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The use of guard llamas to protect sheep from coyote predation

Kelly Johnson Powell
Iowa State University

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by

Kelly Johnson Powell

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GENERAL INTRODUCTION

Predation is a leading cause of mortality in sheep. U.S. sheep losses due to coyotes and other predators reached over $83 million in 1987, up from $72 million in 1986 and $69 million in 1985. The 1987 losses represented 5.4% of the total U.S. sheep population and 8.8% of the total value of all sheep (Terrill 1988). These losses resulted in higher prices paid by the consumer for lamb and wool products. Canid sheep predators, especially coyotes (Canis latrans), are one of the most serious problems facing the sheep industry today. Predation is a critical issue with serious implications to both animal husbandry and wildlife management.

A variety of methods for controlling canid predation have been tried, including lethal and nonlethal techniques (Cadieux 1983, Andelt 1987, Wagner 1988). Methods vary greatly in cost and effectiveness and do not always have the desired outcome. The development of nonlethal predator control methods resulted in the reintroduction of the historically important method of using guard animals (Coppinger et al. 1988). Guard animals currently include dogs (Canis familiaris) (Andelt 1992), donkeys (Equus asinus) (Strom 1987), ostriches (Struthio camelus) and llamas (Lama spp.) (Botkin and Taylor 1985; Markham 1990, 1992). Recent research has focused on dogs, while alternative guard animals remain relatively unresearched.

This project investigated the use of llamas as guard animals for sheep. Many sheep ranchers were already using llamas to protect their flocks (Markham 1990). The goals of this project were to determine the guarding effectiveness of llamas and to determine the most effective way of utilizing them as guard animals. To reach these goals, I considered the following questions: 1) To what degree are they effective? 2) In what types of situations? 3) How much care do the llamas require? 4) What are the expenses involved with using a guard llama?

A nationwide telephone survey of 145 sheep ranchers with 204 guard llamas was conducted from July 1991 to April of 1992 to determine the management and husbandry practices of guard llama programs. I also recorded llama characteristics such as sex, age, and behavior. I compared the reported losses to predators before and after adding a llama to the flock, and the losses to predators among different management situations. The predator losses of guard llama owners were compared with the predator losses of sheep ranchers surveyed by the National Agricultural Statistics Service.

Explanation of Thesis Format

This thesis contains 2 papers suitable for publication. Paper 1 explains the management and husbandry practices used by ranchers with guard llamas. Paper 2 describes the effectiveness of guard llamas at reducing sheep and lamb

predator losses, and also compares the predation losses in different management situations. A General Summary follows Paper 2, and literature cited in the General Introduction and Summary follow the Summary. The 2 papers are written using the format specified by the Wildlife Society Bulletin.

PAPER 1: USE AND MANAGEMENT OF GUARD LLAMAS FOR PROTECTING SHEEP AGAINST PREDATION

ABSTRACT

A 1991/1992 nationwide telephone survey of 145 sheep producers with guard llamas determined how llamas were being used by ranchers. Producers had used guard llamas for an average of 3.2 years. The individual llamas had been used as guard animals for an average of 2.6 years because producers sometimes had owned more than 1 llama. Guarded flock size averaged 283.6 (range 4-2150 sheep and lambs, median = 120) in pastures ranging from 2-3238.6 ha ($\bar{x}$ = 113.7 ha). Most guard llamas were gelded males with an average initial cost of $570, and they were usually introduced to the flock at 0.5-1 year of age. Most llamas (83%, n = 204) were given the same care as the sheep and required no extra care or training. Problems reported were attempted breeding of ewes by llamas and llama aggressiveness towards the flock. Important benefits were easy maintenance and predator control. Eighty percent of 193 llamas were individually rated as very effective or effective at reducing losses to predators. Eighty-eight percent of the producers were either very satisfied or satisfied with their overall guard llama program, and 86 guard llama owners provided average annual savings estimates ($\bar{x}$ = $1,034). Llamas are a low maintenance guard animal with the potential to be a cost effective method of reducing sheep mortality caused by predators.

INTRODUCTION

Canid predation, especially by coyotes (Canis latrans), is one of the most serious problems facing the sheep industry today. Terrill (1988) reported that sheep losses due to coyotes and other predators reached over $83 million in 1987, representing 5.4% of the total U.S. sheep population and 8.8% of the total value of all sheep. The National Agricultural Statistics Service (NASS) reported that the United States had 108,940 ranches/farms with 9,470,600 stock sheep and lambs in 1990 (NASS 1992). Also in 1990, a total of 490,000 sheep and lambs (after tail-docking) were lost to animal predators, representing 37% of the losses from all causes (predator and nonpredator) and a total loss of $21,700,000 (NASS 1991). Sixty-three percent of the total losses were attributed to nonpredator causes such as weather, disease, and poison. Coyotes were the most important predator, accounting for 64% of all predator losses.

A variety of lethal methods for controlling canid predation have been tried or tested, including shooting (Wade 1978), poisoning (Wagner 1988), trapping (Gipson 1975), denning (Till and Knowlton 1983) and toxic collars (Connolly et al. 1978). Methods vary greatly in cost and effectiveness and do not always have the desired outcome. Expensive bounties and indiscriminate poisoning programs have been shown to have little effect on the level of predation on sheep

(Wagner 1988). In addition, many of these technological solutions are too expensive or unavailable to the small-scale sheep farmer. Indiscriminate coyote poisoning and trapping have been the source of environmental and public concern because these methods are not always individual or even species-specific.

This concern has led to the development of nonlethal methods of controlling canid predators, including electric fences (Linhart et al. 1982, Nass and Theade 1988), night confinement of flocks (Robel et al. 1981), aversive conditioning of predators (Lehner 1976, Gustavson et al. 1982), reproductive inhibitors (Balser 1964, Stellflug et al. 1978), and frightening devices (Robel et al. 1981, Andelt 1987). Research on nonlethal techniques has also led to the "rediscovery" of the historically important method of using guard animals to control canid predators (Coppinger and Coppinger 1988). Guard animals currently include dogs (Canis familiaris) (Andelt 1992), donkeys (Equus asinus) (Strom 1987), ostriches (Struthio camelus), and llamas (Lama spp.) (Botkin and Taylor 1985; Markham 1990, 1992). Of these guard animals, the most popular and intensively studied are guard dogs (Green et al. 1984; Coppinger et al. 1988).

Our goal was to investigate the use of camelids as guard animals for sheep. Of the four South American camelids, llamas (L. glama), guanacos (L. guanicoe), and their hybrids

have the most potential as guard animals in North America because of their large size and availability; all are referred to as "guard llamas" in this paper. Antipredator mobbing behavior has been documented for the two wild camelids: vicunas (Vicugna vicugna) and guanacos (Franklin 1983). The domestic llama is believed to have been derived from the wild guanaco (Franklin 1982).

Llamas are already being used by a number of sheep ranchers as guard animals in the western United States. Markham (1992) interviewed 20 sheep producers in Idaho, Montana, and Wyoming who were successfully using guard llamas. All were satisfied with the effectiveness of llamas. Systematic research, however, on the degree of effectiveness, the numbers of successes and failures, and the specific management practices involved in the use of guard llamas has not been conducted. The objectives for this research were to determine the 1) management and husbandry practices ranchers used with guard llamas, and 2) descriptive characteristics of llamas used to guard sheep.

METHODS

The project involved 3 phases: name collection, telephone surveys, and data analysis. We collected names of sheep ranchers with guard llama experience. A news release (Appendix A) was sent to various sheep and llama publications and to state sheep extension specialists requesting names and phone numbers of farmers and ranchers with guard llamas. It stressed the need for information from both successful and unsuccessful attempts at using llamas as guard animals for sheep. In addition, a 2-panel postcard (Appendix B) was sent to 2082 llama owners across North America asking for the same information, of which 101 were returned. A total of 237 names was collected from all sources. However, 62 people had not owned a guard llama, 6 had llamas guarding another type of animal, and 20 were unreachable. A total of 149 guard llama owners were contacted, of which 4 declined to participate (97% response rate).

A telephone questionnaire (Appendix C) with 101 questions was developed in conjunction with the Iowa State University Statistics Department. The questionnaire asked for information on the type of sheep operation (fenced pasture or unfenced rangeland), terrain, number of livestock involved, timing and location of lambing, flocking behavior, pasture acreage, fence height and type, predator losses, predator control techniques, satisfaction, effectiveness, and whether

the producer recommended the use of guard llamas. Information requested for each individual guard llama included: breed, sex, and age; age when placed with livestock; method of introduction to livestock; initial cost and annual expenses; daily care required; behaviors toward predators, people, and livestock; whether the llama stayed with the sheep; problems encountered; and amount of exposure to people.

Telephone respondents were either given a short selection of answers from which to choose or were allowed to respond freely. Interviewers were trained to neutrally probe for more specific responses to avoid leading the ranchers into an expected response (Groves et al. 1988; Frey 1983). Each interview lasted 30 to 60 minutes depending on the number of guard llamas owned.

A total of 145 ranchers/farmers who owned 204 guard llamas was interviewed via telephone from July 1991 to April 1992, who owned a total of 204 guard llamas. Seven ranchers included in this study raised only goats (Capra spp.), 7 owners had flocks of sheep and goats, and the remaining 131 raised only sheep. All guard llama owners are referred to as sheep ranchers or producers, and all guarded flocks are referred to as sheep and/or lambs in this paper. Thirty-nine (27%) of the ranchers interviewed volunteered directly to participate in the survey, while 106 (73%) were referred through a second party, typically the person who previously

owned the llama.

Data were recorded and entered onto an Excel 3.0 spreadsheet (Microsoft Corp. 1990) and summarized with Statview 512+ (BrainPower 1986) or SAS (SAS Institute 1987). Percentages and frequency distributions were used to describe current management practices and llama characteristics. Means and standard errors were calculated for appropriate data and percents rounded to the nearest whole number. Three gelded llamas were excluded from the initial cost comparisons because they were originally purchased as intact males for breeding purposes ($5,000, $10,000, and $12,500) and later gelded and used to guard sheep. One purebred sheep breeder's extremely high estimated average annual savings ($20,000) was excluded from the overall mean.

Sample size (n) varied because some questions were on a per ranch basis and others on a per llama basis. In addition, an individual question could be refused by the rancher or skipped by the interviewer due to time constraints if the individual was on a telephone party line. The average sample size (n) for 18 "ranch questions" was 140 (SE = 0.82, range = 134-145) and the average sample size (n) for 20 "llama questions" was 200 (SE = 0.82, range = 192-204) unless otherwise noted.

RESULTS

Rancher Characteristics

Respondents were distributed across the United States and Canada (Fig. 1). However, 68% of the guard llama owners interviewed were in Montana, Oregon, Colorado, and California. Ranchers had an average of 16.7 years (SE = 1.3, range = 0.5-71 years) of experience raising sheep, and had owned a guard llama an average of 3.2 years (SE = 0.19, range = 0.13-12 years). Sheep producers first learned about guard llamas from magazines/newspapers (38%), llama breeders (32%), other sheep ranchers (11%), word of mouth (9%), and miscellaneous sources (10%). The majority of ranchers (53%) said they obtained information about llamas from llama breeders; other sources included llama publications, llama associations, books, veterinarians, and universities.

Ranchers reported shooting and trapping as the most common types of predator control methods used before and after obtaining the llama (Table 1). Eighty-one percent of ranchers used lambing jugs (indoor lambing pens) or practiced shed lambing during the lambing season.

Ranch Characteristics

Sheep ranchers described their operations as commercial (54%), purebred (26%), combination commercial/ purebred (12%), hobby (6%), and feedlot (2%). Sheep were a source of income on 80% of the ranches and were considered a hobby on the

remaining 20%.

Seventy-eight percent of ranchers reported trouble with predators before obtaining the llama, and 90% said that predator losses occurred regularly in their area. Ranchers reported the predator causing the most problems was coyotes (73%), feral or domestic dogs (23%), or others (4%). When asked if they had problems with any other predators, 50% of the ranchers named (multiple responses possible) coyotes 24%, dogs 35%, foxes (Vulpes spp.) 27%, mountain lions (Felis concolor) 21%, golden eagles (Aquila chrysaetos) 16%, bears (Ursus spp.) 14%, and others.

Sheep Management/Husbandry Characteristics

At the time of the interviews, 7% of the ranchers had >1 flock of sheep being guarded by llamas, and these flocks ranged in size from 5-1100 sheep and lambs. The number of flocks guarded per ranch ranged from 1-3. From 158 guarded flocks, average flock size was 283.6 sheep and lambs (SE = 29.3, range = 4-2150 sheep and lambs, median = 120). Flock size varied as follows: small farm flocks of <50 sheep and lambs (26%), 50-499 (52%), 500-999 (14%), and 1000 or more (8%).

The average pasture size was 113.7 ha (281 acres), (SE = 21.5, range = 2-3238.6 ha). Llamas were used in pastures <16 ha (50%), 16-65 ha (22%), 65-259 ha (14%), and 259 or more ha (14%). Guard llamas were kept in fenced pastures (86%), open

range (5%), either pasture or range depending on the time of year (5%), and other situations (4%). Ranchers used an average of 1.22 llamas per flock (SE = 0.06, range = 1-6 llamas). Average fence height was 1.22 m (4 ft), (SE = 0.02, range = 0-2.13 m), and only 2% (n = 139) said they changed their fencing specifically for the llama. Types of fencing (multiple responses possible) included woven wire (38%), barbless or smooth wire (35%), barbed wire (27%), electric (11%), wooden (7%), and high tensile (4%).

Method of Llama Introduction

Ranchers were asked a series of questions on how their llama was first introduced to the flock. The most common introductory location was a pasture (50%). Small pens/corrals (40%), barns (8%), and range situations (2%) were also used. Sixty-eight percent of the llamas were first introduced to the whole flock, and 32% were first introduced to a portion of the flock. Of the latter category (n = 71), 25% were kept with a portion of the flock 1-6 days, 33% 1-3 weeks, 31% 1-3 months, 4% 4-6 months, and 7% >6 months.

Forty-five percent of the llamas were first introduced to either a group of lambs or a flock with lambs, and 55% were introduced to flocks without lambs. Introductory flock size averaged 127.7 head (SE = 16.9, range = 1-1500 head). The initial behavioral reaction of the sheep was typically described as afraid or neutral (82%), while llamas were

curious or neutral (86%) (Fig. 2). The reported adjustment periods for the llamas and sheep were similar (Fig. 3), with 77% of the llamas and 82% of the flocks adjusting to each other within 1 week.

Llama Characteristics and Management

Seventy-eight percent of the guard llamas were purchased directly from private llama breeders, 6% were obtained at auctions, 10% had been raised on the sheep farm, and 6% came from various other sources such as zoos, sheep producers, or were a trade for some other asset. Ninety-six percent of the guard llamas were reported to be llamas, 1% were alpacas (*Lama pacos*), 1% were guanaco, and 2% were a cross involving 2 of these 3 species. Male and female camelids were used as guard animals with the following distribution: intact (uncastrated) males (26%), geldings (castrated males) (69%), and females (5%).

The llama's age at the time of introduction to the sheep flock ranged from birth to 12 years with a mode of 0.5-1 year (Fig. 4). At the time of the interviews, the age of the llamas ranged from 0.25 to 19 years, with the most common age being 3 years (Fig. 5). The average number of years individual llamas were in use was 2.6 years (SE = 0.15) and ranged from <1 year to 12 years (Fig. 6). This average is slightly less than the average number of years producers had used guard llamas (3.2 years) because some ranchers had owned

more than 1 guard llama. Owners reported a 5.4% mortality of llamas to the following causes: age/disease (5), killed by a hunter (1), euthanasia because of lameness (1), killed by guard dog (1), acorn poisoning (1), snake bite (1), and killed by a pack of coyotes (1). Additionally, 6 llamas had been non-fatally injured by predators. Three had snake bites, 2 were chased through fences by dogs, and 1 had a nose wound from an unknown predator.

Ninety-five percent of the llamas were not trained to guard sheep while 5% of the llamas reportedly received some type of "training." Training essentially meant the llama previously had been pastured with sheep.

When asked to describe the typical everyday interactive behavior of the llama and sheep, ranchers gave a variety of responses which were grouped into appropriate categories (Fig. 7). The majority (98%) of the llamas were described as either neutral, friendly, or protective towards the sheep. Most (98%) of the sheep were neutral (no reaction) or friendly (walked up to, played with, nuzzled, followed).

We also asked ranchers to describe the typical location of the llama in relation to the flock. Seventy percent of the llamas were usually with the sheep, 24% were usually separate from the flock, 5% were found in both situations, and 1% were close by but watchful.

Recommendations (multiple responses possible) on

desirable characteristics to look for in a potential guard llama included: "curious, attentive, alert, and self confident behaviors" (23%); "aggressiveness" (13%); "don't know" (13%); "a gelding" (12%); "bonded to sheep" or "raised with sheep" (12%); "can control/train them" (12%), "younger" (9%); "healthy, good conformation, stout and sturdy" (7%); "large size" (6%); and "natural guarding instinct" (5%).

Llama Care and Maintenance

Ranchers were asked to describe the daily, routine care given the llama in addition to that given their sheep. Eighty-three percent of the llamas received the same care as the sheep while 16% received additional feed and/or water, and 1% received some other type of care. Eighty percent of the llamas were not given any special feed or supplement other than the regular sheep feed. Special feeds that were given to 20% (n = 41) of the llamas included grain (44%), llama food (27%), horse ration (22%), and protein block (7%).

Most llamas (91%) were checked visually by someone on a daily basis, while others were checked every 2-4 days (4%), once per week (4%), or never (1%). Fifteen percent of the llamas were handled (caught) on a daily basis. Others were handled 1-3 times per week (16%), 1-2 times per month (16%), 1-10 times per year (32%), never (12%), or some other time frame (9%).

