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EFFECTIVENESS OF LIVESTOCK GUARDING DOGS FOR REDUCING PREDATION ON DOMESTIC SHEEP

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Estimates indicate coyotes (*Canis latrans*) kill an average of 1–2.5% of the domestic adult sheep and 4–9% of the lambs in the 17 western states (U.S. Fish and Wildl. Serv. 1978, Pearson 1986). Livestock producers reduce losses (mortality) by using various livestock management practices, frightening devices, trapping, snaring, calling and shooting, sodium cyanide guns, denning, aerial gunning, and livestock guarding dogs (Andelt 1987).

Livestock producers in the U.S. began using guarding dogs to protect domestic sheep from predators during the mid-1970's (McGrew and Blakesley 1982, Pfeifer and Goos 1982). Their effectiveness has been evaluated in enclosures (McGrew and Blakesley 1982) and under ranching conditions (Linhart et al. 1979; Pfeifer and Goos 1982; Coppinger et al. 1983; Green and Woodruff 1983, 1988, 1990; Green et al. 1984; Andelt 1985; Black and Green 1985). These evaluations usually compared losses before and after producers obtained guarding dogs. In this study, I compare domestic sheep losses in fenced pastures and on open ranges both with and without livestock guarding dogs in Colorado during 1986. I also provide producer estimates of the value of sheep saved from predators by guarding dogs.

METHODS

The effectiveness of livestock guarding dogs for protecting domestic sheep from predators was determined from 2 postal and 3 telephone surveys. A general survey was mailed to all (433) Colorado Wool Grower Association members. The survey requested information on type of operation (fenced pasture, open range, feedlot); the number of ewes and lambs in an operation; ewe and lamb mortality from all causes (weather, disease, predation, etc.); and ewe and lamb mortality from coyotes, mountain lions (*Felis concolor*), black bears (*Ursus americanus*), and other predators. Responses from 124 of 174 producers that completed the general mail survey were used to estimate sheep mortalities for producers without guarding dogs. A random sample of 29 of the nonrespondents was surveyed by telephone to determine if there was a nonresponse bias. Responses from 21 of these producers were used to estimate herd sizes and mortality rates for nonrespondents without guarding dogs. Respondents with guarding dogs, respondents without sheep, respondents with sheep primarily in feedlots, and incomplete responses were eliminated from both surveys.

Another survey was mailed to all sheep producers ($n = 30$) that used or were suspected of using livestock guarding dogs to protect sheep from predators. Producers using guarding dogs were identified by contacting county extension agents and other producers that used guarding dogs to provide what I believe was

an almost complete survey of producers that used guarding dogs in 1986. All nonrespondents ($n = 9$) using or suspected of using guarding dogs were surveyed by telephone. A total of 22 responses (18 written and 4 telephone) from 16 Colorado Wool Grower Association members and 6 nonmembers was used to estimate sheep mortalities for producers using guarding dogs in 1986 (respondents without guarding dogs or sheep, respondents that used guarding dogs primarily in feedlots, and incomplete responses were eliminated). Sixteen producers that used guarding dogs before, but not during, 1986 were identified and surveyed by telephone to determine why they stopped using guarding dogs. Fourteen of these producers obtained dogs from the Livestock Dog Project, New England Farm Center, Hampshire College, Amherst, Massachusetts, and were identified through their records (J. R. Lorenz, Dep. Rangeland Resour., Oregon State Univ., Corvallis, pers. commun., 1991) whereas the other 2 producers were identified by contacting previous guarding dog owners. All individuals contacted by the 3 telephone surveys provided responses.

Herd sizes compared were the total number of ewes and lambs owned by producers without guarding dogs and the numbers of ewes and lambs in the presence of guarding dogs for producers with dogs. The total number of ewes and lambs owned was used to calculate mortality from all causes, but when calculating the proportion of herds killed by coyotes in guarding dog herds, only the number of ewes and lambs that were in the presence of guarding dogs was considered. The numbers of ewes and lambs killed by coyotes for producers with guarding dogs were reported only for periods when dogs were with the sheep. When dogs were not with sheep for the entire year, the mortalities were extrapolated by dividing by the percentage of the annual period that dogs were with sheep to standardize the data for comparisons to producers without dogs.

