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MIRROR-IMAGE STIMULATION -- WHAT CAN WE ASCERTAIN ABOUT MOUNTAIN GOAT SOCIAL STRUCTURE?

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Abstract: Nine free-ranging and 5 zoological-garden-enclosed mountain goats (Oreamnos americanus) were exposed to a 59 x 79 cm fixed-mirror to elucidate behavior associated with intraspecific interaction and dominance hierarchy. Observations were from ≤ 10 m either by eye or study of video recordings. Agonistic, excitatory, and investigatory behaviors were exhibited in apparent response to the mirror. In free-ranging animals, kids exhibited no agonistic behaviors, adult females exhibited 0.47 agonistic behaviors per exposure (56.4% of the behaviors were agonistic), and a 2-year old male exhibited 0.59 agonistic behaviors per exposure (68.4% of the total behaviors were agonistic). Numbers of agonistic, excitatory, and investigatory behaviors were not significantly different between females and the male, but kids were less agonistic and more investigatory. Agonistic behavior and age appeared to be positively correlated with rank in females. The zoo-enclosed animals exhibited no agonistic behaviors, and fewer types of behaviors and a greater proportion of investigatory behaviors than did the free-ranging animals.

Intraspecific interactions and dominance hierarchies in North American wild bovids, especially in females, have received limited study (Bennett 1986, Chadwick 1977,Dane 1977, Holmes 1988, Masteller and Bailey 1988, Risenhoover and Bailey 1985, Rutberg 1986, Singer 1977). Rutberg (1986) addressed dominance and fitness in bison (Bison bison) cows. Geist (1971:196) mentions dominance in female bighorn sheep (Ovis canadensis). Dominance hierarchies in female mountain goats are often considered, possibly because of their aggressiveness (Chadwick 1983, Stevens 1983).

Most observations of dominance hierarchies in mountain goats have been made on free-ranging animals interacting under supposedly unmanipulated conditions (unaffected by human observers). Some workers (Fisler 1977, Masteller and Bailey 1988) have used both artificial and spatially limited resources to attract animals where close proximity increases interactions. Another approach is to elicit response using mirror-image stimulation (Gallup 1968, Svendsen and Armitage 1973). Here, I report the responses of free-ranging and zoo-enclosed mountain goats to mirror-image stimulation (MIS) and their relevance to intraspecific behavior and a dominance hierarchy.

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STUDY AREA

Free-ranging animals were part of the Mt. Evans introduced herd in central Colorado about 50 km westsouthwest of Denver. Elevation was 3,835 m. A saltlick had been established and used by the animals for 2-3 years. An observation shelter (surplus half-sized army bus) had been regularly positioned within 10 m of the lick, and the animals were well habituated to it. The zoo-enclosed animals were in an approximately 0.1-ha enclosure at the Denver Zoological Gardens.

METHODS

Free-ranging

Of 9 free-ranging animals, 4 were individually collared adult females (estimated ages = 2, 4, 6, and 11), 1 was an unmarked 2-year old male, and 4 were unmarked kids. A 59 x 79 (w x h) cm framed-mirror was mounted upright against a wooden box structure positioned about halfway between the lick and the observation shelter. Once positioned, large rocks were placed inside to stabilize the structure (breaking and/or toppling mirror were possibilities). The mirror was covered by a curtain that could be lowered or raised by a line to initiate and terminate a trial. This precluded unwanted exposure before observers were ready. Once a group with at least 1 collared goat had arrived at the lick and the observers were out-of-sight in the shelter, the curtain was dropped and responses to mirror-images recorded and selectively photographed.

Zoo-enclosed

Of 5 zoo animals, 4 were individually ear-tagged adult females (ages = 5, 5, 6, and 8), and 1 was a 4-year old male. For these trials, which were intended to increase sample size and provide a more controlled environment than with the free-ranging goats, the mirror (same as described above) was placed in the mountain goat enclosure about 10 m from a video system (Reed et al. 1973). Once the video system was activated and the mirror positioned, the observer stayed out of sight in a housing containing the video system. Visual observations were recorded with each video recording for later identification of animals (eartags could not be discerned on the video) and enhancement of behavioral interpretation. The video recordings were later replayed and behavioral response frequencies tabulated.