Expenses

The purchase price of the guard llamas averaged $790 (SE = $99, range = $0-12,000) for both sexes combined (Table 2). Ranchers were asked to estimate each llama's annual cost, not including pasture expenses. Average annual feed and veterinarian expenses were $103 combined (Table 2). Eleven percent of the llamas required miscellaneous expenses for halters, brushes, shearing, or de-worming supplies.

Eighty-six ranchers estimated their guard llama saved an average of $1,034 annually by reducing predation (SE = $116, range = $0-5,000). The highest estimate of $20,000 (not included in average) was from a purebred breeder who owned sheep worth several thousand dollars each. Thirty-seven owners could not estimate how much money their llamas had saved or lost their operations annually, and 10 could not estimate an amount but reported their llamas were an economic asset.

Management Problems

Seventy-five percent of the llamas were reported not to negatively affect the sheep they were protecting. Complaints reported by owners for the other 25% (n = 50 llamas) were attempted breeding of the ewes (46%) and aggression/playing too roughly with the sheep (48%). Chasing was the most common aggressive behavior reported. All problem llamas were males. Twenty-five percent of 61 intact and 5% of 135 gelded males

attempted to breed ewes. Llamas attempting to breed sheep can injure or even kill ewes, as evidenced by 1 ranch which lost 100 ewes before the cause was determined.

Eleven percent of the llamas were adversely affected by the sheep. Of these 22 negative reports, 17 llamas were displaced from food, 3 were butted by the sheep, 1 had its wool pulled by the sheep, and 1 disliked being crowded by sheep.

Llama Effectiveness

Ranchers were asked to rate the effectiveness of each guard llama in protecting their sheep against predators. Eighty percent rated the llamas as either very effective or effective (Fig. 8). Owners also reported their overall satisfaction with their guard llama programs, and 88% were wither very satisfied or satisfied (Fig. 9). Eighty-five percent of these ranchers said they would recommend llamas to other ranchers, while 13% said it would depend on the situation. Only 1% said they would not.

Multiple benefits of guard llamas were reported by ranchers with "easy maintenance" being the most common response (56%), followed by "predator control" (43%), "guarding ability" (14%), "24-hour protection" (13%), "fun to own" (10%), "good sheep companions" (7%), "keep sheep together" (7%), "reduce the need for other predator control methods" (6%), and "saves money" (6%).

Sixty-nine owners described situations where they believed llamas were especially effective. The most common responses included (multiple answers possible): "on open/flat ground" (22%), "with a smaller flock or area" (20%), "with newborns/during lambing season" (19%), and "against coyotes and/or dogs" (17%).

Disadvantages of guard llamas were reported by 36% of the ranchers (multiple answers possible). The most common answers were "overprotective...interferes when we work with the sheep" (5%), "can't use a stud llama" (4%), and miscellaneous responses (1-2%) including: "expensive", "contaminates fleece", "brown ones look like elk...people try to shoot it", "scares other livestock", "can't use 2 llamas", "finds open gates and leads sheep out", "have to feed separately", "mean to people", and "doesn't kill predator."

Sixty-eight ranchers described situations where they believed llamas would <u>not</u> be effective guardians (multiple responses possible). The most common responses included: "in large areas" (25%), "in hilly, wooded areas where llama can't see" (23%), "when sheep spread out" (12%), "when coyotes/dogs run in packs" (10%), "with large flocks" (9%), "against mountain lions and bears" (3%), and "against dogs" (3%).

DISCUSSION

Guard Llama Viability

Rancher response to the survey was high (97%), and most ranchers were enthusiastic about describing their own personal experiences with guard llamas. Many of the sheep ranchers were not knowledgeable about llamas in general and were eager to learn more.

Even though the use of guard llamas is still a relatively new method of predator control, llamas are being used by experienced sheep ranchers who depend on their sheep for income. The guarding potential of llamas was discovered over a decade ago as evidenced by the ranchers in our study who were still using guard llamas after 12 years.

Many ranchers reported having predator problems prior to getting a guard llama, although over 20% apparently purchased a guard llama for preventative reasons. In 1990, the U.S. Department of Agriculture (NASS 1991) reported that coyotes and dogs accounted for the largest proportion (77.3%) of sheep losses to predators in the U.S. Similarly, guard llama owners stated that coyotes (73%) and dogs (23%) were the predators causing the most problems on their ranches. The loss of profits to canid predators is of great concern to sheep producers. The ranchers in our study turned to llamas as a potential solution to their serious predator problems.

Most of the producers said they would recommend llamas to

other ranchers (and many had already done so) but they often found their neighbors to be skeptical. Some owners (13%) stated that they would only recommend guard llamas under certain conditions.

Most of the llamas were rated as either very effective or effective. The producers' estimates of the value of sheep and lambs saved by the llamas supported these ratings. It was interesting to note that some owners were satisfied with their guard llama's performance even though the llama was rated as only "somewhat effective." Some ranchers did not expect the llama to be 100% effective and were satisfied with a partial reduction in losses to predators. As shown in Table 1, other methods of predator control were used by the ranchers in addition to the llamas. However, the frequency of use of these other methods was not measured.

Ranch Management

Flock size and pasture size varied greatly. Few llamas were used on the open range; most were kept with sheep in fenced pastures. However, this does not necessarily mean that llamas do not work in expansive areas because some of the large fenced pastures were analogous to open range conditions.

Most ranchers used only 1 llama per flock, although some used as many as 6. We found several cases of satisfied ranchers using more than 1 llama per flock. For example, 1 midwestern farmer had 4 llamas (2 males and 2 females) with

1000 head of sheep. He used the llamas in different combinations depending on his seasonal grazing needs. He reported his llamas did not "group up and ignore the sheep." However, other ranchers had tried using multiple llamas unsuccessfully. The social traits of the individual llamas should be considered when more than 1 llama is introduced to the flock.

Llama Characteristics

Llamas (L. glama) are the most abundant camelid in North America, so it was no surprise that they were the most common reported type of guardian. However, our study may not represent the true number of llamas (L. glama), guanacos (L. guanicoe), alpacas (L. pacos), and hybrids. Many ranchers were not aware that different types of "llamas" existed, and assumed they had purchased a pure llama (L. glama).

Camelids are highly social herbivores. In the wild, a single male guanaco (llama progenitor) protects a territory containing several females and their offspring against the intrusion of nongroup members (Franklin 1983). While the males' territorial instinct might suggest that intact males would be the most effective guard animals, we found satisfied ranchers (n = 125) using females (4%) and gelded males (79%). Both sexes seem to have the ability to protect a flock of sheep.

Some ranchers in our survey were discouraged when their

llama did not stay with the flock. However, if the llama is positioned on a nearby elevation, separation from the flock does not necessarily mean the llama is not guarding. In the wild, a territorial male will sometimes position himself away from his family group on hilltops or elevated areas for the detection of trespassing animals and predators (Franklin 1983).

Although 95% of the geldings and 75% of the intact males did not show any mounting behavior of ewes, guard llamas should be watched during the breeding season. Separating the llama from the sheep may be necessary.

Llama Introduction

The most common age of introduction was around 6-12 months of age, an age when llamas are typically weaned and available for purchase from llama breeders. Even though llamas do not require training, we would not expect a llama to reach its full guarding potential until later because territorial behavior does not become apparent in the wild guanaco until 2-4 years of age (W. Franklin, Iowa State Univ., unpubl. data).

The introduction of the llama to the sheep flock would seem to be a critical stage in the bonding process. Ironically, a wide variety of methods were used, and most resulted in satisfactory performance. Methods of introduction varied from placing the llama in the barn with one sheep to

releasing the llama near the flock in the pasture or on the range. The majority of ranchers introduced the llama to the whole flock, but many flocks were relatively small in size.

Several llama breeders recommended introducing the llama when lambs were present to facilitate quicker bonding. Many ranchers stated their llama was "crazy about the lambs" and could often be seen playing with or standing guard over newborns. Powell and Franklin (1993), however, did not show that the presence of lambs in the introductory flock made any difference in the effectiveness of the guard llama.

We expected the initial behavioral reactions described because llamas are inherently inquisitive and curious. This facilitates their guarding behaviors. Furthermore, we expected that the sheep initially would be afraid of a large newcomer. Adjustment time was relatively short with most llamas and sheep interacting normally with each other within a few hours to a few days. The process of bonding an herbivorous llama to sheep is not completely understood, but it seems to be a fairly short process that requires little effort from the rancher.

Llama Management

Seventy-eight owners reported that llamas' low maintenance requirements were advantageous. Guard llamas usually did not require additional care and effort beyond the normal sheep maintenance. However, some llamas were sensitive

to sheep crowding their legs at the feed trough. Placing a bucket up higher out of reach of the sheep can solve this problem.

Eighty-six ranchers reported no disadvantages, and of those who did, the answers varied greatly without any obvious trends. Over-protectiveness against people was given as a disadvantage, but the level of interference should be considered. Some ranchers felt that having to separate the llama from the flock before attending to the lambs was a small price to pay for flock protection. Others believed only llamas that are responsive to people should be used.

Cost Effectiveness

The initial investment in a llama depended on the sex of the animal. Males were the least expensive and were commonly available from breeders. Maintenance costs were low because llamas easily live on pasture (Tillman 1981). Veterinary expenses included de-wormings, vaccinations, and castration, if desired. Many ranchers, however, de-wormed the llama themselves along with the sheep. Miscellaneous expenses included the initial one-time investment in halters and lead ropes.

Llamas have the potential to save ranchers thousands of dollars depending on the number of effective working years the llama provides. If a guard llama is used for 5 years (gross savings of $1,034 per year), the potential net savings are

$4,030, including the initial purchase price of a gelded llama ($570) and annual expenses ($114 x 5). After 10 years of use, the potential net savings are $8,630. The average life span of a llama is 15-20 years (Tillman 1981), but some llamas have been known to live longer. Ranchers in our survey reported guard llamas as old as 19 years. The potential working years and annual savings from a guard llama can make it highly cost effective. For an industry operating on a low profit margin, reduced predator losses resulted in rancher satisfaction.

MANAGEMENT IMPLICATIONS

Many factors need to be considered when choosing a predator control technique. The complete elimination of predator problems is not a realistic goal. A system of predator control techniques should be used to reduce predator losses as much as possible. The ideal technique should focus on the problem animal, prevent losses from occurring, require little extra work on the part of the rancher, and be cost effective. The use of guard animals is a preventive technique, as opposed to implementing predator elimination methods after sheep and lamb losses have occurred.

Llamas have the potential to provide ranchers with a nonlethal alternative to traditional predator control methods. Dogs traditionally have been used as guard animals, but we found that llamas are a viable guard animal that are providing effective flock protection on sheep ranches nationwide. Guard llamas can easily be used in conjunction with other methods, and do not require training, special feeds, or equipment. Llamas are readily available in nearly every state due to the expanding llama industry.

This study serendipitously found that a number of ranches and farms successfully use llamas to protect ducks, geese, deer, and even cattle. Such expanded use of guard llamas is intriguing and deserves further assessment.

Llamas are not a guaranteed cure for all predator

problems. Most of the ranchers in our study had also tried and were still using other predator control methods. The versatility and low maintenance of guard llamas makes them a cost-effective part of an overall predator control program.

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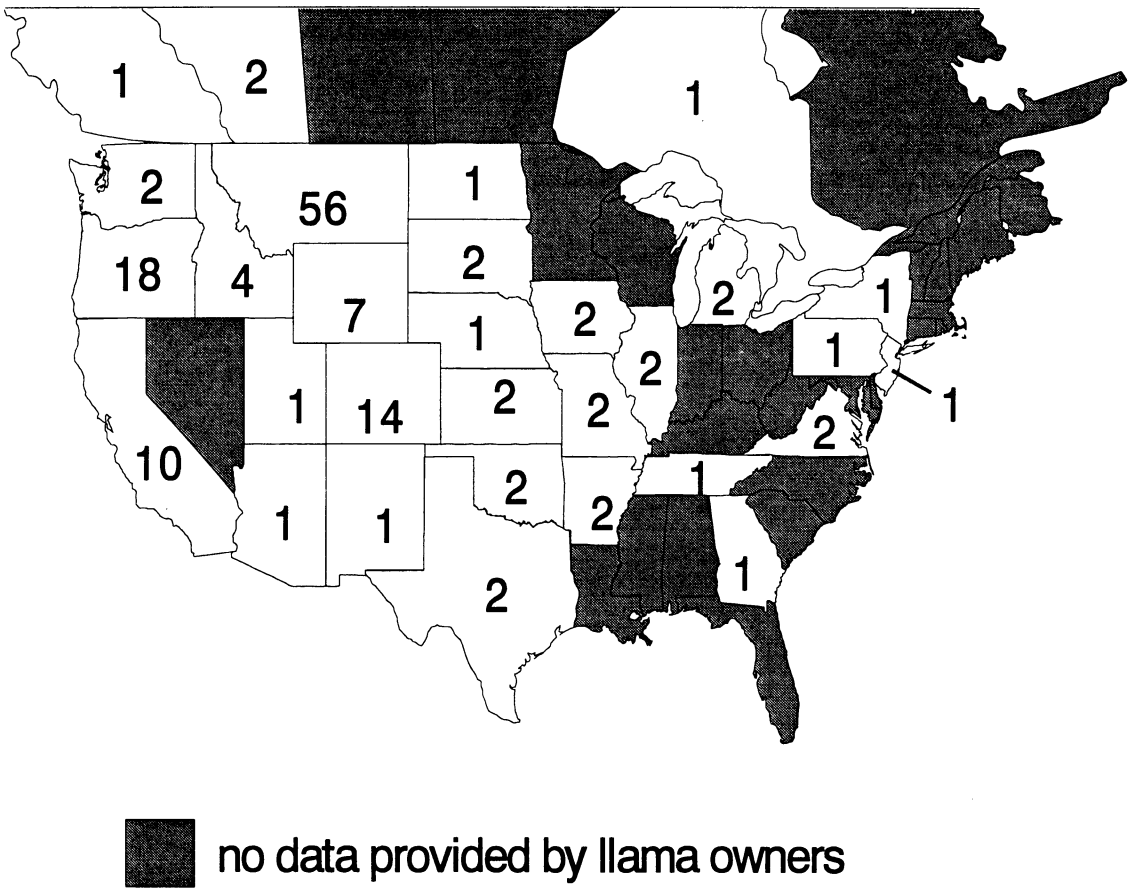

Figure 1. Distribution of guard llama owners responding to a nationwide 1991/1992 telephone.

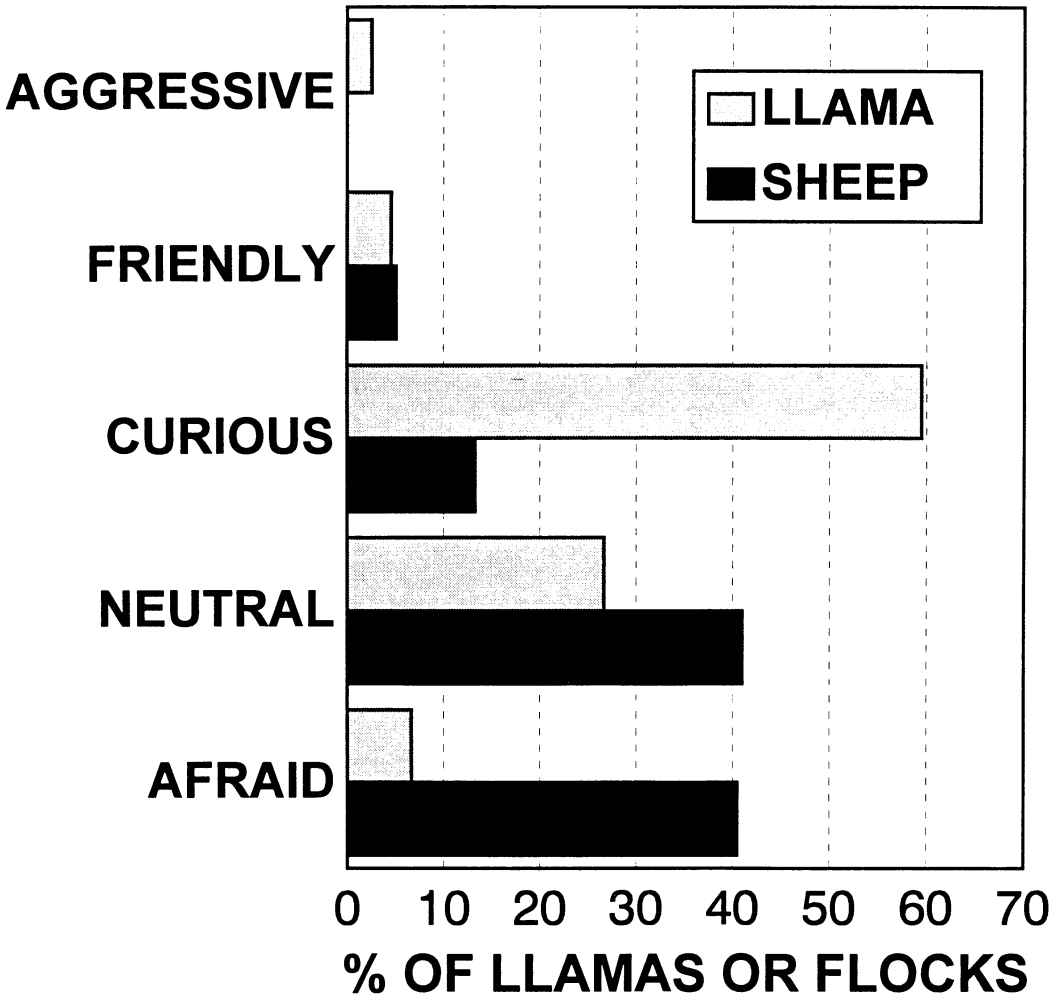

Figure 2. Initial behavioral reactions of sheep and llamas when first introduced to each other as reported by ranchers in a 1991/1992 telephone survey (n = 195 llamas).

