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THE USE OF THREE BREEDS OF DOG TO PROTECT RANGELAND SHEEP FROM PREDATORS

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ABSTRACT

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A total of 24 dogs (11 Komondorok, 9 Great Pyrenees and 4 Akbash Dogs) were placed with rangeland sheep to test their effectiveness in reducing losses of sheep to predators. All but 1 of the dogs (Komondor) had been reared from puppyhood with lambs. Seven of the dogs (4 Komondorok, 1 Great Pyrenees and 2 Akbash Dogs) were determined to be unsuitable for rangeland use after a relatively short period (1—6 weeks), primarily because of their rambunctious behavior and their lack of attentiveness to the sheep. Three of the 24 dogs (2 Komondorok and 1 Akbash Dog) died before their performance could be adequately evaluated. Two of the dogs (Komondorok) were relatively unsuccessful, but details of their performance were not available. The paper focuses on 12 trials with the remaining 12 dogs (3 Komondorok, 8 Great Pyrenees and 1 Akbash Dog). In 7 of the 12 trials, a pair of dogs or a single dog appeared to be influential in reducing the loss of sheep to predators. The effectiveness of the dogs in 2 trials was questionable, and in 3 of the trials, the dogs had little apparent influence on the number of sheep killed by predators. The dogs that appeared most effective barked at night, patrolled the area around the flock, and were aggressive to animals that came near the sheep. A variety of problems occurred when using the dogs, and benefits other than a reduction in predation, such as facilitating trailing and keeping the flock together, were noted in several of the trials. The use of dogs to protect rangeland sheep appears to be a practical technique, however, as with other forms of control, dogs will probably not eliminate predation. Not all dogs will be successful, and their use may be impractical in some situations.

INTRODUCTION

Predation is the cause of a significant loss of sheep (*Ovis aries*) in the western United States. Coyotes (*Canis latrans*) are the principle predator, and in 1974 they killed 728 200 lambs (8.1%) and 229 400 adult sheep

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(2.5%) in 15 western states. Other predators, including bears (*Ursus* spp.), mountain lions (*Felis concolor*), bobcats (*Lynx rufus*), red foxes (*Vulpes vulpes*) and domestic dogs (*Canis familiaris*) accounted for a loss of 297 900 lambs (3.3%) and 85 100 adult sheep (0.9%) during the same period. (Other known causes of death (i.e. disease, unfavorable weather) accounted for the loss of 733 000 lambs (8.2%) and 462 000 adults (5.1%). Losses attributed to unknown causes were 319 400 lambs (3.6) and 170 500 adult sheep (1.9%). All loss-data from Gee et al., 1977.)

Predation has traditionally been combatted by lethal methods (Evans and Pearson, 1980). For a variety of reasons, however, interest in non-lethal control of predators has increased during the past decade (Green, 1982; Linhart, 1983). The use of guard dogs to protect sheep is one non-lethal method that is growing in popularity (Coppinger and Coppinger, 1980b). Although guard dogs were apparently used for centuries to protect livestock in Europe (Coppinger and Coppinger, 1980a), they have been used for that purpose in the United States primarily since the mid- to late 1970's (Green and Woodruff, 1980). However, the Navajo Indians of the American southwest may have used dogs to protect livestock since the early 1700's (Black, 1981). Preliminary research indicated that guard dogs were effective in reducing coyote predation of sheep in fenced pastures (Linhart et al., 1979), and dogs appeared to be an economical form of control (Green et al., 1980). A recent survey in North Dakota indicated that on 36 ranches that used dogs, predation of sheep was reduced (Pfeifer and Goos, 1982).

The majority of dogs (over 90%) used to protect sheep in the United States have been used with relatively small flocks (less than 300 head) in fenced pastures, varying in size from 4 to 260 ha. However, about 80% of the United States' 13 million sheep are raised in the western portion of the country where, during summer months, up to 6 million sheep are grazed in flocks of from 500 to 2500 head on unfenced rangeland under the care of herders (Gee and Magleby, 1976). The loss of these range sheep to predators (primarily coyotes) has increased significantly during the past 2 decades (Gee et al., 1977). Additional effective methods for controlling predation of rangeland sheep are needed.

This paper reports observations and evaluations of the use of guard dogs to protect range sheep from predators.

METHODS

Dogs

This report focuses on the guarding performance of 12 dogs: 3 Komondorok, 8 Great Pyrenees and 1 Akbash Dog. Preliminary observations of 12 additional dogs (8 Komondorok, 1 Great Pyrenees and 3 Akbash Dogs) were also made. All but one of the dogs were acquired as pups at approximately 8 weeks old, and were immediately placed in a small indoor

pen, approximately 40 m^2, with 4—8 lambs ranging in weight from 15 to 40 kg. Each pen opened on to a fenced outer yard which was approximately 60 m^2. The pups were generally kept in groups of 2—4 during the first several weeks of their socialization to lambs, and by the age of 4 months, most dogs were either alone with sheep or were paired with one other dog. As the dogs matured, they were moved to progressively larger pastures (0.1—16 ha) with more lambs (6—20 head). Further details of the rearing process are contained in Green and Woodruff (1983).

The pups were fed a commercial dry puppy ration ad libitum and had free access to water. They were vaccinated for canine distemper, hepatitis, leptospirosis, parainfluenza, parvovirus and rabies, using established methods, and were treated for parasites as required. After one year of age, the dogs were fed either regular or high-protein dry dog chow.

Of the 12 field tests described, 2 were conducted with pairs of dogs. One pair consisted of littermates, a male and female Komondor, and the other pair consisted of a male Great Pyrenees and a female Akbash Dog. The remaining 10 trials were conducted with 7 single Great Pyrenees (2 males and 5 females) and 2 single Komondorok (1 male and 1 female). Several dogs were used in more than one trial.