RESULTS

Free-ranging

Six trials were completed with 9 animals in groups of 3-6 goats from 7 July - 20 September 1984. Trials ranged 18-53 minutes depending on how long a group remained in the area and interacted with the mirror. The 4 females, male, and 4 kids, had totals of 9, 1, and 6 bouts in front of

the mirror, and 112, 44, and 66 exposures to the mirror, respectively (Table 1). The 4 kids were associated (likely maternally) with 3 of the 4 adult females.

Behaviors exhibited in apparent response to the MIS were classified as agonistic, excitatory, or investigatory (Table 1). Of the behaviors exhibited by adult females and the 2-year old male, 56.4 and 68.4 percent, respectively, were agonistic. Adult females and the male exhibited 0.47 and 0.59 agonistic behaviors per exposure, respectively. Kids exhibited no agonistic behavior. There was no significant difference in numbers of agonistic, excitatory, and investigatory behaviors between females and the male ($\chi^2 = 3.748$, df = 2, $P > 0.10$), but kids were significantly less agonistic and more investigatory ($\chi^2 = 102.017$, df = 2, $P < 0.005$). Of the 3 females greater than 2 years old, 11-year old 1^{II} exhibited significantly more agonistic behavior than 6-year old BD ($\chi^2 = 6.065$, df = 2, $P < 0.05$) and 4-year old O ($\chi^2 = 43.539$, df = 2, $P < 0.005$). Similarly, BD exhibited more agonistic behavior than O ($\chi^2 = 10.959$, df = 2, $P < 0.005$), although sample sizes are small (Table 1).

Table 1. Animal(s), number of bouts, exposures, and behaviors exhibited to mirror-images.

			Agonistic				Excitatory			Investigatory			
Animal	Bouts[1]	Exp[2]	Low ear	OT[3]	,Pt[4]	,Pt[5]	Tail-up	Jerk[6]	Paw[7]	Lick mirror	Muzzle to mirror	Stare[8]	Head mvmt[9]
Free-ranging													
1^{II}	5	56	2	0	25	19	0	2	4	0	0	0	0
O	2	15	0	0	0	0	9	1	0	2	2	0	0
V	1	7	0	1	1	0	1	0	0	4	0	0	0
BD	1	34	2	0	3	0	0	0	4	0	0	0	0
TOTAL Ads	9	112	4	1	29	19	10	3	8	6	2	0	0
2 yr ♂	1	44	20	0	6	0	0	6	3	0	0	0	0
4 kids	6	66	0	0	0	0	1	1	0	0	23	6	2
Enclosed - Zoological gardens													
White	16	81	0	0	0	0	7	0	0	-	-	16	12
Blue	7	69	0	0	0	0	2	0	0	-	-	12	1
Purple	20	91	0	0	0	0	4	0	0	-	-	41	7
Yellow	17	60	0	0	0	0	12	0	0	-	-	30	5
TOTAL Ams	60	301	0	0	0	0	25	0	0	-	-	99	25
4 yr ♂	20	38	0	0	0	0	4	0	0	-	-	15	3

[1]Defined as being < 5 m from front of mirror for > 5 sec.
[2]Exposures defined as apparent looking at mirror image during bout.
[3]Orientation threat as defined by Chadwick (1977:78).
[4]Slight present threat (PT as defined by Chadwick 1977:78).
[5]Intense present threat (PT as defined by Chadwick 1977:78).
[6]A sudden start or movement of head away from mirror image.
[7]Paw ground.
[8]Stare or look at mirror (≥ 5 sec.).
[9]Back and forth head movement.

Considering dominance interactions, age, and number of neonates of the 3 females greater than 2 years old involved in the MIS and 10 additional collared females in the study area during 1983 and 1984 (Reed unpub. data), some aspects of a dominance hierarchy emerge. Specifically, 1[11], BD, and O ranked number 1, 9, and 10, respectively, in 1983 and 5, 8, and 9, respectively, in 1984 (Tables 2-4). This hierarchy is consistent with greater agonistic responses in that 1[11] was the most agonistic and of highest rank, BD was considerably less agonistic and of lower rank, and O was least agonistic and of lowest rank. Furthermore, the 1983 and 1984 hierarchy ranks of these 3 females were similarly consistent with their ages (i.e. greater age, higher rank; Table 4). However, of all 13 animals in which dominance had been determined (Table 4), there were no significant regressions of rank on age for 1983 ($T = -1.86$, $df = 9$, $P = 0.09$) or 1984 ($T = -0.99$, $df = 7$, $P = 0.36$). Also, of the 13 animals, there were no significant regressions of rank on number of neonates for 1983 ($T = -1.18$, $df = 9$, $P = 0.27$) or 1984 ($T = -1.49$, $df = 7$, $P = 0.17$) and rank on an "age/number of neonates" index (Table 4) for 1983 ($T = -1.89$, $df = 9$, $P = 0.09$) or 1984 ($T = -1.61$, $df = 7$, $P = 0.15$).