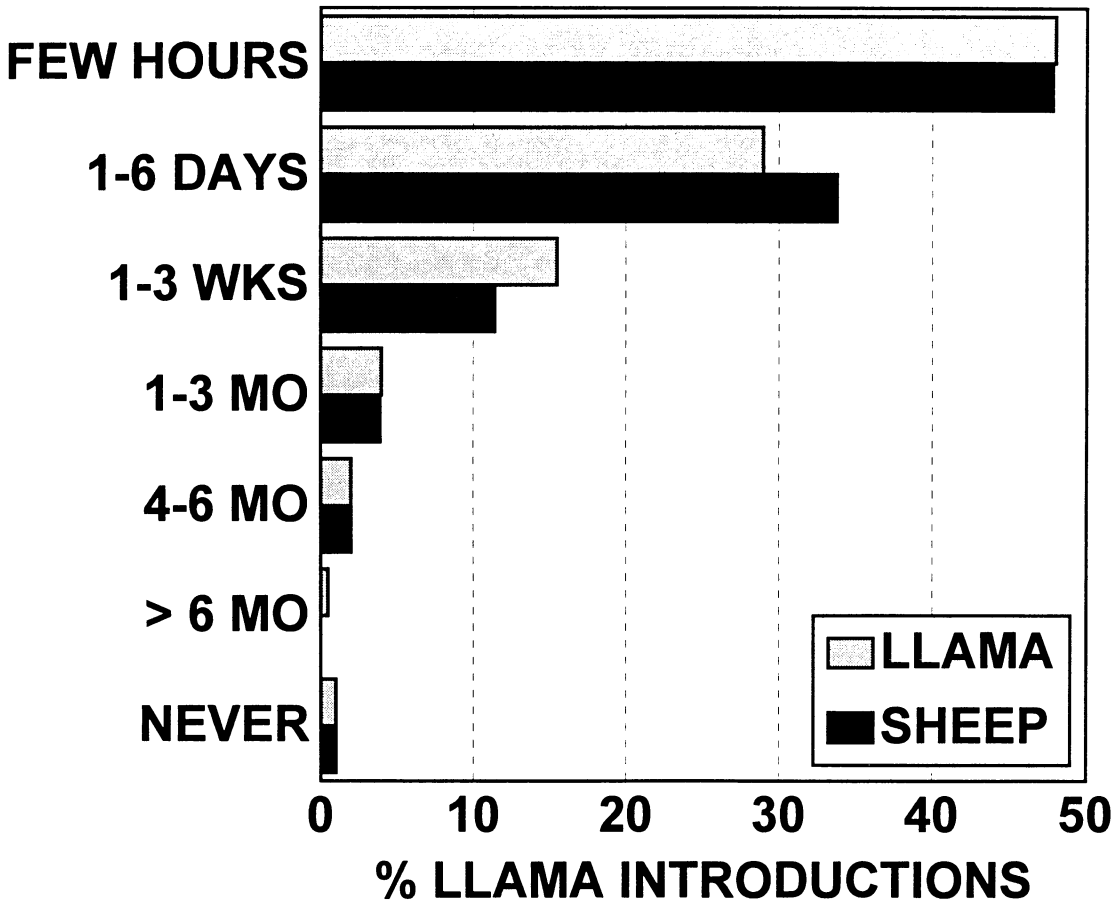

Figure 3. Adjustment periods of sheep and llamas reported by ranchers in a 1991/1992 telephone survey (n = 200 llamas and flocks).

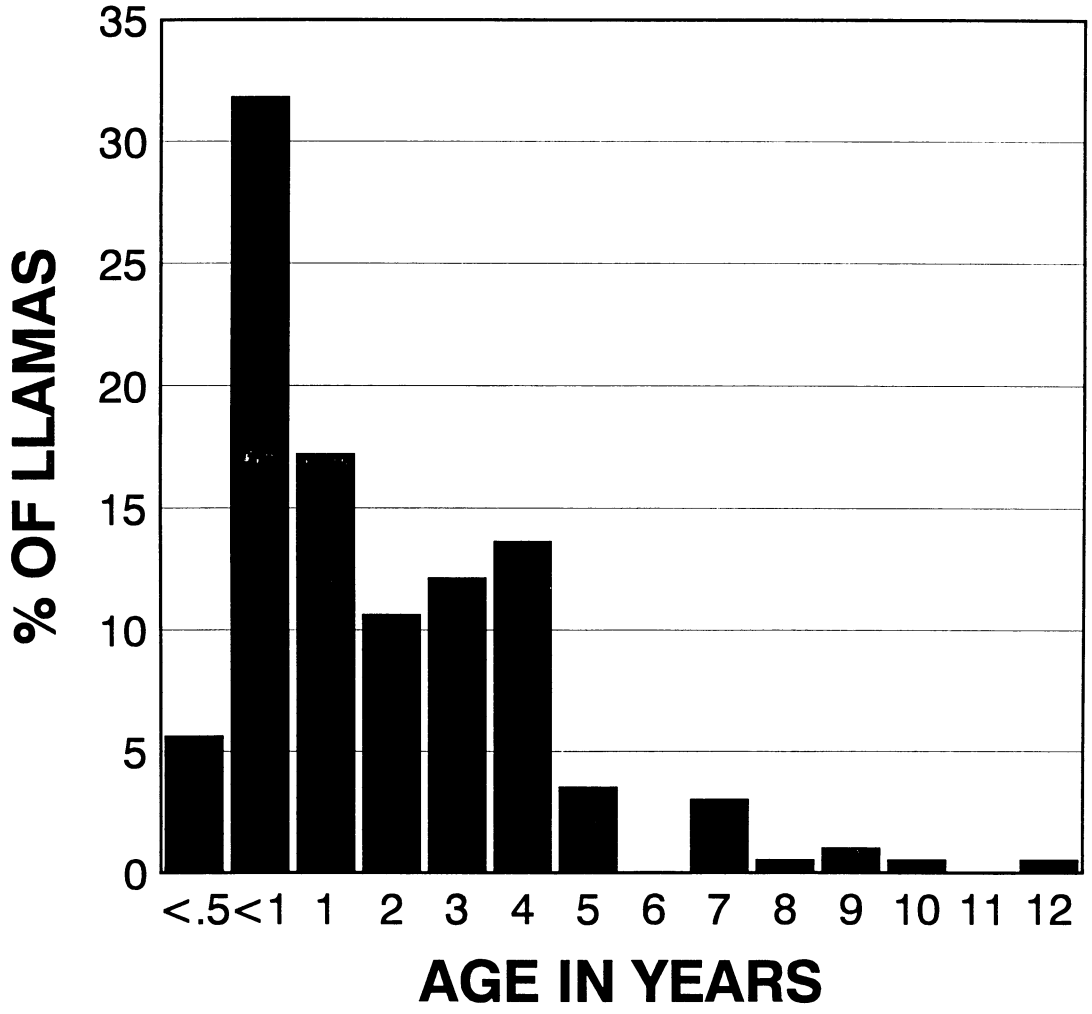

Figure 4. Guard llama age at the time of the initial introduction to the sheep flock as reported by ranchers in a 1991/1992 telephone survey ($\bar{x}$ = 2.1 years, SE = 0.15, n = 198 llamas).

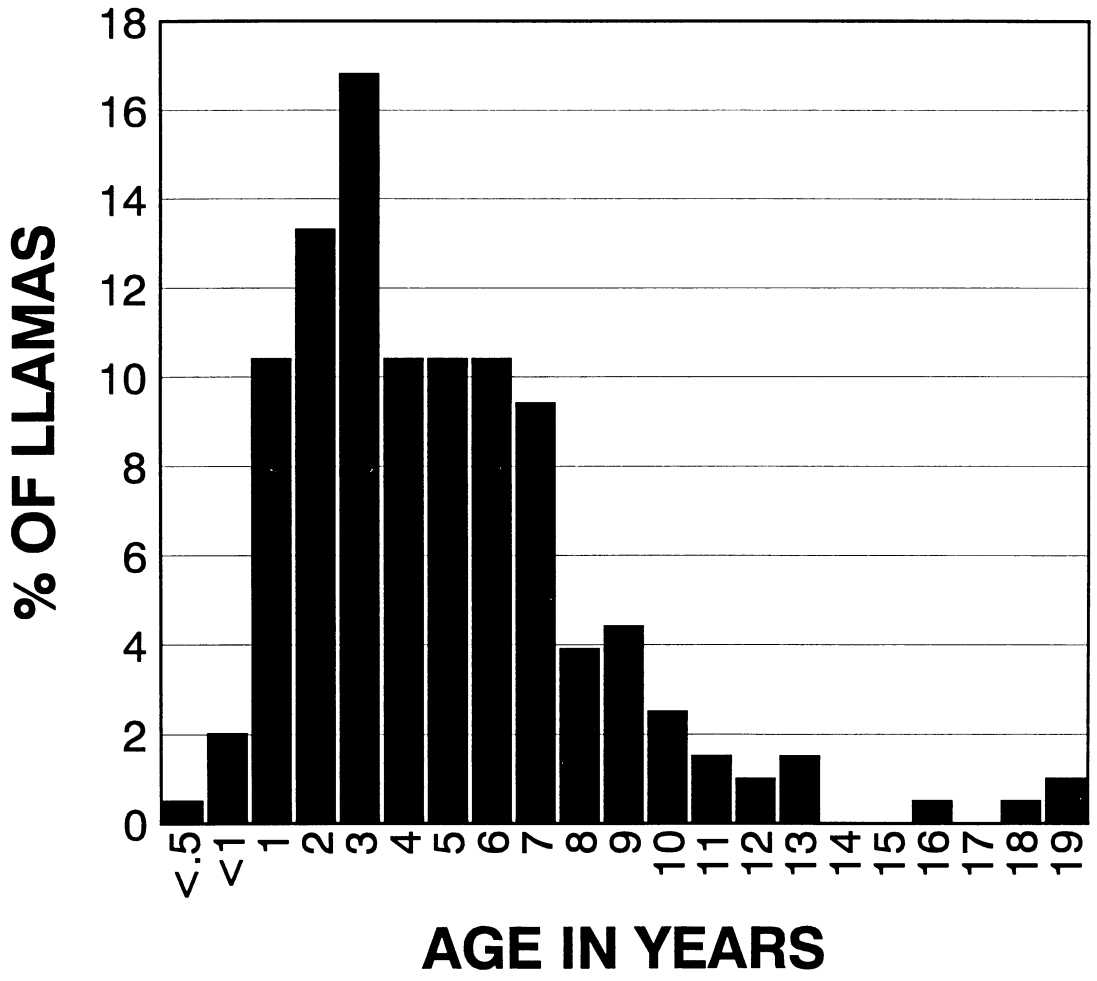

Figure 5. Age distribution of guard llamas as reported by ranchers in a 1991/1992 telephone survey ($\bar{x}$ = 4.7 years, SE = 0.22 years, n = 201 llamas).

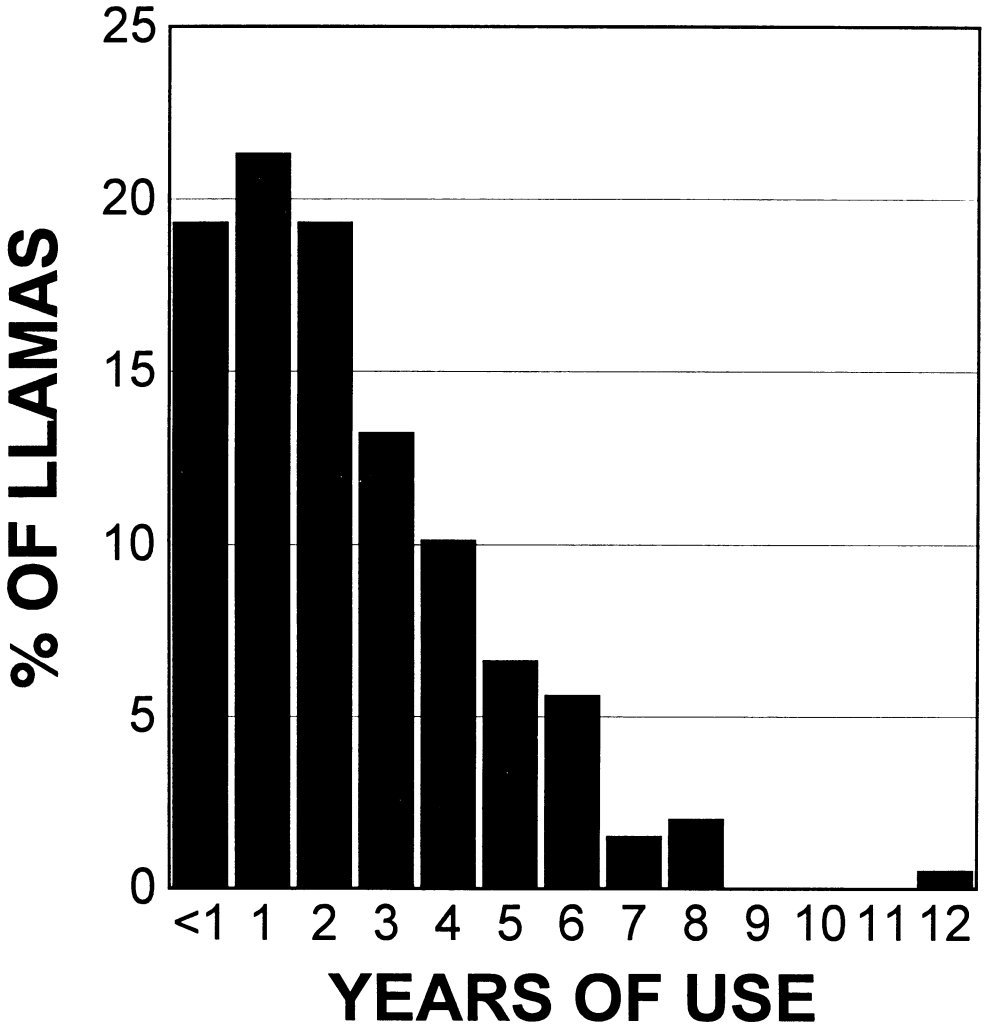

Figure 6. Distribution of the number of years individual llamas were used as guard animals for sheep as reported by the owners in a 1991/1992 telephone survey (n = 197 llamas).

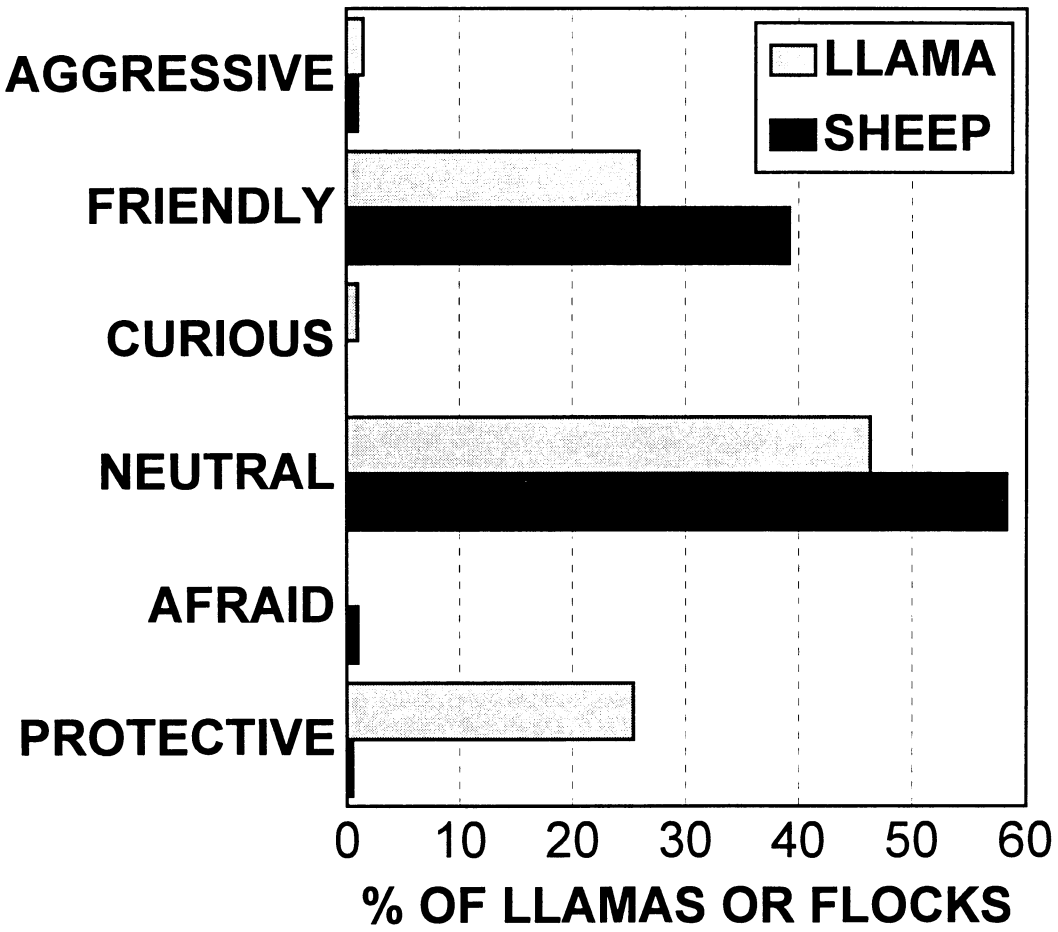

Figure 7. Typical behaviors of guard llamas and sheep towards each other as described by the owners in a 1991/1992 telephone survey (n = 199 llamas).

