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Source: *Wildlife Society Bulletin*, Vol. 27, No. 3 (Autumn, 1999), pp. 706-714

Published by: Allen Press

Stable URL: <http://www.jstor.org/stable/3784092>

Accessed: 23/02/2010 22:27

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Relative effectiveness of guarding-dog breeds to deter predation on domestic sheep in Colorado

William F. Andelt

Abstract Predators kill significant numbers of domestic sheep in Colorado and the western United States. Thus, I obtained data from 119 sheep producers who used 1 breed of livestock guarding dog (either Akbash, Great Pyrenees, or Komondor) in 1993 and 59 producers who used multiple breeds (including Anatolian Shepherd) in 1995 to assess relative effectiveness of breed of dogs to deter predation on domestic sheep in Colorado. For producers using 1 breed of dog, estimates of ewe and lamb mortalities to most predators in most types of sheep operations, value of sheep saved from predators, and ratings of effectiveness did not vary among breeds of dogs. Producers using multiple breeds of dogs rated Akbash as more effective than Great Pyrenees to deter predation. More producers also rated Akbash as more effective than Komondors to deter predation by all predators combined and by coyotes (*Canis latrans*). More producers rated Akbash as more aggressive, active, intelligent, and faster than Great Pyrenees. More producers also rated Akbash as more aggressive, attentive, trustworthy, active, and faster than Komondors. Anatolians were rated as faster than Great Pyrenees. Great Pyrenees were rated as less active than Komondors. Most producers indicated that the most important attributes of dogs were high aggressiveness to predators, great attentiveness to sheep, and great trustworthiness, whereas fewer producers indicated that great activity level, great intelligence, and fast mobility were important attributes.

Key words Akbash dog, animal damage management, black bears, *Canis latrans*, coyotes, *Puma concolor*, Great Pyrenees, Komondor, mountain lions, predation, *Ursus americanus*

Predators killed 41.8% of the domestic sheep and lambs that died in the United States during 1994 (National Agricultural Statistics Service 1995). Guarding dogs have been used successfully to reduce predatory losses on individual ranches (Linhart et al. 1979; Green et al. 1984; Coppinger et al. 1988; Green and Woodruff 1988; Andelt 1992; Andelt and Hopper, in press). However, little data are available on the relative effectiveness of various breeds of dogs to deter predation. Green and Woodruff (1988) conducted a national survey of sheep and goat producers and reported that effectiveness of Great Pyrenees, Komondor, Akbash, Anatolian, Maremma, and hybrids to deter predation

did not vary. However, they reported that more Komondors than Great Pyrenees, Akbash, and Anatolians bit people, and significantly fewer Great Pyrenees than Komondors, Akbash, and Anatolians injured livestock. Green and Woodruff (1983) placed guarding dogs with sheep producers and reported that Great Pyrenees were significantly more successful than Komondors and Akbash to deter predation on rangelands and pastures. Green and Woodruff (1990) also placed guarding dogs with sheep producers and reported that Great Pyrenees were more effective than Anatolians and that a greater proportion of Anatolians injured and killed livestock than did Great Pyrenees. Green and

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Akbash dogs guarding sheep on open range in Colorado. Photo by William F. Andelt.



Great Pyrenees guarding sheep in Colorado. Photo by William F. Andelt

Woodruff (1989) reported that Akbash and Great Pyrenees both deterred black bear (*Ursus americanus*) predation on sheep. Coppinger et al. (1983a, b; 1988) reported Maremmas were significantly more attentive and more trustworthy than Anatolians. In this paper, I report on the relative effectiveness of Akbash, Great Pyrenees, Komondor, and Anatolian breeds to deter predation on domestic sheep in Colorado.

Methods

During 1993, I acquired complete or nearly complete telephone surveys of 182 producers using livestock guarding dogs in Colorado between 1987 and 1993 (Andelt and Hopper, in press). I contacted Colorado State University Cooperative Extension agents in most counties of Colorado, examined past records, and asked all guarding-dog owners surveyed for names of livestock producers who were using or had used dogs during the last 5 years. I attempted to contact all individuals named. I requested information on type of operation (fenced pasture, open range, feedlot); number of ewes and lambs in an operation; ewe and lamb mortalities from all causes, all predators combined, and specifically from coyotes, black bears, mountain lions (*Puma concolor*), and domestic dogs; breed and number of guarding dogs used; ratings of the effectiveness of dogs; and estimated monetary value of sheep saved by dogs during 1993 or the last year they used dogs. I discarded surveys of producers who used dogs only in feedlots, producers who used dogs for <1 year, and producers who used multiple breeds of dogs, but surveyed producers with multiple breeds in more detail in 1995.

