DRY SEASON FORAGE PREFFERENCES OF ALPACA (*LAMA PACOS*) IN SOUTHERN PERU

by

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ABSTRACT

Two hundred eighty adult female alpacas (Lama pacos) and two hundred tui alpacas (3-7 months of age) were grazed on a Festuchetum-Calamagrosetum association at the South American Camelids Research Station, La Raya, Peru, during the dry season and early wet season of 1981 (June-December). Vegetation was sampled monthly during this period for species availability. Fecal material from both adult female alpaca and tui alpaca was collected monthly for microhistological analyses of food habits. Alpacas were primarily grazers rather than forb eaters during the dry season and early wet period of 1981. Forage classes consumed was different for adult and tui alpaca. Tui alpaca consumed more grass-like plants and forbs than adults during the driest months. However, plant species selected varied with animal class and changes in climatic conditions. Diet indices revealed the following as highly preferred, common forage species: Eleocharis albibracteata, Poa spp., Calamagrostis heterophylla, C. vicunarum, Alchemilla pinnata, Muhlenbergia fastigiata, and Carex spp. Highly preferred, trace species (characterized by their extremely low percentage in the available forage) were P. gymnantha, M, peruviana, Stipa brachiphylla, Ranunculus limoselloides, and Trifolium amabile. Species moderately preferred were Juncus brunneus, Luzula peruviana, Werneria pygmaea, Hipochoeris taraxacoides, Plantago tubulosa, and Miriophyllium spp. Relatively unpreferred species were Festuca dolichophylla, F. rigida, F. orthophylla, F. megalura, S. obtusa, Ranunculus peruviana, Lepiquenia spp., and Plantago oficinalis.

Festuca dolichophylla had been considered by range managers as highly preferred species overall. However, because it was the most abundant species (71% of the total forage yield), Festuca dolichophylla had a low preference index during the dry season.

Alpacas consumed remarkable quantities of grass seeds (up to 20% of the diet) during the driest months of the year. Apparently, alpacas compensated for low quality forage by increasing their consumption of nutritious grass seeds.

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CHAPTER I

INTRODUCTION

The Andes of Peru comprises about 22 million ha of rangeland and supports more than 50% of the domestic livestock in Peru (San Juan de Chuquibambilla 1981). From this total, the "Altiplano" or highland plateau accounts for 7 million hectares. Large-scale cultivation in the Altiplano is not feasible and economy primarily is dependent upon herding by local pastoralists.

There are four species of New World Camelids: the alpaca (Lama pacos), the llama (L. glama), the vicuna (Vicugna vicugna), and the guanaco (L. guanicoe). The two former species are domesticated and the latter ones still remain wild. The entire population of these mammals is distributed in the Andes of Peru, Bolivia, Chile, and Argentina. Most of the alpacas and llamas are located in Peru and Bolivia, a few are in Chile, but practically none are found in Argentina (Valdivia 1981). The alpaca is a dual purpose animal because it produces high quality fiber that is exported and meat that is needed to satisfy the requirements of a growing population (Valdivia 1981). Because of the current husbandry practices, rangelands are severely overgrazed (Holgado et al. 1979). In addition, grazing practices are confounded with the seasonal distribution of precipitation. About 80% of the rainfall comes during the wet season (December-April) and the remaining 20% comes during the dry season (May-November). Rangeland production follows this pattern with an abundance of forage in the wet season and scarcity in the dry season. Because of the length of gestation period

(approximately 11 months) for alpaca, the two major periods of nutritional stress, late gestation and early lactation, coincide with the rainy season. However, during the dry season, alpaca females must support maintenance and early gestation on poor quality forage that may also be low in quantity. Consequently, this depressed period of nutrient supply is a major concern of range managers.

West (1981) noted that improvement in alpaca production depends on four basic factors, ranked in order of importance: (1) adequate nutrition, (2) disease control, (3) proper herd management, and (4) genetics. Since adequate nutrition is influenced by plant species selected and accurate evaluation of a grazing animals' diet facilities application of range management principles (Scott and Dahl 1980), the objectives of this study were: (1) to determine the botanical composition of diets of alpaca during the dry season; (2) to determine the forage available to adult and tui alpaca; and (3) to determine dietary preferences of adult and tui alpaca.

CHAPTER II

LITERATURE REVIEW

General Information on Alpaca

The alpaca belongs to the family Camelidae which consists of the genus Lama of South America and the genus Camelus of Asia and North Africa (Reiner and Bryant 1983). West (1981) pointed out two distinct breeds of alpaca, the "huacaya" and the "suri." Huacaya, the more common breed, are characterized by highly crimped fiber which appears much like that found on Lincoln sheep. Suri fiber is straight with very little crimp. There is little selective breeding favoring one breed over the other although huacayas are more common, especially in colder climates. Condorena (1980) analyzed data from the La Raya herd during five consecutive years (1974-79). From a total of 29,162 alpacas, he found 86 and 14% were huacaya and suri, respectively. He also found that 5 year old huacaya alpaca reached an average body weight of 61.7 kg for females and 62.5 kg for males. The suri variety were slightly larger at the same age, averaging 62.7 and 65.5 kg for females and males, respectively. Fiber production (kg/ha) in the huacaya appeared slightly superior to the suri variety.

West (1981) classified alpacas according to the following age categories: "crias" or lambs, birth to 11 months of age; and "adultos maduros" or mature adults, 24 months and older, whereas, Farfan (1982) classified alpacas as: "crias" or offspring, 1-3 months; tuis, 3-24 months; and adults, 24 months and older. Normally, alpacas have only one offspring per year.

Food Habits of Other Small Ruminants

Cattle and sheep have somewhat different grazing behavior. Sheep tend to graze more closely to the ground than cattle (Reynolds et al. 1971). In biological terms, tall pastures possibly are better suited to cattle than sheep. Conversely, sheep prefer short pastures and they graze more selectively (Wilson 1976). Heinemann (1970) stated that animal species differences in the prehension pattern may be related to the anatomy of the stomach. Cattle depend mostly on their mobile tongue, which encircles a mouthful of forage and draws it into the mouth. Thus, cattle cannot graze closer than about 15 mm from the soil. Sheep (and also alpaca) have a cleft upper lip which permits very close grazing.

Cattle are known to consume mainly grass, with forbs and browse of lesser dietary importance. Sheep readily eat grass, but they generally consume greater amounts of forbs and browse than cattle (Cook and Harris 1950). While this relationship generally holds true, late summer diets of sheep in California had only 5% more grass than cattle (Van Dyne and Heady 1965). Also, sheep grazed more forbs than cattle in early and middle summer when herbage was plentiful. Regarding plant part selection, sheep diets were consistently lower in stems than cattle diets, averaging 67 and 72%, respectively (Van Dyne and Heady 1965).

Cory (1927), working with Angora goats in the Edwards Plateau, found that they spent 53% of their time feeding on woody species, 38% grazing grass and forbs, and the remainder of the time was spent eating supplemental feeds and in miscellaneous grazing activities. In

contrast, Malechek and Leinweber (1972) suggested goats should be classified in the popular sense as "grazers" rather than "browsers."

Malpartida and Florez (1980), using the microhistological technique (Sparks and Malechek 1968) with vicuna at the National Reserve of Pampa Galeras, Peru, found that this South American Camel had high degree of selectivity on good condition range. However, on ranges of poor and very poor condition, selectivity declined significantly. Unfortunately, they did not rank the various forage species with regard to their palatability.

Guerra and Murua (1981) worked with guanaco at Parque Nacional Conguillio, Las Paraguas, Chile, but used diet methods other than the microhistological technique. They found that guanaco preferred grasses such as Festuca scaberula, Agrostis spp., and Bromus unioloides. Some trees and browse preferred by guanaco were Nothofagus obliqua, Azara microphylla, Pervetia buxifolia. Other browse eaten by guanaco included Acaena pennatifida and Haplopappus glutinosus.

Pearson (1951) reported that Festuca rigescens was the main forage grass for camelids. He also noted that several other species of the genera Calamagrostis, Festuca, Poa and Stipa were favored. Distichia muscoides was recognized the most valuable species in the alpaca diet (Tapia 1971).

Techniques of Food Habit Analysis

Five major categories of field sampling techniques are used to determine food habits of free ranging animals; (1) direct observation including hand plucking or "bite-count," (2) hand clipping plots before

and after grazing, (3) esophageal fistulated animals, (4) ruminally fistulated animals, and (5) examination of feces or content of the lower digestive tract (Hegg 1961, Schrumpf 1968, Foppe 1972, and Pfister and Malechek 1982). Observational techniques are inexpensive and easy to implement (Tribe 1950, Wallmo et al. 1970, and Pfister and Malechek 1982) and only a small number of animals are needed (Schrumpf 1968). However, Pfister and Malechek (1982) listed some disadvantages in using this technique; herbage can be difficult to distinguish in dense vegetation, observer error or bias can influence the results, and observations yield only qualitative data. Norris (1943) considered the "feeding time" method tedious and that there was little correlation between the time an animal spends in grazing different species and the actual amount of forage consumed. However, with the bite count technique, data were closely correlated with actual consumption (Foppe 1972).