The numbers of ewes and lambs owned were compared among respondents without guarding dogs, nonrespondents without guarding dogs, and producers with guarding dogs using an analysis of variance (ANOVA, PROC GLM; SAS Inst. Inc. 1988) after transforming herd sizes to natural logarithms. These transformations were performed to equalize variances. The "protected" least significant difference test (Milliken and Johnson 1984:31–33, Saville 1990:177) was used to compare average herd sizes among respondents without dogs, nonrespondents without dogs, and producers with dogs when the overall F-test indicated significant ($P < 0.05$) treatment effects.

I regressed the number of mortalities against the number of ewes or lambs owned or maintained with dogs. The numbers of ewe and lamb mortalities from all causes and from coyotes were compared among respondents without dogs, nonrespondents without dogs, and producers with dogs by comparing the slopes of regression lines. The analyses were conducted with PROC GLM after weighting the number of mortalities by herd size. Pairwise comparisons between the above 3 groups of producers were made with t-tests that utilized a pooled error mean square from an overall analysis of slopes when differences were found in overall loss rates. One-sided t-tests were used to compare losses by producers using guarding dogs to producers without dogs, whereas a 2-sided t-test was used to compare respondents without dogs to nonrespondents without dogs. Because 3 pairwise comparisons were made, significance was assigned at $P \leq 0.017$ following the Bonferroni procedure to provide an experiment-wise error rate of 0.05.

RESULTS

Seven of the 22 producers with guarding dogs during 1986 used 41 Akbash, 7 used 12 Komondors, 4 used 9 Great Pyrenees, 1 used 3 Anatolians, 1 used 2 Maremma, 1 used 1 Maremma and 1 mixed-breed (Navajo) dog (Black and Green 1985), and 1 used a Komondor by Collie hybrid.

The average number of ewes and lambs owned by respondents without dogs, nonrespondents without dogs, and producers (respondents and nonrespondents) with dogs did not differ (Tables 1, 2). Among producers with sheep in fenced pastures, nonrespondents without livestock guarding dogs lost a greater proportion of their ewes to all causes than did respondents without dogs or producers with dogs (Table 1). Among producers with sheep on open ranges, respondents without dogs lost a greater proportion of their ewes to all causes than did producers with dogs. Within all operations combined, respondents without dogs lost a greater proportion of their ewes to all causes than did producers with dogs.

Among producers using fenced pastures, nonrespondents without livestock guarding dogs lost a greater proportion of their lambs to all causes than did respondents without dogs, and both groups lost greater proportions of their lambs to all causes than did producers with dogs (Table 2). Among producers using open ranges and among all operations combined, respondents without dogs lost a greater proportion of their lambs to all causes than did producers using dogs.

Among producers using fenced pastures, re-

Table 1. Ewe herd sizes, percent ewe mortality from all causes, and percent ewes killed by coyotes in relation to use of livestock guarding dogs as reported by Colorado sheep producers during 1986.

Characteristics of sheep operations	Respondents[a] without dogs			Nonrespondents[b] without dogs			Respondents and nonrespondents with dogs			df	P[c]
	n	$\bar{x}$ or %	SE	*n*	$\bar{x}$ or %	SE	*n*	$\bar{x}$ or %	SE		
Herd size ($\bar{x}$)											
Fenced pastures	78	170A[d]	50	14	215A	139	7	90A	53	2,96	0.506
Open ranges	20	2,204A	558	5	910A	190	10	1,815A	463	2,32	0.724
All operations[e]	119	682A	128	21	369A	121	22	919A	275	2,159	0.365
Mortality from all causes (%)											
Fenced pastures	78	2.1A	0.1	14	7.5B	0.2	7	1.8A	2.2	2,96	<0.0001
Open ranges	20	6.2A	0.4	5	5.9AB	6.2	10	3.4B	0.8	2,32	0.019
All operations	119	6.0A	0.2	21	6.8AB	2.0	22	3.4B	0.4	2,159	<0.0001
Killed by coyotes (%)											
Fenced pastures	78	1.0A	0.0	14	0.5B	0.0	7	0.0AB	0.5	2,96	<0.0001
Open ranges	20	1.5A	0.2	5	1.1A	3.1	10	0.4A	0.6	2,32	0.229
All operations	119	1.5A	0.1	21	0.8AB	0.9	22	0.4B	0.3	2,159	0.0009

[a] Represents producers without livestock guarding dogs that responded to a mail survey.
[b] Represents producers without livestock guarding dogs that did not respond to a mail survey but responded to a follow-up telephone survey.
[c] Probability that the 3 means or regression slopes (% losses) in a row differ.
[d] Means in a row followed by different letters are different ($P < 0.017$/comparison to obtain an experiment-wise $P \leq 0.05$).
[e] Includes fenced pasture; open range; fenced pasture and open range; fenced pasture, open range, and feedlot; and fenced pasture and feedlot operations.