Table 2. Outcome of dominance interactions between 11 collared female mountain goats, ages 2-10, Mount Evans, 1983.

	Losses											Total wins	Rank
	1[11]	M	FG	3	N	BK[1]	F	4	BD	O	B		
WINS													
1[11]			8	1				1	1		1	12	1
M					1	2	1				1	5	2
FG						5		1			3	9	3
3								1		1		2	4
N											1	1	5
BK[1]	5								1	1		7	6
F												0	7
4												0	8
BD												0	9
O												0	10
B									1	1		2	11
Total losses	5	0	8	1	1	7	1	3	3	3	6	38	

Table 3. Outcome of dominance interactions between 9 collared female mountain goats, ages 3-11, Mount Evans, 1984.

	Losses									Total wins	Rank
	FG	N	K	P	1[11]	B	3	BD	O		
WINS											
FG				3						3	1
N					1				2	3	2
K								2		2	3
P									5	5	4
1[11]									2	2	5
B							1		1	2	6
3										0	7
BD						1				1	8
O										0	9
Total losses	0	0	0	3	1	1	1	2	10	18	

Table 4. Rank, age, and number of neonates of 13 collared mountain goats, Mt. Evans, 1983 and 1984.

	Rank		Age		No. of neonates		Age/no. neonate index ([a+5] + n)[3]	
Animal	1983	1984	1983	1984	1983	1984	1983	1984
1[11]	1	5	10	11	1	2	3.0	4.2
M	2	-[1]	6	7	1	0	2.2	1.4
FG	3	1	7	8	1	1	2.4	2.6
3	4	7	5	6	1	0	2.0	1.2
N	5	2	5	6	1	2	2.0	3.2
BK[1]	6	-	8	9	1	-	2.6	-
F	7	-	2	3	0	-	0.3	-
4	8	-	3	4	1	0	1.6	0.8
BD	9	8	5	6	2	1	3.0	2.2
O	10	9	3	4	0	1	0.6	1.8
B	11	6	7	8	0	0	1.4	1.6
K	-	3	9	10	0	2	1.8	4.0
P	-	4	2	3	0[2]	1	0.3	1.6

[1]Undetermined.
[2]Estimate based on age.
[3]Equation for combining age (a) and no. of neonates (n).

Zoo-enclosed

Four trials were completed with 5 animals in the mountain goat enclosure from 20 February - 26 April 1986. Trials ranged from 20-52 minutes depending on an objective of $\geq$ 20 minutes and how long animals interacted with the mirror. The 4 females and the male had totals of 60 and 20 bouts, and 301 and 38 exposures to the mirror, respectively (Table 1). Behaviors exhibited in apparent response to the MIS were divided into the same categories as those of the free-ranging animals except that 2 investigatory behaviors, "lick mirror" and "muzzle to mirror," could not be determined because of the mirror's position

perpendicular to the video and observer's line-of-sight. No agonistic behaviors to MIS were observed in either the females or the male. Of the 3 excitatory behaviors, only the "tailup" behavior was observed (25 and 4 times for the females and male, respectively, Table 1). The investigatory behaviors, 124 and 18 for the females and male, respectively, were exhibited in greater proportion than those of the free-ranging animals (Table 1). No statistical tests were made between the 3 categories of behavior or the responses of individual animals because of limited sample sizes.

DISCUSSION

It has been suggested that most of the intraspecific social interactions in mountain goats are aggressive, and that males tend to dominate females and older goats dominate younger ones (Chadwick 1983, Dane 1977). But are these relationships based on age or other factors significantly linear as has been suggested for a majority of hierarchies (Jackson and Winnegard 1988)? Furthermore, there is a need to examine the development of dominance relationships (Chase 1980, 1985). Thus, what are the behavioral processes that lead to hierarchy formation?

