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Production and Marketing of Sheep on the Bolivian Altiplano: An Economic Analysis

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PRODUCTION AND MARKETING OF SHEEP ON THE BOLIVIAN *ALTIPLANO*: AN ECONOMIC ANALYSIS

by

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ABSTRACT

Production and Marketing of Sheep on the Bolivian *Altiplano:* An Economic Analysis

by

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Utah State University, 1970

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A study was undertaken to evaluate the general sheep marketing process in Bolivia, to determine the present economic structure of farm units belonging to *Altiplano* sheep producers, to analyze the economics of marketing *Altiplano* sheep at an earlier age, and to analyze the economics of using various local products as a supplemental sheep feed in Bolivia.

In general the Bolivian sheep marketing process is inadequate and inefficient because of lack of marketing information, poor producer-buyer contact, lack of commercial sheep transportation, slaughterhouses lacking in facilities and hygienic conditions, and apparently unattractive retail methods.

By selling their relatively unproductive male sheep before they are one year old and replacing them with ewes and yearling ewes, the results of the study indicate that the "criollo" and semi-improved sheep producers could increase the return to their sheep enterprise by 43 percent and 10 percent, respectively, and that they could increase the value of sheep available for sale or trade by 67 percent and 13 percent, respectively.

To help determine the economics of feeding sheep a supplemental ration in Bolivia, a sheep feeding experiment was designed to test three breed-types of sheep, and two roughage-to-concentrate ratios. Two hundred and thirty-five lambs were fed for 63 days. The results of the study indicate that fattening lambs commercially in Bolivia is potentially profitable.

(75 pages)

INTRODUCTION

A large portion of Bolivia's population consists of peasants who live on an extremely high, dry plateau called the *Altiplano*. Lying between the main eastern and western ridges of the Andes Mountains, the *Altiplano* is about 500 miles long, 80 miles wide, and has an average elevation of 12,350 feet. The *Altiplano* is productive primarily as a pasture-land for hardy animals. Because sheep adapt well to this area they are important to the economy of the Bolivian peasant (*campesino*). Although most *campesinos* raise sheep, the quantity of lamb and mutton actually marketed is nominal. The reasons for the small number of sheep marketed appear to be (a) the production of sheep has been traditionally limited mainly by the meager amount of forage available on the *Altiplano*, and (b) the *campesino* is concerned about producing for his consumption first, and any existing "excess" may or may not be sold or traded.

Increasing the *campesino's* sheep production would increase the number of sheep which could be marketed. An increase in the number of sheep marketed would benefit Bolivia in many ways. It would increase the *campesino's* income. The *campesino* could then become more integrated into the market economy, and his purchases of consumer goods would create a larger market for Bolivian industry. Since Bolivia is a net importer of meat, an increase in national production could free valuable foreign exchange for other uses. Increased meat supply would also make more animal protein available to the Bolivian population.

It has been observed that the only supplemental feed given to most *Altiplano* sheep is occasional small amounts of barley hay. Bolivia has

available significant amounts of products, such as corn and wheat by-products, which have been successfully used in concentrate feeds for sheep in other countries. Since feed for sheep is a relatively scarce resource on the *Altiplano*, additional feed in the form of a concentrate may have a high marginal return. If wheat by-products can be economically used as a supplemental feed for sheep, the program to increase national wheat production could benefit substantially.

It has also been observed that most sheep that are consumed or marketed are two or three years old. Consumption or sale of these sheep at a younger age (e.g., 10-12 months) would reduce the number of relatively unproductive older males in the herd. The number of breeding ewes could then be increased accordingly. This would increase the number of lambs born and thus increase production and marketing.

If sheep production were significantly increased, the previously mentioned benefits of increased marketing would not be realized unless the sheep marketing system were capable of distribution and sale of the increased production.

Objectives

The objectives of this study are:

1. Analyze the economics of alternative methods of producing sheep for market on the Bolivian *Altiplano*.

2. Evaluate the general lamb and mutton marketing system in Bolivia.

REVIEW OF LITERATURE

There is some divergence of opinion among economists as to the role agriculture has and should have in the economic development process. Some believe that agricultural development requires large amounts of capital which could be more profitably used in the development of the industrial sector. Others believe that development of the agricultural sector is a prerequisite to development of the industrial sector.

Much of the conflict among economists on this subject can be resolved by viewing the stages of the agricultural development process. Economists such as Mellor (5), Nicholls (7), and Schultz (8) espouse the idea that, depending on the stage agriculture is in, investment in the agricultural sector could have either relatively high or low returns. If farming is in the traditional phase, where farming has been the same for generations, then an increase in production by increasing traditional inputs is likely to be very costly. On the other hand, the introduction of new techniques and other available modern factors may have a very high return. The innovations would at some point, however, reach a point of diminishing returns, and the amount of capital profitably invested would therefore be limited.

In the study of economic growth, the industrial sector has received by far the largest share of attention. Many countries are striving to achieve economic growth by concentrating on the industrial sector and neglecting the agricultural sector, even though the agricultural sector of low income countries is usually the largest sector. A few countries

notably Japan and Mexico, are obtaining substantial growth from both industry and agriculture.

Schultz (8) states that there are no basic reasons why the agricultural sector of any country cannot contribute substantially to economic growth. Mellor (5) says that agriculture can make a major contribution to the overall development effort because most of the resources used have a low opportunity cost and the resources drawn from industry have a high rate of return. According to Johnson (3), increased agricultural productivity has played a crucial role in the industrial development of modern nations by releasing people from the land for employment, providing food for the growing population, and relieving pressure on the balance of payments due to food imports.

Kuznets (4) maintains that agricultural revolution is the precondition of industrial revolution, and Nicholls (7) believes agricultural progress is normally a prerequisite for industrial development and that under all circumstances increasing agricultural productivity makes important contributions to general economic development. Some of the benefits of increased agricultural production, according to Nicholls, are release of labor to industry, increased food supply for growing industrial sector, creation of rural purchasing power (by raising agricultural incomes), and rural savings which may be used to finance industrial development. Nicholls also mentions that in an open economy increased agricultural production may save scarce foreign exchange needed for financing imports of industrial capital.

Tang (9) asserts that industrialization without concurrent agricultural development is likely to cause much of the benefit from the development effort to accrue to the other countries. This is true, he

says, in underdeveloped countries where a "surplus" of labor prevails in the dominant agricultural sector. Thus, he continues, in an open economy agricultural development is still essential if the gains from industrialization, trade, and increased productivity in the export sectors are to be fully realized.

The following quotations from Schultz (8) seem to best sum up the role of agriculture in the development process:

> The man who farms as his forefathers did cannot produce much food no matter how rich the land or how hard he works. The farmer who has access to and knows how to use what science knows about soils, plants, animals, and machines can produce an abundance of food though the land be poor. Nor need he work nearly so hard and long. He can produce so much that his brothers and some of his neighbors will move to town to earn their living. Enough farm products can be produced without them.
>
> . . . Basically, this transformation is dependent upon investing in agriculture. Thus it is an investment problem. But it is not primarily a problem of the supply of capital. It is rather a problem of determining the forms this investment must take, forms that will make it profitable to invest in agriculture.
>
> . . . there is no longer any room for doubt whether agriculture can be a powerful engine for growth. But in acquiring such an engine it is necessary to invest in agriculture, and this is not simple because so much depends on the form the investment takes. Incentives to guide and reward farmers are a critical component. Once there are investment opportunities and efficient incentives, farmers will turn sand into gold. (8, p. 3-5)

After agricultural production is increased, the products must be distributed and sold. The role of marketing in development is also a subject of some disagreement. Some believe that if there is a demand, sufficient marketing channels will spring up spontaneously. Others believe that the proper marketing system must precede the increased production and development.

Fletcher (2) states that marketing is strategically situated to serve as a "leading sector" in development and it potentially possesses

significant influence on the development of the primary agricultural sector. Bonnen, Eicher, and Schmid (1) say marketing can play an active role in initiating development and accelerating growth.

According to Mellor (5), improved marketing facilities and procedures contribute to the objectives of agricultural development directly through providing fuller use of a given level of production. He states that often there are inefficiencies in the agricultural marketing system which cause actual loss of products; saving these commodities increases the supply available for consumption just as much as does an increase in production. Improved marketing also increases the economic value of output by increasing consumer satisfaction from a given quantity of produce by providing it with the form, time, and location utilities most pleasing to the consumer. Mellor continues that improvements in marketing may encourage increased production through reduced marketing costs and higher prices to producers. He believes that as development occurs, marketing becomes more important because farmers sell a larger share of what they produce and rising income increases the demand for marketing services.

It is generally accepted that increased production and marketing are technical complements, and it is self evident that one without the other is of little value.

DATA COLLECTION AND PROCEDURE

The overall study was made in four parts. First a general survey was made of the general Bolivian sheep marketing process. Then the present economic structure of *Altiplano* sheep producers was determined. Using this as a base, the effects of marketing male sheep at an earlier age were obtained. A sheep feeding experiment was then designed and carried out to help determine the economics of supplemental feeding on the *Altiplano*.