In addition to guard dogs, sheep-herding dogs were used by the shepherds in all of the trials. Herding dogs are different from guard dogs and move sheep from one area to another by chasing and often biting and barking at them. Herding dogs are responsive and work according to commands given by a handler, and they are generally not left alone with sheep. Guard dogs are aloof and usually do not herd sheep. They are discouraged from biting, chasing, and barking at sheep, and usually act independently of people.

Additional methods of predator control

No additional forms of predator control were used in Trials 1—5, with the exception of a brief attempt in Trial 5 to snare bears that were preying upon the sheep. In the remaining trials, U.S. government trappers removed predators (primarily coyotes) by trapping, shooting, or other conventional techniques, and the herders shot coyotes and bears that were found near the sheep. The intensity of these predator-control efforts was variable within and between the trials.

Sheep

The sheep used in all trials were primarily either purebred or grade Columbias, Targhees and Rambouillets. Such whiteface sheep are typical of most western United States range-sheep operations. Ten trials were conducted with relatively large flocks of ewes and their lambs (flocks ranged in size from 562 to 1200 ewes and from 550 to 1500 lambs). One trial was conducted with a smaller flock (242 ewes and 148 lambs), and one trial was conducted with a flock containing ewes only (2150 head).

TABLE I

Summary results of 12 trials using livestock guard dogs to protect rangeland sheep from predators

Trial No.	Age (months), sex and breed	Duration of trial (days)	No. of sheep in flock	Confirmed predator kills		Total loss		Comparative losses without a guard dog
				Lambs	Ewes	Lambs (%)	Ewes (%)	
1	21 ♂ K[1] 21 ♀ K	59	695 ewes 660 lambs	5 (B[2]) 2 (C) 1 (U)	3 (B)	51 (7.7)	23 (3.3)	No comparative data available
2a	13 ♂ GP 11 ♀ A	69	963 ewes 1393 lambs	None	None	46 (3.3)	11 (1.1)	The total loss during this period was similar in this flock to the previous year
2b	Same dogs as 2a	57	952 ewes 1347 lambs	None	None	14 (1.0)	11 (1.1)	34 sheep were killed by predators in a nearby flock during the trial period
3a	30 ♀ K	46	570 ewes 609 lambs	16 (C)	None	—	—	The loss to predation during this trial was similar in adjacent flocks without dogs
3b	Same dog as 3a	27	565 ewes 568 lambs	9 (C)	None	—	—	No comparative data available
4	8.5 ♂ GP	50	562 ewes 550 lambs	2 (C)	None	19 (3.5)	2 (0.3)	9 sheep were killed by predators during a 27-day period prior to the trial
5	6.5 ♀ GP	44	845 ewes 1209 lambs	3 (C) 16 (B)	5 (B)	30 (2.5)	7 (0.8)	The mean total loss in this flock during 4 previous years was 2.5% lambs and 1.4% ewes

6a	7 ♀ GP	52	1200 ewes with lambs	9 (C)	3 (B)	—	—	33 sheep were killed by predators during a 39-day period prior to the trial
6b	9 ♀ GP	37	1200 ewes with lambs	1 (C)	None	—	—	6 sheep were killed by predators during an 11-day period prior to the trial
7	18 ♂ GP	142	900 ewes 1150 lambs	4 (C)	None	—	—	50 ewes and 80 lambs were lost to all causes, including predators, in this flock during the previous season
8	8.5 ♀ GP	167	1200 ewes 1500 lambs	6 (C) 6 (ML)	5 (ML)	19 (1.3)	13 (1.1)	An estimated 20 ewes and 60 lambs were lost to predators in this flock during the previous season
9	12.5 ♂ GP	157	850 ewes 1500 lambs	3 (C)	2 (C)	9 (0.6)	25 (2.9)	The loss of sheep to predators was reportedly greater for the flock in Trials 9 and 10 during the previous year (see text)
10	6 ♀ GP	119	850 ewes 1400 lambs	32 (C)	7 (C)	53 (3.9)	33 (3.9)	See above
11	11 ♀ GP	93	2150 ewes	—	None	—	—	Predators killed 7 sheep in an adjacent flock without a dog during this trial
12	10 ♂ K	356	242 ewes 148 lambs	29 (C) 3 (BC)	None	54 (36)	30 (12)	100 of 200 lambs were lost to all causes the previous year

[1] Dog breed abbreviations: K = Komondor; GP = Great Pyrenees; A = Akbash Dog.
[2] Predator abbreviations: B = bear; C = coyote; ML = mountain lion; BC = bobcat; U = unknown.

Study area

Five trials were conducted on the rangeland of the U.S. Sheep Experiment Station (USSES), a U.S. Department of Agriculture research facility near Dubois, in southeastern Idaho. The remaining trials were conducted on the ranges of cooperating sheep producers; 5 in southeastern Idaho, 1 in southwestern Montana, and 1 in northcentral Utah. All trials were conducted on range-sheep operations typical of those in the western United States. A brief description of western sheep production is given below, and further details are presented in Gee and Magleby (1976).

Range-sheep operations are characterized by ewes and their lambs grazing together in the spring months (April—June) on relatively flat, low-elevation (1.5—2 km) rangeland of native grass, forb and browse species. As summer progresses (July—August), the sheep are trailed or trucked to higher elevations (2—3 km) to graze in grass—forb meadows interspersed with sparse-to-dense stands of timber. The sheep remain on the mountain summer range until early autumn (September or October) when the lambs are weaned. During autumn and early winter (October—December), the ewes graze on lower-elevation, browse-covered foothills. In some instances, the ewes spend the winter months (January—March) in pastures or feedlots until lambing commences. Some producers keep their sheep on open rangeland all the year round.