Table 2. Lamb herd sizes, percent lamb mortality from all causes, and percent lambs killed by coyotes in relation to use of livestock guarding dogs as reported by Colorado sheep producers during 1986.

Characteristics of sheep operations	Respondents[a] without dogs			Nonrespondents[b] without dogs			Respondents and nonrespondents with dogs				
	n	$\bar{x}$ or %	SE	*n*	$\bar{x}$ or %	SE	*n*	$\bar{x}$ or %	SE	df	*P*[c]
Herd size ($\bar{x}$)											
Fenced pastures	73	185A[d]	41	14	321A	209	6	192A	87	2,90	0.724
Open ranges	20	2,440A	631	5	960A	153	10	2,261A	558	2,32	0.722
All operations[e]	116	897A	172	21	460A	155	20	1,292A	359	2,154	0.097
Mortality from all causes (%)											
Fenced pastures	73	6.9A	0.2	14	16.6B	0.2	6	1.4C	2.1	2,90	<0.0001
Open ranges	20	20.6A	1.4	5	11.7AB	28.6	10	6.4B	2.9	2,32	0.0005
All operations	116	13.8A	0.8	21	15.8AB	9.2	21	6.4B	2.2	2,155	0.008
Killed by coyotes (%)											
Fenced pastures	73	2.1A	0.1	14	5.0B	0.1	6	0.0C	0.8	2,90	<0.0001
Open ranges	20	15.7A	1.1	5	3.0AB	21.3	10	1.2B	2.8	2,32	0.0002
All operations	116	9.6A	0.7	21	4.7AB	7.7	20	1.2B	2.5	2,154	0.005

[a] Represents producers without livestock guarding dogs that responded to a mail survey.
[b] Represents producers without livestock guarding dogs that did not respond to a mail survey but responded to a follow-up telephone survey.
[c] Probability that the 3 means or regression slopes (% losses) in a row differ.
[d] Means in a row followed by different letters are different ($P < 0.017$/comparison to obtain an experiment-wise $P \leq 0.05$).
[e] Includes fenced pasture; open range; fenced pasture and open range; fenced pasture, open range, and feedlot; and fenced pasture and feedlot operations.

spondents without dogs lost a greater proportion of their ewes to coyotes than did nonrespondents without dogs (Table 1). On open ranges, the proportion of ewes killed by coyotes did not differ among the 3 groups. Within all operations combined, respondents without dogs lost a greater proportion of their ewes to coyotes than did producers with dogs.

Among producers using fenced pastures, nonrespondents without dogs lost a greater proportion of their lambs to coyotes than did respondents without dogs, and both groups lost a greater proportion of their lambs to coyotes than did producers with dogs (Table 2). Among producers using open range and among all producers combined, respondents without dogs lost a greater proportion of their lambs to coyotes than did producers with dogs.

Respondents without dogs, nonrespondents without dogs, and producers with dogs reported that 0.2, 0.0, and 0.2% of their ewes and 0.2, 0.1, and 0.2% of their lambs were killed by black bears. The above producers also reported that 0.3, 0.7, and 0.0% of their ewes and 0.1, 1.6, and 0.1% of their lambs were killed by mountain lions. The relatively high average-lamb-mortality rate caused by mountain lions reported by nonrespondents was primarily influenced by 1 producer who reported 150 of the 159 total lamb losses to mountain lions. The low number of producers reporting black bear and mountain lion predation did not allow a statistical comparison of mortality rates.