General Bolivian Sheep Marketing Process

Most of the information on the general Bolivian sheep marketing process was gathered by personal observation and interviews in the country. First retail outlets, including public markets, private butcher shops, and street vendors were visited. Many retailers were interviewed and much was apparent from personal observation. Next, public slaughter houses were visited and information obtained. Many middlemen (usually referred to as "Butchers" in Bolivia) were visited and interviewed also. Sheep producers were also interviewed with a prepared questionnaire.

Much information was obtained from personal involvement in buying, feeding, buying feed for, wholesaling, transporting, slaughtering, and retailing sheep in Bolivia.

Present Economic Structure of *Altiplano* Sheep Producers

A budget for a "typical" producer was developed from information obtained by numerous interviews with *campesinos*, experiment station

personnel, extension agents, *Banco Agricola* personnel, and others familiar with the subject. In general, questions were asked from a prepared questionnaire (see Appendix A). Information pertaining to the physical and economic structure of the farm, such as herd size and composition, lambing, mortality, farm consumption, marketing, prices, miscellaneous practices, etc. was obtained.

Because of the difficulty of assigning a realistic value to land (it is almost never bought and sold), it is not included in the capital investment. Return to land is, however, included as a return.

In analyzing the economic structure of the *Altiplano* sheep producer, the concept "return to the factors of production" is used. Return to factors of production (labor, capital, land, and management), in the case of the *Altiplano* sheep producer, is essentially the same as his income. The reason for this is that, generally, all factors of production are provided by him and his family.

Marketing Male Sheep at an Earlier Age

By using the present economic structure of the *Altiplano* sheep producer as a base, the effects of changes in herd structure are approximated. First it is assumed that all male sheep are sold before reaching one year of age. This cuts down the size of the herd significantly.

Number of the pasture years is held constant. A pasture year is equal to one yearling, one ram, or one ewe on pasture for a full year. For example, a pasture year is equivalent to two yearling wethers which are pastured for six months and then sold or it is also equivalent to one ewe pastured for a full year. Other factors remaining constant are lambing percentages, death rates, cost of feed and medicine, depreciation,

repairs, and labor.

With the decrease in the size of the herd, a number of excess pasture years are available for additional breeding ewes. The effect on production and returns of the additional ewes is then calculated.

Supplemental Feeding

To help determine the economics of feeding sheep on the *Altiplano*, a factorially arranged sheep feeding experiment was designed to investigate several combinations of breed-type of sheep and roughage-to-concentrate ratios for gain and consumption.

The experiment, as originally planned, called for a total sample of 240 weanling ram lambs--80 improved, 80 semi-improved, and 80 "criollo." Because of extreme difficulty in obtaining lambs only 235 were used in the experiment. For the sake of simplicity, the following explanation is based on the originally planned experiment which closely approximated the actual one.

An experimental design with factorially arranged treatments was used to test three breed-types of sheep, two roughage-to-concentrate rations, and two pen arrangements (Table 1). The latter variable was necessary due to the shortage of physical penning facilities. There were two replications.

This experiment was carried out in 1969 at the Patacamaya Agricultural Experiment Station in the Department of La Paz on the Bolivian *Altiplano*. The improved lambs used in the experiment were part of the breeding stock of the station. The semi-improved and "criollo" lambs were obtained from various areas of the *Altiplano*. All sheep were fed the same balanced ration for a two-week adjustment period prior to

beginning the experiment. Lambs were randomly assigned to treatment. All animals were treated with Thibenzole for internal parasites and with Gamatox for external parasites. During the experiment the lambs were treated for coccidiosis with Sul Met (sulfadimetilpirimidina) and were vaccinated against hoof and mouth disease.

Table 1. Experimental design for determining the effects of two roughage-to-concentrate ratios and two pen arrangements on "criollo," semi-improved, and improved ram lambs on the Bolivian *Altiplano*

	Pen arrangement[a]				
	Pen of 10		Pen of 30		
	Roughage-to-concentrate ratio[b]		Roughage-to-concentrate ratio		
Breed-type	40:60	75:25	40:60	75:25	
Criollo	2[c]	2	(2[d]	(2	
Semi-improved	2	2	2	2	
Improved	2	2	2)	2)	
Total	6	6	6	6	24

[a]Within a pen containing 10 lambs, all lambs were of the same breed-type and all were fed the same roughage-to-concentrate ratio. Within a pen containing 30 lambs, there were 10 lambs of each breed-type and all were fed the same roughage-to-concentrate ratio.

[b]The roughage was oat silage, and the concentrate was composed of corn, cottonseed meal, and wheat bran.

[c]Each unit of this design was replicated twice with 10 lambs in each unit; 240 lambs total.

[d]Units in parentheses were combined into pens containing 30 lambs, (see a).

All lambs were weighed at the beginning and end of the experiment and at intervals of two weeks throughout a 63-day feeding period. Weights were taken in the morning after the lambs were without food or

water for at least 14 hours. The lambs had free access to fresh water and block salt at all other times. Approximately half of the area of each of the pens was covered by a roof.

The amount of feed given to the lambs was based on 4.5 percent of live weight as recommended by the National Academy of Sciences (6) for fattening small lambs. Rations were calculated on a dry weight basis. One-half of the lambs received ration I, which consisted of 40 percent roughage and 60 percent concentrate. The roughage was oat silage, and the concentrate was composed of 30 percent corn, 30 percent wheat bran, and 40 percent cottonseed meal. After the two-week adjustment period, lambs were built up to the full ration over a period of several weeks. Rejected feed was not weighed back. Because of urinary calculi, which developed in several lambs in ration I, the roughage-to-concentrate ratio of ration I was increased to 50:50 for the last few weeks of the experiment.

RESULTS AND DISCUSSION

General Bolivian Sheep Marketing Process

The sheep marketing process is defined herein as the process by which sheep flow from producer to consumer. The analysis is broken down into the following areas: marketing information, seasonal fluctuations, producer-buyer contact, fair system, transportation, slaughtering, and retailing.

Marketing information

There is almost a complete lack of a national system of marketing information for sheep as well as for potential sheep feed supplements. At any given time the producer and the buyer are only aware of sheep prices within a relatively small geographical area. This creates wide differences which are not due to transportation costs.

Seasonal fluctuations

During the months from October to January there is a marked reduction in the number of sheep which are marketed. This is due mainly to the fact that after the dry winter, forage is so depleted that the sheep generally lose weight and are not in marketable condition. During this period, butchers pay a premium for sheep in fair condition or better. In other months of the year, the quantity marketed is greater with the largest movement during the harvest season (April-May).

Producer-buyer contact

Since there are no formally organized markets where sheep are bought

and sold except some country "fairs," the buyers and sellers encounter considerable difficulty in making contact with each other. The buyer in most cases is also the retailer. He buys, transports, and slaughters. His wife usually does the actual retail selling.

This buyer-butcher usually takes extended trips to areas where he has heard there are sheep for sale or where he has made previous arrangements to buy sheep. If he is able to buy sheep, he drives them toward his market, hopefully acquiring more sheep as he passes along the way. This hit and miss method often leaves prospective sellers without buyers and prospective buyers without sellers--at the same time.

Fair system

In many parts of the *Altiplano*, certain communities have market days or "fairs"--usually once a week. At a few of these fairs large numbers of sheep are sold. This provides the opportunity for several buyers and sellers to gather at one location and creates a "central market" type situation. But, at most fairs there are virtually no live sheep sold and only a relatively small number of sheep carcasses. Some carcasses are brought from the fairs to the larger city markets to be sold, but the slaughtering is usually poorly done. Furthermore, some of the carcasses are those of animals that died of natural causes before being dressed.

Transportation

Almost all sheep on the *Altiplano* are driven to market. The railroad does have livestock cars that could be made into two decks for sheep. With two decks these cars could transport a large number of sheep--but they are not used. There are no known commercial trucks in

Bolivia which are adapted especially for transporting sheep. Although regular trucks could be contracted, they are relatively expensive due to their limited capacity for sheep.

Transportation shrinkage is likely quite high when sheep are driven long distances to market. A two-week drive is not unusual on the *Altiplano*. However, in many cases there is no alternative to driving the sheep because of inaccessibility--especially during the rainy season.

Refrigerated trucks for hauling fresh meat are nonexistent in the country.

Slaughtering

Most of the slaughterhouses in the country are lacking in facilities, cleanliness, and control. An example is the La Paz Municipal Slaughterhouse, which supplies the largest market. It is located in an area which is difficult to reach--especially when animals are driven from El Alto, the usual port of entry for sheep. The facilities for penning and feeding sheep are limited. The few facilities that exist are privately leased; therefore, sheep must be slaughtered almost immediately upon arrival. Facilities for slaughtering sheep include a cement floor with a gutter for killing, open-air benches for dressing, and a concrete water deposit for cleaning viscera. Sanitation is lacking, and meat inspection is very loose. The tax for the use of the La Paz Slaughterhouse facilities is the sheep's head, which is considered a delicacy and is worth 4 to 5 pesos.[1] Many of the butchers contacted indicated

[1]Twelve Bolivian pesos ($b. 12.-) equal one American dollar. See Appendix D for all conversion rates.

a preference to slaughter illegally at their house instead of utilizing the La Paz Slaughterhouse. They believe that slaughtering at the Municipal Slaughterhouse is not convenient and that the tax is much too high.