Predation of sheep is generally most severe in the spring following lambing and through the summer months. Except for one trial on the winter range (Trial 11), all trials took place on spring and summer ranges with ewes and lambs.

Evaluation methodology

It is difficult to measure accurately the effectiveness of a guard dog in reducing predation of sheep under natural conditions. A wide variety of factors affect predation including: (1) density of the predator; (2) availability of alternate prey; (3) experience of the predator (some predators may not be inclined to prey on livestock); (4) intensity of predator control (current and former); (5) management practices; (6) ability and experience of the herder; (7) time of year.

A count of dead and living sheep is seldom an adequate criterion to evaluate the effectiveness of a guard dog. Some sheep are never accounted for, and the exact cause of death is often unknown. Some shepherds fail to keep accurate records of the dead sheep they find. In addition, it is difficult, costly and impractical to obtain frequent and accurate counts in range flocks where large numbers of sheep are grazed under open, loosely-herded conditions. Many counts are made as sheep pass through a gate, and, while some counts can be relatively accurate, many lack precision. At the USSES and in other large operations, several flocks often graze in close proximity, and

mixing of entire flocks, or small groups from different flocks, sometimes occurs. Therefore, the counts of sheep presented in Table I are given for general reference only, and they should not be viewed alone to determine the success or failure of the dogs in the trials.

There are at least 2 methods to evaluate the effectiveness of guard dogs. The first involves the simultaneous comparison of predation in a flock with a dog and that in a nearby flock without a dog. The second compares predation in a single flock during different time-periods, one with, and the other without, a guard dog. The second comparison can be between years or between specific periods within a year. Neither method of evaluation is free from bias resulting from the parameters affecting predation. While each trial has value alone, more accurate conclusions can be determined from an analysis of many trials over several years.

RESULTS AND DISCUSSION

The results from 12 trials with guard dogs and range flocks of sheep will be presented individually. A brief summary of each trial is given in Table I.

Trial 1

Two Komondorok, 21-month-old male and female littermates, were placed with a range flock of approximately 695 ewes and 660 lambs on the USSES summer range from 25 June to 27 August 1979 (63 days). The sheep were tended by a herder, and a dog handler observed and worked with the dogs on a 24-h basis throughout the trial. Despite constant encouragement, the dogs did not remain with or near the sheep unless they were accompanied by the handler. The handler slept near the sheep nightly, and because the dogs remained near him, they were generally near the sheep on the bed-ground.

The first day on the range, the dogs were interested in the sheep and approached them readily. The sheep reacted by retreating when the dogs came within 10—30 m. Although the sheep became more accustomed to the dogs as the trial progressed, they continued to retreat if the dogs came close to them. The dogs showed only occasional interest in the sheep after the first day, and when they did show interest, it was generally toward a small group of sheep or toward an individual sheep separated from the flock by a short distance.

During the trial, 11 sheep were found that had been killed by predators; 3 ewes and 5 lambs by bear, 2 lambs by coyote, and 1 lamb by bobcat. None of the dead sheep were found near the bed-ground. A count at the end of the trial indicated a shortage of 51 lambs and 23 ewes. Whether the 63 unaccounted losses were due to straying, predation, or other factors is not known.

Although the dogs were generally not in constant proximity to the flock,

one dog was observed chasing a coyote and both dogs frequently barked in response to howling coyotes during evening and nighttime hours.

The handler noted several problems during the trial. The dogs developed a stronger bond to the handler than to the sheep. The male Komondor developed aggressive behavior toward one of the 2 herding dogs and harassed and interfered with it when it herded the sheep. The guard dog appeared to be attempting to keep the herding dog away from the sheep. The problem persisted throughout the trial, and could only be solved by restraining the guard dog while the herding dog worked.

Considering all factors, the predation documented during the trial did not appear to be significantly influenced by the presence of the dogs.

Trial 2

A pair of guard dogs, one 13-month-old male Great Pyrenees and one 11-month-old female Akbash Dog, were placed with a USSES range flock consisting of 963 ewes and 1393 lambs on 27 April 1981. The ewes had lambed during the previous month, and the lambs each weighed approximately 11—13 kg.

The dogs had worked as a pair for several weeks during the previous autumn with pastured sheep. The flock grazed on relatively flat sagebrush (*Artemisia* spp.) and grass rangeland under the care of a shepherd.

The flock remained on the sagebrush range for 69 days. During that period, no predator-killed sheep were found. An approximate gate count showed that the number of ewes decreased by 11 and the number of lambs decreased by 46. An undetermined number of those losses was due to natural causes (i.e. pneumonia, lamb starvation). Predation of sheep (1 ewe and 7 lambs) was documented in a nearby flock of comparable size and composition during the same period. The dogs remained with the sheep continually, except for brief excursions to patrol the surrounding area. On several of the excursions, the dogs located other flocks of sheep and remained with them for 1 or 2 days before they were returned to their own flock. The dogs were often in close proximity to each other, but also were frequently widely spaced as the sheep grazed. The shepherd occasionally heard the dogs barking at night. On one occasion, a coyote approached the flock and was seen by the Pyrenees dog. It positioned itself between the coyote and the sheep and moved to maintain that spatial relationship as the coyote moved. The encounter ended after about 35 min, when the coyote retreated upon seeing the shepherd.

