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Improving Andean Sheep and Alpaca Production

Recommendations from a Decade of Research in Peru

Small Ruminant Collaborative Research Support Program

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Recommendations from a Decade of Research in Peru

edited by
Constance M. McCorkle

Small Ruminant Collaborative Research Support Program

Dedication

This volume is dedicated to the memory of

Constantine Gregory, Gustavo Rojas, and Juan Zurita,

for their commitment to improving the

well-being of the people of the Peruvian sierra

through their work with the

Small Ruminant Collaborative Research

Support Program / Peru.

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Improving Andean Sheep and Alpaca Production: Recommendations from a Decade of Research in Peru

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Institutions

CSU	Colorado State University
INIAA	Instituto Nacional de Investigación Agraria y Agroindustrial
IVITA	Instituto Veterinario de Investigaciones Tropicales y de Altura (of UNMSM)
MSU	Montana State University
TTU	Texas Tech University
UCD	University of California-Davis
UMC	University of Missouri-Columbia
UNAP	Universidad Nacional del Altiplano-Puno
UNAM	Universidad Nacional Agraria-La Molina
UNMSU	Universidad Nacional Mayor de San Marcos
UNPRG	Universidad Nacional Pedro Ruíz Gallo
UNSAAC	Universidad Nacional San Antonio Abad del Cuzco
USU	Utah State University
WIIAD	Winrock International Institute for Agricultural Development

Collaborating Cooperatives and Communities

Three Sociedades Agrarias de Interés Social graciously collaborated in the SR-CRSP/Peru research reported in this volume: SAIS Manco Capac, in Puno Department; and SAIS Pachacutec and SAIS Tupac Amaru, both in Junín Department. The members of approximately 10 comunidades campesinas in Cuzco, Junín, and Puno Departments likewise generously lent their time, knowledge, and support to many of the SR-CRSP field trials and investigations on which this volume is based.

*Indicates individuals who have changed institutional affiliation at the time of this writing.

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Abbreviations and Acronyms Used in Text[1]

B.S.	Bachelor's of Science Degree
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (Mexico)
cm	Centimeter(s)
e.e.	Ewe equivalent(s)
g	Gram(s)
ha	Hectare(s)
IDRC	International Development Research Centre (Canada)
INIAA	Instituto Nacional de Investigación Agraria y Agroindustrial (Peru)
INIPA	Instituto Nacional de Investigación y Promoción Agropecuaria (former name of INIAA)
kg	Kilogram(s)
km	Kilometer(s)
l	Liter(s)
m	Meter(s)
ml	Milliliters
mos.	Months
NPK	Nitrogen-phosphate-potassium fertilizer
NVC	Net value change
OPP	Ovine progressive pneumonia
%	Percent
Ph.D.	Doctor of Philosophy Degree
PVTC	Proyecto de Validación de Tecnología en Comunidades
SAIS	Sociedad Agraria de Interés Social
SR-CRSP	Small Ruminant Collaborative Research Support Program

[1] See also the list of institutional collaborators at the beginning of this volume, plus Chapter 4's Annex of plant species codes.

Foreword

Ten years ago, research on sheep and camelids in the highlands of South America was scattered and fragmented, and scientists worked in relative isolation from each other. The establishment of the Small Ruminant Collaborative Research Support Program (SR-CRSP) was a major step forward in linking isolated scientists and bringing to light "hidden" knowledge about Andean sheep and camelid raising. In Peru, a Memorandum of Understanding was signed in 1979 between the Instituto Nacional de Investigación Agraria y Agroindustrial (INIAA) and the University of California, Davis (UCD), the Management Entity for SR-CRSP. Since then, much research has been accomplished in the central and southern Andes of Peru and the United States.

An important focus of the small ruminant collaborative effort has been the integration of economic and sociological factors with biological data obtained in the field, both to delineate current small ruminant production systems and to develop recommendations for improving animal productivity and marketing. The biological constraints to production that the SR-CRSP has tackled in the Peruvian Andes have been broad. For example, research on constraints has spanned such diverse topics as describing individual animal performance to assess the genetic potential of indigenous breeds; developing an understanding of the reasons for poor reproductive rates in native flocks; establishing a profile of the incidence of livestock diseases ranked in order of economic importance and disease control measures; and improving cultivated forages to maintain livestock during deficit periods on the natural range.

The resulting recommendations have addressed how the elements that comprise the various production systems operate in relation to each other to influence the function of the overall small ruminant production systems in Peru. Toward this end, all project participants have cooperated on a baseline study to characterize the entire small ruminant production system in the Andean highlands. This collective approach to confronting the constraints on animal productivity in the harsh and isolated Andean environment has facilitated the development of an integrated research endeavor that views the various livestock and crop problems of the region from a comprehensive, rather than an isolated perspective.

The results of this exciting collaborative research form the basis for the suggestions for technology improvement set forth in this volume. The information presented should be useful to extensionists and others who deal directly with sheep and alpaca producers, and also for teaching animal science in universities throughout the region. This volume will also be useful for improving many facets of sheep and camelid production, not only in Peru, but also in other regions with similar ecological characteristics, like Argentina, Bolivia, Chile, and Ecuador.

These accomplishments also demonstrate the appropriateness and the effectiveness of the Title XII legislation that established the CRSP concept and laid the base for collaboration among U.S. universities and overseas institutions. Funding support from the U.S. Agency for International Development and matching resources from four Peruvian and five U.S. institutions are acknowledged with great appreciation. Without them, the program would not have been possible.

This publication will be available in Spanish at a later time.

Dr. Arturo Flórez	Dr. James W. Oxley
Site Coordinator	Program Director
Small Ruminant CRSP	Small Ruminant CRSP
Lima	University of California Davis
Peru	U.S.A.

CHAPTER 1

A DECADE OF RESEARCH ON ANDEAN SMALL RUMINANT PRODUCTION

Chapter 1

A Decade of Research on Andean Small Ruminant Production

Introduction

The Small Ruminant Collaborative Research Support Program (SR-CRSP) is the oldest of eight innovative, multidisciplinary agricultural education, research, and development initiatives established under the U.S. International Development and Food Assistance Act of 1975 and its Title XII amendment, the Famine Prevention and Freedom from Hunger Act (Lipner 1988). The CRSP mandate is, through training and research, to strengthen the capabilities of participating U.S. and host-country universities and institutions to apply agricultural science in solving world food and nutrition problems. CRSP research focuses on enhancing the production, distribution, storage, marketing, and consumption of food crops among smallholders and the poor in developing countries through design of appropriate technology.

The first target selected for CRSP research was small ruminants. They constitute a commodity common to all of the developing world, and one that plays a key role in both national and local-level food-security systems and economies. Indeed, 56% of the world's sheep, 96% of all goats, and perhaps some 90% of domestic camelids (alpaca and llama) are raised in developing countries. Equally important, these animals are primarily owned by small farmers and herders of very limited means. Hence the establishment of the SR-CRSP in 1978, in cooperation with five nations representing the diversity of small ruminant husbandry systems found among smallholders globally: Brazil, Indonesia, Kenya, Morocco, and Peru. (For more detail, see Blond n.d. and Liper and Nolan 1989.)

With the Instituto Nacional de Investigación Agraria y Agroindustrial (INIAA) as lead host institution, Peru was the first SR-CRSP site to begin field operations when, in 1979, collaborating Peruvian scientists initiated research in the central highlands.

Since that time, five disciplinary projects of the SR-CRSP have been consistently involved in the Peru program: sociology, economics, range management, animal reproduction/genetics, and animal health. These projects are represented in the U.S. by the University of Missouri-Columbia (UMC), Winrock International Institute for Agricultural Development (WIIAD), Texas Tech University (TTU), Montana State University (MSU), and Colorado State University (CSU), respectively. The Management Entity for the SR-CRSP as a whole is housed at the University of California-Davis (UCD). In Peru, some of the major institutions to have collaborated in the research reported in this volume include INIAA, the Universidad Nacional Agraria-la Molina (UNAM), the Universidad Nacional del Altiplano-Puno (UNAP), the Instituto Veterinario de Investigaciones Tropicales y de Altura (IVITA) of the Universdad Nacional Mayor de San Marcos (UNMSM), and the Universidad Nacional Pedro Ruíz Gallo (UNPRG).

From 1979 until the phase-down of the Peru program in late 1990, the SR-CRSP/Peru has expanded its collaborative efforts to work either formally or informally with dozens of other national and international, private and public institutions active in agricultural research, training, or voluntary assistance. Literally hundreds of dedicated students, scientists, and development professionals from Peru, the U.S., and other nations have worked together to elucidate the complexities of small ruminant husbandry systems in the Andes. Some even gave their lives to this endeavor. We dedicate this publication to the memory of our late colleagues.

■ Experience and Results

The pervasive and centuries-old importance of sheep and, especially, the South American camelids to both the physical and cultural survival of Andean peoples is well recognized and documented. In recent decades, many efforts have been made to increase the production and productivity of these valuable species in highland Peru, with the goal of enhancing both national and household-level economy and diet. But these efforts have been hampered by a dearth of scientific information, both sociological and biological, on the actual operation of small ruminant production systems in highland contexts. The SR-CRSP has worked to fill this gap through systematic longterm research on the production-system fundamentals that must be thoroughly understood for any livestock development initiative to work. This volume offers a summary of some of the wealth of hands-on experiences and results to emerge from the SR-CRSP's research in Peru. It has several aims.

- To synthesize useful Peru-program findings. In the process, research results are contextualized in terms of the practical realities of Andean stockraisers, as well as in terms of the broader literature on small ruminant husbandry worldwide.

- Relatedly, to organize and disseminate this information in a form useful to extension and development personnel. In some cases, the information presented may be most helpful to subject-matter specialists charged with evaluating and selecting development interventions or with designing and conducting training exercises. In others, it may be more directly applicable by field agents and development staff working directly with producers.
- To point interested readers to more detailed, selected sources of information on the issues raised herein.

For example, drawing upon years of firsthand SR-CRSP field experiences, Chapter 2 outlines critical considerations in working with Andean peasant communities to design livestock interventions that truly meet local needs and fit comfortably into smallholders' complex but limited-resource farming systems. Such considerations include, e.g.: the delicate balance and multiplex interactions between plant and animal crops in diversified farming systems; the production and consumption goals motivating household choice of product mix; the risks to farmers of experimentation; stockowners' own identification of priority farm problems; the relative roles of different biosocial groups in the agricultural enterprise (women, men, girls, boys, community authorities and common-interest groups, etc.); relatedly, appropriate socio-organizational building blocks for mobilizing for technological change; and the overarching importance of interdisciplinary and participative approaches to agricultural RD&E (research, development, and extension).

Chapter 3 reprises a number of these themes in its discussion of how to collect, organize, and analyze data to assess the economic viability of proposed technological interventions. The discussion explicitly focuses on the variables that are most important for livestock development in the Andes. For economists working in this context, the strategies outlined here should provide a useful complement to source materials that emphasize cropping to the exclusion of stockraising or that are less culture-specific.

Range management for agropastoral (i.e., mixed) production systems in highland Peru forms the subject of Chapter 4. Again, a strength of the presentation is the detailed, "Andeanized" treatment of such technical matters as range-site quality and utilization, composition of vegetative cover, stocking rates with multiple species, cultural practices, special microzonal features like bofedales, and more. A caveat is in order, here, however. Since most of this research was conducted in the context of largescale cooperative enterprises, the recommendations may not always apply *mutatis mutandis* to Peruvian peasant communities or to independent smallholders. However Chapters 2 and 3 provide the tools with which to make such determinations for proposed technological interventions in these smaller-scale and/or less commercialized farming systems.

Chapter 5 examines the possibilities for increasing the productivity of Andean sheep via better-informed timing of mating and judicious selection of both males and females for breeding. The research summarized in this chapter makes a particularly important contribution to scientific knowledge about the physiology of male reproduction in Andean sheep — a topic little studied heretofore. Chapter 5's discussion is careful to point out, however, that improved management of reproduction and breeding will avail little if it is not accompanied by improvements in animal nutrition and health, as set forth in Chapters 4 and 6.

Chapter 6 deals with the latter subject — understanding and managing the health problems of Andean sheep and camelids. This is one of the most visible needs in small ruminant production systems in Peru. A signal feature of this chapter is the inclusion of succinct diagnostic guides to assist field-level extensionists, developers, and stockowners themselves in arriving at more accurate assessments of the many diseases that plague their herds of sheep and camelids. In addition to synthesizing and adding to our knowledge of the more common ailments of Andean small ruminants, the chapter also provides new research information on, and some practical solutions to, a number of less familiar animal health problems of the region.

■ The Future

With a decade of experience behind it, the SR-CRSP/Peru offers many concrete lessons on how Andean people could improve their production of sheep and camelids and, equally important, how agricultural scientists and developers can successfully design, implement, and evaluate appropriate new technology for small ruminant husbandry in the Peruvian highlands.

The SR-CRSP experience does not end with this volume, however. It leaves behind a strong pan-Andean network of scientists and developers with the technical expertise and humanistic commitment to enhancing human well-being through increased production and productivity of small ruminants. The overarching goal of this Andean Small Ruminant Science Network or Red de Rumiantes Menores is to support, enrich, and accelerate the collection, exchange, and utilization of scientific information on small ruminant production among limited-resource farmers in the Andean region (Argentina, Bolivia, Colombia, Chile, Ecuador, Peru, Venezuela).

To achieve this goal, the Network employs a variety of strategies, including: sponsoring workshops and supporting continued professional development for specialists in SR research; distributing a newsletter and disseminating publications on SR research and technology-transfer issues; relatedly, developing a bibliographic data base on small ruminants in the Andean region and compiling a registry of scientists with interests and expertise in this area; assisting scientists in identifying sources of research funding, and facilitating collaboration and cooperation in designing and executing multi-country research on small ruminants; establishing and strengthening relationships among scientists, research institutions, and development agencies in the region; linking with other relevant regional and international networks; and, as in the case of the present volume, translating research findings into useful teaching, policymaking, or extension materials.[1]

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[1]For detailed information on network activities and membership, write to Apartado Postal 110097, Lima 11, Peru.

CHAPTER 2

Sociological Considerations for Agricultural Research and Development in Andean Communities

Chapter 2

Sociological Considerations For Agricultural Research and Development in Andean Communities

Sociology

[1] Introduction

Research programs need to develop technological alternatives for smallscale community-based farmers whose mixed production (crops and livestock) is geared first to subsistence and second to the market. However, this means changing the traditional focus of agronomic research. It also challenges institutional capacities to meet farmers' production objectives (McCorkle et al. 1989).

Biological research is based on a methodological assumption that variables under study can be isolated and maintained in stable states, at least during the experimental period. Traditional research approaches also assume that external conditions can be regulated, at least to the extent that they can be described and replicated for all repetitions. These methods are most easily applied on research stations. They require modification when research is conducted within a working production system (Amir and Knipscheer 1989, Salvatierra and Fernández 1989).

The operational rationale of the mixed-farming system of Peruvian high-altitude communities requires researchers to broaden the concept of "commodity research" (Jamtgaard 1990) so as to encompass the socio-organizational as well as the biological interactions of the plant and animal components of the farming system (Jamtgaard 1989). Research focused on improving only one component of the farming systems (e.g. small ruminant production) cannot solve the interacting problems of the smallscale producer (Hart 1983).

The goal of the SR-CRSP's Project for Validation of Technologies for Communities (PVTC) was adaptive research from an interdisciplinary perspective (Fernández and Canales 1989). The project team was challenged to carry out research within the social process of production. This entailed defining relevant problems while at the same time controlling a sufficient number of variables to provide measurable results. Attaining this goal required modifications in two areas: the criteria by which experimental results are measured in the biological sciences, and the methods used to evaluate the effect of interventions on the efficiency of the system as a whole.

Two central questions were posed by the field team at the onset of the research program with community-based farmers' participation. Who was to set the research agenda? Moreover, how could the target population best apply not only research results, but also the research process itself, to meeting their production goals (Fernández and Salvatierra 1989)?

The target population for the PVTC was mixed crop/livestock producers (Fernández et al. 1986, Fernández and Huaylinos 1986). This group manages 53% of the sheep in Peru and constitutes the majority of the rural population. These producers operate within highly variable climatic conditions, a complex ecology, and an unstable market (Guillet 1984). Thus, the project determined that diversification and self-sufficiency would be given priority over specialized, market-oriented production. It should be noted, however, that these priorities had been set by the producers themselves, long before they had any contact with the SR-CRSP. Within this context, the PVTC reached the following conclusions.

- It was possible to improve small ruminant production on community-based mixed farms in the Andes.
- In such systems, all production components interact and complement each other.
- The Andean ecology together with Peruvian economic trends make diversified production advantageous to the smallscale producer.
- Andean communities have developed organizational, as well as technological and economic, strategies that allow them to produce under adverse ecological and economic conditions.
- Producers themselves are well aware of the rationale behind these strategies, as well as their limitations.
- Therefore, producers must be involved in any research effort to solve their agricultural problems.
- Moreover, to be effective, research must be based on the production strategies in use, and it must take into account the system as a whole.

The PVTC employed a participatory methodology that involved farmers in all phases of the research process, including problem definition, trial design, and implementation, as well as recording and analysis of results (Fernández 1986). During the five years of the project's existence, the team was most successful in involving farmers in problem definition, trial implementation, and analysis of results. The PVTC found that working with farmers on the other phases requires fundamental changes in researcher attitudes and methods.

The project team recognized that, in conducting biological research with the participation of smallscale community-based farmers, it was assuming an unfamiliar task. The team members' specialized knowledge and skills were to be applied to a production system that was ecologically, economically, and organizationally different from the farming systems familiar to the majority of the team. Under these conditions, the "comuneros" were the real "experts"; only they had direct production experience in this farming system (McCorkle 1989b).

The organization and goals of the PVTC called for intense interdisciplinary interaction. This placed some stress on team members, due to their specialization in a given academic or technical area (Lipner and Nolan 1989, McCorkle and Gilles 1987, Nolan 1985a&b). On the other hand, over time the PVTC team and the SR-CRSP generally found that, along with effective project organization and communication, this interdisciplinary interaction formed the key to successful research (McCorkle 1989a).

The following sections present case studies of the PVTC research experience, highlighting the context of the PVTC effort and some of the socio-organizational implications of community-based research. These cases were chosen because of their importance for developing a community-based research process, and hence their potential value to others with similar objectives. Additional readings on SR-CRSP or related experiences are given in each section.

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Sociology: Research and Development Goals

[2] Community Goals Versus Research and Extension Goals

■ Introduction

In collaborative, participative experimentation, both the community and the research team have definite agendas (Fernández 1989a&b). The community often has highly varied objectives, e.g.: improve production; increase financial, genetic, or other resources; obtain technical assistance and training; and win support for civic actions such as land disputes. Research and extension objectives are typically more circumspect: test a new variety, species, or management practice; gather data on production; evaluate the economic feasibility of a technology; measure rates of adoption; or train farmers in new techniques.

Both agendas have multiple goals. But most research and extension teams limit their efforts to problems concerning specific aspects of technology generation, performance, or adoption. In contrast, the community almost always has a multiplicity of social and political, as well as technological, goals. If a project or program is unaware of this difference in agendas or if it is unwilling to support the community in some of its non-technical goals, the research/extension effort will probably fail.

■ Experience and Results

In one community, the PVTC and the community decided to test possible foodcrop and forage mixes on terraces. In selecting a site for this research, the community assembly suggested a one-hectare plot about three kilometers from the village center. The PVTC pointed out that, at this distance, few community members and even fewer people from neighboring communities would be able to observe events in the experimental plot. However, the community leaders indicated that no other land was available.

The site they proposed was finally agreed upon. The community then organized workparties to do the terracing and planting. The project provided seed, fertilizers, and the necessary technical support. Within a month the entire hectare had been terraced and planted, and the collaborating farmer committee had organized all cultivation and evaluation activities. As the growing season advanced, however, it became more and more difficult to mobilize the farmers to observe the progress of the experiments, even though those who had seen them felt that the results were positive.

As the field team learned more about communal land holdings (Canales 1989), it became obvious that there were several, more centrally located slopes where the work might have been done. Why, then, had the assembly insisted on such a remote site?

Months passed before the team discovered that the experimental plot lay in an area claimed by a neighboring community. By cultivating this land, the community collaborating with the PVTC was establishing usufruct rights to the disputed area. Development and use of the land would support a future petition to the Ministry of Agriculture for permanent boundary delimitation in favor of the study community.

Both the community and the PVTC team were interested in slowing erosion using terracing techniques, increasing areas for cultivation of food crops, and enhancing fodder production for use in the dry season. But the community was even more interested in settling a 25-year boundary dispute with its neighbors.

Recommendations

Researchers and extension agents must realize that community-based farmers participating in development endeavors have civic, social, and other goals in addition to production goals.

Some of these goals may be beyond the reach of a project. Therefore, projects should be in contact with other programs (like those of the Ministry of Health and the Campesino Federation) that can best assist the community in problems that lie outside the competence of the project. This will also avoid costly duplication of activities.

The goals of both community and research/extension entities should be carefully analyzed to identify their shared and unshared interests. When the latter are greater than the former, it is better to discard or defer the activity. A research/extension team should continually re-evaluate all these goals to ensure that the results of an activity will fulfill the expectations of both parties.

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Sociology: Research and Development Goals

[3] Production Goals of Community-Based Farmers

■ Introduction

Communities relying on mixed farming systems are made up not only of different socioeconomic groups, but also of varied groups of farmers who have different production goals and concerns (Soto Sulca 1987). For example, Andean men are usually more interested in improving crop production, while women are more concerned to enhance livestock and range conditions (Fernández and Salvatierra 1986). Farmers with more land and capital are more interested in cash-cropping, while poorer farmers focus on diversifying and improving production for family consumption.

The differing goals of these and other groups of producers must be taken into account in the overall research/extension program (Garrett 1986). Otherwise, its efforts to solve a given production problem in the community will almost certainly fail. For example, as the PVTC discovered, when improved plant-crop production is not an explicit part of the development agenda, efforts to improve the livestock sector among smallscale community-based farmers are very unlikely to succeed.

■ Experience and Results

Working with community-based farmers means working with the community assembly — the local, representative body that adjudicates matters affecting the common good. The assembly is composed of one representative (usually the elder male) from each member household. The assembly decides issues like: how many animals each household may graze on communal pastures; when and how to build schools, roads, and health centers; what kind of contacts should be made with government institutions; and which projects and programs should operate within community boundaries. Historically the assembly has been made up of all households within the community's geographic boundaries. However, in some communities, membership in these assemblies is shifting to a voluntary basis (Samaniego Garay and Flores Gutiérrez 1987).

Before beginning work in a community, the PVTC discusses joint research and training possibilities with community leaders. In one community, the following topics were proposed for discussion in the assembly: collaborative crop and livestock experiments on production problems that the community identified as priorities; and the assembly's appointment of a committee to work with the project team in planning, implementing, and evaluating the experiments.

The assembly took three months to discuss and finally accept this proposal. In part, this was because they found the PVTC's experimental approach strange in comparison to that of other projects and institutions. Also, however, the assembly took the time to carefully evaluate the PVTC's capacity to carry out a sustained program in the community. Before signing an one-year renewable agreement, the assembly made it clear that cropping experiments were a priority.

The project accepted the fact that in a mixed-farming community, it would have to work with plant as well as animal crops. An agronomist was therefore added to the field team; and, working with the assembly-designated collaborating committee, plans were made for the first season's research. These included only cropping experiments, the majority of which were designed to test the local adaptability of improved varieties of potatoes, which are grown for sale in the region.

However, during this first year, the PVTC was able to interest a few community members in working on livestock production problems, too. When the agronomist resigned after the first harvest and no immediate replacement could be located during the second season, the project decided to make a virtue out of necessity and emphasize livestock-related experiments.

At the beginning of the third season, it came time to renew the research agreement with the community. But the assembly voted that the project should not be continued. They felt it had not paid enough attention to their stated priority — the introduction of new potato varieties.

■ Recommendations

It is important to remember that community-based farmers are not homogeneous. Different gender, age, and economic groups within a community will have different needs. In Andean communities, men are usually the voting members in the community assembly, and they are more interested in plant crops. In contrast, women are usually more interested in livestock.

Furthermore, those farmers most willing to work with outsiders may not represent the majority. They may be only the most vocal individuals, the ones who have more time, or those who feel more comfortable with outsiders.

Researchers and extension agents must therefore take the time to identify different groups of producers within a community. A clear understanding of the interests, abilities, and objectives within these groups will ensure that research and extension efforts will not be directed to small, atypical groups and that they will not advantage some farmers to the detriment of others.

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Sociology: Groups to Work with in Communities

[4] Experimenting with Communities and Individual Farmers

■ Introduction

There is a difference between experimenting with and validating technological alternatives. "Experimenting" means testing heretofore untried solutions to technological problems. An example might be, e.g., evaluating the adaptability of clover varieties to rainfed farming conditions when the available data apply only to irrigated fields. "Validating" refers to the local testing of a technology that has already proven effective under similar agroecological conditions; validation seeks to assess the technology's "fit" with the production goals and organizational requirements of a specific farming system (Fernández and Canales 1988). From a biological and agroecological standpoint, experimental outcomes are more often negative than are the results of validations (Chapter 3 this volume). Also, it takes longer to achieve reliable experimental results, since an experiment must be repeated across several cropping seasons or livestock lifespans.

The PVTC found it necessary to do both types of research within the community, not only because of the great agroecological diversity in the Peruvian sierra, but also because few alternative technologies were available for smallscale, low-input, diversified farming systems in this zone. Initially, the project attempted to carry out both types of research at the community level. This was done at the request of the community assembly and as a way to involve as many farmers as possible. However, the team soon discovered that it was not feasible to carry out experiments with an entire community. For one thing, it was very difficult to reach a consensus as to when, where, and how to carry out the research plan due to the high risk of failure (Fernández et al. 1989, Guillet 1980). For another, it was almost impossible for community members to maintain an interest in experiments whose results would be visible only in the long term (Salvatierra and Fernández 1989).

■ Experience and Results

When it came time to implement the experiments planned with the community groups, discussions ensued on which land would be used and who would provide the necessary labor and inputs. At this point, however, community members appeared unwilling to carry out the planned activities. Their reticence led the PVTC team to realize what a risky idea experimentation was for the community.

For one thing, the allocation of precious arable land to field trials could waste scarce resources, especially if experimental yields turned out to be poor. For another, for trials conducted on communal lands, a workparty had to be organized. This meant that, to participate in the research, farmers would have to rob time and valuable inputs like manure from their family farm production. Because of the tension between communal-level experiments and family-level production needs, in more than one case, the trials were left unattended between planting and harvest. In another case, the test crop was harvested before yield measurements could be taken.

The PVTC team soon realized that, at the experimental level it was very difficult for a large group of people to have confidence that the proposed modifications in their normal technology could improve production. Only a few farmers were really convinced that the experimental effort was worthwhile. Moreover, initially the community had little confidence in the researchers' technical abilities (McCorkle and Bazalar 1989).

During the second season, the team therefore decided to modify the research plan to instead work with small groups of farmers who would be fully aware of the why's and how's of every experimental step. At the same time, the team decided to limit work with the community as a whole to only the last stages of validating technologies that had already proved useful.

As an example of the latter decision, the productivity of virus-free seed of the Yungay potato (an improved variety) was validated on communal lands with the participation of all the families in the community. One representative from each family took an active part in seed selection, fertilizer and pesticide application, cultivation, and harvest. This group production activity served to train farmers in fertilization and pest control techniques with which they were unfamiliar.

Plans had been made to sell the Yungay potatoes and add the proceeds to the fund for community electrification. After the harvest, however, the assembly instead decided to store the potatoes for seed for the next season and then distribute them among the community's families, thus improving the quality of seed on all their farms.

■ Recommendations

There are risks to carrying out adaptive research in communities. In cases where experimental research is needed — i.e. where appropriate smallscale technology is unavailable — this stage may best be carried out with individual farmers, with the approval of the community assembly.

In conducting such experiments, however, projects should be conscious of the risks of forming or reinforcing local power groups. Individual experiments should be only a first step in providing the collectivity with new information and skills. The collectivity must be incorporated into the process as soon as possible, lest individual farmers gain an advantage over the group as a whole. Moreover, groups are important because they provide a basis for information exchange. It is difficult for individual farmers t build communication and exchange channels alone.

In sum, the PVTC found that, when the results of an experiment are uncertain, it is better to work with an individual family because of the high risk involved. Later, when a technology reaches the validation stage and its biological results are more predictable, it is better to conduct experiments at the community level so that all can reap the benefits.

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Sociology: Groups to Work with in Communities

[5] Agricultural Production Committees

■ Introduction

In mixed farming communities, responsibilities for different areas of production are distributed among different groups of people (Fernández 1987, 1989b; McCorkle 1982, 1986). In the PVTC communities, the assembly was responsible for managing communal resources such as water, trees, rangelands, and roads (Fernández 1990). At the household level, men took primary responsibility for plant-crop production and for the family's plow oxen, while women oversaw the sheep, swine, and guinea pigs. In addition, certain groups performed specialized tasks. For example, women were charged with potato seed selection (Fernández 1988, 1989a).

To be successful, any agricultural development program must work with those producers who are most intimately involved in specific domains of production. It is crucial that project activities be formulated and carried out with the people immediately responsible for, and most knowledgeable and interested in, the relevant production tasks (Fernández 1990).

■ Experience and Results

Because of the way the assembly was organized, the PVTC team initially assumed that elder males directed virtually all aspects of production on the family farm. As the project proceeded, however, these men began to point out areas where they had no knowledge or experience, including the characteristics of native pasture plants, and animal management techniques such as parasite control and castration.

It puzzled the team that, in a community where half the land was devoted to stockraising and where families possessed an average of 25 head of herd animals, the men's knowledge of animal husbandry was so limited. If men were indeed responsible for all farm operations, they should have had the technological expertise to carry out animal management tasks and to make informed decisions about the acquisition and sale of livestock. If the men did not have this knowledge, then someone else must. Simple observation revealed that, in fact, women were the ones castrating, curing, culling, grazing, allocating supplementary fodder to animals, and generally managing animal production.

In order to fulfill its mandate to improve animal production, the project had to find a way to work with women. The PVTC therefore proposed that women be included in the farmer committees collaborating with the project. The assembly accepted this proposal unanimously. Thereafter, women were invited to attend all committee meetings. But only a few women attended a few meetings. Moreover, they sat silently at the edge of the group while the men discussed problems related to plant-crop production. Soon, even these few women quit coming, saying that they had no time to attend the meetings.

In sum, after a year-and-a-half, the project was still unable to systematically address animal production problems because the "experts" in animal husbandry — the women — seemed uninterested. Finally, the team met informally with only the women, to discover what problems were important to them. The response was surprising. Within a month, approximately a third of the women were regularly participating in weekly meetings.

In the first few meetings, the women laid out their priority areas for improvement. These included control of internal and external parasites in sheep, provision of animal fodder during the dry season, potato seed selection and storage techniques, and planting densities for potatoes.

Before the first month of meetings had ended, the women organized their own Women's Agricultural Production Committees and obtained assembly recognition of the committees. These entities provided the PVTC's first opportunity to work with a stable number of community members on animal production problems. The committees represented two innovations within the community: an association based on common interest rather than assembly appointment; and the first, formally organized group for women to deal with production issues that directly interested them.

Recommendations

Since men usually constitute the voting majority in Peruvian community assemblies, women's groups may define interests and needs that appear to diverge from community interests. Both development projects and community leaders must understand why and how women's needs complement and/or diverge from the goals and projects of the community assembly.

Women's groups based on production interests may begin to demand voting rights in the assembly. This implies a broader process of political representation. As outsiders, project teams must define clear roles and policies on such issues, grounded in a respect for the independent decision-making prerogatives of the community and its members.

Moreover, projects must recognize that different groups of women may also have different interests. Married women, single mothers who operate a farm, women who engage in trade, wealthy versus poor women, etc. — all may have different needs and concerns in a given production realm.

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Sociology: Farmer Participation in the Research Process

[6] Defining Problems with Community Groups

■ Introduction

Farmers will actively participate in solving production problems that they are aware of and consider important. But they seldom have the time or capital to work on problems they don't know exist. A project/program must therefore begin work with problems that farmers themselves perceive (Rhoades 1984, 1987).

For example, community-based farmers of the Andes have been led to believe that the only way to improve sheep production is to introduce imported breeds (Chapter 5 this volume). However, the rangelands in most Andean communities cannot support such breeds; the health costs of exotic races are too high for the low-input farmer; and selective breeding of sheep is not a common practice among Peru's community-based farmers. In consequence, few such farmers wish to collaborate in selective breeding trials. However, these same farmers are keenly aware of the lower productivity of animals infested with parasites (McCorkle 1982, 1988, 1989; McCorkle and Bazalar 1989). And they are eager to remedy this health problem among their flocks.

With time, farmers can be instructed in the complex relationships between breeding and disease susceptibility. Projects can then begin activities in such problem areas as the farmer becomes aware of them (Fernández 1989, Quirós and Ashby 1989).