Most of the slaughterhouses in other major cities of Bolivia have facilities for sheep similar to those of La Paz, but they charge a smaller tax per head.

Retailing

Retailing of sheep meat is done almost exclusively by women. Sometimes they sell carcasses that are brought to the city from fairs, but usually they sell sheep that their husbands have bought and slaughtered. Some of them have stalls in municipal markets and others simply sell along the sidewalk. Since sheep are usually small, some of them are sold as whole carcasses, but most are cut into pieces somewhat resembling quarters plus a fatty tail piece and a loin piece. The meat sits out unprotected--exposed to flies and dust. In La Paz, sheep meat is sold by the piece while in most other cities it is sold by the kilogram. Prices range from about 6 pesos per kilo in the smaller cities to about twice that at times in La Paz when sold by the piece.

Present Economic Structure of *Altiplano* Sheep Producers

For purposes of this study, an *Altiplano* sheep producer is defined as an *Altiplano campesino* with at least 15 breeding ewes. *Altiplano* sheep producers were divided into two groups representing producers of "criollo" sheep and producers of semi-improved sheep. The "criollo" and semi-improved sheep producers have several things in common. Each grows

potatoes, quinoa, and barley. Their livestock raising is almost exclusively limited to sheep. Although some *Altiplano* sheep producers grow crops other than the above mentioned and some raise other livestock, these items are not included in this study.

Producers of "criollo" sheep

"Criollo" sheep are degenerated descendants of sheep originally brought to the Americas by the Spanish. They are very small and produce a small quantity of poor grade wool. They make up the largest part of the Bolivian sheep population and most *campesinos* raise "criollo" sheep. The "criollo" sheep producer does not seem to be market or money oriented but is basically a subsistence farmer whose main goal appears to be survival for himself and his family. If he produces an excess over subsistence needs, he may or may not sell or trade the surplus. He usually does have a small cash income and some cash outlay.

The approximate capital investment (not including land or dwelling) of the "criollo" sheep producer is $b. 6,079.-, of which 92 percent is in sheep and the rest is in tools and construction. Table 2 gives the capital investment for the "criollo" sheep producer in detail. He raises an average of about 2.5 hectares of potatoes, barley, and quinoa. The yield from these crops is used mainly for on farm consumption, with a return from the three crops to labor, capital, land, and management of about $b. 2,015 (at market prices). The amount of these crops in excess of farm consumption needs and available for sale or trade is $b. 700.-[2]

[2]For crop costs and returns, see Appendix B.

Table 2. Present capital investment (except land[a] and dwelling) for typical "criollo" sheep producer

Description	Number	Value/unit	Total value
		$b.	$b.
Buildings (except dwelling)			
Sheep corral	1	108	108
Storage shed	1	120	120
Total			228
Equipment			
Shovel	2	20	40
Plow	2	35	70
Yoke	1	40	40
Hoe-pick	2	25	50
Sickle	2	8	16
Miscellaneous			20
Total			236
Livestock			
Ewes	42	70	2,940
Rams	15	70	1,050
Yearling ewes	13	65	845
Yearling rams	13	60	780
Total	83		5,615
GRAND TOTAL			6,079

[a]Land is not included because of the difficulty in assigning a realistic value to it. Farm land is seldom bought and sold on the *Altiplano*, and there is no established market price.

The typical "criollo" sheep producer has 83 sheep of which 51 percent are ewes, 18 percent are rams, and the remaining 31 percent are evenly divided between yearling ewes and yearling rams. Most sheep production and all wool sheared are for farm consumption. The large percentage of relatively unproductive rams acts as a type of reserve. In case of necessity he could sell them and not decrease his breeding stock. Most of these rams are over two years old when they are sold or consumed.

Most "criollo" producers do not use improved management practices such as docking, castrating, and treating for parasites. Their pasture land is severely overgrazed. The average lambing percentage (lambs born divided by mature ewes) is 74 percent with an average first year (lamb) death loss of 17 percent and an average death loss of 8 percent on sheep over one year old.

The return (at market value) of the "criollo" sheep enterprise to labor, capital, land, and management is $b. 936.- The value of sheep in excess of farm consumption, which are available for sale or trade, averages about $b. 560. Present income from the sheep enterprise is presented in Table 3.

Producer of semi-improved sheep

Semi-improved sheep are a cross between the native "criollo" sheep and an improved breed such as Corriedale. On the average, semi-improved sheep are one-half to three-fourths improved and are about 35 percent larger than "criollos." Their wool is of better quality and they yield considerably more than "criollo" sheep.

Table 3. Present income statement for typical "criollo" sheep enterprise

Source		Amount
Receipts:		
Sale or trade--8 rams @ $b. 70		$b. 560
Farm consumption:		
8 old ewes @ $b. 55	$b. 440	
3 rams @ $b. 70	210	
57 lbs. wool @ $b. 1.90	108	
Pelts	30	788
Increase in inventory		115
Total receipts		$b. 1,463
Miscellaneous costs:		
Feed--80 qq. barley hay @ $b. 6	$b. 480	
Medicine	25	
Depreciation--corral	11	
Repairs--corral	11	527
Return to labor, capital, land, and management		$b. 936
Labor and capital costs:		
Labor	$b. 931	
Interest on investment (8 percent)	499	1,430
Return to land and management		$b. -494

The number of semi-improved sheep producers on the *Altiplano* is quite small compared to "criollo" sheep producers. The producer of semi-improved sheep has a much larger land holding than the producer of "criollo" sheep.

The approximate capital investment (not including land or dwelling) of the typical semi-improved sheep producer is $b. 12,750.-, of which 95 percent is in sheep and the rest is in tools and construction. Table 4 presents the capital investment in detail for the typical semi-improved sheep producer. He raises a total of 3.5 hectares of potatoes, barley, and quinoa. As in the case of the "criollo" producer, most of the yield is consumed on the farm. Return from the three crops (at market prices) to labor, capital, land, and management is about $b. 2,543.- The value of the portion of these crops which is excess of farm consumption needs and is available for sale or trade is $b. 880.[3]

The typical semi-improved sheep producer has 140 sheep of which 64 percent are ewes, 2 percent are rams, 19 percent are yearling ewes, and 15 percent are yearling wethers. In contrast with the mainly subsistence sheep production of the "criollo" producer, most of the sheep production of the semi-improved producer is available for sale or trade, and he sells more than half of the wool sheared. The semi-improved producer does not have as many unproductive male sheep as the "criollo" producer. He commonly sells a few wether lambs before they are one year old and the rest before they are two.

Most semi-improved producers use better management practices such as docking, castrating, and medical treatment for parasites. But they

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[3]See Appendix B for cost, receipts, and returns for crops.

Table 4. Present capital investment (except land and dwelling) for typical semi-improved sheep producer

Description	Number	Value/unit	Total value
		$b.	$b.
Buildings (except dwelling)			
Sheep corral	1	145	145
Storage shed	1	130	130
Total			275
Equipment			
Shovel	2	20	40
Plow	2	35	70
Yoke	1	40	40
Hoe-pick	2	25	50
Shears	2	36	72
Sickle	3	8	24
Miscellaneous			30
Total			326
Livestock			
Ewes	89	85	7,565
Rams	3	283	849
Yearling ewes	27	80	2,160
Yearling wethers	21	75	1,575
Total			12,149
GRAND TOTAL			12,750

do not manage their pasture land well, as evidenced by its severe overgrazing.

Lambing percentage for semi-improved sheep averages 76 percent with a first year (lamb) average death loss of 17 percent and a death loss average of 8 percent on sheep over one year old.

Return (at market value) of the semi-improved sheep enterprise to labor, capital, land, and management is about $b. 2,991.- The value of sheep and wool in excess of farm consumption and available for sale or trade is $b. 2,900.- Table 5 gives present income for the sheep enterprise.

Marketing Male Sheep at an Earlier Age

As noted before, both "criollo" and semi-improved sheep producers maintain older male animals (rams or wethers) in their herds which are relatively unproductive (in the sense that they are not useful for breeding and their marginal meat production is nominal). Sale of the excess males when younger would allow the producer to increase the size of his breeding herd thus increasing production.

In this analysis the only change in the present economic structure is the make-up of the herd and the resultant changes in costs, receipts, and returns.

"Criollo" sheep

If the average "criollo" sheep producer maintained only two rams for breeding and sold all other male sheep before they were one year old, he would have 21 additional pasture years available for ewes and yearling ewes. He could increase the number of ewes by 16 and the number of

Table 5. Present income statement for typical semi-improved sheep enterprise

Source		Amount
Receipts:		
Sale or trade:		
7 wether yearlings @ $b. 70	$b. 490	
20 wether yearlings @ $b. 75	1,500	
7 old ewes @ $b. 70	490	
120 lbs. wool @ $b. 3.10	372	
Pelts	48	$b. 2,900
Farm consumption:		
9 old ewes @ $b. 70	$b. 630	
95 lbs. wool @ $b. 3.10	295	
Pelts	48	973
Increase in inventory		127
Total receipts		$b. 4,000
Miscellaneous costs:		
Feed--140 qq. barley hay @ $b. 6	$b. 840	
Medicine	121	
Depreciation--corral and shears	33	
Repairs--corral	15	1,009
Return to labor, capital, land, and management		$b. 2,991
Labor and capital costs:		
Labor	$b. 1,891	
Interest on investment (8 percent)	1,067	2,958
Return to land and management		$b. 33

yearling ewes by five. The new capital investment is $b. 245- less than the present one. See Table 6 for the new capital investment. The lambs from these additional ewes would increase the value of sheep production available for sale or trade by 67 percent, from $b. 560.- to $b. 935.- At the same time the return to labor, capital, land, and management would increase from $b. 936.- to $b. 1,338.-, a change of 43 percent. See Table 7 for new income statement.