Numbers of ewes and lambs that were guarded by dogs were compared among producers with different breeds of dogs using analysis of variance (ANOVA, GLM Procedure, SAS Institute, Inc. 1988) after log transforming herd sizes to equalize variances.

Numbers of ewes and lambs killed by predators were reported only for periods when dogs were with 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. However, ewe and lamb mortality rates to predators were deleted for 3 producers because guarding dogs were not with sheep during lambing, when mortalities from predators likely are greatest. I compared mortality rates only among producers who indicated a specific predator was found in the area of their operation. I compared numbers of ewe and lamb mortalities to all predators combined and individually to coyotes, black bears, mountain lions, and domestic dogs among respondents with different breeds by testing the slopes of regression lines obtained by regressing number of mortalities against number of ewes or lambs maintained with dogs. I conducted analyses with the GLM procedure after weighting number of mortalities by the reciprocal of number of ewes or lambs with dogs to stabilize the residual variance in the regression. When the overall F-test indicated significant treatment effects, I used 2-sided chi-square tests with 1 degree of freedom to determine which mortality rates differed between breeds. I considered a $P < 0.017$ significant in these 3-treatment comparisons to maintain an experiment-wise error rate of 0.05.

I also determined changes in ewe and lamb herd

sizes and mortality rates from 1986 to 1993 among breeds for producers who did not have dogs in 1986 but obtained them by 1993. I determined percentage changes in ewe and lamb herd sizes by subtracting number of ewes or lambs owned in 1986 from those in 1993, dividing by number of ewes or lambs owned in 1986, and multiplying by 100. I compared these changes with ANOVA after weighting percentage changes by herd sizes in 1986. I determined changes in ewe and lamb mortality rates from 1986 to 1993 by subtracting the proportions of ewe or lamb mortalities in 1986 from those in 1993 for individual producers. I compared these differences among treatments with ANOVA after weighting the differences in mortality rates to all causes by mean number of ewes or lambs owned in 1986 and 1993 for each producer, whereas mortality rates to predators were weighted by the mean number of ewes or lambs with dogs.

I used ANOVA to compare the reported monetary value of sheep saved by dog breeds for producers using 1 breed. I assigned numerical rankings to ratings of the effectiveness of dog breeds (excellent=4, good=3, fair=2, poor=1, unacceptable=0) and compared them with ANOVA using the GLM procedure. I used the "protected" least significant difference test (Milliken and Johnson 1984:31-33, Saville 1990:177) to determine which treatment pairs were different for average number of ewes and lambs maintained by producers with dogs, percentage changes in ewe and lamb herd sizes from 1986 to 1993, differences in mortality rates from 1986 to 1993, and producer ratings of effectiveness among breeds when the overall F-test indicated significant ($P<0.05$) treatment effects.

During 1995, I contacted, by telephone, almost all producers who reported using multiple breeds of dogs during 1993. I requested information on

Table 1. Number of ewes with dogs, percentage ewe mortalities to all causes, and percentage ewe mortalities to predators in relation to breed of guarding dog used reported by Colorado sheep producers using 1 breed of dog, 1993.