■ Experience and Results

At the first meeting of the Women's Agricultural Production Committee in one of the communities, the women defined their primary animal management problem as the control of internal and external parasites in sheep. The PVTC accordingly began work on this problem. In discussions with the project team, committee members described their knowledge of animal parasites and their previous experience with controlling them. These conversations allowed the team to identify specific technological and economic constraints to animal production. The discussions also led to valuable exchanges of information among the women participants. The team noted that younger women did not have as much specialized knowledge of animal health and disease as older ones. Furthermore, no woman had any knowledge of the cyst phase of the liver fluke life cycle.

The team parasitologist therefore gave a series of talks to the women about local parasites' habitats and life cycles. Next, the team worked with the women to decide what parasite control options — both traditional and introduced — might prove ecologically, economically, and organizationally viable. Having screened all possible alternatives on the basis of these criteria, the team and the committee jointly designed adaptive experiments on different control strategies. These were to be carried out with the women's own herds.

For two years, experiments were conducted on several parasiticides based on local plant materials (Arevalo and Bazalar 1989a&b, Bazalar et al. 1989, McCorkle 1989). Among others, these included artichoke leaves, to combat liver fluke, and a compound of wild tobacco to kill ticks. The experiments revealed that these treatments were highly effective and very inexpensive. At the same time, the success of these trials won the project team considerable credibility with farmers (McCorkle and Bazalar 1989). In consequence, when the PVTC later proposed a program in selective breeding, the women felt that it might be worthwhile.

■ Recommendations

Farmers themselves must have input into the definition of the problems to be researched. Otherwise, projects risk working on irrelevant issues. If the research topic is not relevant to farmers' perceived needs, farmers will not participate in experiments or validations; much less will they adopt the proposed solutions.

In the definition of research needs, community-based farmers may at first point to problems they think coincide with the interests of institutions and projects. Their stated problems may therefore not always be the ones they in fact deem most important.

Specialists should also be aware that in complex farming systems, production problems may span multiple areas — e.g. animal breeding, veterinary health, and labor organization. This means that each team member must be receptive to and able to understand the importance of technical specialties other than her/his own as these relate to production activities (Knipscheer 1989).

Small farmers will most easily identify readily observable problems — for example, external parasites of sheep. They may be less aware of relatively "invisible" problems, like the need for selective breeding. When researchers and extension agents identify "hidden" problem areas, they must take the time and effort necessary to increase farmers' awareness of these areas. Projects should tackle the most visible problems first, and lead into other areas as farmers gain greater awareness of them.

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Sociology: Farmer Participation in the Research Process

[7] Evaluating Technology Using Farmers' Criteria

■ Introduction

Researchers and community-based farmers generally use different criteria to evaluate technologies (Tripp 1984, Chapter 3 this volume). Agricultural research and development over the past 25 years has emphasized improvement of largescale, monocrop, market-oriented production (Samaniego Garay and Flores Gutiérrez 1987). But the Andean farmer who runs a smallscale mixed farm geared primarily to self-sufficiency does not evaluate technology in the same way that other types of farmers do. Unable or unwilling to modify production objectives to fit technology, such farmers must adopt only those technologies that further the attainment of their goals (McCorkle et al. 1989, Nolan 1985). If a project's criteria for evaluating technology are not appropriate to the scale of production, adoption will not ensue (Jamtgaard 1984). Researchers and extensionists must identify the criteria the farmer uses. Otherwise, the development program will fail.

■ Experience and Results

Before identifying technologies for experimentation or validation, the PVTC sought to list the technological, economic, and social criteria that should be used in the selection process (Fernández 1989, Grupo Yanapai 1989). The team found that the evaluation criteria with which they were familiar applied more to larger-scale production systems. Team members were unfamiliar with the interactions of resource (labor, land, capital) management over time, and with the production goals (money, exchange, family and community well-being, renovation of resources) of community-based farming systems (Chapter 3 this volume).

The project therefore decided to essentially leave evaluation up to the farmers themselves. The team merely took note of the types of technologies that were adopted by members of the collaborating community groups. This method assumed that farmers themselves had the most complete knowledge of the system they were operating, and that they would therefore integrate only those alternatives that complemented their own resource-management and production goals.

By observing and analyzing this process, the team was able subsequently to identify some of the criteria used by the farmers to select technology. These included: "rusticity," i.e. resistance to pests, diseases, and harsh climatic conditions; minimal need for external inputs; maximal use value, e.g. for food, fodder, sale and exchange; "storability"; readily disposable unit size, for sale or trade; and adaptability in terms of the time, space, quality and quantity of labor required.

These criteria differ from those generally used on experiment stations. For example, farmers evaluated new potato varieties not only for yield, but also for: color; resistance to pests, plagues, frost, and hail; capacity for longterm storage; and taste and texture when cooked. Grains were assessed not only for size and color (larger and whiter kernels bring higher prices) but also for the value of their residues as fodder. In sheep, size is important. Because one animal is the smallest unit convertible to cash, larger sheep do not necessarily represent an advantage. Along with adaptability to local range resources, resistance to disease makes rustic breeds more valuable than "improved" ones. Also, since different colors and types of wool are used for different types of weaving, uniformity of color and quality of wool is less important.

■ Recommendations

Farmers' criteria for evaluating the advantages and disadvantages of a given technology often differ from researchers'. New practices will be adopted only if they meet user needs. These needs must be satisfied from biological, ecological, economic, and labor-use perspectives. When a technology or practice is inappropriate in one or more of these aspects, it will probably not be adopted.

Community-based farmers' evaluative criteria often are not immediately evident; neither can farmers always easily verbalize them. Both social and biological specialists will often need to observe over time how and which practices are evaluated in order to generate a list of useful criteria for technology development and delivery among community farmers.

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[8] Planning for the Organization of Labor

■ Introduction

Technology research on experiment stations differs from that done on-farm in collaboration with community-based farmers (Horton 1984, Rhoades 1984). Experiment stations can control soil quality, access to inputs, and the availability and organization of labor for the implementation of research plans. But the quality and quantity of land and animals available to the community-based farmer varies from year to year according to many factors. To name but a few, crop rotation plans and animal life cycles, plus the seasonal availability of labor in general, and of skilled agricultural labor in particular (Martínez and Barrera 1989).

Seasonal demands on Andean farmers' time and skills are extremely complex (McCorkle 1986, 1990). One of the main reasons such producers are reluctant to participate in experiments and validations is that committing their scarce time and much-needed skills to such efforts may imperil their normal production, and with it the very survival of their families. However, it is possible to plan for these labor constraints in the research design (Salvatierra and Fernández 1989, Scheidegger et al. 1987). Indeed, this is not only possible but imperative; otherwise, farmers will not participate.

■ Experience and Results

During the first season of project operation, one community requested that the PVTC test the yield of native potatoes versus "improved" varieties. Because the entire community was interested in this question, they readily allocated a third of a hectare of communal cropland for the trial. Communal workparties (faenas) were organized to plow the experimental plot; and at planting, each community family contributed manure to supplement the chemical fertilizers.

The project agronomist adopted a block design using 21 10 m^2 subplots, so as to allow three repetitions of each variety to be tested. When planting time came, however, the community rejected this research design. They explained that the unplanted corridors between the subplots would make for lower productivity and would allow weeds to proliferate. Also, this plot design would require plowing by hand, and hence a much greater investment of time and labor, because there was no room for an ox team to maneuver in the tiny plots. Farmers also pointed out that the research design would prejudice the next season's crops planted in the unfertilized corridors. The people further noted that the short furrows and the small number of tubers required for each treatment would greatly increase planting time. Planting is normally done by filling a carrying cloth of a size that, on a 0.33

ha plot, will hold enough seed to sow two furrows. The agronomist's subplot design would mean numerous trips to the pile of seed potatoes to re-fill the cloth with each of the different varieties to be tested.

It turned out to be much easier for the farmers to conduct the trials on larger plots, in single or multiple furrows for each variety. When varieties had to be changed in the middle of a furrow, the shift was marked by planting a few tubers of mashua or oca. With these modifications, more farmers were willing to participate in the trials on the communal land. Moreover, they agreed to additional trials on their own land, as well.

■ Recommendations

When experiments and validations are carried out in a real production system, they must be designed to accommodate existing patterns of land and labor use. Because land and labor are less likely to be limiting factors in research-station experiments, researchers are prone to ignore them in planning on-farm trials.

In designing such trials, it is also important to allow for seasonal demands on farmers' labor, and to schedule activities to make sure that farmers will have time to participate in the planning and evaluation phases of the trials. Experimental designs that require reorganization of existing labor patterns and/or that take more time than farmers' normal techniques make it harder for farmers to participate. Modifications in normal labor organization and agronomic practice should be made only if they are absolutely necessary to ensure valid trial results.

Farmers are unlikely to accept experimental methods that have negative consequences, e.g., for soil quality and subsequent crops. The lesson here is clear. Experiments that imperil future production or that risk current crop failure should be carried out on experiment stations. Community-based farmers cannot afford to bear the burden of such risks and the potential loss in productivity of their very limited capital, land, labor, and livestock.

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Sociology: Experimental Designs for Research in Communities

[9] Using Family Herds for Repetitions

Introduction

Livestock experiments are typically carried out with large herds owned by a single farmer. But community-based, mixed farmers usually have small herds. Animal scientists often see this as an impediment to research (Amir and Knipscheer 1989).

Although most livestock in Andean peasant communities are owned by individual families, grazing lands are usually held and utilized communally (Gilles and Jamtgaard 1981, 1982; McCorkle 1987). Because most people graze their herds on the communal rangelands, there is considerable similarity in animal nutrition and breeding across family herds. If livestock researchers consider the total number of animals in a community as a herd and the family herds as lots, then experiments can be designed that use these lots for repetitions and control groups. At the same time, this approach allows more farmers to participate in the experimental process.

Experience and Results

As noted in section 6, some of the PVTC's first livestock experiments involved assessing and improving the effectiveness of home remedies, based on local plant materials, to control internal and external parasites in sheep (Bazalar and McCorkle 1989) via an ethnoveterinary approach to livestock health problems (Mathias-Mundy 1989, Mathias-Mundy and McCorkle 1989, McCorkle 1986, 1989).

Interested farmers offered their herds for repetitions within these ethnoveterinary experiments. However, the participating farmers insisted that all their animals be treated. This left the PVTC with the problem of identifying and maintaining control groups. However, other farmers not participating in these trials allowed the team to weigh their animals and evaluate levels of herd parasitism. These herds became the control groups. Of course, the team choose experimental and control farmers who were similar with respect to access to land and animals, family size, and management practices.

It was fairly easy to match control and experimental herds during the first season's trials. However, when the experiment began to show positive results, the owners of the control herds naturally wanted their animals to be treated, too. The solution was to incorporate these farmers into the experimental group and to select new non-participants in the same community as controls. This strategy meant that re-evaluation of experimental conditions was ongoing and that a continued match of groups could be made. Although the initial experimental group and the last control group would become less similar, at any given moment those being measured were more similar.

Equally important, bringing reluctant farmers into the experimental process as control groups allowed them closer contact with researchers, plus access to more information about the process and results of the experiments.

■ Recommendations

In communities where all families use communal rangelands, for experimental purposes all the animals in the community can be counted as a single herd. However, this approach calls for creativity in defining not only the variables to be tested but also the treatment units.

Even when the community as a whole is not directly involved in a given experiment, farmers' interest and involvement can be increased by including the animals or crops of non-participants as controls.

When non-participants later wish to be included in treatment groups, this should be done as soon as possible, so that increasing numbers of farmers can learn more about the technology or practice being tested and can take an active part in the research process.

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Sociology: The Extension of Technology

[10] Sharing Risks to Ensure Technology Adoption

■ Introduction

The final test in technology adoption is whether the new tools, techniques, inputs, etc. are economically feasible. Most on-farm trials provide incentives such as free seed or fertilizer to motivate farmers to participate. However, until farmers themselves shoulder all of the economic risks of a new technology, there is no guarantee that they will be able to adopt it (Amir and Knipscheer 1989, Scheidegger 1987, Chapter 3 this volume). Since many new technologies require external inputs, farmers often need help at least in assuming the initial investment risks (Fernández et al. 1989). Shortterm loans are one possibility, but they are problematic in inflationary economies. Ways of guaranteeing the economic feasibility of a technology and facilitating farmers' initial investment in it must be devised; otherwise, it will not be adopted.

■ Experience and Results

When community groups requested PVTC help in renovating their potato seed, the project proposed installing plots of virus-free seed provided by a Ministry of Agriculture program. But the community groups did not have the money to buy the seed, much less the necessary fertilizers and pesticides. A discussion ensured on how to fund installation of the plots in a way that would be acceptable to the community groups and that would ensure sustainability of the plots.

At first, a cash loan from the PVTC was discussed. After studying the matter, however, both community and project members agreed that repaying the loan might prove difficult, given the tremendous inflation in the Peruvian economy and the unknown risks of installing and operating the plots. Community members instead proposed an al partir arrangement with the project. This type of risk-sharing agreement is entered into between families who have surpluses or shortages of different kinds of resources. Each party provides certain of the inputs needed for cultivation (e.g., land, labor, manure, ox teams) and then divides the harvest according to the value of their respective inputs.

After many conversations and careful consideration by all concerned, the community groups and the PVTC struck an al partir agreement that was highly satisfactory to all. The harvest would be divided equally, with each party providing stipulated resources. The project would contribute seed, fertilizer, pesticides, technical advice, and incidental cash expenses. The community groups would contribute land, labor, manure, and their participation in extension meetings.

There are at least five advantages to working in this "al partir" mode. First, it assures that a technology is validated within the parameters of control needed for optimal production. Second, the product or outcome remains in the hands of the producers. This guarantees that, if the trial has shown positive results, farmers will reproduce the process on their own. Third, a larger number of farmers acquire firsthand familiarity with the technology. Fourth, researchers learn a great deal about the limitations and possibilities of the technology as a result of their direct collaboration with farmers, whose experiences and opinions may differ from researchers'. Fifth and finally, as production partners rather than merely passive recipients of a gift, farmers take more responsibility for, and put more effort into, the research process.

Recommendations

The economic feasibility of a technology or practice is one of the most important criteria in evaluating its viability. If a project provides all the requisite external inputs free of charge, farmers will be unable to accurately evaluate the economic viability of the technology.

Moreover, cooperative endeavors such as that described here reinforce farmer self-confidence and self-sufficiency. Although this strategy may pose a problem for projects in later disposing of their share of the harvest, the advantages in terms of technology evaluation and sustainability far outweigh this minor inconvenience.

Participative research also affords a way to strengthen community-based farmers' capacity to generate and evaluate alternative technologies over shorter periods of time. However, ample time must be alloted to the joint planning and evaluation phases of such experiments and validations.

In cases such as the one described here, where fresh genetic material is the technological focus, institutional support must also be well-planned for. But again, this should not be provided free of cost lest farmer dependency be increased.

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Sociology: The Extension of Technology

[11] Diffusion of New Technology

Introduction

Research and extension are all-too-often mistakenly viewed and organized as distinct, unconnected parts of the technology adoption process. It is generally assumed that farmers must be "convinced" to adopt a new technology that researchers or extensionists deem worthwhile (McCorkle 1989). In fact, though, when farmers have determined for themselves that a new technology will help them reach their production goals, they will be quick to adopt it if they can possibly marshall the necessary resources.

One of the most effective ways of letting farmers themselves evaluate a new technology is to involve them in the experimentation and validation phases of its development (Fernández 1988, 1989). A technology that shows positive experimental results will be spread through informal channels within and among communities (Guillet 1990). If an effective and efficient technology fails to diffuse in this fashion, it probably means that farmers cannot access the genetic material and/or inputs required for its adoption.

Experience and Results

Native potato varieties are generally hardier and require smaller quantities of chemical inputs than high-yielding "improved" varieties that fetch a higher market price. Yet it is important to community-based farmers to raise some potatoes of marketable quality in order to earn cash.

The PVTC agronomist knew of a hardy, improved potato, named San Cristóbal, that had been successfully adopted in other, high-altitude parts of Peru. But this variety was unknown to farmers in the PVTC area. The agronomist distributed 50 kg of San Cristóbal seed among five community farmers for them to evaluate its local adaptability and comparative yields. They found that it gave yields comparable to the improved varieties they were currently using; moreover, it was less susceptible to insects, disease, and frost.

By the end of these farmers' first season of trials, all of the plots planted with San Cristóbal potatoes showed signs of pilfering. And each of the five farmers had received many requests from relatives and neighbors that he give or trade them a few "San Cristóbales" for next year's planting. By the end of the second season, 50 farmers in a three-community area had sown plots to multiply the new seed. By the third season, small quantities of San Cristóbal potatoes were being sold in the regional marketplace.

The fact that the variety produced well in the community was evidence enough for the farmers and their neighbors. They did not need a distribution program or special extension efforts. Their own validations were sufficient to provide the comparative information they needed.

■ Recommendations

There is an important caveat in the case described here. Technology related to potato production is a specialty of farmers throughout the high Andes. The introduction of genetic material or techniques requiring skills unfamiliar to Andean farmers probably would not be so readily accepted. In such cases, joint project/farmer validations are preferable, not only because this reduces risk to farmers but also because the required knowledge and skills can be acquired at the same time that farmers observe and evaluate the new technology's production advantages (Chambers et al. 1989).

However, as the San Cristóbal case illustrates, technologies that do not call for modifications in management practices and skills are easily transferable if they are good. If farmers fail to adopt technologies of this type, then the innovation is probably not useful.

Finally, farmers' diffusion channels should be carefully observed. For example, often farmers do not allocate cash resources to the purchase of seed. Instead, they obtain it through gifts or exchange and then multiply the seed themselves. Researchers and extension agents must therefore consider not only the immediate effectiveness of a technology but also how farmers can reproduce it or obtain the resources needed to continue using it in future. This may suggest new areas for experimentation and evaluation. When the necessary resources are locally available and inexpensive, however, a useful technology will likely diffuse among farmers on its own.

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CHAPTER 3

ECONOMIC METHODS FOR LIVESTOCK RESEARCH AND DEVELOPMENT IN THE ANDES

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Chapter 3

Economic Methods for Livestock Research and Development in the Andes

Economics

[1] Introduction: Economic Analysis in the Andes

The goal of applied agricultural research is the generation of technologies proven to be acceptable to their end-users. A combination of qualitative and quantitative information and of different methods for organizing and analyzing this information is necessary in order to screen the appropriateness of a technology or a technological alternative. Most producers' ultimate objective is economic viability. However, this does not necessarily mean monetary profits alone. In a broader sense, economic viability usually translates into sustained production and consumption in the long run. Hence the critical role of economists in assessing the probability of producer acceptance of technological changes.

Of course, interdisciplinary integration should be the norm in applied agricultural research and extension. The first step is biological screening through experimental trials, both at the research station and on-farm. Thereafter, technological alternatives are evaluated for economic viability and other considerations. However, biological research results have often constituted the main and sometimes even the sole criterion for deciding whether a technology is ready for extension. But biological criteria alone are insufficient. Social, economic, cultural, and other variables must also be considered.

The absence of a socioeconomic evaluation is an even greater omission when a single-species or commodity approach to agricultural research, development, and extension is taken. Interactions and relationships between crops and livestock, and among different species, have been all but ignored most of the time. Yet if these linkages are not acknowledged, no relevant economic or, for that matter, biological analyses can be done.

Three elements are involved in carrying out sound economic evaluations: data collection, data organization, and evaluation proper. This chapter outlines recommendations for the performance of these three tasks among Andean smallholders, based on the experiences of the SR-CRSP/Peru Economics Project. The project began in late 1979 with a collaborative agreement between the Department of Economics at the la Molina National Agrarian University (UNALM) of Lima, and Winrock International Institute for Agricultural Development, then known as Winrock International Livestock Research and Training Center.

The recommendations presented in the following pages are based on several key assumptions.

- Extension or research personnel already possess a knowledge of the main characteristics of the farm family production units with whom they work — e.g. the beneficiaries' principal crops and livestock, their land holdings, family composition, marketing practices, and so forth. Before any on-farm research and subsequent extension activities can be initiated, this information must be available.
- For each technological alternative being evaluated, the following information is available: the kinds and quantities of resources needed, e.g. land area and type, infrastructure, seed, vaccines, medicines, and other physical inputs; expected yields and their related probabilities; and labor requirements, both quantitative and qualitative, the latter referring to the need for specialized training.
- Because "evaluation" is just a fancy word for comparison, the same information listed in the preceding paragraph must also be available for the equivalent technology currently in use, against which intervention results will be compared.

Obtaining and organizing such data should be a priority for every livestock research or extension unit. However, because there are many different farming systems, no single format of data collection and analysis is adequate. For example, the format for high-altitude alpaca producers will have to be very different from the format for valley-floor farms that raise maize, vegetables, cattle, and goats. Questionnaires and other data collection instruments must therefore be developed according to local circumstances.

The overall objective of an economic evaluation is twofold: to assess whether a technological intervention in fact improves the rural producer's lot; and to determine whether she/he concurs in this assessment and will thus adopt the technology recommendations. In the first instance, a positive assessment implies that the technology is both safe and desirable in the opinion of researchers and extensionists. But this finding alone does not guarantee adoption. The producer may not perceive the advantages of the new technology. Even more likely, the researcher or extensionist may have misjudged the farming system and assigned inappropriate economic weights (usually through prices) to various farm components and resources.

How to evaluate? There is no pat answer to this question. Rather, the issue is one of approach. SR-CRSP experience has shown that the following statements are usually true for the small Andean producer.

First, it is extremely rare for an Andean farm to have idle resources. In economic terms, there will usually be a positive opportunity cost for almost any production factor, including labor. Contrary to common belief, members of small farming families are always busy — whether they are cropping, herding or otherwise caring for animals, spinning and weaving, repairing tools, or working for wages, depending on the time of day or the season of the year. This includes children as young as age six (Martínez and Barrera 1989). This is not to imply, however, that production factors could not be used more efficiently.

Second, closely related to the foregoing is the fact that the poorer a producer, the greater the proportion of farm resources that must be devoted to adopting a new technology. Like most people, poor producers are usually averse to risk, and they place great value on liquid assets. They will not accept an intervention if they are not convinced that they will be better off afterwards — somewhat like stockholders, who will invest only in companies they believe in. There is a big difference here, however. If stockholders lose their investment, they generally do not starve; but the poor farm family may. This constitutes one of the "bottom lines" in economic evaluation.

Third, the poorer the producer, the quicker a new technology must "mature." In other words, the time between the resource commitment (investment) and the technology's revenue yield must be shorter for poorer farmers. The same principle applies to savings behavior. No matter how high the interest rate offered by a bank, one needs to keep some assets in cash to pay for daily necessities like food and fuel. But the lower one's income, the higher the proportion of income that has to be held in cash or some other, very liquid form that can be rapidly converted to cash. Also, the lower the proportion of income that can be put into savings and investments for future consumption. In short, change agents must offer poor farmers relatively inexpensive alternatives with returns considerably above those of technologies aimed at wealthier producers.

Fourth, all on-farm activities are closely interrelated. Yet most research and extension programs focus on only a few, or even one, plant or animal species. This makes it all too easy to overlook critical cross-species interrelationships. In the Peruvian highlands, for example, there is a key synergism between the use of livestock manure for fertilizing plant crops and the use of plant-crop byproducts for feeding animals. Such relationships become critical when they represent constraints to the production activity under study.

The following pages describe ways to define variables, organize data, and evaluate technological alternatives, within the general framework presented above.

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Economics: Data Collection and Organization

[2] Basic Data Requirements

■ Introduction

The data requirements discussed here refer to production units that are under technical surveillance as part of a farming systems technology transfer study. Ideally, there should be information from all locales where on-farm trials are implemented. However, it is difficult to make any general recommendations as to how much information is needed, in terms of quantity and types of variables and frequency of observations. Farming systems research (FSR) projects tend to collect as much information as possible as a precaution against unforeseen data needs. In conventional biological research, and sometimes also in extension work, the tendency seems to be just the opposite, however. I.e., collect only what is necessary to complete the task at hand.

In practical terms, the collection of data that may never be analyzed and that have no clear purpose (the "just-in-case" approach) can have worse consequences than the omission of some variables. This is because data depth generally decreases as breadth increases. Moreover, personnel responsible for amassing data with little apparent utility may become frustrated. Too many variables also make reading and organizing data an extraordinarily difficult task that cannot be accomplished without highly specialized and costly personnel and equipment. Last but by no means least, producers themselves may become justifiably annoyed by too many questions about what they often consider very personal matters.

The list of variables presented here is merely a suggestion developed around a hypothetical economic study on small ruminants in an Andean mixed family farm. Specific investigations may well require far more detailed biological information. Conversely, not all the variables discussed below are necessary for economic evaluations. But as indicated in Section 1, they are important for identifying basic farm characteristics. Still further information will be necessary for successful technology transfer. Although the focus here is on livestock development, many of the same lessons apply to cultivation.

■ Experience and Results

Identification data should minimally include the following: name of family head; location of farm, including type of landholding (communal, private, rented, etc.); family structure, e.g. sexes, ages, education, occupations; person(s) in charge of each plant and animal component.

With regard to resource base and use, the economic resources controlled by the family production unit should be inventoried. Resource availability normally determines the size of the operation and the input mix. In the Andean context, the most important resources are land, labor, and the number of animals per species.

In livestock development projects, the immediate objective of collecting baseline land data is to determine all possible feed sources. However, an equally important objective is to understand the overall production system. Although land tenure arrangements are highly varied in the Peruvian sierra, they can be grouped into three general categories, each of which requires data as to the number of plots, their size, location, use, rental fees if any, and usufruct rules among farm families.

The first category, permanent plots, is comprised of private property in the strictest sense of the term, plus communal land that is permanently assigned to individual farm families. In the case of arable land, a family typically has access to many, very small plots. Crop byproducts are used to feed animals, and should be carefully accounted for. This first category may also include the semi- or fully privatized estancias that are used as reserve pasturage. Second is rented land, including plots paid for in money or in kind, plus plots that are sharecropped. Grasslands rental is very rare. Third is communal lands. These are found in most agropastoral and pastoral communities of the Andes. Usufruct patterns vary. Of particular importance are the moist bofedales, which provide rich pasturage during the difficult dry season and which may therefore be subject to certain restrictions and fees. Families may be preassigned to certain zones in the communal lands; alternatively, they may be allowed to graze their animals anywhere they wish within the commons.

The main objectives in collecting labor data are to assess labor availability for technological alternatives and to understand producers' goals and priorities. A basic premise here is: if a technology demands extra family labor, this input has to be robbed from other production activities. The minimal questions for which labor data are needed are the following. Who will carry out the new tasks? How are these people currently employed? What do they currently produce (in money or in kind) with the time that would be required for the new technology?

In answering these three questions, SR-CRSP economics studies have shown that two facts should be taken into account (Martínez and Barrera 1989). First, peasant families have little free time. Even at the time of year when cultivation tasks are few, considerable labor will be sold off-farm (including temporary wage-labor migration) or otherwise employed in productive tasks. Second, the proportion of labor devoted to livestock is much higher than previously thought. In a typical Andean agropastoral community, SR-CRSP economists found that over 50% of annual family labor went to animal production, while less than 25% was allocated to plant crops.

The relative roles of men, women, and children in plant and animal production must also be delineated in the collection of labor data (Martínez and Barrera 1989). These roles vary according to the type of community and other factors. However, in both the central and southern sierra, the SR-CRSP has observed that women are responsible for much of herd-animal husbandry in agropastoral communities. (Again, see the chapter on sociological considerations.)

The main objective in collecting data on livestock is to inventory the animals by class and species. Each time a producer is visited, the following information should be collected: the number of animals per species, variety or breed, sex, and age group; livestock purchases, sales, births, deaths, consumption, etc. since the last visit; what (and/or where) the animals have been fed in the interim; offtakes of animal products (wool, milk, meat, hides, manure, etc. as applicable); and the person(s) in charge of tending the animals since the last visit.

An understanding of herd dynamics is critical for defining the needs of a particular system. Typically, herd size is linked to environmental conditions. Knowing changes in herd size may help in planning for feed supplies across the production cycle. Also, herd size may be an important index of social prestige. However, this varies across the Andes. For example, in the Mantaro Valley communities studied by the SR-CRSP, wealthier families had smaller herds than middle-income families. The former owed their wealth to investment in service activities such as transportation and milling. In more remote communities of the southern Peruvian sierra, however, livestock play the usual role as a measure of wealth.

■ Recommendations

With regard to land use patterns, many communities contain all the categories described above. Permanent, sharecropped, and rented plots are used for plant crops. This complicates analysis of the farming system, because the use of crop byproducts as animal feed makes carrying capacity calculations futile. So far, little is known about the nutritive quality of Andean crop byproducts. Therefore, no conclusions about this factor should be drawn unless precise biological information is available. More broadly, plant and animal production should be considered so closely interwoven that trying to establish which is the "main" activity is nonsensical.

Common property mainly serves as pasturage. When access to such land is free to all community members, however, it is virtually impossible to calculate family-level resource use. Even though herds are privately owned, they share common grazing grounds. This means that stocking rates, pasture qualities, carrying capacities, and other measurements should be calculated on a community-wide basis.

With regard to labor, a full-fledged labor allocation study is usually unnecessary. However, in-depth specialized studies by a social scientist may be desirable before plunging ahead with any individual intervention. Also, livestock-related technical interventions should be primarily directed to the group most responsible for animal care. In many parts of the Andes, this means the women of the community.

Finally, in Andean communities, on-farm trials with animals usually cannot be conducted with conventional control groups on the same farm at the same time. (Consult the chapter on sociological considerations). Instead, results must be compared across time. Hence the importance of follow-up, or dynamic, information.

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Economics: Data Collection and Organization

[3] Other Input and Output Data

■ Introduction

Before new technologies are introduced into an agricultural production unit, researchers and extensionists must have a measure of the productivity of the current farming system. "Productivity" is defined as the ratio of output to input, i.e. what is usually called yield. The relationship between quantities and qualities of outputs and inputs is a measurement of the technical efficiency of an operation. Yield calculations are most frequently based on land factors, e.g. kilograms per hectare or bushels per acre.

However, other production factors may be equally important. For instance, in the case of livestock raised on a combination of crop byproducts and grasses, meat yields per unit of land may be of little importance in producers' decision-making processes, because as a conceptual factor of production, land may lack precise boundaries (Jaramillo et al. 1985). And under extensive livestock operations like those prevailing in Andean peasant communities, labor is the most important input in animal production.

Also, product destination is as important as product output. Small farmers commonly set aside part of their resources for the production of goods not intended for market sale but for family consumption. In such cases, yield may not be so important as, say, quality and flavor. This is especially true for certain native crops with rather restricted markets.

■ Experience and Results

At every farm visit, the livestock researcher or extensionist should collect the following information: persons in charge of herding each species since last visit, with special attention to the species under study; periods and places of animal feedings in the interim (commons, post-harvest plots, corrals); types and quantities of feed consumed (hay, cut grass, etc.); type and quantity of minerals supplied; health care during the period (vaccinations, topical treatments, etc.); and the quantity, purpose, and frequency of any other livestock inputs provided.

Specialists tend to overlook some of the complementary products of livestock and crops. For example, the grain yield of maize is usually recorded with precision, but not the foliage (chala) yield. If they consider it at all, researchers and extensionists tend to view the foliage as merely a byproduct. However, for Andean farmers, chala is just as important a product as the grain.

Similarly, most animal species in the Andes are raised for multiple purposes. Yet specialists rarely pay attention to more than one of these uses. For example, cattle serve as draft animals, sources of milk, producers of dung for fertilizer and fuel, savings accounts, and a mark of prestige and power within the community. The value of cattle as meat becomes relevant only when an animal dies or is sold for slaughter. While milk and meat production from Andean cattle has received attention, little is known about these many other products.

In addition to the periodic inventories noted in earlier sections, for livestock development issues, the following production data should be collected for both current and new technologies.

First is output of harvested product per period. This applies to any product extracted from the animal without culling it. For small ruminants in the Andes, this includes sheep wool, alpaca and llama fiber, and goat milk. If measurable, dung should also be included. Other minimum information required is: quantity of product (weight, volume, count) in specified units (kilograms, pounds, arrobas, liters, other local units as applicable); frequency of harvesting (daily, monthly, yearly, biennially); and number of animals shorn, milked, etc. Additional desirable information includes market quality of the product, relevant physical aspects of the product (e.g. color, coarseness, flavor, length), and product uses.

Second is product destination. Three main destinations can be identified. One is complete home consumption by the family; in this case, the product disappears after being consumed. Another is intermediate use by the family; i.e. the product serves as an input in other production activities. For example, milk can be used to make cheese, wool to knit sweaters, dung to fertilize crops, and grain to serve as seed for next year's planting. Third is exchange, including both monetary trade and non-monetary barter; i.e. the product is exchanged for something else.

Recording product destination is very important because different qualities of products typically have different uses. For instance, alpaca wool will often go to market, while sheep wool will be kept to make clothes for the family. A more complex example involves potatoes. In the central sierra, the best potatoes go to market or are given as presents (papa de regalo) while some are kept for seed. Second-best potatoes are usually marketed or consumed by the family. The worst potatoes are fed to pigs or transformed into chuño (dehydrated potatoes). Andean farmers need all these potato qualities, because each fills a distinct and important need.

