the organizations and individuals conducting livestock research and extension in Bolivia. Collaborators were identified at the universities, several PVOs, and a producer's cooperative.

A major achievement of the economics program was the preparation of the proposal to obtain PL-480 funds to support the counterpart efforts. The proposal was submitted by the ME to IBTA, received support from the USAID mission, and was granted to begin in January, 1992.

Recruitment of the resident economist is underway; we expect the economist to be at post by the end of April. Purchase of equipment and vehicles has taken an unusual amount of time; it is hoped they will be in La Paz by late April.

The economics counterpart, John Vargas, initiated activities in December with two major plans: a descriptive analysis of the livestock situation in the altiplano assessing the major institutional and market constraints and a production survey to be conducted with the other program components.

In cooperation with the University of Missouri, the economics program has invested significant resources into publication of results from the research carried out in Peru during the last three years, particularly research related to the dissertation of Dr. Corinne Valdivia who graduated in 1990.

Collaborating Personnel

Bolivia

- Sibylle Scholz, Winrock resident economist
- John Vargas, IBTA

United States

- Henk Knipscheer, Co-Principal Investigator, Winrock International
- Corinne Valdivia, University of Missouri
- Domingo Martinez, University of Missouri

Collaborating Institutions

Instituto Boliviano de Tecnologia Agropecuaria (IBTA), Bolivia

Publications

Valdivia, Corinne and Maury E. Bredahl. 1991. The impact of exchange rate policy on producers of tradeable goods: Sheep meat and wool in Peru. Southern Agricultural Economics Association, Fort Worth, Texas, selected paper.

Valdivia, Corinne. Assessing the impact of policy on Peruvian Small Ruminant Production Systems. Development studies series, Winrock International, Morrilton, Arkansas. In press.

Valdivia, Corinne. 1991. Politica económica y ganadería extensiva: El caso de ovinos y camélidos en el Perú.

University of Missouri, Columbia, Missouri.

Abstracts and Presentations

Valdivia, Corinne. 1991. Policy impact assessment of Small Ruminant Production Systems, the Peruvian case. Presented at the Animal Production Systems Global Workshop, Costa Rica, September, 1991. Organized by IDRC.

Budget and General Comments

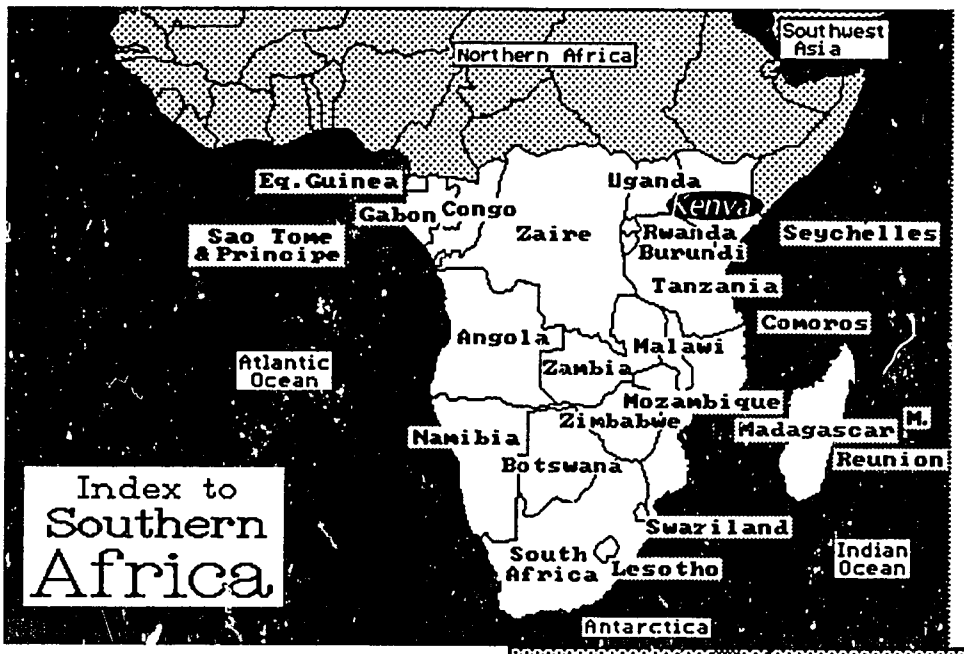
For the 1990/91 fiscal year, the economics program total subgrant funding amounted to $211,434 ($219,000 was budgeted). Winrock contributed $73,820 ($73,000 was budgeted). These resources proved insufficient to maintain a well-organized program in three sites and fund a resident scientist in each site. The amount of work and administration for the PI makes it difficult to administer three sites.

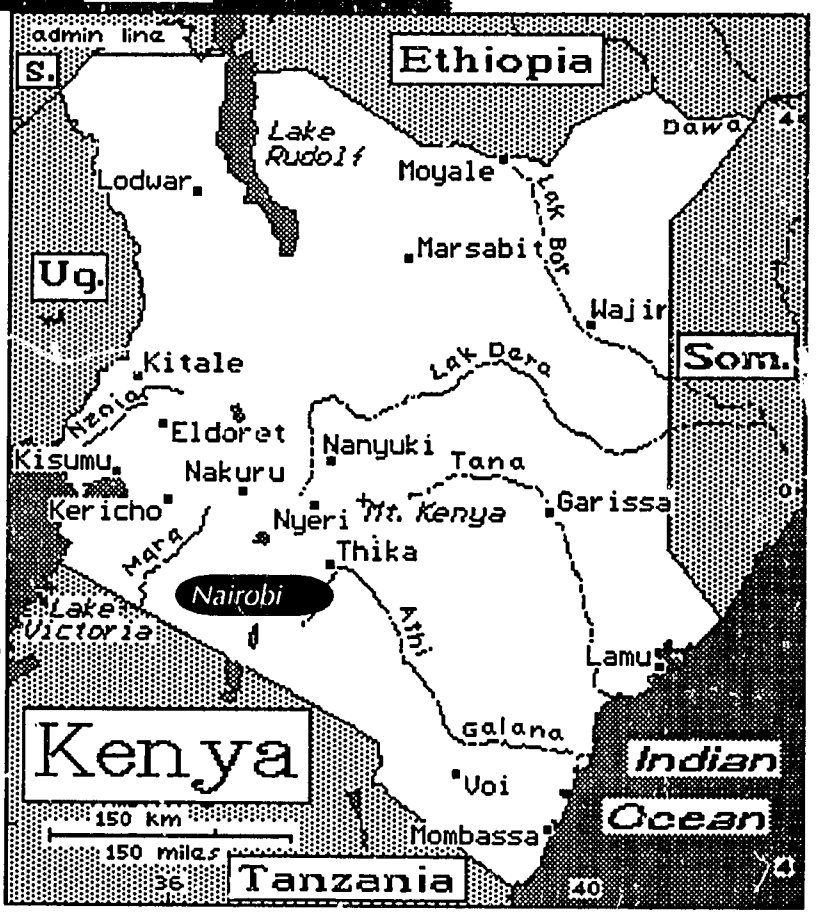
The Bolivia USAID Mission has been very helpful all the way through the process of organization and is interested in being kept informed of the project. Collaboration with host country organizations has been excellent.

Animal Health Management Through Biotechnology Component

"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 (224,961 square miles)
Land use: 3% arable land, 1% permanent crops, 7% meadows and pastures, 4% forest and woodland, 85% other.
Population (1990): 24.6 Million
Population growth: 3.8%
Agriculture accounts for 31% of GNP, 78.2% of workforce, and 50% of exports
Agricultural imports: $165,607,000
Agricultural exports: $908,915,000
Food and animals imported: $94,618,000
Food and animals exported: $827,878,000
Sheep: 7,300,000
Goats: 8,500,000
Mutton and lamb: 26,000 metric tons
Goat meat: 19,000 metric tons
Sheep milk: 29,000 metric tons
Goat milk: 82,000 metric tons
Wool: 1,150 metric tons

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Animal Health Management Through Biotechnology

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Narrative Summary

During the first decade of the SR-CRSP, the role of the animal health component evolved gradually from herd health and extension activities to more focused studies of infectious and parasitic diseases and their diagnosis and control. This work has resulted in a considerable expansion of knowledge of the causes, distribution, diagnosis, and control strategies for sheep, goat, and alpaca diseases in several areas of the world. In the Strategic Plan for the second decade of the SR-CRSP, the animal health component proposed to develop "biotechnology packages" to control infectious and parasitic diseases. Existing and new knowledge of the genetic makeup of selected infectious agents and host immune responses would be used as a foundation for construction, of multivalent recombinant virus-vectored vaccines for sheep and goats using new tools in biotechnology. In implementing this project as a component of the SR-CRSP, it was anticipated that it would have as significant an impact as any other single achievement in improving small ruminant productivity throughout the world. The sociology and economics projects would provide necessary support to assess the capacity for production and distribution of the multivalent vaccines in the LDCs, as well as their social acceptance and economic impact.

In 1982 a workshop on "Priorities in Biotechnology Research for International Development," sponsored by the U.S. National Academy of Sciences, the U.S. National Research Council, USAID, the World Bank, and the Rockefeller Foundation, identified the following diseases of sheep and goats as having highest priority internationally: neonatal diarrhea, hemotropic protozoa, Rift Valley fever, bluetongue, and pulmonary adenomatosis and other retrovirus infections of sheep. The workshop encouraged the development of virus vectored vaccines as well as new diagnostic tests for these and similar diseases of other livestock species. It became apparent that SR-CRSP scientists already had experience working with several of these diseases and that they all occurred in one of the existing SR-CRSP worksites, Kenya. Furthermore, Washington State University (WSU) had established a biotechnology research laboratory within the Kenya Agricultural Research Institute (KARI), one of the very few such laboratories in a lesser developed country, and the Colorado State University (CSU) principal investigator (PI) also had extensive prior experience in livestock research in Kenya. The two retrovirus diseases of sheep, with which the CSU project had prior experience, also occurred in Kenya. Based on these considerations and the need to focus research activities to maximize the use

of resources for an ambitious project, the two animal health PIs proposed to work collaboratively toward the development of multivalent vaccines using one overseas site, Kenya. It appeared that the previous research experience of the animal health projects was complementary, and the goals of the work could be attained by combining this background with the intellectual resources and supplementary grant funding available at both U.S. institutions.

The implementation of the research by the CSU project has involved two major areas of emphasis: (1) development and testing of suitable virus vectors for production of recombinants and (2) identification and cloning of infectious agent genes that encode immunologically relevant ("protective") antigens. Virus vectors being explored include: vaccinia, capripox virus, and raccoonpox virus, and certain recombinants are now available for each of these. Disease agents under investigation for use in vaccines include: Nairobi sheep disease virus, ovine lentiviruses (ovine progressive pneumonia), and another retrovirus-induced disease of sheep, ovine pulmonary carcinoma. Relevant genes have already been obtained for Rift Valley fever virus from research collaborators and could be obtained for such agents as bluetongue, peste des petit ruminants virus, and other diseases of sheep. The goal is to construct and test individual recombinant vaccines, then to prepare mixtures of appropriate recombinant viruses for evaluation in sheep and goats. New diagnostic tests for several of the above diseases, based upon recombinant and monoclonal antibody technology, are expected to be another important outcome of the planned research.

In the area of vaccine vector development, recognizing the need to develop alternative systems to the widely discussed vaccinia vector, we decided to focus initially on alternative poxvirus vectors. The first, capripoxvirus, is used already in an attenuated form as vaccine in Africa, Middle East, and Asia. WSU is the lead project here, but CSU has assisted by developing contacts and obtaining related viruses (lumpy skin disease virus, LSDV) and useful plasmid vectors (LSDV TK-containing plasmids from the University of Capetown, South Africa). The second area of focus is our plan to insert certain viral genes into Raccoonpoxvirus (RPV), which is a vector system developed by Dr. Joseph Esposito at the Centers for Disease Control, Atlanta, and holds great promise for use in North America and other countries free of sheep pox infection. A rabies-G protein recombinant RPV provided by Dr. Esposito was tested for efficacy and safety in sheep at CSU. Results of recent studies in 20 sheep exposed by intradermal, intramuscular, and oral (bait) routes indicate that high levels of protective antibody to rabies virus were generated within four weeks following a single parenteral inoculation. This vector system will be pursued further, and we plan to prepare additional recombinants potentially useful as vaccines by insertion of relevant sheep pathogen genes.

The major emphasis of the CSU animal health project in Kenya, undertaken in January, 1991, was research to identify and clone immunologically relevant genes of Nairobi sheep disease virus (NSDV), considered to cause the most

common and important viral disease of sheep in eastern Africa, and one for which no effective means of control currently exists. Biomedical researchers with the U.S. Army Medical Research Institute for Infectious Diseases have developed a recombinant vaccinia vectored vaccine for Rift Valley Fever (RVF), caused by a virus closely related to NSDV and an important disease of sheep as well as humans. The vaccinia vectored recombinant RVF vaccine has already been shown to be an excellent immunogen for RVF in sheep and, after insertion into the capripox virus vector, will probably be our first multivalent vaccine component ready for evaluation. It will also serve as a model for development of the NSDV vaccine. Dr. Paul Rwambo has cultured several strains of NSDV, identified proteins and cellular sites of replication, and purified and analyzed its RNA, and he is currently in the process of preparing a cDNA library which should yield clones of the critical M segment necessary for insertion into a vaccine virus vector.

Ovine lentivirus cloning and pathogenesis is a project mainly being undertaken at CSU, although this important virus infection of sheep occurs worldwide, including in Kenya. Mr. Dufton Mwaengo has already succeeded in subcloning the OvLV envelope gene, which we plan to include in our multivalent vaccine. Dr. Scott Brodie has made some useful discoveries relating to new methods of diagnosis and pathogenesis of OvLV in naturally infected sheep. In early 1992, Dr. Brodie will travel to Kenya to undertake a study on field occurrence of ovine retroviral infections. With its expertise in pathology and diagnosis of small ruminant disease in the field, the CSU project complements the WSU research effort in Kenya. Establishing criteria for accurate field diagnosis of infectious disease will become even more important when recombinant multivalent virus-vectored vaccines developed by the SR-CRSP are field tested.

Arising out of research conducted in Peru and in the U.S., the final CSU research project, now partially supported with non-SR-CRSP funding, is the ovine pulmonary carcinoma (OPC) project. This disease has been recognized for decades in Kenya and other African countries and occurs worldwide with a flock prevalence of 2 - 20% per year. With the assistance of a postdoctoral fellow, Dr. Steve Hecht, clones of the presumed causative retrovirus have now been obtained, and it will soon be possible to develop recombinant proteins for preparation of a badly needed diagnostic test for infected animals. If protective immune responses and their encoding genes for the OPC virus can be identified, they will be good candidates for the multivalent vaccine.

Research

As stated above, the Animal Health Component of the SR-CRSP consists of scientists from CSU and WSU working with resident scientists and KARI collaborators in Kenya to develop multivalent virus-vectored vaccines for major infectious and parasitic diseases of sheep and goats. Scientists from the sociology (University of Missouri) and economics (Winrock International) components of SR-CRSP are assessing vaccine production capacity in African countries as well as social acceptability and potential economic impact of these new vaccines. The CSU and WSU

integrated research planned for 1990-92 was generally 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 of research activities pertains to work undertaken by the CSU project at the Kenya National Veterinary Center at Kabete and the basic supporting research performed at CSU.