On 4 July, the dogs were removed from the flock for 2 days while the sheep were trailed to a holding pasture. During the next 57 days, the dogs accompanied the flock on the mountain summer range. No predator-killed sheep were found during this period, and at its conclusion there were 11 fewer ewes and 14 fewer lambs. Sixteen had died of natural causes, and the remaining were unaccounted for.

On the mountain range, the shepherd observed several encounters between the dogs and predators. One morning soon after sunrise, he heard the Akbash Dog growling and snarling in the vicinity of the sheep, and as he approached the disturbance on horseback, he saw a black bear standing on its hind legs swatting at the dog with its forepaws. The dog was growling and harassing the bear just beyond the bear's reach. After the shepherd had shot the bear, he observed the Great Pyrenees approaching from the direction of the flock. Both dogs investigated the dead bear.

In another incident, the Akbash Dog confronted a coyote near the front of the flock as the sheep were grazing. The dog and the coyote were facing each other in aggressive postures when the shepherd shot the coyote. The dog attacked the dead coyote at the throat and tossed it into the air several times.

On another occasion, the shepherd was attempting to herd the flock down a hill to a particular grazing area. The Akbash Dog was at the head of the flock barking and running at the sheep. After several futile attempts to move the flock in the desired direction, the frustrated shepherd went to investigate and reprimand the dog. As he approached, he saw 3 coyotes standing near the front of the flock. They dispersed when he shot at them. The sheep then proceeded to the grazing area unhindered.

No particular problems were noted during the trial. The guard dogs did not interfere with the herding dogs, and the sheep were generally undisturbed by the continual presence of the guard dogs and even allowed the dogs to sleep among them.

The overall loss of sheep during the trial was 1.1%, as compared to losses of 1.8, 2.3 and 2.4%, respectively, in flocks that had grazed in the same area during the previous 3 years. In the shepherd's judgement, the guard dogs were an asset. In addition to apparently reducing predation, the dogs were of benefit when the sheep were trailed. During one move, both guard dogs were at the head of the flock and kept cattle (*Bos taurus*) from mingling with the sheep.

A privately-owned flock of sheep (900 ewes and 1250 lambs) grazed in an adjacent area during approximately the same time-period (72 days, 1 July—10 September). This flock was not accompanied by guard dogs, and during the 72-day period, 23 lambs were found that had been killed by coyotes and 11 sheep (ewes and lambs) were found that had been killed by black bears. This loss was similar to that of the previous year; 20 to coyotes and 8 to bears. An additional unknown number of sheep were missing and never found.

Trial 3

A 30-month-old female Komondor (the female used in Trial 1) was placed with a flock of range sheep (approximately 570 ewes and 609 lambs) on 1 May 1980. The sheep grazed on the USSES sagebrush—grass spring range for

46 days. During that period, 16 lambs were found that had been killed by coyotes. The dog showed little interest in the sheep and was generally near them only when it followed the shepherd on the morning and evening rounds. Otherwise, the dog remained near the shepherd's camp.

On 20 June, the dog and the flock moved to the mountain summer range. The dog continued to accompany the shepherd and rarely showed interest in the sheep. In a 27-day period, 5 lambs were found that had been killed by coyotes, and 4 additional suspected predator-killed lambs were found.

During the first several weeks of the trial, the dog interfered with the movement of the sheep by standing or sitting in front of them. This problem was gradually overcome by encouraging the dog to remain some distance from the sheep when they were trailed. The dog rarely patrolled, barked, or displayed other behaviors generally indicative of a successful livestock guard dog. She occasionally appeared to be frightened and generally unconfident during the trial.

Trial 4

The female Komondor of Trial 3 was replaced by an 8.5-month-old Great Pyrenees male on 17 July 1980. The flock consisted of approximately 562 ewes and 550 lambs. The dog remained with the band for 50 days, during which time 2 coyote-killed lambs were found. A count at the end of the trial showed 2 ewes and 19 lambs lost.

The dog stayed with the sheep continuously during the trial, patrolling and barking frequently, particularly in response to coyote howls. He persisted in remaining near the sheep, but because they were not accustomed to his presence, they moved more than is normally observed in a range flock. The dog often disrupted the sheep while they bedded by barking and running to investigate what he apparently perceived to be a disturbance. This often resulted in the sheep becoming split into several groups. However, they gradually became accustomed to the dog. Several times the dog was seen running playfully through the flock. He also solicited play from the herding dogs. Both of these behaviors were discouraged by the shepherd.

The dog often barked in response to the howls of coyotes and patrolled in the direction from which the howls originated, but no physical interactions were observed. On one occasion, this dog joined the herding dogs in running a cow from the midst of the flock. The number of predator-killed sheep found was less than that of the previous trial. Traits characteristic of an immature dog (running through the sheep and attempting to play with the sheep) were a problem to the shepherd.

Trial 5

A 6.5-month-old female Great Pyrenees was placed with a flock of sheep

(approximately 845 ewes and 1209 lambs) on 23 June 1981 on the USSES sagebrush—grass rangeland. Seven days later, the flock was trailed to the mountain summer range where the trial was begun. The dog remained with the flock for 44 days, during which time 19 lambs and 5 ewes were found that had been killed by predators. Coyotes killed 3 lambs and bears killed 16 lambs and 5 ewes. A count at the end of the trial showed a total decrease of approximately 7 ewes and 30 lambs. Two ewes and 4 lambs died of natural causes leaving a total of 7 unaccounted losses. The dog remained with the flock continually, except for brief returns to the shepherd's camp to eat. The dog barked frequently during some nights, particularly when there was evidence of a bear in the area. The shepherd observed 2 encounters between the dog and predators. In the first, he saw the dog trotting behind the flock as it moved away from an approaching coyote. Whether the dog initiated the movement of the sheep was unknown. The encounter ended when the shepherd shot the coyote. The second encounter occurred as the dog was trotting from the flock in the direction of the shepherd's camp. The shepherd observed a mountain lion running parallel to, and approximately 40 m away from, the dog. It appeared that the lion was fleeing from the area. Although the dog was displaying a behavior that was protective of the sheep, there was no evidence that the dog was aware of the lion's presence.