■ Recommendations

When several variable factors are involved (e.g. labor, fertilizer, and seed), the excessive use of yield measurements may be misleading. Why? Because the yield on any one factor depends on the quality of that factor plus the quantity of the other factors used. For this reason, e.g., it does not make sense to compare yields from valley-bottom lands with those from high-altitude slopes.

Collecting all the information on all farm products is difficult and impractical. Thus quantitative data should be collected only when feasible and really necessary.

In spite of these problems, yield measurements usually constitute the first economic evaluation made of a production system. But researchers and extensionists should bear in mind that yields may may not be the most important consideration for producers. The farm family may be more interested in other considerations, like low variability in production levels, nutritional quality and flavor of products, or still other features. Care must always be exercised in collecting information about outputs; quantities and qualities are both important.

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Economics: Data Collection and Organization

[4] Prices and Other Economic Data

■ Introduction

Economic evaluation depends on each physical datum being multiplied by its value. This value is usually given in the form of money per unit, i.e. prices. This procedure would be a simple one, were it not for the fact that the same amount of a product may fetch different prices in different space-time contexts.

In spatial terms, for example, a kilogram of potatoes sold by a farmer will very likely bring a different price at the farmgate, in the village square, or at the weekly market in a neighboring town. The producer sells products at all these places, and each involves different marketing costs, e.g. in the seller's time and transportation. In temporal terms, prices typically vary across the year, depending on the recency of harvesttime and on the harvest's success. Similar principles apply to input prices, too. All these considerations raise the question of which price to use in conducting an economic evaluation.

■ Experience and Results

With regard to price data collection, in monetary transactions, every price observation should include the following variables: price as expressed in monetary units per unit of product; place of transaction, i.e. farmgate, village, town, etc.; quantity sold, because price may vary with quantity; date and time of the transaction; and the socioeconomic relationship between transactors, which may also influence price. In barter trade, each observation should include: quantities of each product exchanged; qualities of the products; place of transaction; transaction date and time; and transactors' relationship. Whenever possible, evaluation should rely on actual observation of transactions and not on secondhand accounts, because farmers may be culturally inclined to distort prices.

The foregoing collection procedures will yield many different prices for the products under study. To carry out the economic evaluation, a decision therefore has to be made regarding which prices to use for both inputs and outputs.

For inputs (e.g. vaccines, mineral supplements, fertilizers, seeds, labor), a "site price" should be calculated. A common mistake is to forget the costs incurred when transporting the input from the place of purchase to the farmer's field (Martínez and Barrera 1989). Yet these costs can be critical in people's adoption decision making. To estimate the site price, one must know the distances to and from the farmer's plots. If applicable, the corresponding transportation cost should be added to the input. When the producer her/himself handles transport of the input, the time she/he invests in doing so should be added to the input price.

For outputs, the price used should be that of the place and time in which sales most commonly occur. If the farmer sells all of the product at one place and time, the prices collected on that occasion can be used. But if she/he sells the product on several different occasions, a decision has to be made regarding which price to use.

■ Recommendations

For both inputs and outputs, the SR-CRSP Economics Project has found that it is best to use the price at the location and time that farmers most commonly buy or sell the product in question. It is misleading to simply average all the prices, because they may have been taken at different locations and periods with different transportation costs or market conditions (Knipscheer et al. 1989).

■ References

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Economics: Data Collection and Organization

[5] Basic Principles of Data Organization

■ Introduction

The guiding principle in data organization is that no data should be left unprocessed. Even though the use of small computers is increasing, they are still unavailable at most research and extension stations in Peru. This situation is not likely to change in the near future. Thus, most data will have to be organized manually. This section presents a brief general discussion of data organization based on SR-CRSP experiences.

■ Experience and Results

If farmers are visited periodically (as versus having researchers and extensionists reside in the community), then field personnel should have a checklist of data to be collected during each visit. This checklist should be reviewed by an experienced professional, taking into account the specific characteristics of the production unit and the level of data previously gathered. This is part of an on-going, uninterrupted process of data flow. The SR-CRSP has found the following data flow system useful (Barrera 1986, Valer 1984).

Field personnel record information in a field notebook as soon as possible after a farm visit. Two kinds of information, quantitative and qualitative, are usually registered. The former includes numerical inventories, yields, weights, prices, etc. While such data are very important for economic and biological analyses, in order to fully understand the production system, they must be complemented with qualitative data, i.e. information that cannot be easily transformed into numbers. Cultural observations usually fall into this category, as well as certain kinds of biological and economic information. For example, many "beliefs" among Andean farmers reveal a deep knowledge of their ecology; other beliefs may impose constraints on producers' economic behavior; still others help define the objectives of the producer as an economic subject.

Soon after personnel return from the field, they should transfer the information collected to forms designed to track each production unit. Quantitative information (yields, quantities of inputs, hours of labor, etc.) is transferred to survey-like worksheets that are structured so as to make information retrieval easy. Qualitative information is perhaps best kept in a notebook for each production unit, with a separate section devoted to the observations made at each visit and indicating the date, time, and field agent who gathered the data. Alternatively, this information can be transferred onto large index cards organized by topic, region, or other criteria. However, a disadvantage in this system is that cards can be lost or misplaced more easily than notebooks.

Quantitative information should be processed soon after it is transferred to the worksheets. For processsing qualitative information, the SR-CRSP is developing a computer software system based on key words. Called FiCam (after "fichas de campo"), this system can be easily adapted to almost any situation. When it is completed, FiCam will be made available to Peruvian researchers and extension agents.

■ Recommendations

More specific recommendations cannot be made here because they will depend on the availability of personnel, equipment, and infrastructure, as well as on the problem under consideration. For example, if during the last visit to a given farm the field agent collected checklist data on wool yields and lamb mortality, then presumably such information was needed, and new average yields and lamb mortality rates should be calculated as soon as possible.

Calculations do not need to be done by field personnel themselves. Computers can make this process automatic. Transferring information directly from field records to a computer saves considerable time. In research or extension facilities working with small farmers, back-logs of unprocessed data are a common problem, and one that grows geometrically according to the amount of data collected and any delays in processing.

For qualitative information, the basic task is to keep it physically well organized, so as to facilitate its location and retrieval.

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Economics: Evaluation

[6] Basic Principles of Economic Evaluation

■ Introduction

In market economies, obtaining a profit is considered the driving force behind production. This is why sound economic evaluations are so critical to successful technology development and transfer. Throughout the Andes, however, the market is imperfect due to some or all of the following reasons: lack of information among producers; high climatic risk, which influences resource allocation; price uncertainty, arising from the market itself or from erratic government policies; biological risk in the form of pests and diseases; political risk, particularly the possibility of finding no market in which to sell one's products or of their being forcibly seized; and distance of the marketplace.

These factors mean that economic evaluations will yield different results if made at different occasions and locations. Put another way, a non-profitable technological alternative may become profitable under a different set of circumstances (Jaramillo et al. 1985). These circumstances may be economic (prices, subsidies), environmental (altitude, latitude, frosts, rainfall), political (instability, war), and even spatial (distance to main roads). Therefore, a negative finding in the economic evaluation should not automatically lead to the definitive shelving of a technological alternative. The same technology may be acceptable under different circumstances.

Since most research and extension stations in the Andes lack a staff economist, the basic economic analyses of technical interventions usually has to be done by non-economists. Actually, most extension and research personnel carry out economic analyses without realizing it. For instance, many a livestock extension specialist knows that the main reason a small farmer does not control parasites is the high cost of treatments relative to the price of the animal products.

The foregoing case exemplifies an economic analysis based on relatively obvious information. But most analyses are not so obvious; and intuition alone is inadequate. Small farms are complex systems comprised of several subsystems (natural, biological, technological, and sociocultural) that interact with each other. A change in one of these subsystems affects the others, and the whole system must then attain a new equilibrium. Farm production is itself a system. Hence technical intervention in any one component affects the overall performance of the system.

■ Experience and Results

The complexity of these interactions requires a systemic approach to small-farm agriculture. That is, the secondary effects of any intervention must always be considered. Notwithstanding, technological interventions are usually developed along the lines pertaining to each component. In other words, farming systems research (FSR) does not imply that technical change has to be planned for the whole farm. On the contrary, the common practice is to prioritize interventions in some components, and then evaluate the effects of these interventions on the other components of the farming system.

For example, Andean small farms usually raise five or more plant crops and two or more animal species. Suppose it has been discovered that the introduction of a leguminous forage crop on fallow plots could provide additional feed for animals, and at the same time improve soil fertility through nitrogen fixation. This intervention has positive effects in two components: animal production and crop production. The only apparent costs would be those required to establish the legume. There is, however, little doubt that many other things may change as a consequence of this intervention. Herd size may increase, and with it the production of manure and therefore of plant crops. Conversely, greater labor demands for, e.g., cutting and carrying the new forage may handicap cultivation or other farm family activities.

■ Recommendations

Precise evaluation of such changes entails sophisticated mathematical models that utilize complex programming and demand a wealth of very detailed information. However, for practical purposes, such approaches are usually unnecessary. In any case, they are often infeasible and non-cost-effective. In the same way that biological experiments performed under controlled conditions do not reproduce real-world contexts, economic analyses are typically based on simplifying assumptions.

The validity of the results of an economic evaluation will depend on the method chosen, which is only valid provided certain conditions prevail in the real world. The choice of method depends on the nature of the problem, and on the available professional staff and computer infrastructure. There are several approaches to analyzing the economic performance of a technological alternative. Four of the most basic methods are discussed in Knipscheer et al. 1989. And CIMMYT (1988) offers a good training manual and workbook on the topic. The next and final section discusses one method that has worked well for the SR-CRSP in Peru — partial budgeting.

References

CIMMYT

1988 From Agronomic Data to Farmer Recommendations: An Economics Training Manual. Mexico: CIMMYT.

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Economics: Evaluation

[7] Partial Budget Analysis

■ Introduction

As its name implies, in partial budget analysis, only a part of the farm operation is evaluated. This method makes the following underlying assumptions. (For greater detail, see CIMMYT 1988, Jaramillo et al. 1985, and Knipscheer et al. 1989).

- Divisibility — all inputs and outputs can be used or obtained in fractional units.
- Linearity — an additional unit of input yields the same quantity of output as the last unit used.
- Transparency — perfect knowledge exists of the outcome of the decisions made by the producer. In other words, there is no uncertainty regarding the results of the intervention.

At the core of partial budget analysis is a basic comparison of benefits and costs, particularly added or reduced benefits and costs, that result from a technological intervention. Recall that any technological intervention on a farm involves reallocating resources among activities and obtaining different quantities and/or qualities of output. Simply stated, both the input mix and the output mix change.

In economic terms, if a change is made in production of a given item "X," any of the following changes may also occur: an increase in the value of the factors used to produce X, i.e. an added cost (negative sign); a decrease in the value of using a factor, i.e. a reduced cost (positive sign); an increase in the value of the output of X (deriving from larger quantities, better qualities, or a combination of the two), i.e. an added return (positive sign); and a decrease in the value of the output of some other product "Y", normally because resources are being shifted from Y to X, i.e. a reduced return (negative sign). Hereafter, the sum of all changes in costs and returns is termed net value change (NVC).

■ Experience and Results

A list of common questions and answers about partial budget analysis follows, based on the interpretation of results vis-a-vis the peculiarities of small ruminant production in Peru. The answers given here assume that all the other recommendations outlined in this chapter have been followed.

Question: Does a negative NVC suggest that the technology is not suitable and should be discarded?

Answer: A negative NVC means that the technological alternative will not be adopted by producers under the current circumstances (place, time, market, farmer knowledge). But it does not imply that the technology should be totally discarded. Circumstances may change, thereby affecting the result.

Question: Does a positive NVC imply that the technology will be adopted by the farmer?

Answer: Not necessarily. There are considerations not included in the partial budget analysis that may outweigh the positive value of the NVC. For example, putting money in a savings account might yield a better rate of return than the new technology.

Question: Animal husbandry is not like cropping, in that the results of a change decision may not be visible for several years. Does this affect the way in which the NVC should be interpreted?

Answer: Yes. The poorer the producer, the sooner positive economic results must be obtained. For very poor farmers — like those possessing the majority of Peru's small ruminants — it is difficult to invest money now and then wait several years to see the results. The money invested might be needed for emergencies. Thus, poor farmers generally prefer to keep some of their assets in cash or in goods easily converted to cash. In some cases, no matter how high the rate of return on the new technology, a producer may prefer to keep the cash on hand.

Question: Besides the sign of the NVC, the rate of return, and the preference for liquidity, what factors affect a farmer's decision to adopt a technology?

Answer: Many factors. Perhaps the most important is variability. Normally, researchers give too much weight to the average results, rather than to the variance. The technology currently in use commonly has a low average associated with low variance. This means that a good or bad year will not greatly affect the outcome of a farming decision. Just the opposite may be true of the equivalent new technology. Moreover, the latter may show a higher overall probability of non-attainment of the minimum yield considered essential for survival. Another important factor is relative wealth; i.e. the more you have, the more you can risk.

■ Recommendations

Since it is difficult and costly to model the whole-farm operation, the most logical and practical alternative is to evaluate the most evident changes triggered by the technological intervention under study. Partial budget analysis is the most widespread method for such assessments, and the one that has worked best for the SR-CRSP/Peru.

While none of the three basic assumptions behind partial budget analysis ever actually holds in real life, under certain conditions they do not greatly distort reality. For example, fractional results, obtained as a consequence of divisibility, can normally be approximated to the nearest integer value without affecting the final outcome. Linearity mirrors reality relatively well, provided the right amount of inputs is being used. Finally, transparency may also be acceptable if external conditions do not change dramatically. I.e., the producer often knows with acceptable precision the yields she/he can obtain under different conditions of weather, pests, and diseases.

In partial budget analysis, if all increases and decreases are properly identified and added (taking into account the negative values), the result represents a first economic evaluation — a picture of how much better off the farm family is (or isn't) after adopting a new technological alternative.

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CHAPTER 4

Range Management for Agropastoral Systems of Peru

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Chapter 4

Range Management for Agropastoral Systems of Peru

Range Management

[1] Introduction: Range Sites and Range Ecology

Within any broadly defined area dominated by a particular kind of vegetation, great differences exist in the productive capacities of rangelands (Stoddart et al. 1975). These differences are caused by climatic and topographical factors, and further by soil characteristics. These areas of differing potentialities are called range sites. They are defined by their potential productivity. Once range-site potentials are determined, their ecological status must be evaluated. In this way, different standards are developed for forage production and plant composition. A good site in poor condition may be more productive than a poor site in its best possible condition.

Rangelands cannot be successfully managed without consideration of these differences in site quality. Proper grazing capacities will vary dramatically among range sites. If the grazing capacity for sites of differing potential is not estimated, some sites may be underutilized. Conversely, others may be overutilized. The latter is the most common problem in the Andes of Peru, where too many range sites are overutilized by livestock.

Overutilization of plants severely impairs their growth and may even kill the most valuable and productive species. It is helpful to apply a proper-use factor, i.e. the percentage use that is made of a forage species under proper management, in order to prevent a plant from being utilized beyond its limit of tolerance. This percentage of proper use usually falls between 40% and 60%.

Because animals selectively graze certain species, it is up to the manager to determine when proper use has been achieved for a given area of rangeland. Her/his decision will be affected by the kind of animal, season, yearly rainfall, and past grazing use. Table 1 shows how vegetation communities are affected by grazing. On mountain slopes, Fedo and Cavi disappear and are replaced by Feri, Agbr, and Alpi when overgrazed. (See Annex of plant species codes at the end of this chapter).

Range sites are mapped according to soil and vegetation measurements. Once maps of range sites have been constructed and vegetation associations are known, grazing capacity for each site is established. The examples in Table 2 apply for the central and southern Andes of Peru.

Extension agents should help producers develop range site maps and evaluate productivity and grazing capacities for their grazing lands. Expertise in range management now is available at UNA, UNTA, UNPG, and IVITA-San Marcos to assist extensionists. Only through this effort will sustainable livestock production be achieved. Moreover, deterioration and degradation of native rangelands will be halted, thus providing longterm stability to the grazing ecosystems of Andean rangelands.

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1986 Grassland communities and soils on a high elevation grassland of central Peru. Phytologia 61:231-250.

Table 1. Basal Cover (Percent) and Associated Standard Errors for the Ranching Cooperative, Community Lands, and Holding Pasture at SAIS Pachacutec[1]

	Ranching Cooperative (Good Condition)	Community Land (Poor Condition)	Holding Pasture (Very Poor Condition)
Grasses			
Aciachne pulvinata	1.4(0.4)	2.9(1.3)	.0(0)
Agrostis breviculumis	0.6(0.2)	3.3(0.8)	2.4(0.8)
Bromus lanatus	1.0(0.2)	0.2(0.2)	0.4(0.4)
Calamagrostis vicunarum	4.4(0.6)	4.2(0.9)	1.8(0.6)
Dissanthelium calycinum	0.1(0.3)	0.7(0.3)	0.4(0.2)
Festuca dolichophylla	14.9(1.1)	1.6(0.7)	.0(0)
Festuca rigescens	2.2(0.5)	5.8(1.0)	6.9(1.5)
Hordeum muticum	0.1(0.1)	0.2(0.2)	.0(0)
Muhlenbergia ligularis	0.2(0.1)	0.4(0.3)	0.8(0.6)
Poa candomoana	0.4(0.2)	.0(0)	0.6(0.3)
Stipa brachyphylla	0.4(0.1)	1.6(0.6)	0.6(0.5)
Total grasses	**26.0(1.0)**	**20.9(1.2)**	**13.9(2.3)**
Forbs			
Alchemilla pinnata	0.4(0.1)	0.8(0.5)	1.8(0.7)
Baccharis alpina	0.4(0.3)	1.8(0.7)	0.2(0.2)
Geranium sessiliflorum	0.1(0.1)	0.4(0.3)	0.4(0.2)
Paronychia andina	0.5(0.2)	1.4(0.7)	0.6(0.5)
Total forbs	**1.8(0.5)**	**5.3(1.1)**	**6.0(1.6)**
Sedges			
Carex ecuadorica	2.6(0.4)	2.2(0.7)	1.6(0.7)
Scirpus rigidus	1.0(0.3)	.0(0)	.0(0)
Total sedges	**3.6(0.5)**	**2.2(0.3)**	**1.8(0.7)**
Litter	57.5(1.7)	60.2(1.6)	38.4(4.6)
Bare ground	7.5(1.0)	9.8(1.4)	36.2(6.3)
Moss	3.3(0.7)	1.1(1.8)	3.7(1.2)
Rock	0.3(0.1)	0.5(0.4)	.0(0)

[1]Data from Wilcox et al. 1987.

Table 2. Examples from SAIS Pachacutec of Range Site Descriptions and Estimates of Grazing Capacity for Rangelands of Peru[1]

Range Site	Dominant Vegetation	Range Conditions	Stocking Rate (ewes/ha)	Area (ha)	Grazing Capacity (total ewes)
Flood plain	Pogi/Fedo/Cabr	Good	1.5	200	300
Glaciated valleys					
Bottomland	Cabr/Fedo	Good	1.3	400	520
Hesic upland	Fedo/Pogr	Good	1.0	300	300
Xeric upland	Fedo	Good	0.8	500	400
Mountain slopes					
Gravelly loam	Cama/Fedo	Good	0.4	300	120
Andesite	Care/Stbr	Good	0.4	200	80
Siltstone	Stbr/Care	Good	0.4	100	40
Deep loam	Fedi/Stbr	Good	0.4	200	80
High ridges	Feri/Stbr	Good	0.1	200	20
Bofedales	Pltu/Hyta/Casp	Good			
				1,900	1,860

[1]Data from Wilcox et al. 1986.

Range Management: Livestock Management

[2] Stocking Rate and Grazing Capacities

■ Introduction

In addition to the problems of rangeland degradation discussed in the section on range sites and range ecology, animal production is dramatically affected by excessive stocking rate, i.e. too many animals. In Peru, there simply are too many animals for sustained animal production. Disease or parasites can lead to listless, unthrifty, and unproductive animals, but in Peru this condition can usually be traced directly to too many animals.

This fact cannot be overemphasized. The single most important cause of poor animal production in Peru is inadequate nutrition from low quantity and/or quality of forage. This problem is most acute during the dry season. During this period, if alternative forage resources are not available, correct stocking rates are particularly critical.

■ Results

Data from research at SAIS Pachacutec in the Department of Junín illustrate this point. There, five stocking rates were evaluated in combination with two grazing strategies: continuous grazing with 3 sheep/ha; and rotational grazing with 2, 3, 4, and 6 sheep/ha (Tables 1 to 2). The study began at the end of shearing in 1981 and concluded at the end of shearing in 1983. Only Corriedale sheep from first parturitions (18 months of age) were utilized. A total area of 31.5 ha with groups of 20 sheep per treatment was employed. Rotation treatments were fenced into eight subdivisions and animals were placed in a single herd. Sheep were allowed to graze each subdivision for 6 days before moving to the next subdivision.

Extension agents should note that SAIS Pachacutec represents some of the best-managed ranges in Peru. The condition of its grazing lands is better than almost any production unit in the nation. Extensionists therefore should not suggest to producers in areas where the range condition is poorer that they will achieve stocking rates and animal production values like those displayed in Tables 1 through 4. Range productivity and corresponding animal production could be as much as 50% to 75% lower on poor condition rangelands. This is especially true where Criollo sheep are raised, rather than Corriedales as at SAIS Pachacutec.

Notice in Tables 1 and 2 that both sheep and land productivity declined at a stocking rate of 6 sheep/ha. Data from the continuously grazed pasture stocked at 3 sheep/ha, were similar to rotational grazing at 2, 3, and 4 sheep/ha. Thus rotational grazing is recommended both because it maintains animal performance and it improves the longterm health of the range.

Table 1. Sheep Production at Four Levels of Stocking under Rotational Grazing Compared to SAIS Production Data Averaged over Three Years (1982 to 1984) at SAIS Pachacutec

Parameter	Stocking Rate				
	2 ewes/ha	3 ewes/ha	4 ewes/ha	6 ewes/ha	SAIS
Gross lamb crop (%)[1]	80.0	87.0	0.0	52.0	62.0
Lamb birth weight (kg)[1]	4.1	3.7	3.7	3.3	3.3
Net lamb crop (%)	72.0	65.3	83.6	37.0	0.0
Weaning weight (kg)1	28.2	24.1	23.3	26.0	17.2
Greasy fleece weight (kg)[2]	3.2	—	2.9	3.0	—
Fiber staple length (cm)[2]	9.6	—	8.9	10.3	—
Fiber diameter (microns)[2]	25.5	—	24.5	24.1	—

[1]Data from F.órez et al. 1986.
[2]Data from irey et al. 1988.

Table 2. Percent of Cover and Valuable Plant Species, 1981-1983

Treatments	Foliar Cover	Valuable Species[1]
Continuous Grazing		
3 sheep/ha	95	30
Rotational Grazing		
2 sheep/ha	95	33
3 sheep/ha	94	27
4 sheep/ha	93	30
6 sheep/ha	94	16

[1]Valuable plant species are considered to be the desirable forage species, including Calamagrostis breviofolia, C. vicunarun, Muhlenbergia ligularis, Poa sp., Bromus lanatus, and Stipa brachyphylla.

Recommendations

Extension agents should help producers arrive at correct stocking rates for sustained animal production and improved health of native rangelands. Excessive stocking rates not only reduce productivity (as noted for valuable species under stocking rate of 6 sheep/ha in Table 2); they also increase toxic plants and soil erosion.

In terms of risk management among Andean herders, a conservative approach whereby stocking is kept at a constant rate is preferred (Browman 1987). In the Andes of Peru, this constant rate should be directed at what the rangeland can support in the dry season. Some suggestions for reducing animal numbers during the critical dry season include the following.

- Sell or trade adult animals beginning in June or July, especially in drought years.
- Sell or trade young animals and keep only breeding stock during the dry season.
- Sell or slaughter inferior animals that are sick, unthrifty, or have produced no young for 2 or 3 years.
- Move young animals to fallowed lands, crop residues, or cultivated pastures.
- Keep the breeding stock adjusted to the appropriate stocking rate for sustained yield and proper use of native pastures.
- Move yearling females to cultivated pastures during the dry season to enhance their breeding potential.

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Range Management: Livestock Management

[3] Rotational Grazing Programs: Pasture Deferment and Rest

Introduction

Plants need rest from grazing. Continuous grazing wherein livestock are placed on the range or an area and allowed to remain there yearlong or throughout the grazing season results in undesirable changes in plant communities. In Peru, herders normally move their animals from area to area. This system of rest for the plants is helpful only if: (1) the herder does not return to the same area for 30 to 40 days; or (2) no other herder grazes his or her animals on the same area for 30 to 40 days. These rest periods are important to restore the vigor of forage plants and to allow the plants to produce seed.

Movement of animals can be based simply on the criterion that when an area has achieved 40% to 60% utilization, the animals should be moved to another area. When this second area is grazed at 40% to 60% utilization, the animals should be moved again. The grazing period probably should be about 4 to 6 days per area, and should not exceed 10 days.

Results

Data from Puno (Table 1) suggest that range condition improves if areas are properly stocked (Section 2). For example, stocking rates of 4 ewe equivalents/ha caused a decline in perennial grasses and an increase in annual grasses. Such a trend suggests a decline in range health and condition. A stocking rate of 2 ewe equivalents/ha was best for rangeland productivity. At the latter stocking rate, December values indicated that either a 30-day or 45-day rest benefitted perennial grasses, Carex, and forbs. These forages are very important for ovine nutrition.

Data from Junín suggest that animal production is not reduced or otherwise affected by rotational grazing at the same stocking rate. Three different grazing systems were studied in Junín: continuous; rotational; and complementary, i.e. with mixed herds of sheep and cattle. Birth weights of lambs varied by no more than an average of .25 kg in the three systems. For weight at weaning, this figure was .82 kg (Table 2). Other measures — like daily weight gain in lambs, and lamb production by sheep and by hectare — showed improvements under rotational grazing (Table 3).

Table 1. Basal Cover (Percent) of Plant Groups Four Years after Seven Grazing Treatments Were Initiated (Puno)

	Two Ewe Equivalents/ha				Four Ewe Equivalents/ha			
Plant Group	Continuous yearly grazing	Rotational grazing, 30-day rest	Rotational grazing, 45-day rest	Exclosure	Continuous yearly grazing	Rotational grazing, 30-day rest	Rotational grazing 45-day rest	Exclosure
Perennial grasses								
May	16.7	16.7	16.3	16.8	15.2	13.6	12.9	16.8
December	13.2	19.1	17.9	20.1	15.0	14.8	14.2	20.1
Annual grasses								
May	7.7	10.2	11.6	12.3	9.9	13.0	13.8	12.3
December	--	--	--	--	--	--	--	--
Carex sp.								
May	8.9	5.0	4.7	7.0	7.9	6.4	7.2	7.0
December	2.8	5.9	6.0	6.9	1.1	7.4	7.6	6.9
Forbs								
May	0.6	4.5	3.4	1.5	1.3	2.6	2.8	1.5
December	3.4	8.2	5.9	7.5	5.6	7.8	7.3	7.5

Table 2. Animal Response to Rotational Grazing at SAIS Pachacutec

Grazing System	Lamb Weight at Birth (kg)	Lamb Weight at Weaning (kg)
Continuous	3.67	26.66
Rotational	3.65	27.48
Complementary	3.32	28.09

Table 3. Daily Weight Gain of Corriedale Lambs and Lamb Production (kg) by Sheep and by Hectare During Two Years' Research on Three Grazing Systems in Junín

	Grazing System		
	Continuous	Rotational	Complementary
Daily weight gain (g)			
1981/82	128 ± 69	135 ± 76	128 ± 44
1982/83	149 ± 51	151 ± 65	153 ± 47
Production of lambs/sheep			
1981/82	14.4	15.5	13.8
1982/83	20.0	22.7	7.5
Production of lambs/ha			
1981/82	43.1	46.4	41.4
1982/83	60.0	68.1	22.6

■ Recommendations

Extension agents should help producers carefully plan rotational grazing programs. The grazing area could be divided into 6 or 8 equal parts and a plan established to graze one part for 4 to 8 days before moving to another part. The herder should not return to any part of the grazing area for 30 to 40 days.

Extension agents also could help plan the grazing of fallowed fields or crop residues so as to provide 30 to 40 days of rest to the native pastures at least 6 to 9 times per year after grazing for 4 to 10 days. For further reading and suggestions, see Flórez and Malpartida 1987, and Flórez and Bryant 1989.

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Range Management: Livestock Management

[4] Grazing Distribution

■ Introduction

Overgrazing on a range is not dependent entirely upon the number of animals. It can also result if livestock are not distributed properly. Even under herding in the Andes, animals naturally are congregated near communities, villages, watering points, valley bottoms, bed grounds, etc.

■ Results

Although no data are available from Peru, data from the U.S. and Mexico illustrate this point (Figure 1 and Tables 1 and 2).

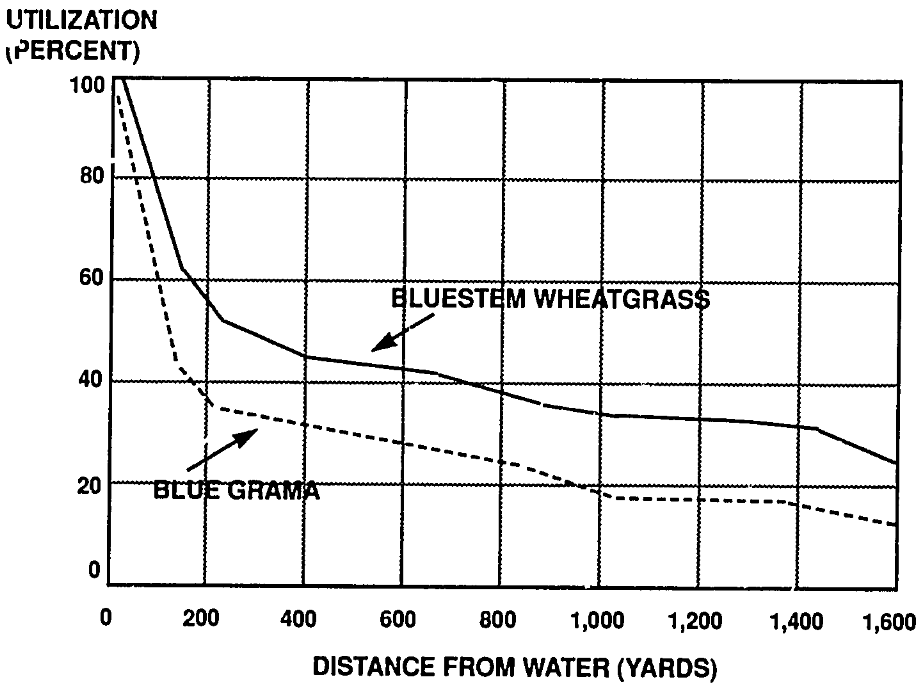

Figure 1. Relationship between percentage utilization of major forage species and distance from water on winter range in eastern Montana plains (after Stoddart et al. 1975).

Table 1. Percent Utilization on a Range with Water Available Yearlong Compared to One Where Water Was Available Parttime[1]

	Use away from Water		Use near Water		Seasons when Parttime Water was Open
Year	Yearlong	Parttime	Yearlong	Parttime	
1959-60	34	44	73	65[2]	None
1960-61	48	57	78	73	Summer-fall
1961-62	20	32	63	45[2]	Spring
1962-63	67	77	80	79	None
1963-64	24	62	63	73	Summer
1964-65	33	52	69	71	Summer/ spring
1965-66	41	42	75	62[2]	Fall
Average	38	52	71	67	

[1]Data from Stoddart et al. 1975.

[2]Years when difference in use near water between yearlong and parttime water was significant at 95% level.

■ Recommendations

Extension agents should encourage herders to graze the underutilized areas while resting overgrazed areas. To some extent, this is already practiced by Andean herders in that they graze their livestock on the steeper, more rugged slopes during the wet season and they exploit more level topography in the dry season.

Table 2. Standing Crop Biomass of Grasses (kg/ha) at Different Distances from the Watering Point under Short Duration Grazing in Northern Mexico[1]

Distance (m)	1983	1984	1985	1986	Mean[2]
0-300	257	484	373	419	383[a]
300-600	414	675	451	613	538[b]
600-900	526	752	609	870	691[c]
900-1200	580	849	965	1027	855[d]
1200-1500	546	778	870	1026	805[cd]
Mean[2]	465[x]	707[xy]	654[xy]	792[y]	——

[1]Data from Soltero et al. 1988.

[2]Means within the same row or column with the same superscript are not significantly different ($P < 0.05$).