Characteristics of sheep operations	Akbash			Great Pyrenees			Komondor			P^a
	n	\bar{x} or %	SE	n	\bar{x} or %	SE	n	\bar{x} or %	SE	
Ewes with dogs (\bar{x})										
Fenced pastures	9	483A ^b	160	53	337A	126	13	145A	60	0.059
Open ranges	17	3,073A	565	15	2,475A	933	0			0.139
All operations ^c	31	2,021C	386	75	806B	225	13	145A	60	≤ 0.001
All causes (%)										
Fenced pastures	9	6.4A	1.1	53	4.1A	0.5	13	4.0A	1.6	0.159
Open ranges	16	5.8A	0.9	15	6.5A	1.0	0			0.631
All operations	30	5.9A	0.5	75	5.7A	0.5	13	4.0A	2.8	0.793
All predators (%)										
Fenced pastures	9	2.1A	0.6	53	0.5A	0.3	13	1.4A	0.9	0.052
Open ranges	17	1.1A	0.3	14	1.8A	0.3	0			0.118
All operations	31	1.2A	0.2	74	1.3A	0.2	13	1.4A	1.1	0.896
Coyotes (%)										
Fenced pastures	9	2.1B	0.6	53	0.3A	0.3	13	1.4AB	0.9	0.032
Open ranges	17	0.8A	0.3	14	1.5A	0.3	0			0.136
All operations	31	0.9A	0.2	74	1.0A	0.2	13	1.4A	1.1	0.791
Black bears (%)										
Fenced pastures	2	0.0A	0.2	18	0.1A	0.1	4	0.0A	0.3	0.905
Open ranges	16	0.3A	0.1	10	0.2A	0.1	0			0.375
All operations	22	0.3A	0.1	33	0.2A	0.1	4	0.0A	0.8	0.567
Mountain lions (%)										
Fenced pastures	3	0.0A	0.0	20	0.0A	0.0	7	0.0A	0.1	0.866
Open ranges	13	0.1A	0.0	9	0.0A	0.0	0			0.327
All operations	20	0.1A	0.0	32	0.0A	0.0	7	0.0A	0.1	0.245
Dogs (%)										
Fenced pastures	8	0.0A	0.0	44	0.1B	0.0	11	0.0AB	0.1	0.021
Open ranges	9	0.0A	0.1	8	0.3B	0.1	0			0.026
All operations	21	0.0A	0.0	58	0.2B	0.0	11	0.0AB	0.1	0.003

^a Probability that the 3 means or regression slopes (% mortalities) in a row do not differ; numerator $df=2$, denominator $df=\text{sum of } n\text{'s in a row minus } 3$.

^b Means in a row followed by different letters differ significantly ($P<0.017/\text{comparison}$ to obtain an experiment-wise $P<0.05$).

^c Includes fenced pasture, open range, fenced pasture–open range, fenced pasture–open range–feedlot, and fenced pasture–feedlot operations.

Table 2. Number of lambs with dogs, percentage lamb mortalities to all causes, and percentage lamb mortalities to predators in relation to breed of guarding dog reported by Colorado sheep producers using 1 breed of dog, 1993.

Characteristics of sheep operations	Akbash			Great Pyrenees			Komondor			<i>P</i> ^a
	<i>n</i>	\bar{x} or %	SE	<i>n</i>	\bar{x} or %	SE	<i>n</i>	\bar{x} or %	SE	
Lambs with dogs (\bar{x})										
Fenced pastures	9	631B ^b	187	52	461AB	141	13	166A	64	0.042
Open ranges	16	3,394A	600	15	2,706A	923	0			0.179
All operations ^c	30	2,290C	413	74	966B	233	13	166A	64	≤0.001
All causes (%)										
Fenced pastures	9	7.1A	1.7	52	5.0A	0.8	12	7.5A	2.7	0.399
Open ranges	14	8.9A	1.4	15	7.7A	1.5	0			0.564
All operations	28	8.9A	0.8	73	6.5A	0.7	12	7.5A	4.1	0.082
All predators (%)										
Fenced pastures	8	2.2A	1.1	52	1.3A	0.5	12	4.1A	1.8	0.267
Open ranges	15	4.0A	0.8	14	3.9A	0.9	0			0.971
All operations	28	4.0A	0.5	73	2.8A	0.5	12	4.2A	2.6	0.201
Coyotes (%)										
Fenced pastures	8	2.2A	1.0	52	0.8A	0.5	12	4.1A	1.6	0.081
Open ranges	15	3.7A	0.6	14	3.0A	0.7	0			0.436
All operations	28	3.7B	0.4	73	2.1A	0.4	12	4.2AB	2.2	0.016
Black bears (%)										
Fenced pastures	2	0.0A	0.6	18	0.3A	0.2	4	0.0A	0.7	0.872
Open ranges	15	0.3A	0.1	10	0.1A	0.1	0			0.137
All operations	21	0.3A	0.1	33	0.1A	0.1	4	0.0A	0.8	0.166
Mountain lions (%)										
Fenced pastures	3	0.0A	0.6	20	0.1A	0.2	7	0.0A	0.7	0.982
Open ranges	12	0.4A	0.2	9	0.1A	0.2	0			0.161
All operations	19	0.4A	0.1	32	0.1A	0.1	7	0.0A	1.0	0.091
Dogs (%)										
Fenced pastures	7	0.0A	0.3	44	0.4A	0.2	11	0.0A	0.6	0.490
Open ranges	9	0.0A	0.0	8	0.0A	0.0	0			1.000
All operations ^c	20	0.0A	0.1	58	0.2A	0.1	11	0.0A	0.5	0.374