Because animals generally select forage higher in crude protein and lower in fiber than the average available in the vegetation, hand clipping before and after grazing usually does not correspond well with the chemical composition of animal diets (Coleman and Barth 1973). Further, Theurer et al. 1976 (cited by Pfister and Malechek 1982) stated that clipped samples did not give good estimates of botanical composition. The advantage of using the technique is the low cost of equipment (Foppe 1972), although it is time consuming (Hegg 1961). Also, data from before and after clipping indicate the amount consumed and cannot be assigned to specific consumers (Hegg 1961, Foppe 1972).

certain types of forage pass through the stomach at a more rapid rate than do others (Norris 1943). According to Hegg (1961), rumen analysis is primarily a supplement or a "check" of other methods. Van Dyne and Heady (1965) stated that methods based on hand sampling, observations, and stomach analysis are of questionable accuracy for evaluating quantitatively the dietary botanical composition of animals on range areas. They felt the esophageal and ruminal fistulae techniques were best fitted to this purpose.

Because esophageally fistulated domestic animals are difficult to maintain, and sampling with these animals involves considerable effort, fecal analysis is sometimes used as an alternative (Pfister and Malechek 1982). This method has been used for a variety of herbivores including kangaroos (Macropus giganteus) and wallabies (Macropus rufogriseus) (Storr 1961), snowshoe hares (Lepus americanus bairdini) (Adams et al. 1962), deer (Odocoileus virginianus and O. hemionus) (Ziznar and Urness 1969), elk (Cerus canadiensis) (Hansen and Clark 1977) and the vicuna (Vicugna vicugna) (Malpartida and Florez 1981). Foppe (1972) named some advantages in using fecal analysis; (1) ease of collection of feces, (2) wide range of application to many animals species, (3) low equipment cost, (4) low labor cost compared to other available methods, (5) budgeting flexibility, i.e. samples can be preserved and stored indefinitely until funding for the analysis is obtained, and (6) ability to verify the data, i.e. slides can be stored and rechecked at a later date if needed. The primary disadvantage of fecal analysis is the amount of time required to process the samples. Differential digestion

of plant species also may significantly influence the results. Vavra et al. (1978) and Vavra and Holechek (1980) indicated that grasses are more resistant to digestion than are forbs. However, Johnson and Pearson (1981) maintained that fecal analysis is reliable, but perhaps the accuracy expected from the fecal analysis is less than that obtained from the use of esophageal fistula extrusa.

CHAPTER III

STUDY AREA AND EXPERIMENTAL PROCEDURE

Study Area and Description

The National Center for South American Camelids Research Station at La Raya is located in the highlands of Southern Peru, Department of Cusco, near coordinate 14° 30' southern latitude and 71° western longitude. The altitude ranges from 4,000 - 5,500 meters, with the lowest altitude at Aguas Calientes and the highest altitude on Chimboya (Holgado et al. 1979).

According to Holdridge (1967), La Raya is classified as very wet subalpine life zone. Beck (1981), taking into account the altitudinal belts and subregions of humidity, classified La Raya as very cold thermic region and subhumic subregion of humidity.

Orlove (1977) divided the Peruvian Andes of Sierra in two zones. The intermountain valleys with altitudes below 3,000 meters had a relatively mild climate, generally fertile soils, abundant water and favored agriculture. Cultivation is generally restricted to the rainy season. The second major zone, the Puna, consists of rolling grasslands suitable for grazing. The Puna lies above 3,600 meters (Orlove 1977). Agriculture is possible only in lower, more sheltered areas during the rainy season. The Puna contains the Altiplano which lies above 3,800 meters and is an extensive plateau grassland suitable mostly for grazing. Even with high risk of frost, Altiplanians grow some plants such as quinoa (Chenopodium quinoa), canihua (Chenopodium palidicaule), and bitter potatoes (Solanum tuberosum). Koford (1957) stated that the

Puna summer is the wet season, as in the grasslands of Central North America.

At high altitudes there is low atmospheric pressure, very dry climate, low oxygen availability, and intense radiation. Additionally, the highlands of Peru have a diurnal temperature regime rather than a seasonal one (Thomas and Winterhalder 1976). As in other high altitude regions, the diurnal variation in temperature is great, at times exceeding 30°C. During the dry season, the shorter day length and lack of cloud cover permits heat loss from radiation. Nightly frosts are more frequent and more severe. In most places in the Sierra, frost can occur any time of the year and the risk increases with increasing altitude (Orlove 1977). Meteorological data (1972-78) from the La Raya Research Station showed a mean temperature of 6.52°C and 952 mm of precipitation (Holgado et al. 1979). Mean temperature and precipitation for 1981 are presented in Figures 1 and 2.

The data for soils is sketchy. Wilcox and Bryant (1982) characterized three major soil sites in the Andes of Central Peru. Bottomland sites (<8% slope) generally were classified as organic soils. Soils of upland sites (8-30% slope) were organic soils and mollic cryoborolls. Steep slope sites (≥30% slope) were mollic cryoborolls and developed from glacial till or residual rock.

Koford (1957) stated that the geology of the Puna is complex. Evidently these soils are fertile, but coolness and aridity limit plant growth. In general, these soils are pale in color and sandy in texture. Papadakis (1969), using the FAO System, divided the soils of the

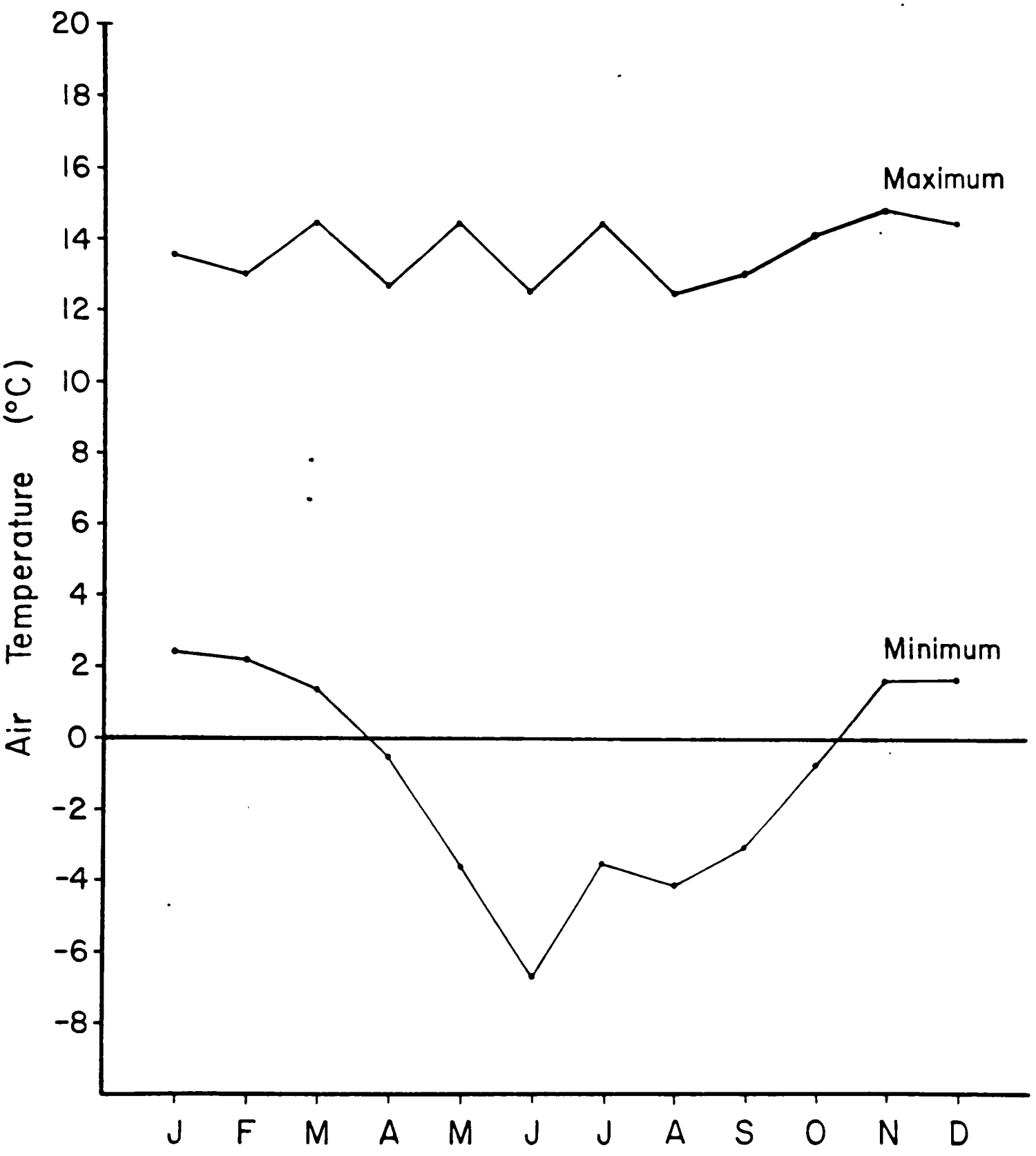

Figure 1. Air temperature (°C) at the La Raya Research Station in Southern Peru during 1981.