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Range Management: Livestock Management

[5] Stocking Ratios and Kind of Livestock

■ Introduction

Because each kind of livestock grazes most heavily on certain plant species, most efficient use likely can be attained by grazing more than one kind of animal. In Peru, mixed flocks are common and can include sheep, llama, cattle, and alpaca. Even so, the combined numbers of each kind of animal must be adjusted to forage production. Otherwise acute overgrazing results.

■ Results

The following data (Tables 1 and 2) are from San Martín and Bryant 1987. They illustrate dietary differences among sheep, llama, and alpaca. The data also depict comparative differences in voluntary intake.

Table 1. Indices of Similarity (percentages) among the Diets of Llama, Alpaca, and Sheep in a Cultivated Pasture and on Natural Pastures Dominated by Festuca dolicophylla (Fedo) and Festuca rígida (Feri)

	Cultivated Pastures		Fedo		Feri	
Comparison	D[1]	R[1]	D	R	D	R
Llama versus alpaca	99	94	67	59	84	51
Llama versus sheep	75	73	60	55	61	60
Alpaca versus sheep	76	74	83	61	70	59

[1]D = dry season, R = rainy season.

Table 2. Values of Daily Consumption for Llama, Alpaca, and Sheep under the Grazing Conditions Cited in the Literature Indicated

	Daily Consumption[1]			
Type of Forage[2]	Season[3]	Llama[4]	Alpaca[4]	Sheep[4]
Festuca dolicophylla and Muhlenbergia fastigiata [9]	D	--	50.5 g OM/kgW$^{.75}$	--
	R	--	44.3 g OM/kgW$^{.75}$	--
Festuca rígida [5]	D	42.0 g OM/kgW$^{.75}$	--	--
	R	40.0g OM/kgW$^{.75}$	--	--
Festuca calamagrostis [4]	D	--	1.4 kg DM/animal	1.6 kg DM/animal
Festuca dolicophylla and Calamagrostis vicunarum [8]	LD	1.9 kg DM/animal	1.2 kg DM/animal	--
Festuca dolicophylla, Calamagrostis vicunarum, and introduced species [8]	LD	2.1 kg DM/animal	1.4 kg DM/animal	--
Festuca dolicophylla and Plantago tubulosa [7]	D	--	59.4 g DM/kgW$^{.75}$	--
	R	--	51.7 g DM/kgW$^{.75}$	--
Festuca calamagrostis [6]	D	--	--	85.4 g OM/kgW$^{.75}$
	R	--	--	99.8 g OM/kgW$^{.75}$
Festuca dolicophylla [10]	D	40.3 g DM/kg W$^{.75}$	35.8 g DM/kgW$^{.75}$	54.8 g DM/kgW$^{.75}$
	R	38.6 g DM/kgW$^{.75}$	54.0 g DM/kgW$^{.75}$	61.2 g DM/kgW$^{.75}$
Festuca rígida [10]	D	44.3 g DM/kgW$^{.75}$	42.4 g DM/kgW$^{.75}$	61.4 g DM/kgW$^{.75}$
	R	39.7 g DM/kgW$^{.75}$	41.2 g DM/kgW$^{.75}$	48.6 g DM/kgW$^{.75}$
L. perenne, F. rubra and T. repens [10]	D	67.0 g DM/kgW$^{.75}$	61.8 g DM/kgW$^{.75}$	94.2 g DM/kgW$^{.75}$
	R	51.2 g DM/kgW$^{.75}$	53.3 g DM/kgW$^{.75}$	88.5 g DM/kgW$^{.75}$

[1] All consumption values were estimated using the ratio of daily feces excretion to indigestibility.

[2] Data drawn from literature sources cited as follows: [4] = Espinosa 1975, [5] = Farfán et al. 1986, [6] = Fierro 1985, [7] = Huisa 1985, [8] = Ravillet et al. 1985, [9] = Reiner et al. 1987, [10] = San Martín 1987.

[3] D = dry, R = rainy, LD = late dry season.

[4] OM = organic matter, DM = dry matter.

■ Recommendations

Extension agents of Peru should encourage producers to follow the stocking ratios and guidelines mentioned below when estimating stocking rates. This is particularly true because sheep in Peru eat so much more per day than was previously thought. While the importance of Criollo and Corriedale sheep cannot be ignored, extensionists should encourage producers to shift to camelids. Their advantages include the following.

- Camelids are more efficient in digesting fibrous material than sheep (San Martín and Bryant 1987).
- Camelids are better adapted to the high elevation and harsh environment.
- Camelids are more resistant to drought than sheep or cattle. For example, in the 1982-1983 altiplano drought, sheep and cattle suffered mortality rates of up to 30%, but alpaca and llama mortality rates were only 5% (Browman 1987). Also, meat yields were 40% lower in cattle and sheep, versus 30% in alpaca. Likewise, wool yields dropped by 30% for sheep, but only 10% for alpaca and llama.
- Alpaca fiber is of higher quality and brings better prices than sheep wool.

Recommended exchange ratios should be 1.0:1.0 for sheep and alpaca, 1.0:1.5 for sheep and llama, and 1.0:1.5 for alpaca and llama (San Martín and Bryant 1987). Table 3 gives an example of how these data are used, with the notation that 1 adult sheep equals 1 ewe equivalent or e.e.

Table 3. An Example of Using Stocking Ratios Once Grazing Capacity Has Been Determined at 2 e.e./ha

Grazing Capacity with 1000 ha and a Biomass of 2000 kg/ha	
Sheep alone (1 e.e.)	500
Alpaca alone (1 alpaca = 1 sheep)	500
Llama alone (1.5 llama = 1 sheep)	333
Sheep:alpaca	250:250
Sheep:llama or alpaca:llama	250:167[1]
Sheep:alpaca:llama	150:150:133[2]

[1] $500 \text{ e.e.} - 250 \text{ e.e.} = \dfrac{250 \text{ e.e.}}{1.5 \text{ llama/e.e.}} = 167 \text{ llama}$

[2] $500 \text{ e.e.} - 150 \text{ e.e. (sheep)} - 150 \text{ e.e. (alpaca)} = \dfrac{200 \text{ e.e.}}{1.5 \text{ llama/e.e.}} = 133 \text{ llama}$

Complementary grazing should be considered on Andean rangelands of Peru, especially where one species could be used to manipulate tall, coarse bunchgrasses to facilitate use by smaller, more selective species. For example, cattle, horses, or llama could be grazed on such pastures ahead of sheep and/or alpaca to open up the herb layer to these smaller, more selective animals. Data from SAIS Pachacutec suggest this is a feasible alternative (Gamarra et al. 1985). However, if the lead species (e.g. cattle) is overstocked, productivity from sheep or alpaca will decline (Gamarra et al. 1985). Furthermore, the high (65%+) dietary overlap of alpaca with sheep and llama suggests that alpaca should be grazed alone at least during the dry season.

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Range Management: Livestock Management

[6] Poisonous Plants

■ Introduction

Preventing plant poisoning is much easier than curing it. Curing has little chance of success at any time, and almost no chance under range conditions (Stoddart et al. 1975). Although management is not a complete solution to the poisonous plant problem, in most instances it is the only thing that is economically feasible.

■ Results

Extension agents should acquain themselves with the symptoms of poisoning. At the very least, they should know the plant species that cause the problem. Table 1 lists some of the most common poisonous species of Peru.

Table 1. Poisonous Plants of Peru

Common Name	Scientific Name	Symptoms of Toxicity
Garbancillo	Astragalus garbancillo	Loss of appetite, weakness, trembling. Death may occur by starvation.
Romerillo	Baccharis coridifolia	Increase in body temperature, general depression, nervousness, intestinal aches, and in some cases death.
Cornezuelo	Clavicens purpurea	Respiratory problems.
Cebadilla	Bromus catharticus	Intestinal irritation, loss of appetite, general weakness.
Alfilerillo	Erodium cicutarium	Special smell near the animal, dense urine, distended glands.

Recommendations

If carefully followed, a few rules of good range management and livestock husbandry will prevent the majority of losses.

- Do not misuse the range so as to bring about the invasion of new species or the spread of poisonous species that already exist in amounts not dangerous to animals.
- Avoid areas where poisonous plants are abundant. This may require fencing of certain areas; but such areas can also be avoided through proper herding.
- Do not move animals hastily through an area where poisonous plants are present. Unhurried animals select a variety of forage and are less likely to consume poisonous plants in toxic quantities.
- Do not force animals to remain on the range after they have utilized the good forage species. Otherwise, they will turn to less desirable, and often poisonous, species.
- Some plant species are more poisonous in fall, others when they are in fruit, and still others in spring. These factors should be considered in grazing plans.
- When animals have been deprived of forage, as during trailing or corralling, they should not be put on ranges containing poisonous species until they are well fed.
- Provide ample water so that animals will not be induced to eat increased amounts of forage following water deprivation and subsequent watering.
- Use plenty of salt; shortage of salt may cause animals to eat plants not normally eaten. Shortage of other minerals, especially phosphorus, induces abnormal appetite, usually evidenced by bone chewing. Animals thus affected are sure to eat abnormally low-value vegetation such as poisonous plants. Feeding bone-meal supplement has been shown to reduce poisoning losses.
- Graze with a kind of stock not poisoned by the plant in question. Many plants that are seriously poisonous to one kind of animal are not poisonous to another or, at least under practical range conditions, are not dangerous.

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Range Management: Livestock Management

[7] Reserve Pastures

■ Introduction

A strategy for drought management might include reserve pastures. As already noted in other sections, forage quantity can be an important nutritional limit to animal production in the dry season. Thus, temporary pastures might be held in reserve as "hay on the ground" for dry season grazing.

■ Recommendations

Select a different area each year to hold in reserve. The reserve should be only about 5% of the total area grazed, e.g. 50 ha out of 1000 ha. Reserve pastures would be grazed normally until about the first of March, when grazing would be halted to allow forage to grow and accumulate. The reserve area could then be utilized in August and September when forage availability elsewhere is low.

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Range Management: Livestock Management

[8] Supplementing Nutritionally Deficient Forage

Introduction

Even when forage quantity is adequate, nutritional deficiencies may exist (Stoddart et al. 1975). This is especially true of Andean grass ranges, which decline in quality with maturity and subsequent leaching.

Results

Data from SR-CRSP research document the dietary nutrient levels of alpaca, sheep, and llama throughout the year. Alpaca may be deficient in crude protein during the entire dry season (July-November) and in energy during the late dry season (Fierro and Bryant 1989, Reiner and Bryant 1986, San Martín and Bryant 1989). San Martín 1987 also reports nutrient levels for llama, sheep, and alpaca during the dry and rainy seasons.

Recommendations

Regardless of range conditions or range sites, grazing animals should be provided the most common minerals (calcium, phosphorus, and salt). Deficiencies of these nutrients, especially phosphorus, will reduce animal production. Extension agents should encourage mineral supplementation.

The most feasible way to supplement Andean forage with crude protein and energy would be from cultivated pastures (Section 13). Concentrates, although expensive, should also be considered as another alternative for supplementing nutrient deficiencies on Andean rangelands.

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Range Management: Cultural Practices

[9] Interseeding

■ Introduction

On many sites in the Peruvian altiplano and puna, heavy and indiscriminate grazing has so modified the natural vegetation that only low-value species remain. Thus, there are potentials for improvement by interseeding ranges with native or foreign plants. Existing vegetation should be appraised to determine the relative merit of interseeding versus with natural revegetation. Furthermore, possible management changes of the area should be studied to determine how to correct the misuse that made interseeding necessary in the first place (Stoddart et al. 1975). Then, and only then, should interseeding be considered.

■ Results

Several methods of interseeding were tested in the rangelands of the high Andes of Peru. The method found to be most economical is as follows.

The most appropriate area for interseeding is flat or gently sloping, overgrazed rangelands. Steps for interseeding include: applying 80 kg of P205 (phosphate)/ha in October; in November, at the beginning of the rainy season, scratching the overgrazed area with a drill and then broadcasting the seed to be sown; and finally, covering the seed by using herds of camelids or sheep to trample it into the earth.

Different forage species are recommended according to soil type. If the soil pH is over 5.5, 12 kg/ha of perennial ryegrass plus 6 kg of inoculated red clover seed is recommended. For soils with a pH lower than 5.5, the ryegrass must be replaced by 12 kg/ha of Dactylis glomerata, coupled with clover or alfalfa, as above. The best time to utilize the interseeded area is 1 year after seeding. Grazing systems should be rotational, with short periods of grazing and 40 days of rest.

With the foregoing techniques, considerable improvements can be obtained. Depending upon altitude, soil moisture, and other microclimatic factors, it is possible to go from an initial stocking rate of only .5 sheep units/ha/year on the overgrazed range to 4 or 5 units/ha/year.

Recommendations

The following objectives may justify interseeding.

- To revegetate barren areas such as abandoned cropland.
- To replace vegetation altered by fire.
- To improve the quality and quantity of forage.
- To reestablish native forage plants that would not naturally become established.
- To protect an area from erosion.

References

Stoddart, L. A., A. O. Smith, and T. W. Box
1975 Range Management (3rd edition). New York: McGraw-Hill.

Range Management: Cultural Practices

[10] Fertilization

Introduction

Fertilization is costly. Even so, it should not be excluded from the options presented to agropastoralists. Fertilization has certain advantages. It needs no highly specialized equipment; it may cost less than interseeding; and it requires no periods of non-use. Other benefits include: a more varied forage mix; more palatable and nutritious forage; a longer grazing season; a way to better distribute grazing pressure; and better seedling establishment.

Results

The data in Table 1 derive from studies at the Chuquibambilla Research Station in the Department of Puno. They illustrate the benefits of fertilization. Fertilizer and rates were 60-60-0 kg/ha of NPK.

Table 1. Forage Production (kg/ha) from Fertilized versus Unfertilized Native Range at Chuqibambilla

	Cutting Height		
Time of Cutting	2 cm	4 cm	6 cm
Initial cutting, Dec 1985			
Fertilized	10,099	6,728	6,509
Unfertilized	8,655	8,578	7,204
Second cutting, May 1986			
Fertilized	2,850	3,159	3,081
Unfertilized	2,346	2,415	2,745
Third cutting, May 1987			
Fertilized	4,208	5,988	4,249
Unfertilized	3,232	3,480	3,747

■ Recommendations

Fertilization should be considered as an option, particularly as it relates to hay production from native meadows. In the example above, at a cutting height of 4 cm, forage production was increased 74% via fertilization.

■ References

Astorga, Juan
n.d. Unpublished data. Department of Agronomy, UNAP.

Range Management: Cultural Practices

[11] Conserving Water to Increase Range Production

■ Introduction

A factor that universally limits range production is lack of adequate soil moisture. Mechanical modification of range sites may improve water infiltration into the soil and thus reduce soil-moisture stress and increase production. Examples of mechanical modifications include "pitting," "chiseling," "furrowing," "terracing," and water spreading.

■ Results

None at this time.

■ Recommendations

Of all mechanical treatments, water spreading structures are most beneficial to forage production. They consist of dams and dikes that intercept surface runoff and convey it out of natural drainage areas at low gradients across the land surface where it can be absorbed. The aim should be to bring the maximum amount of land under the influence of the dikes by so spacing and locating them that flooding will affect the greatest possible areas (Stoddart et al. 1975). In this fashion, it might be possible to create artificial bofedales in the puna (Section 14). Contour furrows might also be considered because of the high costs of terracing.

■ References

Stoddart, L. A., A. O. Smith, and T. W. Box
1975 Range Management (3rd edition). New York: McGraw-Hill.

Range Management: Cultural Practices

[12] Controlled Range Burning

■ Introduction

For centuries, fires caused by lightning and humans have been one of the major forces affecting grassland ecosystems. Fire in the Peruvian altiplano and puna commonly is used to remove rank growth of desirable and undesirable species to make them more palatable to grazing animals. Fire also removes litter and other unutilized material so that new growth can develop unhindered.

■ Results

Research was conducted on the effects of fire in the rangelands of the central and southern Andes by Flórez and Malpartida (1987). Results are presented in Table 1. The data reveal that burning each year on a Fedo range site hurts valuable species like Fedo and Muli and encourages the dominance of unwanted species like Stich. Burning every 3 years left the vegetation complex virtually unchanged.

Table 1. Effects of Burning on Percent of Species[1] Composition of Andean Rangelands

	Initial, 1962			Final, 1968		
Burning Treatment	**Fedo**	**Muli**	**Stich**	**Fedo**	**Muli**	**Stich**
Each year	35	15	5	5	1	15
Every 2 years	34	17	5	21	11	9
Every 3 years	30	16	4	29	15	5
Check without burning	36	14	6	5[illegible]	9	11

[1]See Annex for plant species codes.

Recommendations

Prescribed burning is recommended for improving forage quality and removing undesirable plants, including poisonous plants. The timing and frequency of the burn are critical factors; extension agents must watch them carefully. For example, we do not recommend annual burning. Every 3 to 5 years would be better. Also, since livestock prefer to graze burned ranges, it is essential to burn large areas and to base stocking capacity on these areas. Otherwise, severe overgrazing will occur on the burned range to the detriment of better plants.

References

Flórez, A., and E. Malpartida
1987 Manejo de Praderas Nativas y Pasturas en la Región Altoandina del Perú. Volumes 1 and 2. Lima: Banco Agrario.

Range Management: Use of Special Pastures

[13] Establishment and Maintenance of Cultivated, Irrigated Pastures

■ Introduction

Cultivated, irrigated forages and pastures frequently suffer from mismanagement in the Andes of Peru. Once established, they commonly lose their productive potential within 2 to 3 years after establishment unless strict guidelines are followed relative to irrigation and fertilization schedules and animal management procedures. Proper animal management in terms of stocking rates and pasture rotation holds the key to the longevity of these expensive pastures.

Stocking rates are recommended in Table 3, but these should be viewed only as guidelines. Producers should always begin with lower rates and gradually increase numbers if forage biomass appears unaffected.

A plan of controlled, rotational grazing is as essential to the satisfactory production of quality pasturage as is the time of cutting to the yield and quality of the associated species. The time interval between grazings influences the yield and the quality of forage produced. The number of days each pasture is grazed influences the amount of waste and the degree of selectivity in grazing.

■ Results

Tables 1 and 2 present the parameters for establishment and maintenance of cultivated pastures of legumes and gramineas, respectively, in the Andean sierra.

■ Recommendations

Once it is determined that the site is suitable for planting forage crops, all that usually is needed to prepare the land for forage crops is a firm seedbed that permits uniform, shallow coverage of the seed. Disking or other suitable surface preparations are preferable to plowing in order to achieve the firm seedbed that forage seedings require. However, shallow plowing can serve as well as disking.

If irrigation is used, the method should be determined by topography, amount and location of water supply, water costs, and soil characteristics. Flood irrigation is the most common method in the highlands of Peru. Usually, 1 litre/second of water is sufficient for irrigation of 1 hectare. After seeding, 8 days of irrigation will assure good pasture establishment. Thereafter, irrigating every 15 days is recommended.

Table 1. Parameters for Establishment and Maintenance of Cultivated Sierran Pastures: Legumes

Parameters	Alfalfa Atlantica[1]	Alfalfa Dupuits[1]	Alfalfa Mcapa[2]	Alfalfa Ranger[1]	White Clover[2]	Red Clover[3]	Lotus[4]
Climate[5]	MC-C	MC-C	M	MC-C	MC-C	MC-C	M-C
Soil humidity[6]	W-D	W-D	W-D	W-D	L-D	D	D
Soil pH	6.5-7.5	6.5-7.5	6.5-7.5	6.5-7.5	5.5-7.0	6.5-7.0	5.5-7.0
Altitude (m)	3500-4000	3000-4000	up to 2500	3200-4200	3000-4200	3000-4200	2500-4200
Drought resistance	x	x		x			x
Frost resistance	x	x		x			x
Kg seed/ha, broadcast	30	30	30	30	4	15	10
Kg seed/ha, rows	25	25	25	25	3	10	8
NPK at seeding	20-100-50	20-100-50	20-100-50	20-100-50	20-100-50	20-100-50	20-100-50
NPK for maintenance	100-50	100-50	100-50	100-50	100-50	100-50	100-50
Establishment time with irrigation	6 mos.	6 mos.	6 mos.	6 mos.	6 mos.	4 mos.	12 mos.
Establishment time without irrigation	12 mos.	12 mos.	12 mos.	12 mos.	12 mos.	6 mos.	15 mos.
Pure seed strength	98%	98%	98%	98%	96%	98%	96%
Pure seed germinations	90%	90%	90%	90%	90%	90%	90%

[1] Medicago sativa
[2] Trifolium repens
[3] Trifolium pratense
[4] Lotus corniculatus
[5] M = mild, MC = mild/cold, C = cold, M-C = mild to cold
[6] D = drained, W-D = well-drained, L-D = little-drained

Table 2. Parameters for Establishment and Maintenance of Cultivated Sierran Pastures: Gramineas

Parameters	Forage Oats[1]	Dactylis Glomerata	Festuca Ky[2]	English Ryegrass[3]	Italian Ryegrass[4]	Timothy[5]	Hardingrass[6]
Climate[7]	MC	MC-C	M-C	M-C	M-C	M-C	MC-C
Soil humidity[8]	D	W-D	L-D	L-D	L-D	D	D
Soil pH	5.0-7.0	4.5-7.0	5.0-7.0	5.5-7.0	5.5-7.0	4.5-7.0	5.0-7.0
Altitude (m)	2500-4200	2500-4200	2000-4200	2500-4000	2500-3000	2500-3000	2500-3000
Drought resistance			x				x
Frost resistance	x		x	x			
Kg seed/ha, broadcast	35	20	25	30	30	15	15
Kg seed/ha, rows	35	15	20	25	25	10	10
NPK at seeding	50-80-50	50-80-50	50-80-50	50-80-50	50-80-50	50-80-50	50-80-50
NPK for maintenance	100-80-50	100-80-50	100-80-50	100-80-50	100-80-50	100-80-50	100-80-50
Establishment time with irrigation	6 mos.	6 mos.	6 mos.	6 mos.	6 mos.	6 mos.	6 mos.
Establishment time without irrigation	12 mos.	12 mos.	12 mos.	12 mos.	6 mos.	12 mos.	12 mos.
Pure seed strength	85%	85%	97%	96%	98%	99%	90%
Pure seed germination	80%	85%	90%	90%	90%	90%	60%

[1] _Arrhenatherum elatius_

[2] _Festuca arundinacea_ Ky 31

[3] _Lolium perenne_

[4] _Lolium multiflorum_

[5] _Phleum pratense_

[6] _Phalaris tuberosa_

[7] M = mild, MC = mild/cold, C = cold, M-C = mild to cold.

[8] D = drained, W-D = well-drained, L-D = little-drained.

On irrigated pastures, seeding should take place in October or November. On rainfed lands, seeding should begin with the first rains. Seeds should be sown at a depth of 1 to 2 cm depending upon the size of the seed. When row-planted on unirrigated land, the distance between rows should be 25 cm; for irrigated pastures, a distance of 35 cm between rows is recommended. For new sowings of leguminous seed, inoculation of bacteria is necessary.

All the species listed in Tables 1 and 2 can be grazed, ensiled, or consumed green. The age at which they may be grazed or cut is at the beginning of flowering. Table 3 presents recommended average stocking rates for sheep and alpaca on irrigated pastures by altitude for common mixtures of cultivated species.

Table 3. Average Recommended Stocking Rates in Sheep and Alpaca Units/Ha/Year on Cultivated, Irrigated Pastures of Ryegrass+Clover, Dactylis+Clover, or Dactylis+Alfalfa, by Altitude

	Altitude (m)		
Stocking Rates[1]	3800	4000	4200
Sheep units/ha/year	30-40	20-25	10-15
Alpaca units/ha/year	20-26	13-16	6-10

[1]Varies according to local conditions (soil moisture, climate, topography, etc.).

A scheme of rotational grazing is critical to the proper use of cultivated pastures. Limiting the grazing period to no more than 7 days decreases selectivity in grazing and keeps feed waste relatively low. For the Peruvian highlands, it is recommended that cultivated, irrigated pastures be grazed for 3 days and then rested for 40.

Detailed economic and range analyses (Jaramillo et al. 1985, Pfister et al, 1989) demonstrate that the use of cultivated pastures as the only forage base for either sheep or alpaca production is currently unattractive for integrated range livestock production systems in the central and southern Andes of Peru. However, improved pastures were found to be profitable if they are used as a supplement to native rangelands. Supplementation practices might include the following:

- Restrictive grazing by several herds of livestock of the improved pastures; e.g. 2 to 3 days/week or 3 hours/day, thus integrating several herds of livestock for utilization of one plot of improved pasture.
- Harvesting hay from such pastures during the rainy season, to be fed in the dry season;
- Flushing at breeding and late gestation;
- Fattening lambs and tuis during the rainy season;
- Grazing female alpaca on improved pasture during the dry season; and
- Using cultivated pastures to induce earlier sexual maturation of female tuis so they will produce one extra offspring across their productive life.

Mixed alpaca/sheep production systems utilizing cultivated pastures also appear economically promising. Examples of such systems include the following:

- Raising female tuis to 1 year of age on improved pastures plus cutting hay from these pastures in the rainy season to be fed to ewes in late gestation;
- Raising female tuis to 1 year plus fattening wethers during the rainy season;
- Combining raising alpaca tuis to 1 year with dry season grazing of ewes after weaning plus fattening wethers in the rainy season.

In sum, the practical use of cultivated, irrigated pastures in the Peruvian Andes is as strategic feed resources during critical periods of interaction between animals' biological cycle and biomass production of the range.

References

Jaramillo, J., J. DeBoer, A. Flórez, F. C. Bryant, and L. C. Fierro

1985 Economic Analysis of Range and Forage Management Strategies for Increasing Small Ruminant Productivity in the Peruvian Andes. Technical Article T-9-433. Lubbock, TX: TTU, College of Agricultural Sciences.

Pfister, J. A., F. C. Bryant, A. Flórez, and J. Gamarra.

1989 Flushing of range sheep with cultivated pasture in the Andes of Peru. Journal of Range Management, (in press).

Range Management: Use of Special Pastures

[14] Management and Use of Bofedales

■ Introduction

Four important vegetative formations can be identified for the rangelands of highland Peru: the puna mat (cushion and rosette) that seems to be the richest of all formations in numbers of species; the bunch grass formation, which surpasses all others in extent; the vegetation of rocky areas and stone fields; and the Distichia moor or bofedales.

Bofedales are areas with constant moisture underground. They most often develop on level land, but they also border slow brooks and encircle ponds. Indeed, many a pond has been supplanted by this formation. Bofedales always retain a fresh green color. In strong contrast with their surroundings, they are closed without gaps, and have neither bunch grasses nor shrubs.

■ Results

From measurements at La Raya Research Station in southern Peru, it appears that the species most characteristic of bofedales is Distichia muscoides, a member of the Juncaceae family. Its short, needle-shaped leaves end in a sharp point. The branches crowd together in highly convex, solid cushions that give the moor a wavy surface. When the ends of the branches grow upward, the lower parts are transformed into peat that serves as fuel. Distichia is accompanied by several small herbs, especially in the hollows between the cushions, where puddles frequently form. Table 1 shows the vegetative composition of bofedales at five different altitudes.

■ Recommendations

Bofedales should be managed as special foraging sites because of their unique ability to provide green forage throughout the dry season. Stocking rates should be carefully controlled and bofedales should be used to supply nutritional boosts to producing animals only. Males or non-lactating females could be grazed only partially (3 days/week or 3 hours/day), with lactating females and sub-adult females receiving the most forage from these sites. In some cases, bofedales are too wet and water drainage could help the plants growing on them.

Table 1. Density and Percent of Botanical Composition of Five Bofedales at Different Altitudes

Species	Altitude (m) 3000	4100	4300	4400	4600
Gramineas (density)					
Alchinea pulvinata					11
Calamagrostis vicunarun				2	
Calamagrostis rigescens		1	15	14	12
Calamagrostis curvula				10	
Calamagrostis anmohena			6		2
Calamagrostis ovata				5	
Calamgrostis antoniana	2				
Festuca dolichophylla	1	7	2	13	1
Muhlembergia gastigiata		4	2		
Poa candamoana	6	1	3	2	6
Percent of composition	**8**	**16**	**6**	**8**	**16**
Graminoides (jancaceas and cyperaceas)					
Carex ecuadorica			15	8	
Carex sp.		4	2		3
Distichia muscoides			60	46	11
Eliocharis albibracteata	6	5	31	39	2
Juncus sp.	1	8	2		
Luzula peruviana	3	2			
Oxichloe andicola			37	64	8
Percent of composition	**9**	**20**	**32**	**28**	**12**
Herbaceas					
Alchemilla pinnata	1	23	9	15	21
Alchemilla diplophylla			6	84	9
Castilleja pissifolia				2	1
Cotula mexicana					6
Eriocaulium sp.	4		72	11	
Geranium sessiflorum	3		3		
Gentiana postrata	2			2	
Hypochoeris taraxocoides	38		30	4	32
Hypochoeris stenocephala			10	2	
Plantago tubulosa	33	17	71	115	28
Plantago rigescens				33	
Ranunculus sp.			6		5
Roripa nana			1	1	
Stylitis andicola			21	10	
Liliasposis andina		11	7	15	
Lucila tunaerenses			1	43	
Werneria pigmea	3		37	4	14
Total percentage	**78**	**54**	**59**	**61**	**59**

References

Reiner, R., and F. C. Bryant
1986 Botanical composition and nutritional quality of alpaca diets in two Andean rangeland communities. Journal of Range Management 39:424-427.

Range Management

[15] Special Topics

Introduction

At the time of writing, work was on-going in two areas that are potentially useful within agropastoral peasant communities of Peru: cropping and intercropping of legumes on fallow lands, and forage conservation.

Cropping and Intercropping of Legumes on Fallow Lands

Two technologies are being evaluated. The first consists of interseeding a legume with the last crop in the agricultural rotation. The aim is to reduce labor and to utilize the growing time of the food crop for establishment of the forage crop. The second technology consists of seeding fallow lands after harvest of the last crop in the agricultural rotation.

In both cases, forage quality, quantity, and growing time, and increments in soil nitrogen content are being examined, as well as collateral effects on the interseeded crops in the first case. Economic evaluation will be based on partial budgeting to take into account establishment and cutting costs where applicable. Benefits will be measured in terms of increased forage and increased soil nitrogen content, and hence reduced need for commercial nitrogen products. These measures have been adopted because of the difficulties of assessing changes in animal weight given the grazing patterns practiced in communities.

Forage Conservation

Two technologies being validated in this area are family-level use of micro-silos and improved drying practices for hay. For the microsilos, the costs of labor to prepare the needed ditch and cut the forage, plus the price of plastic sheeting, will be evaluated using partial budgeting. Care will be taken to consider only the appropriate proportion of building costs in the first year. Benefits will be measured in terms of increased quantities of fodder available during the dry season as well as comparative animal weight changes in relation to a control group. With regard to improved hay drying, cost-benefit ratios will be calculated. Increased labor will be measured against animal weight changes.

Range Management: Annex

Plant Species Codes

Agbr ....Agrostis breviculmis

Alpi..Alchemilla pinnata

Cabr ....Calamagrostis brevifolia

Cama..Calamagrostis macrophylla

Care ....Calamagrostis recta

Casp ....Carex sp.

Fedi ....Festuca disti charaginata

Fedo ....Festica dolichophylla

Feri..Festuca rigescens

Hyta ....Hypochoeris taraxacoides

Muli..Muhlembergia ligularis

Pltu ....Plantago tubolosa

Pogi ....Poa gilgiana

Pogr..Poa gracilis

Stbr ....Stipa brachyphylla

Stich..Stipa ichu

CHAPTER 5

Management of Reproduction and Genetics in Sheep of Highland Peru

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Chapter 5

Management of Reproduction and Genetics in Sheep of Highland Peru

Reproduction and Breeding

[1] Introduction: Why Practice Animal Improvement?

The improvement of sheep both genetically and phenotypically can increase levels of offtake per animal, produce animals that the stockowner will be proud to exhibit, and provide additional incentive to better husbandry. Because animals furnish so many benefits — meat, milk, fiber and other byproducts, companionship, recreation, and still more — people are usually interested in improving their animals. However, by far the most important reason for practicing animal improvement is to increase livestock productivity.

In Andean sheep, the usually low reproductive rates probably result from inadequate nutrition at critical points in the animals' reproductive process. Following the range management suggestions put forth in Chapter 4 could significantly enhance the nutritional status of Andean sheep during key reproductive stages. Further, inadequate management of animal health can significantly reduce reproductive rates (Chapter 6). Animals must be in good enough condition to lactate and to raise their young. However, much of the low reproductive rates observed in highland sheep is attributable to poor reproductive management.

Reproductive management involves the careful timing of mating. This ensures not only high conception rates but also the production of viable gametes by both males and females that in turn ensures maximum opportunity for fertilization and embryonic development. The work of the SR-CRSP/Peru reproduction group reported in this chapter focuses mainly on factors affecting these two parameters: timing of mating and production of viable gametes so as to achieve the highest reproductive rate possible.