a Probability that the 3 means or regression slopes (% mortalities) in a row do not differ; numerator $df=2$ (except on open ranges, $df=1$), denominator $df=\text{sum of } n\text{'s in a row minus } 3$.

b Means in a row followed by different letters differ significantly ($P<0.017/\text{comparison to obtain an experiment-wise } P<0.05$).

c Includes fenced pasture, open range, fenced pasture–open range, fenced pasture–open range–feedlot, and fenced pasture–feedlot operations.

breeds used; ratings of the relative effectiveness of various breeds to deter predation by all predators combined and specifically coyotes, black bears, mountain lions, and domestic dogs; comparisons of various behaviors among breeds; and the producer's rating of the importance of these behaviors to deter predation. I compared ratings of the relative effectiveness to deter predation and ratings of behaviors of various breeds by producers using multiple breeds with the sign test using exact significance levels from a cumulative binomial distribution table. I considered a $P<0.05$ significant in all analyses.

Results

During 1993, I used surveys from 119 producers who used only 1 breed of dog (Akbash, Great Pyrenees, or Komondor). During 1995, I obtained and used surveys from 59 producers (22 in fenced

pastures, 23 on open range, 11 in fenced pasture–open range operations, 2 on open range–feedlot operations, and 1 in a fenced pasture–open range–feedlot operation) that used multiple breeds (including Anatolian Shepherd).

Number of ewes maintained with dogs did not vary among breeds within fenced pastures and on open ranges, but within all operations combined, producers maintained more ewes with Akbash than with Great Pyrenees and Komondors and more ewes with Great Pyrenees than with Komondors (Table 1). Proportion of ewes lost to all causes, to all predators combined, and individually to black bears and mountain lions did not vary among breeds. In fenced pastures, proportion of ewes killed by coyotes was less for herds guarded by Great Pyrenees compared to Akbash, whereas in fenced pastures, on open ranges, or in all operations combined, the proportion of ewes killed by domes-

Table 3. Number of ewes with dogs, percentage ewe mortality from all causes, percentage ewes killed by predators, and differences in these parameters from 1986, before sheep producers had guarding dogs, to 1993, after producers obtained Akbash and Great Pyrenees guarding dogs in Colorado.

Characteristics of sheep operations	Akbash					Great Pyrenees					<i>P</i> ^a
	<i>n</i>	1986	1993	Percentage change	SE	<i>n</i>	1986	1993	Percentage change	SE	
Ewes with dogs (\bar{x})	10	2,587	2,700	4.4	9.5	13	596	409	-31.4	18.1	0.093
Mortalities											
All causes (%)	10	6.5	6.1	-0.4	1.0	13	5.8	4.5	-1.3	0.9	0.602
All predators (%)	10	2.5	1.5	-1.0	0.5	13	1.2	0.3	-0.8	0.4	0.854
Coyotes (%)	10	1.4	1.0	-0.4	0.1	13	1.0	0.1	-0.9	0.4	0.298
Black Bears (%)	9	0.2	0.4	0.1	0.1	8	0.1	0.1	0.1	0.1	0.753
Mountain Lions (%)	9	0.6	0.1	-0.5	0.5	7	0.0	0.0	0.0	0.0	0.517
Domestic dogs (%)	5	0.5	0.1	-0.3	1.0	10	0.0	0.1	0.1	0.1	0.657

^a Probability obtained by subtracting number of ewes or proportion of ewes killed during 1986 from those values for 1993 for individual livestock producers and comparing the differences between ewes guarded by Akbash and Great Pyrenees.

tic dogs was less for herds guarded by Akbash than by Great Pyrenees.