Twelve of the 22 producers using guarding dogs rated their dogs' predator control performance as excellent, 8 rated their dogs' performance as good, 1 producer rated his dogs' performance as good and poor, and 1 producer did not provide a rating. The 18 producers that responded to the mail survey indicated that 72 of 80 dogs that they owned during 1986 or previously were effective guardians; similar data were not requested from the producers contacted by phone. Eleven of the producers estimated that each of their dogs saved an average of $3,216 (SE = $1,025, range = $225–10,000) of sheep annually. One producer indicated that each dog saved thousands of dollars annually. The other 10 producers did not provide estimates.

Eight producers indicated that they spent an average of 7.5 hours (range = 0–15 hours) per month training, feeding, and working with each guarding dog that was <9 months old, whereas 1 producer reported that 90 hours were spent per month per dog. Four other producers reported that they spent few hours, very few hours, negligible hours, and little time training, feeding, and working with each guarding dog <9 months old. Seven producers reported that they spent an average of 10.1 hours (range = 2–30 hours) per month feeding and working with each dog >9 months old. These 7 producers also reported that each dog saved an average of 17.6 hours (range = 0-30 hours) per month in reduced management of sheep.

Fourteen producers indicated that guarding dogs reduced their reliance on other predator control techniques, whereas 7 producers indicated that guarding dogs did not. Twelve producers indicated that guarding dogs reduced their reliance on animal damage control agencies, whereas 6 producers indicated that guarding dogs did not. Twenty producers indicated that they had a greater peace of mind knowing that a dog was protecting their flock, whereas 1 producer indicated that use of guarding dogs did not result in a greater peace of mind.

Five of 6 producers that owned Komondors indicated that their dogs were aggressive to people, whereas 0 of 6 owners of Akbash, 0 of 3 owners of Great Pyrenees, 0 of 1 owner of Anatolians, and 0 of 1 owner of a Komondor by Collie hybrid indicated that their dogs were aggressive to people. One producer that owned a Maremma and a Navajo dog indicated that his dogs were mildly aggressive toward people.

Thirty producers that started using guarding dogs (Anatolian, Great Pyrenees, Komondor, Maremma, Shar Planinetz, and various crosses

between these breeds) between the mid-1970's and 1982 were identified. Fourteen of these producers were still using guarding dogs in 1986; 11 were included in the previous comparisons of producers with and without guarding dogs, 1 was not included because of incomplete data, and 2 were not included because they were not identified in the original surveys. Both of these producers expressed satisfaction with their dogs.

Sixteen producers that used guarding dogs before, but not during 1986, were further evaluated to determine their success with dogs. Four (all open-range operators) of the 16 producers again used guarding dogs between 1987 and 1991 and expressed satisfaction with them. Seven (3 open-range, 2 fenced-pasture, and 2 open-range and fenced-pasture operators) of the 16 producers sold their sheep but indicated that they were pleased with the dogs. One open-range producer quit using dogs because his herder did not feed nor like the dogs; he felt the dogs would have been successful with another herder. One producer's dog was killed by a vehicle before it was used with sheep. One producer that grazed sheep on open range and in fenced pastures had 3 dogs <1 year old; 1 was thought to have been killed by a mountain lion, 1 was working well with sheep but was killed by a vehicle, and 1 was unsuccessful. One open-range producer quit using dogs because they often returned to previously used pastures instead of staying with the sheep and were primarily attached to 1 herder. Another open-range producer apparently stopped using dogs because they did not stay with the sheep; however, a past employee and subsequent guarding dog owner indicated that the producer did not know how to manage the dogs.

DISCUSSION

Sheep producers that used livestock guarding dogs in 1986 generally lost a smaller proportion of their ewes and lambs to all causes and to coyotes than did producers without guarding dogs. Comparison of ewe and lamb mortality rates (Tables 1, 2) suggests that some of the lower losses of ewes and most of the lower losses of lambs in guarded herds were attributed to a reduction in coyote predation.

The comparisons of sheep mortality to coyotes in herds with and without guarding dogs do not allow a definitive conclusion that the reduced mortalities were caused by dogs because this study was not an experiment. Lower sheep mortalities to coyotes were correlated with the presence of dogs. Other confounding variables such as possibly more progressive management by producers with guarding dogs could have resulted in lower mortality from coyotes. A cause and effect relationship could be tested by randomly assigning guarding dogs to some producers while others would serve as controls. However, the producers' estimates of the value of sheep saved by guarding dogs strongly suggest that the lower mortalities were the result of guarding dogs.