Component Objective 1. Develop Virus Vectors for Sheep and Goats

CSU Objective 1A. Raccoon poxvirus Vector Development. Hypothesis: Raccoon poxvirus expressing a foreign gene will induce antibodies in sheep and goats. In order to maximize the likelihood of developing multivalent recombinant virus-vectored vaccines for sheep and goats, it is important to explore virus vector systems in addition to vaccinia virus (which has human health concerns) and capripoxvirus (the use of which will probably not be permitted in countries which do not have sheeppox). Raccoon poxvirus (RPV) is an indigenous orthopoxvirus in raccoons of North America which seems to be nonpathogenic for humans. A rabies G protein gene RPV construct (rRPV-G) produced by Dr. J. Esposito of the Centers for Disease Control, Atlanta, has been shown to be capable of inducing neutralizing antibody and protection against a rabies challenge in a variety of animals after oral immunization. The RPV recombinant constructs were produced using chimeric plasmids (pGS62-JE-1 and pKB-JE-13) designed for inserting gene sequences into vaccinia virus and containing the vaccinia promoters $P_{7.5}$ and P_{11}. Success in insertional inactivation of the RPV TK gene with these plasmids indicates that similar plasmids containing other genes can be inserted into RPV using similar techniques.

Although rabies occurs in sheep and goats in many underdeveloped countries such as Kenya, the primary purpose of evaluating the rabies rRPV-G construct in sheep is to develop an alternative vaccine virus vector rather than to evaluate the potential of this construct as a vaccine. Production of high levels of serum neutralizing antibodies in immunized animals will be indicative of protection against rabies and will encourage further development and application of the RPV vector. Experiments were designed to compare the immunogenicity, pathologic responses, and transmissibility of rRPV-G in sheep inoculated by several routes. An oral route of administration employing grain-covered wax ampules containing the virus was tested as a novel, convenient route of vaccine administration, particularly in a small family farm setting. Experimental controls included sheep inoculated with wild type RPV, unimmunized contact control sheep used as sentinels for virus transmission, and sheep inoculated intradermally with 10-fold dilutions of both viruses to evaluate histopathologic responses. Serum neutralizing antibody titers to rabies virus and RPV were evaluated weekly over an 11 week period. At the termination of the experiment, the sheep were necropsied, tissues were collected for virus reisolation attempts and inoculation sites were sectioned for histopathology. The capacity of rRPV-G virus to replicate in sheep and goat cell lines was studied concurrently.

In research conducted at CSU, 20 adult sheep were grouped in five separated rooms and used in the experiments summarized in table 1. After collection of preinoculation samples, two sheep were intradermally (ID) exposed to wild type RPV as controls (Group A), three sheep were orally exposed to RPV-G (by syringe dosing, Group B), three sheep were given RPV-G ID (Group C), three were given RPV-G intramuscularly (IM, Group D), and two were used for intradermal titrations of RPV and RPV-G for histopathology. Two sheep were included in the same room with Groups B, C, D, and one sheep with Group A as contact control sentinel animals to monitor horizontal transmission of virus among non-vaccinated sheep. On day 47 after vaccination, sheep in groups A-D were reinoculated with RPV-G ID, IM, or orally with virus in alfalfa-coated wax ampules.

The results in table 1 indicate that administration of RPV-G by ID and, to a lesser extent, IM routes but not orally was immunogenic and led to excellent priming of subsequent inoculations. Protective levels of rabies neutralizing antibody (>.5 IU/ml) developed in all sheep vaccinated by the ID route within four weeks post vaccination. Sheep revaccinated by ID or IM routes consistently developed several fold higher levels of neutralizing antibodies which persisted for at least four weeks. Neutralizing antibodies also developed in response to wild type RPV inoculation and these may have interfered to subsequent RPV-G inoculation in Group A. Unfortunately, oral administration of vaccine virus either by syringe dosing or by feeding grain covered ampoules did not induce protective levels of anti-rabies antibody, even after re-vaccination at seven weeks. Efficacy evaluation has not yet been performed in goats, but responses similar to those in sheep would be expected. In summary, RPV seems to be a very effective and useful sheep virus vector system worthy of further attention. Preparation of RPV recombinants containing genes encoding immunologically relevant proteins of sheep and goat pathogens would be the next step in developing this vector system.

Component Objective 2. Identification of Vaccine Genes for Sheep and Goat Diseases.

CSU Objective 2A. Nairobi Sheep Disease Virus Cloning. Hypothesis: Genes encoding viral envelope glycoproteins G1 and G2 can be identified in a cDNA library expressed in E. coli.

Nairobi sheep disease (NSD) is a highly fatal, tick transmitted viral disease of sheep and goats in eastern Africa. Viral infection in susceptible sheep and goats causes an acute febrile gastroenteritis with a mortality up to 90% in affected flocks and abortion in pregnant ewes. Outbreaks are associated with movement of sheep from lowlands to endemic areas, which includes the Nairobi area and increases in tick populations associated with periods of high rainfall.

Nairobi sheep disease virus (NSDV) is a member of the Nairovirus genus of the Bunyaviridae family of negative strand, segmented RNA viruses. Presently, NSD can only be prevented by control of the tick vector using expensive and labor-intensive methods or by use of an attenuated viral vaccine, which must be given annually. This vaccine has not been produced in Kenya since 1968. A highly successful recombinant vaccinia

Table 1. Rabies virus neutralizing antibodies (reciprocal titer and International Units/ml) in sheep vaccinated by various inoculation routes with raccoon poxvirus (RPV) or recombinant RPV rabies G protein (RPV-G) & reinoculation of animals at 47 days postvaccination (DPV) with RPV-G.

		Rabies Virus Serum Neutralizing Antibodies[1]										RPV Ab[2]
Animal*	DPV:	0	8	15	29	43	47 route (pfu)	54	61	70	77	77
A/91RS18/IDWt		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	Ir ID ($10^{8.0}$)	0 (0)	0 (0)	8 (0.08)	9 (0.09)	118
A/91RS19/IDWt		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	Ie ID ($10^{8.0}$)	0 (0)	0 (0)	0 (0)	0 (0)	106
A/91RS20/IDS/Wt		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	Ii OB ($10^{9.2}$)	0 (0)	0 (0)	0 (0)	0 (0)	0
B/91RS31/PO/S-Rc		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	In OB ($10^{9.2}$)	0 (0)	6 (0.06)	0 (0)	0 (0)	0
B/91RS32/PO/Rc		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	Io OB ($10^{8.7}$)	0 (0)	10 (0.1)	0 (0)	0 (0)	0
B/91RS33/PO/Rc		0 (0)	11 (0.11)	14 (0.14)	56 (0.49)	42 (0.37)	Ic OB ($10^{8.7}$)	16 (0.16)	0 (0)	14 (0.14)	21 (0.21)	0
B/91RS34/PO/Rc		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	Iu OB ($10^{8.7}$)	0 (0)	0 (0)	0 (0)	0 (0)	0
B/91RS35/PO/S-Rc		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	Il OB ($10^{9.2}$)	0 (0)	0 (0)	0 (0)	0 (0)	0
C/91RS21/ID/Rc		0 (0)	56 (0.56)	280 (2.80)	280 (2.40)	56 (0.49)	Ia ID ($10^{8.0}$)	>1400(>14)	>1400(>14)	>1400(>14)	---	237
C/91RS22/ID/Rc		0 (0)	56 (0.56)	280 (2.80)	280 (2.40)	56 (0.49)	It ID ($10^{8.0}$)	>1400(>14)	>1400(>14)	>1400(>14)	---	475
C/91RS23/ID/Rc		0 (0)	56 (0.56)	210 (2.10)	280 (2.40)	280 (2.40)	Ie ID ($10^{8.0}$)	1300(13)	625(6.25)	625(6.25)	---	85
C/91RS24/ID/S-Rc		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	I OB ($10^{8.9}$)	7 (0.07)	0 (0)	0 (0)	0 (0)	0
C/91RS25/ID/S-Rc		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	IR OB ($10^{8.9}$)	0 (0)	0 (0)	0 (0)	0 (0)	0
D/91RS26/IM/Rc		0 (0)	0 (0)	0 (0)	11 (0.10)	11 (0.10)	IC IM ($10^{8.0}$)	>1400(>14)	>1400(>14)	>1400(>14)	---	ND
D/91RS27/IM/Rc		0 (0)	56 (0.56)	280 (2.80)	70 (0.61)	56 (0.49)	IN IM ($10^{8.0}$)	>1400(>14)	>1400(>14)	>1400(>14)	---	232
D/91RS28/IM/Rc		0 (0)	11 (0.11)	56 (0.49)	11 (0.11)	11 (0.11)	II IM ($10^{8.0}$)	>1400(>14)	>1400(>14)	1000 (10)	---	150
D/91RS29/IM/S-Rc		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	IG OB ($10^{8.9}$)	0 (0)	0 (0)	0 (0)	0 (0)	0
D/91RS30/IM/S-Rc		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	I OB ($10^{8.9}$)	0 (0)	0 (0)	0 (0)	0 (0)	0
E/91RS16/ID/Wt		0 (0)	0 (0)	ID site histopathology---			---	---	---	---	---	---
E/91RS17/ID/Rc		0 (0)	0 (0)	ID site histopathology---			---	---	---	---	---	---

* Animal number code shows animal group/sheep number/inoculation route/virus

Animal Group:

A = intradermal (ID) $10^{8.0}$ pfu RPV-Wt

B = syringe-fed (PO) $10^{8.7}$ pfu RPV-G

C = intradermal (ID) $10^{8.0}$ pfu RPV-G

D = intramuscular (IM) $10^{8.0}$ pfu RPV-G

E = ID inoculation of RPV-Wt or RPV-G at doses 10^{8} to 0 pfu. Animals were euthanized for histopathology of inoculation sites.

Virus code:

Wt = RPV wild-type raccoon poxvirus

Rc = RPV-G construct PRV-KB3-JE13 that expresses the CVS rabies virus glycoprotein under control of the P-11 late promoter (Esposito et al., 1988)

S = nonvaccinated sentinal animals of the respective group (i.e., S-Rc = sentinal animals penned with Rc-inoculated animals)

Reinoculations of animals were done ID, IM, or OB (oral-baited) with the RPV-G dose shown

Oral-balts were similar to those described by Linhart et al. (1991) except that sorghum0alfalfa paste was used to coat wax-ampules that contained RPV-G

[1] Rabies neutralizing antibodies were determined by the Rapid Fluorescence Focus Inhibition Test (Smith et al., 1973)

[2] RPV Ab - Serum neutralizing antibodies (reciprocal titer) to raccoon poxvirus

vectored vaccine has been produced for a related virus of sheep, Rift Valley fever (RVF), and this will serve as a model for the NSD vaccine. The aim of the project is to develop a recombinant vaccine for the control of NSD in the East African region where the disease is most prevalent. It is intended that the NSD recombinant vaccine will be a component in the capripoxvirus vectored multivalent vaccine for sheep.

Generally, our approach was to propagate NSD virus, analyze its structural polypeptides and host antibody response to them, and extract and purify viral RNA. The M RNA of bunyavirus encodes G1 and G2 glycoproteins which induce and interact with neutralizing antibodies of importance in the immune response. Therefore we planned to clone genes within this RNA segment of NSD virus. The experimental procedures to be used were those described in detail in the workplan. After propagating a strain of NSD virus, concentrating and purifying it, analyzing its structural proteins, and isolating M segment RNA, we planned to construct a NSDV expression cDNA library in SUPERSCRIPT pSPORT1 plasmid. After screening the transformed bacterial colonies for expression of NSD antigens with polyclonal sheep sera from recovered animals, colonies were to be expanded and the expressed protein assessed in SDS-PAGE and Western blotting. Finally, antisera to the expressed recombinant proteins would be evaluated for NSD neutralizing capacity and the immune-protective capacity of recombinant G glycoproteins and the N protein will be evaluated in sheep challenge experiments.

Ten virus isolates obtained over a long period of time from different locales within eastern Africa were selected for further characterization. Field isolate NSDV I-34 has been used in earlier attempts to make an inactivated vaccine was selected as the prototype virus. All the ten virus isolates had previously been propagated in a variety of cell systems including mouse brain. These viruses have now been adopted to replicate in BHK-21 cells and the 143B human osteosarcoma (TK-) cell line. Adaptation of the viruses to replicate in sheep peripheral blood leukocytes and endothelial cells is in progress; these cell systems are more relevant in studying NSD pathogenetic mechanisms.

The NSD prototype virus I-34 replicates well both in BHK-21 cells and in the 143B cells. In the 143B cell line, the virus induces extensive cytopathic expression characterized by cell rounding and detachment within 48 hours after infection. Work on the adaptation of the other virus isolates of NSDV will continue, particularly as it will be necessary to determine the ability of the recombinant NSD vaccine to protect sheep and goats against a variety of virus isolates from divergent epidemiological settings. Polyclonal anti-NSDV serum for screening expression cDNA libraries was generated by inoculating the I-34 isolate intravenously into sheep and screening NSDV antibodies using an indirect fluorescence antibody test (FAT). In one experiment, three of four sheep died with clinical manifestations of acute NSD. Characterization of antigenic specificity of the polyclonal sera using the Western blotting procedure has not been conclusive thus far. However, work in determining the

immunogenic antigens of NSDV is in progress.

Morphogenesis of NSD virus. Members of the virus family, Bunyaviridae, generally mature and accumulate in the smooth endoplasmic reticulum and Golgi of infected cells before cytolysis occurs. Thus, serological and morphogenetic characteristics of a virus are useful in classifying it as a bunyavirus. In addition, knowledge of the maturation process of NSDV in infected cells would aid in the design of protocols to purify virus nucleocapsids for synthesis of a cDNA library.

In BHK-21 cell cultures fixed for electron microscopy, virions comparable to those of other bunyaviruses were observed extracellularly 15h post infection. However, interpretation of the intracellular location of NSDV virions was complicated by the accumulation of R-particles in the endoplasmic reticulum. Evidence from other workers indicate that BHK-21 cells generally contain "virus-like particles" possibly related to endogenous retroviruses. As a result of this, the morphogenesis of NSDV was determined in the human 143B cell line from 5 to 30 hours post-infection, with a mock infected cell culture and used as a control.

The results showed that at five hours post-infection NSD virions accumulated in the Golgi with no virus located extracellularly. At 10h post-infection both intracellular and extracellular virions were observed. From the thin section EM studies, NSD virions at different stages of maturation were observed. The virions (unlike the R-particles) were exclusively associated with the SER and Golgi. By 30h post infection only very few virus particles were observed in the cells. There was no clear evidence of virions budding from the membrane. The morphogenetic pathway observed with NSDV generally conformed with that of other members of the family, bunyaviridae. More work is on-going to include 30 min, 1h, 2h, 5h post infection so as to critically elucidate the virus replication pathway.

The finding that NSDV replicates rapidly and accumulates intracellularly within a few hours post infection has enormous implications in the design of protocols for purifying virus nucleocapsids from infected cells and also for processing infected cells for use in FAT. Our attempts to purify nucleocapsids of NSDV from infected cells at 24-30 hours post-infection (CPE not extensive) have not been successful. In other bunyavirus systems, nucleocapsids have been purified $\geq$ 30 hours post-infection. Using the knowledge gained from the EM studies, experiments to purify NSD viral nucleocapsids at 5h post-infection are ongoing.