Semi-improved sheep

If the average semi-improved sheep producer sold all wether lambs before they reached one year of age, he would have an additional 13 pasture years available for ewes and yearling ewes. He could increase the number of ewes by nine and the number of yearling ewes by four. The lambs from these additional ewes would increase the value of sheep production available for sale or trade by 13 percent from $b. 2,480.- to $b. 2,800.- This would also increase his return to labor, capital, land, and management by 10 percent from $b. 2,991.- to $b. 3,299.- See Tables 8 and 9 for new capital investment and income.

With the present birth and death rates there is very little increase per year in herd size. It would take many years for the herds of both the "criollo" sheep producer and the semi-improved sheep producer to naturally replace the less productive male sheep with ewes. Under present conditions, the producer would have to either buy the ewes or implement better management techniques in order to raise the birth rate and/or lower the death rate in order to replace the unproductive males. A small change in birth and/or death rates can have a significant effect on production. Table 10 summarizes the gains possible by replacing the

Table 6. Capital investment for typical "criollo" sheep operator if less productive rams are replaced by ewes

Description	Number	Value/unit	Total value
		$b.	$b.
Buildings (except dwelling)			
Sheep corral	1	103	108
Storage shed	1	120	120
Total			228
Equipment			
Shovel	2	20	40
Plow	2	35	70
Yoke	1	40	40
Hoe-pick	2	25	50
Sickle	2	8	16
Miscellaneous			20
Total			236
Livestock			
Ewes	58	70	4,060
Rams	2	70	140
Yearling ewes	18	65	1,170
Total	78		5,370
GRAND TOTAL			5,834

Table 7. Derived income statement for typical "criollo" sheep enterprise if less productive rams are replaced by ewes

Source		Amount
Receipts:		
Sale or trade--17 rams @ $b. 55		$b. 935
Farm consumption:		
11 old ewes @ $b. 55	$b. 605	
1 ram lamb @ $b. 55	55	
57 lbs. wool @ $b. 1.90	108	
Pelts	30	798
Increase in inventory		132
Total receipts		$b. 1,865
Miscellaneous costs:		
Feed--80 qq. barley hay @ $b. 6	$b. 480	
Medicine	25	
Depreciation--corral	11	
Repairs--corral	11	527
Return to labor, capital, land, and management		$b. 1,338
Labor and capital costs:		
Labor	$b. 931	
Interest on investment (8 percent)	480	1,411
Return to land and management		$b. - 73

Table 8. Capital investment for typical semi-improved sheep producer if less productive wethers are replaced by ewes

Description	Number	Value/unit	Total value
		$b.	$b.
Buildings			
Sheep corral	1	145	145
Storage shed	1	130	130
Total			275
Equipment			
Shovel	2	20	40
Plow	2	35	70
Yoke	1	40	40
Hoe-pick	2	25	50
Shears	2	36	72
Sickle	3	8	24
Miscellaneous			30
Total			326
Livestock			
Ewes	98	85	8,330
Rams	3	283	849
Yearling ewes	31	80	2,480
Total			11,659
GRAND TOTAL			12,260

Table 9. Derived income statement for typical semi-improved sheep producer if less productive wethers are replaced by ewes

Source		Amount
Receipts:		
Sale or trade:		
31 wether lambs @ $b. 70	$b. 2,170	
9 old ewes @ $b. 70	630	
120 lbs. wool @ $b. 3.10	372	
Pelts	48	$b. 3,220
Farm consumption:		
9 old ewes @ $b. 70	$b. 630	
95 lbs. wool @ $b. 3.10	295	
Pelts	48	973
Change in inventory		115
Total receipts		$b. 4,308
Miscellaneous costs:		
Feed--140 qq. barley hay @ $b. 6	$b. 840	
Medicine	121	
Depreciation--corral and shears	33	
Repairs--corral	15	1,009
Return to labor, capital, land, and management		$b. 3,299
Labor and capital cost:		
Labor	$b. 1,891	
Interest on investment (8 percent)	1,028	2,919
Return to land and management		$b. 380

Table 10. Summary of the effects of replacing less productive male sheep with ewes

	Return from sheep[a]	Percentage of present return from sheep	Value of sheep available for sale or trade[b]	Percentage of present value of sheep available for sale or trade
	$b.	%	$b.	%
Present situation				
Criollo producer	936	100	560	100
Semi-improved producer	2,991	100	2,480	100
Replace unproductive males with ewes				
Criollo producer	1,338	143	935	167
Semi-improved producer	3,299	110	2,800	113

[a]Return to labor, capital, land, and management.
[b]Does not include wool.

less productive male sheep with ewes.

The percentage increase in return and in value of sheep available for sale or trade (assuming farm consumption remains constant) is highest for the "criollo" sheep producer, because he has the largest percentage of unproductive male sheep. The increase in return (43 percent) and the increase in sheep available for sale or trade (67 percent) for the average producer of "criollo" sheep are large increases and they could make "significant increase" in his participation in Bolivia's market economy.

Although the percentage increase in return and in sheep available for sale or trade is not as large for the average semi-improved sheep producer (10 percent and 13 percent, respectively), the increases are still significant.

Supplemental Feeding

Physical relationships

A summary of the results of the lamb feeding experiments is presented in Table 11. There were obvious differences in weight gains and feed consumption among the animal breed-types. "Criollo" lambs averaged a gain of 4.1 kg. during the experiment, while the semi-improved gained an average of 5.3 kg. and the improved lambs gained 9.4 kg. on the average. Average total weight of feed (on a dry matter basis) consumed per lamb during the experiment was 24.5 kg., 32.9 kg., and 59.9 kg. for each breed-type, respectively. Differences in gain were statistically significant ($p < .001$).[4] Because it was not possible to keep individual consumption data, no statistical analysis was made of the differences in consumption. The feed per kg. of gain was 5.94 kg., 6.21 kg., and 6.41 kg. for the "criollo," semi-improved, and improved lambs, respectively.

The difference between the 6.30 kg. average total gain by the lambs on the 40:60 roughage-to-concentrate ratio and the 6.21 kg. average total gain by the lambs on the 75:25 roughage-to-concentrate ratio was not statistically significant.[5]

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[4]This means that the probability of this difference occurring by chance is less than one in one thousand.

[5]This means that the difference between the two gains could have occurred because of chance variation.

Table 11. Average beginning and ending weights, weight gains, feed consumption, and feed efficiency of lamb feeding experiment

Treatment	Average beginning weight	Average ending weight	Average gain	Average roughage consumption[a]	Average concentrate consumption[a]	Average total feed consumption[a]	Feed per kg. of gain[a]
	kg.	kg.	kg.	kg.	kg.	kg.	kg.
Breed-type							
Criollo	9.33	13.44	4.12	14.68	9.80	24.48	5.94
Semi-improved	12.90	18.20	5.30	19.69	13.23	32.92	6.21
Improved	23.62	32.98	9.35	35.83	24.11	59.94	6.41
Combined ave.	15.28	21.54	6.26	23.40	15.71	39.11	6.25
Roughage-to-concentrate 40:60[b]							
Criollo	9.66	13.66	4.00	12.26	13.10	25.36	6.34
Semi-improved	12.91	18.35	5.43	16.15	17.54	33.69	6.20
Improved	23.37	32.84	9.47	29.23	31.58	60.81	6.42
Combined ave.	15.31	21.61	6.30	19.21	20.74	39.95	6.34
75:25							
Criollo	8.99	13.23	4.24	17.10	6.49	23.59	5.56
Semi-improved	12.90	18.06	5.16	23.23	8.91	32.14	6.23
Improved	23.88	33.11	9.24	42.44	16.64	59.08	6.39
Combined ave.	15.25	21.46	6.21	27.59	10.68	38.27	6.16
Pen arrangement							
Pen of 10							
Criollo	9.55	13.29	3.74	14.96	9.94	24.90	6.66
Semi-improved	12.94	17.83	4.89	19.85	12.89	32.74	6.70
Improved	23.69	32.76	9.07	36.56	24.34	60.90	6.71
Combined ave.	15.39	21.29	5.90	23.79	15.72	39.51	6.70
Pen of 30							
Criollo	9.10	13.60	4.50	14.40[c]	9.65[c]	24.05[c]	5.34
Semi-improved	12.87	18.58	5.71	19.53	13.55	33.08	5.79
Improved	23.55	33.19	9.64	35.10	23.89	58.99	6.12
Combined ave.	15.17	21.79	6.62	23.01	15.70	38.71	5.85

[a]All feed weights are on a dry matter basis. Roughage was assumed to be .29 dry matter and concentrate .92.
[b]Because several lambs on this feed developed urinary calculi, the roughage-to-concentrate ratio was changed to 60:40 for the last few weeks of the experiment.
[c]Feed consumption in the pens of 30 was apportioned among breed-types according to body weight and is therefore only approximate for individual breed-types. The combined average, however, is accurate.