Within fenced pastures, producers maintained more lambs with Akbash than with Komondors (Table 2). Within all operations combined, producers maintained more lambs with Akbash than with Great Pyrenees and Komondors and also had more lambs with Great Pyrenees than Komondors. Proportion of lambs lost to all causes; to all predators combined; and individually to black bears, mountain lions, and domestic dogs did not vary among producers using Akbash, Great Pyrenees, and Komondors in fenced pastures, on open ranges, or in all operations combined, but a greater proportion of lambs was killed by coyotes in herds guarded by Akbash than by Great Pyrenees in all operations combined.

Percentage changes in numbers of ewes and lambs owned from 1986, before producers used guarding dogs, to 1993, after producers used them, did not differ between herds guarded by Akbash and Great Pyrenees (Tables 3, 4). Ewe and lamb mortalities to all causes, to all predators combined, and specifically to coyotes, black bears, mountain lions, and domestic dogs generally were less during 1993 than during 1986, but these differences in mortality rates did not vary for sheep guarded by Akbash and Great Pyrenees. Producer estimates of the monetary value of sheep saved did not vary among breeds of guarding dogs in fenced pastures, on open ranges, or within all operations combined (Table 5).

Producers who used only 1 breed of guarding dog rated Akbash, Great Pyrenees, and Komondors

Table 4. Number of lambs with dogs, percentage lamb mortality from all causes, percentage lambs killed by predators, and differences in these parameters from 1986, before sheep producers had guarding dogs, to 1993, after producers obtained Akbash and Great Pyrenees in Colorado.

Characteristics of sheep operations	Akbash					Great Pyrenees					<i>P</i> ^a
	<i>n</i>	1986	1993	Percentage change	SE	<i>n</i>	1986	1993	Percentage change	SE	
Lambs with dogs (\bar{x})	9	2,712	3,039	12.0	10.1	12	752	548	-26.7	18.2	0.074
Mortalities											
All causes (%)	9	9.2	10.9	1.7	1.3	12	5.9	8.0	2.1	0.9	0.861
All predators (%)	8	5.7	6.4	0.7	1.2	12	3.9	2.6	-1.3	0.8	0.229
Coyotes (%)	8	5.4	5.7	0.2	1.1	12	3.8	2.4	-1.4	0.8	0.285
Black Bears (%)	7	0.2	0.6	0.5	0.2	7	0.0	0.2	0.2	0.2	0.253
Mountain lions (%)	7	0.1	0.9	0.8	0.3	6	0.0	0.0	0.0	0.0	0.076
Domestic dogs (%)	5	0.0	0.0	0.0	0.0	9	0.0	0.0	0.0	0.0	1.0

^a Probability obtained by subtracting number of lambs or proportion of lambs killed during 1986 from those values for 1993 for individual livestock producers and comparing the differences between lambs guarded by Akbash and Great Pyrenees.

Table 5. Producer estimates of the value (\$) of sheep saved from predators by each guarding dog of 3 breeds in Colorado, 1993.

Characteristics of sheep operations	Akbash			Great Pyrenees			Komondor			<i>P</i> ^a
	<i>n</i>	\bar{x}	SE	<i>n</i>	\bar{x}	SE	<i>n</i>	\bar{x}	SE	
Fenced pastures	7	2,138	947	41	1,326	332	6	417	242	0.339
Open range	13	3,763	1,307	12	5,178	2,162	0			0.574
All operations	24	3,152	763	59	2,110	525	6	417	242	0.256

^a Probability that the means for guarding dog breeds do not differ.

as similar in effectiveness to protect sheep from all predators combined and for specific predators (Table 6). Both Akbash ($P=0.040$) and Great Pyrenees ($P=0.013$) were rated as more effective to deter predation by coyotes compared to black bears and mountain lions in all operations combined, but the ratings of effectiveness for all 3 breeds did not vary among predators within fenced pastures and on open ranges.

More producers who owned multiple breeds rated Akbash as more effective than Great Pyrenees to deter predation by all predators combined and specifically by coyotes, black bears, mountain lions, and domestic dogs (Table 7). A greater number of producers rated Akbash more effective than

Komondors to deter predation by all predators combined and by coyotes. Producers generally rated Anatolians as more effective than Great Pyrenees; however, small sample sizes did not allow definitive conclusions. Akbash and Anatolians and Great Pyrenees, Komondors, and crosses between these latter breeds generally were rated as similar in effectiveness, but small sample sizes do not allow definitive conclusions.