Total RNA purified from the 5h infected cultures when analyzed on 1.2~ agarose formaldehyde gels showed evidence suggestive of the L and M segments of the viral genome. Identity of the S segment was made difficult by the large amounts of cellular RNA migrating in the presumed location of the S RNA (data not shown).

Further evidence that massive accumulation of virions occurs at 5h post infection has been obtained using indirect FAT. Infected cell cultures were trypsinized and processed for indirect FAT using an anti-Ganjam

mouse ascitic fluid. Fluorescence was observed to be predominantly polar, discrete but extensive and just beneath the outer cell membrane. The polarity of the staining can be explained by the EM finding that NSD virions accumulate within the smooth vesicles of the Golgi.

Purification of RNA. To purify viral RNA, confluent monolayer cultures of 143B cells were inoculated with the I-34 isolate. After maximum cytopathic expression, the cell culture fluid was harvested, clarified, and concentrated by ultrafiltration. RNA was either purified directly from the concentrated cell culture suspension or from a pellet obtained by high speed centrifugation, using a 30% glycerol cushion. The pellet was resuspended in TEN buffer, and the viral RNA was purified using the acid guanidinium thiocyanate-phenol-chloroform extraction. RNA was also purified from mock infected cells after trypsinization. The RNA concentration estimated spectrophotometrically for viral RNA was 0.67 ug/ul and for the control RNA was 3.44 ug/ul. Pure RNA will exhibit a A260/A280 ratio of 2.0. However, due to variations in the starting material and procedure, RNA preparation with A260/A280 ratios from 1.7 to 2.0 are indicative of highly pure RNA. In some RNA purifications we obtained ratios of 2.0.

The integrity and the characteristics of the purified RNA were assessed in 1.2% agarose formaldehyde gels in the presence of RNA ladder markers (high and low). The RNA was electrophoresed in the presence of ethidium bromide. The control RNA showed intense staining of eukaryotic 28S and 18S ribosomal RNA. Bands distinct from the ribosomal RNA were observed in the putative viral RNA.

To determine that the samples were RNA in nature, aliquots of the viral RNA and the control RNA were treated with DNase free ribonuclease to digest any RNA. Mycoplasma DNA was treated as a control. Both the untreated and the treated samples including Mycoplasma DNA were electrophoresed and the results indicated that the purified samples were RNA in nature. In the RNA purified from the 19K virus pellet, the large (L), middle (M), and small (S) genomic RNA of NSDV were observed; they had approximate sizes of 7.5 Kb for L, 4.5 Kb for M, and 1.7 Kb for S RNA segment respectively. Degradation of RNA was most evident in the RNA purified from the 19K virus pellet. The RNA purified directly from the cell culture supernate by a modification of Chomczynski and Sacchi method had two major bands of 2.4 Kb and 1.4 Kb, respectively. At this stage it is not clear what species of RNA they represent. The RNA purified from the 19K pellet was used for cDNA synthesis using the SUPERSCRIPT plasmid system (BRL).

Purification of virus nucleocapsids from infected cells has been shown to be a good source of large amounts of bunyavirus RNA. To purify nucleocapsids from infected cells, it is important to lyse the cells when most of the virions are intracellular. Our attempts to purify viral nucleocapsids at 30h after infection were unsuccessful. After centrifugation at 35,000 rpm for 4h, no visible bands were detectable at the interface of a 20-35% discontinuous

cesium chloride gradient. This method has been reported to work well in other bunyavirus systems.

Our data from EM studies, together with indirect FAT indicate that at 5h after infection, NSD virions are predominantly intracellular. Preliminary results of total RNA purified from 143B cells at 5h after infection showed two distinct bands migrating above the 28 S rRNA. These two RNA bands possibly represent the L and M viral RNA. The position of the S RNA segment was obscured by the cellular RNA. These results suggested that NSD viral nucleocapsids should be harvested from 143B cells a few hours after infection.

cDNA Synthesis. Members of the family, Bunyaviridae, possess a tripartite single stranded RNA genome with negative polarity. The lack of poly (A) tail in the genomic RNA of bunyaviruses poses a unique challenge in the construction of a cDNA library. In an attempt to overcome this problem, we obtained a synthetic oligonucleotide containing a ninemer complementary to the 3'-end of sequenced Nairoviruses and linked to a sequence containing the Not-I restriction site. The Not-I Nairovirus primer-adapter was used to prime the synthesis of the first strand cDNA using the SUPERSCRIPT plasmid system. The efficiency of conversion to first strand cDNA and second strand cDNA was not monitored as radio-labelled materials were not used. Consequently, evaluation of the cDNA synthesis was done at the transformation stage. After ligation of the cDNA was ligated to Not-I - Sal 1 cut plasmid pSPORTI, the ligated cDNA/pSPORTI was used to transform competent bacterial cells according to the vendor's instructions. Intact pSPORTI was used as a control in the transformation experiment. After overnight incubation at 37°C, there were no colonies in the cDNA plates while there were numerous blue colonies in the control plasmid plate. The putative viral RNA was thus not converted into cDNA.

Analysis of the ligation mixture on alkaline agarose gels revealed only two bands; 4.1 Kbp (pSPORTI) and a 7.2 Kbp band that also represents pSPORTI. The same two bands were resolved when intact purified pSPORTI plasmid was run on similar gels. This evidence points to a problem in the cDNA synthesis that is upstream of the ligation reaction. Likely sources of problems would be: (1) RNA not of NSDV origin; (2) synthetic Nairovirus primer not appropriate; (3) problems associated with long storage of enzymes.

At this stage, it is difficult to identify where the problem is. However, it is advisable that we exploit other alternatives of priming the first strand cDNA synthesis. These include addition of a poly A tail to the viral RNA using *E. coli* poly A synthetase. The other alternative is to use random primers. Of the two alternatives, the former is more likely to generate longer cDNAs. Addition of poly (A) tails to the purified viral RNA (from various nucleocapsids) before cDNA synthesis using the SUPERSCRIPT plasmid system is the next urgent goal in our attempt to develop recombinant vaccine against NSD in sheep. Viral nucleocapsids purified from 143B cell cultures 5h after infection will be the source of viral RNA for cDNA synthesis.

CSU Objective 2B. Ovine lentivirus cloning. Hypothesis: Envelope proteins of ovine lentiviruses expressed in vaccinia virus will induce a protective immune response.. Ovine progressive pneumonia (OPP) is a important disease of sheep which is caused by ovine lentivirus (OvLV). This virus is widespread and has been described not only in the United States and Europe but also in the developing world. In Kenya, OvLV has been established as a frequent cause of mortality of adult sheep due to pulmonary and other diseases. Since sheep are one of the main sources of protein and revenue for the small scale peasant farmers in lesser developed countries, the demand for OvLV control and eradication measures in form of a vaccine is long overdue.

CSU investigators have obtained two full-length molecular clones of the North American OvLV strains 84/28 and 85/34, which differ in cytopathogenicity in vitro and in virulence upon inoculation into newborn lambs. In other related viruses, retroviral envelope gene products have been shown to play major roles in immune responses, and further, vaccinia viruses have been proven to be useful vehicles for delivering these genes to the appropriate host cells. Therefore, we have chosen to concentrate our efforts in characterizing the envelope glycoprotein and in using the vaccinia virus as our expression vector.

Our studies aim to identify protective immunodominant epitopes resident on the envelope glycoprotein which will serve as candidates for subunit vaccine development. Thus, we planned to subclone the envelope genes of the two OvLV strains 84/28 and 85/34 which differ in cytopathogenicity and virulence. The strategy to have been employed involved 3' end deletion of the envelope genes (approx. 300 bp deletions) and expression of these mutant genes in vaccinia virus. This would produce glycoproteins of various lengths which share the same leader sequence but differ only in their C-terminal end. *In vitro* cytotoxic T lymphocyte or lymphoproliferative assays would then be performed and the regions within the envelope gene responsible for cytolysis and lymphoproliferation identified. These regions could then be expressed as individual entities and their capacity to induce protective immune responses evaluated in naive animals.

By employing polymerase chain reaction of amplification of specific virus regions, we have found that both the slow/low (84/28) and the rapid/high (85/34) full-length molecular clones contained the genes of interest. Initial efforts were to PCR-amplify and subclone the entire env genes but this approach has not been completely successful. The most we have been able to amplify is a 2.2 kb fragment which represented the entire extracellular domain of the envelope glycoprotein up to the transmembrane (TM) region; most of the C-terminal or cytoplasmic domain was not covered.

Recent efforts using the previously known restriction enzyme sites have enabled the subcloning (in pBluescript) of a SacI/EcoRI DNA fragment of approximately 5 kb of the rapid/high virus strain. This recombinant clone contains the entire *env* gene, according to set criteria. Similar efforts are underway to subclone a HindIII/SacI

DNA fragment of approximately 6 kb for the slow/low virus strain.

We next plan to obtain limited nucleotide sequence information, especially nucleotides flanking the first codon of the open reading frame (ORF) of *env* in order to assess how far downstream of the vaccinia viral promoter sequence the env gene is cloned. We envision that a gene can be expressed without its prior nucleotide sequence information, and therefore at this point we anticipate that expression of the gene(s) and their mutant forms, as well as sequencing of the envelope genes, will proceed simultaneously.

CSU Objective 2C. Ovine Pulmonary Carcinoma Cloning. Hypothesis: Probes specific for a type D retrovirus associated with ovine pulmonary carcinoma (OPC) can be obtained from sheep lung fluid RNA and/or tissue culture systems using the polymerase chain reaction (PCR). Ovine pulmonary carcinoma (OPC) is a contagious lung tumor of adult sheep. The disease is a particular problem in South and East Africa, South America (Peru), Southern Europe, the British Isles, Asia, and the Middle East. Convenient diagnostic tests or vaccines have yet to be developed. 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.

Development of diagnostic tests, control programs, and vaccines—eventual goals in this research—requires the ability to screen for the virus and its products as well as to produce the agent in sufficient quantities. Currently, the virus cannot be propagated in tissue culture. We designed a two-fold approach to overcome this obstacle in order to be able to achieve the above goals: (1) obtain a portion of the OPC viral genome from lung fluid RNA or genomic proviral DNA using PCR and (2) determine a permissive cell line host for propagating the OPC virus.

We have been successful in our first objective of obtaining a portion of the OPC virus. Degenerate primers were designed based on comparison of the capsid and polymerase regions of retroviruses that we had shown cross-reacted with the OPC virus in several immunological tests. These tests included Western immunoblotting tests that showed specific reaction of the capsid and nucleocapsid proteins with several type B and D viruses. Sheep lung fluid from affected sheep was used to obtain viral-fraction RNA. This RNA was first shown to contain transcripts of interest by in vitro translation and radioimmunoprecipitation and then used as a substrate for cDNA and then PCR using the above primers. We have cloned two portions of the OPC virus from the PCR amplifications.

Objective number two, developing a tissue culture system for the OPC virus, is still incomplete at this time. We were able to successfully repassage the tumor in experimental lamb studies in order to provide a source of new tumor cells and virus. Our immunological assays are now of sufficient sensitivity to screen cells for specific viral expression. More importantly, the OPC viral clones obtained above will allow us to probe directly for viral sequences. This will

enable us to obtain genomic clones of the virus that can be used in transfection of cell lines. This approach simplifies our search for an appropriate cell system.

These OPCV partial clones can be used in several other ways. We now have preliminary sequence information from these regions of the OPC viral genome. Specific new primers can be made to create diagnostic probes. Expression of our clones should enable development of a diagnostic kit using the viral antigens and concordant new antisera. The clones can be used directly to probe for the virus, not only in genomic cloning as mentioned above, but also in dissection of viral pathogenesis in the sheep hosts.

Report on Supplementary Funds

Short-term Training for Dr. Paul Rwambo
In June and July, 1991, Dr. Rwambo attended a three-week short course entitled "Biology of Disease Vectors." Sponsored by the MacArthur Foundation at Colorado State University in Fort Collins, Colorado, the course covered the biology, natural history, taxonomy, and molecular biology of ticks, mosquitos, and other arthropod disease vectors and interactions with viral, bacterial, and protozoan disease agents. As Nairobi sheep disease is tick-transmitted, this educational experience will be very useful for Rwambo's work in Kenya.

During his visit to Colorado State University, Dr. Rwambo also attended the annual meeting of the American Society of Virology and presented a paper on characterization of Nairobi Sheep Disease Virus.

Graduate Training Support for Dr. Scott Brodie
Funds were used to support Dr. Brodie's attendance at a course in Techniques of Molecular Biolgy offered by the ATCC in Rockville, Maryland. In addition, support was provided for Brodie's Ph.D. studies on ovine lentivirus infection in naturally infected sheep.

Other contributions

To U.S. Agriculture
The SR-CRSP is becoming widely known as a comprehensive research program for sheep and goat research worldwide. It can be an important vehicle for testing and applying technological innovations or procedures developed for other species of animals or by other research laboratories. Linkages with widely divergent institutes are being developed by the CSU Animal Health project as well as other projects within the SR-CRSP. These collaborative linkages are usually mutually beneficial and promote U.S. agricultural research, particularly in the livestock sector. Particular examples cited above are the raccoonpox virus vector system provided by the Centers for Disease Control, the Rift Valley fever recombinant vaccinia virus provided by the U.S. Army Medical Research Institute of Infectious Diseases, and capripoxvirus isolates and vectors provided by the University of Capetown and Oxford University. Without the linkages established through the SR-CRSP, it is unlikely that these important products and the

technology they represent would have been evaluated for potential application for control of sheep disease.

The role of retroviruses in domestic animals is of extreme and widespread interest, and development of this work at CSU should add a great deal of understanding to vaccine and diagnostics not only for this virus but for related retroviruses of economic importance. This work may possibly yield two more intriguing contributions. The first is based on use of these clones as probes of normal and infected sheep DNA. We found that there are related sequences present in sheep, presumably endogenous retroviruses. It is possible that these may be involved in a number of genetic traits and diseases. A potential application of this work is the development of a number of genetic markers based on endogenous viruses in the sheep germ line. Such markers have proved useful in other systems (eg. murine) and may aid in future analysis and design of sheep genetics. The second contribution refers to the potential interaction of lentiviruses with the type D viruses. We now have the tools to begin looking at this possible co-factor system. It would not be unexpected that these types of systems should prove to be important in animal diseases. With the changes in international movement of livestock and public concerns over safety of the food supply, the ability to follow and diagnose retroviral and lentiviral presence will become more important.

To Host Country

The year 1990-91 was marked by development of closer linkages and collaboration with various research and training institutions in Kenya. The resident scientists representing the various facets of SR-CRSP activities in Kenya held monthly meetings, which among other issues discussed the need to constantly keep the target users of our innovations in sight. The meetings were held at alternate sites of SR-CRSP activities in Kenya. Besides our monthly meetings, we have held three monthly seminars convened by the Host Country Representative of SR-CRSP, Dr. Cyrus G. Ndiritu (Director, KARI), and arranged by the resident scientist for CSU. Participants during these seminars have been drawn from KARI (the Host Country Institution), the University of Nairobi (Faculty of Veterinary Medicine), and the International Laboratory for Research on Animal Diseases (ILRAD). Linkages with other research institutions are also underway.