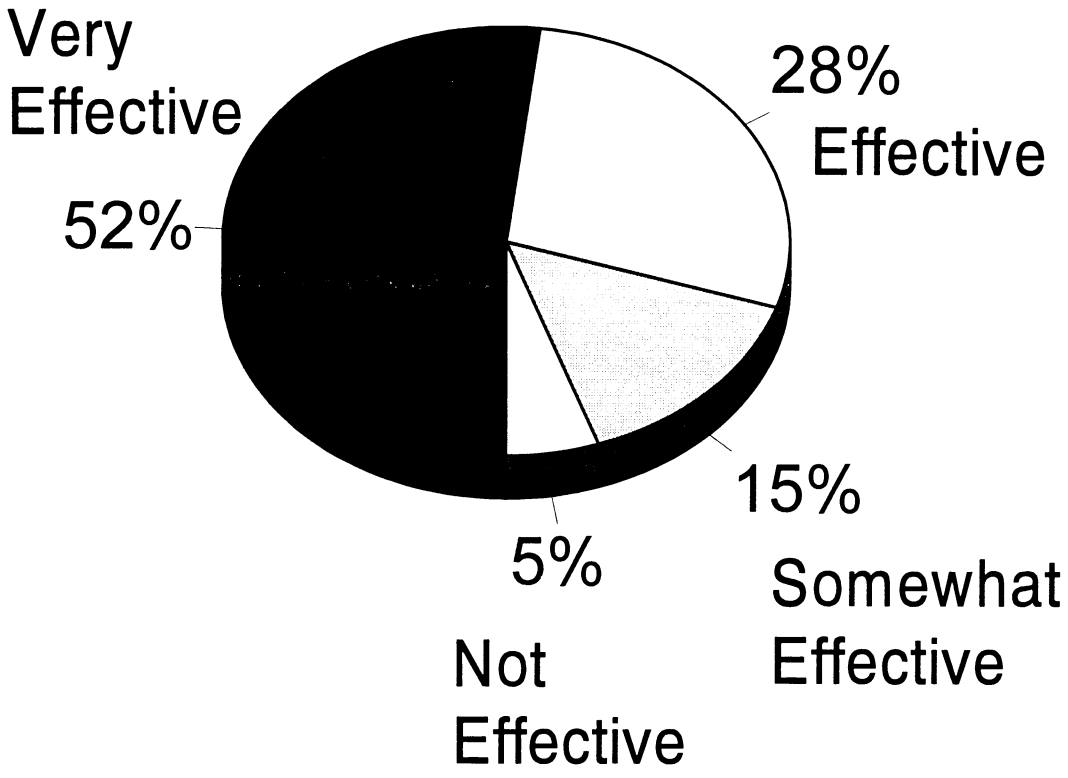

Figure 8. Effectiveness ratings of individual guard llamas reported by owners in a 1991/1992 telephone survey (n = 193 llamas).

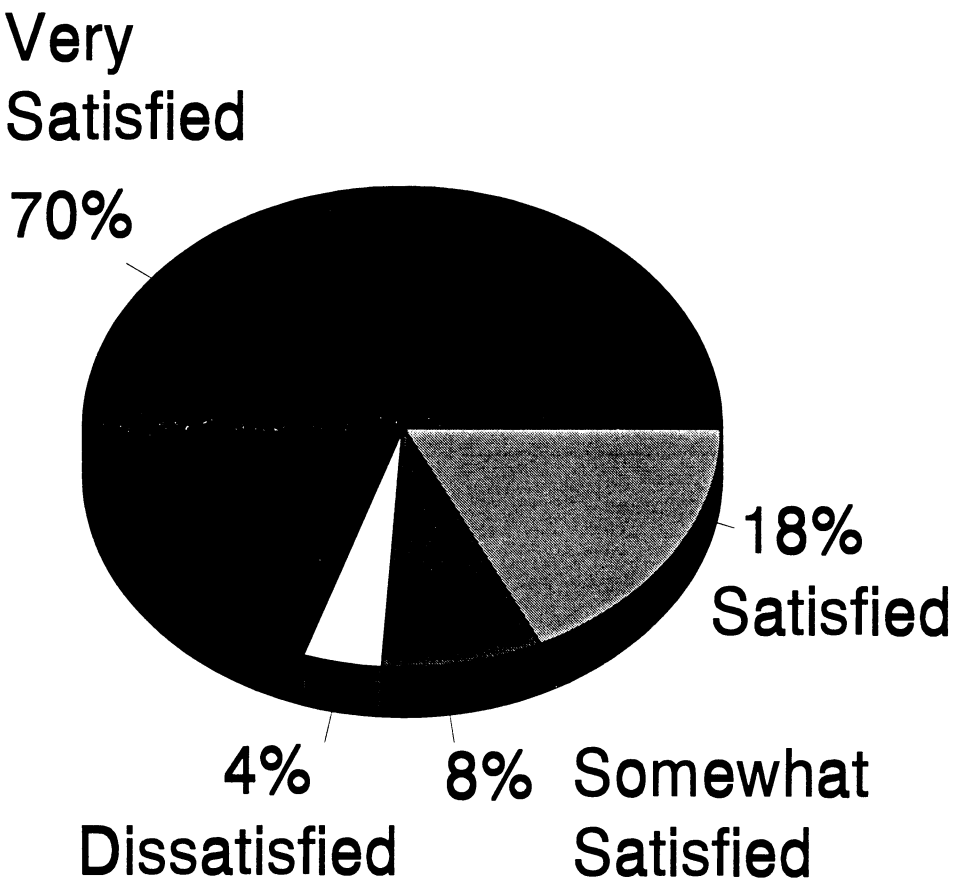

Figure 9. Guard llama owner satisfaction ratings reported in a 1991/1992 telephone survey (n = 142).

Table 1. Predator control methods used by ranchers prior to and after obtaining a guard llama. Multiple responses possible.

Predator Control Method	Percent of Ranches	
	Prior to Guard Llama (n = 135)	After Guard Llama (n = 144)
Shooting	44	40
Traps/Snares	38	34
None	23	23
Guard Dog	15	17
Electric Fence	13	13
Aerial Shooting	7	8
Poison	6	1
Night Confinement of Flocks	4	6
Antipredator Fence	4	4
Herder/Camping	4	2
Scare Devices[a]	3	1

[a]Includes strobe lights, cannons, radios, etc.

Table 2. Costs associated with the use of guard llamas reported by ranchers in a 1991/1992 telephone survey.

Categories	n	$\bar{x}$(SE)	Range
Purchase price (1979-1991)[a]			
Intact male	50	$647(124)	$0-5,000
Gelded male	137	$570(29)	$0-1,500
Female	10	$4,395(1,389)	$0-12,000
Feed expense/year/llama[b]	109	$87(13)	$0-800
Annual veterinary care	194	$16(2)	$0-150
Miscellaneous expenses[c]	22	$11(2)	$3-20

[a]Not including shipping/transportation fees.

[b]Not including pasture.

[c]Includes such items as halters, brushes, and shearing.

PAPER 2. THE EFFECTIVENESS OF GUARD LLAMAS FOR PROTECTING SHEEP AGAINST COYOTE PREDATION

ABSTRACT

Llamas have been used in North America as guard animals for over a decade, but their effectiveness has not been documented. The objective of this study was to determine the effect of llamas on sheep losses to predators, as well as the most useful guard llama management methods. A 1991/1992 nationwide telephone survey of 145 sheep ranchers using guard llamas between 1972 and 1991 found a decrease ($P < 0.001$) in sheep and lamb losses to predators from 11% to 1% after a llama was added to the flock. We compared the guard llama data with predator losses experienced by sheep ranchers surveyed by the National Agricultural Statistics Service in 5 western states. Ranchers with guard llamas reported lower 1990 losses to predators (1.3%) than producers participating in a 1990 survey unrelated to llama ownership (7.7%). Owners using 1 llama per flock reported lower annual predator losses (1.3%) than owners using more than 1 llama per flock (7.0%, $P = 0.04$). Guard llama owners practicing shed lambing reported lower predator losses (1.1%) than other owners (6.4%, $P = 0.03$). Therefore, as with any predator control technique, we recommend the use of a comprehensive program to lower sheep losses to predators. We concluded that llamas are a viable guard animal that has significantly reduced predator losses on sheep ranches nationwide.

INTRODUCTION

Predation is a leading cause of sheep mortality. Canids (coyotes, Canis latrans, and domestic and feral dogs, Canis familiaris) are the most common predators of sheep as reported by the U.S. Department of Agriculture (NASS 1991). Field studies in southern Iowa (Schaefer et al. 1981) have estimated that 41% of all sheep losses were from canid predators, 46% were due to nonpredator causes (disease, starvation, and other causes), and 13% were from unknown causes. Terrill (1988) reported that nationwide economic losses to the sheep industry due to coyotes and other predators reached over $83 million in 1987, representing 8.8% of the total value of all sheep and 5.4% of the total U.S. sheep population.

Many different methods of predator control have been investigated by ranchers and scientists. Livestock producers have reduced losses to predators through management practices (Robel et al. 1981), shooting (Wade 1978), denning (Till and Knowlton 1983), trapping (Gipson 1975), frightening devices (Robel et al. 1981), electric fencing (Linhart et al. 1982), guard animals (Andelt 1992), and a variety of other methods (Andelt 1987; Wagner 1988). The major advantage of guard animals is that sheep are protected day and night with little time and effort required from the producer after the initial training period. Dogs are the most popular animals being used to guard sheep in North America. Guard dog breeds originated

in eastern Europe and are different from herding dogs, which use predatory behavior to herd sheep (Coppinger and Coppinger 1982; Green and Woodruff 1988).

This study investigated the use of South American camelids as guard animals for sheep. Llamas (Lama glama), alpacas (L. pacos), and guanacos (L. guanicoe) are referred to as "llamas" or "guard llamas" in this paper. Powell and Franklin (1993) found guard llamas across the United States and Canada with the largest numbers in Montana, Oregon, and Colorado. Guarded flock sizes averaged 284 sheep and lambs (range = 4-2150), and pasture size varied from 2 to 3239 hectares ($\bar{x}$ = 114 ha). Sheep ranchers reported that the most important benefits of guard llamas were easy maintenance and predator control, while potential problems were llama aggressiveness towards the flock and attempted breeding of the ewes. Ranchers typically used 1 gelded male, and the average age of the llamas was 4.7 years.

Even though Powell and Franklin (1993) documented that llamas have been used as guard animals in North America since 1979, the degree of effectiveness has remained sparsely examined. The University of Wyoming collected information on field trials of 2 guard llamas (Botkin and Taylor 1985), and Markham (1992) interviewed 20 producers with guard llamas who reported reduced losses to predators.

Camelids are highly social, inquisitive herbivores who

typically approach anything "new" in their area. In the wild, a single male guanaco (llama progenitor) protects a territory containing females and their offspring by chasing away intruders and sounding alarms when predators are sighted (Franklin 1983). Antipredator mobbing behavior has been documented for the two wild camelids: vicunas (Vicugna vicugna) and guanacos (Franklin 1983). Although not fully understood, once a guard llama becomes familiar with an area and is attached to the sheep, the pasture becomes his territory and the flock becomes his family group.

We collected information about guard llamas from sheep ranchers using llamas to protect their flocks. The objectives of this study were 1) to determine the effectiveness of the llamas in reducing predator losses by comparing reported losses before and after the introduction of the llama to the flock, 2) to compare the losses reported by ranchers with guard llamas to losses reported by sheep ranchers in general (without llamas) in the same geographic region, and 3) to determine the types of situations where llamas were most and least effective.

METHODS

We collected names of guard llama owners with a news release (Appendix A) distributed to llama and sheep publications and sheep extension agents. Furthermore, we sent 2000 postcards (Appendix B) requesting the names of guard llama owners to llama producers across North America. A telephone questionnaire (Appendix C) with 101 questions pertaining to predator losses, ranch management practices, and llama characteristics was developed in conjunction with the Iowa State University Statistics Department.

A total of 145 ranchers/farmers owning 204 guard llamas was interviewed from July 1991 thru April 1992 (Powell and Franklin 1993). Seven ranchers included in this study raised only goats (Capra spp.), and 7 owners had flocks of sheep and goats, while the remaining 131 had only sheep. However, all guard llama owners are referred to as sheep ranchers or producers, and all guarded flocks are referred to as sheep and/or lambs in this paper.

Telephone interviewees were either given a short selection of answers from which to choose or were allowed to respond freely. Interviewers were trained to neutrally probe for more specific responses to avoid leading the ranchers into an expected response (Groves et al. 1988; Frey 1983) Each interview lasted from 30 to 60 minutes depending on the number of guard llamas owned.

Of the 145 producers interviewed, 39 volunteered for the study, and 106 producers were referred to us. The average annual percent losses between these groups were compared with the SAS procedure GLM (SAS Institute 1987) to check for bias due to volunteer responses.

Average annual losses due to predators before the llama was introduced to a flock will be referred to as "before-losses." Likewise, average annual predator losses after the introduction of a llama will be referred to as "after-losses."

We examined the relationship between predator losses due to flock size and pasture size with a regression. An outlying data point from the largest flock, which had 500 sheep and lambs lost to predators annually, was eliminated from this analysis. We found that flock size significantly affected the predator losses, so the before- and after-losses to predators were converted to per capita mortality rates by dividing losses by flock size.

The difference between the per capita before- and after-losses was analyzed with a pairwise comparison t-test in the SAS procedure MEANS (SAS Institute 1987) using a $\underline{P} = 0.05$ level of significance. Ranches were excluded from this analysis if llamas had been used for <1 year ($\underline{n} = 6$) or if the sheep and llama were obtained at the same time ($\underline{n} = 22$) and therefore did not have data on before-losses. Three missing

values also adjusted the sample size for this analysis.

We also performed pairwise comparisons on subsets of ranches which were categorized by flock size. The purpose of this analysis was to investigate the possibility that some classes of ranches reported different trends in predator losses than the total sample. We used the following flock size categories: <100, 100-299, 300-599, and ≥600.

Ranch locations in the five states with the highest concentration of guard llamas (Montana, Colorado, Wyoming, Oregon, and California) were mapped. Predator loss data from our survey for ranchers from these states using llamas in 1990 were pooled, and a 95% confidence interval was calculated for the ranchers' percent loss. The estimated total number of sheep and lambs in these districts, as well as the estimated total number of sheep and lambs (pre-docking and post-docking) lost to predators in 1990, was obtained from the National Agricultural Statistics Service (NASS), a division of the U.S. Department of Agriculture. This 1990 data was compared with the predator losses reported by guard llama owners in our survey (1991/92) from the same geographic region (the same districts within the same states) so that predator levels could be considered as constant as possible. Because we did not have an estimate of variance from NASS, we compared their estimate to our 95% confidence interval.

We investigated the most effective means of utilizing a

guard llama. Unless otherwise noted, we used the SAS procedure GLM (SAS Institute 1987) to compare the per capita predator losses among discrete ranch and llama categories. Ranches were excluded if the llama had been used for <1 year (n = 6 ranches with 7 llamas). Missing values due to skipped questions and individual exclusions due to multiple answers caused variation in each comparison's n-size and resulting degrees of freedom.

We compared the per capita predator losses among categories within several ranch management methods, especially those relating to the llamas' introduction to the flock. These included the presence of lambs, the location of the initial introduction, and the adjustment periods of the llamas. We used chi-square analysis to compare the adjustment periods between llamas introduced with and without lambs present. Ranches using >1 llama (as a group or separately, n = 75 llamas) and past llamas (n = 17) were excluded from this part of the analysis, because we only recorded predator losses for the entire ranch.

Categories, such as additional predator control techniques, vegetation types, the number of llamas used together, the sex of guard llamas, and the flocking behavior of the sheep were used to compare per capita predator losses among ranches using different management techniques. We also compared differences in predation losses between sexes: intact

males, gelded males, and females. Ranches using >1 llama (as a group or separately, n = 75 llamas) and past llamas (n = 17) were excluded from the sex comparison.

We used the ranchers' description of their llamas' guarding behaviors to compare annual predator losses between llamas which were usually "with the flock" and llamas which were "separate" within the pasture. Ranches using >1 llama (n = 75 llamas) and past llamas (n = 17) were excluded from this part of the analysis.

Ranchers had observed 85 llamas interacting with predators, and the behaviors were described with a frequency distribution. We also compared the annual per capita between dogs and coyotes, the most common type of predators reported by the ranchers.

RESULTS AND DISCUSSION

Our survey included both volunteers and referred participants. The effectiveness of the guard llamas could potentially be biased by volunteers eager to tell us success stories. However, the 0.30% annual predator loss reported by 37 volunteers did not differ from the 2.62% reported by 102 referred participants (F = 1.37, 1,138 df, P = 0.25).

Flock sizes were positively correlated with reported "after-losses" (R^2 = 0.21, n = 138, P < 0.001, Fig. 1), meaning ranches with larger flocks reported higher losses to predators. Because of this relationship, the per capita mortality rate was used in our comparisons of annual sheep and lamb losses to predators.

Effectiveness

The average annual losses of sheep and lambs due to predation on 114 ranches using guard llamas between 1972 and 1991 dropped from 11% of the flock ($\bar{x}$ = 25.8 sheep and lambs, SE = 6.15) before obtaining a guard llama to 1.0% of the flock ($\bar{x}$ = 7.9 sheep and lambs, SE = 4.45) after introducing the llama (Fig. 2). The mean difference between the per capita before- and after-losses was 10% (SE = 1.6, t = 6.49, 113 df, P < 0.001). Sixty-two percent of 97 producers which reported before-losses experienced no loss to predators after the introduction of the llama.

Significant reductions in predator losses were reported

by ranchers within all 4 flock size categories (<100: 38 df, $P < 0.001$; 100-299: 32 df, $P < 0.001$; 300-599: 20 df, $P = 0.04$; $\geq$ 600: 20 df, $P = 0.004$, Fig. 3). Although the reduction in per capita losses on small ranches was dramatic, llamas also have the potential to significantly reduce losses on ranches with large flocks ($\geq$ 600).