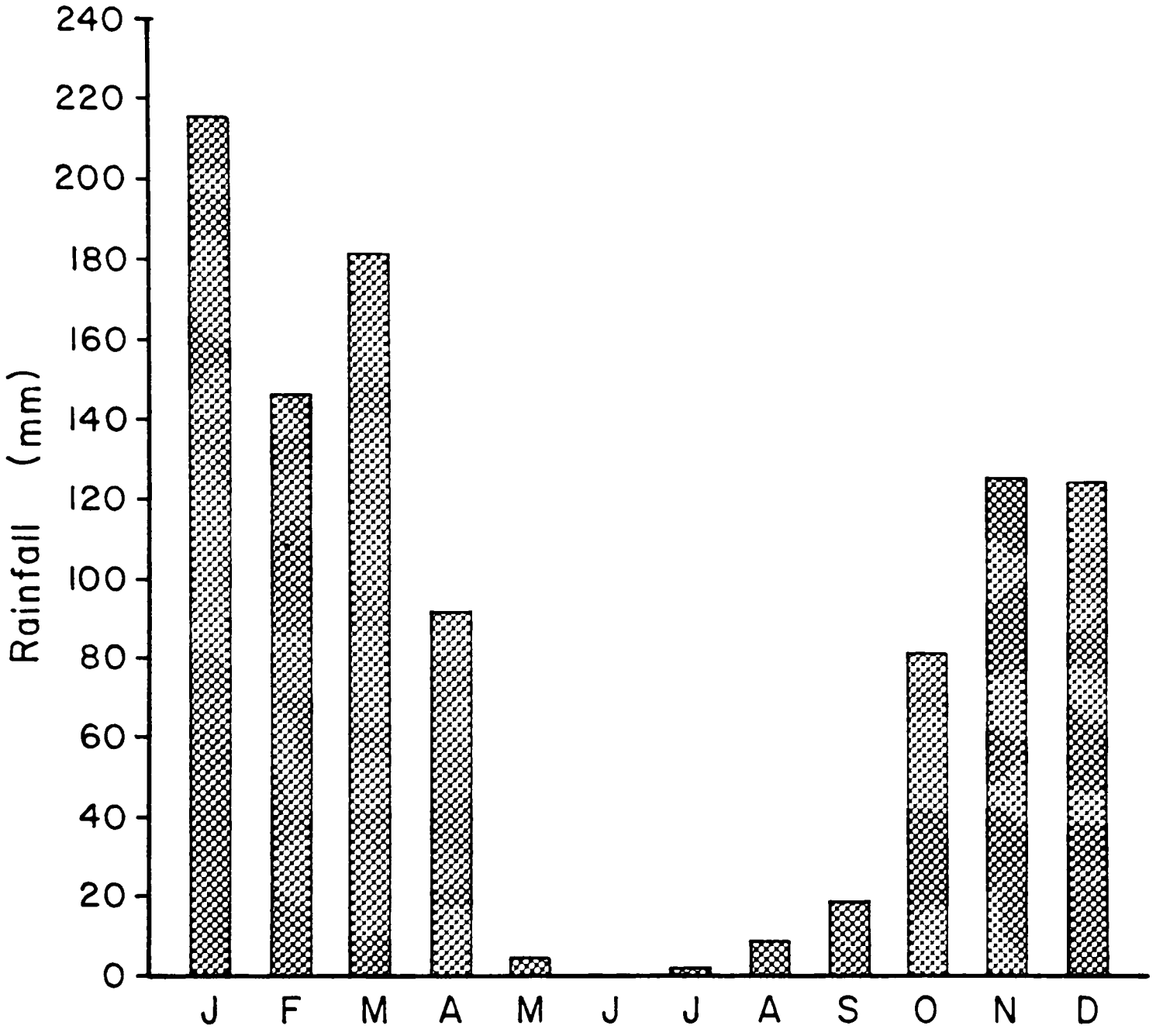

Figure 2. Rainfall (mm) at the La Raya Research Station in Southern Peru during 1981.

Altiplano into recent brown soils and the chernozemic brown soils. The recent brown sub-group is composed of unmodified or little modified parent material, such as recent alluvium or unconsolidated rock. Chernozemic soils have a low degree of leaching and a dark humic layer at least 25 cm thick and were formed under the influence of grass cover. The soils are generally poor in nitrogen but the alluvial till that corresponds to the more glaciated land forms of the tropical rain forest appear to be relatively rich in nitrogen and trace minerals.

Orlove (1977) pointed out that the dominant vegetation forms are bunchgrasses, known locally as "ichu." They are classified among several genera including Stipa, Festuca, and Calamagrostis. Each contains a number of species but the pattern of growth is similar, i.e. dense, deeply rooted, clumps 5 to 20 cm in diameter and 15 to 60 cm in height, and composed of many single blades. Smaller grasses and forbs grow around the base of each clump. These plants, at most a few cm high, find the microclimate adjacent to the bunchgrass favorable.

Beck (1981), considering plant physiognomy, differentiated eight major sod-forming formations of natural grassland in the Altiplano: (1) aquatic plants including floating species (Lemma spp., Azolla filiculoides), emergents (Scholnoplectus californicus, Hidrocotile ranunculoides), submergents (Miriophyllium elatinoides, Elodea spp.), and marginals (Polipogun elongatus); (2) "bofedales" or short species (Plantago tubulosa, Werneria pygmaea, Carex spp., Distichia muscoides); (3) tall, dense species in stagnated water (Juncus brunneus, Eleocharis spp.); (4) tall, dense species with bunchgrasses on humic steep slopes

(Scirpus rigidus, Luzula peruviana, Aciachne pulvinata); (5) wet puna or tall bunchgrasses with a short forb layer and annual grasses (Festuca dolichophylla, Calamagrostis spp., Stipa ichu, Muhlenbergia fastigiata, Hipochoeris spp.); (6) shrubs with some bunchgrasses (Baccharis penteandii, Ribes spp., Budleja montana, Festuca dolichophylla, Paspalum pygmaeum); (7) short shrubs with some bunchgrasses and forbs (Baccharis spp., Adesmia spp., Parastrepia spp., Stipa ichu, Muhlenbergia peruviana); and (8) short species, sometimes with bunchgrasses on salt plateau (Distichlis humilis, Festuca orthophylla, Muhlenbergia fastigiata). According to Beck (1981), the study area could belong to a combination of bofedal-tall sod-forming bunchgrasses with a short forb layer.

Holgado et al. (1979), using step transects, estimated palatable species for alpaca at the La Raya Research Station by classifying species according to utilization categories of desirable, moderately desirable and undesirable. These, in conjunction with soil characteristics at the La Raya Research Station, yielded four classes (Field I, II, III, and IV productivity classes) of pastures according to productivity of preferred alpaca foods. Field I productivity class was a bottomland site not found at the La Raya Research Station. The 200 ha study site was located on a Field II productivity class.

Methods

Forage availability was estimated from three parallel transects placed through the 200 ha study area. Thirteen 0.25 m^2 plots (Clements 1905) were randomly placed along the transects (Stoddart et al. 1975).

Herbage from each plot was clipped monthly, by species, air dried and weighed.

Microhistological analyses of fecal material was used to identify plant fragments for botanical composition of diets. Reference plants were collected during February, 1981. Fresh fecal samples of adult and tui alpaca were collected monthly from dung piles and were thoroughly hand-mixed (Hansen and Lucich 1980). Samples were preserved in a 10% formalin solution as recommended by Medin (1970). After a two-day treatment with formalin, samples were dried, weighed, stored in plastic bags, and transported to the Texas Tech University Food Habits Laboratory for subsequent analyses.

Forage availability and fecal collections were made during a 7-month period from June through December. Fecal material from tuis was collected for only four months from June to weaning (September). Reference slides were made from the reference plant collection and for individual plant parts such as stems, leaves, flowers and seeds. Plants and plant parts were placed in a blender and agitated for one minute. Frequently, it was necessary to soak plant parts in a weak clorox solution for one to two days in order to remove chlorophyll for clarification of plant parts. The Sparks and Malechek (1968) technique was used for preparation of fecal slides. Slides were cleared by boiling with a few drops of Hertwig's Solution (Baumgartner and Martin 1939) and Hoyer's Solution (Baker and Wharten 1952) (See Appendix A). The slides were oven dried at 60°C. Two slides were prepared for each species and plant part for reference and five slides were prepared for

each fecal sample. Additionally, microphotographs were taken of each species and plant part reference slide.

The microhistological identification process for monocots and dicots was based on comparisons of epidermal material in samples with the epidermal patterns on reference slides (Foppe 1972). If the assumption is correct that the epidermal and cuticle of all consumed plant parts resist digestion, then it would be possible to determine the proportion of still recognizable species in the total sample (Hegg 1961). The digestion and slide preparation process break the plant materials down to skeletons. By examining the skeletons with compound microscopes equipped with phase contrast at 125 magnification, one can observe stomatas, epidermal hairs, patterns of cell walls, silica cells, plus many other features (Metcalfe and Chalk 1950, Metcalfe 1960, Cutler 1969, and Metcalfe 1971).