In September 1991, Dr. Flora M. Mbithi. a 1991 graduate of Veterinary Medicine from University of Nairobi joined KARI and became attached to the animal health project at Kabete. Dr. Mbithi is currently working with Dr. Rwambo on the NSD virus project. It is hoped that she will be trained at M.S. level. Further discussions regarding her training are in progress.

Our linkage with the Ministry of Livestock Development has over the year been directed at improvement of disease surveillance through networking and exchange of diagnostic reagents for NSD. Collaboration with ILRAD (one of the IARCs in Nairobi) has progressed very favorably, particularly because the resident scientist for CSU was working at the Institute before joining SR-CRSP. The collaboration with ILRAD scientists has for the first

time produced insight into the maturation pathway of Nairobi Sheep Disease Virus. Areas of collaboration include virus morphology using electron microscopy, molecular biology of sheep and goat pathogens, and immunology of ruminants. Besides sharing their facilities, collaboration at consultancy level has also been very favorable. Also during the year, a Ph.D. student from the faculty of Veterinary Medicine visited our lab to learn and use our facilities in immunochemistry. His research endeavors include development of a vaccine for control of camelpox in Kenya.

Because of our concern for the environment, the project has aspired to avoid use of environmentally hazardous reagents and materials including radioactive substances. Where use of mildly harmful substances is unavoidable the recommended methods for disposal are strictly adhered to.

Training

In progress

- Scott Brodie (U.S. citizen), PhD , 1992, Microbiology, CSU
- Dufton Mwaengo (Kenya), PhD, 1994, Virology, CSU

Short term (Workshops attended):

- P. Rwambo, Gaithersburg, MD, BRL/ LTI cDNA synthesis. workshop, Nov.1990
- P. Rwambo, Fort Collins, CO, Biology of Disease Vectors, June 1991
- S. Brodie, Rockville, MD, Techniques and Applications of Molecular Biology, Nov. 1991

Collaborating Personnel

Kenya

- Paul Rwambo, KARI
- Fred Rurangirwa, KARI
- Flora Mbithi, KARI
- M. Shaw, ILRAD, Kenya

United States

- D. Mwaengo, Dept. of Pathology, CSU
- S. Brodie, Dept. of Pathology, CSU
- S. Hecht, Dept. of Pathology, CSU
- Y. He, Dept. of Pathology, CSU
- Joseph Esposito, Centers for Disease Control, Atlanta, GA
- Travis McGuire, Veterinary Microbiology and Pathology, WSU
- W. Cheevers and D. Knowles, Vet. Microbiology and Pathology, WSU
- J. Dalrymple and J. Smith, 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 Capetown, Republic of South Africa
- Dept. of Microbiology and Pathology, WSU
- Institute of Virology and Environmental Microbiology, Oxford University, UK

Publications

Journal Articles, Refereed (SR-CRSP)
Kajikawa, O., J.E. Dahlberg, R.H. Rosadio, and J.C. DeMartini. 1990. Detection and Quantitation of a type D retrovirus *gag* protein in ovine pulmonary carcinoma (sheep pulmonary adenomatosis) by means of a competition radioimmunoassay. Vet. Micro. 25:17-28.

Journal Articles, Refereed (Supporting)
Marcom, K.A., L.D. Pearson, C.S. Chung, J.M. Poulson, and J.C. DeMartini. 1991. Epitope analysis of capsid and matrix proteins of North American ovine lentivirus field isolates. J. Clin. Micro. 29:1472-1479.

Book Chapters
DeMartini, J.C., R.A. Bowen, J.O. Carlson, and A. dela Concha. Chaper 17. Strategies for the genetic control of ovine lentivirus infections, pgs. 293-314. *In: Breeding for Disease Resistance in Farm Animals* (J.B. Owen and R.F.E. Axford, eds). Oxon, U.K., A.B. International, 1991, 499 pp.

Technical Communications (SR-CRSP)
Ameghino, E. and J. DeMartini. Mortalidad en Crias de Alpacas. Published by SR-CRSP for IVITA/INIAA, Peru. 1991. 128pp.

Ameghino, E. and J. DeMartini. El Aspecto Sanitario en Alpacas y Ovinos de las Communidades del Departmento de Puno. Published by SR-CRSP for IVITA/INIAA, Peru. 1991. 89 pp.

Villafane, F. and J.C. DeMartini. 1991. Clasificacion de celulas neoplasticas en casos espontaneos e inducios del carcinoma pulmonar ovino. Revista Acovez 15:5-9.

Abstracts and Presentations
Brodie, S.J., K.A. Marcom, A. de la Concha, L.D. Pearson, B.C. Anderson, S. Magnus-Corral, J.M. Poulson, G.D. Snowder, and J.C. DeMartini. 1990. Comparative efficiency of methods for identifying sheep infected with ovine lentivirus. Proceedings of the 71st Conference of Research Workers in Animal Disease. Chicago, IL, November 5-6, 1990.

Brodie, S.J., K.A. Marcom, A. de la Concha, L.D. Pearson, and J.C. DeMartini. 1990. Evaluation of a focal immunoassay for the detection and quantitation of infectious ovine lentivirus. Proceedings of the 71st Conference of Research Workers in Animal Disease. Chicago, IL, November 5-6, 1990.

DeMartini, J.C. 1990. Ovine Pulmonary Carcinoma Virus. Workshop on Animal Models of Retrovirus-Associated Malignancies. National Cancer Institute, Bethesda, MD, November 15, 1990.

de la Concha, A., J.C. DeMartini, S.J. Brodie, S. Magnus-Corral, R.A. Bowen, G.E. Seidel, J.O. Carlson, and R. Grant. 1990. Pathogenesis of ovine lentivirus infection in isogeneic twin lambs. 41st Annual Meeting of the American College of Veterinary Pathologists, Phoenix, AZ, December 9-14, 1990.

Rwambo, P.M. Current research to develop a recombinant vaccine for control of Nairobi Sheep Disease. SR-CRSP Workshop, KETRI, Muguga,

Kenya, February, 27-28, 1991.
S.J. Brodie, A. de la Concha, K.A. Marcom, L.D. Pearson, B.C. Anderson, S. Magnus-Corral, and J.C. DeMartini. Detection of ovine lentivirus DNA in seronegative naturally infected sheep by polymerase chain reaction: Relative sensitivity compared with immunodiffusion and immunoblotting tests. 12th Annual Food Animal Disease Research Conference. Laramie, Wy. April 3-4, 1991.

K.A. Marcom, S.J. Brodie, L.D. Pearson, and J.C. DeMartini. Utilization of monoclonal antibodies in the detection of ovine lentiviruses. 12th Annual Food Animal Disease Research Conference. Laramie, Wy. April 3-4, 1991.

de la Concha-Bermejillo, A, S.J. Brodie, S. Magnus-Corral, S. J. Hecht, C.V. Kimberling, and J.C. DeMartini. Attempts to detect ovine lentivirus in semen of infected rams using the polymerase chain reaction. 12th Annual Food Animal Disease Research Conference. Laramie, Wy. April 3-4, 1991.

Hecht. S., S. Magnus, Y. He, and J.C. DeMartini. Antigenic and molecular characterization of a type D retrovirus in ovine pulmonary carcinoma. RNA Tumor Virus Meeting. Cold Spring Harbor Laboratory, Cold Spring Harbor, New York. May 21-26, 1991.

de la Concha-Bermejillo, A, S. Magnus-Corral, and J.C. DeMartini. Lentivirus infections of small ruminants. Symposium on the Health and Disease of Small Ruminants. Kerrville, TX, June 14, 1991.

de la Concha-Bermejillo, A, S. Magnus-Corral, R.A. Bowen, S. J. Brodie and J.C. DeMartini. A different approach to study the pathogenesis of lentivirus infections. Symposium on the Health and Disease of Small Ruminants. Kerrville, TX, June 14, 1991.

S.J. Brodie, K.A. Marcom, A. de la Concha, L.D. Pearson, and J.C. DeMartini. Ovine lentivirus expression in alveolar macrophages correlates with antigenemia and clinicopathologic manifestations of disease. 10th Annual Meeting of the American Society for Virology, Fort Collins, CO. July 7-11, 1991.

K.A. Marcom, L.D. Pearson, S.J. Brodie and J.C. DeMartini. Detection of ovine lentivirus major core antigen in serum and culture. 10th Annual Meeting of the American Society for Virology, Fort Collins, CO. July 7-11, 1991.

Rwambo, P.M. and DeMartini, J.C. Characterization of the structural polypeptides of Nairobi Sheep Disease Virus, A Nairovirus. 10th Annual Meeting of the American Society for Virology, Fort Collins, CO. July 7-11, 1991.

DeMartini, J.C. Y. He, and S.J. Hecht. Antigenic and Molecular Characterization of Type D retrovirus-associated CA expression in ovine pulmonary carcinoma. 10th Annual Meeting of the American Society for Virology, Fort Collins, CO. July 7-11, 1991.

DeMartini, J.C. Ovine Lentivirus-induced lymphoid interstitial pneumonia. International Symposium on the

Changing Role of Mycoplasmas in Respiratory Disease and AIDS. Scottsdale, AZ, November 30-December 5, 1991.

DeMartini, J.C., S.J. Hecht, and Y. He. Molecular characterization of type D retrovirus associated ovine pulmonary carcinoma. Third workshop on the pathogenesis of non-acute retroviruses. Philadelphia, PA, December 4-7, 1991.

DeMartini, J.C. Pathogenesis of ovine lentivirus in experimentally and naturally infected sheep: Viral expression, antibody responses, and lesions. Annual Meeting of the American College of Veterinary Pathologists, Orlando, FL December 10-13, 1991.

Comments on Funding

Our research on Nairobi sheep disease will further be enhanced by a USAID PSTC grant of US $150,000 for development of a diagnostic test and reagents. The project (proposal 9.307) title is "A two-site monoclonal antibody assay for Nairobi Sheep Disease Virus Infection." Funding for the 3-year project may be in place in Jan. 1992 and it will be administered through the USAID Kenya Mission. The funding will consolidate our research on viral infections of small ruminants in East Africa. Thus, improved methods of diagnosis of NSD coupled with novel recombinant vaccines will have a major economic impact on the small-scale farmers who are the predominant owners of small ruminants in Kenya.

Washington State University

Animal Health Management through Biotechnology

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Narrative Summary

This report is for the first 15 months of a new SR-CRSP animal health management through biotechnology component that includes a focused research goal, strong inter-institutional collaboration, and limitation to one primary site. Investigators from WSU and CSU work with resident scientists and KARI collaborators in Kenya to develop multivalent virus-vectored vaccines for major infectious and parasitic diseases of sheep and goats in Africa and other parts of the world. SR-CRSP investigators from the sociology (University of Missouri) and economics (Winrock International) projects are engaged in assessing the capacity of African countries to produce and apply the vaccines, evaluating the social acceptability of vaccines, and assessing the potential economic impact of vaccines.

Research was begun on the component's objective to develop virus vectors for multivalent vaccines for sheep and goats. WSU's part of this objective is to evaluate attenuated capripoxvirus (CPV) as a virus vector. Experiments attempted to use an existing vaccinia virus insertion plasmid, pSC11, to insert the ß-galactosidase gene into CPV. Recombinant virus expressing the gene could not be identified and new insertion plasmids were obtained from other investigators. These experiments will continue until methods to make recombinant CPV are identified.

Another objective of the component is to identify vaccine genes for sheep and goat diseases. WSU has four diseases targeted: Pleuropneumonia, heartwater, haemonchosis, and caprine arthritis encephalitis virus (CAEV). The basic approach is to identify proteins on the surface of the various organisms that will induce a protective immune response. Genes encoding these proteins will then be cloned and expressed by the virus vector. For pleuropneumonia, antibodies specific for surface antigens were isolated from immune goat serum to screen recombinant libraries. For heartwater, a cDNA probe was further characterized and is being used by a heartwater research project in Zimbabwe sponsored by the University of Florida (UF), USAID, and SADCC. Monoclonal antibodies to an immunodominant protein of *Cowdria ruminantium*, the agent that causes heartwater, were also identified. For haemonchosis, monoclonal antibodies were made to gut surface antigens, and one native surface antigen was isolated by monoclonal antibody affinity chromatography and used to immunize goats. For CAEV, a recombinant vaccinia virus expressing the *env* gene was used to immunize goats. Antibodies from immunized goats reacted with gp135, the major viral coat glycoprotein.

Research

Problem Statement and Approach
The component on animal health management through biotechnology has as a goal the development of multivalent, recombinant, virus-vectored vaccines to control infectious diseases of sheep and goats. Arguments justifying this goal are summarized here.

1) Infectious diseases are a constraint to small ruminant production and in some cases limit the introduction of improved breeds.

2) One of the best methods for controlling infectious diseases is vaccination, but current univalent vaccines are expensive because of the number of different vaccines that must be produced and distributed under a variety of storage conditions, including refrigeration.

3) A long term solution to the problem is to make a single multivalent vaccine that is easy to produce, store, and use.

4) The biotechnology approach to make multivalent virus-vectored vaccines capitalizes on previous SR-CRSP research in Kenya, Peru, and Brazil.

5) Collaboration with other SR-CRSP disciplines allows evaluation of the acceptance and the utility of new vaccines.

Component Objective 1. Develop Virus Vectors for Multivalent Vaccines for Sheep and Goats

WSU Objective 1A (capripoxvirus-CPV) hypothesis. Attenuated CPV (Kenya vaccine isolate) will undergo homologous recombination with pSC11 and express a foreign gene (ß-galactosidase).

Problem Statement and Approach
The problem is to find a safe virus vector that will express foreign genes in sheep and goats while inducing immune responses to expressed genes. One possibility is CPV, which causes sheep pox and goat pox. These are economically important diseases in countries throughout Africa and the Middle East as well as Turkey and Pakistan. 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.

We are evaluating the suitability of CPV as a virus vector by doing recombination studies with the vaccinia virus insertion plasmid pSC11, which contains vaccinia virus thymidine kinase gene fragments for homologous recombination. These fragments flank the ß-galactosidase gene plus another vaccinia virus promoter upstream of a cloning site for a foreign gene. Since the CPV thymidine kinase gene is 60% homologous with vaccinia virus thymidine kinase, homologous recombination may occur between pSC11 and CPV. If recombination occurs and the vaccinia virus promoters work in CPV as reported, then the ß-galactosidase gene

should be inserted and expressed. Expression of this gene in CPV will indicate that pSC11 can be used as an insertion vector for CPV and that other foreign genes can be inserted using pSC11.

Progress

These procedures were done at the KARI laboratory at Kabete, Kenya, primarily as a part of R. Soi's Ph.D. thesis. He is a KARI employee and WSU graduate student who is meeting both an SR-CRSP objective and one of another project. The attenuated Kenya isolate of CPV was obtained and grown in cell culture then titered virus stocks were made for transfection studies. The pSC11 plasmid was obtained from investigators at the National Institutes of Health, grown in E. *coli*, and plasmid DNA purified for transfection. In initial transfection experiments, the cells were overlaid with agar containing X-gal. If virus plaques are expressing ß-galactosidase, then the X-gal will be converted to a blue color, and the virus plaque will appear blue. No recombinant CPV plaques expressing ß-galactosidase were identified. A series of transfection experiments were done varying the amount of plasmid DNA, the amount of CPV used for cell culture infection, and the reagents in the transfection protocol. We still have not identified a recombinant CPV and have concluded that other insertion plasmids are needed to increase the efficiency of homologous recombination. Two new insertion plasmids were obtained from investigators working with other poxviruses. One of these plasmids was used by others to insert foreign genes into CPV, increasing our optimism that this plasmid will solve our current problems.