Predator loss reductions may not have been due to the llamas if predator losses were reduced for all ranchers in the same area. However, the average proportion of flocks lost to all predators in five states for ranches with guard llamas in 1990 (1.3%) was less than other ranches in the same area participating in a NASS survey of sheep producers unrelated to llama ownership (7.7%, Fig. 4). Although we did not randomly assign llamas to ranches and measure other variables, the comparison with the NASS data, the estimated average annual savings of $1034, and the 88% of llama owners that were satisfied reported by Powell and Franklin (1993) strongly suggests that guard llamas reduce sheep predation.

Most Effective Use

Introduction Methods.--Ranchers either introduced their llama to groups of sheep with lambs or groups without lambs. During the interviews, many ranchers reported their llama was "crazy about lambs," and several writers (Markham 1990) have recommended introducing new guard llamas into flocks with lambs to facilitate the bonding process. However, there was

no difference in the eventual effectiveness of llamas in reducing losses whether they were originally introduced to flocks with or without lambs (F = 1.68, 1,97 df, P = 0.19). Similarly, the presence of lambs had no effect on the length of the adjustment period of llamas to sheep (χ^2 = 2.05, 3 df, P = 0.56, Fig. 5). The close interaction between llamas and lambs may exist and be an impressionable sight, but we did not find this management practice to be influential to the llama's eventual effectiveness.

The location of the initial introduction of the llama to the flock did not explain the variance in predator losses (F = 1.49, 3,99 df, P = 0.22), whether introduced to sheep in a barn, corral, pasture, or range. However, there was a difference ($P < 0.05$) in the annual losses to predators between introduction into a corral (0.80%, n = 43) and the open range (4.26%, n = 4). This result was expected because of the greater vulnerability of range sheep to predators, but the small number of open ranges in our sample makes this difference tenuous.

Ranchers described the initial behaviors and length of adjustment periods of the llamas and the sheep. Upon introduction, the sheep were neutral or afraid of the llama, and the llamas were neutral or curious of the sheep. The adjustment periods were similar with 77% of the llamas (n = 200) and 82% of the flocks (n = 201) adjusting within a few

days. We did not find a difference in the eventual average annual losses to predators based upon the length of the adjustment periods of llamas to sheep (F = 0.36, 4,94 df, P = 0.84) or sheep to llamas (F = 0.99, 3,94 df, P = 0.40). However, we did not collect yearly data. We used the average annual losses since obtaining the llama. It is possible that llamas with shorter adjustment periods may reach their guarding potential sooner than llamas with longer adjustment periods. A shorter adjustment period suggests faster bonding between the llama and the sheep, potentially resulting in earlier guarding behaviors by the llama. This may also apply to the presence of lambs in the introductory flock of sheep. Llamas introduced to lambs may reach their guarding potential sooner than llamas introduced without lambs.

Ranch Management Methods.--We expected to find lower average annual losses on ranches utilizing other predator control methods in addition to their guard llama. Although producers using additional methods did report slightly lower annual losses ($\bar{x}$ = 1.4%, n = 101) compared with producers using only a llama ($\bar{x}$ = 4.2%, n = 31), these losses were not significantly different (F = 1.64, 1,131 df, P = 0.20).

When jugs (lambing pens) or sheds were used during the lambing season, annual losses to predators were lower ($\bar{x}$ = 1.1%, n = 104) than ranches which did not use them ($\bar{x}$ = 6.4%, n = 24, F = 4.82, 1,127 df, P = 0.03). Based on their

responses to the survey, producers did not consider the use of lambing jugs to be an additional predator control technique, but listed it as an optional "lambing practice." Shed lambing removes lambs from a potential predator situation during the vulnerable time period immediately following birth. Whether or not this practice is feasible depends on the size of the flock and the facilities available to the rancher.

The majority of producers (87%, n = 138) used only 1 llama per flock, and several had been told that more than 1 llama would not work. Powell and Franklin (1993) reported ranchers using 2-6 llamas together, and some multiple llama users felt their llama group was effective at reducing predator losses. However, analysis found that producers with multiple llamas ($\bar{x}$ = 6.98%, n = 18, F = 4.55, 1,131 df, P = 0.04) reported higher annual losses to predators than producers using 1 llama per flock ($\bar{x}$ = 1.3%, n = 114). We suspect the reason why multiple llamas are less effective than a single llama is that the highly social llamas are devoting more attention to each other than to the flock. This problem was mentioned by a few of the owners that had tried using more than 1 llama, but switched to a single guardian when the group of llamas ignored the sheep.

Twenty-six percent of the guard llamas were intact (uncastrated) males, 69% were geldings (castrated males), and 5% were females (Powell and Franklin 1993). We found no

differences (F = 0.26, 2,101 df, P = 0.77) in the average annual losses to predators among the sex categories of llamas, including intact males ($\bar{x}$ = 0.69%, n = 18), gelded males ($\bar{x}$ = 1.25%, n = 85), and females ($\bar{x}$ = 4.55%, n = 2). Although not significant, both male categories had lower average losses to predators than the female llamas, but the survey found only 2 females used singly to protect flocks from predation. Fertile female llamas are higher priced than males (Powell and Franklin 1993) which probably eliminates them as an economically viable option for many ranchers. Infertile females, however, would be lower priced.

We asked ranchers to describe the vegetation or terrain of the area where the llama was usually pastured. We classified the answers into either "open" habitat, meaning relatively flat with low grass vegetation, or habitat with "cover," meaning the area contained higher vegetation (shrubs, trees) and/or has visually obstructed terrain (hilly, ravines). Unexpectedly, we found no difference between the annual proportional losses of sheep being guarded by a llama in "open" or "cover" habitat types (F = 0.37, 1,131 df, P = 0.55). Additionally, there was no difference in the annual predation level based on whether or not the sheep stayed together or spread out across the pasture (F = 0.08, 1,125 df, P = 0.77). Theoretically, however, a llama that could observe the entire flock at once would have a greater chance of

detecting predators. There may also be other factors affecting sheep and lamb losses to predators which were not measured by this study, such as predator density.

Guard Llama Behaviors

Ranchers were allowed to freely describe the typical daily behaviors of the llamas and sheep, and their responses were categorized as aggressive, friendly (follows, approaches, nuzzles), neutral (no reaction), curious, afraid, and protective (Powell and Franklin 1993). We found no difference, however, in the average losses to predators on ranches based on the llamas' behavior (F = 0.11, 2,98 df, P = 0.90) or the sheep's behavior (F = 0, 1,94 df, P = 0.98) toward each other.

Llamas are not passive bystanders but are active leaders and protectors of their flocks. Fifty-six percent of 144 producers in this survey had seen 85 llamas interacting with a predator various numbers of times and described the observed behaviors in detail. The most common behavior was that the llama moved toward ("walked to," "ran to," "chased") the predator (Fig. 6). If the llama overtook the predator, kicking and trampling behaviors were observed. In 3 encounters the predator was injured by the llama, and 1 rancher reported finding a trampled coyote in his field, although he did not see the encounter. Other species found trampled in pastures include a woodchuck (*Marmota monax*) and a

muskrat (Ondatra zibethicus)

The coyote is primarily a visually oriented predator (Lehner 1976). The prey response of running from predators can stimulate an attack from a coyote, whereas the behavior of facing and threatening a coyote can be a successful defense strategy (Connolly et al. 1976). The walking, running, and chasing behaviors of llamas toward coyotes may be even more intimidating.

Guard llamas do not necessarily stay with their flocks at all times (Powell and Franklin 1993). In some cases this may be akin to the territorial behavior of the wild guanaco. Territorial males typically segregate themselves from the family group to watch over their territory for potential intruders or predators from an adjacent hilltop or slope (Franklin 1983). We did not find a difference in annual losses to predators between llamas that stayed with the flock and those that did not (F = 0.75, 1,89 df, P = 0.39). In fact, this type of behavior in a llama could be an encouraging sign that the llama has assumed the role of a guard animal.

Coyotes (73%) and dogs (23%) were the two most common predators encountered on sheep ranches (n = 143) (Powell and Franklin 1993), but it is unknown whether llamas were more effective in guarding against one predator or the other. We found no difference (F = 0.84, 1,127 df, P = 0.36) in the annual sheep and lamb predator losses on ranches having coyote

problems ($\bar{x}$ = 2.56%, n = 98) compared with ranches having dog problems ($\bar{x}$ = 0.49%, n = 30).

LLAMAS COMPARED WITH GUARD DOGS

Many ranchers nationwide have successfully employed guard dogs. Effective guard dogs do not demonstrate stalking and chasing behaviors, but instead show a mixture of juvenile, maternal, and courtship behaviors toward sheep (Coppinger and Coppinger 1980b; Coppinger et al. 1987). Effective guard dogs are trustworthy, attentive, and protective toward sheep (Coppinger et al. 1983). Dogs are active guards, but their physical presence also makes them effective as passive guards (Johnson 1990). A six-year study with over 60 guard dogs at the U.S. Sheep Experiment Station in Dubois, Idaho, showed that 80% of the dogs tested were effective in reducing coyote predation on sheep (Green and Woodruff 1985). Andelt (1992) reported that in 1986 Colorado sheep operations with guard dogs lost a smaller proportion of sheep and lambs to coyotes than did producers without dogs.

There are, however, a number of disadvantages with guard dogs. A significant problem has been the premature death of dogs due to accidents, culling, and disease. Lorenz et al. (1986) studied 449 dogs and reported 50% of the farm dogs died before 38 months of age, and nearly 75% of the open rangeland dogs were dead by the same age. Both situations resulted in frequent replacement costs. Dogs require special food, and owners spend additional time feeding the dog which contributes to the overall cost.

The lifespan of llamas is 15-20 years (Tillman 1981). Powell and Franklin (1993) reported the mortality of only 5% of 204 guard llamas. Of those that died, the average years of experience was 2.5 at the time of death, and the average age of death was 4.3 years. However, because llamas are still a relatively new predator control technique (average years of use is 3.2 years) these results may not be representative of the true longevity of guard llamas.

Important guard animal characteristics are considered in Table 1. The average first year cost of a guard dog pup is $834, including purchase price, shipping, feed, veterinary expenses, travel, damages, and miscellaneous costs, with subsequent annual expenses around $286 (Green and Woodruff 1985). The purchase price of a llama included in this study was higher than a dog's, but the predicted lifespan is longer and the estimated annual expenses are less for llamas.

The adjustment time of a guard animal is important. Most guard dogs are not effective in the field during the first year while undergoing training and habituation (Coppinger and Coppinger 1980a). Most guard llama owners reported adjustment periods of only a few days or less (Powell and Franklin 1993). Dogs also require daily care and feeding by the owner. Most guard llamas in our survey received the same care as the sheep with no extra work reported by the owner (Powell and Franklin 1993).

Over-attachment to people and over-aggressiveness towards sheep are problems sometimes encountered with a guard dog. A dog's play behavior can result in injury or death to sheep (Coppinger et al. 1988). Potential llama problems include aggressiveness towards the flock and attempted breeding of the ewes.

Both llamas and dogs offer producers a nonlethal alternative method of preventive predator control, and both have advantages and disadvantages as guard animals for sheep. Powell and Franklin (1993) reported an average annual estimated savings of $1,034 with llamas (range = $0-5,000, $\underline{n}$ = 86 producers). One purebred producer reporting $20,000 saved annually was excluded from this average. Green et al. (1984) reported $3,836 for dogs (range = $0-50,000, $\underline{n}$ = 40). This comparison is difficult to interpret, however, because the guard dog study included a larger proportion of range operations (27%) with larger flocks compared with the llama study (10% range at least part of the year). The flock size distribution in the guard llama study included ewes and lambs, while the guard dog study included ewes only. Green et al. (1984) also did not provide information on the number of purebred operations, if any, that were included in the survey. The potential savings of any guard animal depends on both the extent of the predator problem and on the market value of the sheep.

MANAGEMENT IMPLICATIONS

Guard llamas are a viable, nonlethal alternative for reducing predation. Ranchers reported significantly reduced losses to predators after using a llama, and they reported fewer losses than sheep ranchers in a survey unrelated to llama ownership. These reductions in predation losses involved ranchers across North America with llama introductions spanning over the last decade.

Single guard llamas are more effective than multiple llamas. This study did not show an increase in effectiveness when the llama was introduced to a group of sheep that included lambs. While we recommend further study into ranch management practices, no specific rigorous set of procedures must be followed to successfully introduce a llama to a sheep flock. The ultimate effectiveness of the llama was not dependent on the sex of the llama, typical and initial behaviors, introduction methods, habitat type, length of adjustment period, major predator type, or the llamas' location relative to the flock.

Llamas have the potential to actively protect the flock by moving towards the predator and, in some cases, engaging in physical contact with the predator. While the results of this research are encouraging, no predator control technique is effective at all times and in all situations. Not all llamas in this survey were reported to be effective. Most of the

producers in this study were using other predator control methods in conjunction with the guard llama.

The coyote is an opportunistic predator that is well known for adapting to new situations. It hunts alone, in pairs, and in small groups or even packs (Bowen 1981, Andelt 1985). How llamas will react to group-hunting coyotes has not been determined. One rancher reported their 7-month-old guard llama was killed by a pack of coyotes. To sustain an effective guard animal management program, it may prove necessary to rotate guard animal species every few years. While not a panacea, guard llamas can be a vital part of a rancher's overall predator prevention and control program.

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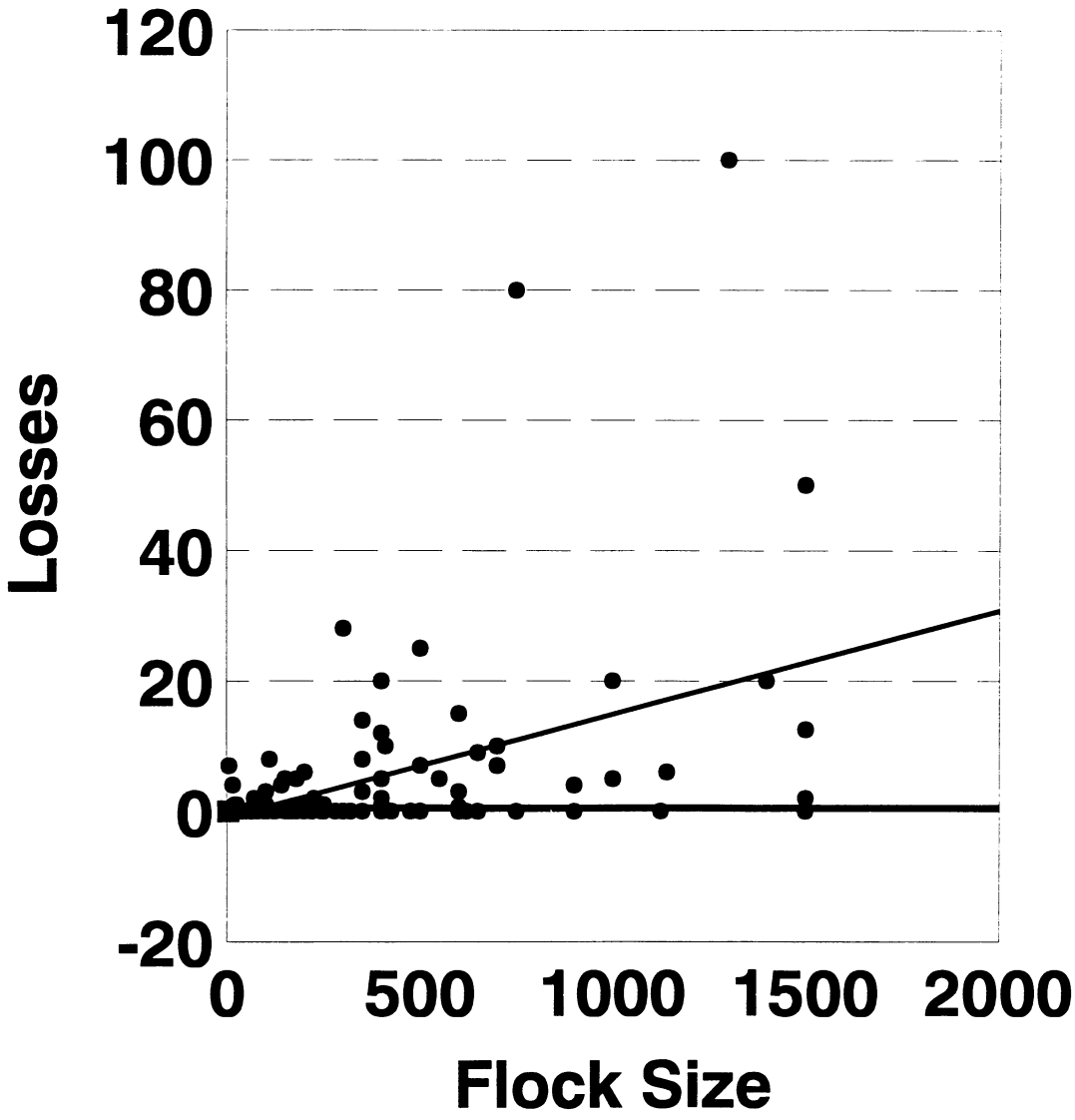

Figure 1. Regression of sheep flock size to predator losses reported by ranchers with guard llamas (slope = 0.01, $\underline{R}^2$ = 0.21, $\underline{n}$ = 138, $\underline{P}$ < 0.001).