The slides were read in a systematic pattern by reading 20 fields per slide. Data were recorded as frequency of occurrence on each item in the 20 fields, then coverted to percent relative density (Krueger 1972). Percent density has been shown to be a better estimate of percent dry weight in a sample than percent frequency (Sparks and Malechek 1968).

The ratio of the percentage of a plant in the diet to the percentage available, used in this study, is a good estimate of the preference of range plants (Krueger 1972). A ratio 1.0 is the base in the preference scale. Species at a much higher ratio than 1.0 are considered highly preferred. Species near a ratio of 1.0 are considered

moderately preferred and species with a ratio of less than 1.0 are considered relatively unpreferred.

CHAPTER IV

RESULTS AND DISCUSSION

Forage Availability

There was a high proportion of grasses and grass-like plants over forbs in the standing crop biomass (Fig. 3). This proportion was maintained almost constantly during the study period (June-December). Forb contribution to the overall production was low. The lowest and highest percentage of forb standing crop was only 3 and 12%, respectively (Fig. 3).

The individual contribution of each species to the total forage biomass is in Table 1 and Appendix Table B. The most relevant observation from these tables is that a single grass species, Festuca dolichophylla, accounted for 71% of the total herbage production during the grazing period. A group of 11 grasses, grass-like plants and forb species comprised 26% of the total herbage production, and included Calamagrostis antoniana, Carex spp., Eleocharis albibracteata, F. rigida, Juncus brunneus, Mulenbergia fastigiata, Poa spp., and Stipa obtusa among the grass and grass-like forages, and Alchemilla pinnata, Hipochoeris taraxacoides, Plantago oficinalis among the forbs. The group of species lowest in availability averaged 3% of the total herbage production. These included Bromus lanatus, Calamagrostis heterophylla. C. vicunarum, Festuca megalura, F. orthophylla, Luzula peruviana, Muhlenbergia peruviana, Poa gymnantha, Stipa brachiphylla and S. ichu among the grasses and grass-like forages, and Miriophyllium spp.,

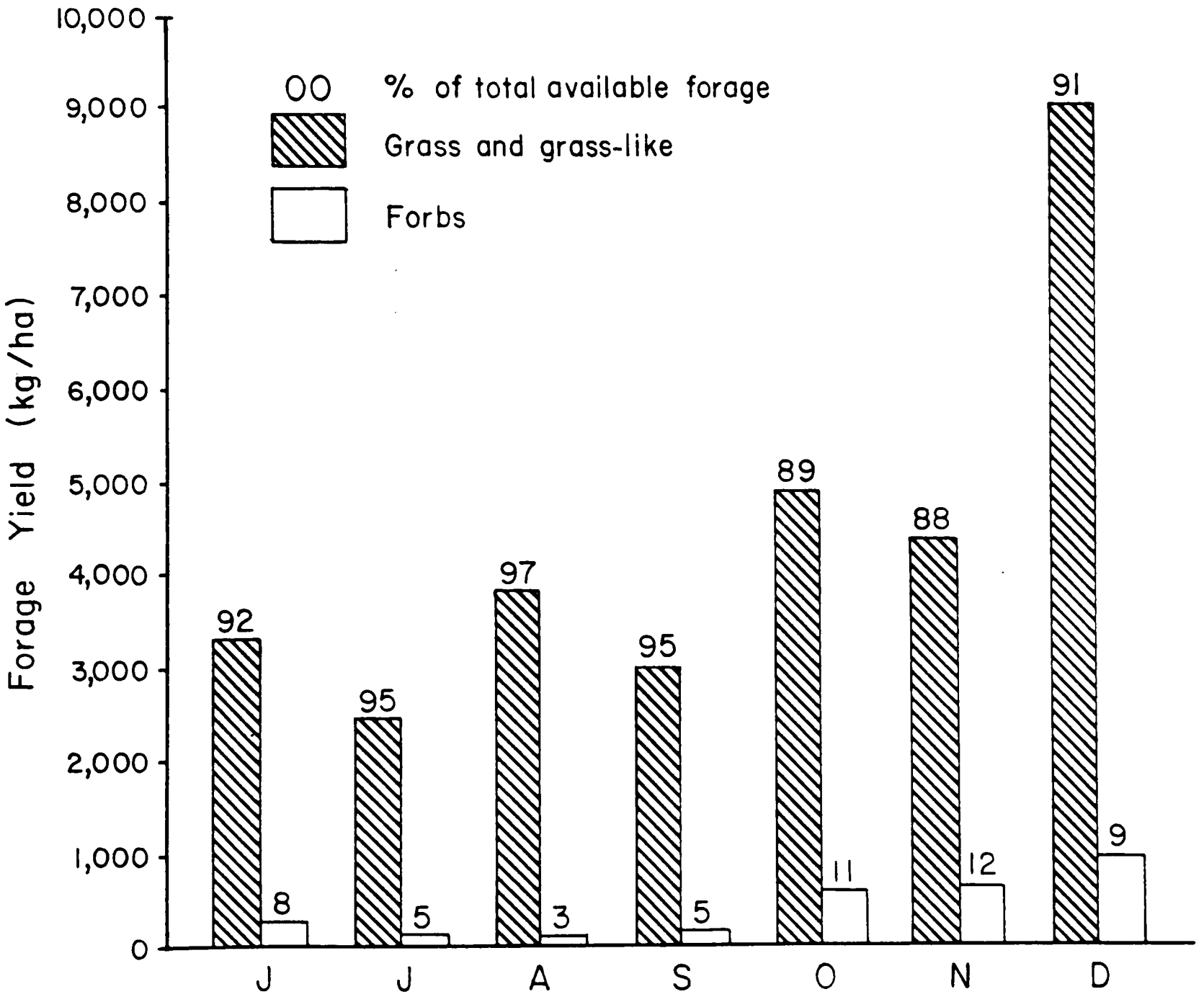

Figure 3. Monthly availability of grasses, grass-like plants, and forb species on the study site in Southern Peru.

Table 1. Botanical composition (%) of the experimental pasture based on clipped herbage samples.

Type of herbage	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Grass & grass-like species							
Bromus lanatus	0.0	<.1[1/]	0.0	0.0	<.1	0.1	0.1
Calamagrostis antoniana	1.6	0.0	1.0	0.0	0.0	7.0	0.0
Calamagrostis heterophylla	1.0	0.6	2.1	0.5	0.1	<.1	<.1
Calamagrostis vicunarum	0.3	0.2	0.8	0.3	0.2	0.2	<.1
Carex spp.	4.5	6.8	3.3	3.4	1.9	2.6	1.2
Eleocharis albibracteata	4.1	1.3	1.0	1.7	1.2	<.1	0.1
Festuca dolichophylla	66.6	56.6	73.5	74.1	79.2	65.3	79.3
Festuca megalura	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Festuca orthophylla	1.7	0.0	0.3	3.6	0.0	0.5	0.0
Festuca rigida	4.5	7.3	5.9	0.2	2.8	3.1	3.0
Juncus brunneus	2.5	16.6	1.3	1.7	0.8	1.7	0.6
Luzula peruviana	0.0	0.3	0.0	0.0	.1	0.1	0.1
Muhlenbergia fastigiata	1.8	2.5	2.7	2.1	1.7	0.9	1.9
Muhlenbergia peruviana	<.1	<.1	<.1	<.1	<.1	0.0	0.0
Poa spp.	1.4	2.1	0.8	0.4	0.7	1.7	1.3
Poa gymnantha	0.2	0.6	0.0	0.0	0.0	0.0	0.0
Stipa brachiphylla	0.1	<.1	0.1	<.1	<.1	<.1	<.1
Stipa ichu	0.0	0.0	1.1	1.3	0.0	0.3	0.0
Stipa obtusa	1.7	0.0	3.1	5.3	0.6	3.9	2.8
Total percent	92.1	95.0	96.9	94.6	89.2	87.5	91.0
Forbs							
Alchemilla pinnata	1.8	0.5	0.7	0.7	1.6	1.5	1.5
Hipochoeris taraxacoides	2.1	1.9	0.4	1.4	3.9	1.0	1.0
Miriophyllium spp.	0.3	<.1	<.1	0.1	<.1	<.1	<.1
Lepiquenia spp.	<.1	0.5	<.1	<.1	<.1	0.5	<.1
Plantago oficinalis	0.6	2.0	0.0	0.7	3.3	0.8	3.2
Plantago tubulosa	1.9	<.1	0.5	1.2	0.7	6.5	2.8

Table 1. Continued.

Type of herbage	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Ranunculus limoselloides	0.0	0.0	<.1	<.1	0.1	0.1	0.4
Ranunculus peruvianus	0.0	0.0	<.1	0.1	0.4	1.0	0.2
Trifolium amabile	<.1	<.1	<.1	<.1	<.1	0.2	<.1
Werneria pygmaea	1.1	<.1	1.2	1.1	0.7	0.5	0.1
Total percent	7.7	4.9	2.8	5.2	10.6	12.0	9.2

1/ Values of <.1 represent herbage species that were present in less than 0.1% in the botanical composition.

Lepiquenia spp., Ranunculus limoselloides, R. peruvianus, Trifolium amabile and Werneria pygmaea among the forbs.