Component Objective 2. Identification of Vaccine Genes for Sheep and Goat Diseases

WSU Objective 2A (contagious caprine pleuropneumonia-CCPP) hypothesis. Genes for *Mycoplasma* F38 surface proteins can be identified in genomic DNA libraries expressed in *E. coli.*

Problem statement and approach

SR-CRSP scientists developed an effective vaccine for contagious caprine pleuropneumonia (CCPP). The vaccine made of inactivated mycoplasma organisms is safe, and one dose provides protection against challenge for at least one year. To include CCPP in a multivalent vaccine, however, we need to identify a gene encoding a protective protein. The strategy is to express plasmid libraries of *Mycoplasma* F38 DNA in *E. coli* and then screen with antibodies to surface proteins. Surface proteins are targeted because they induce a protective immune response against other organisms. Once a gene encoding a protective protein is identified, the gene can be expressed in the virus vector developed in objective 1 and used to immunize goats.

Progress

This research was done in the KARI laboratory at Kabete, Kenya, and includes the M.S. thesis work of S. Kihara, a KARI employee and WSU graduate student. Genes expressing proteins reacting in immunoscreens with serum from goats that have recovered from CCPP were identified, but more are needed to increase the probability of expressing surface proteins. To this end, surface specific antibodies were isolated from immune goat serum by absorption to and elution

from intact F38 Mycoplasma. These antibodies were used to identify F38 surface proteins and will be used to preferentially identify recombinant surface proteins.

A DNA clone expressing Mycoplasma F38 protein also was identified with a previously reported monoclonal antibody and used to immunize goats. Antisera were obtained and will be reacted with isolated organisms in an agglutination test. Only those antibodies reacting with surface proteins will cause agglutination. This procedure will be used to evaluate other candidate recombinant proteins until one that is a replica of native surface protein is identified.

WSU Objective 2B (heartwater) hypothesis. Monoclonal antibodies to C. *ruminantium* surface proteins will identify recombinant proteins expressed in *E. coli.*

Problem statement and approach
Heartwater was chosen for inclusion in a multivalent vaccine for both sheep and goats because of its widespread occurrence in Africa and the Caribbean. No heartwater vaccine is available, and, as a result, this tick-transmitted disease causes high morbidity and mortality in susceptible sheep and goats. The approach is similar to the one described for CCPP.

Progress
The pCR9 DNA probe described in last year's report was used by the UF, USAID, and SADCC Heartwater Research Project. The project is located in Zimbabwe and the probe was shown to react with eight strains of C. *ruminantium* from around the world, including several strains from Africa. Current studies with the probe are focused on epidemiology, including both animal and tick infections. SR-CRSP investigators continue to collaborate in this research.

With regard to the vaccine project, L. Ndung'u, a KARI employee and WSU graduate student, finished her M.S. coursework and is returning to Kenya to do her thesis work on specific aims of this vaccine project. Completed research demonstrates that all our monoclonal antibodies made to the Kenya Kiswani isolate reacted with an immunodominant 32 kilo Dalton protein. The monoclonal antibodies are being used to determine if epitopes of this protein are expressed on the surface of live organisms. Organisms were isolated from tissue culture cells currently being maintained at Kabete and used in agglutination tests. Mice were also immunized to make another monoclonal antibody library to find antibodies that neutralize the organism in the tissue culture cells. cDNA libraries will be screened with these monoclonal antibodies to identify colonies expressing surface proteins.

WSU Objective 2C (Haemonchus contortus) hypothesis. Isolated proteins from an organ homogenate will induce a protective immune response.

Problem statement and approach
Haemonchosis affects most sheep and goats in the world and in tropical and subtropical countries causes severe disease requiring expensive and regular

drug treatment. A vaccine for haemonchosis would be of significant benefit to sheep and goat 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. 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 isolating proteins from complex mixtures.

Progress
In addition to studies on worm gut antigens, graduate student research is also being done to identify and isolate proteases from the worm's excretory/secretory products. Others have shown that these proteases can also induce protective immune responses, and epitopes from these proteases may be needed to enhance immunization with gut antigens. This part of the project is F. Karanu's M.S. thesis. He is a KARI employee and a WSU graduate student doing research at the KARI laboratory at Kabete, Kenya.

Research on immunizing goats with gut homogenates of H. *contortus* and challenging with larva was completed and published (see publication list). Kid (<6 months of age) and yearling goats were immunized against challenge. A 95% reduction in fecal egg counts in both ages of goats was achieved for the immunized compared to the control group. Reduction in worm numbers in immunized goats was 65% (kids) and 89% (yearlings) compared to controls.

Several monoclonal antibodies were identified that reacted with antigens similar to those identified with serum from immune goats. Two monoclonal antibodies reacting with gut surface antigens were selected for initial study and used to isolate parasite gut proteins from homogenate by monoclonal antibody affinity chromatography. Hybridomas making antibodies of appropriate specificities were cloned by limiting dilution and used to make ascitic fluid in pristane primed Balb/C mice. Monoclonal antibodies were isolated from ascitic fluid, coupled to agarose, and used to isolate the protein of interest. The protein was eluted from the affinity matrix and evaluated for purity by silver staining PAGE-SDS gels. To date, one affinity purified protein was used to immunize goats for challenge.

WSU Objective 2D (caprine arthritis encephalitis and arthritis virus-CAEV) hypothesis. Envelope proteins of CAEV expressed in vaccinia virus will induce a protective immune response.

Problem statement and approach
CAEV causes chronic arthritis and mastitis of goats in several countries. Project investigators have worked on this disease for several years, and progress has reached a stage where genes encoding viral envelope glycoproteins are available for early testing of the virus-vectors in goats. Selection of the viral envelope glycoproteins is based on the results with other retrovirus glycoproteins. If the CAEV

gene delivered by vaccinia virus works, then the gene can be tested in a more acceptable vector such as CPV (objective 1).

Progress
A recombinant vaccinia virus was made that contains the complete *env* gene of CAEV63 and expresses gp135. The recombinant gp135 reacted with antibodies to native gp135 and had the same relative mobility in western immunoblots. This construct, designated VCAEV63e, was used to immunize goats, and the immune response was monitored. Goats immunized with recombinant virus made antibodies that reacted with native gp135. None, however, made neutralizing antibody. The immunized goats and control goats were challenged with 106 $TCID_{50}$ of CAEV. One early observation is that immunized goats made neutralizing antibodies before the control goats.

Training

- Leah Ndung'u, BVM, KARI employee, WSU graduate student in Veterinary Immunology, major professor is Guy Palmer, expected M.S. completion in Spring of 1993.
- Francis Karanu, BVM, KARI employee, WSU graduate student in Veterinary Parasitology, major professor is Doug Jasmer, expected M.S. completion in Spring of 1992.
- Stanley Kihara, BVM, KARI employee, WSU graduate student in Veterinary Microbiology, major professor is Travis McGuire, expected M.S. completion in Spring of 1992.
- Donald Siamba, BVM, KARI employee, University of Nairobi graduate student in Veterinary Parasitology, research supported by WSU SR-CRSP project, tuition support from Kenya SR-CRSP matching funds, SR-CRSP contact is Fred Rurangirwa, expected M.S. completion in Spring of 1993.

Other Contributions

Collaborative research with the University of Florida, USAID, and SADCC (group of Southern African countries collaborating on development issues) Heartwater Research Project was performed. The research resulted in a completed, SR-CRSP sponsored, WSU Ph.D. thesis by Suryakant Waghela. The initial work was published and is listed in section 10. The cDNA probe is now being used in further collaborative studies on heartwater epidemiology in Zimbabwe where the UF, USAID, and SADCC Heartwater Research Project is headquartered.

Initial funding for the haemonchosis project was derived from SR-CRSP and from the Washington Technology Center, an agency of the State of Washington. Based on the Washington Technology Center's mandate for working with industry, initial funding was also obtained from a Washington-based company. Subsequently, a major pharmaceutical company expressed interest and is supporting the project by sponsoring collaborative research with their research staff. Our initial *Haemonchus* cDNA library was obtained as a result of that collaboration.

Fred Rurangirwa, WSU Resident Scientist in Kenya, participated in the International Workshop on Effective Control of Ticks and Tick-borne Diseases, Kampala, Uganda, September, 1991.

Collaborating Personnel

Kenya (SR-CRSP sponsored KARI graduate students are listed in the "Training" section on page 142)

- G. Mulira, KARI, Kabete Center Director
- D. Muriu, KARI scientist, Kabete
- M. Bogori, KARI scientist, Kabete
- S. Shompole, KARI, Kabete (WSU graduate student sponsored by another project)
- R. Soi, KARI (WSU graduate student sponsored by another project)
- R. Waruiru, U. of Nairobi
- A. Wambugu, Res. Technician, Kabete

United States

- F. Rurangirwa (WSU Resident Scientist in Kenya)
- D. Jasmer, WSU
- T. Crawford, WSU
- G. Palmer, WSU

Collaborating Institution

Kenya Agricultural Research Institute (KARI)

Publications

SR-CRSP publications in refereed journals during the report period:

Rurangirwa, F.R., Kouyate, B., Niang, M. and McGuire, T.C. CCPP: Antibodies to F38 polysaccharide in Mali goats. Veterinary Record. 127:353, 1990.

Mwamachi, D.M., Rurangirwa, F.R., Musoke, A.J. and McGuire, T.C. Clone-specific immune colostrum induces increased resistance in goat kids challenged with *Trypanosoma congolense.* Acta Tropica. 49:27-36, 1991.

Rurangirwa, F.R., McGuire, T.C., Mbai, L., Ndung'u, L. and Wambugu, A. Preliminary field test of lyophilised contagious caprine pleuropneumonia vaccine. Research in Veterinary Science. 50:240-241, 1991.

Oluoch, E.A., Magnuson, N.S., McGuire, T.C. and Barbet, A.F. *Trypanosoma brucei:* Peptide mapping of partially homologous variable surface glycoproteins. International Journal for Parasitology. International Journal for Parasitology. 21:573-578, 1991.

Jasmer, D.P. and McGuire, T.C. Protective immunity to a blood sucking nematode induced by parasite gut antigens of *Haemonchus contortus.* Infection and Immunity. 59:4412-4417, 1991.

Waghela, S.D., Rurangirwa, F.R., Mahan, S.M., Yunker, C.E., Crawford, T.B., Barbet, A.F., Burridge, M.J. and McGuire, T.C. A cloned DNA probe identifies *Cowdria ruminantium* in *Amblyomma variegatum* ticks. Journal of Clinical Microbiology. 29:2571-2577, 1991.

Abstracts and Presentations

Rurangirwa, F.R. and McGuire, T.C. Identification and characterization of target antigen of a monoclonal antibody (WM-25) which inhibits the growth of *Mycoplasma* strain F38. Proceedings of the SR-CRSP Workshop, Nairobi, Kenya, 1991.

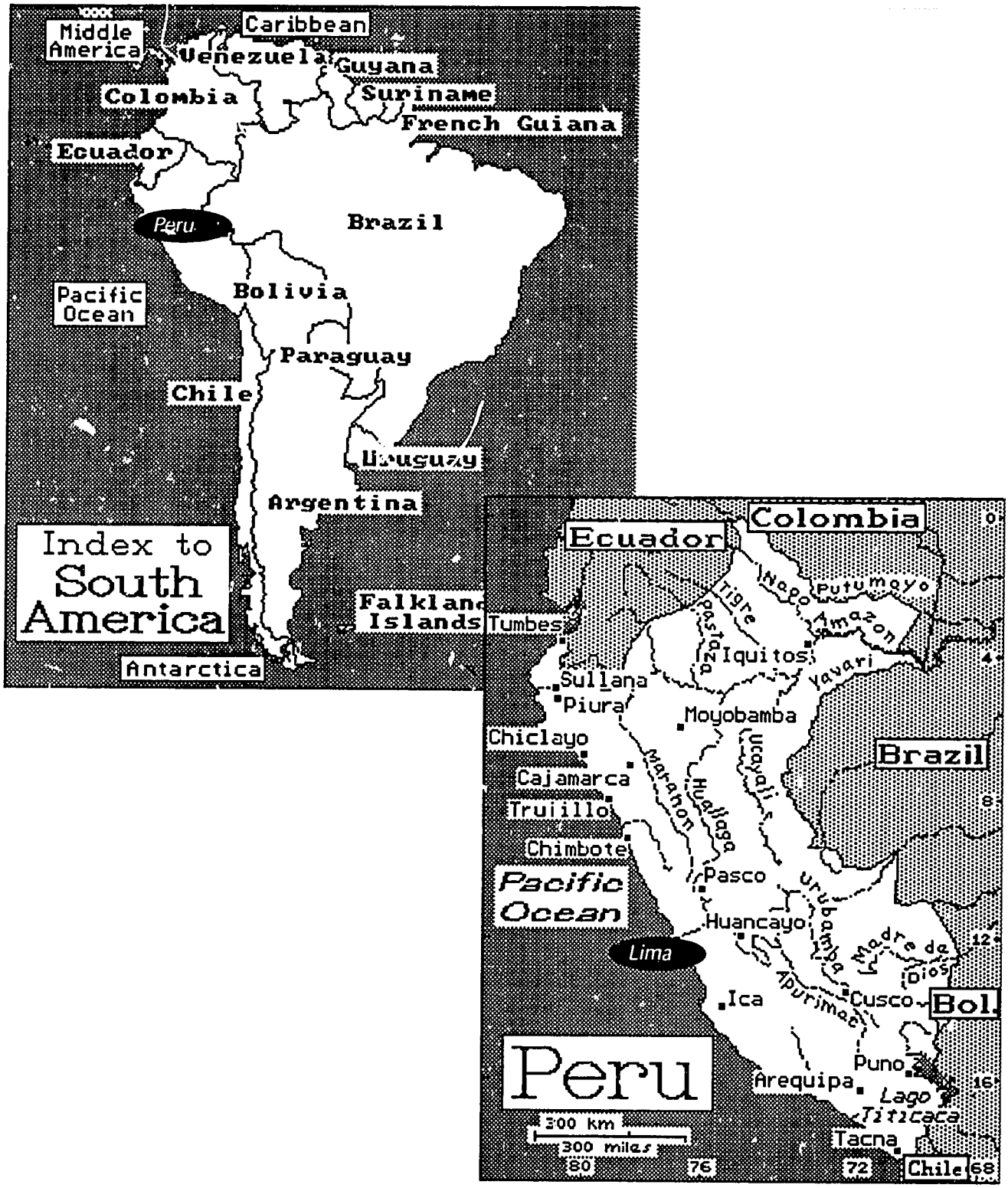
Jasmer, D.P., Perryman, L.E., Conder, G.A., Crow, S. and McGuire, T.C. Protection against a bloodsucking nematode induced by parasite gut antigen of *Haemonchus contortus.* Meeting of the American Society of Parasitologists, Madison, WI. August 1991.