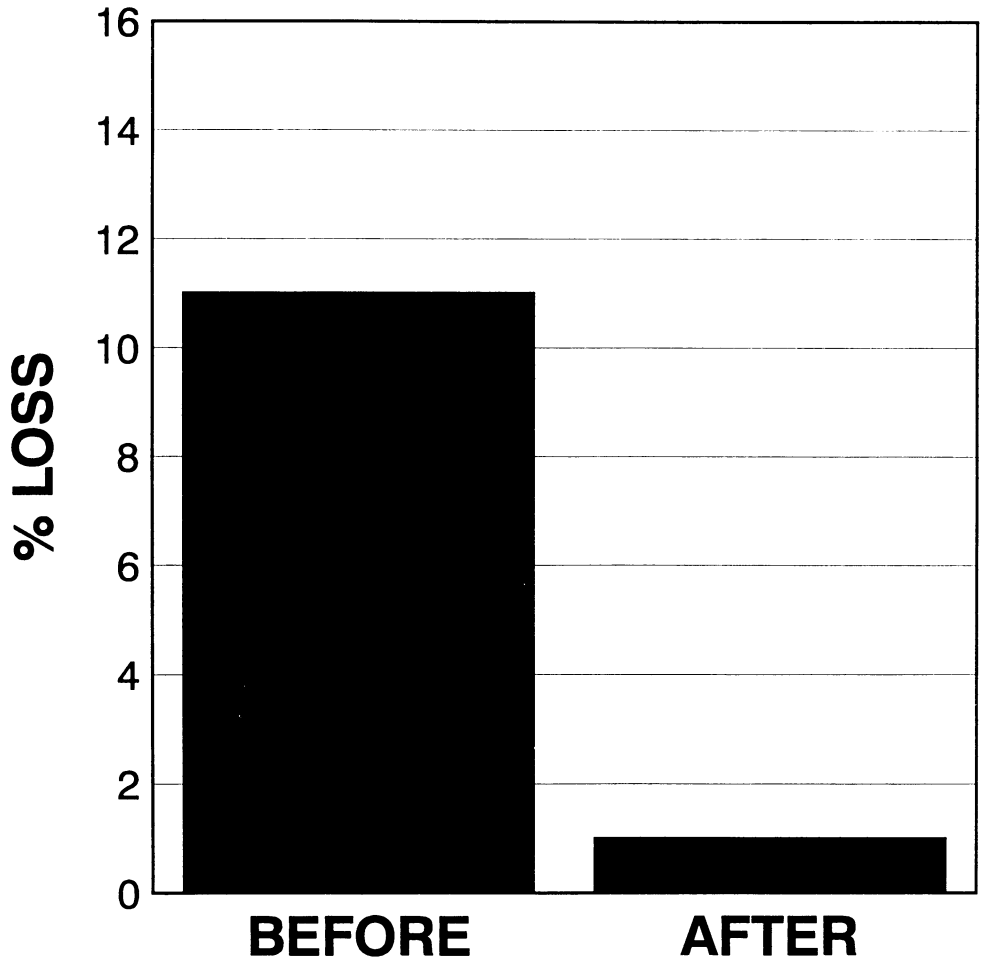

Figure 2. Comparison of annual losses to predators before and after obtaining a guard llama reported by owners between 1972 and 1991. The mean difference is 10% (SE = 1.6, $\underline{t}$ = 6.49, 113 df, $\underline{P}$ < 0.001).

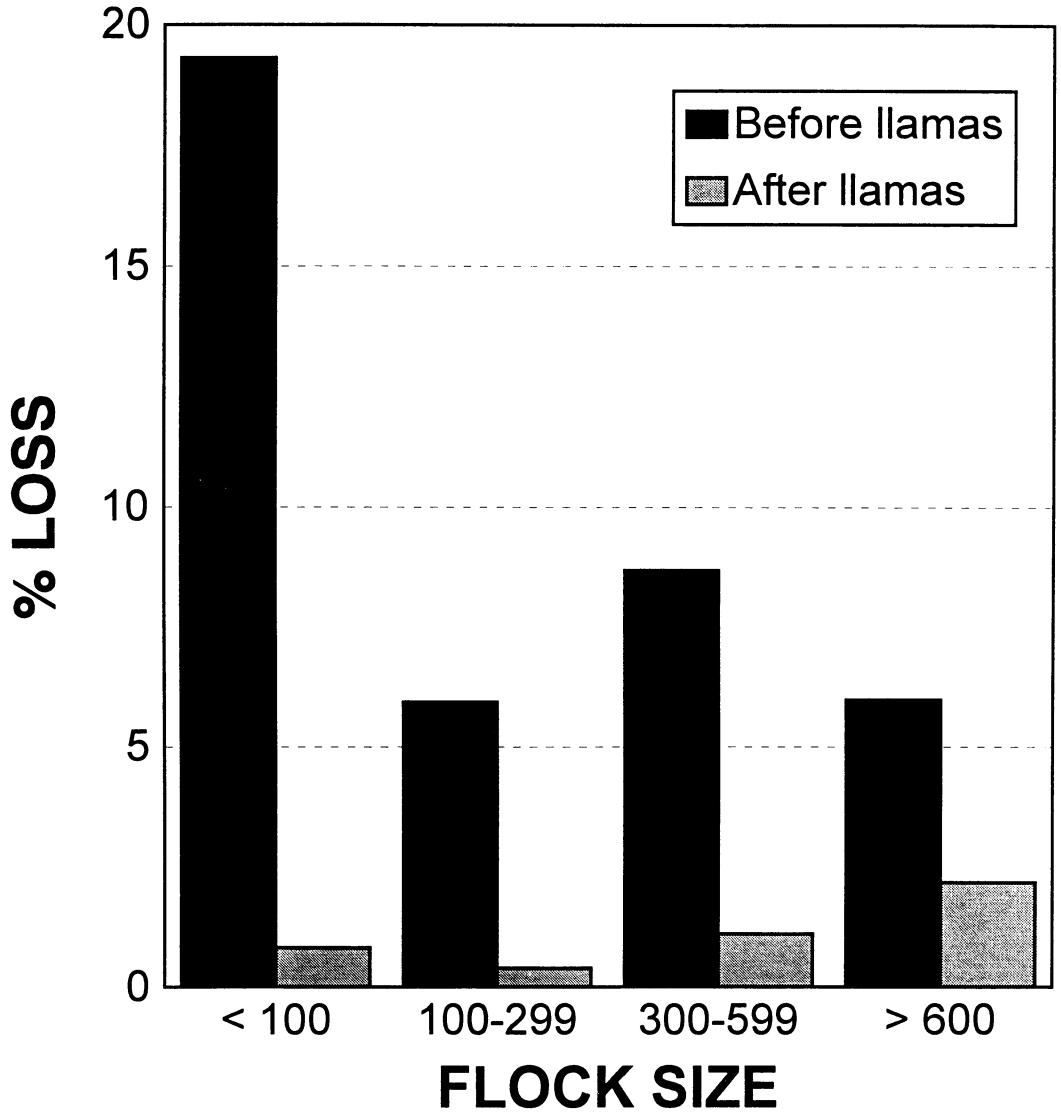

Figure 3. Comparison of annual losses to predators before after using a guard llama among flock size categories.

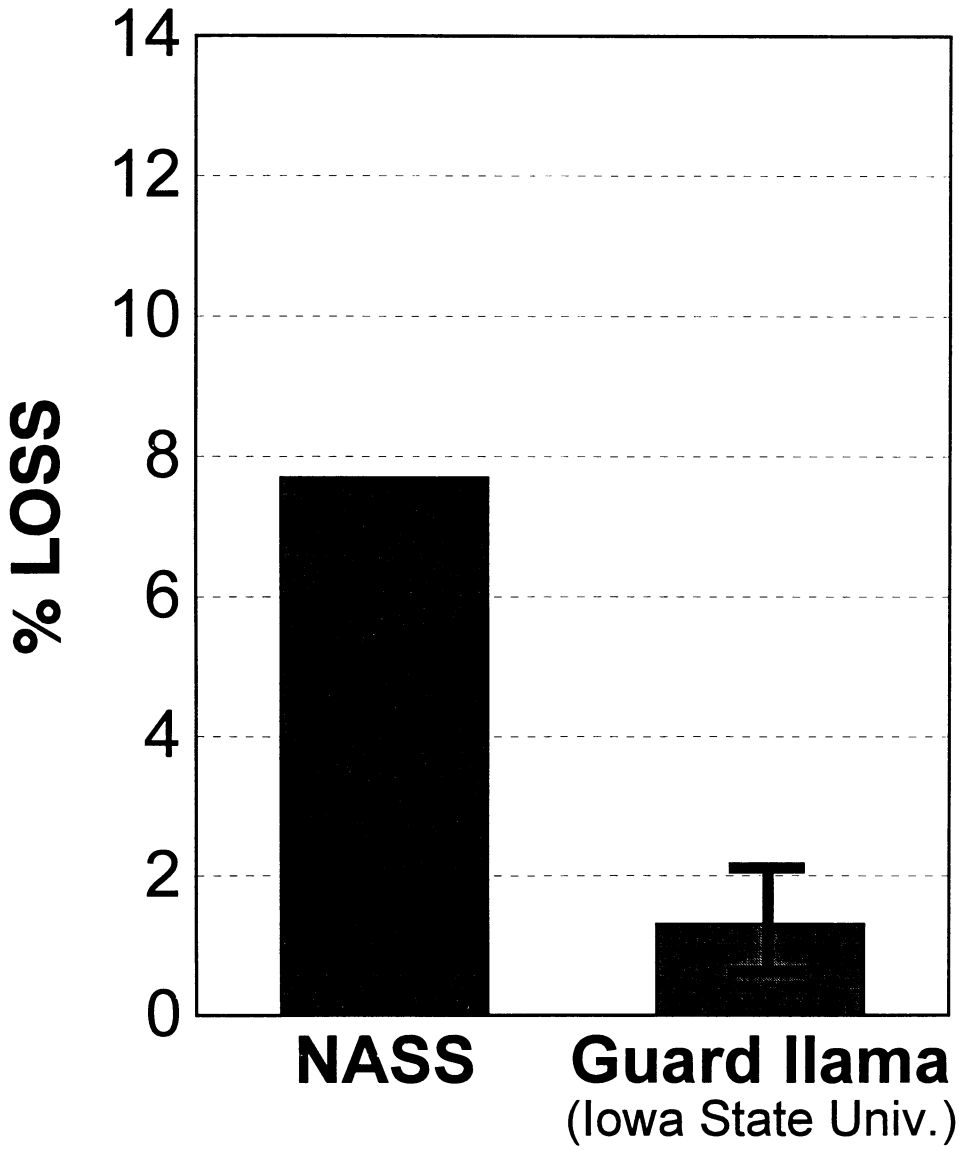

Figure 4. Proportion of sheep and lambs lost to predators in California, Colorado, Montana, Oregon, and Wyoming for 1990 guard llama owners in this study compared with sheep ranchers in the same region as reported by the National Agricultural Statistics Service. Guard llama predation loss includes the 95% confidence interval. The NASS variance estimate was unavailable.

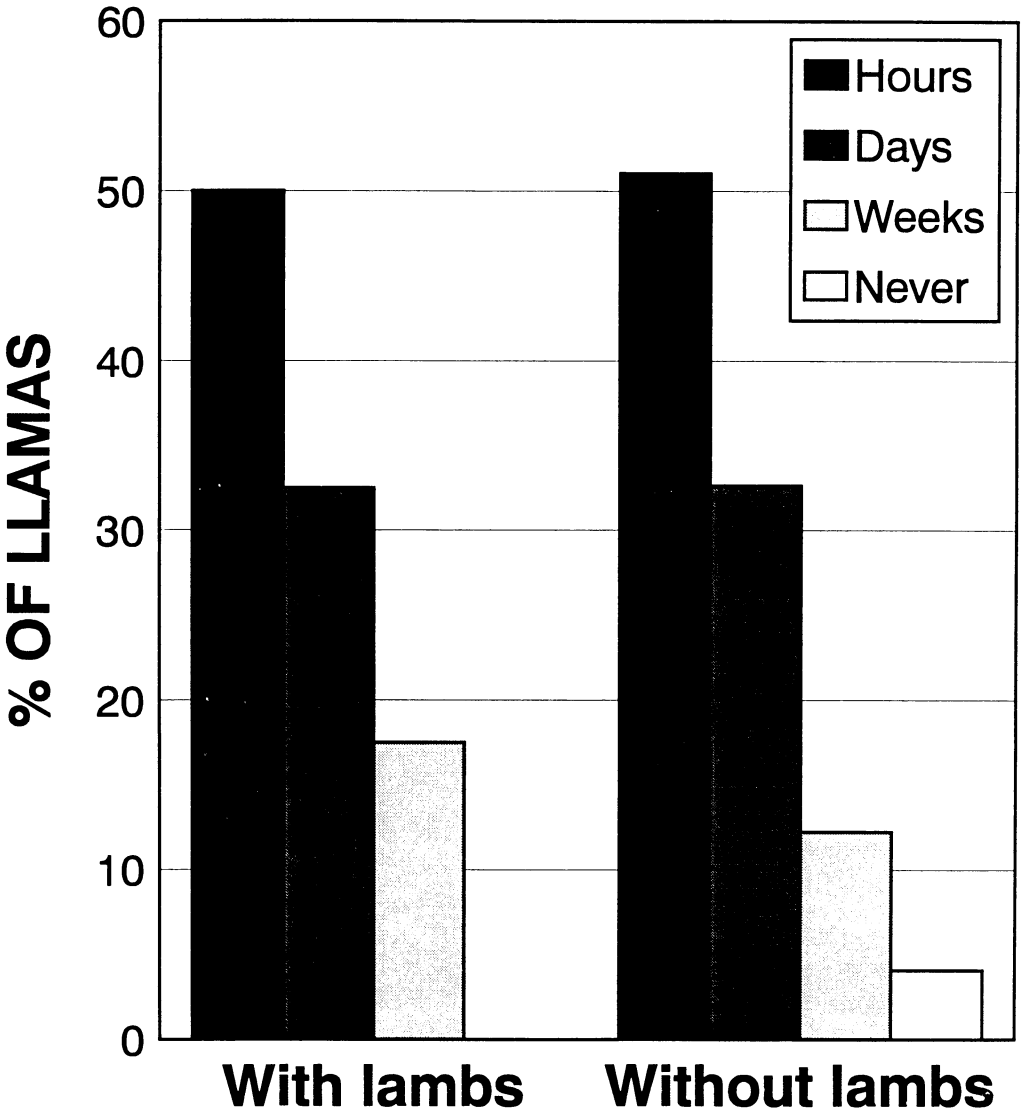

Figure 5. Relative length of reported adjustment periods of guard llamas introduced to sheep flocks with and without lambs (χ^2 = 2.05, 3 df, P = 0.56).

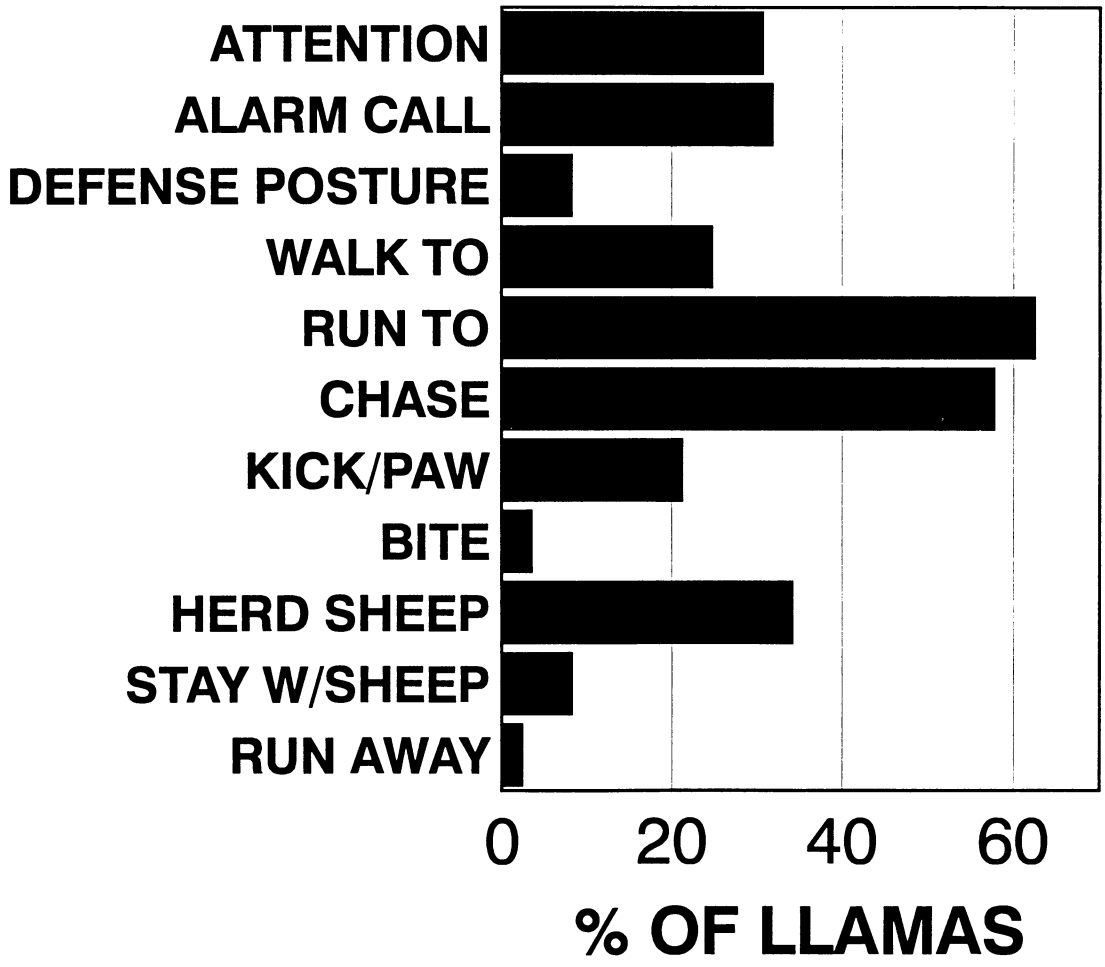

Figure 6. Guard llama behaviors when interacting with predators reported by owners in a nationwide survey (n = 85 llamas, multiple responses per llama).