Although the difference in consumption between the lambs penned in groups of 10 and those penned in groups of 30 was relatively small (2 percent), the difference in weight gain was relatively large (12 percent) and was statistically significant ($p < .01$). The lambs in pens of 30 gained more than those in pens of 10.

There were no significant interactions--which means that the results stated above were statistically consistent throughout all treatment combinations. For example, it was stated that the larger breed-types had significantly larger gains. This was consistent in both roughage-to-concentrate ratios and in both pen arrangements.

Economic relationships

The purpose of this experiment was to determine whether or not it is economical for the Bolivian sheep producer to feed a supplemental ratio containing concentrate feeds. To help determine this, prices and/or price ranges were assigned to costs and returns.

Animal weight gains were valued at $b. 3.50 per kg. live weight. This is consistent with the price most often observed being paid by Bolivian butchers-buyers.

In determining costs, several assumptions were made. It was assumed that medical costs and death loss costs remain constant. In other words, it was assumed that the sheep producer would treat the lambs for parasites, etc., and would have the same death loss whether he gave his lambs supplemental feed or not. Therefore, although medical and death loss costs are part of a general sheep operation, they were not included as an additional cost of supplemental feeding for the sheep producer.

Another assumption was that although some labor is required in supplemental feeding, it would be done mainly by family labor with little or no opportunity cost. Therefore, no additional labor cost is assigned to the supplemental feeding operation.

Finally, there is generally a nominal additional capital investment required for supplemental feeding. This investment (for a small lot or corral and troughs, etc.) would average approximately $b. 5.00 per "criollo" lamb, $b. 7.00 per semi-improved lamb, and $b. 10.00 per improved lamb. The difference is due to the difference in size of the facilities required by the breed-types. When depreciated over a 10-year period, the average annual investment cost would therefore approximate $b. .50, $b. .70, and $b. 1.00 per "criollo," semi-improved, and improved lamb, respectively.

In determining the cost of feed, all ration components were given two prices--a high price and a low price. The high price is the estimated cost of the component if it is bought under fairly unfavorable circumstances (wrong time of year, smaller quantities, etc.). The low price is the estimated cost of the component if it is bought under fairly favorable circumstances (right time of the year, larger commercial quantities, etc.). Transportation costs to the farm (the experiment station in this case) are included in the price. Table 12 shows the estimated high and low prices of the feed ration components. Feed costs for Bolivian sheep producers would likely lie somewhere between the two cost limits. These cost limits are utilized in the calculations of Table 13. Also included in Table 13 are average weight gains, value of gains, depreciation of capital investment, and differences between value

of gain and various costs. Column 4, value of gain less depreciation, is essentially equal to a break-even variable feed cost. Column 6 is the break-even feed cost less the higher feed cost.

Table 12. Estimated high and low prices for feed components used in lamb feeding experiment

Component	Estimated low price per cwt. as fed[a]	Estimated high price per cwt. as fed
	$b.	$b.
Corn	31.00	36.00
Cottonseed meal	30.00	34.00
Wheat bran	14.00	17.00
Oat silage[b]	2.10	4.20

[a]Cwt. is 100 pounds.
[b]See Appendix C for information on price calculation for oat silage.

The value of the average weight gain in all of the treatments was larger than the depreciation of capital investment cost and the high feed cost combined. Some treatments had considerably larger returns than others. The return from the lambs in pens of 30 was much higher than that from the lambs in pens of 10. The author knows of no explanation for this phenomenon and since the penning arrangement is a factor which producers would not normally duplicate (the pens of 30 had 10 lambs each breed-type), it is not analyzed separately. The following data reflect the combined effect of the two penning arrangements. Lambs on both roughage-to-concentrate ratios gained approximately the same amount of weight, but lambs fed the 75:25 ratio had a higher net return because

Table 13. Difference between value of average gain and average costs using a low feed cost and a high feed cost

Treatment	(1) Average gain	(2) Value of gain[a]	(3) Depreciation of capital investment	(4) 2-3	(5) Low feed cost	(6) 4-5	(7) High feed cost[b]	(8) 4-7
	kg.	$b.	$b.	$b.	$b.	$b.	$b.	$b.
Breed-type								
Criollo	4.12	14.42	.50	13.92	8.13	5.79	11.41	2.51
Semi-improved	5.30	18.55	.70	17.85	10.96	6.89	15.36	2.49
Improved	9.35	32.73	1.00	31.73	19.97	11.76	27.98	3.75
Combined ave.	6.26	21.91	.73	21.18	13.02	8.16	18.25	2.93
Roughage-to-concentrate								
40:60								
Criollo	4.00	14.00	.50	13.50	9.57	3.93	12.79	.71
Semi-improved	5.43	19.01	.70	18.31	12.78	5.53	17.05	1.26
Improved	9.47	33.15	1.00	32.15	23.03	9.12	30.74	1.41
Combined ave.	6.30	22.05	.73	21.32	15.12	6.20	20.19	1.13
75:25								
Criollo	4.24	14.88	.50	14.38	6.69	7.69	10.03	4.35
Semi-improved	5.16	18.06	.70	17.36	9.13	8.23	13.69	3.67
Improved	9.24	32.34	1.00	31.34	16.92	14.42	25.26	6.08
Combined ave.	6.21	21.74	.73	21.01	10.92	10.09	16.32	4.69
Pen arrangement								
Pen of 10								
Criollo	3.74	13.09	.50	12.59	8.26	4.33	11.60	.99
Semi-improved	4.89	17.12	.70	16.42	10.79	5.63	15.18	1.24
Improved	9.07	31.75	1.00	30.75	20.22	10.53	28.38	2.37
Combined ave.	5.90	20.65	.73	19.92	13.09	6.83	18.39	1.53
Pen of 30								
Criollo	4.50	15.75	.50	15.25	8.00	7.25	11.22	4.03
Semi-improved	5.71	19.99	.70	19.29	11.13	8.16	15.53	3.76
Improved	9.64	33.74	1.00	32.74	19.72	13.02	27.60	5.14
Combined ave.	6.62	23.17	.73	22.44	12.95	9.49	18.12	4.32

[a]At $b. 3.50 per kg. live weight gain.
[b]See Table 12 for feed prices.

feed cost was less. Although all three breeds on the 75:25 roughage-to-concentrate level had fairly good returns even using the high feed cost, it would be helpful to know how dependable these gains are. How much variation can be expected and how much confidence may one have in these gains?

To answer these questions, a statistical "confidence interval" was calculated. Using this technique, one can calculate a lower limit and an upper limit with a predetermined level of confidence (e.g., 99 percent or 95 percent) that if the process is repeated the average would fall between the two limits. The confidence level used in this analysis is 95 percent. Since the best economic returns were from those lambs fed the 75:25 roughage-to-concentrate ratio, the technique will be applied to all three breed-types for only that feed ratio. Table 14 gives the confidence intervals for the gains and the resultant net returns.

Table 14. Average gain limits using 95 percent confidence interval and resultant returns using high and low feed costs for lambs on 75:25 roughage-to-concentrate feed ratio

Breed-type	Low gain limit[a]	High gain limit[b]	Returns using low gain limits[c]		Returns using high gain limits[c]	
			Low feed cost	High feed cost	Low feed cost	High feed cost
	kg.	kg.	$b.	$b.	$b.	$b.
Criollo	3.76	4.72	5.97	2.63	9.33	5.99
Semi-improved	4.65	5.67	6.45	1.89	10.02	5.46
Improved	8.58	9.90	12.11	3.77	16.73	8.39

[a] $\bar{x}$ - (1.96) $S\bar{x}$ where $\bar{x}$ = mean and $S\bar{x}$ = standard error of the mean.
[b] $\bar{x}$ + (1.96) $S\bar{x}$.
[c] Assuming value of gain at $b. 3.50 per kg. and feed costs given in Table 13, depreciation of capital investment is also subtracted. See Table 13.

The range of net returns for the "criollo" lamb is from $b. 2.63 (using the lowest gain and the high feed price) to $b. 9.33 (using the highest gain and the lower feed price). The range of net returns for the semi-improved lamb is from $b. 1.89 to $b. 10.02 and the net returns range for the improved lambs is $b. 3.77 to $b. 16.73.

Return, as a percentage of feed cost, using high and low feed costs, the low gain limit, the average gain, and the high gain limit is given in Table 15.

Using the average gain and an estimated average feed cost (average of high and low feed costs), net return would be more than 50 percent of feed costs for all three breed-types on the 75:25 roughage-to-concentrate level.

These returns are very encouraging--especially since the additional capital investment and labor are nominal. The results of the experiment indicate that fattening lambs commercially in Bolivia is potentially profitable.