Selection of animals (i.e., mating the best to the best) is one way to improve the genotype for many traits. However, response to selection varies depending upon the heritability and genetic variation of the trait under selection and upon the generation interval. As a result of selection, many other traits may change, some in a positive way and some in a negative way. For example, selection can lessen adaptability to the harsh Andean environment. Generally, survival and reproductive performance are the first characteristics to be lost. Good knowledge of these correlated responses is important in understanding selection results.

Crossbreeding is another method of genetic improvement. However, some of the observed improvement from crossbreeding arises from heterosis rather than from permanent genetic change. Thus the improvements can be lost in future generations if crossbreeding is not continued. Dramatic declines in adaptability can also result from crossbreeding with imported animals that are not adapted to the environment. In the new environment, their offspring are often less productive than the native animals they were imported to improve.

In sum, selection or crossbreeding without concomitant improvement in the environment will result in failure of the improved genotype to express itself.

[2] Male Reproduction

■ Introduction

Male sheep have a tremendous impact on production. They account for approximately 80% of the genetic change that occurs in a flock. Moreover, since males are exposed to females in a ratio of 2 or 3 rams per 100 ewes, failure or inefficiency in the male reproductive process can greatly reduce the reproductive rate of the females to which they are joined. Yet highland producers generally assume that the rams joined with the ewes are fertile and will produce lambs.

Little information is available about the physiological characteristics of male sheep in the highlands of Peru. Therefore, the SR-CRSP Reproduction Project undertook a series of studies designed to improve our understanding of puberty and sexual development among male sheep in the Peruvian sierra. The studies reported here were conducted at SAIS Tupac Amaru's Consac production unit, in the central sierra of Peru. SAIS rams of three breeds — Criollo, Corriedale, and Junín — were compared across three years (1981-1984).

■ Results

SR-CRSP studies of puberty in male lambs in highland Peru show significant differences between years in several traits, including body weight and scrotal circumference at penis separation of the preputial attachments, plus scrotal circumference at first ejaculation (Vivanco et al. 1985). Moreover, as Table 1 indicates, there are significant differences between breeds in these regards.

Table 1 also displays the mean reproductive characteristics at puberty (defined as penis separation from the sheath or first ejaculation) for three breeds. These differences, although small, almost always indicate that the Criollo has better reproductive characteristics than either of the improved breeds. With the exception of the semen characteristics, the differences are probably not of practical importance, however. Findings indicate that the rams could probably be used shortly after 7 months of age.

The results of SR-CRSP studies of reproductive characteristics in adult rams are displayed in Tables 2 and 3. Across the three years of research, the effects of breed, age, and season (dry or rainy) on five characteristics were investigated: body weight, scrotal circumference, semen volume, sperm concentration, and sperm motility. The first year of evaluation, all characteristics showed better means.

Junín rams had higher body weight, scrotal circumference, and semen volume than Corriedales and Criollos, but sperm concentration and motility were highest in Criollos (Table 2). There were no differences in seminal characteristics between ages, seasons, or body weight. However, scrotal circumference was higher during the rainy period (October-March), when nutritional conditions were the best (Table 3).

Table 1. Mean, Body Weights, Age, and Scrotal Circumference in Ram Lambs in Puberty Study[1]

Variables	Criollo	Corriedale	Junín
Age (months)			
At penis separation	6.4[b]	6.6[b]	7.8[a]
At first ejaculation	7.0[a]	7.2[a]	8.8[a]
Weight (kg)			
At penis separation	29.1[b]	30.5[a]	28.0[a]
At first ejaculation	22.6[b]	31.7[a]	35.3[a]
Scrotal circumference (cm)			
At penis separation	25.7[a]	24.7[a]	17.3[b]
At first ejaculation	25.3[a]	24.5[a]	21.0[a]
Semen characteristics			
Ejaculate volume (ml)	0.9[c]	0.8[b]	0.6[a]
Motility (%)	50.9[c]	41.9[b]	29.9[a]
Concentration (x 10^6/ml)	1.1[a]	1.1[a]	1.1[a]

[1]P < .05 for means between columns not bearing the same superscript letter.

Table 2. Means of the Characteristics Evaluated by Breed for Adult Rams[1]

Variables	Criollo	Corriedale	Junín
Body weight (kg)	(165)41.7[c]	(145)50.6[b]	(177)64.6[a]
Scrotal circumference (cm)	(251)29.4[c]	(243)31.1[b]	(270)32.5[a]
Semen volume (ml)	(351) 1.1[b]	(296) 1.2[b]	(381) 1.2[a]
Sperm concentration (x 10^6/ml)	(338) 2.2[a]	(284) 2.1[a]	(368) 1.9[b]
Sperm motility (%)	(348)56.4[a]	(295)54.8[a,b]	(379)51.8[b]

[1]Number of observations are shown in parentheses. P < .05 for means with different superscript letters between columns.

Table 3. Means of the Characteristics Evaluated by Years, Breed, Age, and Season for Adult Rams (May 1981 - April 1984)[1]

	Age in Years			Season	
	1.5	2.5	3.5	dry	rainy
Body weight (kg)	(164)47.5^{b}	(157)54.8^{a}	(166)55.7^{a}	(335)52.9^{a}	(152)52.2^{a}
Scrotal circumference (cm)	(260)30.2^{c}	(253)31.2^{b}	(251)31.7^{a}	(388)30.3^{b}	(376)31.8^{a}
Semen volume (ml)	(349) 1.2^{a}	(336) 1.1^{a}	(343) 1.1^{a}	(515) 1.1^{a}	(513) 1.2^{a}
Sperm concentration ($x10^6$/ml)	(337) 2.0^{a}	(324) 2.1^{a}	(329) 2.1^{a}	(512) 2.1^{a}	(478) 1.9^{a}
Sperm motility (%)	(347)55.8^{a}	(335)52.7^{a}	(340)54.2^{a}	(511)55.3^{a}	(511)53.3^{a}

[1]Number of observations are shown in parentheses. $P < .05$ for means with different superscript letters between columns.

Recommendations

Overall, findings denote the Criollo's superior adaptation to sierran conditions. Criollo ram lambs reach puberty and sexual maturity at an earlier age than Junín and Corriedale lambs. Also, adult Criollo rams show higher sperm concentration and motility than the other two breeds. These reproductive characteristics can be useful for breeding programs and for adapting other breeds to similar highland environments.

Findings on seminal characteristics indicate that rams of all breeds studied maintain a level of semen quantity that is high enough for adequate fertility rates throughout the year. Thus, spermatogenic activity and seminal production do not constrain production systems with yearround mating in any of the breeds considered. But Criollo rams were less seasonal than the other two breeds. However, since electro ejaculations were used to obtain semen in the SR-CRSP studies, it still remains to be determined whether highland rams maintain adequate levels of libido yearround.

References

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Breeding: Management of Reproduction

[3] Female Reproduction

Introduction

To achieve the most efficient use of resources in sheep production systems, the ewe flock must reproduce at the optimum rate for its environment. But sheep are seasonally polyestrus, and different breeds have different lengths of breeding season. An understanding of breeding seasons and of seasonal effects on different breeds is therefore important for determining the ideal time to mate ewes. To this end, between April 1981 and April 1984 the SR-CRSP conducted studies of estrus, ovulation, fertility, and prolificacy among Criollo, Corriedale, and Junín ewes in the central sierra of Peru at the Consac production unit of SAIS Tupac Amaru.

Results

Mean results of the three-year evaluation of the incidence of estrus by breed and age are displayed in Table 1. Junín and Corriedale ewes showed higher proportions of estrus than Criollos (Novoa 1988, Vivanco et al. 1985).

Table 1. Incidence (Percent) of Ewes in Estrus and Ewes Ovulating Per Ewe Observed by Breed and Age[1]

	Age in Years			
Breed	**1.5**	**2.5**	**3.5**	**Total**
Percent in Estrus				
Junín	(555)28	(518)33	(545)31	(1618)31 ^{a}
Corriedale	(538)27	(546)31	(554)29	(1638)29 ^{a}
Criollo	(549)24	(549)22	(549)20	(1647)22 ^{b}
Total	**(1642)26 ^{a}**	**(1612)28 ^{a}**	**(1648)27 ^{a}**	**(4902)27**
Percent Ovulating				
Junín	(284)31 ^{a}	(254)32 ^{a}	(253)37 ^{a}	(791)34 ^{a}
Corriedale	(269)26 ^{a}	(279)34 ^{b}	(264)40 ^{ab}	(810)33 ^{a}
Criollo	(252)53 ^{a}	(213)56 ^{a}	(209)54 ^{a}	(674)54 ^{b}
Total	**(805)36**	**(744)41**	**(726)43**	**(2275)40**

[1]Number of observations or number of ewes laparoscopized is shown in parentheses. $P \leq .01$ for means not having the same superscript letter.

Figure 1 displays the means of incidence of estrus by breed and month. Junín and Corriedale ewes showed a higher incidence from March to August. For Criollos, incidence was higher from February to June. All breeds had very low incidence of estrus in October, November, and December.

The number of ewes that ovulated per ewes observed by laparoscopy was significantly higher in Criollos, but there was no difference between Junín and Corriedale ewes. Neither were there any differences between Junín and Criollo age groups. However, older Corriedales (2.5 and 3.5 years) had a higher incidence of ovulation than those in the 1.5-year-old group (Table 1).

The incidence of ewes ovulating per ewes observed by breed and month is displayed in Figure 2. In Junín ewes, this figure was higher from March to June; in Corriedales, from March to July; and in Criollos from January to July. But there was no drastic drop in ovulation incidence in the other months. In November, the incidence of estrus in Criollos was 0.76%, but the ovulation incidence was 49%.

Ovulation rates were similar across breeds and ages (Table 2), but there were variations between months. For all breeds and ages, ovulation rates were lower in September and October, and highest in March.

Table 2. Ovulation Rate Per Ewe Ovulating by Breed and Age[1]

	Age in Years			
Breed	**1.5**	**2.5**	**3.5**	**Total**
Junín	(87)1.1	(88)1.1	(93)1.1	(268)1.1
Corriedale	(70)1.1	(94)1.1	(105)1.2	(269)1.1
Criollo	(133)1.2	(119)1.2	(112)1.1	(364)1.1
Total	**(292)1.1**	**(301)1.1**	**(310)1.1**	**(903)1.1**

[1]Number of ewes ovulating is shown in parentheses.

Table 3 presents the results of the three-year evaluation of the main reproductive traits — fertility and prolificacy — among Junín and Criollo ewes in the central sierra.

There were significant differences in fertility rates (defined as ewes lambing per ewes exposed) between Junín (84%) and Criollo (64.7%) breeds. These findings do not agree with other published results, however. Generally Criollo ewes have higher fertility. Age significantly influenced the fertility rate, which was higher in older ewes, i.e. aged 4.5 years or more.

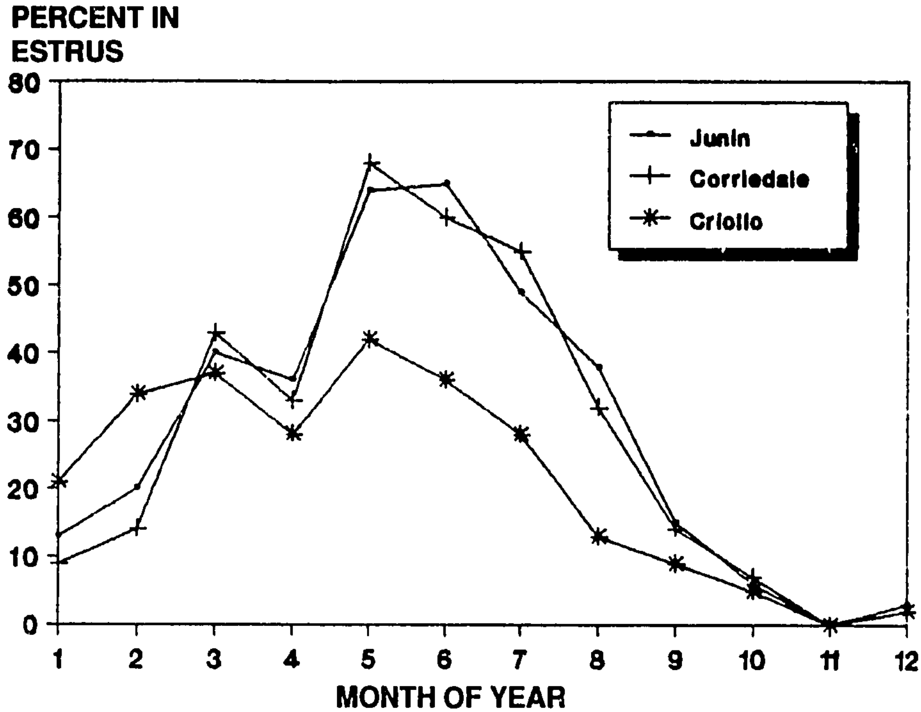

Figure 1. Incidence of ewes in estrus.

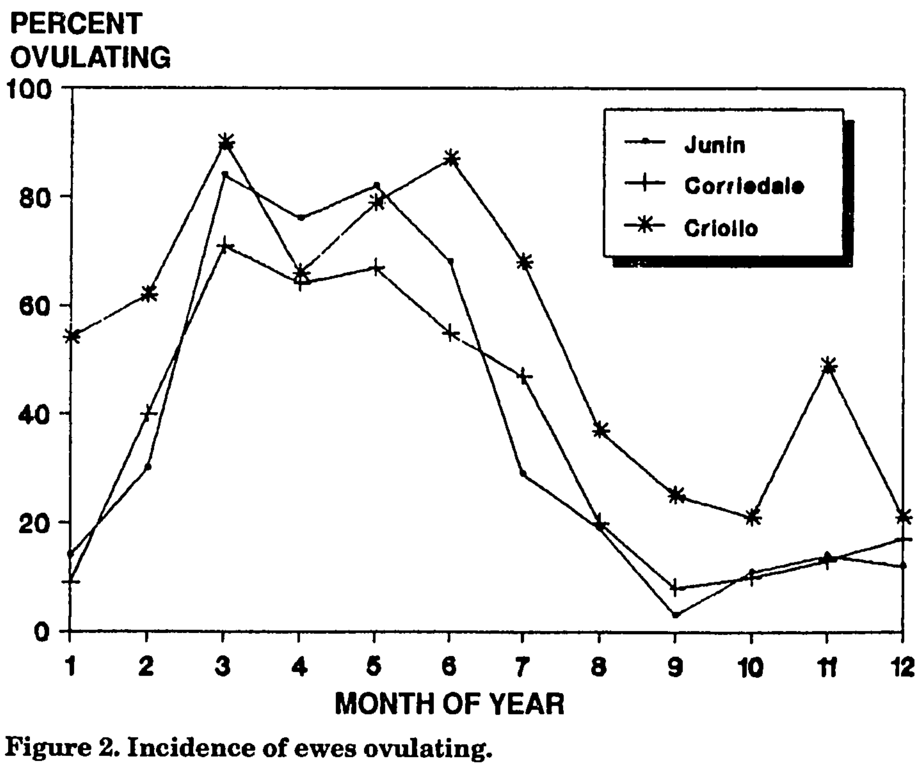

Figure 2. Incidence of ewes ovulating.

The low fertility rate at 1.5 years indicates that many of the ewes had not reached puberty by the start of breeding. The interaction between breed and age was also highly significant. Criollo fertility rates increased with age, from 37.3% at 1.5 years to 93.6% at 4.5 years. In Junín ewes, fertility increased between 1.5 and 3.5 years of age, but decreased at 4.5 years or more.

Table 3. Mean Reproduction Traits of Ewes[1]

Variables	Fertility (percent)	Abortions (percent)	Prolificacy (N)
By Breed			
Criollo	64.7[a]	1.4	1.0
Junín	84.0[b]	1.5	1.0
By Age			
1.5 years	49.5[a]	3.8	1.0
2.5 years	71.3[b]	0.7	1.0
3.5 years	82.3[c]	0.0	1.0
4.5 years	85.2[d]	2.2	1.0
Overall	74.5	1.4	1.0

[1]$P < .05$ for means with different superscript letters by columns within main effects.

Abortion rates were similar across breeds. But again, age had a significant influence. Abortions were higher at 1.5 years and at 4.5 or more years. There were virtually no differences between breeds and ages in prolificacy, which averaged 1.01 lambs born per ewe. Again, as many other studies have also demonstrated, the prolificacy of ewes in the Andean highlands is low compared to other regions of the world. The cause of this is unknown.

All three breeds manifested seasonality in estrus incidence. In ovulation, however, Criollos showed no clear seasonality whereas Junín and Corriedale ewes demonstrated higher incidence from March to June. For Criollos, the period of ovulation was more extended, from January to July. In all breeds, estrus activity was lower from September to January. Incidence of both estrus and ovulation was higher from late summer to early winter, peaking in the fall for Junín and Corriedale ewes.

■ Recommendations

These results suggest that in many cases the breeding season currently being used could be adjusted to get the maximum number of ewes in estrus and thus get more ewes bred.

These findings also explain why, if Criollo ewes are herded with rams yearround, matings can be expected in a significant proportion of the population in seasons other than just autumn. Criollo ovulation is maintained in more than 20% of the ewes during the winter and spring, and in more than 50% during the summer. The ovulation incidence in all breeds was highest in March. This finding should be considered in programming for breeding. It suggests that in order to regulate lambing to a time of the year when nutrition is best, males need to be managed separately from females.

There are no differences in ovulation rates across the three breeds. The average is 1.15 ovulations per ewe that ovulated. So, no one of these breeds can be used to increase the ovulation rate. This finding suggests that under the conditions in which these ewes were raised, if breeding is to occur at 1.5 years then better nutrition may be required, as suggested by the research work of the SR-CRSP Range Management Project (Chapter 4). Not only can low fertility be expected, but also higher abortion rates and lower lamb birth weights.

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Breeding: Management of Reproduction

[4] Mating Systems

■ Introduction

The seasonal timing of mating can drastically affect the percent of ewes that lamb. Since ewes are seasonal breeders, if they are bred when part of the flock is in anestrous, a smaller percentage than normal will lamb. Based on SR-CRSP data collected at SAIS Tupac Amaru on the seasonality of estrus in ewes, a trial was designed to evaluate the effect of changes in the breeding season on lambing rates and ewes' reproductive performance.

■ Results

Results from the first year's evaluation (the 1984 mating season) are displayed in Table 1. There was a significant interaction between breeds and mating periods in reproductive traits (Novoa 1988, Vivanco et al. 1985).

As Table 1 indicates, Junín ewes showed high mating efficiency during the advanced and current mating periods, with rates of 100% and 96.7%, respectively. In the delayed period, only 62% were mated due to anestrus in some ewes. In contrast, Criollos displayed no differences in mating efficiency between periods. Eighty-six percent, 90%, and 93% were mated in periods 1, 2, and 3, respectively.

In both breeds, the percent of ewes that lambed and the fertility rate were higher in the first and second period than in the third. This was probably due to lack of ovulation. The lambing rate was similar for all breeds. The interval between initiation of the mating and actual date of mating was higher in period 3 and lower in period 2 in both breeds.

■ Recommendations

Even with only one year of data, these results clearly show that altering the lambing season can have a deleterious effect on reproductive performance. Moving the lambing season too late in the year significantly reduces the percent of ewes lambing.

However, it is important to remember that lambing should coincide as closely as possible with the start of grass growth, close to the beginning of the rainy season. Otherwise, ewes' milk production will be inadequate to rear their lambs. Moving lambing ahead of the start of the rainy season into the dry season could disastrously increase lamb mortality. Thus, great care must be exercised in making adjustments to the breeding season.

Table 1. Mating Efficiency, Fertility, and Lambing Rates in Adult Ewes According to Mating Periods During the Breeding Season (1984)[1]

Reproductive Traits	Mating Period 1 (16 Apr-30 May)		2 (3 May-16 Jun)		3 (17 Jun-30 Jul)	
Junín						
Ewes mated (%)	100.0	30/30	96.7	29/30	62.0	18/29
Ewes lambed (%)	79.3	23/30	73.3	22/30	13.8	4/29
Fertility rate (%)	96.0	29/30	82.0	24/29	33.3	6/18
Lambing rate (N)	1.0	23/23	1.0	22/22	1.0	4/4
Breeding period to mating date (days)	$14.10 \pm 1.9^{b,B}$		$12.8 \pm 1.7^{a,B}$		$14.3 \pm 5.6^{b,A}$	
Criollo						
Ewes mated (%)	86.7	26/30	90.0	27/30	93.1	27/29
Ewes lambed (%)	70.0	21/30	70.0	21/30	65.5	20/29
Fertility rate (%)	92.0	24/26	85.0	23/27	74.0	20/27
Lambing rate (N)	1.0	21/21	1.0	21/21	1.0	20/20
Breeding period to mating date (days)	$12.6 \pm 1.6^{b,A}$		$10.6 \pm 1.5^{a,A}$		$15.4 \pm 2.1^{c,B}$	

[1]Means with different superscripts in lower-case letters indicate significant differences ($P < 0.01$) between mating periods. Means with different superscripts in capital letters indicate significant differences ($P < 0.01$) between breeds.

References

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Breeding: Management of Reproduction

[5] Ram Stimulation, Lambing Rates, and Estrous Activity

■ Introduction

For many years, the "ram effect" — teasing ewes by introducing sterile rams into the flock just prior to the breeding season — has been practiced as a reproductive management strategy at the farm level. However, the full potentials for commercial application of this practice have become apparent only recently. The ram effect represents a powerful, natural tool for controlling the time of year at which ewes can be mated. It thus makes for concentrated lambing and improvements in fecundity.

SR-CRSP reproductive research at SAIS Tupac Amaru indicated that only 65% to 70% of Junín and Corriedale ewes were cycling during the May-June mating season. Thus a series of trials were mounted to test whether the ram effect could be used to increase the number of ewes in estrus at the start of the breeding season.

The first trial (T1) was conducted at the Consac production unit of SAIS Tupac Amaru, with Junín sheep. Using only animals that had lambed on an annual basis in October and November, 2244 ewes aged 2 to 6 years were randomly assigned by breeding group to one of two ram effect treatments: (1) non-stimulated (n = 1483), i.e. with no exposure to vasectomized rams prior to the start of the breeding season; and (2) stimulated (n = 1501), i.e. with exposure to vasectomized rams for 14 days prior to the start of the breeding season (26 April to 10 May 1986). Ewes in the latter group were exposed to vasectomized rams at a ratio of approximately 75:1.

The second trial (T2) was conducted at the Centro Experimental Chuquibambilla research station of the Universidad Nacional del Altiplano, north of Puno, Peru. The station's 2016 improved Corriedale ewes aged 2 to 8 years were randomly assigned within age to non-stimulated (n = 1035) and stimulated (n = 981) treatments. Exposure to vasectomized rams began on 27 May 1987, 14 days prior to the start of the mating season on 10 June 1987. Ewes were exposed to vasectomized rams to check for estrus. When estrus was detected, the ewes were removed from the flock and bred to a selected sire by artificial insemination.

■ Results

Ram stimulation resulted in 3% more ewes lambing during the lambing season in T1 (Table 1) and 19% more ewes detected in estrus in T2 (Table 2). Stimulation changed the distribution of the lambing dates (T1, Figure 1) and the percent of ewes in estrus (T2, Figure 2). It resulted in 14% more ewes' lambing during the first 17 days of lambing (T1) and 33% more in estrus during the first 17 days of breeding (T2).

Table 1. Effect of Ram Stimulation on Number of Ewes Lambing (Trial 1)[1]

Treatment	Non-stimulated Ewes	Stimulated Ewes
Total ewes	1483	1505
First 17 days		
Number	588	789
Percent	53.9[a]	68.3
Second 17 days		
Number	412	297
Percent	27.8[a]	19.7
Last 21 days		
Number	89	69
Percent	6.0	4.5
Lambing season (55 days)	1089	1155
Percent	73.4[b]	76.7

[1]For figures with superscripts a and b, $P < .01$ and .05, respectively.

Table 2. Effect of Ram Stimulation on the Number of Ewes Detected in Estrus During Successive Intervals of 17 Days (Trial 2)[1]

Treatment	Non-stimulated Ewes	Stimulated Ewes
Total ewes	1035	981
First 17 days		
Number	530	830
Percent	51.2[a]	84.6
Second 17 days		
Number	253	101
Percent	24.4[a]	10.2
Breeding season		
Number	783	931
Percent	75.6[a]	94.9

[1]For figures with a superscript, $P < .01$.

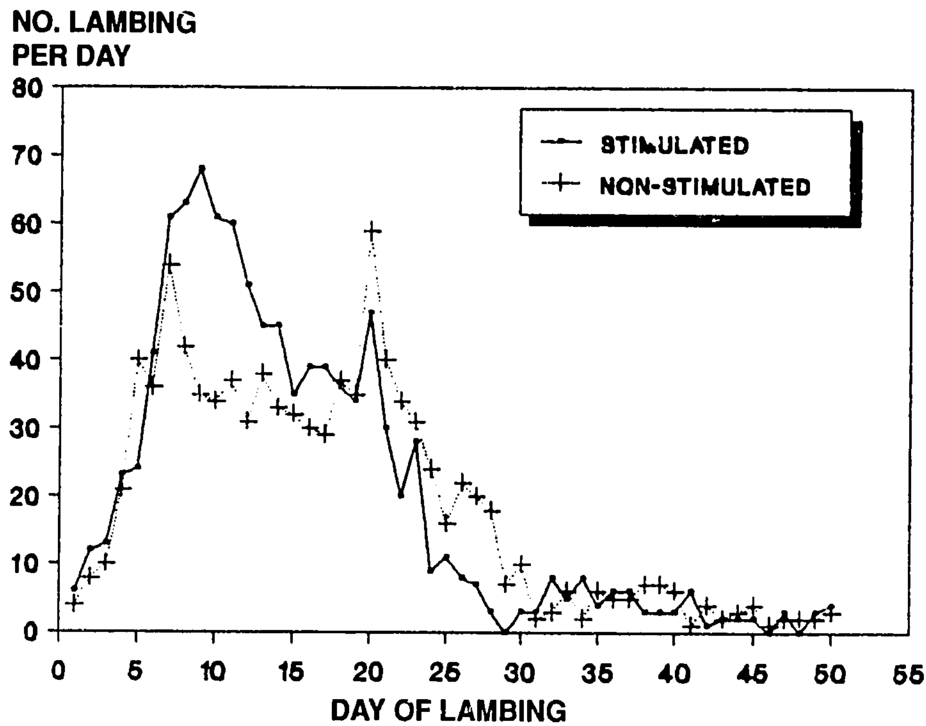

Figure 1. SAIS Tupac Amaru.

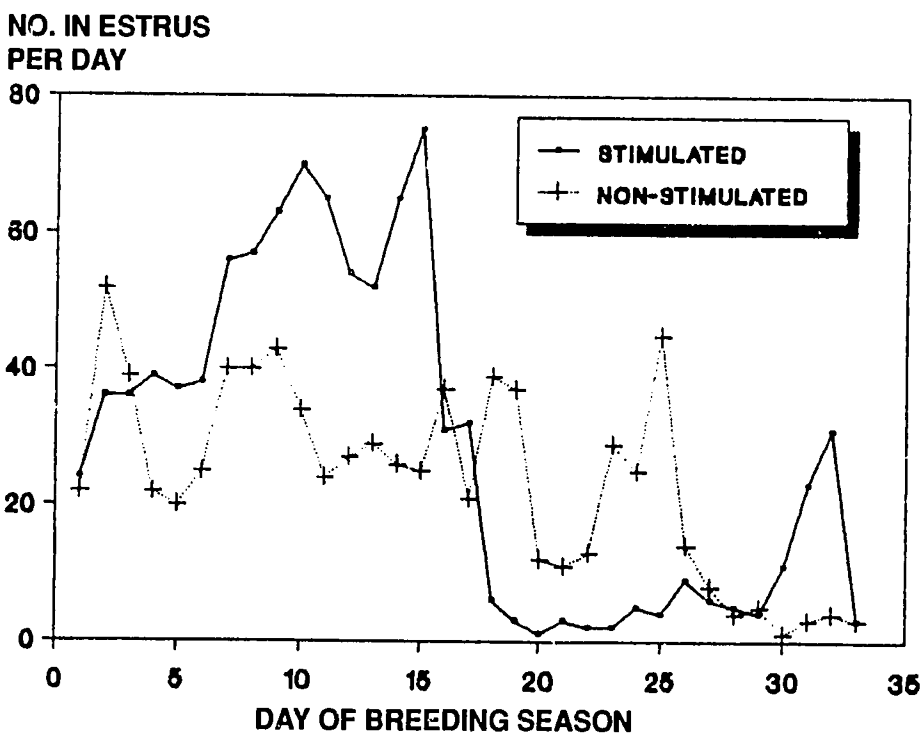

Figure 2. Chuquibambilla.

During the second 17 days of the lambing season, 10% more ewes lambed (T1) and 14% more were in estrus (T2) in the non-stimulated group than in the stimulated group (Tables 1 and 2). However, these figures should be adjusted to discount ewes that became pregnant and lambed during the first 17 days of the lambing season, or ewes that were in estrus during the first 17 days of the artificial insemination season. This adjustment gives an approximation of the actual number of animals that could have been bred so as to give birth during the second 17 days of the lambing season. This recalculation reveals 82% and 81% of the non-stimulated and stimulated ewes lambing, respectively, in T1. In T2, it yields 51% of non-stimulated and 67% of stimulated ewes in estrus.

It would appear that the ram effect had no influence on the pregnancy rate, as estimated from the lambing rate during the second 17 days of the lambing season (T1). Studies from Australia and New Zealand indicate that the ram effect probably works by causing anestrous ewes to begin to cycle rather than by improving conception rates (Burfening et al. 1989).

Recommendations

These findings indicate that even at the peak of the sierran breeding season, exposing ewes to vasectomized rams 14 days prior to the start of the season has a significant impact on reproductive performance in the flock. T1 results indicate a small but significant increase in the number of ewes lambing.

The most dramatic effect in both T1 and T2 was a much higher proportion of ewes lambing early in the lambing season. This should result in more kilograms of lamb weaned and lamb fleece shorn, since the mean age of the lambs would be greater at weaning and first shearing due to their mothers' conceiving earlier in the mating season.

However, it is important to recognize that this practice will be effective only in seasonally anestrous/anovular ewes exposed to rams or vasectomized rams after a period of isolation.

References

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Breeding: Genetics

[6] Genetic Improvement of Criollo Sheep

■ Introduction

Genetic improvement represents a permanent and often inexpensive way to increase livestock productivity. However, altering the genotype of the animal can also impair its adaptation to the environment. Importation of "superior" genotypes from other environments may not necessarily improve indigenous stocks.

For example, studies in the highlands of Colombia found that Criollo ewes significantly out-performed four imported breeds (Rambouillet, Corriedale, American and British Romney) in lamb production, although Criollo growth rate and wool production were lower (Alderson et al. 1982). The Criollo's superiority in lamb production was mainly due to higher pregnancy rates and better lamb survival. These traits relate to biological "fitness" and are generally better in animals that are adapted to their environment.

Therefore, the importation of "improved" breeding stock is not necessarily the best way to enhance indigenous populations. Neither does crossing indigenous stock with improved animals from within the country ensure a superior genotype in terms of lamb production. Faced with a harsher physical environment and less intensive management, such genotypes often suffer depressed rates of reproduction and lamb survival.

For sheep in highland Peru, therefore, selection of animals from either indigenous or improved local populations of Criollos offers an important alternative for genetic improvement. Improvements can result from crossbreeding domestic with Criollo sheep or Criollos with imported breeds. This can significantly enhance some traits of the crossbred lambs and ewes; but as noted above, it can also result in loss of fitness.

An experiment was designed to test these ideas at SAIS Tupac Amaru's Consac production unit, using Junín ewes from the unit's A Class flock along with Criollo ewes purchased from nearby peasant communities. The ewes were exposed to rams of the following four breeds: Junín, also selected from the A Class flock; Targhee, a medium-wooled, large-bodied breed; one-half Targhee by one-half Finnish Landrace, a small but highly fertile and prolific breed; and Criollo.

■ Results

Mating occurred in May with lambing in November. Body weights were measured at birth and weaning. Also, both body and fleece weights were taken at first and second shearing (approximately 8 and 18 months of age, respectively).

Table 1. Reproduction of Junín and Criollo Ewes Mated to Junín (J), Targhee (T), One-half Finn (F), or Criollo (C) Rams

Breed Sire x Breed Dam	Number Mated	Number Lambing[1]	Number Weaned[1]
JxJ	598	(82) 494	(71) 353
TxJ	547	(78) 427	(69) 297
FxJ	552	(72) 402	(71) 287
JxC	103	(74) 77	(92) 71
TxC	106	(70) 75	(89) 67
FxC	95	(74) 70	(94) 66
CxC	140	(84) 118	(89) 105

[1]Percent of observations are shown in parentheses.