Networks & 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


Middle America
Caribbean
Venezuela
Guyana
Suriname
French Guiana
Colombia
Ecuador
Peru
Brazil
Pacific Ocean
Bolivia
Paraguay
Chile
Uruguay
Argentina
Falkland Islands
Antarctica
Index to South America
Colombia
Ecuador
Tumbes
Iquitos
Sullana
Piura
Moyobamba
Chiclayo
Cajamarca
Trujillo
Chimbote
Pasco
Huancayo
Lima
Ica
Cusco
Puno
Arequipa
Tacna
Lago Titicaca
Brazil
Bol.
Chile
Pacific Ocean
Peru
300 km
300 miles
80
76
72
68

Montana State University

Andean Small Ruminant Network

Peter J. Burfening, Animal and Range Sciences Department, Montana State University, Bozeman, Montana, 59717. Telephone (406) 994-5573, Fax (406) 994-6579.

Narrative Summary
As part of the continuing SR-CRSP effort, support of scientific networking was identified as an activity that should be undertaken. Therefore an Andean Small Ruminant Research Network (RERUMEN) was established in October, 1990. At the present time the countries actively participating in RERUMEN are Argentina, Bolivia, Chile, Ecuador, Peru and Venezuela.

The first annual meeting of the RERUMEM directors was held in Lima, Peru, December 4 - 6, 1990. At that meeting directors from each country presented an overview of small ruminant production in their respective countries and the procedures that RERUMEN would follow were adopted. In conjunction with this meeting, a workshop jointly sponsored by RERUMEN (SR-CRSP) and Winrock International was held. The topic of the workshop was "Grantsmanship and Development of Competitive International Projects" and was conducted by Ms. Judith Killen of Winrock International.

The second annual meeting of the directors was held in Santiago, Chile, November 5 - 7, 1991, and at that time the following accomplishments were discussed. RERUMEN has developed a data base using the program MICROISIS supplied by UNESCO. The data bases contain both bibliographical data from literature on small ruminant research in the Andean region and a register of professionals working in the countries involved in the RERUMEN. Each country provides a national coordinator (one of the directors) and a computer for the data base, and each country makes their own arrangements as to how investigators and students can access the data base. A manual of procedures for using the data base was prepared by Dr. Florez's office in Lima and distributed to each director along with copies of the data base.

Problem statement
Latin American researchers, like researchers in many parts of the world, tend to work in an information vacuum. Although they often times have access to international scientific journals, they rarely have access to current research that is being conducted in other neighboring Latin American countries or elsewhere in the world. This often results in tremendous duplication of effort with very limited resources. Networks which serve small ruminant scientists and specialists are one method of addressing such problems by providing for:

- continued professional development
- prompt flow and interchange of research results, experience, and methods

• mechanisms to facilitate collaboration and cooperation in planning and executing research on a multi-country or regional basis
• identification of sources of funds to support research
• increased attention to issues involved in the rapid and efficient transfer of new technology from the laboratories and research stations to application in farmers' flocks and fields.

Approach
• Conduct and sponsor workshops on small ruminant production and provide a forum for development of collaborative proposals to send to funding organizations.
• Publish a newsletter regularly on research topics and technology transfer and other items of interest to small ruminant scientists.
• Inventory, develop and maintain a data base of scientists with common interests in small ruminant research and extension in the Andean region.
• Develop a bibliographical data base for small ruminants in the Andean region.
• Establish linkages with other Andean Networks and other regional small ruminant networks.

Progress

The workshop on "Grantsmanship and Development of Competitive International Projects" was conducted in Lima, Peru, December 4 - 6 1990, and was jointly sponsored by RERUMEN (SR-CRSP) and Winrock International. The workshop was conducted by Ms. Judith Killen of Winrock International and was attended by the RERUMEM directors and approximately 15 Peruvian scientists, many who were former co-PIs.

The workshop focused on how researchers could develop better research proposals that would be competitive in their own country and with international funding agencies. Much of the discussion focused on how to approach international funding agencies and specifically how to respond to specific RFPs.

Concurrently, with this workshop, the first directors meeting was held. Mechanisms as to how data would be entered and extracted from the data base were discussed and the responsibilities of each of the directors was agreed upon. In general each national director is responsible for mailing newsletters within their own countries, supplying facilities for use of the data base, and sending data to the international coordinator in Lima to be entered into the data base.

RERUMEN has developed a data base using the program MICROISIS supplied by UNESCO. The data bases contain both bibliographical data from literature on small ruminant research in the Andean region and a register of professionals working in the countries involved with RERUMEN. Each country will provide a national coordinator (one of the directors) and a computer for the data base, and each country will make their own arrangements as to how investigators and students can access the data base.

Part of the data base includes scientists and extensionists from the Andean area of South America with a common interest in small ruminants. Through September, 1991, the directory has over 400 registers from six countries. Cur-

rently the directors are checking the data from their respective countries for accuracy, and additional data is being entered. During this fiscal year RERUMEN will publish a directory of Small Ruminant researchers.

The bibliographical data base on Small Ruminant research in the Andean region has the following registers (through September 1991):

Sheep	950
Goats	460
Range and Pastures	2,010
South American Cameloids	
General Information	747
Alpacas	2,032
Llamas	479
Vicunas	449
Guanacos	116

Approximately 80% of this information is not included in either AGRIS (FAO's program) or in AGRCOLA (USDA's program) and is therefore very valuable in the Latin American region. Approximately 25% of the bibliographical entries in the data base have abstracts. A manual of procedures for using the data base was prepared by Dr. Florez's office in Lima and distributed to each director, at the second annual meeting, along with copies of the data base.

Three RERUMEN newsletters have been published to date. Each newsletter has contained general information on Sheep (Vol. 1, No. 1), Cameloids (Vol. 1, No. 2), and Goats (Vol. 1, No. 3) supplied by each national director. Each newsletter also contains information on the SR-CRSP activities, meetings, and other items of interest to Andean small ruminant scientists. The newsletter is distributed within each country by the national coordinators and is mailed to approximately 200 people or institutions in the U.S. and the rest of the world.

Conversations began with networks similar to RERUMEN in Latin America, which culminated with a cooperative agreement between ISAPLAC (Information Systems in Animal Production for Latin America and the Caribbean) and RERUMEN being signed in September, 1991. Another agreement is being developed between RERUMEN and REPAAN (Andean Pasture Network), where Dr. Florez is a member of REPAAN's directory and was recently elected president of the REPAAN advisory committee.

The Second RERUMEN International Meeting and Workshop was held in Santiago, Chile, November 5 - 7, 1991. The purpose of this meeting was to bring the directors of RERUMEN together and formulate the following: (1) define for the Andean area of South America the common problems of greatest interest in the production of cameloids, sheep, and goats that could be investigated most effectively by interregional cooperation; (2) establish small work groups that could collaboratively write proposals for research in particular areas of interest; (3) establish how scientists in each country can access the bibliographical data base for their use in updating their research knowledge; and (4) conduct a workshop on "Technical Assistance to the Small Producers: The Chilean Experience." In this workshop four Chilean speakers explained different development programs for small producers in different areas of the country. Each presentation covered the following topics: problems, objectives of the extension developed, methodol-

ogy used, and results. These extension projects are a mixture of on-farm research and extension and have been successful in Chile. Considerable time was left at the end of each presentation for an exchange of experiences among the attendants from all countries.

Since September 30, 1991, more than 1,000 citations have been added to the bibliographical data base. Directors are beginning to formulate proposals to be sent to granting agencies for additional funding for research projects.

The Pasture and Forages Manual by Drs. Arturo Florez, Felipe San Martin, and E. Malpartide ("Manual de Pastos y Forrajes") was revised and published in January 1992.

Training

In Progress

Miguel Paz, Peru, Montana State University, January 1, 1989-September 1992, Ph.D. in Statistics

Horarico Cardanes, Peru Montana State University, January 1, 1989 - January 15, 1991, MS in Animal Science, specialization in Reproductive Physiology.

Short Term (Workshops)

"Grantsmanship and Development of Competitive International Projects," Lima, Peru, December 4-6, 1990 Attended by 35 people. Jointly sponsored by RERUMEN and Winrock International.

"Technical Assistance to the Small Producers: The Chilean Experience," Santiago Chile, November 5-6, 1991, Attended by 28 people (RERUMEN directors and 14 Chilean Professionals). Jointly sponsored by RERUMEM and INIA-Chile.

"Diagnosis of Research and Technology Transfer on Cameloids in the Last 20 years," Arequipa, Peru, June 1991. Attendance Unknown. Jointly sponsored by INIAA, RERUMEM and PAL.

"Regionalization of SR-CRSP-Peru at the VII International Meeting of Specialists in South American Camels," April 1991. Jujuy, Argentina, Attendance 150 people. Travel of SR-CRSP Co-PI's supported by Linkage funds.

"Sustainable Agropastoral systems in Bolivian Altoplano: SR-CRSP Research Priorities for the next Decade." Drs. Burfening and Florez participated in this workshop.

Other Contributions

U.S. Agriculture

We have already had one request for information from our data base relative to diseases in Llamas. This data base will make information on research done in Latin America available to researchers in the U.S. and the world.

Host Country

Linkage grants to former Co-PIs provided for the following: 1) Travel to present papers and participate in the "VII International Meeting of Specialists in South American Camels," held in Jujuy, Argentina; 2) improving the Post-graduate training in Camelids at IVITA and UNA-Puno; 3) South American Camelids, Production Unit to Develop Basic Research Studies (Dr. Felipe San Martin) and 4) Sheep Production, Textile and Meat Industries (Dr. Corinne Valdivia). Due to restriction of

the Brooke Amendment, linkage grants were not offered to Peruvians in fiscal 1991-1992.

Collaborating Personnel

Dr. Arturo Florez, Jeffe Red de Rumiantes Menores, Apartado 110097, Lima 11, Peru. Telephone 51-14 367460, Fax 51-14 367460.

Collaborating Institutions

Instituto Nacional de Investigacion Agraria y Agroindustrial (INIAA)

Publications

Novoa, C. and Florez, A. 1991 Production de rumiantes menores: Alpacas. Lima Peru.

Alencastre, R. 1991. Estudios sobre caracteristics geneticas y produccion de ovinos corriedale en Puno-Sierra del Peru. Published by SR-CRSP for IVITA/INIAA, Peru.

Alencastre, R. 1991. Resultados de estudios sobre algunas caracteristicas productivas de ovinos Criollas en Puno sierra su del Peru. Published by SR-CRSP for IVITA/INIAA, Peru.

Ameghino, E and DeMartini, J. 1991. El aspecto sanitario en Alpacas y ovinos de las comunidades del departamento de Puno. Published by SR-CRSP for IVITA/INIAA, Peru. 89 pp.

Ameghino, E and DeMartini, J. 1991. Mortalidad en crias de Alpaca. Published by SR-CRSP for IVITA/INIAA, Peru. 128 pp.

Berardinelli, J.G., Cardenas, H., Burfening, P.J., and Adair, R. 1991. Testicular histomorphology and seminal characteristics of Rambouillet rams from lines selected for low and high reproductive rate. Presented at American Soc. Anim. Sci. Laramie, Wyoming.

Burfening, P.J., J.G. Berardinelli and R. Adair. 1991. Response of LH and testosterone (T) to GnRH in Rambouillet ram lambs selected for low and high reproductive rate. Presented at Soc. for the Study of Reproduction, Vancouver, B.C., Canada.

Berardinelli, J.G., Cardenas, H., Burfening, P.J., and Adair, R. 1991. Testicular hCG/oLH and in vitro gonadotropin-stimulated testosterone (T) secretion in Rambouillet rams from lines selected for low and high reproductive rate. Presented at Soc. for the Study of Reproduction, Vancouver, B.C., Canada.

Linkage Projects

Post Graduate Education and Research Support

Dr. Peter Burfening, Animal and Range Sciences, Montana State University, Bozeman, Montana, 59717. Telephone (406) 994-5573, Fax (406) 994-6579.

Total funding: $10,000

Narrative Summary
The purpose of this work was to improve the organization of the recently established post-graduate studies at San Marcos University and Altiplano National University. As stated in the proposal, the scope of our work was to organize the curricula, to prepare graduate program policies and regulations, to assist in course preparation, establishment of thesis research priorities, and to assist in seeking research funding for the initiation or completion of ongoing thesis research.

Results and Conclusions

San Marcos University Graduate School

• The Veterinary faculty of San Marcos University should attempt to reorganize its post-graduate studies very selectively, involving those areas of specialization they are most competent in. accordingly, three areas have been identified and course planning outlined for each area of specialization.

• Policies and regulations of graduate studies have been outlined to conform with policies of the Veterinary Faculty, School of Graduate Studies, and San Marcos University.

• The following lectures, oriented towards the identification of research priorities, were given:

- ♦ Interpretaciones sucesionales de la pradera nativa (Dr. Arturo Florez)
- ♦ Tecnología de fibra de camélidos (Ing. Manuel Carpio)
- ♦ Estimación de Parámetros Genéticos (Dr. Juan Chávez)
- ♦ Infecciones hepáticas de la ganadería peruana (Dr. Raúl Rosadio)
- ♦ Sondas de ADN en Medicina Veterinaria (Dr. Antonio Ramírez)

• Student support for thesis work, including laboratory, office, and computer supplies, and publication was provided.

• Some research funding from Fundeagro and IDRC-Canada was obtained.

Support Program for the Master of Andean Livestock (UNA-Puno)
Background
The degree of Master of Andean Livestock was first granted in 1989 at the Altiplano National University at Puno (UNA-Puno). The purpose of this degree is to train professionals of the region in the breeding of cattle in the Andean zone. In April, 1991, the degree was expanded to include more academic subjects.

Diagnostic
The Masters of Andean Livestock degree is important to UNA-Puno

because it enables professionals outside of Lima to learn new techniques and research and because it emphasizes the regional resources of native cattle and natural ranges.

Although the program focuses on all the livestock species native to the Andean area, it gives special emphasis to the breeding of South American camelids because these are considered to be potentially more adaptable to the agroecological and sociocultural conditions of the highland zones. However, the limited economic resources of the University make it difficult to sustain a high academic level and to create a truly professional program in livestock.

Therefore, this project, in conjunction with livestock professionals, supported the University to achieve the following objectives:

- To train students and professors of the Master's degree in research methods and techniques, as well as the newest techniques in reproduction, genetic improvement, range and nutrition, animal health, fiber technology, and meats.

- To improve the curricula of the Master's degree by eliciting suggestions from livestock specialists.

- To improve the skills in cameloid breeding of professionals of the Pedagogic and Technological Institutes and Livestock Schools and professionals of the sector.

Strategy and Methodology

Training

In order to achieve the first objective, a non-scholarship training program was initiated in May, June, and July. The program was held over three days and was led by Drs. Florez, San Martín, Novoa, Chávez, Ameghino, Rosadio, and Ramírez.

The topics covered were:
- Research in range and pasture management
- Multiple use concept and rangelands of Peru
- Advances in small ruminant nutrition
- Research focus in the Sierra of Peru
- Advances in cameloid reproduction research
- Advances in sheep reproduction research
- Advances in sheep and cameloid genetic improvement
- Model of a genetic improvement program
- Genetic markers and the possibilities of their use in livestock
- Diagnosis and ontrol of diseases in sheep and alpaca
- Small ruminant flock management
- Diseases of neonates, young, and yearling animals
- Diseases of adult animals
- Diseases associated with reproduction

Each topic used the following methodology:
- Lecture with the aid of slides, projectors, and blackboards.
- Distribution of study materials on the topic.
- Field trips to study animals, the use of registry data, laboratories, and experimental fields.
- Group discussion.
- Written evaluation of participants.