Table 1. Generalized comparison of characteristics of guard llamas and guard dogs.

Characteristic	Guard Animal	
	Dogs[a]	Llamas[b]
Expenses		
Initial cost	$400	$570
Shipping fees	$97	Unknown
Feed expense/year/animal	$193	$87
Annual health care	$19	$16
Miscellaneous expenses	$23	$11
Total annual expenses (w/o purchase price and shipping)	$235	$114
Bonding/adjustment	1 year	Few days
Feed	Dog food daily	Pasture/hay in winter
Mortality	3.2 years[c] 50% of farm dogs 75% of range dogs died	2.5 years[d] 5.4% of llamas died
Percent of animals rated effective by sheep producers	80%	80%
Purchase Price Per Year of Use[e]	$100	$57

[a]Guard dog information from Green et al. (1984).

[b]Guard llama information from Powell and Franklin (1993). Initial cost estimate is for gelded llama.

[c]Guard dog mortality from Lorenz et al. 1986.

[d]Average age of death for 5.4% of 204 guard llamas.

[e]Assume 4 yrs of use for dog and 10 yrs. for gelded llama.

GENERAL SUMMARY

Predation, especially by coyotes, is a leading cause of mortality in sheep, and many different predator control methods have been tried. I investigated the use of llamas as guard animals for sheep. Many sheep ranchers were already using guard llamas to protect their flocks, but an extensive study documenting the llamas' effectiveness, management characteristics, and owners' opinions had not been conducted.

I completed a nationwide telephone survey of 145 sheep ranchers with 204 guard llamas in July 1991 thru April of 1992. The survey contained 101 questions pertaining to ranch and llama characteristics, llama effectiveness, annual predator losses, expenses, and management practices.

Llamas were being used in a variety of situations. Ranchers used from 1 to 6 llamas at a time to guard flocks consisting of 4-2150 sheep and lambs ($\bar{x}$ = 284, median = 120). Pasture size averaged 113.7 ha but ranged from 2-3238.6 ha. Introduction methods varied from ranchers who introduced the llama to a few sheep in the barn to ranchers who just put the llama out with the whole flock on the open range. All sexes and ages of guard llamas were being used, but geldings (castrated males) were the most common type with an average purchase cost of $570. Most llamas were given the same care as the sheep and required no extra care or training.

Ranchers reported significantly reduced predator losses

after introducing a llama to their flocks ($P < 0.001$). Data were compared to statistics from the National Agricultural Statistics Service on predator losses in five states in 1990. Ranchers with guard llamas in these five states reported lower losses (1.3%) than ranchers in a survey unrelated to guard llama ownership (7.7%). Owners using 1 llama per flock reported lower annual predator losses (1.3%) than owners using multiple llamas per flock (6.98%, $P = 0.04$). Lower losses to predators were also reported by owners who practiced shed lambing ($P = 0.03$).

Eighty percent of 193 llamas were owner-rated as very effective or effective, while the remaining 20% were described as somewhat or not effective. The majority of producers (88%) were either very satisfied or satisfied, and 86 owners attributed an estimated average annual savings of $1,034 to their llamas. The remaining owners did not know or could not estimate how much money their llama saved or lost annually. Average annual feed, veterinary, and miscellaneous expenses were $114. Llamas are a low maintenance guard animal with the potential to be a cost effective method of reducing sheep mortality caused by predators.

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APPENDIX A:

A RESEARCH NE

NEWS RELEASE PG. 1 OF 1

IOWA STATE'S FRANKLIN INVESTIGATING USE OF LLAMAS AS GUARD ANIMALS FOR SHEEP

Contact Person: William L. Franklin, 124 Science II, Dept. of Animal Ecology, Iowa State University, Ames, Iowa 50011, (515)294-1240 or -6148.

Coyote predation is one of the most important problems facing the sheep industry today. Predators cost sheep ranchers over $83 million in 1987. These losses result in higher prices paid for lamb and wool products, which may discourage consumers from buying these products.

A variety of methods for controlling coyote predation have been tried, including shooting, poisoning, trapping, aversive conditioning, and toxic collars. Methods vary greatly in cost and do not always have the desired outcome. Environmental concern over the destruction of coyotes has led to the development of nonlethal predator control methods such as electric fences, chemical repellants, and guard animals.

Dr. William L. Franklin, professor of Animal Ecology at Iowa State University, and graduate assistant Kelly Powell are conducting a study of llama owners and their experiences using llamas as guard animals for sheep. Both llamas and guanacos are instinctively aggressive towards canids, and will investigate, pursue, and even attack canid intruders.

Llamas are already being used by an estimated 100 to 150 ranchers in the United States because of their apparent effectiveness as guard animals. Llamas are herbivores that can be pastured with sheep without required daily feeding by the owner. This offers convenient 24 hour protection for the flock. Both the llama and guanaco are adaptable to a variety of environments and do not seem to require training.

Franklin and Powell will be interviewing sheep ranchers who have used or are using llamas as guard animals. They are interested in the management and husbandry practices involved with both unsuccessful and successful guard programs. Failed attempts at using guard llamas are just as important to the project as successful ones. They invite interested parties who have used guard llamas, or who know of another person who has, to contact them at the following address: Dr. William L. Franklin, 124 Science II, Dept. of Animal Ecology, Iowa State University, Ames, Iowa 50011. Phone number: (515)294-1240 or -6148.

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APPENDIX B:

GUARD LLAMA RESEARCH POSTCARD

Dear Llama Enthusiast:

We are investigating the effectiveness of llamas and guanacos as guard animals for protecting sheep against coyotes. U. S. sheep losses due to coyotes and other predators reached over $83 million in 1987. From the preliminary information available, guard llamas have a high potential for being an effective method of predator control. This project potentially will provide sheep ranchers with a nonlethal alternative for controlling canid predation, and add importance to the raising and promoting of llamas in North America.

We would like to interview sheep and llama owners who have used or are using llamas as guard animals. We are interested in the management and husbandry practices involved in both unsuccessful and successful guard programs. Failed attempts at using guard llamas are just as important to the project as successful ones.

If you are using llamas in this manner or know of someone who is, and you are interested in participating in this important study, please return the attached card. Please feel free to call us collect at (515)[illegible]3148 if you have any questions. Thank you.

Dr. William L. Franklin
Dept. of Animal Ecology
Iowa State University

Kelly Powell
Research Assistant

010-2389

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Dr. William Franklin
124 Science II Building
Dept. of Animal Ecology
Iowa State University
Ames, IA 50011

_____Yes, I have used or am using llamas as guard animals, and I am interested in being interviewed for this project.

_____I know of others who have used or are using llamas as guard animals (name, address and phone numbers follow) or you can contact me for their names:

_____
_____
_____
_____

My Name: _____
Address: _____
_____
Phone Number: _____

APPENDIX C:

1991/1992 GUARD LLAMA OWNER SURVEY

IOWA STATE UNIVERSITY
GUARD LLAMA RESEARCH
IDENTIFICATION SHEET

I.D. # _____

NAME: _____

ADDRESS: _____

_____

_____

PHONE: _____

SOURCE: _____

COMMENT: _____

DATE CALLED	TIME START	TIME END	CALLER	RESPONSE
1.				
2.				
3.				
4.				
5.				
6.				
7.				

Caller's Comments _____

_____

_____

Caller recommends visiting: Yes No Maybe_____

Respondent willing to be visited. Yes No Maybe_____

Read the following telephone script to respondents:

Hello, my name is _____ and I am researching the use of guard llamas under Dr. William Franklin at Iowa State University, a project jointly supported by the International Llama Association, the Rocky Mountain Lama Association, and Iowa State University.

1. (*If person is a postcard respondent*) We wanted to thank you for returning our survey postcard earlier this spring. You indicated you were willing to be interviewed about your experiences with guard llama. (*Continue with text*)

2. (*If we were referred to this person*) We received your name from _____ as a possible contact. Have you used guard llamas either in the past or present?

1=YES - We would like to interview your about your experiences with guard llamas. *Continue with text*

2=NO - Do you know of anyone else who has experience with guard llamas?

NAME _____
ADDRESS _____

PHONE _____

Thank you for your time. Good-bye.

It would take 35-45 minutes. Is this a convenient time for you?

1=YES Your participation in this study is completely voluntary and you may refuse to answer any specific questions or stop participating at any point in the interview, but your cooperation and participation is greatly appreciated. Let me stress that the information collected during the interview will be used only for university research purposes and will be kept strictly confidential. No information will be identified by your name without your permission. I would be happy to answer any questions you may have about the study, either now or later. We expect the results to have significant impact on the use of llamas as guard animals.

Can you give us your complete address to be sure our information is complete?

Would you be interested in receiving copies of our research results?
Yes_____ No_____ *Continue with questions.*

2.=NO, NOW IS NOT A GOOD TIME When should I call back to interview you? _____. Thank you for your time and I will call back on _____ at _____. If you have any questions about the survey you can call us collect at 515-294-6148. Good bye.

3=NO, I DO NOT WISH TO BE INTERVIEWED. Thank you for your consideration. Good-bye.

IOWA STATE UNIVERSITY
GUARD LLAMA RESEARCH
INTERVIEW QUESTIONS
ID #_____

1. How many years of experience have you had with llamas in general?
   1. < 6 months
   2. 6 mo. - 11 mo.
   3. 1 yr
   4. 2 yrs
   5. 3 yrs
   6. 4 yrs
   7. 5 yrs
   8. Other _____

2. Where do you get information about llamas? *(Circle all that apply)*
   1. Llama Assoc. _____
   2. Llama Publications (Magazines) _____
   3. Llama Breeders
   4. Llama Displays (Fairs, etc.)
   5. Extension
   6. Vet
   7. Other _____

3. Where did you first hear of using llamas as guard animals?
   1. Llama Assoc. _____
   2. Extension
   3. Magazine/Newspaper Article
   4. Llama Breeder
   5. Sheep Rancher
   6. Vet
   7. Other _____

4. a) Are you using a guard llama right now or have you used one at sometime in the past?
   1. Using now *(Go to 5)*
   2. Used prior to this time but discontinued
   3. Other _____

   b) Why did you stop using guard llamas? *(Can you be more specific?) (Go to 5b)*
   (Use past tense from now on)

   _____
   _____
   _____

5. a) How many guard llamas do you own right now?
   1. None
   2. One
   3. Two
   4. Three
   5. Other _____

b) How many guard llamas have you owned in the past?

1. None *(Go to 6)*
2. One
3. Two
4. Three
5. Other_____

c) What happened to your past llamas?

_____
_____
_____

6. How long have you used llamas as guard animals?

1.	< 6 months	5.	3 yrs
2.	6 mo. - 11 mo.	6.	4 yrs
3.	1 yr	7.	5 yrs
4.	2 yrs	8.	Other _____

7. What predator control method(s), if any, do you use in addition to your guard llama(s)? *(Circle all that apply) Do you do anything else (shooting, trapping, poisoning) to control predators?*

01.	Electric fencing	08.	Livestock Protection Collar
02.	Aerial shooting	09.	Guard Dog
03.	Shooting	10.	Scare Devices - Cannons
04.	Trapping	11.	Den Fumigation
05.	Aversive Conditioning	12.	Sonic Spook Collar
06.	M-44 Ground Device	13.	Poisoning
07.	Anti-predator fencing	14.	Other _____
		15.	None

8. What predator control method(s), if any, did you use before using llamas as guard animals? *(Circle all that apply) Did you do anything else (trapping, etc.)*

01.	Electric fencing	08.	Livestock Protection Collar
02.	Aerial shooting	09.	Guard Dog
03.	Shooting	10.	Scare Devices - Cannons
04.	Trapping	11.	Den Fumigation
05.	Aversive Conditioning	12.	Sonic Spook Collar
06.	M-44 Ground Device	13.	Poisoning
07.	Anti-predator fencing	14.	Other _____
		15.	None

9. How would you rate the effectiveness of (each of) your guard llama(s)? *(Read all options)*

NAMES_____ _____ _____ _____

Is it:

1.	Very effective	1.	Very effective	1.	Very effective	1.	Very effective
2.	Effective	2.	Effective	2.	Effective	2.	Effective
3.	Somewhat effective	3.	Somewhat eff.	3.	Somewhate eff.	3.	Somewhat eff.
4.	Not effective	4.	Not effective	4.	Not effective	4.	Not effective

NAMES _____ _____ _____ _____

10. How did you obtain your guard llama(s)?

1. Auction	1. Auction	1. Auction	1. Auction
2. Private breeder	2. Private breeder	2. Private breeder	2. Private breeder
3. Raised since birth	3. Raised...birth	3. Raised...birth	3. Raised...birth
4. Other _____	4._____	4._____	4._____
Specify	*Other*	*Other*	*Other*

11. What kind of animals do/did the llama(s) guard?
    1. Sheep
    2. Ducks/Geese *(Go to non-sheep page)*
    3. Other _____ *(Go to non-sheep page)*

12. Which of the following best describes your sheep operation? *(Read options)*

    Is it a:
    1. Purebred operation
    2. Commercial operation
    3. Lamb Feedlot operation
    4. Other _____

13. Are sheep a source of income for your family or are they a hobby?
    1. Source of income
    2. Hobby

14. Is your ranch on the edge of the open range/wilderness or surrounded by other ranches?
    1. Open range/wilderness
    2. Surrounded by other farms
    3. Other _____

15. How far is it to the closest ranch? _____miles

16. What types of terrain surround your farm?

    Is it: *(Read all options and circle all that apply)*
    1. Open grassland
    2. Shrubby
    3. Forested
    4. Rocky
    5. Other _____

17. Would you describe the terrain as: *(Read all options)*
    1. Very flat
    2. Rolling hills
    3. Steep hills
    4. Combination _____
    5. Other _____

18. How many years have you raised sheep ? _____

19. Which breed of sheep does your llama guard? *(Circle/write out all breeds)*

01.	Suffolk	06.	Finn	11.	Romanov
02.	Hampshire	07.	Rambouillet	12.	Panama
03.	Columbia	08.	Targhee	13.	Crossbred _____
04.	Dorset	09.	Polypay		_____
05.	Merino	10.	Texel	14.	Other_____

20. In an average year, how many sheep are on the ranch/farm? _____

21. What month(s) do you lamb? _____
_____
_____

22. Do you lamb inside or outside?
    1. Inside
    2. Outside

23. Do you use lambing jugs or shed lambing?
    1. Yes
    2. No

24. How many flocks of sheep are guarded by a llama? _____

25. How many llamas are guarding each flock of sheep?

Group #1_____ **#2**_____ **#3**_____ **#4**_____

26. How many sheep are there in each flock guarded by a llama(s)?

Group #1 _____ **#2** _____ **#3** _____ **#4** _____

ASK EACH QUESTION FOR <u>EACH</u> GUARD LLAMA OWNED
USE ADDITIONAL SHEETS AS NEEDED

27. What is the name of your guard llama?

<u>LLAMA #1</u>	**<u>LLAMA #2</u>**	**<u>LLAMA #3</u>**	**<u>LLAMA #4</u>**
_____	_____	_____	_____

(Use llamas' name for each question to avoid confusion.)

28. What breed or species of guard llama do you use?

1. Llama	1. Llama	1. Llama	1. Llama
2. Guanaco	2. Guanaco	2. Guanaco	2. Guanaco
3. Alpaca	3. Alpaca	3. Alpaca	3. Alpaca
4. Cross/Mix_____	4. Cross_____	4. Cross_____	4. Cross_____

NAMES_____ _____ _____ _____

29. What sex is your llama?

1. Intact male	1. Intact male	1. Intact male	1. Intact male
2. Female	2. Female	2. Female	2. Female
3. Gelding	3. Gelding	3. Gelding	3. Gelding

30. How old is your llama now?

1. < 6 months	1. < 6 mo.	1. < 6 mo.	1. < 6 mo.
2. 6 mo.-11 mo.	2. 6 mo. - 11 mo.	2. 6 mo. - 11 mo.	2. 6 mo. - 11 mo.
3. 1 yr	3. 1 yr	3. 1 yr	3. 1 yr
4. 2 yrs	4. 2 yrs	4. 2 yrs	4. 2 yrs
5. 3 yrs	5. 3 yrs	5. 3 yrs	5. 3 yrs
6. 4 yrs	6. 4 yrs	6. 4 yrs	6. 4 yrs
7. 5 yrs	7. 5 yrs	7. 5 yrs	7. 5 yrs
8. Other _____	8. Other_____	8. Other_____	8. Other_____

31. How much did you pay for your guard llama(s)?

#1 $_____ **#2 $**_____ **#3 $**_____ **#4 $**_____

32. What type of daily routine care is given to your llama(s) in addition to the care given to your sheep? *(Circle all that apply - Read options as follows:)*

Does someone:

1. Feed it daily	1. Feed	1. Feed	1. Feed
2. Water it daily	2. Water	2. Water	2. Water
3. Do anything else? _____	3. Else_____	3. Else_____	3. Else_____
4. Same as sheep	4. Same	4. Same	4. Same
LLAMA #1	**LLAMA #2**	**LLAMA #3**	**LLAMA #4**

33. How often do you check on the guard llama?

#1_____ **#2**_____ **#3**_____ **#4**_____

34. a) Does the llama receive any kind of special feed or supplement other than what the sheep eat?

1. Yes	1.	1.	1.
2. No *(Go to 35)*	2.	2.	2.

b) What kind of special feed is given?

#1_____ **#2**_____ **#3**_____ **#4**_____

35. a) In addition to pasture, approximately how much does it cost per year to feed your guard llama?

#1_____ #2_____ #3_____ #4_____

b) How much are your veterinary fees per year for the guard llama? (Shots, worming, injuries)

#1_____ #2_____ #3_____ #4_____

c) Are there any other expenses for your guard llama?