Table 2. Growth Rates and Fleece Weights of Progeny of Junín and Criollo Ewes Mated to Junín (J), Targhee (T), One-half Finn (F), or Criollo (C) Rams

	Body Weight (kg)				Fleece Weight (kg)	
Breed Sire x Breed Dam	Birth	Weaning	First Shearing	Second Shearing	First Shearing	Second Shearing
JxJ	3.8	22.4	28.8	40.6	1.4	2.0
TxJ	3.7	22.3	27.7	40.0	1.4	1.9
FxJ	3.6	21.5	27.5	39.1	1.3	1.9
JxC	3.1	20.2	25.6	34.4	n.d.	2.2
TxC	3.1	19.9	25.5	33.8	n.d.	2.2
FxC	3.0	19.4	25.1	30.7	n.d.	1.9
CxC	2.4	16.5	20.3	25.2	n.d.	1.3

The reproductive rates of the Junín and Criollo ewes mated to the various breeds of sires are shown in Table 1. It is noteworthy that the percent of ewes lambing is highest for Junín-Junín and Criollo-Criollo matings. This suggests that these breeds may be the best adapted for this trait in the highland environment.

Survival from birth to weaning was notably higher in Criollo (91%) as versus Junín ewes (71%). Interestingly, growth rate was the opposite of survival rate. Birth weight was heavier in lambs with Junín as versus

Criollo sires. Body weight at weaning and at first and second shearing was also heaviest in Junín-sired lambs. Criollo-Criollo crosses ranked the lowest on all growth traits (Table 2).

Growth to weaning, first shearing, and fleece weight at first shearing normally only tell part of the story about crossbred animals. Many ewes are kept and used to produce other offspring for sale or consumption later in life. The crossbred females' productivity after they entered the breeding flock was therefore also studied. The growth rate and fleece production of the lambs they produced are shown in Table 3.

Table 3. Body Weights and Fleece Weights of Progeny from Crossbred Ewes[1]

Breed	Birth Weight	Weaning Weight	Body Weight FS	Fleece Weight FS	Body Weight SS	Fleece Weight SS
JxJ	3.8[a]	21.4[a]	27.5[a]	1.4[a]	39.1[a]	1.9[a]
TxJ	3.7[b]	22.3[b]	27.7[a]	1.4[a]	40.6[a]	1.9[a]
FxJ	3.6[c]	22.4[b]	28.8[b]	1.3[b]	39.1[b]	1.9[a]
JxC	3.1[a]	20.3[a]	25.6[a]	n.d.	34.4[a]	2.2[a]
TxC	3.1[a]	20.0[a]	25.4[a]	n.d.	33.9[a]	2.2[a]
FxC	3.0[a]	19.5[a]	25.1[a]	n.d.	30.8[b]	1.9[b]
CxC	2.4[b]	16.4[b]	16.5[b]	n.d.	25.3[c]	1.3[c]

[1]All weights are given in kilograms. $P < .05$ for figures with different superscript letters between columns. C=Criollo, J=Junín, T=Targhee, F=Finnish Landrace. FS=first shearing, SS=second shearing.

The least productive in terms of these two traits was the Criollo group. But the lambs raised by the Criollo by Junín, Targhee, or Finnish dams were always smaller and produced less fleece than those raised by the Junín by these same species dams. However, when reproductive rate and lamb survival are taken into account, the ranking of the breed groups changes considerably (Table 4). Lamb weaning weight per ewe lambing always favors the ewes sired by the Junín, Targhee, or Finnish rams from the Criollo ewes. This is a result of the superior survival of the lambs raised on these dams. Furthermore, when productivity is expressed in terms of lamb weaned per ewe exposed for breeding (which takes into account fertility, survivability, and growth rate), then regardless of sire, all of the groups from Criollo ewes were superior to the ewes derived from the Junín breed as the ewe base.

When the crossbred lambs became mothers, their superior maternal ability for fertility and survival made them more than competitive with the improved breed groups. Therefore in terms of kilograms of lambs weaned per ewe in the flock, the crossbred ewes of Criollo origin equalled or bettered those of "improved" origins. These results clearly indicate that crossing the Criollo ewe with other breeds can greatly improve productivity.

Table 4. Reproductive Rate and Kilograms Weaned per Ewe from Crossbred Groups

Breed[1]	Number Ewes Exposed	Number (percent) Lambs Born	Number (percent) Lambs Weaned	Lamb Weaning Weight (kg) per Ewe	
				Born	Exposed
JxJ	603	(82) 494	(71) 353	15	12
TxJ	560	(76) 427	(70) 297	16	12
FxJ	555	(72) 402	(71) 287	16	11
JxC	103	(75) 77	(92) 71	19	14
TxC	102	(74) 75	(89) 67	18	13
FxC	93	(75) 70	(94) 66	18	14
CxC	138	(86) 118	(89) 105	15	12

[1]C=Criollo, J=Junín, T=Targhee, F=Finnish Landrace.

Recommendations

These findings suggest that under the conditions in which these ewes were being maintained, the Criollo was much better adapted for lamb survival. This difference would likely be even more pronounced in the flocks of peasant communities, where conditions are generally poorer than at SAIS Tupac Amaru. However, Criollo lambs lagged behind Junín lambs in growth.

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Breeding: Genetics

[7] Genetic and Environmental Factors Affecting Growth Rate and Survival of Junín Sheep

■ Introduction

In order to make genetic improvements in growth rate and fleece production of sheep, accurate estimates of environmental and genetic parameters affecting these traits are necessary. This information is also important for calculating direct and correlated response to selection and for constructing selection indexes where appropriate.

Although many estimates of such parameters are available for sheep in other parts of the world (see Turner and Young's 1969 summary), there are none for the Andes. The SR-CRSP therefore mounted a program to systematically evaluate the environmental and genetic factors impinging upon survival, growth rate, and fleece production of lambs in the highlands of the South American Andes.

This study was carried out at the Consac production unit of SAIS Tupac Amaru in the central highlands of Peru, using Junín sheep. The SAIS generally conducts breeding in May-June so that lambing occurs in October-November at the start of the rainy season. The lambs are weaned in late March, around the start of the dry season. Shearing is done annually in February, except for the first shearing of lambs at 8 months of age.

■ Results

The results of the studies of the environmental factors that affect lamb growth and fleece weight are presented in detail in Carpio and Burfening 1988. In summary, however, year of birth, sex of lamb, age of dam, and age of lamb were all very important factors affecting the body and fleece weights of lambs. These effects need to be taken into account when considering lambs for selection.

Sire within year of birth affected all traits studied. In general, heritability estimates (Table 1) were somewhat lower than most of those reported in the literature (Turner and Young 1969). However, no similar estimates are available for sheep managed in highland Andean environments.

Estimates based on the heritabilities and genetic correlations presented in Table 1 indicated a direct and correlated response to selections (Falconer 1981). As Table 2 suggests, selection for lamb birth weight would improve survival, a trait that cannot be selected for directly. However, this would result in only a small increase in weaning weight. Direct selection for weaning weight or for body weight at first shearing would result in a large direct effect on growthrate and a correlated effect on fleece weight. But such selection would still have only a small positive influence on birth weight; this would increase lamb survival only slightly.

Table 1. Heritabilities and Genetic Correlation among Traits Studied[1]

Trait	Birth Weight	Survival	Weaning Weight	Body Weight FS	Fleece Weight FS	Body Weight SS	Fleece Weight SS
Birth weight	.17 ± .03	.34 ± .19	.42 ± .13	.07 ± .19	.50 ± .16	.28 ± .20	-.22 ± .22
Survival		.04 ± .02					
Weaning weight			.21 ± .04	.90 ± .06	.72 ± .11	.82 ± .12	.15 ± .21
Body weight FS				.24 ± .05	.75 ± .11	.92 ± .14	.02 ± .32
Fleece weight FS					.18 ± .05	.50 ± .19	.32 ± .34
Body weight SS						.14 ± .04	.13 ± .23
Fleece weight SS							.12 ± .04

[1]Heritabilities are displayed on the main diagonal with genetic correlations shown above the diagonal. FS = first shearing, SS = second sheering. All weights are given in kilograms.

Table 2. Direct and Correlated Responses to Selection for Traits Studied[1]

Correlated trait	Direct Trait						
	Birth Weight	Survival (Percent)	Weaning Weight	Body Weight FS	Fleece Weight FS	Body Weight SS	Fleece Weight SS
Birth weight	.11	.02	.04	.01	.06	.03	-.02
Survival (percent)	1.15	1.75	.44[2]	.09[2]	.59	.29[2]	-.21
Weaning weight	.31		.83	.79	.55	.45	.10
Body weight FS	.05		.79	.92	.62	.66	.01
Fleece weight FS	.02		.04		.05	.02	.01
Body weight SS	.20		.68	.56	.40	.67	.09
Fleece weight SS	-.01		.05	.01	.02	.01	.04

[1]FS = first shearing, SS = second shearing. All weights are given in kilograms.

[2]Estimated indirectly via correlated response in birth weight.

Recommendations

Selection for birth weight will improve lamb survival by .66 compared to direct selection for lamb survival. Still, selection by birth weight yields only a .31 kg increase in weaning weight, as compared to .83 kg with direct selection for weaning weight. Further, direct selection for weight at weaning would result in a small increase in lamb survival through the positive genetic correlation with birth weight. It would also increase fleece weight at both the first and second shearings.

These results clearly indicate that even in the harsh, high-altitude environment of the Andes, there is considerable genetic variation for growth and fleece weight traits in improved sheep. Hence, selection within these flocks would result in genetic progress in these traits. The data also clearly show that environmental effects such as year, sex of lamb, and age of dam also need to be accounted for in a selection program.

Currently, however, selection in Peru's improved flocks is largely based on phenotypic measures of growth and fleece production. No program at either the flock or the national level exists to accurately estimate the breeding value of animals selected to parent the next generation. Hence little genetic progress is being made except through importation of rams from other countries with such programs.

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CHAPTER 6

DIAGNOSIS AND CONTROL OF DISEASES IN SHEEP AND ALPACA IN PERU

Chapter 6

Diagnosis and Control of Diseases in Sheep and Alpaca in Peru

Animal Health

[1] Introduction

Peru is currently the largest camelid-producing country in the world and the fourth largest sheep-producing nation in the Americas. Peru's sheep and camelid populations are estimated at 13.7 million and 3.6 million, respectively. The sheep and alpaca industries are vital to the national economy, as well as to rural communities, which depend upon these animals for food, fiber, and fertilizer.

The Animal Health Project of the Small Ruminant Collaborative Research Support Program (SR-CRSP) has been investigating diseases of sheep and South American camelids since 1980. The present publication provides up-to-date information collected by SR-CRSP researchers on these diseases. The chapter is directed to people responsible for the maintenance of small ruminant health in Peru and neighboring Andean countries.

The chapter is divided into six parts, including diseases of neonates, young animals, yearlings, and adult animals; diseases associated with infertility and abortions; and flock management. Spanish or local names for diseases are underlined. Within each section, relevant diseases are defined and their cause, diagnosis, prevention, and treatment are discussed. The results of SR-CRSP research and consequent recommendations for disease control are incorporated into the diagnosis and prevention/treatment sections of each disease.

Selected references are given at the end of each section. These references are not intended to reflect a comprehensive review of the subject, but rather to emphasize the results of SR-CRSP-sponsored research and to provide the reader with a few additional, general references relevant to the subject of each section.

Diagnostic guides have been prepared to help differentiate diseases with similar clinical signs. These guides are grouped together in an annex at the end of the chapter.

Animal Health: Diseases of Neonates

[2] Neonatal Diarrhea Complex
(scours, enteritis, diarrea neonatal)

Introduction and Causes

Diarrhea is commonly associated with neonatal deaths in alpaca crias (Moro 1987), young lambs, and goat kids. It consists of inflammation of the intestines, which can result from a number of infectious agents and toxic substances, including bacteria (Ameghino 1979, 1985; Ameghino et al. 1984; Meyers et al. 1986), viruses, or protozoa (Annex Table 1).

- Colibacillosis. Also known as white and yellow scours, this diarrheal disease is associated with pathogenic strains of Escherichia coli and death in neonates after 5 days of age. However, the disease can be observed in camelids over a month old (Ellis et al. 1984, Ramírez 1988, Ramírez and Ellis 1988). It is most common where animals are born under unhygienic conditions. The animals scour profusely and become weak and dehydrated. Death is usually due to dehydration or, more rarely, terminal colisepticemia.
- Salmonellosis. Many serotypes of salmonella can cause disease in several species and classes of animals, but newborns are the most vulnerable to scouring and death from septicemia. This pathogen has not yet been reported among neonates in Peru.
- Lamb dysentery. Also known as bloody scours or enteritis, most cases are associated with Clostridium perfringens type B; but C. perfringens types can also be involved (see section 3). The bacteria affect lambs during the first 10 days of life. Clinical signs include profuse blood-stained scours, abdominal pain, and rapid death. C. perfringens type A is more frequent in lambs in Peru's central sierra while type B is more common in Puno Department.
- Viral diarrhea. Viruses are an important cause of neonatal diarrhea in most species. In lambs, rotavirus is considered the most frequent causal agent. It is common throughout the world, but its relative importance as a cause of diarrhea in small ruminants in Peru has yet to be determined, although this virus has been observed by electron microscopy in feces of diarrheic lambs.
- Protozoal enteritis or crytosporidium. The most recently described cause of neonatal diarrhea in lambs, this disease is caused by a small protozoan parasite related to the enteric coccidia. However, the parasite has a short life (10 to 15 days) and apparently lacks host specificity. It has been found in healthy llama and alpaca (Rojas et al. 1988).

Diagnosis

Because the clinical signs and postmortem lesions are similar in all cases of neonatal diarrhea, laboratory examination is required for diagnosis. Samples submitted to the laboratory should include feces or intestinal contents (20-30 ml if possible) and carcasses. For definitive diagnosis of colibacillosis, an acutely infected untreated lamb should be sacrificed. To diagnose lamb dysentery, laboratory demonstration of the specific toxin is necessary.

Prevention and Treatment

Suckling immediately after birth helps prevent some of the problems of the diarrheal complex (Garmendia et al. 1987, Garmendia and McGuire 1987). Antibodies in the dam's colostrum are absorbed into the bloodstream of the newborn, where they ward against septicemic diseases. Continued suckling helps protect the intestine against many causes of diarrhea. Lamb dysentery or enteritis is the only form of neonatal diarrhea for which specific prophylactic measures are available. An adequate clostridial vaccination program should be instituted. Young ewes should have two doses at least two weeks apart, and be re-vaccinated yearly. The booster must be given at least two weeks before lambing, and never during the last two weeks of gestation.

Rapid diagnosis is important so that adequate steps can be taken in face of an outbreak. These include isolation and early treatment of affected animals. Antibiotics and sulphonamides are widely used for prophylaxis and treatment of neonatal diarrhea in lambs, but these drugs are not usually effective in controlling the disease. Due to the difficulty of differentiating pathogenic and nonpathogenic bacteria, however, the efficacy of these drugs is questionable. Septicemic animals should be treated both parenterally and orally. Specific treatments for viruses and cryptosporidia are not available. With these and other causes of neonatal diarrhea, non-specific treatments are the most effective, e.g., using an absorbent such as kaolin backed up by fluid and electrolyte replacement therapy, and isolating, nursing, and warming sick animals.

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Animal Health: Diseases of Neonates

[3] **Enterotoxemia**

(sudden death, clostridiosis, enteritis, muerte súbita)

Introduction and Cause

Enterotoxemia is the most important infectious disease in neonatal camelids (Moro 1987, Ramírez and Ellis 1988, Ramírez et al. 1985). It is characterized by sudden death, with neonate mortality rates as high as 50% during the first month of life. The disease is also a problem for sheep enterprises (Ameghino et al. 1984, Myers et al. 1986).

Clostridium perfringens type A is usually involved (Ramírez et al. 1988). This bacterium mainly affects camelid neonates from 1 to 4 weeks old, and lambs after 24 hours of age (Ameghino 1985). It lives in the soil and is normally found in the intestines of both humans and animals. Heavy rainfall, poor sanitation, and herd concentration encourage the disease. Enterotoxemia can also be triggered by changes in normal digestive development that allow the bacteria to multiply, thus producing a potent toxin.

Diagnosis

During the camelid birth season, sudden deaths among crias in good body condition may indicate enterotoxemia, as do abdominal distention and neurological signs such as rapid convulsions and opistotonus. Diarrhea is usually not observed in camelids (Annex Table 1), except when sudden death is associated with viral or E. coli infections. However, diarrhea is often observed in affected lambs. At necropsy, fluid and gas accumulation, mainly in the small intestine, is common. In some cases, changes in lung color (congestion) and red spots on the external membranes of the intestines (hemorrhages in the intestinal subserosa) are also observed (Figure 1). Sometimes the only pathologic finding of enterotoxemia in lambs is fluid in the heart sac. Definitive diagnosis is achieved through laboratory detection of the enterotoxin.

Prevention and Treatment

Adequate care and management of neonates during the birth season will help prevent enterotoxemia. At present, no commercial vaccine exists, but one is under development. Antimicrobial drugs and fluid and electrolyte replacement can be used in mixed enterotoxemia cases.

Figure 1. Enterotoxemia in a 4-day-old lamb. Observe the hemorrhagic enteritis and congestion in other parts of the intestine.

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Animal Health: Diseases of Neonates

[4] Acute Pneumonia

(enzootic pneumonia, neumonia aguda)

■ Introduction and Cause

This disease complex affects both sheep (Ameghino 1985, Ameghino et al. 1984, Kimberling et al. 1988, Martin 1983, Rosadio 1988) and goats. Neonatal alpaca also frequently die from acute pneumonia. Various microorganisms (virus, bacteria, etc.) damage the lungs (pneumonia) or other organs (septicemia). The microbes usually infect immunologically weak lambs, i.e. those that receive insufficient colostrum. Acute pneumonia is also common among animals raised in poor sanitary conditions, where microbe concentrations are highest. The disease may be chronic or acute. In the latter case, death ensues within a few hours. Acute pneumonia is commonly associated with pneumonic pasteurellosis caused mainly by Pasteurella multocida or P. haemolytica, but the role of these bacteria is still poorly understood (Ellis 1984). In more severe and fatal cases, Pasteurella bacteria are present.

■ Diagnosis

The affected lambs exhibit sudden depression and may have respiratory difficulties (Annex Table 2). The disease is usually fatal, and lambs may die suddenly without any previous clinical signs (acute septicemia or acute pneumonia). Examination of the thoracic cavity of every dead animal is recommended. Lungs are firm and red, and they sometimes adhere to the ribs. If the animal has died from septicemia, red spots (hemorrhages) will be observed under the skin and in the lungs, liver, or heart. A veterinarian, field technician, or veterinary laboratory can help clarify the cause of death.

■ Prevention and Treatment

Many lambs die as a result of poor care. Special precautions must be taken during the birth season (see section on care of newborns). Acute pneumonia is usually associated with immunologically weak animals, low-resistance neonates, and severe weather. Therefore, make sure that neonates suckle within the first 6 hours after birth and protect them against extreme weather. Try to place abandoned young with a foster dam. At the first sign of sickness, oral antibiotics may be useful. But remember that the survival of newborn lambs will depend on how much protection (antibodies) they get from their mother's milk during the first 24 hours of life. This is their best protection against infectious diseases.

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[5] Navel Infections

(omphalophlebitis, pyosepticemia, navel ill, onfaloflebitis, piosepticemia)

■ Introduction and Cause

This neonatal disease is observed in 3 to 7-day-old lambs (Ameghino 1985, Ameghino et al. 1984, Myers et al. 1986). The disease is caused by bacteria (Staphyloccus aureus) that produce pus. The microbes usually enter the bloodstream through the navel, leading to a generalized infection (septicemia) that may concentrate in the joints and thus produce arthritis. Microbial infection occurs when the umbilical cord is not properly disinfected immediately after birth.

■ Diagnosis

Navel infections are easy to recognize because the affected lambs exhibit high fever, severe depression, and enlargement of the navel stump (Annex Table 3). Some animals may also develop swollen and painful joints that may exude a yellow or greenish pus. Lameness from suppurative arthritis may ensue. Necropsy reveals enlarged, pus-filled joints and internal organs (mainly the liver, but also spleen, pericardial sac, lungs, kidneys, and even the spinal cord) with purulent nodules (abscesses) that destroy the tissues (Figure 1). Tissue samples from the joints or any internal organ may be used to identify the microbes in the laboratory.

■ Prevention and Treatment

This disease is easily controlled by good management during lambing. Lambing paddocks should be kept clean. To avoid contamination, no other animals should ever be placed in these paddocks. The umbilical stump must be cleaned and disinfected immediately after birth. An effective and economical method is to dip the stump in a flask containing 7% iodine or merthiolate solution. In the early stages of the disease, antibiotics may be beneficial; but if the joints have been affected, full recovery is unlikely. The microbes can also infect humans, so be very careful when handling infected animals and wash your hands afterwards.

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Figure 1. Pyosepticemia in a young lamb. The disease may have been a consequence of inadequate colostral antibody absorption. Besides suppurative arthritis in the forelimbs, this lamb had an abscess in the spinal cord.

Animal Health: Diseases of Young Animals

[6] The Diarrhea Complex in Young Animals
(complejo diarreico en crias)

■ Introduction and Causes

This section concerns diarrhea observed among animals from 4 weeks of age to weaning (Ameghino 1979, Leguía et al. 1988, Moro 1987, Ramírez 1987). Various causes are possible. Consult Annex Table 1 for differential diagnoses.

- Salmonellosis. In this age group the frequency of occurrence of salmonellosis is the same as in newborns.
- Coccidiosis. Clinical cases of coccidiosis in sheep in Peru are rare; but in alpaca young, coccidiosis appears to be a common cause of bloody diarrhea and even of sudden death (Moro 1987). Infection occurs through ingestion of the coccidial oocysts. The ubiquity of the parasite guarantees considerable oocyst contamination of pastures and hence the exposure of young animals to the disease. Chronic infection of adult animals ensures a continuing reservoir of infection. Normally oocysts first appear in the feces when lambs are about 2 weeks old; incidence peaks at 4 to 8 months and then progressively declines.
- Parasitic gastroenteritis. Caused by helminth parasites, in lambs this disease is a major source of indirect economic loss for the sheep industry. Losses are due not only to lamb mortalities and weight loss during clinical outbreaks of the disease, but also to the more insidious but equally important effects of unthriftiness, poor growth rates, and inefficient feed conversion that accompany subclinical infection (Leguía et al. 1988). In Peru, the major helminth species involved are: for sheep, Ostertagia and Nematodirus spp. and, less frequently, Cooperia and Trichostrongylus spp.; and for alpaca, Ostertagia, Graphinema, Spiculoteragia, Nematodirus, and Lamanema spp. The disease normally results from a build-up of infestation in pastures repeatedly grazed by ewes and lambs over several years. In these pastures, animals ingest the third-stage larvae that develop from the eggs passed in the feces of infected ewes or lambs. The larvae invade the gastric or intestinal mucosa, where they impair digestion and absorption of nutrients, thus causing diarrhea and, in severe cases, death.

■ Diagnosis

For salmonellosis and coccidiosis, signs include diarrhea, blood-stained feces, loss of weight, dehydration, and sometimes death. In coccidiosis, diagnosis based on oocyst counts is difficult. At necropsy, coccidiosis can be diagnosed by raised "white spots" of varying length in the small and large intestine. The mucosa of these parts is thickened and inflamed.

Parasitic gastroenteritis must be suspected when diarrhea, weight loss, and dehydration are observed in a group of lambs. A presumptive diagnosis can be made based on grazing history and the seasonality of outbreaks. Fecal egg counts of undosed lambs may be useful. Inflammation and thickening of the abomasum, intestinal lesions, and post-mortem observation of large numbers of worms are diagnostic.

■ Prevention and Treatment

Prophylactic measures include grazing young lambs on pastures not grazed by sheep in the previous year and changing the parturient field annually. This prevents deposition of the oocysts, which are capable of surviving the winter in the soil. Where this is not possible and the problem occurs annually, feeding ewes a coccidiostat near lambing time limits oocyst exposure for young susceptible animals. Various drugs have been used as water or feed additives to treat and prevent salmonellosis and coccidiosis. Cocciostats may also be incorporated in salt blocks.

The best preventive measures for parasitic gastroenteritis are routine worming and keeping feces out of the feed source, i.e. strategic anthelmintic therapy combined with grazing management. A variety of anthelmintics are available, but the newer broad-spectrum drugs are generally the most effective. To reduce the build-up of infestation, avoid grazing successive lamb crops on the same pastures. If animals cannot be moved to safe pastures, then a more intense therapy will be necessary. A number of home remedies have been used with some success by peasant communities (Bazalar and McCorkle 1989).

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Animal Health: Diseases of Young Animals

[7] **Contagious Ecthyma**
(orf, sore mouth, ectima)

Introduction and Cause

Ecthyma is an infectious and contagious skin inflammation or dermatitis (Ameghino 1979). Camelids are less susceptible to this disease (Moro 1987, Rivera et al. 1987). Ecthyma is caused by parapoxvirus. The virus can spread rapidly when too many animals are grazed on ligneous pasture. This induces mouth lesions through which the virus can enter the body.

Diagnosis

The disease is diagnosed by scabs on the lips, nose, eyelids, or other parts of the face, and on the udder, feet, and occasionally the mouth and gums. The affected lambs cannot feed well and lose weight. Ewes are rarely impaired, but lesions on the teats and udders may lead to rejection of suckling lambs and to mastitis. Affected lambs sometimes have foot lesions (Annex Table 3).

Prevention and Treatment

The virus is highly resistant. It can survive in the scabs for several months. To control ecthyma, examine ewes and newborn lambs and isolate all affected animals. Effective vaccines are available, but they consist of virulent, infectious virus. Therefore, lambs should be vaccinated in a hairless area such as the axillary area ("armpit") within the first month of life. In an outbreak, healthy lambs should be vaccinated to shorten the course of the disease and to avoid secondary bacterial infection. The skin lesions can be treated with antibiotic ointments. Since the ecthyma virus can also infect humans, do not handle vaccines or sick lambs without some protection such as gloves.

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[8]

Necrotic Stomatitis

(buccal necrobacillosis, laryngitis, estomatitis)

■ Introduction and Cause

This disease is caused by a microorganism (Fusobacterium necrophorum) that normally lives in the soil (Moro 1987). The microbe may penetrate through cuts made by grazing ligneous pastures or from drenching. Both sheep (Ameghino 1979) and alpaca young are quite susceptible to necrotic stomatitis.

■ Diagnosis

The disease is characterized by a sore and swollen throat, breathing difficulties, and necrotic, malodorous lesions on the soft and hard palate, tongue, and glottis. The lesions sometimes descend and produce an aspiration pneumonia and necrotic gastritis (abomasitis).

■ Prevention and Treatment

Good neonate management is the way to prevent necrotic stomatitis. Reserve fresh pastures for lambs and lambing. Carefully avoid mouth damage during drenching and oral administration of antibiotics to lambs. Treat sick animals with antibiotics, sulfonamides, or nitrofuranes for at least 3 days parenterally, and topically treat the lesions.

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[9] Keratoconjunctivitis

(blindness, infectious keratitis, cequera)

■ Introduction and Cause

Keratoconjunctivitis is characterized by wet eyes and vision problems (Ameghino 1979, Kimberling et al. 1988, Martin 1983). While it can affect sheep of any age, it is most common among young lambs. This disease can be caused by several pathogens as well as by genetic predisposition. In newborn lambs, keratoconjunctivitis results from a congenital defect in which the eyelid is turned inward (entropion) so that the eyelashes irritate and inflame the eyeball. Infections of both the conjunctiva and the cornea (infectious keratoconjunctivitis) are associated with chlamydial organisms. These infections occur after the first month of life, sometimes affecting up to 50% of the lambs. Chlamydial strains have been identified that initially damage the eyeball and predispose the animal to secondary bacterial infections. Other eyeball damage may result from physical injuries.

■ Diagnosis

Lambs with cloudy and wet eyes may suffer from this disease. An inward-turned eyelid may be caused by inbreeding. Infectious blindness can affect one or both eyes. Early changes include red (pink eye) and profusely watering eyes (conjunctivitis). As the disease progresses, a cloudy membrane appears and covers part or all of the eye (keratitis). These changes sometimes lead to ulceration and perforation of the eye. Vision problems may lead to poor feeding, accidental death, and increased losses to predators.

■ Prevention and Treatment

Entropion can be corrected surgically. Infectious keratoconjunctivitis usually occurs during dry weather when dry grasses and seeds can injure the eyeball. Avoid using dry pastures for lambs and keep sleeping areas clean. Since this disease is transmitted by close contact with affected animals, separate them from the rest of the flock. Treat the infected eyes with sulfa and/or antibiotics.

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[10] Atypical Pneumonia
(neumonia)

■ Introduction and Cause

In contrast to fatal acute pneumonia (pasteurellosis), atypical pneumonia is often subclinical and frequently fatal (Kimberling et al. 1988, Martin 1983). It affects animals aged 2 weeks to 12 months (Ameghino 1988), and is also believed to affect young camelids. This pneumonia appears to be directly related to stress. The disease is produced by various microorganisms — including viruses, mycoplasma, and bacteria — that parasitize the lungs (Hung et al. 1988). These agents act alone or in cooperation to damage the lungs of poorly-managed animals or of those exposed to extreme daily variations of temperature. Severe and fatal cases are accompanied by bacterial pneumonia, which can lead to death (Rosadio 1988).

■ Diagnosis

Animals suffering from atypical pneumonia exhibit sudden depression, breathing difficulties, fever, and cloudy nasal (mucopurulent) secretions. Animals less than one year old are most likely to die, especially if they are stressed by adverse climate or poor management. At autopsy, the lungs are firm and red or gray in color, with lesions of varying severity depending on the microorganisms present. The affected areas lie near the trachea, and visibly contrast with the normal lungs. In more severe cases, the lungs adhere to the rib cage (pleuritis). This type of pneumonia differs from chronic pneumonia in adult livestock. Animal age can help to differentiate between atypical versus chronic, virus-induced pneumonias (Annex Table 2).

■ Prevention and Treatment

Respiratory problems are commonly observed in animals that have been poorly protected immunologically or that have been exposed to severe weather. Hence it is important to maintain a good drenching program for young lambs; and during cold weather, avoid stressful activities (e.g. shearing, moving flocks) that decrease the normal immune defenses. No treatment is available for viral infections. Drug therapy with antibiotics by parenteral routes will control only mycoplasma and secondary bacterial infections.

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[11] Verminous Bronchitis

(lungworm, estrongilosis pulmonar, bronquitis verminosa)

■ Introduction and Cause

Primarily a condition of young sheep, verminous bronchitis is caused by a round, white worm (Dictyocaulus filaria) in the airways, i.e. the trachea and bronchi (Kimberling et al. 1988, Martin 1983). However, alpaca may also be affected (Guerrero and Leguía 1987)).

■ Diagnosis

Affected sheep exhibit coughing, respiratory difficulties, weight loss, and in some cases, nasal and ocular discharges (Annex Table 2). At post-mortem examination, adult parasites are easily recognized in the main airways (bronchi). In severe cases the worms may even block terminal air passages. Verminous bronchitis must be differentiated from infection by Muelleris capillaris, which produce micronodular lesions deep in the lung.

■ Prevention and Treatment

Rotate and drain pastures during the dry season in order to reduce the number of larvae. Drugs are available to treat this disease.

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[12] **Taeniasis**
(tapeworm, teniasis)

Introduction and Cause

Tapeworms (taenia) cause problems in sheep between 2 to 4 months of age and in alpaca during the fourth month of age and after weaning (Guerrero and Leguía 1987). The most common taenia is a cream-white worm 2 m or more long and 2.5 cm wide (Moniezia expansa). It affects alpaca and goats as well as sheep. In communities, Thysanosoma and Thysaniezia are also important. M. expansa resides in the small intestine of young animals. Its body is divided in segments that are expulsed in feces, where they look something like grains of rice. Generally, infection by this parasite is associated with infection by roundworms.

Diagnosis

Diagnosis is made by observing segments of taenia in the feces. Severely parasitized animals exhibit poor condition, due to the worms' interference with digestion and nutrient absorption. Mild diarrhea may also be present (Annex Table 1). Sheep dead of taeniasis are emaciated and tapeworms fill their intestines.

Prevention and Treatment

Remedies can be prepared from nicotine sulfate and copper sulfate. Commercial remedies are also available. Cambendazole, Fenbendazole, and Albendazole are effective against the fringed tapeworm. Preparations of squash (Cucurbita maxima Duch) seeds have shown some effectiveness against tapeworms (Arévalo and Bazalar 1989). Paico and Swiss chard leaves are likewise being assayed.

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[13] **Enzootic Ataxia**

(swayback, ataxia enzoótica, renguera)

■ Introduction and Cause

This crippling disease affects newborn and young lambs. Renguera is observed enzootically in Criollo lambs raised near the smelting plant of La Oroya in the central sierra (Ameghino 1985, 1988). It is thought that the mineral-heavy fumes released by the plant interfere with lambs' uptake of copper from native pasturage of the zone. In southern Peru's Puno Department, however, the disease is associated with low copper content in the soil. To date, this disease has not been reported in alpaca.