Botanical Composition of Diets

Adult alpacas

Grasses and grass-like forages averaged 89% of adult female alpaca diets (Table 2) during the driest months of the year (June-September) and 85% when averaged over the dry season and early wet season. Percent of grasses and grass-like species in the fecal samples varied from month to month. Grass consumption was highest during the driest months and declined during the early wet season. The trend in consumption of grass-like plants was opposite of grasses with low levels during dry months and increasing consumption levels as the rainy season began. Also, alpaca consumed the most grass in August and least in December. The reverse was true for grass-like plants.

Table 2. Mean percentages of grasses, grass-like plants, forbs and plant parts in diets of adult female alpaca in Southern Peru.

Dietary component	Months							Mean
	June	July	Aug.	Sep.	Aug.	Nov.	Dec.	
Grasses	60	70	76	72	60	48	44	61
Grass-like plants	22	18	14	22	30	29	30	24
Forbs	18	12	10	6	10	23	26	15
Leaves	71	73	78	69	79	84	94	78
Stems	25	24	16	10	8	5	5	13
Seeds	5	3	6	21	13	11	1	9

On the Edwards Plateau of Texas, Malechek and Leinweber (1972) found an extensive season to season variation in the diet composition of Angora goats for three dietary forage classes (grasses, forbs and

browse), but grasses and grass-like plants never made up more than 55%. Bryant (1977), also working on the Edwards Plateau, found that Angora goat diets contained percentages of grass and browse similar to each other but still much lower than grass/grass-like percentages found in alpaca diets. Also, grass in Spanish goat diets was slightly higher than browse with 45 and 42%, respectively (Bryant 1977). Apparently sheep diets are more similar in diet selection to alpaca diets than goats, but they still do not approach the high levels of grass and grass-like plants consumed by alpaca. Bryant (1977) found that grasses contributed 60%, browse 22%, and forbs 18% in sheep diets during the twelve-month study period. During the growing season, grasses and forbs dominated sheep diets, similar to alpaca food habits found in this study.

Forbs averaged 15% of the adult female diets (June-December) (Table 2). Surprisingly, there was a high consumption of forbs by alpacas during the initial months of the dry-season trial. This was because the experimental area was excluded from grazing during the late wet months, forb standing crop accumulated and when alpacas were allowed to graze in June, there was high availability of forbs.

Data indicate adult alpaca are dependent almost exclusively on grasses and grass-like forages during the driest months of the year. Lack of a browse component in the high Andes forces alpaca to consume primarily grass and grass-like plants when forb availability declines. The increase in forb consumption in November and December (early wet season) suggests adult alpaca eat more forbs when climatic conditions

favor plant growth. Increased forb consumption during the growing season also has been demonstrated for sheep (Kothmann 1968, Bryant 1977), cattle (Van Dyne and Heady 1965), goats (Malechek and Leinweber 1972), and deer (Chamrad and Box 1968).

Adult alpaca diets were consistently high in leaf material, averaging 78% over the dry and early wet season. Leaf consumption for was relatively unchanged during the dry months (June-September) (Table 2), but increased dramatically during the early wet season (94% in December (Table 2). This response by adult alpacas was probably a response to increased rainfall (Fig. 2) that stimulated leaf growth. Malechek and Leinweber (1972) found that leaf parts were the major constituent in goat diets with 88 and 83% on lightly and heavily grazed ranges, respectively. Likewise, Bryant (1977) found that leaf material comprised the bulk in average annual sheep (97%), Angora goat (96%), and Spanish goat (95%) diets. Alpaca diets were considerably lower in leaf parts and did not reach high levels normally found in sheep and goat diets until rainfall favored plant growth in December (Table 2).

Seed consumption in adult female alpaca diets averaged 9% for the grazing period. Seed consumption was lowest in June (5%) and reached its highest level in September (21%) (Table 2). Thus, adult alpaca substituted seeds for stem material as the dry season advanced, holding leaf consumption relatively constant. For many years, people working with alpacas wondered how this animal could support late gestation, pregnancy, and maintenance during the dry months of the year on mature forage of low quality. These data suggest that alpacas compensate for

the lack of quality forage in critical months by eating large quantities of seeds which are rich in proteins, fats, and carbohydrates. This high comsumption of seeds has not been reported for other small ruminants (Van Dyne and Heady 1965, Kothmann 1968, Malechek and Leinweber 1962, Bryant 1977).

Six major grasses and grass-like species averaged 60% in diets through the seven month grazing period (Appendix Table C). Individually, Festuca dolichophylla averaged 15.5%, Poa spp.--12.6%, Carex spp.--8.8%, Muhlenbergia fastigiata--8.3%, Stipa brachiphylla--7.5%, and Calamagrostis heterophylla--5.9% of the dry season diets.

Tui alpaca

Grass and grass-like herbage consumption averaged 85% of the tui diets (Table 3) during the driest months, similiar to adults. But the pattern of grass and grass-like forage consumption was different from adult female alpaca, as they had higher dietary levels of grass-like plants than adults. Six major grass and grass-like species averaged 64% in diets through the four month grazing period. Individual species contribution to their diets was Festuca dolichophylla (15%), Poa spp. (12.3%), Eleocharis albibracteata (12.2%), M. fastigiata (9.2%), Stipa brachiphylla (8.5%), C. heterophylla (6.6%) (Appendix Table B). Whereas, Carex spp. was the third dominant species in adult diets, Eleocharis albibracteata replaced Carex spp. as the third most important species in the tui diets.

Table 3. Mean percentages of grasses, grass-like plants, forbs, and plant parts in diets of tui alpaca in Southern Peru.

Dietary component	Months				
	June	July	Aug.	Sep.	Mean
Grasses	53	64	69	66	63
Grass-like plants	26	20	20	22	22
Forbs	21	16	11	12	15
Leaves	71	73	42	68	71
Stems	22	14	11	9	14
Seeds	7	13	17	23	15

There was a considerable decrease in forb consumption by tuis from 21% in June to 12% in September, but dry season (June to September) forb use was higher in tuis than adults. Forbs averaged 15% in tui diets during the four-month period (June-September) and only 12% in adult diets. It was observed that tui alpaca searched more for forbs than adults.

Two major forb species averaged 14% of the total diet and 82% of the forbs consumed through the four-month dry-season grazing period. These were Alchemilla pinnata (12.9%) and Trifolium amabile (14.4%) (Appendix Table D).

The pattern of consumption of leaves, stems, and seeds by tui alpacas was similar to adults (Table 3). However, tuis ate even more seeds than adults during the driest months of the year, especially during July and August. They behaved almost as "seed-picking machines."

Preference Indices for Forage Species

Adult alpaca

Among the highly preferred species for adult alpaca during the dry season and the transition period from dry to wet season were Eleocharis albibracteata, Poa spp., Calamagrostis heterophylla, C. vicunarum, Alchemilla pinnata, Muhlenbergia fastigiata, and Carex spp. Also, there was a group of highly preferred species for which it was not possible to determine their preference index because they comprised very little of the available forage (less than 0.1%), or they did not appear at all in the field sampling. Consequently, the ratings were very high and infinite in some cases. These were species like Poa gymnantha, M. peruviana, Stipa brachiphylla, Ranunculus limoselloides and Trifolium amabile.

A group of moderately preferred species were not available during the dry season but were present during the transition period from dry to wet season (October to December). They were primarily grass-like plants and forbs and included Juncus brunneus, Luzula peruviana, Werneria pygmaea, Hipochoeris taraxacoides, Plantago tubulosa, Miriophyllium spp. (Table 4).

The group of relatively unpreferred species included Festuca dolichophylla, F. rigida, F. orthophylla, C. antoniana, F. megalura, S. ichu, S. obtusa, R. peruvianus, Lepiquenia spp., and P. oficinalis (Table 4).

Table 4. Preference indices for forage species important to adult female alpaca in Southern Peru.

Type of herbage	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Grass & grass-like species							
Bromus lanatus	23.3[1]	150.0[1]	+	+	3.0	4.3	15.2
Calamagrostis vicunarum	21.0	25.3	8.2	11.3	1.0	8.5	72.7
Calamagrostis heterophylla	4.4	12.4	3.6	14.9	52.2	79.7	35.1
Carex spp.	2.1	1.0	2.4	3.1	5.6	2.9	6.9
Eleocharis albibracteata	2.1	6.0	5.0	6.3	14.4	221.8[1]	134.8[1]
Festuca dolichophylla	0.3	0.3	0.3	0.3	0.2	0.1	0.2
Festuca rigida	0.6	0.6	0.7	17.4	1.1	0.7	0.4
Festuca orthophylla	0.0	+	0.2	0.1	1.2	0.0	0.0
Juncus brunneus	0.0	0.1	0.7	0.6	1.7	29.0	6.7
Luzula peruviana	1.1	1.0	+	0.0	0.0	0.1	5.1
Muhlenbergia fastigiata	3.7	3.4	3.3	5.4	5.0	9.2	2.8
Muhlenbergia peruviana	+	30.8[1]	42.0[1]	24.0[1]	+	0.0	0.0
Poa spp.	5.9	4.1	14.8	35.4	21.8	7.8	10.5
Poa gymnantha	7.4	0.9	+	0.0	0.0	0.0	0.0
Stipa brachiphylla	89.0[1]	518.0[1]	94.0[1]	253.3[1]	1518.0[1]	164.0[1]	106.5[1]
Stipa obtusa	0.9	+	0.5	0.4	0.7	0.1	0.1
Forbs							
Alchemilla pinnata	7.6	19.4	10.4	7.9	5.0	10.8	7.3
Hipochoeris taraxacoides	1.3	0.3	0.0	0.0	0.0	0.9	4.8
Miriophyllium spp.	1.6	8.0[1]	+	1.1	7.7	0.1	14.8[1]
Plantago oficinalis	0.1	0.0	0.0	0.0	0.0	0.6	0.0
Plantago tubulosa	0.2	0.0	0.0	0.0	0.0	0.2	1.3
Ranunculus limoselloides	+	+	24.0[1]	1.3[1]	0.6	1.4	0.7
Ranunculus peruvianus	0.0	+	0.0	0.0	0.0	0.0	0.0

Table 4. Continued.