A 10-month-old female Akbash Dog was placed with the Great Pyrenees for approximately 14 days near the end of the trial. The routine of the pair of dogs remained similar to that previously observed for the Great Pyrenees. Both dogs were generally near the sheep, except when they went to the shepherd's camp to eat. No observable differences in the degree of predation-deterrence were noted during the relatively brief period with the paired dogs.

The total loss of sheep during the trial was approximately 1.8%. Yearly losses from flocks that had grazed in the same area during the previous 3 years were 1.7, 2.3 and 0.7%, respectively. Predation from bears during the trial was higher than that experienced in that area during previous years. However, the shepherd felt that the guard dog was an asset and may have helped to keep the predation by bears from being worse than it was. He was generally pleased with the performance of the young dog.

Trial 6

A trial was conducted with a cooperating sheep producer in southwestern Montana. His flock of approximately 1200 ewes and their lambs was turned out under the care of a shepherd on 11 May 1980 to graze on a rangeland of rolling hills with a vegetative cover of native grasses, sparsely interspersed with small stands of aspen (*Populus tremuloides*) and conifers. During the first 39 days without a guard dog, 31 lambs were found that had been killed by coyotes and 1 ewe and 1 lamb were found that had been killed by bears.

On 19 June, a 7-month-old female Great Pyrenees was placed with the flock. She was usually tied to the shepherd's camp during the day and was

released each night to accompany the shepherd as he bedded the sheep. She remained with the sheep at night and returned to the camp with the shepherd by mid-morning of the following day. During the 18 days following the dog's arrival, no predator-killed sheep were found, and after an additional 39 days, a total of 9 coyote-killed lambs and 3 bear-killed ewes had been found. Four of the lambs that were killed were part of a small group of sheep that had been separated from the flock for several days.

On 15 August, the guard dog was found dead near the bedding grounds. The cause of death was unknown. During the following 11 days, 5 lambs were found that had been killed by coyotes and 1 ewe was found that had been killed by a bear.

On 27 August, a 9-month-old female littermate to the previous guard dog was placed with the flock. During the remaining 37 days of the trial, 1 lamb was found that had been killed by a coyote.

The owner of the flock had raised sheep for a relatively short time and had no predation records from previous years. However, based on the results obtained, he was confident that the dogs had reduced losses to predators. The cooperator noted that within a few weeks, the sheep had become accustomed to the presence of the dog, and no serious management problems were encountered.

During the trial, a government trapper continued to catch coyotes, and his subjective evaluation was that coyotes were plentiful in the area.

Trial 7

On 1 May 1981, an 18-month-old male Great Pyrenees (used previously in Trial 4) was placed with a band of approximately 900 ewes and 1150 lambs. The sheep grazed on sagebrush—grass foothills during May and early June, and gradually moved into higher-elevation conifer and aspen forests as the summer progressed. The sheep were removed from the summer range on 20 September. During these 142 days, 4 lambs were found that had been killed by coyotes. Approximately 11 lambs and 9 ewes died of natural causes, and there were no unaccountable losses.

During the first months, the dog generally remained near the sheep. However, during mid-summer he wandered away 3 times to follow people in the vicinity of the sheep. His absences from the sheep ranged from 2 to 5 days. The only predation documented during the trial occurred during one of the absences. Following the wanderings, the shepherd tied the dog at camp during the day and released him each night.

The shepherd indicated that coyotes were abundant in some of the areas grazed and he often saw up to 3 or more coyotes together near the sheep (in one evening he saw 7 coyotes). He frequently heard coyotes howling during the night, and he bedded the sheep near his camp to deter predation.

During the previous year, the cooperator grazed a flock of sheep (700 ewes and 1000 lambs) in the same general area. Although an exact record of

losses was not kept, he reported that losses to predators were considerably greater, and that total losses during the season were approximately 50 ewes and 80 lambs. However, the herder employed at that time was not dependable, and his performance reportedly contributed to the relatively high losses.

In addition to leaving the sheep as noted previously, the dog was observed chasing cattle on at least 1 occasion. The chasing appeared to be in the context of play behavior. A common technique used by shepherds to frighten away predators at night is to fire a rifle into the air. The dog seemed to cease patrolling when the shepherd used this technique.

The rancher and his shepherd were pleased with the dog's performance and felt that he minimized predation. No problems were observed between the guard and herding dogs.

Trial 8

An 8.5-month-old female Great Pyrenees was placed with a rancher's sheep in southeastern Idaho on 15 April 1981. The band of 1200 ewes and 1500 lambs grazed on sagebrush—grass foothills until late June, when it was moved higher to sagebrush—grass hills interspersed with stands of conifers and aspen. The trial was terminated after 167 days. Reported losses of sheep were 6 lambs to coyotes, and 6 ewes and 6 lambs to mountain lions. Seventeen lambs and 7 ewes died from natural causes, and 1 ewe was missing. An estimate of sheep losses to predators in the same area for a comparable period in 1980 was 20 ewes and 60 lambs.

The rancher had another ewe—lamb flock of comparable size that grazed on range adjacent to the trial flock. Data from the second flock were incomplete, but it was estimated that 30 lambs were killed by coyotes and 10 by mountain lions. A band of yearling ewes also grazed in the vicinity of the trial flock, and the total loss of sheep to all causes was estimated to be 50.