■ Diagnosis

Clinical diagnosis is based on the characteristic ataxia of affected lambs. They lose limb coordination, particularly in the hind legs (Annex Table 4). This progresses to weakness in the limbs, an ataxic gait, and posterior paralysis (Figure 1). Exercise may exacerbate the condition. Occasionally, lambs are congenitally ataxic; their muscles twitch, their heads shake, and they cannot stand up without assistance. Diagnosis can be confirmed only by postmortem examination.

■ Prevention and Treatment

Routine prevention should be considered in regions where soils are poor in copper. Copper can be administrated in several ways. Like most trace elements, however, it is easy to give a toxic dose. Veterinary advice should therefore be sought. A safe but expensive option is oral administration of capsules containing copper oxide needles in abomasum.

Mineral drenches can be used, such as CuCoFe: copper sulfate 600 g, cobalt sulfate 60 g, and iron sulfate 800 g. Dosages for cooperative enterprise animals consist of 5 to 10 ml per lamb, 20 ml for young ewes and young rams, 32 ml for adult ewes, and 40 ml for adult rams. These amounts need to be modified for community animals. It is convenient to first dose 10% of the flock one day before the general dosing (Ameghino 1988). Drenching ewes early in pregnancy will ensure normal fetal development. Although some lambs may respond to copper administration during the early stages of swayback, the treatments are usually unsuccessful. More important, the rest of the flock should be treated since all are likely to have copper deficiency, even if they display no visible signs.

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Figure 1. Swayback due to copper defi:iency. This lamb had paralysis of the rear limbs.

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[14] Sheep Pulmonary Adenomatosis
(ovine pulmonary carcinoma, poliadenomatosis)

■ Introduction and Cause

Pulmonary adenomatosis is a major economic problem in Peruvian sheep husbandry (Ameghino 1979, 1988; DeMartini et al. 1985). This disease is caused by a virus that produces an ultimately fatal lung tumor, which has been experimentally transmitted to lambs (DeMartini et al. 1987, 1989; Rosadio et al. 1984, 1988a&b). The virus is highly concentrated in nasal secretions; it is transmitted among animals in close contact through droplets in the air. The virus may remain dormant for months or years before producing a tumor.

■ Diagnosis

Pulmonary adenomatosis may be suspected among sheep over 7 months of age that exhibit extreme weight loss, breathing problems after exercise, an inability to keep up with the flock, and massive watery nasal secretions in the morning or when the hind limbs are elevated (Annex Table 2). Although the animals do not experience fever or loss of appetite, they are very thin (Cuba 1945). Since a number of other diseases produce weight loss and similar respiratory signs, diagnosis can be difficult. However, sheep with progressive pneumonia or hydatid disease (see relevant sections) do not exhibit the clear nasal secretion characteristic of pulmonary adenomatosis. Histologic examination of a lung sample obtained at necropsy is necessary to confirm a diagnosis of pulmonary adenomatosis. A viral protein recently associated with the disease may be the basis for a diagnostic test in the future (DeMartini et al. 1987, Rosadio et al. 1986).

■ Prevention and Treatment

This chronic, progressive, and ultimately fatal disease is untreatable. Therefore, it is best to periodically identify and cull all affected animals to reduce the prevalence of the causative virus in the flock. Sheep pulmonary adenomatosis frequently coexists with ovine progressive pneumonia or OPP (Snyder et al. 1983). Detection and culling of animals that serologically test positive for ovine progressive pneumonia thus helps decrease the incidence of both diseases (Ameghino 1988, Madewell et al. 1987) (see next section).

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[15] Ovine Progressive Pneumonia

(maedi, lymphoid interstitial pneumonia, OPP)

■ Introduction and Cause

A chronic disease of mature animals, ovine progressive pneumonia (OPP) is caused by a virus that damages many different organs of the body — especially the udder, joints, and brain, but preferentially and sometimes solely the lungs. It is transmitted through the colostrum and milk of infected ewes to their lambs, where it remains dormant for months or years (Ameghino 1988, Lairmore et al. 1986). It may also be transmitted through close contact.

■ Diagnosis

Clinical diagnosis of ovine progressive pneumonia is sometimes difficult, particularly in flocks also afflicted with sheep pulmonary adenomatosis (Annex Table 2). As noted earlier, these two diseases share several clinical manifestations. The only distinction is the clear nasal fluid of sheep pulmonary adenomatosis. OPP lung lesions observed at autopsy are also difficult to differentiate from lung tumor. While pulmonary parasitic infection (hydatid disease) and caseous lymphadenitis may also produce clinical signs similar to OPP, the lesions are quite different (see previous section). A serological test exists that can diagnose OPP virus infection in the laboratory (Madewell et al. 1987).

■ Prevention and Treatment

OPP is chronic, progressive, and untreatable. No vaccine exists to prevent the disease. There are two control options. One is testing and culling serum antibody-positive animals every 6 or 12 months. The other is to cull the ewes that test positive, and their lambs. The second strategy can more dramatically decrease the incidence of the disease. Vaccines to prevent the disease probably will not be available for many years (Pearson et al. 1989).

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[16] **Caseous Lymphadentis**
(abscesos, tumores)

■ Introduction and Cause

Caseous lymphadenitis is a disease of the peripheral lymph nodes in sheep (Ellis 1983). General health is not usually affected, but the disease is economically important because affected carcasses are condemned whenever abscesses are found. Generalized or visceral cases of this disease are frequently associated with chronic unthriftiness. Caseous lymphadenitis is caused by the microbe Corynecterium ovis, which inhabits the soil, the skin, and infected organs (Kimberling et al. 1988, Martin 1983). Superficial skin wounds are generally believed to be its entry point. Thus, procedures such as castration and docking may lead to caseous lymphadenitis in young animals. Small abrasions from shearing also serve as portals of entry.

■ Diagnosis

Clinical signs vary according to the extent of the disease. In many cases, only superficial lymph nodes are involved, especially those around the head and neck, the front of the foreleg, the side, and the rump. In visceral forms of the disease, there are no evident signs. When lung and regional lymph nodes are affected, respiratory difficulties and progressive loss of condition and weight occur (Annex Table 2). Necropsy findings of laminated lymph nodes (they look like a sliced onion) are highly suggestive of caseous lymphadenitis.

■ Prevention and Treatment

Control measures include: elimination of the source of infection by culling animals with palpably enlarged lymph nodes; good hygiene during lambing and docking; and shearing aids that reduce the number of wounds and abrasions. It is important to eliminate affected animals before dipping since a single draining abscess can contaminate an entire tank. Also, dipping after shearing can promote the spread of caseous lymphadenitis. Treatment of peripheral abscesses in individual animals is neither economically feasible nor prudent since the animals serve as a reservoir for the bacteria that cause the disease.

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[17] **Mastitis**
(mastitis)

■ Introduction and Cause

Udder inflammation or mastitis is an uncommon disease of sheep and camelids that occurs during the lambing season (Kimberling et al. 1988, Martin 1983). Microorganisms such as bacteria are almost invariably associated with mastitis (Ameghino and Rosadio 1983). They can come from the skin, the teat canal, or dirty corrals. Predisposing factors, such as anomalous development of the udder and teats, affect the incidence and prevention of mastitis. The virus of ovine progressive pneumonia can also produce mastitis.

■ Diagnosis

Diagnosis in ewes is based on clinical signs. Palpation and inspection of the udder for asymmetry usually help to diagnose mastitis (Figure 1). Laboratory cultures aid in determining the causative agent of acute mastitis and in selecting the appropriate antibiotic therapy.

■ Prevention and Treatment

To prevent mastitis, regularly check for abnormalities of the udder and teats, and cull all affected animals right after the lambing season. Treatment by udder infusion is less successful in ewes than in dairy cattle. If the intramammary route is not effective, antibiotics should be administered parenterally.

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Figure 1. Hard mastitis. The udder is deformed due to the large abscesses that have formed in half of it. It then becomes hard and fibrotic.

[18] **Footrot**
(pedera)

■ Introduction and Cause

Footrot is by far the most common disease of sheep; almost all sheep suffer from it (Ameghino 1979, 1988). It is highly contagious, particularly during the rainy season (Kimberling et al. 1988, Martin 1983). Footrot is also a severe problem among goats on Peru's north coast in years of high rainfall. The disease is rare in alpaca. Footrot is caused by two microorganisms that together produce lesions in the sole and hoof. Bacteroides nodosus lives in the healed hooves of carrier sheep; Fusobacterium necrophorum is prevalent in fecal material, but can be found almost everywhere.

■ Diagnosis

Lameness in one or all feet is the most obvious sign. The first indication is appearance of a moist reddened area between the toes (scald), accompanied by hair loss and a putrid odor. Later the infection spreads under the hoof, destroying the connective tissue between the wall, sides, and sole of the foot. However, lameness may also result from other causes (Annex Table 3).

■ Prevention and Treatment

For footrot to be transmitted, longterm exposure to moisture or rough terrain leading to maceration of the skin is generally necessary. Hence, livestock should be kept in dry pastures, especially during the rainy season. Corrals or tracks used within a few days of occupation by an infected flock can be a source of infection. To eradicate footrot from a farm, it is essential to isolate affected animals and to cull animals with recurring infections.

Treatment includes foot trimming, bathing, and soaking, topical medications, parenteral therapy, and vaccination. Incomplete trimming during treatment or lack of treatment with spontaneous healing during dry weather make for carrier animals. Footbaths using 10% copper or zinc sulfate produce good results. Walking herds through a portable footbath every 5 or 7 days greatly reduces transmission of footrot. The portable footbath may consist of a wooden trough 2.5 cm gross by 3 to 4 m long by 30 cm wide and 15 cm deep. If only a few animals are affected, they can be topically treated individually. Bacteriostatic dyes like crystal violet, methylene blue, and others are useful topical treatments, and are available as commercial sprays. For better results, baths must be combined with careful and extensive trimming of affected hooves. A good alternative treatment is soaking with 10% zinc sulfate plus a detergent as a wetting agent. Two soaks should be given 7 to 10 days apart. Parenteral administration of penicillin and streptomycin is also useful. A vaccine that protects against footrot for 3 to 4 months is available.

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[19] Blackleg
(symptomatic carbuncle, carbunclo)

■ Introduction and Cause

Along with malignant edema, blackleg is a clostridial disease of sheep and goats. So far it has not been reported in alpaca. Blackleg is caused by the microorganism Clostridium chauvoei, which is transmitted through wounds — e.g., from shearing and marking lambs, from fighting between rams, and even from birthing (Ameghino 1979, Kimberling et al. 1988, Martin 1983).

■ Diagnosis

Clinical signs include fever and, if limb muscles are involved, stiffness and unwillingness to move. Skin lesions on the limbs may produce lameness (Annex Table 3); lesions in the genital tract make for a stiff gait. The mucous membranes may also turn purple. Sudden death is common in this disease. The animal dies within 24 to 48 hours after the first clinical signs are observed. The carcass is typically bloated. At autopsy a reddish fluid is often found in the nostrils and rectum, and a bloody edema without gas bubbles is found around the site of infection. The more marked lesions in the muscles are dark red and dry. Because of the general infection (septicemia), internal organs are severely affected. The lungs are congested, and the liver and spleen are soft and swollen.

■ Prevention and Treatment

Because C. chauvoei spores survive in the soil, it is necessary to use caution in marking, docking, and castrating lambs, and in shearing. Penicillin should be applied to prevent blackleg in dystocia cases. Multicomponent mixture vaccines exist to protect against blackleg and other diseases. Vaccines should be administered at the beginning of the rainy season in October. Carcasses of animals suspected to have died of this disease must not be necropsied. They should be deeply buried in order to prevent the spores' spreading. Treatment is impractical, so the best strategy is prevention.

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[20] Malignant Edema
(edema, enlunados)

■ Introduction and Cause

This clostridial disease affects sheep, goats, and alpaca. Malignant edema is usually caused by Clostridium septicum and less frequently by C. chauvoei and C. perfringens. In communities of the central sierra of Peru, this disease is called enlunado 'glassed' due to its characteristically gelatinous and transparent subcutaneous edema (Ameghino 1979). The causal agent enters through shearing, marking, and lambing wounds. Malignant edema is commonly observed after dipping.

■ Diagnosis

Clinical manifestations vary according to the species of microorganisms involved. Gas may or may not be present. Affected animals are restless, depressed, and uninterested in feeding. Death occurs 24 to 48 hours after infection. At necropsy a marked and swollen subcutaneous bloody edema is observed.

■ Prevention and Treatment

The mixed vaccines against blackleg also protect against malignant edema in sheep. Keep in mind the measures described for blackleg. If a wound is not extensive, it can be washed with hydrogen peroxide or another antiseptic. Parenteral treatment can also be utilized, but it is not always satisfactory. C. septicum is one of the microorganisms responsible for gaseous gangrene in human beings. Therefore, use extreme care when handling dead animals, and wash your hands.

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[21] Epidermoid Carcinoma of the Ear

(squamous cell carcinoma, warts, papillomatosis, verruga)

■ Introduction and Cause

Mainly observed in sheep, this disease is characterized by tumor lesions — erroneously called papillomatosis or warts — on the ears, eyes, and other parts of the body (Ameghino et al. 1983). This tumor has not been observed in alpaca. The cause is unknown, but a virus is suspected. It is believed that ear wounds (e.g. from earrings and eartags) and exposure to intense sunlight predispose animals to epidermoid carcinoma. Genetic predisposition is also a possibility.

■ Diagnosis

The tumor lesions are mainly located in the cephalic region: ears, eye (cornea and eyelids), face, lips, and sometimes in the body. The lesions consist of cauliflower-like growths with a wide base and an ulcerated surface. The lesions necrotize and become infected by saprophytic microorganisms, thus producing an offensive odor. Spread of the tumor to internal structures (metastasis) has also been observed, primarily in local lymph nodes. Definitive diagnosis is made in the laboratory by histopathology. Tissue samples can be sent to the lab in a jar containing a 10% solution of formalin; this will preserve them for examination.

■ Prevention and Treatment

Protect the ears of sheep from wounds whenever possible. Affected animals should be eliminated from the flock. For valuable animals, however, the affected ear can be amputated. The lesions are not treatable.

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[22] **Rabies**
(hydrophobia, mad dog, rabia)

■ Introduction and Cause

Rabies is a highly fatal viral disease that can infect wildlife and many domestic animals (including sheep, goats, and alpaca), as well as human beings. In the Peruvian sierra, the rabies virus is transmitted mainly by rabid carnivores (Ameghino 1979, Fulcrand 1983, Kimberling et al. 1988). The tendency of sheep to huddle together when scared may result in many animals being bitten by rabid dogs or foxes in a short period of time.

■ Diagnosis

Among small ruminants in Peru, rabies is believed to be associated with outbreaks of canine rabies (Ameghino and Salas 1972). Rabid sheep exhibit marked sexual excitation and try to mate indiscriminately (Annex Table 4). They are very aggressive, attacking people who enter the corral and fighting among themselves. They may also bite the wire and posts of their pens, and attempt to eat almost anything, including stones and their own wool. Some sheep stare at the horizon, while others grind their teeth and yawn. The rabid animals become more and more nervous and uncoordinated, and exhibit involuntary movements of face muscles (nervous tics) that end in severe paralysis before death. Rabies must be confirmed in the laboratory. Ask for veterinary help.

■ Prevention and Treatment

In areas where canine rabies is endemic, all sheep dogs and neighboring community dogs must be periodically vaccinated. Stray, unvaccinated dogs should be eliminated. All rabid animals must be handled with extreme care since the disease can be transmitted to humans through skin wounds and abrasions. Wear gloves when handling animals or carcasses suspected of having rabies. Rabies is a communicable, fatal disease for human beings, so report any cases to local authorities.

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[23] **Liverfluke**
(flukes, distomatosis, alicuya, jallu taca)

■ Introduction and Cause

Liverfluke is the most important trematode infection of domestic ruminants in Peru and a serious zoonotic disease (Kimberling et al. 1988, Martin 1983). High prevalence has been reported in rural and urban people, particularly in the central and northern sierra where the disease is endemic (Bendezú and Landa 1973). The disease is caused by a leaf-shaped worm (Fasciola hepatica) which, in its adult form, parasitizes the host's liver. Eggs from the adult form pass into the intestines and are expelled in the feces. Under conditions of proper temperature and humidity, the eggs hatch into the miracidium stage and invade a snail host, where they reproduce the cercariae that infect ruminants. Ingested by sheep, goats, and camelids, the immature flukes penetrate the gut mucosa and traverse the peritoneal cavity to reach the liver, where they grow to adulthood (Leguía 1988).

■ Diagnosis

Liverfluke infections in sheep may be acute or chronic, depending on the degree and duration of infection, the time of year, and the numbers of immature and adult larvae. The acute form results in sudden death with no prior clinical signs. Surviving animals are lethargic and have pale mucosa. Chronic liverfluke is more common, however. It is characterized by progressive weight loss that develops into severe emaciation, typically with submandibular edema ("bottle jaw") (Figure 1). Chronic infestation is confirmed by finding fluke eggs in a number of animals in the flock.

Post-mortem diagnosis of both forms can be made. Animals dead of acute infection have severely damaged hemorrhagic livers as a result of large number of flukes migrating through the liver. Squeezing a section of the liver into water will expel many small immature flukes. In chronic cases the liver is enlarged and very firm (cirrhotic), with adult flukes in the bile ducts. Also, sometimes the bile ducts are dramatically enlarged and thickened.

■ Prevention and Treatment

Liverflukes can be prevented by management methods. Avoid grazing in areas infested with larvae. This can be achieved by fencing off well-defined snail habitats. Where possible, one of the most desirable and efficient methods is to drain ponds, ditches, puddles, etc. where snails live. In some circumstances, molluscicides like copper sulfate are useful, but their application

Figure 1. Bottle jaw. This submandibular edema is observed in gastrointestinal parasitism and liverfluke infection. It signals heavy infestation.

should be supervised by a specialist. These management methods can be combined to achieve better results.

A range of highly efficient, safe flukicides are available to kill both immature and adult flukes. Diagnosis of the fluke form present in outbreaks will indicate choice of drug. In endemic fluke areas, routine use of flukicides is recommended; however, certain regions will require more intense drug usage.

Certain herbal home remedies have been used with some success in communities (Arévalo and Bazalar 1989). A remedy based on artichoke leaves (Cynara scolymus) is prepared as follows: 250 g of leaves per kilogram of live body weight are boiled in 5 l of water, down to a volume of 4 l. The 4 l of liquid are strained; then 250 ml of cooking or mineral oil are added, along with 100 g of common salt. The dosage for sheep is 5 ml/kg of body weight, administered orally. Research is underway to try to reduce the dosage. The efficacy of another remedy based on a plant known as jaya-shipita is also being investigated.

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Animal Health: Diseases of Adult Animals

[24] Hydatid Disease
(water bags, hidatidosis)

Introduction and Cause

This is a very important zoonotic disease that affects both animals andhumans (Ameghino 1979, Guerrero and Leguía 1987). Hydatid disease is caused by a parasitic larvae whose adult form (Echinococcus granulosum) lives in normal-looking dogs. Infected animals eliminate parasite eggs in their feces. Sheep and other ruminants are infected by ingesting contaminated pasture. The eggs pass through the gut into the blood, to settle in the lungs and liver, where they grow into larval cysts (water bags). The cysts' growth destroys normal tissues, eventually killing the host. Human beings are also very susceptible to this disease and can be infected by petting carrier dogs. The dogs are in turn infected by eating the lungs, liver, or kidneys of infected sheep.

Diagnosis

Affected animals exhibit weight loss and respiratory difficulties (Annex Table 2). Necropsy reveals multiple, various-sized "water bags" in the lungs, liver, and sometimes the kidneys. These cysts contain hundreds or thousands of infectious tapeworm heads (scolex).

Prevention and Treatment

Since hydatid disease is also a human health problem, its discovery on a farm threatens the whole family. To control the disease, keep as few dogs as possible on your farm and treat them at least 10 times per year with an antiparasite drug (e.g. Praziquantel, Droncit). Bury or burn the infected organs of dead animals, and do not under any circumstances allow dogs to consume these organs. No treatment is available for hydatid disease in animals.

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[25] Coenurosis

(gid, torneo)

■ Introduction and Cause

Coenurosis is a parasitic disease that causes many ovine mortalities in cooperative enterprises in Peru (Ameghino et al. 1983, 1985). It also attacks goats, but has not been reported in alpaca. It is caused by the larval stage (Coenurus cerebralis) of an intestinal tapeworm (taenia or Multiceps) of dogs. The tapeworms use sheep and goats as secondary intermediate hosts. The life cycle is maintained by pastures contaminated with taenia eggs, which ruminants ingest along with the forage. The larvae migrate from the intestines to the nervous system and settle in the brain and sometimes the spinal cord.

■ Diagnosis

Coenurosis is easily recognized by the affected animals' habit of walking in circles (torneo) (Figure 1) — a consequence of the pressure exerted by cysts in the cerebral cavity. Other signs include an uncoordinated gait, leaning the head against a support, falling, prostration, convulsions, and death (Annex Table 4). In severe cases, the enlarged cysts sometimes produce a softening of the skull, which is detectible by manual palpation. At necropsy, diagnosis is confirmed by cysts in the cerebral cortex.

■ Prevention and Treatment

The disease can be easily controlled by eliminating the mature worms from dogs, or by interrupting the parasite's life cycle in the intermediate hosts. Dogs can be treated with either Praziquantel (Droncit) or Nitroscanato (Lopatol) every 3 months. Destroy strays and never feed infected sheep brains to dogs. Following the steps described for controlling hydatid disease will also decrease losses from coenurosis. Surgical treatment is advisable only if an animal has great genetic or economic value. As with hydatidosis, coenurosis can infect people if they accidentally ingest dog tapeworm eggs.

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Figure 1: Gid (torneo), a very common disease in young sheep, causes important economic losses. The nervous signs are evident, and vision is impaired.

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[26] Abdominal Cysticercosis
(tenia)

■ Introduction and Cause

Cysticercus tenuicollis is the larval stage of Taenia hydatigena, a common intestinal tapeworm of dogs. Sheep and other ruminants are infected by grazing forages contaminated with dog feces that contain T. hydatigena eggs (Guerrero and Leguía 1987). Larval cysts with a clear fluid form on the walls of abdominal organs. This larval stage also affects alpaca, goats, and other species.

■ Diagnosis

Infestation with this tapeworm produces no visible signs. Most diagnoses are established at necropsy, when the larval cysts are observed on the omentum, mesentery, and intestinal organs (Figure 1).

■ Prevention and Treatment

Do not feed the organs of infected animals to dogs.

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Figure 1. Bladder worms are normally located in the abdominal organs of sheep. These cysts were 2.5 to 5.0 cm in diameter. Abdominal cystercercosis results from grazing pastures with contaminated dog feces.

[27] External Parasitism
(ectoparasitosis)

Introduction and Cause

A range of skin parasites can cause loss or damage of the fleece and economic losses due to impaired production in both sheep and camelids (Guerrero and Leguía 1987a&b).

- Mites. The most important infectious mites of sheep in Peru is Psoroptes ovis, followed by Sarcoptes scabiei ovis. These mites cause scabies or mange (sarna, caracha). Alpaca are susceptible to Sarcoptes scabei vas. aucheniae (Guerrero and Alva 1986).
- Keds. Sheep keds, Melophagus ovinus, are wingless flies. Normally they are of limited pathological significance, although heavy infestations can cause anemia.
- Lice. There are two main groups of lice: biting body lice (Linognathus ovillus) and foot lice (L. pedalis).

Diagnosis

General clinical signs include irritation, fleece loss, and dermatitis. However, these signs are common to many infestations. Hence laboratory examination may be required to establish an accurate diagnosis. To detect outbreaks of skin disease in sheep, it is useful to observe the flock from a distance for itchy and restless behavior or animals' attempts to bite or rub areas of their own bodies. Individual sheep should be carefully examined for the character and distribution of fleece loss, skin lesions, and general body condition.

Ked infestations can thus be readily diagnosed. Severe ked and lice infestations cause marked irritation, restlessness, and rubbing resulting in the loss of fleece. In severely affected flocks, fleece decoloration and retarded growth rates are observed.

For mites, however, further investigation is required, including examination of skin scrapings. Sarcoptic mange affects body parts devoid of wool; and the mites' deep penetration causes intense irritation with thickening and roughening of the skin. The psoroptic mites live on the skin surface and penetrate the epidermis to feed on lymph ducts. Their punctures induce pustules. These then rupture and exude serum that hardens into a yellow crust and separates from the skin together with the wool. There is extensive fleece loss; and exposed skin is thickened, with raw patches that often become secondarily infected with bacteria. The lesions commonly occur on the shoulders and sides of the animal, but they can spread to the whole body. The mites are found mostly at the edges of expanding lesions, which is characteristically moist. The moist scab is likely to be seen only with psoroptic mange.

Treatment and Prevention

The most common approach to controlling ectoparasitism is the use of ectoparasiticides to kill the parasites on the host. Various methods have been developed for applying parasiticides, whether through dipping, spraying, dusting, or systemic application.

Dipping is the surest way to achieve thorough distribution of the chemical over the whole animal. It is the only effective control for sheep mange. Sheep should remain in the bath until the fleece is saturated. Their heads should be immersed twice. Dipping baths should be accurately calibrated. The exact volume of sheep dip recommended by the manufacturer should be added to clean water in the bath to produce the "dip wash." Showers and sprays are faster than dipping, but they are less thorough and therefore inadequate for mange.

Parenteral application of Ivermectin has been successful in controlling mites of alpaca and sheep. Lice and keds are very susceptible to insecticidal treatments. They spend their entire life cycle on the host and thus can be eradicated in one dipping with organophosphate compounds. This will prevent reinfestation for about 5 months.

Some folk parasiticide treatments have been used by peasant communities with some success. These include wild tobacco-leaf (utashayli) baths against ked infestation (Bazalar et al. 1989), and tarwi (Lupinus mutabilis) seeds in water against mites and other external parasites, like lice (Avila et al. 1985).

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[28]

Nasal Myiasis

(nasal bot, miasis cavitaria)

Introduction and Cause

Nasal myiasis is caused by the larval stage of a hairy, yellow-gray fly (Oestrus ovis) that deposits its larvae in the nasal cavities of sheep and goats. The larvae adhere to the nasal cartilage and grow to approximately 2 cm in length. After 10 months they are expelled through sneezing. This disease is observed mainly in valley areas, but it also occurs at higher elevations.

Diagnosis

The larvae produce nasal irritation, runny nose, noisy respiration, and frequent sneezing (Kimberling et al. 1988). The nasal exudate is clear at first, but rapidly becomes mucopurulent. Nasal myiasis produces a chronic rhinitis and sinusitis (Annex Table 2). In rare cases the larvae may penetrate to the brain, trachea, and lungs. Affected sheep shake their heads and blow and rub their noses against any available object. These acts may traumatize and infect the nostrils.

Prevention and Treatment

An ointment can be applied to the nose of sheep to repel flies. Tar (liquid pitch) plus vaseline can be used every 3 days. Commercial drugs like Ivermectin parenterally and Rafoxanide or Closantel orally are effective against maggots. They also act against liver flukes.

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[29] **Photosensitization**
(jacapo)

■ Introduction and Cause

Jacapo is a severe acute dermatitis characterized by irritation, edema, and necrosis of nonpigmented skin areas (ears, eyes, eyelids, and lips). It affects primarily sheep, although camelids are also susceptible to this disease. There is some evidence that humans also suffer from acute dermatitis after eating affected animals' livers (Morales et al. 1983). The ailment occurs mainly during the dry season (May to September), and it is associated with the ingestion of certain plants in ponds (Fulcrand 1983).

Causes are multiple and depend on the interaction between sunlight and a highly active photodynamic substance in the blood. The causes of jacapo in Peru are poorly understood. One possibility is ingestion of a photodynamic substance from plants (primary photosensitization). The liver damage sometimes associated with clinical cases of jacapo in the central sierra suggests that the hepatogenous form of the disease may be more common than suspected. In this form, the liver lesions interfere with the normal excretion of phylloerythrin, a photodynamic agent produced by the degradation of chlorophyll in the gastrointestinal tract.

■ Diagnosis

Animals affected with either form of photosensitization exhibit acute dermatitis on the skin areas most exposed to light (face, eyelids, lips, etc.). These parts become swollen and edematous, and rapidly progress to necrosis, with sloughing and scarring. Abortion is frequent in pregnant ewes.

■ Prevention and Treatment

During the dry season, keep sheep out of ponds suspected of harboring photosensitizing plants. Affected animals should be separated in a shady place and given fresh food and water. Dexamethasone helps reduce edema in sheep recovering from jacapo. Applications of certain natural/artesanal dyes and chemical dyes (e.g. methylene blue) are useful for protecting the skin of both affected and healthy animals from solar radiation.

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[30] Astragalus Poisoning
(garbanzo)

Introduction and Cause

Astralagus spp. (locoweed) poisoning is characterized by progressive muscular and nervous incoordination in animals grazed where these plants are present and the soil contains an abnormally high level of selenium. (See also Chapter 4, Section 8.) Plant alkaloids may cause brain lesions. This disease occurs where weeds of the poorly characterized Astragalus genus grow. There are at least six suspect species (garbanzo or garbancillo) in the Peruvian sierra, but their selenium content is unknown. The disease is usually observed during the dry season (May to September) after sheep have fed on these drought-resistant plants for several weeks.

Diagnosis

A clear predisposition for poisonous plants is the first evidence of plant dependency. Initially, affected animals put on weight (Kimberling et al. 1988). But thereafter, they become progressively emaciated and show nervous signs such as staggering, impaired sight and hearing, and ultimately severe muscular incoordination (Annex Table 4). During the course of the disease, abortion may occur at any stage of pregnancy (Annex Table 5). Stillbirths and weak and/or deformed lambs are also observed. At necropsy the animals are severely emaciated and sometimes have prominent fat atrophy (gelatinous and yellowish fat). The meat of affected animals may have a bitter taste, but no symptoms of disease have been observed in humans.

Prevention and Treatment

Do not allow sheep to graze where these toxic plants grow. Also, plants can be manually removed. Affected animals may recover on fresh pastures. Herbicides have not been successful in controlling Astragalus spp. The disease is untreatable.

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Also see Chapter 4, Section 8, of the present volume.

Animal Health: Diseases Associated with Reproduction

[31] Infertility and Abortion in Ewes

■ Introduction and Causes

Infertility and abortion are of great concern to producers. Abortive agents can cause premature, weak lambs that die within a few hours or days. Ewes seldom show clinical signs prior to abortion. The farmer merely finds an aborted fetus from a ewe in the last month of gestation (Figure 1). Following an abortion, the placenta may be retained, but the ewe seems otherwise healthy. Ewe deaths from abortion are rare. In sheep, infertility and abortions are associated with several factors, including nutritional deficiencies, infections, parasites, and genetic defects. Often the causes cannot be determined (consult Annex Table 5 for differential diagnosis), but up to 50% of abortions are usually associated with infections.

- Brucellosis. Brucella ovis may cause abortions in sheep. These may occur on farms with a high prevalence of ram epididymitis (next section) due to B. ovis (Ameghino 1979, 1988; Kimberling et al. 1988).
- Chlamydial or enzootic abortion. Enzootic abortion in ewes is caused by the bacterium Chlamydia psittaci. The agent is transmitted by contaminated feed or water and the disease is transmitted during lambing via fetal membranes and uterine discharges from infected ewes (Kimberling et al. 1988, Martin 1983, Rivera et al. 1985).
- Toxoplasmosis. Toxoplasmosis has been reported in association with abortion in Peru. Serological evidence shows that Toxoplasma gondii is fairly common in Peruvian sheep (Leguía et al. 1987, Reif et al. 1989). T. gondii is believed to be a form of the coccidia that naturally infect domestic and wild cats. Domestic cat feces are considered the primary source of infection in sheep.
- Other infectious causes. Other infectious agents such as bacteria of the Leptospira species (Vargas et al. 1983, 1984) and the viruses of border disease and bluetongue can cause abortion in sheep and have been diagnosed or serologically identified in Peruvian sheep (Rivera et al. 1985). Viral-associated abortions require further study. The high serological prevalence of bluetongue virus in these ruminants in Peru is puzzling. Bluetongue virus has not been isolated in Peru and the vectors have not been identified (Ameghino 1988).

■ Diagnosis

Brucellosis infections in ewes lead to abortions, premature births, or weak lambs. The aborted fetuses are apparently normal, but not the placenta. Diagnosis is made by identification of B. ovis in placental exudate, vaginal discharges, and fetal stomach contents.

Recently in Peru, enzootic infections and their agents have respectively been detected serologically and in impression smears from placental tissue. The classical abortion storm, however, has not been described. In an infected flock, first- and second-lamb ewes are the most susceptible because they lack previous exposure to the microorganism. Pathological changes of the aborted fetuses are generally nonspecific. The gross appearance of the placenta may suggest chlamydia infection. Definitive diagnosis is made by staining or isolating the organisms in the laboratory.