More producers rated Akbash as more aggressive, active, intelligent, and faster than Great Pyrenees (Table 8). A greater number of producers also rated Akbash as more aggressive, attentive, trustworthy, active, and faster than Komondors. Anatolians were rated as faster than Great Pyrenees. Great Pyrenees

Table 6. Producers using 1 breed of guarding dog and ratings of effectiveness of various breeds to deter predators from preying on domestic sheep in Colorado, 1993.

Characteristics of sheep operations	Akbash			Great Pyrenees			Komondor			<i>P</i> ^b
	<i>n</i>	\bar{x} ^a	SE	<i>n</i>	\bar{x}	SE	<i>n</i>	\bar{x}	SE	
Fenced pastures										
All predators	9	3.67	0.17	52	3.61	0.09	13	3.15	0.30	0.119
Coyotes	9	3.56A ^c	0.18	53	3.64A	0.08	13	3.12A	0.32	0.071
Black bears	2	3.50A	0.50	10	3.40A	0.22	1	3.00A		0.838
Mountain lions	2	3.50A	0.50	9	3.56A	0.18	4	3.75A	0.25	0.805
Domestic dogs	8	3.50A	0.38	40	3.30A	0.15	10	3.05A	0.34	0.612
Open ranges										
All predators	17	3.38	0.21	15	3.50	0.24	0			0.715
Coyotes	17	3.44A	0.19	15	3.53A	0.24	0			0.762
Black bears	16	2.69A	0.28	7	3.14A	0.34	0			0.361
Mountain lions	8	2.63A	0.50	6	2.67A	0.56	0			0.957
Domestic dogs	8	3.00A	0.38	8	2.88A	0.48	0			0.841
All operations										
All predators	31	3.44	0.14	74	3.55	0.08	13	3.15	0.30	0.222
Coyotes	31	3.48B	0.12	75	3.60B	0.08	13	3.12A	0.32	0.102
Black bears	22	2.82A	0.22	21	3.14A	0.19	1	3.00A		0.546
Mountain lions	13	2.81A	0.36	16	3.13A	0.26	4	3.75A	0.25	0.338
Domestic dogs	20	3.35AB	0.22	54	3.17AB	0.14	10	3.05A	0.34	0.701

^a Means were obtained by averaging producer ratings of the effectiveness of guarding dogs (excellent=4, good=3, fair=2, poor=1, and unsatisfactory=0).

^b Probability that the means for guarding dog breeds do not differ.

^c Means in a column within fenced pastures, open ranges, and all operations followed by the same letter do not differ.

Table 7. Number of livestock producers rating 1 livestock guarding-dog breed better or the same as another breed to protect domestic sheep from predators in Colorado, 1995.

Guarding-dog breeds	Predator														
	Coyotes			Black bears			Mountain lions			Domestic dogs			All predators		
	1	E	2	1	E	2	1	E	2	1	E	2	1	E	2
Akbash, Anatolian	2	2	2 ^a	2	1	1	1	0	1	0	4	0	3	0	3
Akbash, Great Pyrenees	17	5	0 ^{***b}	10	4	1*	10	3	0 ^{**}	8	5	0 ^{**}	17	4	1 ^{***}
Akbash, Komondor	7	0	0*	2	0	1	2	1	0	6	0	1	7	0	0*
Anatolian, Great Pyrenees	4	3	0	4	1	0	2	0	0	2	2	1	5	0	2
Great Pyrenees, Komondor	4	13	1	1	3	0	1	1	0	2	7	6	6	9	3
Great Pyrenees, Great Pyrenees-Komondor cross	4	6	2	0	1	0	0	0	0	3	4	2	4	6	2
Komondor, Great Pyrenees-Komondor cross	0	3	1	0	1	0	0	0	0	1	2	0	0	3	1

^a The first number represents number of producers rating the first breed better than the second, the second number represents number producers rating the breeds equal, and the third number represents number of producers rating the second breed better than the first breed.

^b *= $P < 0.05$, **= $P < 0.01$, ***= $P < 0.001$.

were rated less active than Komondors. Most producers felt that the most important attributes to deter predation were high aggressiveness to predators, high attentiveness to sheep, and high trustworthiness; some felt that high activity levels, intelligence, and mobility were important attributes (Table 9).