In early June, the cooperator purchased a female Great Pyrenees puppy and placed it with the trial flock and the older guard dog. The pup stayed with or near the older dog for much of the time throughout the remainder of the trial. The following discussion primarily focuses on the performance of the older Great Pyrenees.

The dog remained with the sheep during the trial. After an initial adjustment period of several weeks, the sheep became accustomed to the dog and allowed it to sleep among them. It would not tolerate animals other than the herd dogs near the sheep. The shepherd observed the dog chasing mule deer (*Odocoileus hemionus*), pronghorned antelope (*Antilocapra americana*), and cattle away from the flock. He also observed the dog trailing after a coyote that was several hundred meters away from the flock. Two mountain lions were seen in the vicinity of the flock, and the dog followed their trail and was gone for several hours. When the dog returned, she had wounds on her back that may have been bite or claw marks.

The shepherd noted that the dog helped to keep the flock together and did not let small groups of sheep stray. Several times it attempted to herd groups of sheep not belonging to the trial flock. The shepherd saw both guard dogs pulling sheep upright after they had become immobilized on their back. The dogs were also observed coaxing a dead ewe to stand. No problems were observed between the guard dogs and the herding dogs.

The shepherd concluded that the use of guard dogs was beneficial in reducing predation. He reported that he did not worry about predators during the night when the dogs were with the flock.

Trials 9 and 10

A 12.5-month-old male Great Pyrenees was placed with a rancher's flock (Flock 1) on 25 April 1981. The flock, of 850 ewes and 1500 lambs, grazed on rolling hills of sagebrush and grass until late June, when it moved to coniferous timber and montane meadows. During the 157 days of the trial, 2 ewes and 3 lambs were found that had been killed by coyotes. Twenty-three ewes and 6 lambs died of natural causes, and no unaccountable losses were reported.

The rancher had 2 other flocks of sheep that grazed for a comparable length of time on similar terrain near Flock 1. In Flock 2, composed of 600 ewes and 368 lambs, 1 lamb was found during the trial that had been killed by a coyote. Five ewes and 11 lambs died of natural causes. Coyotes and black bears were known to be in the area. The cooperator attributed the relative lack of predation to intensive management by a very competent shepherd.

Flock 3 contained 850 ewes and 1400 lambs and was accompanied by a 6-month-old female Great Pyrenees for the last 119 days of the 157-day trial. During the first quarter of the trial when no guard dog was present, 6 coyote-killed lambs were found. During the remainder of the trial, 7 ewes and 32 lambs were found that had been killed by coyotes, and 26 ewes and 15 lambs died of natural causes. The loss of sheep to predators in Flock 3 was less than that experienced in the flock that had grazed the same area the previous year.

The total reported loss of sheep to predators in all 3 flocks was 9 ewes and 42 lambs. Approximately 300 lambs were reportedly lost to predation during the previous year. The cooperator attributed the reduced losses in 1981 to better shepherds, better management, and the use of guard dogs. Other forms of predator control, including aerial hunting, trapping, and sport hunting, were practiced during 1981, but they were also used to a similar degree in 1980. The cooperator felt that the number of predators in his grazing allotments was similar during both years.

The dog with Flock 1 spent the majority of the daylight hours in the vicinity of the shepherd's camp and travelled near the sheep at night and during early morning hours. The shepherd heard the dog bark at night and

noted that the dog chased animals other than sheep away from the flock. This behavior was generally not a problem, except when the dog scattered the sheep by chasing hares (*Lepus* spp.) through the flock. He once treed a black bear that was feeding on a sheep.

The dog in Flock 3 spent more time with the shepherd than it did with the sheep. The rancher attributed this behavior to a lack of maturity and felt that the dog would improve as it grew older. The rancher attributed the relatively high losses in Flock 3 to poor herding. Despite the problems experienced with the guard dogs, the cooperator considered the benefits to be worth the effort.

Trial 11

An 11-month-old female Great Pyrenees (the same dog used in Trial 5) was placed with a flock of 2150 ewes on 1 November 1981. The flock was tended by the same shepherd who worked with the guard dog described in Trial 8. The sheep grazed on a winter range of hay stubble and sagebrush—grass foothills for 93 days. No predation was observed in the trial, although 7 sheep died of natural causes. In a nearby flock of ewes and yearling lambs without a guard dog, 7 losses to predators were documented, and approximately 70 sheep were unaccounted for.

Initially, the dog attempted to remain with the shepherd, but he easily encouraged the dog to stay away from the camp with appropriate praise and reprimand. The shepherd spent 2—3 h, 4 days per week, for 2—3 weeks, walking with the dog (on a lead during the first week) around and through the sheep to accustom them to the dog. After the adjustment was completed, the dog remained with the flock continuously.

The shepherd was watching the sheep graze on hay stubble one evening with the guard dog nearby. A Blue Healer cattle dog approached the flock and began chasing the sheep. The shepherd set the Great Pyrenees on to this dog, which was attacked and killed with a bite to the throat. Previous to this encounter, the guard dog had displayed no behavior indicative of aggressiveness.

One morning, the shepherd heard coyotes approaching the sheep. The guard dog barked repeatedly as it moved in an arc between the coyotes and the sheep. The coyotes fled as the shepherd approached. On another morning, the shepherd observed 2 coyotes being chased from the flock by the dog. The chase proceeded out of view of the shepherd, and the dog was gone for approximately 1.5 h. Later that day, 2 coyote hunters arrived at the shepherd's camp and reported that earlier that morning they had shot a coyote that was being followed by a guard dog.