Table 15. Return as a percentage of feed cost for lambs on 75:25 roughage-to-concentrate feed ratio[a]

	Return as a percentage of feed cost using:					
	Low gain limit		Average gain		High gain limit	
Breed-type	Low feed cost	High feed cost	Low feed cost	High feed cost	Low feed cost	High feed cost
	Percent		Percent		Percent	
Criollo	89[b]	26	115	43	139	60
Semi-improved	71	14	90	27	110	40
Improved	72	15	85	24	99	33

[a]See Tables 13 and 14 for returns and feed costs.
[b]For example, this 89 percent was obtained by dividing $b. 5.97 (row 1, column 3, Table 14) by $b. 6.69 (row 9, column 5, Table 13).

SUMMARY

A study was undertaken to evaluate the general sheep marketing process in Bolivia, to determine the present economic structure of *Altiplano* sheep producers, to analyze the economics of marketing *Altiplano* sheep at an earlier age, and to analyze the economics of using various local products as a supplemental sheep feed in Bolivia. A summary of the results is presented below:

1. In general the Bolivian sheep marketing process is inadequate and inefficient because of lack of marketing information, poor producer-buyer contact, lack of commercial sheep transportation, slaughterhouses lacking in facilities and hygienic conditions, and apparently unattractive retail methods.

2. Although the marketing process is poor, there appears to be a demand for more sheep than those presently marketed because sheep buyer-butchers actively seek sheep to buy--even during the time of year when there is supposed to be an abundance of sheep available for sale. It is not known, however, that quantity would satisfy this demand.

3. Both "criollo" and semi-improved sheep producers maintain older male sheep in their herds which are relatively unproductive.

4. The typical Bolivian sheep producer does not give his sheep any supplemental feed other than a little barley hay.

5. The approximate capital investment (not including land or dwelling) of the typical producer of "criollo" sheep is $b. 6,079.-, of which 92 percent is in sheep and the rest is in tools and construction. He raises a total of about 2.5 hectares of potatoes, barley, and quinoa.

The yield from these crops is used mainly for on-the-farm consumption, with a return from the three crops (at market value) to labor, capital, land, and management of about $b. 2,015.- The amount of these crops in excess of farm consumption needs and available for sale or trade is $b. 700.- annually.

6. The typical producer of "criollo" sheep has 83 sheep of which 51 percent are ewes, 18 percent are rams, and the remaining 31 percent are evenly divided between yearling ewes and yearling rams. The lambing percentage (lambs born divided by mature ewes) is 74 percent with a first year (lamb) death loss of 17 percent and a death loss of 9 percent on sheep over one year old. The return (at market value) of the "criollo" sheep operation to labor, capital, land, and management is $b. 936.- The value of sheep, in excess of farm consumption, which are available for sale or trade is $b. 560.-

7. The approximate capital investment (not including land or dwelling) of the typical producer of semi-improved sheep is $b. 12,750.-, of which 95 percent is in sheep and the rest is in tools and construction. He raises a total of 3.5 hectares of potatoes, barley, and quinoa. As in the case of the "criollo" producer, most of the yield is consumed on the farm. The return from the three crops (at market value) to labor, capital, land, and management is $b. 2,543.- The value of the portion of these crops in excess of farm consumption needs and available for sale or trade is $b. 880.-

8. The typical producer of semi-improved sheep has 140 sheep of which 64 percent are ewes, 2 percent are rams, 19 percent are yearling ewes, and 15 percent are yearling wethers. The lambing percentage for semi-improved sheep is 76 percent with a first year (lamb) death loss of

17 percent and a death loss of 8 percent on sheep over one year old. The return (at market value) of the semi-improved sheep operation to labor, capital, land, and management is $b. 2,991.- The value of sheep and wool which is in excess of farm consumption and is available for sale or trade is $b. 2,900.-

9. By selling his relatively unproductive rams before they are one year old and replacing them with ewes and yearling ewes, the results of the study indicate that one "criollo" sheep producer could increase the return to his sheep operation by 43 percent and that he could increase the value of sheep available for sale or trade by 67 percent.

10. The results of the study indicate that by selling his relatively unproductive wethers before they are one year old and replacing them with ewes and yearling ewes, the semi-improved sheep producer could increase the return to his sheep operation by 10 percent and he could increase the value of sheep available for sale or trade by 13 percent.

11. To help determine the economics of feeding sheep a supplemental ration in Bolivia, a factorially arranged sheep feeding experiment was designed to test three breed-types of sheep ("criollo," semi-improved and improved), two roughage-to-concentrate ratios (75:25 and 40:60), and two pen arrangements (pens of 10 and pens of 30). Two hundred and thirty-five lambs were fed for 63 days.

12. There were obvious differences in weight gains and feed consumption among the breed-types. The "criollo" lambs averaged a total gain of 4.1 kg. during the test while the semi-improved gained 5.3 kg. and the improved gained 9.4 kg. The average total weight of feed consumed per lamb (on a dry-matter basis) was 24.5 kg., 32.9 kg., and 59.9 kg. respectively. The differences in gain were statistically

significant ($p < .001$).

13. The lambs in pens of 30 had a considerably higher average weight gain (12 percent) than those in pens of 10. The difference in weight gain was significant ($p < .01$). The author knows of no explanation for this difference as the lambs in pens of 30 consumed less feed than those in pens of 10. The variable of pen arrangement was made necessary because of lack of penning facilities. The pens of 10 contained 10 sheep--all of the same breed-type. The pens of 30 contained 10 sheep of each breed-type.

14. The difference between the 6.30 kg. average total gain by the lambs on the 40:60 roughage-to-concentrate ratio and the 6.21 kg. average total gain by the lambs on the 75:25 roughage-to-concentrate ratio was not statistically significant.

15. Two feed costs were assigned--one using an estimated high cost for feed components and one using an estimated low cost for feed components. A depreciation of capital investment cost was also estimated. The value of the weight gain was estimated to be $b. 3.50 per kg. live weight. The net return, obtained by subtracting feed and depreciation costs from the value of the average weight gain, was positive for all treatments using both high and low feed costs. The best returns were from the lambs on the 75:25 roughage-to-concentrate ratio because the cost of feed was least.

16. A confidence interval (using an 0.95 confidence coefficient) was calculated for the gains of all three breed-types on the 75:25 roughage-to-concentrate ratio. Net returns were calculated for the interval limits using a high and a low feed price. All returns were

positive, including those using the lowest weight gain and the highest feed cost.

17. Return as a percentage of feed cost, using a high and a low feed cost, and the low gain limit, the average gain, and the high gain limit was calculated for the lambs on the 75:25 roughage-to-concentrate ratio. Using average gain and estimated average feed cost (average of high and low feed cost), net return would be more than 50 percent of feed costs for all three breed-types on the 75:25 roughage-to-concentrate ratio.

CONCLUSIONS AND RECOMMENDATIONS

1. The *Altiplano* sheep producer should sell his male sheep (which are not necessary for breeding) before they are one year old. By doing so, the number of unproductive males would decrease and he could then increase the number of breeding ewes, which would in turn increase his production. A program to encourage this type of improved herd management could be initiated immediately.

2. Fattening lambs commercially in Bolivia is potentially profitable but more research should be done before initiating a large scale program. The physical relationships found in this experiment should be verified by two or three replications. Investigations should also be made on feeding a supplemental concentrate ration to sheep with access to pasture (i.e., feed them a concentrate and let them forage for their roughage).

3. If the results of further research confirm that fattening lambs is economical, a campaign to get sheep producers to fatten sheep should be introduced. This campaign should be initially directed toward fattening and selling young male sheep. If they were fattened and sold, they would not develop into older unproductive male sheep and the number of these older males would soon diminish. The number of breeding ewes could then be increased. Pending formal research verification of the physical relationships of feeding, selected on-farm feedings could be introduced with interested *campesinos* to ascertain the results of feeding under actual farm conditions.

4. The nature of the demand for sheep meat in Bolivia and the magnitude of the markets should be quantified before starting an extensive program which would greatly increase sheep production.

5. One of the most important limiting factors to sheep production is the carrying capacity of the native pastures. The native pastures are severely overgrazed. The varieties of improved pastures best adapted to the *Altiplano* and the economics of improved pasture use should be determined as soon as feasible. The *campesino* should be introduced to better pasture management practices such as irrigation, proper use of fertilizer, and controlled grazing for maximum production.

6. Weekly information should be provided pertaining to the prices of sheep products and sheep feeds in the major markets. This would not only help distribute the supply and demand of sheep more evenly, but it would also orient the sheep producer toward selling and fattening.

7. Sheep fairs should be encouraged in areas of large sheep production. This would help get buyers and producers together and would also help orient the producer toward selling.

8. The feasibility and economics of transporting sheep to the markets by rail and truck should be further investigated.

9. Slaughterhouses should have hygienic facilities and more rigid meat inspection. The tax for slaughtering sheep in La Paz should be reduced perhaps to no more than 1 peso per head. This would tend to cut down on "home" slaughtering and produce a healthier product.

10. The effect of selling sheep meat in "American" type cuts and differentiating prices according to cut should be studied.

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APPENDIXES

Appendix A

Questionnaire Used in Campesino Interviews

Las preguntas se refieren a los últimos doce meses.