Discussion

The proportion of ewe and lamb mortalities to most predators in most types of sheep operations, changes in mortality rates before compared to after

obtaining guarding dogs, estimates of the value of sheep saved from predators, and ratings of effectiveness did not differ among Akbash, Great Pyrenees, and Komondors as reported by producers using 1 breed of dogs during 1993. These findings concur with a national survey that indicated no difference in effectiveness among breeds (Green and Woodruff 1988). In contrast, producers in this study who used multiple breeds rated Akbash as more effective than Great Pyrenees and Komondors

to deter predation. These findings differ from Green and Woodruff (1983), who reported that Great Pyrenees were more successful than Akbash. The differences between these studies may be related to differences in strains within breeds or perhaps selection for more effective Akbash in recent years.

The lack of correspondence between ratings of effectiveness of producers using single and multiple breeds of dogs in this study indicates that the differences noted by producers who used multiple breeds are small or that comparisons among producers who used only 1 breed are at too coarse a

Table 8. Number of livestock producers rating 1 livestock guarding-dog breed's behavior above or the same as another breed when protecting domestic sheep from predators in Colorado, 1995.

Guarding-dog breeds	Behavior																	
	Most aggressive			Most attentive			Most trustworthy			Most active			Fastest		Most intelligent			
	1	E	2	1	E	2	1	E	2	1	E	2	1	E	2	1	E	2
Akbash, Anatolian	3	0	3 ^a	1	2	2	4	0	1	3	1	2	3	0	3	3	2	1
Akbash, Great Pyrenees	18	3	0 ^{***b}	10	6	5	8	9	4	18	4	0 ^{***}	19	2	0 ^{***}	16	4	2 ^{**}
Akbash, Komondor	6	1	0*	7	0	0*	6	1	0*	7	0	0*	7	0	0*	5	2	0
Anatolian, Great Pyrenees	6	0	1	2	2	2	0	3	3	5	1	1	6	1	0*	4	2	1
Great Pyrenees, Komondor	3	7	8	8	5	5	12	2	4	2	4	11*	3	5	8	5	8	5
Great Pyrenees, Great Pyrenees-Komondor cross	4	3	5	3	6	3	4	6	2	2	4	6	1	6	5	6	3	3
Komondor, Great Pyrenees-Komondor cross	3	1	0	2	1	1	0	1	3	2	0	2	3	1	0	3	0	1

^a The first number represents number of producers rating the first breed better than the second, the second number represents number producers rating the breeds equal, and the third number represents number of producers rating the second breed better than the first breed.

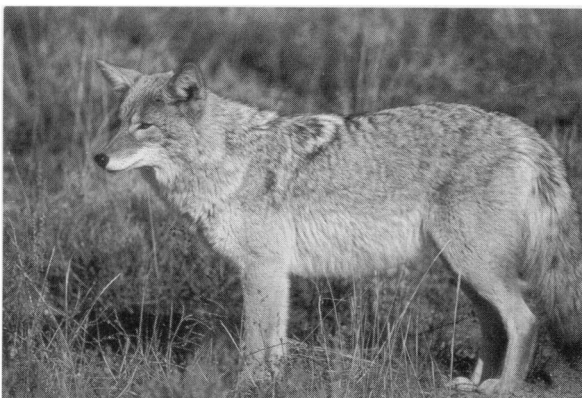
^b *= $P < 0.05$, **= $P < 0.01$, ***= $P < 0.001$.

Table 9. Livestock producer ratings of the importance of various livestock guarding-dog behaviors for reducing predation on domestic sheep in Colorado, 1995.

Guarding-dog behaviors	Number producers	Percentage		
		Very important	Medium importance	Not important
Very aggressive to predators	58	88	12	0
Very attentive to sheep	59	92	8	1
Very trustworthy	59	93	7	0
Very active/energy level	58	22	77	2
Fastest for chasing/ frightening predators	59	42	55	3
Very intelligent	57	54	45	2

scale to determine relative effectiveness of different breeds. I surmise that ratings of relative effectiveness are most accurately portrayed by producers who used multiple breeds because the dogs generally were used under similar conditions by individual producers.