The shepherd frequently observed and heard coyotes on the winter range. One coyote hunter shot 19 coyotes in an area approximately 2—5 miles away from the grazing allotment. The shepherd believed that the guard dog was largely responsible for the lack of predation.

Trial 12

A 10-month-old male Komondor was placed with a small flock of ewes (242) in December 1980 and remained with them for 12 months. The ewes were wintered on lowland crop stubble, and following lambing in April and May, they grazed a rugged canyon with oak (*Quercus* spp.) overstory. Approximately 148 lambs were turned out with the ewes in the spring. During the year, a total of 30 ewes and 54 lambs were lost as follows: 29 lambs to coyotes and 3 lambs to bobcats, 7 ewes and 1 lamb to disease, 11 ewes and 5 lambs to lightning, and 12 ewes and 16 lambs missing and unaccounted for. During the previous year (1980), approximately 100 lambs (50% of the lamb crop) were lost to all causes, and the number of sheep lost to predators was higher than in 1981.

The dog remained near the shepherd's camp (a permanently fixed facility) during the day. During the evening, the dog either followed the shepherd to the area where the sheep were bedded or trailed off in another direction. He showed relatively little attachment to the sheep, who were unaccustomed to having a guard dog with them. The shepherd (owner) camped near the bed-ground each night. The dog usually slept nearby, and barked and investigated during the night if there was a disturbance.

The shepherd felt that the dog was of some benefit in reducing predation. He considered that the dog's principle asset was in finding the scent of a coyote or other predator and following its trail. The trailing behavior of the dog may have discouraged some predators from remaining in the vicinity of the sheep.

The guard dog was aggressive to strange dogs that came near the sheep, and it was observed chasing deer from the flock. The shepherd reported no major problems with the dog and generally felt that it was of benefit to his operation.

Dog performance on rangeland

We used several criteria for evaluating the success of the dogs, the most critical being the propensity of the dog to remain with or near the sheep, particularly during crepuscular and nighttime periods. Other criteria included the calmness of the dog when near the sheep, the aggressiveness of the dog to potential predators, and the degree of predation of sheep that occurred during the trial.

Of the 24 dogs that were observed under various rangeland conditions, 9 were judged to be successful (1 of 11 Komondorok representing 4 different breedings, 7 of 9 Great Pyrenees representing 4 different breedings, and 1 of 4 Akbash Dogs representing 3 different breedings). Three dogs (2 Komondorok and 1 Akbash Dog) died before their performance could be adequately evaluated. Seven dogs (4 Komondorok, 1 Great Pyrenees and 2 Akbash Dogs) were determined to be unsuitable for rangeland use after a

relatively short period (1—6 weeks), primarily because of their rambunctious behavior and their lack of attentiveness to the sheep. The undesirable behavior of these 7 dogs may have been due in part to immaturity. Five of the 24 dogs (4 Komondorok and 1 Great Pyrenees) had little apparent influence on the number of sheep killed by predators. (Six of the 12 dogs (5 Komondorok and 1 Akbash Dog) that were not successful in the rangeland trials later performed well under fenced-pasture conditions.)

The degree of attentiveness of a dog to sheep is dependent on a number of factors, including instinct and experience. Except for 1 Komondor, all of the dogs were socialized to sheep from puppyhood. The behavioral differences between dogs may have resulted from individual and breed-inherited traits.

In addition to the Komondorok and Great Pyrenees dogs used in this study, 30 other dogs (15 Komondorok and 15 Great Pyrenees) have been observed at the USSES. Several behavioral differences were noted between the 2 breeds. The Great Pyrenees were not as playful with sheep and were generally less rambunctious at a younger age. They displayed the calm behavior and temperament suited for working on rangeland by 6—10 months of age, while the Komondorok did not reach a comparative level of calmness until later (18—36 months of age). The Pyrenees did not bond as strongly to people as the Komondorok and were thus more apt to stay with the sheep rather than following the shepherd. The Pyrenees generally adapted to new people and terrain more easily than Komondorok, and consequently worked well with sheep that were continually moving into new territory.

The Komondorok may have performed more successfully under rangeland conditions if they had been in the 2—3-year-old age class, since increased maturity usually results in a calmer dog. Despite the results on rangeland, most of the Komondorok worked well under fenced pasture conditions, as did most of the dogs from other breeds.

Problems with guard dogs and rangeland sheep

A variety of problems occurred when dogs were used to protect sheep on open rangeland. The most frequently encountered, and possibly the most problematic, was integration of the dog into the flock. It is not only important for the dog to have a bond with the sheep, but it is also equally important that the sheep be accustomed to the dog. If the sheep are not accustomed to a dog on the range, they may react to the dog by moving away. As the dog follows, small groups may split off, resulting in sheep scattered over a wide area. Increased predation, decreased weight gain in lambs, lost sheep, and increased work for the shepherd may result. Familiarization of sheep to the dog is more easily achieved when the sheep and the dog are confined in a small pasture. Most rangeland flocks are under such confinement during winter and spring months. In general, sheep that exhibit close flocking behavior are better suited for use with a guard dog than sheep that do not form a cohesive flock.

In one trial (Trial 1), a guard dog and a herding dog fought when they were together. In general, however, the guard dogs and herding dogs in this study performed their respective roles without major conflicts or problems.

There is a potential for the additional serious problems of guard dogs killing sheep and dogs biting people. In our experience, these problems have occurred relatively infrequently. During 4.5 years of research with over 60 guard dogs at the USSES, sheep-killing incidents were documented for 1 Komondor and 1 Great Pyrenees. Four other Komondorok and 1 Akbash Dog were thought to be involved in isolated incidents of killing sheep, although documentation was lacking. In a survey of livestock producers who used dogs for deterring predation, 2 owners of Komondorok reported that their dogs had killed livestock (Green and Woodruff, 1980).