1. ¿Cuántas hect. posee?
2. ¿Posee título?
3. ¿Cuántas hect. riega?
4. ¿Cuántas hect. suyas cultiva?
5. ¿Cuántas hect. suyas usa para pastoreo?
6. ¿Cuántas hect. comunitarias cultiva?
7. ¿Cuántas hect. comunitarias usa para pastoreo?
8. ¿Posee las siguientes cosas?
   a. Canal para riego
   b. Alambrados
   c. Pastos mejorados
   d. Otros
9. ¿Posee las siguientes construcciones?
   a. Almacén
   b. Corral para ovejas
   c. Corral para vacunos
   d. Corral para chanchos
   e. Otros
10. ¿Posee las siguientes herramientas?
   a. Pala
   b. Picota
   c. Arado
   d. Yugo
   e. Otros

11. ¿Hay alguna otra inversión de capital?
12. ¿Qué reparaciones ha tenido?
    a. Corrales
    b. Otros edificios
    c. Herramientas
    d. Otros
    e. Suma
13. ¿Qué suma de impuestos ha pagado?
14. ¿Qué deudas tiene? (¿Cuánto y por qué?)
15. ¿Qué interés ha pagado sobre deudas? (¿Cuánto y por qué?)
16. ¿Qué cantidad de leña ha vendido? (En $b.)
17. ¿Alquila alguna tierra? (Dimensión y costo)
18. ¿Qué ingresos tiene fuera de la finca? (Fuente y suma)
19. ¿Pertenece a alguna cooperativa?
20. ¿Cuántas ovejas tiene?
21. ¿Cuántas ovejas hembras mayores de 2 años tiene?
22. ¿Cuántos machos (no de raza) mayores de 2 años tiene?
23. ¿Cuántos machos reproductores (de raza) tiene?
24. ¿Cuántas borregas de 1 a 2 años tiene?
25. ¿Cuántos borregos de 1 a 2 años tiene?
26. ¿Cuántos corderos hembras menores de 1 año tiene?
27. ¿Cuántos corderos machos menores de 1 año tiene?
28. ¿Cuántos corderos nacieron?
29. ¿Cuántas ovejas ha comprado?
30. ¿Cuántas crías han muerto?
31. ¿Cuántas ovejas han muerto?
32. ¿Cuántas ovejas ha consumido en la granja?

33. ¿Cuántas ovejas ha vendido?

34. ¿Cuáles ha vendido y a cuánto?

    a. Machos menores de 1 año

    b. Machos de 1 a 2 años

    c. Machos mayores de 2 años

    d. Viejas

    e. Otros

35. ¿Cuál es el número de ovejas del rebaño de un año a otro?

    a. Es estable

    b. Aumenta un poco

    c. Disminuye un poco

    d. Aumenta bastante

    e. Otros

36. ¿Cómo clasifica su rebaño de ovejas?

    a. Criollo

    b. Criollo y media sangre

    c. Media sangre

    d. Tres cuartos y siete octavos

    e. Otros

37. ¿Pastorea sus ovejas con los rebaños de otras personas?

    (¿Cuántas personas?)

38. ¿Cuántos pastores utiliza y para qué animales?

39. ¿Son los pastores?

    a. De la familia (sin jornales)

    b. A jornal

    c. 50 por ciento sin jornal - 50 por ciento a jornal

d. 75 por ciento familia - 25 por ciento a jornal

e. 25 por ciento - 75 por ciento a jornal

40. ¿Cuánto cuesta el jornal por un pastor?

41. ¿Qué porcentaje de sus ovejas ha esquilado?

a. 0

b. 10

c. 25

d. 50

e. Otros

42. ¿Cuántas libras de lana ha esquilado? (total)

43. ¿Cuántas libras de lana ha vendido?

44. ¿En qué precio ha vendido la libra?

45. ¿Cuántas libras de lana ha usado en la granja?

46. ¿Ha pagado jornales para la esquila? (¿Cuántos?)

47. ¿Cuánto cuesta un jornal para la esquila?

48. ¿Cuántas cabezas puede esquilar un jornalero en un día?

49. ¿Cuántas libras de lana puede esquilar de una cabeza?

50. ¿Ha usado las siguientes técnicas con sus ovejas?

a. Baño antisárnico

b. Dosificación contra parásitos internos

c. Descolar

d. Castrar

51. ¿Cuánto ha gastado en medicinas para ovejas?

52. ¿Cuánto ha pagado por un doctor veterinario para ovejas?

53. ¿Cuánto ha gastado en alimentos concentrados para ovejas?

54. ¿Cuánto ha gastado en ensilaje y heno para ovejas?

55. ¿Cuánto ha gastado en paja para ovejas?

56. ¿Cuánto ha gastado en pastoraje alquilado?

57. ¿Cuánto ha gastado en transporte de ovejas?

58. ¿Tiene algún costo no mencionado en cuanto a ovejas?

59. ¿Qué valor tiene los corrales de ovejas?

60. ¿Qué valor tienen los alimentos para ovejas que posee en el momento?

61. ¿Cuántos vacunos posee?

62. ¿Cuántos vacunos nacieron?

63. ¿Cuántos vacunos ha vendido y en cuánto?

64. ¿Pastorea los vacunos?

    a. No

    b. Con las ovejas

    c. Con otros canímales

    d. Separados

    e. Otro

65. ¿Qué cantidad de queso o leche ha vendido?

66. ¿Qué cantidad de leche ha consumido en la granja? (lts.)

67. ¿Cuánto ha gastado en la compra de forraje para vacunos?

68. ¿Tiene algún otro gasto en cuanto a vacunos?

69. ¿Cuántos burros posee?

70. ¿Qué aves de corral posee?

    a. Gallinas

    b. Patos

    c. Pavos

    d. Gansos

    e. Cantidad

71. ¿Ha vendido aves de corral o huevos?
    a. No
    b. Gallinas
    c. Otras aves
    d. Huevos
    e. Cantidad y suma
72. ¿Cuánto ha gastado en comida para las aves?
73. ¿Cuántos chanchos posee
74. ¿Cuántos chanchos nacieron?
75. ¿Cuántos chanchos consumio en la granja?
76. ¿Cuántos chanchos a vendido y en cuánto?
77. ¿Ha tenido algún gasto en cuanto a chanchos? (Qué y suma)
78. ¿Qué auquénidos posee y cuántos?
79. ¿Cuántas crías nacieron?
80. ¿Cuántos auquénidos ha vendido y a qué precio?
81. ¿Cuántos auquénidos ha consumido en la granja?
82. ¿Ha tenido algún gasto en cuanto a auquénidos?
83. ¿Cuántas libras de pelo de auquénido ha vendido y a qué precio?
84. ¿Cuántas libras de pelo de auquénido ha usado en la granja?
85. ¿Qué otros animales posee?
    a. Caballos
    b. Mulas
    c. Conejos
    d. Cuy
    e. Otros
86. ¿Tienen sus corderos bastante que comer?
87. ¿Tienen sus otros animales bastante que comer?

88. ¿Cuántas hect. de papa ha sembrado?

89. ¿Cuántos qq. de semilla se necesita para sembrar 1 hect. de papas?

90. ¿Cuánto cuesta un qq. de semilla de papa?

91. ¿Cuántos jornales ha pagado para preparar el terreno y sembrar papas?

92. ¿Cuánto cuesta un jornal para preparar el terreno y sembrar papas?

93. ¿Cuántas personas trabajaron cuántos días sin jornal para preparar el terreno y sembrar papas? (personas x días)

94. ¿Cuántos jornales ha pagado para cosechar la papa?

95. ¿Cuánto cuesta un jornal para cosechar la papa?

96. ¿Cuántas personas trabajaron cuántos días sin jornal para cosechar la papa? (personas x días)

97. ¿Qué otros costos ha tenido en cuanto a la papa?

    a. Ninguno

    b. Fertilizantes

    c. Transporte

    d. Otros

    e. Suma

98. ¿Cuántos qq. de papa ha rendido una hect.?

99. ¿Cuántos qq. de papa ha vendido y a qué precio?

100. ¿Cuántos qq. de papa ha consumido en la granja?

101. ¿Cuántas hect. de cebada ha sembrado?

102. ¿Cuántos qq. de semilla se necesita para sembrar 1 hect. de cebada?

103. ¿Cuánto cuesta 1 qq. de semilla de cebada?

104. ¿Cuántos jornales ha pagado para preparar el terreno y sembrar cebada?

105. ¿Cuánto cuesta un jornal para preparar el terreno y sembrar cebada?

106. ¿Cuántas personas trabajaron cuántos días sin jornal para preparar el terreno y sembrar cebada? (personas x días)

107. ¿Cuántos jornales ha pagado para cosechar cebada?

108. ¿Cuánto cuesta un jornal para cosechar cebada?

109. ¿Cuántas personas trabajaron cuántos días sin jornal para cosechar cebada? (personas x días)

110. ¿Qué otros gastos ha tenido en cuanto a la cebada?

    a. Ninguno

    b. Fertilizantes

    c. Transporte

    d. Otros

    e. Suma

111. ¿Cuántos qq. de cebada ha rendido una hect.?

112. ¿Cuántos qq. de cebada ha vendido y a qué precio?

113. ¿Cuántos qq. de cebada ha consumido en la granja?

114. ¿Cuántas hect. de quinoa ha sembrado?

115. ¿Cuántas libras de semilla se necesitan para sembrar 1 hect. de quinoa?

116. ¿Cuánto cuesta 1 libra de semilla de quinoa?