Type of herbage	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Trifolium amabile	100.0[1/]	71.3[1/]	176.0[1/]	24.0[1/]	135.0[1/]	9.3	48.3[1/]
Werneria pygmaea	0.0	0.0	0.0	0.0	0.0	3.3	20.4

[1/] These forage species had high values because they appeared in less than 0.1% of the available forage.

+ Forage species that were not detected in the sampling for available forage but appeared in the diets.

Tui alpaca

Basically, preference indices for tuis resembled those of adult alpaca. However, the order of this rating was different for tuis (Table 5). Among the highly preferred species during the dry season were Poa spp., Alchemilla pinnata, Calamagrostis vicunarum, C. heterophylla, Muhlenbergia fastigiata, and Carex spp. A second group of highly palatable species which appeared in the tui diet but were not detected during botanical sampling of species on the range included Bromus lanatus, Poa gymnantha, M. peruviana, Stipa brachiphylla, Ranunculus limoselloides, and Trifolium amabile.

There also was a group of unpreferred species. They included Festuca dolichophylla, F. rigida, F. orthophylla, S. ichu, S. obtusa, R. peruvianus, Lepiquenia spp., Plantago oficinalis (Table 5).

Antezana (1972) (cited by Tapia 1982) classified Southern Peru native forage species in terms of palatables (84 species), low palatables (33 species), and relatively unpalatables (30 species). Comparing the results of Antezana's (1972) observational method with the microhistological technique used in the present study to determine alpaca diet preferences, Alchemilla pinnata, C. vicunarum, M. fastigiata, M. peruviana, Poa spp., T. amabile were the only forage species used by alpacas that were highly preferred in both studies. Calamagrostis heterophylla, Carex spp., and Poa gymnantha, considered highly preferred forage species in this study, were considered species of low palatability by Antezana (1972). Festuca dolichophylla was a forage species of low palatability in both studies.

Table 5. Preference indices for forage species important to tui alpaca in Southern Peru.

Type of herbage	June	July	Aug.	Sept.
		per cent		
Grasses				
Bromus lanatus	7.8[1/]	14.0[1/]	+	+
Calamagrostis vicunarum	28.9	25.7	4.7	8.7
Calamagrostis heterophylla	5.2	6.9	4.8	14.0
Carex spp.	1.2	0.7	2.8	2.7
Eleocharis albibracteata	2.1	9.3	9.3	6.7
Festuca dolichophylla	0.2	0.2	0.2	0.3
Festuca rigida	0.4	0.3	0.3	5.9
Juncus brunneus	+	0.1	1.1	0.8
Luzula peruviana	1.5	0.9	0.0	0.0
Muhlenbergia fastigiata	4.3	4.1	3.0	5.1
Muhlenbergia peruviana	+	40.0[1/]	36.7[1/]	64.0[1/]
Poa spp.	4.1	4.3	20.8	38.8
Poa gymnantha	1.9	3.9	+	0.0
Stipa brachiphylla	77.2[1/]	559.0[1/]	82.0[1/]	204.7[1/]
Stipa obtusa	2.7	+	0.1	0.1
Forbs				
Alchemilla pinnata	10.6	28.2	12.6	15.2
Hipochoeris taraxacoides	0.1	0.2	0.0	0.1
Miriophyllium spp.	0.4	12.5[1/]	+	3.6
Lepiquenia spp.	2.0	0.0	0.0	0.0
Plantago oficinalis	0.2	0.0	+	0.1
Plantago tubulosa	0.0	0.1	0.0	0.0
Ranunculus limoselloides	0.0	+	12.0[1/]	1.0[1/]
Ranunculus peruvianus	+	+	0.0	0.0
Trifolium amabile	67.0[1/]	45.5[1/]	150.0[1/]	38.0[1/]

[1/] These forage species had high values because they appeared in less than 0.1% of the available forage.

\+ Forage species that were not detected in the sampling for available forage but appeared in the diets.

It is interesting that, when ranked in order of importance, the top seven species preferred by adults also were the top seven species preferred by tuis (Table 6). The order of moderately preferred species was different for adults and tuis.

Table 6. Average rank of preferred species for adult female and tui alpaca in Southern Peru during the driest months (June-September).

Plant species	Adults	Tuis
Common species[1/]		
Eleocharis albibracteata	1	5
Poa spp.	2	1
Calamagrostis heterophylla	3	4
Calamagrostis vicunarum	4	3
Alchemilla pinnata	5	2
Muhlenbergia fastigiata	6	6
Carex spp.	7	7
Juncus brunneus	8	11
Werneria pygmaea	9	8
Festuca rigida	11	14
Hipochoeris taraxacoides	12	9
Luzula peruviana	13	10
Festuca dolichophylla	14	12
Plantago tubulosa	15	15
Stipa obtusa	16	16
Festuca orthophylla	17	-
Plantago oficinalis	18	-
Lepiquenia spp.	19	-
Trace species[2/]		
Stipa brachiphylla	1	1
Trifolium amabile	2	3
Bromus lanatus	3	4
Muhlenbergia peruviana	4	2
Miriophyllium spp.	5	5
Ranunculus peruvianus	6	6

[1/] Species comprising at least 1.0% of the available forage.

[2/] These species were extremely minor components in the available forage (less than 0.1%) or they did not appear at all in the field sampling.

CHAPTER V

SUMMARY AND CONCLUSIONS

During the driest months of the year at the La Raya Research Station, adult and tui alpaca almost exclusively depended on grass and grass-like forage species for their diets, but tuis consumed more grass-like plants than adults. The most dramatic relationship of diet selection, for both adults and tuis, with the dynamic variability of available forage was the consumption of forbs. But again, forbs were more important to tuis than adults. Higher nutritional requirements of tuis may explain why they consumed more forbs and grass-like plants.

Twelve grass, grass-like and forb species were highly preferred by adult and tui alpaca. Among the most important were Eleocharis albibracteata, Poa spp., Calamagrostis heterophylla, Alchemilla pinnata, Carex, spp., Stipa brachiphylla, and Trifolium amabile. One grass species, Festuca dolichophylla, largely believed to be a highly preferred species to alpaca in Southern Peru, averaged 71% by weight of the total yield in the field but only 15% in the diet. Thus, the preference index showed it to be a relatively unpreferred species, but its importance as a dietary component cannot be overlooked.

Generally, adult and tui alpaca consumed more leaves than stems during the entire grazing period. Leaf consumption was relatively constant while stems in the diet declined steadily throughout the dry season and into the wet season. This observation is in direct contrast with data from other small ruminants where consumption of stems

generally increases during dry months in North America (Van Dyne and Heady 1965, Malechek and Leinweber 1972, Bryant 1977).

Alpaca and tui alpaca consumed large quanitites of seeds during the driest months of the year. Compared with other small ruminants, seed consumption by alpaca was remarkable. This high seed consumption could help explain, in part, how both female and growing alpaca cope energetically during the driest months when high quality forage is in short supply.

LITERATURE CITED

Adams, E. W., W. G. O'Regan, D. J. Dunaway. 1962. Analysis of forage consumption by fecal examination. J. Wildl. Manage. 26:108-111.

Antezana, C. 1972. Estado y tendencia de las pasturas alpaqueras en el Sur Oriente Peruano. Tesis UNSAAC-Cusco, Peru.

Baker, E. W., and B. W. Wharten. 1952. An introduction to acarology. MacMillan Press. New York. 465p.

Baumgartner, L. L., and A. C. Martin. 1939. Plant histology as an aid in squirrel food-habit studies. J. Wildl. Manage. 3:266-268.

Beck, S. 1982. Apuntes sobre formaciones de pastos naturales en el Altiplano. I Reunion de Especialistas de las Region Alto-andina. Puno, Peru. Resumen. 3p.

Bryant, F. C. 1977. Botanical and nutritive content in diets of sheep, Angora goats, Spanish goats, and deer grazing a common pasture. Ph.D. Dis., Texas A&M Univ., College Station. 72p.

Chamrad, A. D., and T. W. Box. 1968. Food habits of white-tailed deer in South Texas. J. Range Manage. 21:158-164.

Clements, F. E. 1905. Research Methods in Ecology. Arno Press. Lincoln, Neb. 334p.