While the percentage of guard dogs that kills livestock is small, the percentage that harass or play with livestock is greater. Most puppies are playful, and may often include the livestock in their play. With proper training, the incidence of dogs playing with livestock decreases as the dogs mature. However, if allowed to go unchecked, playing can lead to injury and killing. Younger dogs harass sheep more frequently than older dogs, and dogs in close confinement or in small pastures with sheep are more prone to harass sheep than those in large pastures or on open rangeland. Some dogs never harass livestock.

Three USSES dogs, all Komondorok, have bitten people. Each incident was minor and occurred only once for each dog. In this study, aggressive behavior of guard dogs toward strangers was rare. However, most of the dogs were less than 2 years old, and aggressiveness may increase as a dog matures. We have received reports of aggressive livestock-guarding dogs, primarily Komondorok, that were guarding livestock near the home of their owner. We have not heard of any dogs under rangeland use that have been aggressive to people.

The use of a guard dog may require some changes in established management practices. The shepherd may need to tend the sheep more closely during the first several weeks on the range, and he must be aware of the increased likelihood of the sheep moving during the night. Firing a gun at night to ward off predators frightened one dog in this study and decreased its effectiveness. The shepherd will need to carry dog food to feed a dog that remains with the flock continually.

Several of the dogs kept cattle and wild ungulates from grazing near the sheep. None of the dogs were exposed to cattle during their rearing, and some were apparently responding to the cattle as they would to any intruder. If cattle are routinely grazed near the sheep to be protected by a dog, it may be advantageous to expose the puppy to cattle during the rearing process. Any dog that chases cattle or wild game routinely, as a play behavior, must be corrected by appropriate reprimand and praise.

There are a number of hazards for dogs on rangeland. Steel traps, snares, M-44's (a sodium cyanide spring-loaded delivery device), and other predator-

control techniques may be encountered by guard dogs. Almost all of the dogs encountered a porcupine (*Erethizon dorsatum*) at least once. Quills can often be removed by the shepherd, but sometimes veterinary care is required. Dogs can be injured by horses, sheep, other dogs, or predators. Further injuries to feet can result from rocks, thorns, or awns from grasses. A dog must be adequately cared for if optimum performance is to be expected.

Although no special technical skills are needed to work with a guard dog, some people may not possess the patience or disposition to use this form of predator control. It is not an automatically effective technique, and considerable patience and effort may be required to achieve success.

If the continual presence of a dog caused the sheep to move more frequently, to bed for shorter periods, or to graze inadequately, the weaning weight of the lambs at the end of the grazing season could be decreased. We evaluated this possibility by comparing the mean weaning weight of lambs from 3 bands of USSES sheep over a 2-year period. None of the flocks had guard dogs with them in 1980, and 2 of the 3 flocks (Trials 2 and 5) had dogs with them in 1981. Least-squares analysis of variance revealed that the weaning weights of the flocks were less ($P < 0.01$) in 1981 than in 1980, but the lowered weight was about 24% greater in the flock without the dogs than in either of the 2 flocks with dogs. There was no interaction between flocks and years ($P > 0.05$). In this study, the addition of guard dogs to the flock did not appear to significantly decrease mean weaning weight.

Benefits with guard dogs and rangeland sheep

In addition to the primary benefit of reducing predation, the use of guard dogs provided other advantages to some sheep producers. Sheep display allelomimetic behavior and are followers. Several dogs travelled at the front of the flock when the sheep were trailed. Not only did individual dogs act as leaders, but some also aggressively kept cattle from entering the flock and disrupting the trailing process.

Several shepherds noted that the dog helped to keep the sheep in a more cohesive unit by preventing individuals or small groups of sheep from straying, and dogs were often aware of individuals or small groups of sheep that were apart from the flock. On several occasions, they located sick, injured or dead sheep, and several attempted to right sheep that were unable to regain their footing. Several shepherds and producers said that they worried less when the guard dog was with the band.

SUMMARY AND CONCLUSIONS

Twenty-four dogs were evaluated as deterrents to predation in rangeland flocks of sheep. Three dogs died before an adequate evaluation could be made, and trials with 7 dogs were terminated after a relatively short period

due to the failure of the dog to integrate successfully into the flock. These failures may have been due largely to a lack of maturity in the dogs. Two dogs (Komondorok) were generally considered to be unsuccessful, but details of their performance were not available. The trials of the remaining 12 dogs were described. In 2 trials (Trials 2 and 11), no predator-killed sheep were found, and in 5 trials (Trials 4, 6, 7, 8 and 9), the loss of sheep to predators appeared to be appreciably less than would have occurred without the use of dogs. Although the number of sheep killed by predators seemed relatively high in 2 trials (Trials 5 and 12), the shepherds felt that the use of dogs helped to reduce predation. In 3 trials (Trials 1, 3 and 10), the dogs appeared to have had a negligible effect on predation.

In this study, 11% of the Komondorok and 78% of the Great Pyrenees were successful in deterring predation in rangeland flocks of sheep. The use of dogs was not free from problems, the most common being the reluctance of the sheep to accept the dog.

Benefits, in addition to a reduction of predation, included keeping the sheep in a cohesive unit and alerting the shepherd to sick or injured sheep.

Several important questions remain to be answered. What is the longevity of successful performance for a guard dog, and does increased experience and maturity result in a more effective guardian?

The adaptive nature of the coyote has necessitated that a variety of control measures be available to minimize predation. The use of guard dogs is one of those control techniques that has application with rangeland flocks of sheep. It is not a method without problems, and it may not be suitable or effective under all conditions.

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