The comparisons of sheep mortalities sustained by producers with and without guarding dogs and data on effectiveness of dogs used in 1986 primarily reflect the success of producers that have effectively deployed dogs. These comparisons do not reflect the overall success of all guarding dogs because producers that ceased using dogs were not included in these evaluations. However, I believe these comparisons do not grossly overestimate the overall success of guarding dogs because most producers that started using dogs before 1982 but did not use them in 1986 either were pleased with their performance or started using dogs again after 1986. One producer and a past employee of another producer indicated that their lack of success with guarding dogs before 1986 was primarily related to a general lack of information on how to select and manage the dogs.

Twenty of 21 producers that used dogs in 1986 rated their dogs' predator control performance as excellent or good. The ratings were

similar to those reported in Kansas (Andelt 1985) and somewhat higher than those reported across the United States (Green et al. 1984, Green and Woodruff 1988).

Fourteen of 21 producers in this study and 15 of 17 producers in Kansas (Andelt 1985) indicated that guarding dogs reduced their reliance on other predator control techniques. Green et al. (1984) indicated that 8 of 44 and approximately half of 25 other producers reported that guarding dogs were their only method of controlling predation.

The ewe and lamb mortality from coyotes reported in this study was similar to that reported by the U.S. Fish and Wildlife Service (1978) and Pearson (1986). These findings suggest that rates of mortality from predators are fairly static and substantial for the sheep industry.

MANAGEMENT IMPLICATIONS

The lower ewe and lamb mortality from coyotes sustained by producers with guarding dogs and the producers' estimates of the value of sheep saved by dogs indicate that dogs likely reduce mortality from predators. About one-third of producers with guarding dogs indicated that the use of dogs did not reduce their reliance on other predator control techniques or on predator control agencies. Hence, guarding dogs were viewed by some producers as a complement rather than a substitute for other predator control techniques.

Livestock guarding dogs were considered a cost-effective method of reducing sheep mortality from predators for the majority of producers employing them in 1986. The reported annual savings of $3,216 in ewes and lambs per dog by guarding dog owners in Colorado is far above the purchase and annual maintenance costs of dogs. Andelt (1985) reported that guarding dog pups cost an average of $240 and adults $690 plus $26 in shipping fees. I also reported that food, veterinary care, and miscellaneous costs averaged $250 per year. Green et al. (1984) reported that the first-year expenses for a Komondor dog (the most expensive of the breeds surveyed) totaled $883, which included purchase cost, shipping, feed, veterinary expenses, travel, damages caused by the dog, and miscellaneous costs. They also reported that subsequent yearly expenses for food, veterinary care, travel, and miscellaneous expenses averaged $286.

Green et al. (1984) reported that the time required to raise, train, and care for dogs is often overlooked. They reported that 37 ranchers spent an average of 9 hours per month feeding and working with dogs after they were 1 year old, whereas 4 other ranchers spent an average of 11 hours per month. In my study, producers that used guarding dogs in 1986 reported that dogs >9 months old saved more time in sheep management than the amount of time spent feeding and working with each dog, indicating that a savings in time may be an additional benefit of using guarding dogs for some producers.

Green and Woodruff (1988) and my study reported that Komondors were more aggressive toward people than were Akbash, Great Pyrenees, and Anatolians. These differences in aggressiveness should be considered before guarding dogs are purchased. In remote areas or areas where theft of livestock is a concern, Komondors might be considered. Where encounters between guarding dogs and humans are likely, such as on public lands, breeds that are less aggressive than Komondors should be considered.

SUMMARY

Domestic ewe and lamb mortality from all causes and from predators were estimated from surveys of producers with and without livestock guarding dogs in Colorado during 1986. In general, producers without guarding dogs lost a greater proportion of their ewes and lambs from all causes and from coyotes than did producers with guarding dogs. Twenty of 22 pro-

ducers that used guarding dogs in 1986 rated their dogs' predator control performance as excellent or good. Eleven producers estimated that each of their guarding dogs saved an average of $3,216 of sheep annually. The majority of producers also indicated that guarding dogs reduced their reliance on other predator control techniques and on predator control agencies. Twelve of 16 producers that used guarding dogs before, but not during, 1986 either were pleased with their performance or used dogs again after 1986. Guarding dogs may be a cost-effective method of reducing sheep mortality caused by predators for some producers in Colorado.

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