Coleman, S. W. , and K. M. Barth. 1973. Quality of diets selected by grazing animals and its relation to quality of available forage and species composition of pastures. J. Anim. Sci. 36:754-761.

Condorena, N. 1980. Algunos indices de produccion de la alpaca, bajo el sistema de esquila anual establecido en La Raya. Rev. Inv. Pec. (IVITA), Univ. Nac. Mayor San Marcos. 5:50-55.

Cook, C. W., and L. E. Harris. 1950. The nutritive content of the grazing sheep diet on summer and winter ranges of Utah. Utah Agr. Exp. Sta. Bul. 342. 66p.

Cook, C. W., J. T. Blake, and J. C. Call. 1963. Use of esophageal fistula for collecting forage samples from both sheep and cattle grazing in common. J. Anim. Sci. 22:579-581.

Cory, V. L. 1927. Activity of livestock on the range. Texas Agr. Exp. Sta. Bul. 367. 47p.

Cutler, F. D. 1969. Anatomy of the monocotiledons. V. Juncales. Ed. C. R. Metcalfe. Oxford Press. 357p.

Farfan, R. D. 1982. Ranch plan for La Raya Ranch, Cusco, Peru. Range and Wild. Manage., Texas Tech Univ., Lubbock. Mimeo. 20p.

Foppe, T. M. 1972. Determining animal diets on rangeland. Composition Analysis Lab. Co. Sta. Univ., Ft. Collins. 6p.

Guerra, G., and R. Murua. 1981. Habitos alimenticios del guanaco (Lama guanicoe) en semicautiverio en el Parque National Conguillio-Las Paraguas. Corp. National Forestal IX. Region-Chile. Anales IV Congreso Inter. sobre Camelidos Sudamericanos, Punta Arenas, Chile.

Hansen, R. M., and R. C. Clark. 1977. Foods of elk and other ungulates at low elevations in Northwestern Colorado. J. Wildl. Manage. 41:76-80.

Hansen, R. M., and G. C. Lucich. 1980. A field procedure of study design for fecal collections to be used to determine wildlife and livestock food habits. Composition Analysis Lab., Co. Sta. Univ., Ft. Collins. 11p.

Heady, H. F., and D. T. Torell. 1959. Forage preference exhibited by sheep with esophageal fistulas. J. Range Manage. 12:28-34.

Hegg, O. 1961. Analysis of big-game droppings to determine their dietary composition in the Swiss National Park. Botanical Institute of the University of Beru, Swiss. Mimeo. 9p.

Heineman, W. W. 1970. Dual grazing of irrigated pastures by cattle and sheep. Proc. XIth Int. Grassland Cong. p.810-814.

Holdridge, L. R. 1967. Life Zone Ecology. Tropical Science Center. San Jose, Costa Rica. 206p.

Holgado, D., R. D. Farfan, and M. E. Tapia. 1979. Evaluacion Agrostologica de los Pastizales de La Raya, Puno, Peru. Rev. Inv. Pec. (IVITA). Uni. Nac. Mayor San Marcos. 4:32-37.

Johnson, M. K., and H. E. Pearson. 1981. Esophageal, fecal and exclosure estimates of cattle diets on a longleaf pine-bluestem range. J. Range Manage. 34:232-234.

Koford, C. B. 1975. The vicuna and the Puna. Ecol. Monogr. 27:153-219.

Kothmann, M. M. 1968. The botanical composition and nutrient content of the diet of sheep grazing on poor condition pasture compared to good condition pasture. Ph.D. Diss., Texas A&M Univ., College Station. 60p.

Krueger, C. W. 1972. Evaluating animal forage preference. J. Range Manage. 25:471-475.

Malechek, J. C., and C. L. Leinweber. 1972. Forage selectivity by goats on lightly and heavily grazed ranges. J. Range Manage. 25:105-111.

Malpartida, E., and A. Florez. 1980. Estudio de la selectividad y consumo de la vicuna en Pampa galeras. UNA. No. 23. Peru. 15p.

Medin, D. E. 1970. Stomach analyses: Collection from wild herbivorous and birds. p. 133-145. In Range and Wildl. Habitat Evaluation. U. S. For. Serv. Misc. Pub. No. 1147. 220p.

Metcalfe, R. C., and L. Chalk. 1950. Anatomy of the monocotyledons. I. Graminae. Oxford Press. 723p.

Metcalfe, R. C. 1960. Anatomy of the monocotyledons. I. Graminae. Oxford Press. 723p.

Metcalfe, R. C. 1971. Anatomy of the monocotyledons. V. Cyperaceae. Oxford Press. 597p.

Norris, J. J. 1943. Botanical analyses of stomach contents as a method of determining forage consumption of range sheep. Ecology. 24:244-251.

Orlove, B. S. 1977. Alpacas, sheep and man. Academic Press. 270p.

Pearson, O. P. 1951. Mammals in the highlands of Southern Peru. Bul. Mus. Comp. Zool. 108:117-174.

Pfister, A. J., and J. C. Malechek. 1982. Techniques for evaluating diets of livestock grazing native range. A review. J. Range Manage. (In Press).

Reiner, R., and F. C. Bryant. 1983. A different sort of sheep. Rangelands (In Press).

Reynolds, J. P., J. Bond, G. E. Carlson, C. Jackson, Jr., R. H. Hart, and I. Linddahl. 1971. Co-grazing of sheep and cattle on an orchardgrass sward. Agron. J. 63:533-536.

Rice, R. W. 1970. Stomach content analysis: a comparison of the rumen vs esophageal fistulae techniques. p. 127-132. In Range and Wildl. Habitat Eval. U.S. For. Serv. Misc. Pub. No. 1147. 220p.

Scott, G., and B. E. Dahl. 1980. Key to selected plant species of Texas using plant fragments. Occasional papers. The Museum. Texas Tech. Univ., Lubbock. No. 64. 37p.

San Juan de Chuquibambilla. 1981. Reunion de Especialistas de pastos de la Region Alto-andina. Puno, Péru. Abstract.

Schrumpf, B. J. 1968. Methodology for cuticular identification of selected Eastern Oregon range plants. M.S. Thesis. Oregon State University, Corvallis. 38p.

Sparks, D., and J. C. Malechek. 1968. Estimating percentage dry weight diets using a microscope technique. J. Range Manage. 21:264-265.

Stoddart, L. A., A. D. Smith, and T. W. Box. 1975. Rangeland Management. MacGraw-Hill Book Co., 532p.

Storr, G. M. 1961. Microscopic analysis of feaces, a technique for ascertaining the diet of herbivorous mammals. Aust. J. Biol. Sci. 14:157-164.

Tapia, M. E. 1971. Pastos Naturales del Altiplano del Peru y Bolivia. Publicacion miscelanea No. 85. Programa de Investigacion Zona Andina. Quito, Ecuador.

Tapia, M. E. 1982. Clasificacion, evaluacion y condicion de los pastizales del Sur del Peru. Curso corto. Manejo y mejoramiento de pastizales naturales. Small Ruminant CRSP-Texas Tech Univ., Lima, Peru. 15p.

Theurer, C. B., A. L. Lesperance, and J. D. Wallace. 1976. Botanical composition of the diet of livestock grazing native range. Agr. Exp. Sta., Univ. of Ariz. 233p.

Thomas, R. B., and B. P. Winterhalder. 1976. Physical and biotic environment of southern highland Peru. P. 21-46. In P. T. Baker and M. A. Little (eds.). Man in the Andes (US/IBP. Sintheses. Series II). Dowden Hutchenson and Ross, Inc. PA.

Torell, D. T. 1954. An esophageal fistula for animal nutrition studies. J. Anim. Sci. 13:878-884.

Tribe, D. E. 1950. The composition of a sheep's natural diet. J. Brit. Grassl. Soc. 5:81-91.

Valdivia, R. 1981. Digestive physiology and reprodiction in the alpaca. Seminar. Texas Tech. Univ. Mimeo. Unpublished. 4p.

Van Dyne, G. M., and H. F. Heady. 1965. Botanical composition of sheep and cattle diets on a mature annual range. Hilgardia. 36:465-492.

Vavra, M., R. M. Rice, and R. M. Hansen. 1978. A comparison of esophageal fistula and fecal material to determine steer diets. J. Range Manage. 31:11-13.

Vavra, M., and J. L. Holechek. 1980. Factors influencing microhistological analysis of herbivore diets. J. Range Manage. 33:371-374.

Wallmo, O. C., and D. J. Neff. 1970. Direct observation of tamed deer to measure their consumption of natural range. p. 105-110. In Range Wildl. Habitat Eval. U. S. For. Serv. Misc. Pub. No. 1147 220p.

West, T. L. 1981. Alpaca production in Puno, Peru. Small Ruminant CRSP, Dep. of Rural Sociology, Univ. of Missouri, Columbia. Pub. 3. 110p.

Wilcox, B., and F. C. Bryant. 1982. Soil and vegetation complex in the Andes of Central Peru. Research Highlights 1981. Noxious brush and weed control. Range & Wildl. Manage. Vol. 13. Texas Tech Univ., Lubbock.

Wilson, A. D. 1976. Comparison of sheep and cattle grazing on a semi-arid grassland. Aust. J. Agric. Res. 27:155-162.