In this study dominance ranks were determined for only 2 consecutive years, whereas an animal's life-long interactions, as well as previous maternal dominance, would provide a better basis for estimating how, if not why, dominance hierarchies are maintained in mountain goats. Additionally, the limited sample sizes reported here for both the number of interactions in each of the years and the number of animals and trials may not adequately describe the variation of these phenomena. But the study provides a basis for hypotheses about differences between sexes, between females of different ages and reproductive states, and the difference between free-ranging and zoo-enclosed animals.

It is hypothesized that the greater the number of agonistic behaviors elicited from MIS in free-ranging animals, the higher the rank in a dominance hierarchy. Also,age appears positively correlated with rank in females. Although it is attractive to ascribe higher status with having at least 1 neonate, no pattern emerged to support this hypothesis. Other factors including dominance of dam, early separation from dam, development of dominance via cohort interactions, body size, vigor, and inherited characters may be related to rank.

Intraspecific interactions and a dominance hierarchy may influence mountain goat distribution, fitness, and ultimately population size. Also, interspecific competition may be complicated by individuals that occupy different ranks within their own species' hierarchy. Intraspecifically low-ranking individuals may act the same way interspecifically, at least with individuals of their size (Fisler 1977). Social mechanisms in mountain goats may have evolved to regulate population size, especially in the absence of important interspecific competition and predation. An understanding of such phenomena is important for effective management of this species.

LITERATURE CITED

Bennett, B. 1986. Social dominance in female bighorn sheep. Zoo Biol. 5:21-26.

Chadwick, D. H. 1977. The influence of mountain goat social relationships on population size and distribution. pp. 74-91 in W. Samuel and W. G. Magregor (Eds.). Proc. First Internat. Mountain Goat Symp. Kalispell, MT. 243pp.

_____. 1983. A beast the color of winter. Sierra Club Books. San Francisco, CA. 208pp.

Chase, I. D. 1980. Social process and hierarchy formation in animal societies. Amer. Sociol. Rev. 45:905-924.

_____. 1985. The sequential analysis of aggressive acts during hierarchy formation: an application of the "jigsaw puzzle" approach. Anim. Beh. 33:86-100.

Dane, B. 1977. Mountain goat social behavior: social structure and "play" behavior as affected by dominance. pp. 92-106 in W. Samuel and W. G. Magregor (Eds.). Proc. First Internat. Mountain Goat Symp. 243pp.

Fisler, G. F. 1977. Interspecific hierarchy at an artificial food source. Anim. Behav. 25:240-244.

Gallup, G. G., Jr. 1968. Mirror-image stimulation. Psychol. Bull. 70:782-793.

Geist, V. 1971. Mountain sheep: a study in behavior and evolution. Univ. Chicago Press, Chicago, IL. 383pp.

Holmes, E. 1988. Foraging behaviors among different age and sex classes of Rocky Mountain goats. Bienn. Symp. North. Wild Sheep and Goat Counc. 6:13-25.

Jackson, W. M., and R. L. Winnegrad. 1988. Linearity in dominance hierarchies: a second look at the individual attributes model. Anim. Beh. 36:1237-1240.

Masteller, M. A., and J. A. Bailey. 1988. Agonistic behavior among mountain goats foraging in winter. Can. J. Zool. 66:2585-2588.

Reed, D. F., T. M. Pojar, and T. N. Woodard. 1973. A video time-lapse system for wildlife surveillance. Colo. Div. of Wildl., Game Infor. Leafl. 94. 3pp.

Risenhoover, K. L., and J. A. Bailey. 1985. Relationships between group size, feeding time, and agonistic behavior of mountain goats. Can. J. Zool. 63:2501-2506.

Rutberg, A. T. 1986. Dominance and its fitness consequences in American bison cows. Behaviour 96 (Part 1-2):62-91.

Singer, F. J. 1977. Dominance, leadership and group cohesion of

mountain goats at a natural lick Glacier National Park, Montana. pp. 107-113 in W. Samuel and W. G. Magregor (Eds.). Proc. First Internat. Mountain Goat Symp. Kalispell, MT. 243pp.

Stevens, V. 1983. The dynamics of dispersal in an introduced mountain goat population. Ph.D. Dissert., Univ. of Washington, Seattle, WA. 201pp.

Svendsen, G. E., and K. B. Armitage. 1973. Mirror-image stimulation applied to field behavioral studies. Ecol. 54:623-627.