Improve the Curricula
The second objective was achieved by revising the curricula of the graduate program in Andean Livestock. Groups of SR-CRSP specialists visited the campus between April and July of 1991 and recommended that the curriculum was too focused and narrow, specializing only in the Altiplano and not the entire Andean region. The disadvantage to this approach is that some graduates of the program may not be able to find employment in the region and their degree will be too specialized to apply to other areas. In addition, the group recommended that the number of required courses be reduced.

The curriculum design of the program is based on the urgent need to contribute to the socioeconomic development of the Andean region and to exploit the native livestock resources. UNA-Puno and the department of Veterinary Sciences and Zootechniques have found that implementing research on the entire Andean region has been very difficult. One reason is that the role of ecology in production systems is still not very well understood and knowledge of the potential of the resources is fragmented or non-existent. Technologies developed for other regions is often not applicable to the Andean zone. Therefore, there is a real need for researchers who have a global perspective, yet can also focus on the specialized needs of this region.

The team suggested that the program define an academic-professional profile. The definition should describe the characteristics which typify the graduating student. It is important to describe the academic and professional qualities of the degree.

The team also suggested that the program define its objectives: what will the students learn? After these objectives are defined, it is important to examine the required and optional courses and redesign the curriculum to achieve the objectives.

Lastly, the team suggested that a chronological sequence be established for required and optional courses.

Other
While the team was visiting UNA-Puno, they met with many of the graduate students to consult on their research and theses. In addition, the team was able to offer basic financial support to some of the students for a few months.

In addition, the team assisted the faculty and students in preparing funding proposals, resulting in a grant from the Swiss government for U.S.$10,000 to implement the curriculum change.

Collaborating Personnel
Dr. Enrique Ameghino
Dr. Manuel Carpio
Dr. Juan Chavez
Dr. Arturo Florez
Dr. Cesar Novoa
Dr. Antonio Ramirez
Dr. Raul Rosadio
Dr. Felipe San Martin

Regionalization of the SR-CRSP/Peru at the VII International Meeting of Specialists in South American Cameloids, Jujuy, Argentina

Dr. Peter Burfening, Animal and Range Sciences, Montana State University, Bozeman, Montana, 59717. Telephone (406) 994-5573, Fax (406) 994-6579.

Total Funding: $14,300

Narrative Summary
The objectives of the project were to publicize the research results of the SR-CRSP/Peru project from 1980-1990 to other Latin American countries at the VII International Meeting of Specialists in South American Cameloids. This meeting was held in Jujuy, Argentina, from April 17-20, 1991. The emphasis was placed on the regional applicability of the research. In addition, the goal was to establish institutional and personal relationships with other small ruminant specialists in order to lay the groundwork for future collaboration and the Small Ruminant Network.

Results and Conclusions

The VII International Meeting of Specialists in South American Cameloids was held in San Salvador de Jujuy, Argentina, from April 17-20, 1991. It was organized by the Instituto de Biología de Altura-Universidad Nacional de Jujuy and the Dirección Nacional de Fauna Silvestre-Secretaría de Agricultura, Ganadería y Pesca of Argentina. Attending were approximately 250 scientists and professionals.

The small Ruminant CRSP was one of 17 sponsoring institutions. The meeting consisted of round table discussions, symposiums, seminars, and displays.

Dr. Arturo Florez, a co-principal investigator with the SR-CRSP and the Coordinator of the Small Ruminant Andean Network, was appointed to the Honorary Scientific Committee along with Dr. Jorge Cajal (Argentina), Dr. Claudio Cunazza (Chile), Dr. Carlos Nuevo Freire (Argentina), Dr. Rodolfo Merlino (Argentina), and Dr. Armando Cardozo (Bolivia).

Dr. Cesar Novoa (co-investigator, SR-CRSP) and Dr. Walter Bravo (former SR-CRSP trainee) participated in a round table discussion on reproduction.

Dr. Raul Rosadio (co-investigator, SR-CRSP), Dr. Enrique Ameghino (co-investigator, SR-CRSP), and Dr. Antonio Ramírez (co-investigator, SR-CRSP) participated in a round table discussion on animal health.

Dr. Arturo Florez and Dr. Felipe San Martín (co-investigator, SR-CRSP) were speakers at a roundtable on range and pastures.

Dr. Juan Chávez (co-investigator, SR-CRSP) and Dr. Victor Bustinza (co-investigator, SR-CRSP) participated in a symposium on genetic and productive improvement.

The SR-CRSP displayed four posters on management and reproduction, three posters on nutrition, two posters on genetics, and three posters on products, by-products, and industrialization.

A special session was held by Dr. Arturo Florez on the Small Ruminant Andean Network (RERUMEN). *Research Accomplishments of the SR-CRSP-Peru 1980-1990*, a bulletin about RERUMEN, and the first RERUMEN newsletter was distributed.

Dr. Arturo Florez was invited by the organizing committee to give the closing speech.

Conclusion
Participating in this meeting was valuable because it enabled the SR-CRSP/Peru to publicize research results from a decade of work in Peru, and it allowed the scientists to make important contacts with other researchers and professionals. In addition, it enabled Dr. Florez to publicize the Small Ruminant Andean Network and to register scientists for the RERUMEN data base.

Collaborating Scientists

Dr. Enrique Ameghino
Dr. Fred Bryant, Texas A&M
Dr. Victor Bustinza
Dr. Manuel Carpio
Dr. Juan Chavez
Dr. Arturo Florez
Dr. D. Martinez
Dr. Cesar Novoa
Dr. Antonio Ramirez
Dr. Raul Rosadio
Dr. Felipe San Martin

South American Camelids Production Unit to Develop Basic Research Studies

Dr. Fred Bryant, Department of Range and Wildlife Management, Texas Tech University, Lubbock, Texas, 79409-2125. Telephone (806) 742-1983, Fax (806) 742-2280.

Total Funding: $7,000

Narrative Summary
A small cameloid production unit in the Veterinary Faculty of San Marcos University with the support of the SR-CRSP. This goal was to begin basic research by graduate students in the areas of nutrition, reproduction, and animal health. In addition, funding was able to provide animals for research that were previously unavailable due to security problems. Facilities were made available to students in animal health to study mycoplasmosis and parasitic diseases. Financial support was given to the departments of histology, clinical pathology, anatomy, animal production, and animal health to provide specimens for experiments and academic courses. Approximately 250 students have been trained in the management of South American cameloids.

Results and Conclusions

Nutrition

Comparison among techniques for evaluating digestive parameters in South American Cameloids
Evaluations of the techniques for measuring the digestive parameters in South American Cameloids have not been made. Two laboratory techniques were evaluated for the estimation of the digestibility with these animals: the *in situ* Digestion Technique (dracon bag technique) versus *in vitro* Digestibility Technique (Tilley & Terry). For this work were ruminally fistulated three alpacas and were evaluated six different types of forage. The results are shown in table 1.

Table 1. Regressions and determination coefficient between the *in situ* Digestibility Technique (x) and *in vitro* digestibility technique (y) of the different parameters of the digestion.

Parameters	Coefficients a	b	r	Significance
Digestibility 72h	13.10	0.71	0.89	**
Digestibility 48 h	16.91	0.64	0.91	**
Digestion Rate	0.67	0.93	0.66	ns
Medium Time	6.52	0.49	0.71	*

** (P 0.01)
* (P 0.01)
ns (P 0.05)
a) Differences were not obtained between these techniques for the estimation of the digestive rate (P 0.05)
b) A high and significant correlation exists between both techniques for the digestibility at 48 hours and 72 hours (P 0.05)

The estimates of *in situ* digestibility are always superior to the ones obtained with the *in vitro* digestibility; for this reason, when the first one is applied, the correction formula should be used.

Evaluation of the Rates of Different Agricultural By-Products

In view of not having parameters of digestive rate of the different agricultural by-products available for utilization of South American cameloids, the following study was suggested using four by-products of more availability in the interandean valleys. The technique of *in situ* digestibility (dracon bag technique) was sued estimating the digestion of the dry matter in the times of 6, 12, 24, 48, and 72 hours. The results are shown in table 2.

The digestive rates of the by-products were in general low, which explains its low nutritive value and consumption. Studies should be performed which allow it to increase its nutritive potential.

Treatment of Barley By-Product with Urea

Due to the low nutritive value of the agricultural by-products and its potential use as supplement in South American Cameloids, this study put the barley by-product to treatment with urea (3%) and evaluated it from the point of view of chemical nutrition and its voluntary consumption in alpacas, llamas, and sheep. The results obtained are shown in tables 3 and 4.

Table 2. Comparison of the digestion rates and medium time of disappearance of the dry matter from the principal agricultural by-products.

Agricultural By-Product	Digestion Rate %/h	Medium Time h
Oat	2.83a	26.19a
Barley	3.67ab	22.76ab
Wheat	4.00ab	18.13ab
Chala Maize	4.90b	14.51b

Averages of columns with different letters are statistically significant (P 0.05)

a) The by-product of oat showed the lower digestion rate and higher medium time.
b) The Chala Maize showed the best digestion rates and medium time.
c) The *in situ* digestive technique appeared to be a technique of easy application in South American Cameloids.

The treatment with urea (ammonization of the agricultural by-products increase significantly its nutritive value and consumption, and for this reason its feeding potential. This treatment is simple and of low cost, being necessary to give a wide diffusion as technological alternative to the producers.

Reproduction

Research has shown that biological principles governing reproduction in cameloids are peculiar to the species and must be taken into account in applying techniques to improve birth rates. Improved mating systems for small herds are lacking; therefore, a hand-mating system was tested in the small alpaca unit (n=40) at the veterinary facility in Lima, which consisted of exposing females to the males every fortnight after copulation and those females showing estrus were allowed to remate. At the same time, blood samples were taken for progesterone determinations. The results are as follows.

- Females in estrus showed undetected or low progesterone levels (1 ng/ml).
- Progesterone levels seven days after copulation were high (2 ng/ml) indicating that ovulation had occurred and that corpora lutea were functioning. In this group (n=40) only two animals failed to ovulate after copulation but did ovulate after reserve 15 days later.
- Fifty percent (20/40) of the ovulating females showed high progesterone levels and rejected the males during 15, 30, 45, and 60 days after copulation and were confirmed to be pregnant by rectal palpation 30 days afterwards.
- The rest of the females returned to estrus and showed low progesterone levels (1 mg/ml) during the first 45

Table 3. Comparison of the dry matter digestibility at 48 hours (DMS 48) and 72 hours (DMS 72) and the digestive rate and medium time of the barley by-product without treatment and treated with urea (3%).

By-product	DMS 72	DMS 48	Digestive (% / h)	Medium time (h)
Barley without treatment	58.20	46.55	3.67	22.76
Barley treated (3% Urea)	65.57	63.04	6.60	10.63

The treatment with urea (3%) achieved a significant improvement of all the digestive parameters evaluated (P 0.05).

Table 4. Consumption of dry matter of the barley by-product without treatment (ST) and treated (3%) (T Urea) in llamas, alpacas, and sheep.

Consumption	Llama		Alpaca		Ovino	
	ST	Turea	ST	Turea	ST	Turea
Animal, KG	0.63	0.92	0.47	0.61	0.48	0.54
100 Kg live weight, KG	0.98	1.43	1.22	1.65	2.17	2.44
Kg metabolic weight, kg	0.03	0.04	0.03	0.04	0.47	0.53

a) The treatment with urea increased significantly the voluntary consumption in the three species.
b) The llama had a bigger increase of consumption (43%) than the alpaca (34%) and the sheep (13%).
c) The consumption increase in the treated barley was due to the improvement in the parameters of the digestion shown in table 3, as well as the increase (52.4%) of the nitrogenated tenor.

days after copulation, indicating that embryo mortality had occurred. However, 8/20 females that were remated became pregnant.

Reproductive inefficiency is due to high embryo mortality; however, females which spontaneously abort are able to become pregnant if remated. Nutritional levels might be involved in these reproductive losses and need further investigation.

Animal Health
The respective facilities are studying the following:

- Use of "Vitimate" (antiparasitary) for the control of *Otobius megnini.*
- Study of mycoplasma in alpacas.

Other Disciplines
The following have been developed with the collaboration of the Unit.

- Histology and histochemical studies of the alpaca skin.
- Population of Langerhans cells in alpaca skin.
- Alpaca reproduction apparatus: macroscopic anatomy.

General Conclusions

The South American Cameloid Production Unit has and will continue given service to the research and the academic activities to professors and alumni of the Veterinary Medicine Faculty of the San Marcos University (UNMSM). Actually, there are different investigations that are being developed and others that will begin, principally through graduate student research. UNMSM and the SR-CRSP scientists will continue to search for funding to continue this production unit to develop basic studies in this species in its natural breeding zone.

Collaborating Scientists

Dr. R. Ellis, Colorado State University
Dr. Felipe San Martín
Dr. Cesar Novoa
Dr. Antonio Ramirez
Dr. Raul Rosadio
Enrique Ameghino
Luis Coronado

The Small Ruminant Sector of Peru: Sheep Production and the Textile and Meat Industries

Dr. Enrique Ospina, Winrock International, Route 3, Morrilton, Arkansas, 72110. Telephone (501) 727-5435, Fax (501) 727-5417.

Total Funding: $3,500

Narrative Summary
The project consisted of writing a publication in Spanish on the Small Ruminant Sector of Peru by Dr. Corinne Valdivia. This included the farm producers and the industries for meat and textiles. A chapter describing the peasant economy of small producers and their diversity was written by Domingo Martinez.

The preparation of the document took six and a half months. The manuscript was sent to Peru for the editing process which took from July to the middle of September. The photo-ready version was prepared by Domingo Martinez and was printed at the University of Missouri.

The publication is entitled *Politica economica y ganaderia extensiva: El caso de ovinos y camelidos en el Peru.* Five hundred copies were distributed to Latin American countries.

Results and Conclusions

The document's objective was to present research on the impact of government policies on the small ruminant sector of Peru in Spanish. Policies that may increase sheep and alpaca producer welfare in the Andean region were discussed. The small ruminant sector, a system of interrelated markets of farm sheep and alpaca production, the textile and sheep meat processing industries, and the national and international markets were analyzed.

The document gives an overview of the different policies that have influenced the sector through any of its markets and shows the volatility and unreliability of these policies for the farm producers. Government policies have protected urban consumers through controlling meat prices. An important mechanism for this policy was subsidies to the exchange rate for food imports, which encouraged meat imports. Overvalued domestic currency discouraged exports of textiles and encouraged imports of sheep meat; both of these policies were detrimental to farm production and the domestic industries.

The joint nature of wool and meat production allows producers to build a buffer to price changes; sometimes when meat prices were low, wool prices were high. However, in the end, the effects of these economic policies is negative. Production of both wool and meat fell because the population of sheep decreased in the last twenty years.

Policies that favor the elimination of price controls and a movement towards market-oriented policies can favor producers if the exchange rate also moves towards the real exchange rate. This last condition has been difficult to achieve. With an over-priced currency, the native industry has not been able to develop.