Zyznar, E., and P. J. Urness. 1969. Quantitative identification of forage remnants in deer diets. J. Wildl. Manage. 33:506-510.

APPENDIX

Appendix Table A. Chemical quantities comprised in Hertwigs' and Hoyers' solutions for slide preparation for the microhistological technique (from Hansen 1971).

Chemical	Hertwig's solution	Hoyer's solution
Chloral hydrate	270 g	200 g
HCL	19 ml	-
Glycerine	60 ml	20 ml
Water	-	50 ml
Photopurified gum arabic	-	30 g

Appendix Table B. Monthly standing crop (kg/ha) of grass, grass-like and forb plants in the study area in Southern Peru.

Type of herbage	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Grass & grass-like species							
Bromus lanatus	4	0	0	0	2	7	15
Calamagrostis antoniana	5	0	35	0	0	345	0
Calamagrostis heterophylla	32	15	80	15	6	3	9
Calamagrostis vicunarum	9	6	30	9	11	11	3
Carex spp.	155	171	129	105	104	128	120
Eleocharis albibracteata	139	32	40	53	65	4	13
Festuca dolichophylla	2,267	1,435	2,876	2,293	4,292	3,217	7,933
Festuca megalura	5	1	0	0	0	0	0
Festuca orthophylla	59	0	11	110	3	25	0
Festuca rigida	153	185	232	8	149	155	296
Juncus brunneus	84	422	51	54	44	86	58
Luzula peruviana	0	8	0	0	0	6	14
Muhlenbergia fastigiata	60	64	105	64	92	46	193
Muhlenbergia peruviana	0	2	1	0	0	0	0
Poa gymnantha	6	15	0	0	0	0	0
Poa spp.	47	54	32	14	40	86	131
Stipa brachiphylla	3	1	8	1	0	2	4
Stipa ichu	0	0	41	39	0	16	0
Stipa obtusa	59	0	122	164	31	193	279
Total grasses & grass-like	3,037	2,411	3,793	2,929	4,839	4,330	9,068
Forbs							
Alchemilla pinnata	60	12	28	21	85	75	145
Hipochoeris taraxacoides	72	47	17	42	209	31	98
Lepiquenia spp.	2	12	3	2	3	23	5

Appendix Table B. Continued.

Type of herbage	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Plantago oficinalis	20	50	0	20	180	37	322
Plantago tubulosa	65	1	20	38	36	320	286
Ranunculus limoselloides	0	0	0	2	5	5	41
Ranunculus peruvianus	0	0	1	4	21	50	20
Trifolium amabile	1	1	0	1	0	8	8
Werneria pygmaea	39	2	48	34	36	24	11
Miriphyllium spp.	10	1	0	3	4	3	7
Total forbs	269	126	117	167	579	576	943
TOTAL	3,306	2,537	3,910	3,096	5,418	4,906	10,011

Appendix Table C. Mean percent of grass, grass-like and forb species in diets of adult alpaca at monthly intervals on the study area in Southern Peru.

Type of herbage	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Grasses							
Bromus lanatus	2.8	1.5	1.3	0.1	0.1	0.6	2.3
Calamagrostis heterophylla	4.2	7.5	7.6	7.3	6.3	5.6	3.2
Calamagrostis vicunarum	5.5	6.1	6.3	3.2	2.4	1.8	2.2
Festuca dolichophylla	16.2	16.6	19.5	20.0	17.3	10.3	10.9
Festuca orthophylla	0.0	0.2	0.1	0.3	0.0	0.0	0.0
Festuca rigida	2.8	4.2	3.8	4.2	3.1	2.2	1.2
Muhlenbergia fastigiata	6.8	8.5	8.8	11.4	8.6	8.6	5.5
Muhlenbergia peruviana	1.8	2.5	1.3	0.2	0.1	0.0	0.0
Poa gymnantha	1.3	1.9	2.6	0.0	0.0	0.0	0.0
Poa spp.	8.3	8.7	12.2	15.6	16.2	13.5	13.8
Stipa brachiphylla	8.9	11.6	10.4	7.6	5.2	4.9	4.3
Stipa ichu	0.5	0.3	0.1	0.1	0.0	0.0	0.0
Stipa obtusa	1.4	1.2	1.5	1.8	0.4	0.2	0.2
Grass-like plants							
Carex spp.	9.5	6.8	8.0	10.4	10.7	7.6	8.3
Eleocharis albibracteata	8.4	7.8	5.0	10.8	17.2	17.7	17.5
Juncus brunneus	2.6	2.3	0.8	1.0	1.4	3.5	3.9
Luzula peruviana	0.9	0.8	0.1	0.0	0.0	0.1	0.7
Forbs							
Alchemilla pinnata	13.7	8.9	7.5	5.3	7.9	16.4	10.6
Hipochoeris taraxacoides	0.2	0.6	0.0	0.0	0.0	0.9	4.7
Miriophyllium spp.	0.5	0.3	0.4	0.2	0.5	0.8	1.0
Plantago oficinalis	0.1	0.0	0.0	0.0	0.1	0.5	0.0
Plantago tubulosa	0.2	0.0	0.0	0.0	0.0	1.3	3.7

Appendix Table C. Continued.

Type of herbage	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Ranunculus limoselloides	0.2	0.5	0.2	0.1	0.1	0.1	0.3
Ranunculus peruvianus	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Trifolium amabile	2.0	2.1	1.8	0.5	0.5	1.5	2.9
Werneria pygmaea	0.1	0.0	0.0	0.0	0.0	1.1	2.2

Appendix Table D. Mean percent of grass, grass-like and forb species in diets of tui alpaca at monthly intervals on the study area in Southern Peru.

Species	June	July	Aug.	Sept.
Grasses				
Bromus lanatus	0.9	1.1	0.3	0.5
Calamagrostis heterophylla	4.9	4.1	10.2	7.1
Calamagrostis vicunarum	7.5	6.2	3.6	2.4
Festuca dolichophylla	11.1	13.2	16.0	19.9
Festuca orthophylla	0.0	0.1	0.0	0.0
Festuca rigida	1.8	2.2	2.2	1.4
Muhlenbergia fastigiata	7.7	10.2	7.9	10.7
Muhlenbergia peruviana	5.3	3.2	1.1	0.6
Poa gymnantha	0.3	2.4	1.6	0.0
Poa spp.	5.8	9.0	17.6	17.6
Stipa brachiphylla	7.7	11.2	9.2	6.1
Stipa ichu	0.1	0.1	0.0	0.0
Stipa obtusa	0.3	0.2	0.2	0.2
Grass-like plants				
Carex spp.	5.3	4.9	9.2	9.4
Eleocharis albibracteata	15.9	12.4	9.3	11.5
Juncus brunneus	3.7	1.8	1.5	1.4
Luzula peruviana	0.8	0.3	0.0	0.0
Forbs				
Alchemilla pinnata	19.6	12.3	9.0	10.5
Hipochoeris taraxacoides	0.2	0.4	0.0	0.1
Miriophyllium spp.	0.1	0.5	0.5	0.6
Lepiquenia spp.	0.1	0.0	0.0	0.0
Plantago oficinalis	0.1	0.0	0.1	0.1
Plantago tubulosa	0.1	0.0	0.0	0.0
Ranunculus limoselloides	0.0	0.6	0.1	0.1
Ranunculus peruvianus	0.1	0.2	0.0	0.0
Trifolium amabile	1.3	1.8	1.2	0.8

Appendix Table E. Scientific and common names of plants of the study area in Southern Peru.

Scientific name	Common Name[1/]
Grasses	
Bromus lanatus H.B.K.	Cebadilla
Calamagrostis antoniana (Griseb) Steud.	Crespillo
Calamagrostis heterophylla (Wedd) Pilg.	Huaylla ichu
Calamagrostis vicunarum (Wedd) Pilg.	Crespillo
Festuca dolichophylla Presl.	Chillihua
Festuca megalura	- - - - - -
Festuca orthophylla Presl.	Iru ichu
Festuca rigida (Presl) Kunth	- - - - - -
Muhlenbergia fastigiata (Presl) Henr.	Grama
Muhlenbergia peruviana (Beanv) Steud.	Coja napa
Poa candamoana Pilg.	K'acho
Poa gymnantha Pilg.	K'acho
Poa spp.	K'acho
Stipa brachiphylla Hitchc.	- - - - - -
Stipa ichu (R. et P) Kunth	Ichu
Stipa obtusa	Tisna
Grass-like Plants	
Carex spp.	- - - - - -
Eleocharis albibracteata	Quemillo
Juncus brunneus	- - - - - -
Luzula peruviana	Uma sutu
Forbs	
Alchemilla pinnata Pilg.	Sillo sillo
Hipochoeris taraxacoides	Pilli (yellow flower)
Miriophyllium spp.	Llacho
Lepiquenia spp.	Salvia
Plantago oficinalis	- - - - - -
Plantago tubulosa	- - - - - -
Ranunculus limoselloides Presl.	Unu pirca
Ranunculus peruvianus Turz.	Unu pirca
Trifolium amabile H.B.K.	Layo
Werneria pygmaea	- - - - - -

1/ These common names are currently used in Southern Peru.