1. Yes _____	1. Yes_____	1. Yes_____	1. Yes_____
2. No *(Go to 36)*	2. No	2. No	2. No

d) How much?

#1_____ #2_____ #3_____ #4_____

36. At what age was your llama first introduced with the sheep?

1. < 6 months	1. < 6 mo.	1. < 6 mo.	1. < 6 mo.
2. 6 mo.-11 mo.	2. 6 mo. - 11 mo.	2. 6 mo. - 11 mo.	2. 6 mo. - 11 mo.
3. 1 yr	3. 1 yr	3. 1 yr	3. 1 yr
4. 2 yrs	4. 2 yrs	4. 2 yrs	4. 2 yrs
5. 3 yrs	5. 3 yrs	5. 3 yrs	5. 3 yrs
6. 4 yrs	6. 4 yrs	6. 4 yrs	6. 4 yrs
7. 5 yrs	7. 5 yrs	7. 5 yrs	7. 5 yrs
8. Other _____	8. Other_____	8. Other_____	8. Other_____
LLAMA #1	**LLAMA #2**	**LLAMA #3**	**LLAMA #4**

37. Where on your ranch was the llama introduced to the sheep? *(Read options)*
In the:

1. Barn	1. Barn	1. Barn	1. Barn
2. Small Pen/Corral	2. Sm. pen/corral	2. Sm. pen/corral	2. Sm. pen/corral
3. Pasture	3. Pasture	3. Pasture	3. Pasture
4. Range	4. Range	4. Range	4. Range
5. Other _____	5. Other_____	5. Other_____	5. Other_____

38. How long did it take for the llama to adjust to the sheep? (get along with/ be accepted by)

1. A few hours	1. A few hours	1. A few hours	1. A few hours
2. One day	2. One day	2. One day	2. One day
3. Two days	3. Two days	3. Two days	3. Two days
4. Three days	4. Three days	4. Three days	4. Three days
5. Other _____	5. Other_____	5. Other_____	5. Other_____

39. How long did it take for the sheep to adjust to the llama? (get along with/ be accepted by)

1. A few hours	1. A few hours	1. A few hours	1. A few hours
2. One day	2. One day	2. One day	2. One day
3. Two days	3. Two days	3. Two days	3. Two days
4. Three days	4. Three days	4. Three days	4. Three days
5. Other _____	5. Other_____	5. Other_____	5. Other_____

40. a) Was the llama introduced to the whole herd or a small group of sheep?

1. Whole herd *(Go to 41)*	1. Whole herd	1. Whole herd	1. Whole herd
2. Small group	2. Small group	2. Small group	2. Small group

b) How long was the llama kept with the smaller group?

Llama #1_____ #2_____ #3_____ #4_____

41. a) Which sheep was the llama introduced to? *(Read options)*

1. Ewes	1. Ewes	1. Ewes	1. Ewes
2. Ewes & lambs	2. Ewes/lambs	2. Ewes/lambs	2. Ewes/lambs
3. Rams	3. Rams	3. Rams	3. Rams
4. Mixes _____	4. Mixed_____	4. Mixed_____	4. Mixed_____

b) How many sheep was the llama introduced to?

Llama #1_____ #2_____ #3_____ #4_____

42. What was the initial reaction of the llama to the sheep?
(Looking for specific behaviors like aggressive, afraid, friendly, curious, submissive, neutral, etc. or description of the llama's body position.)

Could use - Can you be more specific?
- Can you describe the behavior or body position of the llama?

Llama #1 _____
_____
_____
_____

Llama #2 _____
_____
_____
_____

Llama #3 _____
_____
_____
_____

Llama #4 _____

_____

_____

_____

43. What was the initial reaction of the sheep to the llama?
(Looking for specific behaviors like aggressive, afraid, friendly, curious, submissive, neutral, etc. or description of the body position.)

Could use - Can you be more specific?
- Can you describe the behavior or body positions?

Reaction to Llama #1 _____

_____

_____

_____

Reaction to Llama #2 _____

_____

_____

_____

Reaction to Llama #3 _____

_____

_____

_____

Reaction to Llama #4 _____

_____

_____

_____

44. Where are the sheep usually kept? *(Read options)*

1. Fenced pasture	1. Fenced pasture	1. Fenced pasture	1. Fenced past.
2. Open range	2. Open range	2. Open range	2. Open range
3. Combo_____	3. Combo _____	3. Combo _____	3. Combo_____
4. Feedlot/drylot	4. Feedlot	4. Feedlot	4. Feedlot
5. Other _____	5. Other_____	5. Other_____	5. Other_____
_____	_____	_____	_____

45. On what type of terrain are your sheep usually kept? *(Read all options as follows:)*

Is it:

1. Open grassland
2. Shrubby
3. Forested
4. Feedlot/Corral
5. Other _____

46. What size is the pasture/range where the sheep are guarded by the llama? (in acres)

Llama #1 _____ **#2** _____ **#3** _____ **#4** _____

47. What type of fencing do you use for your flock where you keep the guard llama?

1. Wooden
2. Woven wire
3. High Tensile
4. Barb
5. Barbless
6. Welded wire
7. Other _____

48. In feet, what is the height of the fencing? _____

49. a) Did you have to change fencing for the llama?

1. Yes
2. No *(Go to 50)*

b) What adjustments were made and why?

_____

_____

50. Was the llama(s) trained to guard sheep?

1. Yes	1. Yes	1. Yes	1. Yes
2. No *(Go to 53)*	2. No	2. No	2. No

51. Who trained your guard llama(s)?

1. Yourself	1. Yourself	1. Yourself	1. Yourself
2. Llama breeder	2. Breeder	2. Breeder	2. Breeder
3. Other_____	3. Other_____	3. Other_____	3. Other_____

52. How was it trained?

Llama #1 _____

_____

_____

_____

Llama #2 _____

_____

_____

_____

Llama #3 _____

_____

_____

_____

Llama #4 _____

_____

_____

_____

53. How does the llama act towards the sheep most of the time?
(Looking for specific behaviors like aggressive, afraid, friendly, neutral, etc. or description of the body position.)

Could use - Can you be more specific?
- Can you describe the behavior or body positions?

Llama #1 _____

Llama #2 _____

Llama #3 _____

Llama #4 _____

54. How do the sheep act towards the llama most of the time?
(Looking for specific behaviors like aggressive, afraid, friendly, neutral, etc. or description of the body position.)

Could use - Can you be more specific?
- Can you describe the behavior or body positions?

Llama #1 _____

Llama #2 _____

Llama #3 _____

Llama #4 _____

_____

_____

_____

55. Has the llama ever negatively affected the sheep in any way?

1. Yes	1. Yes	1. Yes	1. Yes
2. No *(Go to 58)*	2. No	2. No	2. No

56. What did the llama do to the sheep? *(Want specifics like chasing, breeding, displaced for food, etc.)*

Llama #1 _____

_____

_____

_____

Llama #2 _____

_____

_____

_____

Llama #3 _____

_____

_____

_____

Llama #4 _____

_____

_____

_____

57. What group of sheep was affected? *(Circle all that apply)*

1. Adult ewes	1. Adult ewes	1. Adult ewes	1. Adult ewes
2. Adult rams	2. Adult rams	2. Adult rams	2. Adult rams
3. Lambs	3. Lambs	3. Lambs	3. Lambs
4. Other _____	4. Other_____	4. Other_____	4. Other_____

58. Do the sheep ever negatively affect the llama?
    1. Yes
    2. No *(Go to 62)*

59. Which llama(s) are affected? *(Circle all that apply)*

    1. Llama #1
    2. Llama #2
    3. Llama #3
    4. Llama #4
    5. Other _____

60. How do the sheep adversely affect the llama? *(Want specifics like chasing, breeding, displaced for food, etc.)*

Llama #1 _____
_____
_____
_____

Llama #2 _____
_____
_____
_____

Llama #3 _____
_____
_____
_____

Llama #4 _____
_____
_____
_____

61. Which sheep abuse the llama?

1. Adult ewes	1. Adult ewes	1. Adult ewes	1. Adult ewes
2. Adult rams	2. Adult rams	2. Adult rams	2. Adult rams
3. Lambs	3. Lambs	3. Lambs	3. Lambs
4. Other _____	4. Other_____	4. Other_____	4. Other_____

62. a) Have you experienced any other problems with the use of your guard llama?
1. Yes
2. No *(Go to 63)*

b) What kind of problems? _____
_____
_____

63. Would you say your sheep flock together well or are they spread out most of the time?
1. Flock together well
2. Spread out
3. Other _____

64. Is the llama usually with the sheep or is he usually separate from the flock?

1. With the sheep	1.	1.	1.
2. Separate from the sheep	2.	2.	2.
3. Other _____	3. _____	3. _____	3. _____

65. How often do you and your family handle the guard llama(s)?

Llama #1_____ **#2**_____ **#3**_____ **#4**_____

66. Was the llama handled by humans as a cria (baby llama)?

1. Yes	1. Yes	1. Yes	1. Yes
2. No *(Go to 68)*	2. No	2. No	2. No
3. Unknown *(Go to 68)*	3. Unknown	3. Unknown	3. Unknown

67. How often was the cria handled by humans?

#1_____ **#2**_____ **#3**_____ **#4**_____

68. How does the llama react to people now?
(Looking for specific behaviors like aggressive, afraid, friendly, neutral, etc. or description of the body position.)

Could use - Can you be more specific?
- Can you describe the behavior or body positions?

Llama #1 _____
_____
_____
_____

Llama #2 _____
_____
_____
_____

Llama #3 _____
_____
_____
_____

Llama #4 _____
_____
_____
_____

69. How does the llama behave around other llamas?
(Looking for specific behaviors like aggressive, afraid, friendly, neutral, etc. or description of the body position.)

Could use - Can you be more specific?
- Can you describe the behavior or body positions?

Llama #1 _____
_____
_____
_____

Llama #2 _____

_____

_____

_____

Llama #3 _____

_____

_____

_____

Llama #4 _____

_____

_____

_____

70. How tame/trained is your guard llama? *(Read each response and circle all that apply)*

Can you :	LLAMA #1		LLAMA #2		LLAMA #3		LLAMA #4	
	YES	NO	YES	NO	YES	NO	YES	NO
Catch it easily	1	2	1	2	1	2	1	2
Lead it around	1	2	1	2	1	2	1	2
Load it into a trailer	1	2	1	2	1	2	1	2
Trim its toenails	1	2	1	2	1	2	1	2
Does it:								
Do anything else?	1	2	1	2	1	2	1	2
Specify -	_____		_____		_____		_____	

71. Did you have trouble with predators before you used the guard llama?
    1. Yes
    2. No

72. How many sheep did you lose per year before using the guard llama? _____

73. Do predator losses occur regularly in your area?
    1. Yes
    2. No

74. During what month(s) do your highest losses occur? _____

75. a) What kind of predator do you have the most problems with?
    1. Coyotes
    2. Dogs
    3. Bears
    4. Mountain Lion
    5. Eagle
    6. Other _____

    b) Do you have problems with any other predators?
    1. Yes
    2. No *(Go to 76)*

c) What kind of predator?

1. Coyotes
2. Dogs
3. Bears
4. Mountain Lion
5. Eagle
6. Other _____

76. a) How did you know it was a *coyote, bear, dog*? *(Read options and circle all that apply)*
Did you:

Predator #1_____	**Predator #2**_____	**Predator #3**_____
1. See it	1. Visually	1. Visually
2. See tracks	2. Tracks	2. Tracks
3. Use an extension specialist	3. Extension	3. Extension
4. Look at the carcass injuries	4. Carcass injuries	4. Carcass injuries
5. Other _____	5. Other_____	5. Other_____

b) What kind of carcass injuries did you find?

1. Puncture wounds - neck	1. Puncture - neck	1. Puncture - neck
2. Hind legs/extremeties chewed	2. Extremeties chewed	2. Extremeties chewed
3. Flank opened - organs eaten	3. Flank opened	3. Flank opened
4. Hindquarters chewed	4. Hindquarters chewed	4. Hindquarters chewed
5. Other _____	5._____	5._____
_____	_____	_____

77. How many sheep are you losing per year now to predators since using a guard llama?
_____

78. Has your llama(s) ever been injured by predators?

1. Yes
2. No *(Go to 81)*

79. Which guard llama(s) have been injured?

#1._____ #2._____ #3._____ #4._____

80. What type of injury? *(Specific injury like puncture wound, open bites, etc. and where they were injured.)*

Llama #1 _____
_____
_____
_____

Llama #2 _____
_____
_____
_____

Llama #3 _____
_____
_____
_____

Llama #4 _____

_____

_____

_____

81. Has a predator ever killed one of your guard llamas?
    1. Yes
    2. No *(Go to 85)*

82. How many llamas have you lost to predators? _____

83. What kind of predator? (Circle all that apply)

	First Llama Lost	Second Llama	Third Llama
1.	Coyotes	1. Coyotes	1. Coyotes
2.	Dogs	2. Dogs	2. Dogs
3.	Bears	3. Bears	3. Bears
4.	Mountain lion	4. Mountain lion	4. Mountain lion
5.	Eagle	5. Eagle	5. Eagle
6.	Other _____	6. Other_____	6. Other_____

84. a) How did you know it was a <u>coyote, bear, dog</u>? *(Read options and circle all that apply)*
Did you:

	Predator #1_____	Predator #2_____	Predator #3_____
1.	See it	1. Visually	1. Visually
2.	See tracks	2. Tracks	2. Tracks
3.	Use an extension specialist	3. Extension	3. Extension
4.	Look at the carcass injuries	4. Carcass injuries	4. Carcass injuries
5.	Other _____	5. Other_____	5. Other_____

b) What kind of carcass injuries did you find?

1.	Puncture wounds - neck	1. Puncture - neck	1. Puncture - neck
2.	Hind legs/extremeties chewed	2. Extremeties chewed	2. Extremeties chewed
3.	Flank opened - organs eaten	3. Flank opened	3. Flank opened
4.	Hindquarters chewed	4. Hindquarters chewed	4. Hindquarters chewed
5.	Other _____	5._____	5._____
	_____	_____	_____

85. Have you seen your llama protecting the sheep from a predator?
    1. **Yes**
    2. **No** *(Go to 91)*

86. a) How many times have you seen your llama(s) protecting the sheep?
    1. Once
    2. Twice
    3. Three times
    4. Other _____

I'd like to ask a few questions about your observations.

MARK FOR EACH ENCOUNTER OBSERVED. USE EXTRA SHEETS AS NECESSARY.

87. Which guard llama(s) did you see protecting the flock?

Encounters:

#1 _____	#2_____	#3_____	#4_____

88. What kind of predator was it?

1. Coyotes	1. Coyotes	1. Coyotes	1. Coyotes
2. Dogs	2. Dogs	2. Dogs	2. Dogs
3. Bears	3. Bears	3. Bears	3. Bears
4. Mountain lion	4. Mountain lion	4. Mountain lion	4. Mountain lion
5. Eagle	5. Eagel	5. Eagle	5. Eagle
6. Other _____	6. Other_____	6. Other_____	6. Other_____

89. What did the llama do to the predator? *(Write a brief description and then read each option. Circle all that apply)*

ENCOUNTER #1	**#2**	**#3**	**#4**
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Did the llama: *(Read slowly)*

01.	Alarm Call	01.	01.	01.
02.	Stand at attention	02.	02.	02.
03.	Walk towards the predator	03.	03.	03.
04.	Walk away from the predator	04.	04.	04.
05.	Run towards the predator	05.	05.	05.
06.	Run away from the predator	06.	06.	06.
07.	Chase the predator	07.	07.	07.
08.	Kick/Paw the predator	08.	08.	08.
09.	Bite the predator _____	09.	09.	09.
10.	Herd the sheep together	10.	10.	10.
11.	Stayed with the sheep	11.	11.	11.
12.	Other_____	12._____	12._____	12._____
_____		_____	_____	_____
_____		_____	_____	_____

90. I'd like to know more about what happened. *(Circle all that apply and read the options)*

	ENCOUNTER #1		#2		#3		#4	
a) Was the:	YES	NO	YES	NO	YES	NO	YES	NO
Predator killed	1	2	1	2	1	2	1	2
Predator injured	1	2	1	2	1	2	1	2
b) Was the:								
Llama killed	1	2	1	2	1	2	1	2
Llama injured	1	2	1	2	1	2	1	2
c) Did the:								
Predator kill or injure sheep before leaving	1	2	1	2	1	2	1	2

91. In your opinion, what are the main benefits of using a guard llama?

_____
_____
_____

92. What are the disadvantages of using a guard llama?

_____
_____
_____

93. Are you:
    1. Very satisfied
    2. Satisfied
    3. Somewhat satisfied
    4. Unsatisfied (with your guard llamas?)

94. Are there certain situations (specific situations) where the llama is especially effective?
    1. Yes
    2. No *(Go to 96)*

95. In what situation(s) is the llama especially effective?

_____
_____
_____

96. Are there certain situations (specific situations) where the llama is not effective?
    1. Yes
    2. No *(Go to 98)*

97. In what situation(s) is the llama not effective?

_____
_____
_____

98. In an average year, how much money do you estimate your llama has saved (or lost)?

_____

99. Would you recommend using guard llamas to other sheep ranchers?
    1. Yes
    2. No
    3. Depends on situation _____

100. What characteristics should someone look for in a potential guard llama? (physical and behavior)

_____
_____
_____

101. Thank you for taking the time to answer our questions.

We are planning on traveling out west this summer to visit some ranches using guard llamas. We will be discussing the use of guard llamas in greater detail and taking some pictures.

Would you be interested in being visited by us and showing us your ranch?

1. Yes — If it works out that we can visit you we will call you and set up a time for the interview.
2. No

Thank you again. Good-bye.