The study shows the results of trade liberalization and a real parity exchange rate. The technology of the processing sector was important in determining the outcome of policies. The degree of substitution of the inputs used from the sheep sector with other inputs should be taken into account when designing the type of innovations to be designed and introduced.

This Spanish publication gives an overview of policy throughout the last twenty-five years and the simulation model experiments with alternative policies that can favor farm producers. An essential lesson to keep in mind is that several markets have an impact on producers—the international market plays a role by competing with domestic production. Market oriented policies, and the opening of the domestic market, will impact producers. The degree of this impact will depend upon, among other things, the behavior of the exchange rate. These are factors to be taken into consideration in the development of innovations for the farm producers.

Collaborating Scientists

Dr. Corinne Valdivia, University of Missouri
Domingo Martinez, University of Missouri

Project Expenditures

Small Ruminant CRSP
Expenditures by Program

Institution	Year Six 1984/85	Year Seven 1985/86	Year Eight 1986/87	Year Nine 1987/88	Year Ten 1988/89	Year Eleven 1989/90	Year Twelve 1990/91	Total
California	$192,562.10	$258,979.52	$216,229.92	$193,411.97	$235,093.47	$280,426.85	$331,324.81	$1,708,028.64
California	$119,308.75	$142,139.33	$132,401.92	$0.00	$0.00	$0.00	$0.00	$393,850.00
Colorado	$159,902.05	$157,787.88	$131,447.80	$168,782.58	$164,143.00	$174,396.00	$179,497.99	$1,135,957.30
Missouri	$270,247.05	$307,072.42	$204,442.54	$240,555.18	$249,231.09	$289,260.30	$201,575.76	$1,762,384.34
Montana	$145,000.00	$144,000.00	$126,400.00	$104,717.98	$149,281.30	$162,589.57	$110,568.80	$942,557.65
North Carolina	$235,178.00	$244,088.00	$165,900.00	$205,718.10	$185,710.05	$199,348.87	$383,672.90	$1,619,615.92
Texas A & M	$158,827.67	$144,451.44	$65,380.21	$0.00	$0.00	$0.00	$0.00	$368,659.32
Texas A & M	$143,469.80	$155,636.79	$175,909.65	$207,766.64	$184,271.32	$192,747.00	$141,524.58	$1,201,567.98
Texas Tech	$262,151.09	$246,138.86	$113,615.10	$187,549.88	$151,354.00	$150,000.00	$84,122.34	$1,214,931.27
Utah State	$180,566.51	$178,183.00	$126,400.00	$104,699.92	$90,289.48	$185,881.00	$91,342.42	$957,361.33
Utah State	$195,000.00	$156,755.09	$21,900.00	$0.00	$0.00	$0.00	$0.00	$373,655.09
Washington	$158,632.69	$176,310.01	$123,022.15	$168,985.00	$150,000.00	$164,985.35	$160,000.00	$1,111,935.20
Winrock Econ	$235,000.00	$258,584.43	$198,365.61	$234,960.01	$251,500.00	$251,677.74	$212,325.07	$1,642,413.06
Winrock DPG	$200,019.76	$223,936.79	$207,610.00	$245,509.31	$244,606.72	$285,739.00	$233,000.00	$1,625,421.58
Subtotals	$2,675,865.47	$2,799,263.56	$2,009,025.10	$2,062,678.77	$2,065,479.43	$2,317,051.68	$2,128,954.67	$16,058,338.68
Host Countries								
Brazil	$125,202.15	$108,969.41	$59,874.67	$0.00	$0.00	$0.00	$0.00	$294,046.23
Indonesia	$95,001.04	$70,454.82	$25,735.50	$72,204.58	$45,678.07	$120,074.50	$0.00	$429,148.51
Kenya	$73,777.56	$55,922.68	$40,597.29	$72.36	$721.12	$36,876.83	$0.00	$207,967.84
Morocco	$39,681.21	$47,894.74	$69,230.01	$12,448.94	$19,425.65	$22,468.10	$14,609.18	$225,757.83
Peru	$129,422.10	$121,942.83	$59,778.00	$99,470.95	$34,169.86	$53,761.34	$0.00	$498,545.08
Bolivia	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$42,656.96	$42,656.96
Subtotals	$463,084.06	$405,184.48	$255,215.47	$184,196.83	$99,994.70	$233,180.57	$57,266.14	$1,698,122.25
Management Entity *	$376,306.95	$415,263.66	$436,094.62	$453,412.46	$442,225.41	$584,734.57	$439,035.03	$3,149,072.70
Misc Expenses	$0.00	$11,541.71	$0.00	$0.00	$0.00	$0.00	$0.00	$11,541.71
Subtotals	$376,306.95	$426,805.37	$436,094.62	$453,412.46	$442,225.41	$584,734.57	$439,035.03	$3,160,614.41
TOTALS	$3,515,276.48	$3,631,253.41	$2,702,335.19	$2,700,288.06	$2,607,699.54	$3,134,966.82	$2,625,255.84	$20,917,075.34

* Expenditures include those for the External Evaluation Panel, Board and Technical Committees, Workshops, and Strategic Meetings and Conferences.

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Revised/Updated: Cherri Madsen (04/27/92)

Small Ruminant CRSP
Approved Program Budgets 1984-1991

Institution	Discipline	Year 6 84/85	Year 7 85/86	Year 8 86/87	Year 9 87/88	Year 10 88/89	Year 11 89/90	Year 12 90/91	Total
California	Breeding	$242,034.00	$226,100.00	$165,900.00	$160,000.00	$210,000.00	$210,000.00	$281,246.00	$1,495,280.00
California	Health	$170,000.00	$150,750.00	$73,100.00	$0.00	$0.00	$0.00	$0.00	$393,850.00
Colorado State	Health	$170,000.00	$153,450.00	$126,400.00	$160,000.00	$160,000.00	$160,000.00	$201,570.00	$1,131,420.00
Missouri	Sociology	$307,800.00	$295,700.00	$173,400.00	$210,000.00	$210,000.00	$210,000.00	$313,500.00	$1,720,400.00
Montana State	Breeding	$145,000.00	$144,000.00	$126,400.00	$100,000.00	$125,000.00	$125,000.00	$113,025.00	$878,425.00
North Carolina	Nutrition	$235,178.00	$240,488.00	$165,900.00	$160,000.00	$179,500.00	$190,000.00	$295,000.00	$1,466,066.00
Texas A&M	Management	$185,000.00	$121,500.00	$67,200.00	$114,000.00	$0.00	$0.00	$0.00	$487,700.00
Texas A&M	Systems	$185,000.00	$187,026.00	$142,200.00	$11,000.00	$140,000.00	$140,000.00	$210,659.00	$1,015,885.00
Texas Tech	Range	$297,000.00	$239,850.00	$126,400.00	$160,000.00	$150,000.00	$150,000.00	$180,000.00	$1,303,250.00
Utah State	Physiology	$195,000.00	$161,030.00	$21,900.00	$0.00	$0.00	$0.00	$0.00	$377,930.00
Utah State	Range	$190,000.00	$168,750.00	$126,400.00	$120,000.00	$118,505.00	$150,000.00	$120,000.00	$993,655.00
Washington	Health	$170,000.00	$165,150.00	$126,400.00	$160,000.00	$160,000.00	$160,000.00	$160,000.00	$1,101,550.00
Winrock Int'l	Economics	$235,000.00	$258,829.00	$165,900.00	$210,000.00	$210,000.00	$210,000.00	$255,000.00	$1,544,729.00
Winrock Int'l	Management	$232,000.00	$234,900.00	$169,900.00	$180,000.00	$180,000.00	$180,000.00	$200,000.00	$1,376,800.00
Subtotal:		$2,959,012.00	$2,747,523.00	$1,777,400.00	$1,745,000.00	$1,843,005.00	$1,885,000.00	$2,330,000.00	$15,256,940.00
Management Entity *		$450,000.00	$432,000.00	$300,200.00	$450,000.00	$440,000.00	$500,000.00	$600,000.00	$3,172,200.00
Contingency Funds		$89,200.00	$27,412.00	$55,600.00	$220,000.00	$183,295.00	$122,800.00	$0.00	$698,307.00
Overseas Sites		$501,788.00	$393,065.00	$316,000.00	$300,000.00	$333,700.00	$292,200.00	$310,000.00	$2,446,753.00
Linkages		$0.00	$0.00	$0.00	$93,000.00	$0.00	$0.00	$65,000.00	$158,000.00
Subtotal:		$1,040,988.00	$852,477.00	$671,800.00	$1,063,000.00	$956,995.00	$915,000.00	$975,000.00	$6,475,260.00
Total:		$4,000,000.00	$3,600,000.00	$2,449,200.00	$2,808,000.00	$2,800,000.00	$2,800,000.00	$3,305,000.00	$21,762,200.00

* Allocations include funding for External Evaluation Panel, Board Meetings, Technical Committee, and other Meetings.

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CREATED BY: Lucia Lojewski
UPDATED: August 8, 1991

Small Ruminant CRSP
Matching Contributions from U.S. Institutions

#	Subgrantee	Year 6 84/85	Year 7 85/86	Year 8 86/87	Year 9 87/88	Year 10 88/89	Year 11 89/90	Year 12 @ 90/91	Total
101	UCD – Genetics	$106,746.75	$117,007.00	$104,646.00	$96,529.00	$93,626.00	$96,488.00	$118,292.08	$733,534.83
102	UCD – Health	$60,184.00	$40,921.00	$45,289.00	$0.00	$0.00	$0.00	$0.00	$146,394.00
104	Colorado State	$56,667.00	$53,833.00	$53,334.00	$53,333.00	$53,333.00	$56,767.00	$53,333.04	$380,600.04
105	Missouri	$95,388.54	$94,190.49	$53,386.56	$74,120.23	$83,436.34	$77,286.01	$66,184.42	$543,992.59
106	Montana State	$331,265.00	$262,557.00	$184,001.30	$221,920.86	$242,705.80	$85,682.45	$60,734.04	$1,388,866.45
107	North Carolina	$87,462.00	$80,549.04	$64,731.00	$71,184.27	$67,342.08	$73,287.88	$64,731.14	$509,287.41
109	Texas A&M	$66,474.41	$67,573.65	$77,098.72	$56,144.27	$59,605.21	$49,486.79	$46,289.63	$422,672.68
110	Texas A&M Mgt	$59,755.04	$64,026.43	$46,311.50	$0.00	$0.00	$0.00	$0.00	$170,092.97
111	Texas Tech	$114,381.91	$110,950.00	$59,125.79	$83,694.40	$101,011.71	$71,304.27	$51,422.63	$591,890.71
113	Utah State Repro	$90,408.40	$126,057.46	$8,998.17	$0.00	$0.00	$0.00	$0.00	$225,464.03
114	Utah State Range	$103,929.97	$116,204.92	$122,213.49	$82,321.87	$84,474.79	$71,965.92	$46,379.09	$627,490.05
115	Washington St.	$89,817.59	$85,610.80	$129,872.17	$67,314.96	$61,959.01	$53,372.42	$53,333.00	$541,279.95
116	Winrock Intl–Econ	$76,111.67	$73,975.07	$88,262.09	$75,969.90	$93,318.13	$86,298.87	$75,406.90	$541,340.63
117	Winrock Intl–DPG	$58,364.49	$73,428.47	$79,461.02	$85,773.51	$82,981.46	$79,511.28	$68,022.61	$527,542.84
	Total:	$198,958.77	$1,368,884.33	$1,094,730.81	$968,306.27	$1,014,191.53	$801,448.89	$704,128.58	$7,350,649.18
	* Percentage:	44.57%	42.72%	48.35%	43.10%	46.83%	31.43%	32.18%	41.39%

USAID Grant No. DAN–1328–G–SS–4093–00 (From year 6 through year 11).
USAID Grant No. DAN–1328–G–00–0046–00 (Starting year 12).
* Cost sharing is based on expenditures incurred at the participating institutions and oversea sites.
@ Actual amount reported for year 12.

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CREATED BY: Cherri Madsen
UPDATED: April 6, 1992

Small Ruminant CRSP
Summary of Host Country Contributions

Country	1985	1986	1987	1988	1989	1990	1991
Brazil	$1,925,625.95	$2,100,442.16	$2,276,953.84	$0.00	$0.00	$0.00	$0.00
Bolivia	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$809.00
Indonesia	$367,022.00	$352,472.00	$353.372.00	$354,972.00	$354,972.00	$1,420,400.00	$1,428,400.00
Kenya	$252,831.00	$258,364.00	$289,912.00	$293,782.00	$308,113.00	$317,081.00	$218,771.00
Morocco	$1,000,000.00	$1,064,000.00	$1,152,000.00	$1,192,000.00	$1,239,000.00	None reported	$1,044,000.00
Peru	$276,400.00	$276,960.00	$249,270.00	$225,663.00	$189,819.00	$118,695.00	$6,845.00
SUBTOTAL	$3,821,878.95	$4,052,238.16	$4,321,507.84	$2,066,417.00	$2,091,904.00	$1,856,176.00	$2,698,825.00
Non-SR-CRSP Support							$46,615.00
TOTAL							**$2,745,440.00**

Glossary

AARD	Agency for International Research and Development, Indonesia
AID	Agency for International Development, Washington, D.C., U.S.A.
BPP	National Rubber Research Institute, Indonesia
BPT	Balai Penelitian Ternak, Bogor, Indonesia (Animal Husbandry Research Institute)
CIDR	Controlled Internal Drug Release dispensers
CRIAS	Coordinating Research Institute for Animal Science, Indonesia
DPG	Dual Purpose Goat
ENA	National School of Agriculture, Meknes, Morocco
EPG	Eggs per Gram
ha	Hectare
IARC	International Agricultural Research Center
IAV	Institut Agronomique et Veterinaire, Morocco
IBTA	Instituto Boliviano de Technologia Agropecuaria
IDRC	International Development Research Centre (Canada)
ILCA	International Livestock Center for Africa, Addis Ababa, Ethiopia
INIAA	Instituto Nacional de Investigaccion Agraria y Agroindustrial, Peru
INI ANSREDEF	Indonesia International Animal Science Research and Development Foundation
KARI	Kenya Agricultural Research Institute
KDPG	Kenya Dual Purpose Goat
Ksh	Kenya Shilling
LDC	Lesser Developed Country
MARDI	Malaysian Agricultural Research and Development Institute
MOET	Multiple Ovulation and Embryo Transfer
MUCIA	Midwest Universities Consortium for International Agriculture
NGO	Non-Government Organization
PAC	Program Advisory Committee
PAR	Photosynthetic Active Radiation
PI	Principal Investigator
PMSG	Pregnant Mare Serum Gonadotropin

RAPD	Random Amplified Polymorphic DNA
RERUMEN	Andean Small Ruminant Research Network
RIAP	Research Institute for Animal Production, Bogor, Indonesia
RS	Resident Scientist
SBPT	Balai Penelitian Ternak, Sei Putih, Indonesia (Animal Husbandry Research Institute)
SR-CRSP	Small Ruminant Collaborative Research Support Program
SRUPNA	Small Ruminant Production Systems Network for Asia
Techpack	Technology Package
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

Country	Discipline	Principal Investigator	Collaborating Scientist
Indonesia	Animal Nutrition	K. Pond	S. Cinting
	Breeding	E. Bradford	Subandriyo
	Economics	E. Ospina	S. Karo Karo
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