Producers using 1 breed of guarding dog and in all operations combined reported larger numbers of ewes and lambs guarded by Akbash than by Great Pyrenees and Komondors. These differences apparently were related to larger herds of sheep grazed on open range compared to those grazed in fenced pastures and to a preponderance of Akbash used on open range, whereas most Great Pyrenees and all Komondors were used in fenced pastures (Tables 1, 2). In all operations combined, the greater proportion of lamb mortalities to coyotes in herds guarded by Akbash compared to Great Pyrenees likely was related to relatively greater use of Akbash on open range and the associated greater sheep mortalities there rather than Akbash being



Coyotes are the major predator of domestic sheep in Colorado. Photo by William F. Andelt.

less effective than Great Pyrenees.

Coppinger et al. (1983a,b) indicated that attentiveness, trustworthiness, and protectiveness are the most important behaviors of guarding dogs. Similarly, McGrew and Blakesley (1982) reported that aggressive and attentive dogs were more successful in protecting sheep. Livestock producers in this study concurred.

Producers using multiple breeds of dogs rated Akbash as more aggressive toward predators, active, intelligent, and faster than Great Pyrenees. Green and Woodruff (1990) reported that Great Pyrenees (presumably compared to Akbash, Anatolians, and Kuvasz) were less likely to be aggressive toward unfamiliar domestic dogs. Thus, the lower proportion of ewes killed by domestic dogs in herds guarded by Akbash compared to Great Pyrenees for producers using 1 breed of dog and the ratings of greater effectiveness of Akbash compared to Great Pyrenees by producers using multiple breeds probably were related to the greater aggressiveness of Akbash. However, the Akbash's greater activity, intelligence, and mobility behaviors also may have contributed. The more aggressive, attentive, and trustworthy ratings of Akbash compared to Komondors apparently attributed to their rating of greater effectiveness to deter predation.

Green and Woodruff (1990) recommended using aggressive breeds, such as Anatolian, Akbash, and Komondor, where bears (*Ursus* spp.), mountain lions, and wolves are frequent predators. Producers using multiple breeds of dogs concurred by rating Akbash as more effective than Great Pyrenees against all predators. They also rated Akbash as more effective than Komondors against all predators combined and coyotes.

Coppinger et al. (1983a,b; 1988) rated Anatolians less in attentiveness and trustworthiness than Maremmas. Green and Woodruff (1990) reported that Anatolians were rated less in performance than Great Pyrenees, with a greater proportion of Anatolians injuring or killing livestock. Producers using multiple breeds of dogs in my survey also tended to rate Anatolians less trustworthy than

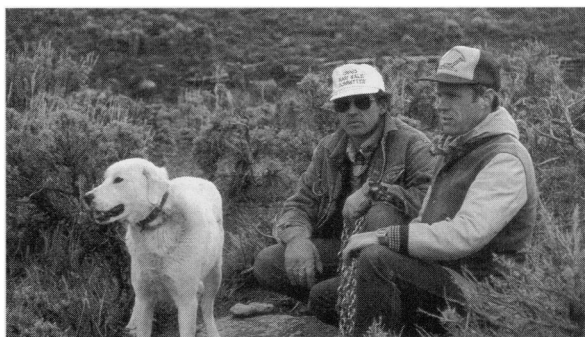
Great Pyrenees and Akbash; however, Anatolians were rated as effective as Akbash and Great Pyrenees to deter predation; unfortunately, small sample sizes did not allow enough power to determine significant differences, if present.

Using livestock guarding dogs has been successful to deter predation on sheep (Green et al. 1984; Coppinger et al 1988; Green and Woodruff 1988; Andelt 1992; Andelt and Hopper, in press). Producers who have used 1 breed of dog usually have rated the breeds similar in effectiveness (Green and Woodruff 1988, this study). However, the greater number of producers using multiple breeds of dogs that rated Akbash better than Great Pyrenees and Komondors in this study suggests Akbash may be the breed of choice in fenced pastures and on rangelands.

Acknowledgments. I thank the many sheep producers who responded to this survey. J. S. Green provided suggestions on the survey. S. N. Hopper conducted the telephone surveys. M. G. Fuentes obtained telephone numbers of producers and entered the data. K. P. Burnham provided statistical advice. P. A. Vohs reviewed an earlier draft of the manuscript.

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Associate Editor: Conner