During the first or second months of pregnancy, toxoplasmosis can cause fetal death, resorption, and consequently barren ewes. In late pregnancy, T. gondii can induce premature birth, weak lambs, and death shortly after birth (i.e. perinatal mortality). Final diagnosis of toxoplasmosis can be made by isolating T. gondii from uterine discharge and/or finding increased levels of toxoplasma antibodies in paired serum samples from aborting ewes. Positive diagnosis, however, requires detection of the microorganism in placental or fetal brain tissues in the laboratory.

Border disease can cause abortion, "hairy shaker" and deformed lambs, mummified fetuses, and cerebellar hypoplasia. These changes have been observed in Peruvian sheep.

For most cases of abortion, accurate diagnosis ideally calls for submitting the entire fetus and the placenta for laboratory analysis. Every effort should be made to obtain the placenta, because this allows for more accurate diagnosis of chlamydial and toxoplasma agents. More than one fetus and placenta should be submitted to a diagnostic laboratory.

■ Prevention and Treatment

There is an effective vaccine (REV 1) against ovine brucellosis (Rosadio 1980). But this is applied only to 4-month-old rams; it thereafter protects them for life against testicular lesions (epididymitis and/or orchitis) (Ameghino et al. 1982). Females are not vaccinated. Treatment is both ineffective and unnecessary. Where leptospiorsis is a problem, vaccinations can be given to prevent it. Diseased sheep respond to treatment with streptomycin and penicillin, oxytetracycline, or chlortetracycline. Control and prevention of toxoplasmosis is very difficult since both domestic and perhaps wild felines may be involved in disseminating the disease. No vaccine exists for this disease; and treatment of ewes is not practical.

For all these diseases, placentas and/or fetuses must be deeply buried. They should never be given to dogs or hung on paddock fences. Following

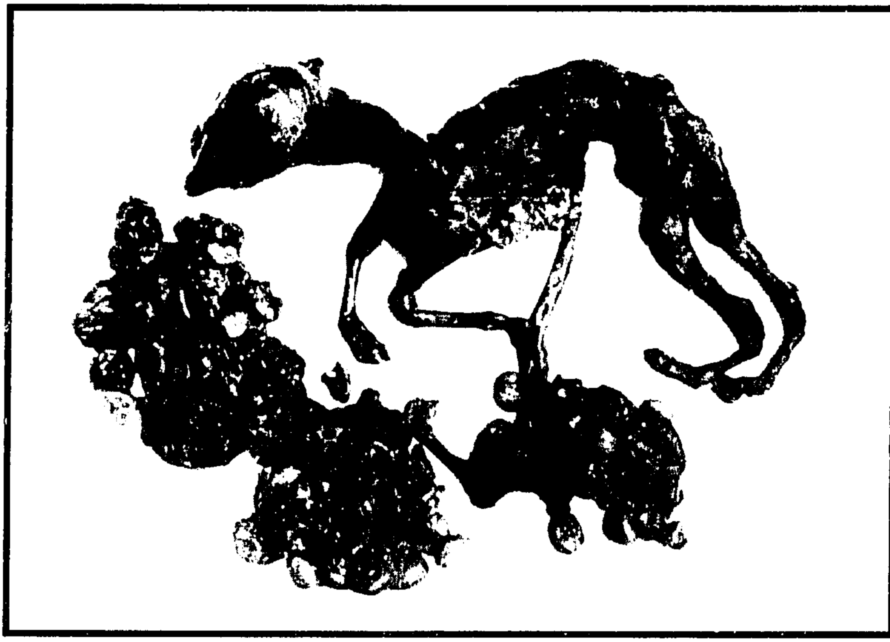

Figure 1. Mummified sheep fetus. This kind of abortion is caused by certain viral diseases currently being serologically identified in Peru.

these simple rules will avoid spreading these, as well as other, diseases. At the time of abortion, all affected ewes should be isolated until uterine discharge ceases and all their surviving lambs are normal. Aborted ewes must be identified for later removal from the flock. Also, ewes suffering from metritis should not be mated.

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[32] **Ulcerative Dermatosis**
(ulcerative balanitis, ulcerative vulvitis)

■ Introduction and Cause

Ulcerative dermatosis is a sexually transmitted (venereal) disease characterized by ulceration of the lips, legs, feet, and external genitalia. This is an acute infectious disease of sheep caused by an unclassified poxvirus. The virus is believed to enter the animal through breaks in the skin of the lips and legs. Saprophytic pus-forming bacteria (e.g. Staphylococcus sp., Corynebacterium sp., Fusobacterium necrophorum) are commonly found in the resulting lesions.

■ Diagnosis

In typical outbreaks of ulcerative dermatosis, lesions occur on the face, feet, or genitalia (Annex Tables 3 and 6). During the non-breeding period (anestrus), lip and leg lesions are typical. Ulcers on the genitalia are observed mainly during the breeding season (Ameghino and Laos 1983, Kimberling et al. 1988, Martin 1983). The first sign is blood around the vulva. Located on the prepuce or on the skin of the vulva, genital ulcers cause acute swelling. In rams, lesions are found mainly on the glans penis (the head of the penis), where they produce balanitis. The urethral process may degenerate and disappear. The prepuce is also affected (posthitis). In ewes, vulvar ulcerations (vulvitis) develop. Usually painful and surrounded by a reddened zone, such ulcerations can be deep; removal of the scabs reveals a raw, bleeding surface.

■ Prevention and Treatment

To prevent this disease, sheep should generally be protected against wool contamination by plants with spiny seeds and abrasive awns that can cut or abrade the skin. If the wool around the genitalia contains this sort of material, it can be removed by clipping before breeding. There are no vaccines for ulcerative dermatosis. Before breeding, both rams and ewes should be examined for the characteristic lesions. Affected sheep should be isolated until all lesions have healed.

There is no specific treatment. Treatment with antibacterial ointments or topical solutions may minimize secondary infections. The latter include bacteriostatic dyes like gentian violet and methylene blue combined with antibiotics — now available in commercial sprays. Also useful are parenteral treatments with antibiotics.

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Animal Health: Diseases Associated with Reproduction

[33] **Ram Epididymitis**
(hinchazon testicular)

Introduction and Cause

Epididymitis is a testicular inflammation found in males (Ameghino 1979, 1988). It is usually associated with ram infertility and with abortion in some pregnant ewes. The disease is prevalent in poorly managed flocks. Epididymitis is caused by bacteria (mainly Brucella ovis) with a predilection for the testicles and the placenta and fetus of pregnant ewes (placentitis and abortion). B. ovis is transmitted in a variety of ways: homosexually, i.e. ram to ram; heterosexually, i.e. ram to ewe to ram; by rams' smelling or licking the reproductive organs of infected rams or of ewes recently bred by infected rams. Trauma is believed to cause ram epididymitis on rare occasions.

Diagnosis

This disease must be suspected in flocks with low fertility rates. Ram epididymitis may be clinically diagnosed by manual palpation to detect testicular lesions and/or orchitis (Annex Table 6) (Figure 1). If epididymitis lesions are found in 6% or more of the rams in a flock, B. ovis is unquestionably to blame. To confirm the causal agent, however, semen and serum should be submitted to a laboratory for analysis.

Prevention and Treatment

The disease is more prevalent where mature and immature rams are raised together. Hence, whenever possible, keep adult and yearling rams in separate bands. To prevent B. ovis infections in flocks with a high prevalence of such infections, vaccinate male lambs right after weaning with REV 1 vaccine; they will then be protected for life. Palpate the testicles of both yearling and mature rams for abnormalities, such as uni- or bilaterally enlarged testicles, at least 3 times per year — at shearing and before and after the mating season. Ask for a serological test of your animals and cull all clinically affected and test-positive rams.

A combined program of vaccination with REV 1 (Rosadio 1980) and thorough culling has yielded good results at one large central sierra enterprise. The success of this program is based on complete separation of adult and young rams and vaccination of the entire population of the latter. The vaccination program may even be a way to eliminate the disease altogether, and thus increase lamb production.

There is no indication that B. ovis can infect human beings. However, administration of REV 1 must be supervised by a veterinarian because the vaccine can infect human beings if not properly handled.

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Figure 1. Ovine epididymitis. One testicle is apparently normal (the one at the top of the photo). The other is affected in the head and tail by epididymis. These lesions cause infertility in rams.

[34] Other Infectious Diseases Associated with Ram Infertility

Introduction and Causes

There are other infections and parasites that can also produce permanent or transitory infertility in rams (Annex Table 6).

- Actinobacillary epididymitis. Caused by Actinobacillus seminis, this disease produces testicular lesions similar to those of ovine brucellosis. However, it is much less prevalent (Kimberling et al. 1988).
- Chronic infections. Chronic cases of diseases such as the respiratory complex of sheep pulmonary adenomatosis and ovine progressive pneumonia (SPA/OPP), which are caused by viruses, lead to progressive weight loss and disinterest in breeding. Likewise for rams with caseous lymphadenitis, chronic fascioliasis, or external parasitism (scabies, lice, or keds).
- Febrile and other diseases. Among the infectious causes for transitory infertility are footrot, foot abscesses, pneumonias, and any other condition that produces fever. Fever impairs spermatogenesis (sperm production). This can cause different degrees of infertility for up to 2 months after the fever. The increased temperature of the animals (hyperthermia) produces primary and secondary abnormalities in the sperm and may even reduce sexual libido (Ameghino 1979).

Diagnosis

See section 33.

Prevention and Treatment

Along with aged rams, all rams with acute or chronic diseases and palpable testicular lesions should be prevented from breeding because their fertility is impaired. Special care must be taken before mating season to prevent infections in rams. Among the infectious diseases responsible for ram infertility one must consider those that are passed on to ram lambs. Border disease, for example, may produce subfertile animals with small testicles. Rams that have recently been ill or fevered in any way should not be used unless a sperm analysis is first done.

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Animal Health: Diseases Associated with Reproduction

[35] Congenital Testicular Conditions

■ Introduction and Cause

Congenital malformations such as testicular hypoplasia and cryptorchidism are present at birth and are not the result of disease (see Chapter 5).

Testicular hypoplasia consists of abnormally small testicles. This characteristic is mainly of genetic origin, i.e. it is transmitted from parents to their descendants. It is associated with infertility or reduced fertility (Kimberling et al. 1988). Hypoplasia is quite frequent in alpaca, probably due to inbreeding.

Cryptorchidism consists of retention of one or both testicles within the abdominal cavity so that the scrotum is either empty or contains only one testis. This malformation is also thought to be of genetic origin, although mechanical obstructions and local infections may also block the inguinal ring. Due to high abdominal temperature, the cryptorchid testis fails to develop functional seminiferous tubules and spermatogonia, the primitive germinal epithelial cells for sperm. Bilateral cryptorchidism in rams means sterility, but those affected unilaterally may be fertile. Cryptorchidism's prevalence in alpaca may be due to inbreeding.

■ Diagnosis

Histologically, rams with testicular hypoplasia exhibit lesions in the seminiferous tubules where sperm is formed. The condition is evidenced by abnormal development of the testicular region and can be detected shortly after birth. In unilateral hypoplasia, marked asymmetry in the scrotum is observed and the affected testicle is softer than the normal one and sometimes fibrotic (Annex Table 6). Animals with double hypoplasia resemble castrated males, with a small penis, reduced or nonexistent libido, and complete sterility.

Cryptorchidism can be diagnosed by palpating the scrotum to determine the presence or absence of testicles (Annex Table 6). Unilateral cryptorchidism has no clinical manifestations; sexual libido is normal and physical features are masculine.

■ Prevention and Treatment

Defective rams with small or undetectable testicles must not be used for breeding.

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Kimberling, C. V., R. Jensen, and B. Swift
1988 Diseases of Sheep (3rd edition). Philadelphia: Lea and Febinger.

[36] Sheep Flock Management

Introduction

Flock management involves all human activities associated with raising food animals: marking, docking, castrating, vaccination, drenching, dipping, trimming hooves, breeding, lambing, pregnancy diagnosis, weaning, shearing, etc. The goal of good management is to increase productivity. This section discusses the importance of understanding certain diseases of sheep as they relate to all these management activities. Emphasis is placed on newborn lambs because they usually experience higher mortality rates than adult sheep.

The management activities described below are those practiced at highly successful sheep enterprises in the central sierra of Peru. For discussion of some of the equivalent activities in communities, see McCorkle 1983. Where socioeconomic conditions permit (Chapters 2 and 3), ideally most of these management practices used in enterprises should also be applied to community flocks (Table 1).

Breeding

Breeding involves planned mating of rams and ewes to obtain offspring with desirable characteristics (Chapter 5). Males selected for breeding should be vigorous and healthy. Those with infectious lesions (epididymitis and/or orchitis) and uni- or bilateral hypoplasia or cryptorchidism should never be allowed to breed. Likewise, chronically ill and parasitized males suffering from conditions such as sheep pulmonary adenomatosis, ovine progressive pneumonia, caseous lymphadenitis, severe footrot, chronic fascioliasis, undernutrition, or any other condition causing progressive weight loss should be eliminated. Those with ulcerative dermatosis and/or posthitis (infectious or noninfectious) should be cured and the surrounding wool removed.

A practical recommendation based on breeding animals' differing sexual experience is that young ewes be mated with old rams, and in some cases old females with young males. Large sheep-breeding enterprises perform mating between April and July, depending upon the climate; in communities, sheep mate throughout the year. The age of first mating for ewes is about 2.5 years. In enterprises where sheep are well nourished, ewes can be bred at 1.5 years.

The percentage of rams to ewes in mating varies from 4% to 8%, depending on the age of the rams and reproductive health. In selecting breeding males, sound body conformation, live weight, and wool quality should also be considered.

Table 1. Current Management Calendar for Sheep in Peru

Month	In Organized Enterprises	In Communities[1]
January	General drenching against roundworms, worms in lambs, and tapeworms.	Lambing
February	Beginning of shearing. General classification and reclassification of ewes, young ewes, rams, and young rams. CuCoFe administration to adult sheep, to prevent swayback.	Marking Shearing
March	Shearing and CuCoFe administration continue, along with genital examination of rams.	Shearing Dipping
April	General drenching against roundworms. General dipping.	Dipping
May	Examination of rams. Beginning of breeding season.	Lambing
June	Breeding continues. Beginning of weanling shearing.	Lambing Marking
July	Weanling shearing continues. Selection of young rams. Vaccination with REV 1. Dipping of weanlings. Breeding finishes.	
August	Genital examination of rams after breeding.	
September	Drenching against roundworms. Preparation for lambing.	
October	Beginning of lambing.	
November	Clinical diagnosis of pregnant ewes. Marking of first lambs. Drenching ewes against roundworms.	
December	Marking of second lambs. Drenching ewes against roundworms. Lambing finishes.	Lambing

[1]In communities, breeding occurs yearround, but lambing mainly falls in two periods, December-January and June-July.

Pregnancy Diagnosis

Ballotment (perneo, desempreño) is generally used to identify and separate the following groups: pregnant females before the birth season, animals that have aborted prior to or during the birth season, females that refuse to nurse or that produce insufficient milk, non-pregnant animals, and dams whose neonates have died. Ballotment consists of externally palpating the abdomen for signs of a fetus. Performed by a specialist, this technique is rapid, economic, safe, and relatively accurate, especially during the last month of pregnancy. Other techniques include laboratory testing and ultrasound (Gamarra 1988).

Some sheep enterprises conduct pregnancy diagnosis prior to lambing; others do so 30 days after lambing or when 80% of ewes have lambed. With early diagnosis, non-pregnant ewes can be removed from the flock, thus saving more feed for the pregnant ewes. But later pregnancy diagnosis is safer in terms of avoiding induced abortions.

Birth Season and Care of Newborns

Parturition occurs 5 months after breeding in sheep. The birth season is a critical time; it requires the participation and dedication of many people in order to obtain satisfactory results. For sheep, lambing paddocks should be located on level ground, be protected from the wind, be free of cactus, and contain fresh pasturage and abundant water. These paddocks should be used only during the lambing season. Dogs should not enter them (Ameghino 1985).

Lambing pens are usually constructed of wire mesh. A 100 m roll supported by 14 posts will enclose an area large enough for approximately 1000 pregnant ewes. Pens should be moved every 2 to 3 days or, if it rains, daily. Sleeping areas used in previous lambing seasons should be avoided. This strategy will reduce the prevalence of infectious diseases such as colibacillosis, enterotoxemia, coccidiosis, pyosepticemia, hepatic necrobacillosis, omphalophlebitis, polyarthritis, and keratoconjunctivitis, as well as parasitic diseases (Ameghino 1985). Also, lambing pens facilitate identification of lamb-ewe pairs and disinfection of the navel; and they decrease mismothering and losses to predation. A special hut should be constructed near the pens to protect newborns on nights of hail, severe frost, snow, or heavy rainfall. Neonates suffering from exposure should be rubbed dry to activate peripheral circulation and then be wrapped in warm cloth as long as severe weather continues.

Placentas, aborted fetuses, and dead lambs should be submitted to a diagnostic laboratory for examination. All remaining tissues should be buried to forestall the spread of disease via dogs and vultures.

For the first 3 days after birth, lambs should be separated in a special enclosure where they can be observed and treated. Statistics show that 87%

of newborn deaths among Peruvian sheep occur during the first 3 days of life (Ameghino 1985). At day 4, the newborns should be placed with other lambs aged 4 to 12 days in a second group. After 12 days, the lambs are put in yet another group, comprised of animals 12 to 30 days old. Although this management system involves considerable labor, it increases lamb survival during the first month of life. A simpler alternative is to create only two groups, from 1 to 4 and 5 to 30 days old.

Some ewes refuse to nurse due to lack of experience, infected teats, mastitis, malnutrition, or other reasons. Their lambs must be bottle-fed or placed with a foster ewe. If the foster ewe refuses an abandoned or orphaned lamb, tie the lamb to the ewe or cover the lamb with the skin of the foster ewe's deceased lamb.

Since the ruminant placenta does not allow transfer of antibodies in utero, it is essential that neonates receive colostrum as soon as possible within the first 6 hours of life. Otherwise, they will have no defense against disease. Suckling within a few hours of birth allows active transfer of antibodies from the dam's colostrum through the intestinal wall into the circulatory system. If suckling is impossible, hand-milk the dam and feed the colostrum to the lamb. Colostrum is produced only during the first 36 hours after birth. Newborns must nurse at least 4 times daily.

■ Ear Marking, Castration, Docking, and Vaccination

In sheep enterprises in Peru, ear marking, castration, docking, and vaccination of lambs are all conducted at one month of age (Fulcrand 1983). Marking serves to indicate ownership and date of birth. Both ear tags and ear notches are used. Ownership marks are registered with the Ministry of Agriculture and denote legal property. For practical reasons, males and females are marked on opposite ears.

Selection of animals for castration begins during marking. Males with poor wool, prognathism, or any of the other defects outlined in this chapter and in Chapter 5 should be castrated, along with ram lambs born at the end of the breeding season. Castration can be accomplished by applying pressure with the teeth or a rubber band until the testicles drop off.

All sheep production enterprises of the Peruvian central sierra vaccinate lambs against contagious ecthyma at the time of marking. Some also vaccinate against enterotoxemia and, right after weaning, against ovine epididymitis.

Docking consists of partially amputating the tail. This is done to reduce the accumulation of fecal material on the tail, to facilitate breeding, and for aesthetic reasons. Docking may be performed with a knife, hot forceps, or rubber bands. The latter technique is safer because infection is less likely.

■ Weaning

Weaning is often associated with the formation of new flocks divided according to age classes, sex, and quality. Male lambs should be weaned between 3 and 3.5 months, and females at 4 to 5 months. If cultivated pastures are available, lambs can be weaned as early as 3 months of age. Early weaning is desirable because the ewe will return to estrus and can thus be re-mated (Gamarra 1988).

■ Shearing

Shearing is an economically important activity because it produces immediate profit from the sale of the wool harvests. In large enterprises, sheep are sheared in special sheds in January-March. Both electric and manual clippers are used (Gamarra 1988). Large enterprises shear all sheep every year. Some even harvest the wool of October-born lambs in June-July since lambs' wool fetches a high market price. In communities, most shearing is done from January to March, using shears or sometimes knives, tin can lids, or slivers of glass. Animals are generally shorn every two years. However, economic necessity often leads to yearround harvesting and sale of wool in communities. Shearing should always be done on sunny days and in relatively clean areas. After shearing, when shearing wounds have healed, the animals should be treated for external parasites. Since most adult parasites, eggs, and nymphs are removed along with the fleece, those remaining are quite vulnerable to external treatment.

■ Dipping

Dipping eliminates external parasites such as keds, mites, and lice (Figure 1). Spraying and dusting may achieve the same goal when mange is not present, but dipping is the most common procedure. Dips are found at all central sierra sheep enterprises and in many communities.

Many commercial dipping products are available; for best results, follow the manufacturers' instructions. The administration of Ivermectin parenterally or Closantel orally for mange control will also eliminate mites and internal parasites, and may help control opportunistic infections such as pneumonia, malignant edema, blackleg, and caseous lymphadenitis, among others.

All sheep and sheep dogs must be treated at the same time since a single untreated animal can reinfect the entire flock. The head of each sheep must be immersed twice. If mange is present, it may be necessary to repeat the dipping 13 days later. Dipping should be done every April or May, when shearing wounds have healed yet the wool is still short. A footbath of 10% to 30% copper sulfate solution should precede dipping. If this is not feasible, the

Figure 1. A flock with foot lice is treated in a portable wooden foot bath containing an antiparasitic drug.

bath should contain 1% copper sulfate, which acts as a bacteriostatic; but the bath must be renewed when the insecticide is replaced. Sick, emaciated, or lactating animals should not be dipped, and treated animals should not be slaughtered for several days.

Drenching

Drenching is the oral or parenteral application of drugs to eliminate internal parasites. It is an essential part of flock management and should be practiced in conjunction with pasture rotation in order to prevent reinfection from unsanitary, overcrowded paddocks. Sheep are especially prone to parasitic infection at stressful times, such as weaning, shearing, and dipping. In sheep enterprises every animal is treated for roundworm in September before lambing, during the rainy season in January, and in April after the rains e... Liverfluke infestation can also be treated at the same time. Treatment agai st tapeworm is administered when lambs are 3 months old because massive taenia infection can obstruct the intestines; this apparently favors development of pulpy kidney and enterotoxemia from Clostridium perfringens type D. Young animals are drenched against roundworm immediately after weaning. Broad-spectrum antihelmintics that eliminate roundworms, liverflukes, and tapeworms are now available. However, their use must be restricted in areas where mixed parasitic infection is well known.

In enterprises, sheep are drenched in portable wire mesh pens using special drenching guns for orally administered drugs. In communities, bottles are sometimes used for drenching; but this practice can cause pneumonia from false aspiration. Sheep dogs should also be treated for internal parasites — especially for the control of taenia. The latter transmit hydatid disease and coenurosis, which can infect humans as well as sheep. Orally administered Arecoline Hydrobromide and Praziquantel are used to treat dog tapeworm.

■ Sulfatation

Sulfatation is the chemical treatment of paddocks and water sources to eradicate the intermediate snail host of Fasciola hepatica, the liverfluke. Five hundred liters of 2% copper sulfate solution or a mixture of 1 kg copper sulfate to 80 kg sand should be spread over each hectare of paddock. Streams should also be treated by placing cloth bags of the copper sulfate suspension in the water, taking into account the width, depth, and velocity of the stream. The velocity in cubic meters is calculated by multiplying these three factors. The result is in turn multiplied by the constant 375 in order to calculate the amount of copper sulfate necessary per cubic meter per second for a concentration of 1:250,000 for a 1.5 km length in 24 hours.

For example, a stream that averages 1.2 m wide, 0.20 m deep, and a velocity of 0.5 m per second yields 1.2 X 0.2 x 0.5 = 0.12 m^3 per second. Multiplied by 375, this equals 45, which is the number of kilograms of cooper sulfate needed to treat 1.5 km of the stream for 24 hours. A 1% copper sulfate solution can be used on the surface of stagnant water and surrounding plants to eliminate snails. The ratio for treating stagnant water is 10 kg of solution per hectare. It is advisable to treat at the end of the dry season (October) and after the rainy season (April) to best control snails.

■ Control of Predators

In some enterprises in the central sierra, predators account for the majority of lamb losses. But everywhere, predation is a problem for lambs — particularly from the Andean fox. Because the birth seasons for foxes and sheep coincide, lambs are predilect prey. Foxes preferentially attack the jugular vein. A single fox may kill a group of 10-15 lambs, leaving behind severely mutilated animals. On occasion, foxes eat only the abomasum. Puma prefer to claw the face; they also mutilate other body parts. Wildcats mainly attack the head, neck, and ears. Skunks attack the sides; they prefer the brain, eyes, and tongue.

To prevent fox attacks, handmade lamps consisting of cans containing kerosene, petrol, or burned oil can be set out every 40-50 m around the lambing paddocks and burned all night. Shooting off a few firecrackers also helps frighten off predators at night. Fox hunts help control the population of this predator.

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In addition, see the references cited in earlier sections of this chapter.

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Table 1. Differential Diagnosis of Diarrhea in Lambs

		Clinical Signs	
Disease[1]	Agent	Dehydration	Other Signs
From Birth to 4 Weeks			
Colibacillosis [2]	Bacteria	Frequently	Watery or yellow diarrhea, sometimes fever, severe dehydration. Death losses.
Salmonellosis [2]	Bacteria	Rarely	High fever, yellow or green diarrhea.
Lamb dysentery [2]	Bacteria	Rarely	Bloody diarrhea, sometimes with abdominal pain. Rapid death.
Viral diarrhea [2]	Virus	Rarely	Fever. High death losses when complicated with other agents.
Protozoal enteritis or cryptosporidium [2]	Parasite	Rarely	Not well defined.
Enterotoxemia [3]	Bacteria	Rarely	Sudden death of healthy lambs. Abdominal distention, neurological signs, sometimes opisthotonos and/or diarrhea.
From 4 Weeks to Weaning			
Salmonellosis [6]	Bacteria	Rarely	High fever, bloody or yellow diarrhea.
Coccidiosis [6]	Parasite	Frequently	Acute bloody diarrhea, dehydration, and sometimes death. Occasionally nervous signs.
Parasitic gastroenteritis [6]	Parasites	Frequently	Weight loss, dehydration, and diarrhea in a group of lambs.
Taeniasis [12]	Parasite	Rarely	Mild diarrhea, grainy feces.

[1]Numbers in brackets indicate relevant sections of chapter.

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Table 2. Differential Diagnosis of Respiratory Diseases in Sheep

		Clinical Signs			
Disease1	Agent	Nasal Discharge	Fever	Cough	Other signs
Acute pnuemonia [4]	Bacteria	Thick mucous	Yes	Frequently	Usually affects lambs Sudden presentation. Frequently associated with management and climate factors.
Necrotic stomatitis [8]	Bacteria	No	Yes	Frequently	Usually affects lambs. Breathing difficulties, mal-odorous oral lesions.
Atypical pneumonia [10]	Complex	Mucous to mucopur-ulent	Yes	Frequently	Usually affects lambs and yearlings.
Verminous bronchitis [11]	Parasite	Mucopur-ulent	No	Occasionally; dry	Respiratory difficulties, sometimes with noisy inspiration.
Sheep pulmonary adenomatosis [14]	Virus	Abundant, watery	No	Frequently; moist	Progressive weight loss, "abdominal" respiration, moist respiratory sounds.
Ovine progressive pneumonia [15]	Virus	No	No	Rarely	Progressive weight loss, "abdominal" respiration. Lungs, udder, joints, or brain may be affected.
Caseous lymphadenitis [16]	Bacteria	Rarely	No	Rarely	Severe emaciation, sometimes with respiratory difficulties and enlarged superfi-cial lymph nodes.
Hydatid disease [24]	Parasite	Rarely	No	Rarely	Usually affects mature animals. Severe emaciation, sometimes with respiratory diffi-culties.
Nasal myiasis [28]	Parasite	Mucopur-ulent	No	Rarely	Respiratory difficulties, usually with noisy respiration mainly in the upper respiratory tract.

[1]Numbers in brackets indicate relevant sections of chapter.

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Table 3. Differential Diagnosis of Lameness

		Clinical Signs	
Disease[1]	Agent	Swollen joints	Other signs
Foot and mouth disease [0]	Virus	Rarely	Small blisters and erosions between toes, and on teats and mouth. Systemic, vesicular disease. High morbidity.
Navel infections [5]	Bacteria	Frequently	Usually affects lambs. Enlarged navel stump. Suppurative arthritis. Systemic disease involving one or two joints.
Contagious ecthyma [7]	Virus	Rarely	Usually affects lambs. Proliferative lesions mostly on mouth, lips, nose, and occasionally feet.
Footrot [18]	Bacteria	Rarely	Mostly affects mature animals. Necrosis of the sole. Highly contagious.
Blackleg [19]	Bacteria	Swollen muscles	Lesions on limbs and in genital tract, leading to stiff gait.
Chlamydial arthritis [31]	Bacteria	Occasionally	Mostly affects lambs. Occasionally produces conjunctivitis in lambs and abortions in ewes. Systemic disease.
Ulcerative dermatosis [32]	Virus	Rarely	Venereal disease with severe proliferative lesions. Lips, legs, and external genitalia also affected. Severe proliferative lesions.
Foot abscesses [34]	Bacteria	Occasionally	Mostly affects mature animals. Soft tissue swollen above the coronet. Noncontagious.

[1]Numbers in brackets indicate relevant sections of chapter

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Table 4. Differential Diagnosis of Nervous System Diseases

		Clinical Signs				
Disease[1]	Agent	Convulsions	Blindness	Rubbing head against objects	Circling	Other signs
Enterotoxemia [3]	Bacteria	Yes	No	No	No	Usually affects lambs. Opisthotons, prostration.
Navel infections [5]	Bacteria	No	No	No	No	Occasionally observed in lambs, when abscesses in the spinal cord produce posterior weakness and paralysis.
Enzootic ataxia [13]	Metabolic	No	No	No	No	Usually affects lambs. Weakness, posterior paralysis.
Rabies [22]	Virus	Yes	No	No	No	Affects all ages. Aggressive behavior, hypersexual activity.
Coenurosis [25]	Parasitic	Yes	Yes	Yes	Yes	Mainly affects weanlings and adults. Typical circling movements.
Astragalus poisoning [30]	Metabolic	No	No	No	No	Strong dependency on toxic plants. Uncoordinated gait progressive paralysis.
Listeriosis [31]	Bacteria	Yes	Yes	Yes	Yes	Rare. Torticollis, facial paralysis.

[1] Numbers in brackets indicate relevant sections of chapter

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Table 5. Differential Diagnosis of Abortion in Ewes

Disease[1]	Agent	Serological Test(s) Available	Clinical Signs: Time of Abortion	Clinical Signs: Other Signs
Photosensitization [29]	Metabolic	No	At any age	Acute dermatitis, edema, necrosis in ears, eyes, eyelids
Astragalus poisoning [30]	Metabolic	No	At any age	Abortion, perinatal mortalities, sometimes deformed extremities.
Chlamydial or enzootic abortion [31]	Bacteria	Yes	After third month	Acute outbreak of abortion in young ewes; endemic abortions in older ewes. Weak lambs, still borns, some mummified fetuses.
Toxoplasmosis [31]	Parasitic	Yes	After mid-gestation	Abortion in ewes in mid-gestation, and in lambs in late pregnancy.
Leptospirosis [31]	Bacteria	Yes	After third month	Low incidence of abortion.
Border disease [31]	Virus	Yes	At any age	Macerated, mummified, or swollen anasarcous fetuses. Stillborns or neonates with abnormally hairy coats. Sometimes muscular tremors in ewes.
Bluetongue [31]	Virus	Yes	At any age	Mummified fetuses, stillborns, congenital deformations, or retarded growth.
Brucellosis (B. ovis) [31, 33]	Bacteria	Yes	At the end	Epididymitis in rams; abortions, stillborn and weak lambs.

[1]Numbers in brackets indicate relevant sections of chapter.

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Table 6. Differential Diagnosis of Male Genital Diseases and Conditions

Disease[1]	Agent	Serological Test(s) Available	Clinical Signs: Lesions	Clinical Signs: Other Signs
Ulcerative posthitis [0]	Metabolic/ bacteria	No	Posthitis	Rigid and stiff gait.
Ulcerative dermatosis [32]	Virus	No	Posthitis and balanitis	Crusted ulcerative lesions on skin and mucosa of the prepuce and penis. Sometimes ulcerative lesions on lips, legs, and feet.
Brucellosis (B. ovis) [33]	Bacteria	Yes	Epididymitis/ orchitis	Affects adult and young rams. Infertility with outstanding epididymitis and/or orchitis.
Traumatic epididymitis [33]	Accidental	No	Epididymitis/ orchitis	Rare.
Miscellaneous infectious epididymitis [34]	Bacteria	Yes	Epididymitis/ orchitis	Mainly affects young rams. Epididymitis and/or orchitis. Enlarged testicles.
Testicular hypoplasia [35]	Inherited	No	Asymmetric testicles	One or both testicles abnormally small.
Cryptorchidism [35]	Inherited	No	One or both testicles absent	One or both testicles located in the abdominal cavity.

[1]Numbers in brackets indicate relevant sections of chapter.