117. ¿Cuántos jornales ha pagado para preparar el terreno y sembrar quinoa?

118. ¿Cuánto cuesta un jornal para preparar el terreno y sembrar quinoa?

119. ¿Cuántas personas trabajaron cuántos días sin jornales para preparar el terreno y sembrar quinoa? (personas x días)

120. ¿Cuántos jornales ha pagado para cosechar la quinoa?

121. ¿Cuánto cuesta un jornal para cosechar quinoa?

122. ¿Cuántas personas trabajaron cuántos días sin jornal para cosechar quinoa? (personas x días)

123. ¿Qué otros gastos ha tenido en cuanto a quinoa?

    a. Ninguno

    b. Fertilizantes

    c. Transporte

    d. Otros

    e. Suma

124. ¿Cuántos qq. de quinoa ha rendido una hect.?

125. ¿Cuántos qq. de quinoa ha vendido y a qué precio?

126. ¿Cuántos qq. de quinoa ha consumido en la granja?

127. ¿Cuántas hect. de habas ha sembrado?

128. ¿Cuántos qq. de semilla se necesita para sembrar 1 hect. de habas?

129. ¿Cuánto cuesta 1 qq. de semilla de habas?

130. ¿Cuántos jornales ha pagado para preparar el terreno y sembrar habas?

131. ¿Cuánto cuesta un jornal para preparar el terreno y sembrar habas?

132. ¿Cuántas personas trabajaron cuántos días sin jornal para preparar el terreno y sembrar habas? (personas x días)

133. ¿Cuántos jornales ha pagado para cosechar habas?

134. ¿Cuánto cuesta un jornal para cosechar habas?

135. ¿Cuántas personas trabajaron cuántos días sin jornal para cosechar habas? (personas x días)

136. ¿Qué otros gastos ha tenido en cuanto a habas?

    a. Ninguno

    b. Fertilizantes

    c. Transporte

    d. Otros

    e. Suma

137. ¿Cuántos qq. de habas ha rendido una hect.?

138. ¿Cuántos qq. de habas ha vendido y a qué precio?

139. ¿Cuántos qq. de habas ha consumido en la granja?

Appendix B

Miscellaneous Tables

Table 16. Receipts and returns from one-half hectare of potatoes for typical Bolivian sheep producer

Receipts	
1. For sale or trade--10 qq. @ $b. 40	$b. 400
2. For farm consumption--23 qq. @ $b. 40	920
3. For seed--11 qq. @ $b. 40	440
4. Total--44 qq. @ $b. 40	$b. 1,760
Returns	
Receipts	$b. 1,760
Less all costs except labor, capital, land, and management costs	736
Return to labor, capital, land, and management	$b. 1,024
Less labor and interest on investment (except land)	332
Return to land and management	$b. 692

Table 17. Costs for one-half hectare of potatoes for typical Bolivian sheep producer

Costs		
	$b.	
1. Seed--11 qq. @ $b. 50		$b. 550
2. Fertilizer and fumigation		53
3. Ox-teams to prepare land and plant--5 @ $b. 20		100
4. Depreciation (apportioned to potatoes)		29
a. Storage shed	4	
b. Miscellaneous tools	25	
5. Repairs--storage shed		4
6. Subtotal (does not include labor, capital, land or management costs)		$b. 736
7. Labor		264
a. Prepare land and plant--10 days @ $b. 6	60	
b. Cultivate--8 days @ $b. 6	48	
c. Dig--18 days @ $b. 6	108	
d. Select--3 days @ $b. 6	18	
e. Transport--5 days @ $b. 6	30	
8. Interest on investment (except land) 8 percent		68
a. Storage shed	3	
b. Miscellaneous tools	8	
c. Operating capital	57	
9. Total (does not include land or management costs)		$b. 1,068

Table 18. Receipts and returns from one hectare of quinoa for typical Bolivian sheep producer

Receipts	
	$b.
1. For sale or trade--4 qq. @ $b. 60	240
2. For farm consumption--6 qq. @ $b. 60	360
3. Total--10 qq. @ $b. 60	$b. 600

Returns	
Receipts	$b. 600
Less all costs except labor, capital, land, and management	113
Return to labor, capital, land, and management	$b. 487
Less labor and interest on investment (except land)	184
Return to land and management	$b. 303

Table 19. Costs for one hectare of quinoa for typical Bolivian sheep producer

	Costs		
		$b.	$b.
1.	Seed--8 lb. @ $b. 90		7
2.	Ox-teams to prepare land and plant--4 @ $b. 20		80
3.	Depreciation (apportioned to quinoa)		22
	a. Storage shed	4	
	b. Miscellaneous tools	18	
4.	Repairs--storage shed		4
5.	Subtotal (does not include labor, capital, land, or management costs)		113
6.	Labor		
	a. Prepare land and plant--7 days @ $b. 6	42	
	b. Cut--10 days @ $b. 6	60	
	c. Transport--4 days @ $b. 6	24	
	d. Thresh--7 days @ $b. 6	42	
7.	Interest on investment (except land) 8 percent		16
	a. Storage shed	3	
	b. Miscellaneous tools	6	
	c. Operating capital	7	
8.	Total (does not include land of management costs)		$b. 297

Table 20. Receipts and returns from two hectares of barley for typical semi-improved sheep producer

Receipts		
	$b.	$b.
1. For sale or trade--40 qq. hay @ $b. 6		240
2. For farm consumption		1,000
a. 140 qq. hay @ $b. 6	840	
b. 4 qq. grain @ $b. 40	160	
3. For seed--4 qq. grain @ $b. 40		160
4. Total		$b. 1,400

Returns	
Receipts	$b. 1,400
Less all costs except labor, capital, land, and management costs	368
Return to labor, capital, land, and management	$b. 1,032
Less labor and interest on investment (except land)	362
Return to land and management	$b. 670

Table 21. Costs for two hectares of barley for typical semi-improved sheep producer

	Costs	
	$b.	$b.
1. Seed--4 qq. @ $b. 45		180
2. Ox-teams to prepare land and plant--8 @ $b. 20		160
3. Depreciation (apportioned to barley)		24
a. Storage shed	4	
b. Miscellaneous tools	20	
4. Repairs--storage shed		4
5. Subtotal (does not include labor, capital, land, or management costs)		$b. 368
6. Labor		324
a. Prepare land and plant--16 days @ $b. 6	96	
b. Cut--22 days @ $b. 6	132	
c. Transport and stack--8 days @ $b. 6	48	
d. Thresh--8 days @ $b. 6	48	
7. Interest on investment (except land) 8 percent		38
a. Storage shed	3	
b. Miscellaneous tools	7	
c. Operating capital	28	
8. Total (does not include land or management costs)		$b. 730

Table 22. Receipts and returns from one hectare of barley for typical "criollo" sheep producer

Receipts		
	$b.	$b.
1. For sale or trade--10 qq. hay @ $b. 6		60
2. For farm consumption		560
a. 80 qq. hay @ $b. 6	480	
b. 2 qq. grain @ $b. 40	80	
3. For seed--2 qq. grain @ $b. 40		80
4. Total		$b. 700

Returns	
Receipts	$b. 700
Less all costs except labor, capital, land, and management costs	196
Return to labor, capital, land, and management	$b. 504
Less labor and interest on investment (except land)	185
Return to land and management	$b. 319

Table 23. Costs of one hectare of barley for typical "criollo" sheep producer

	Costs		
		$b.	$b.
1.	Seed--2 qq. @ $b. 45		90
2.	Ox-teams to prepare land and plant--4 @ $b. 20		80
3.	Depreciation (apportioned to barley)		22
	a. Storage shed	4	
	b. Miscellaneous tools	18	
4.	Repairs--storage shed		4
5.	Subtotal (does not include labor, capital, land, or management costs)		$b. 196
6.	Labor		162
	a. Prepare land and plant--8 days @ $b. 6	48	
	b. Cut--11 days @ $b. 6	66	
	c. Transport and stack--4 days @ $b. 6	24	
	d. Thresh--4 days @ $b. 6	24	
7.	Interest on investment (except land) 8 percent		23
	a. Storage shed	3	
	b. Miscellaneous tools	6	
	c. Operating capital	14	
8.	Total (Does not include land or management costs)		$b. 381

Appendix C

Calculation of Value of Oat Silage

Since oat silage is not bought and sold on the *Altiplano*, there is no known market price. The following method derives a value from the value of barley hay which has a known market value.

Oat silage and barley hay are assumed to be equivalent in feeding value on a dry weight basis. It is also assumed that oat silage is 29 percent dry matter and barley hay is 83 percent dry matter. Therefore, oat silage is worth about 35 percent of the value of barley hay on a wet basis (29/83). The market price of 100 pounds of barley hay fluctuates between $b. 6 and $b. 12. It is therefore assumed that the price of oat silage would fluctuate between $b. 2.10 (35 percent of six) and $b. 4.20 (35 percent of 12).

Appendix D

Conversion Rates

$b. 1 (peso Boliviano) = $ .083 or 8.3 cents

1 kg. (kilogram) = 2.205 pounds

1 hect. (hectare) = 2.471 acres

1 qq. (quintal) = 100 pounds (1 cwt.)

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