

DO PERSISTING MATRILINEAL GROUPS PARTITION RESOURCES ON MOUNTAIN GOAT
WINTER RANGES?

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Abstract: Agonistic behavior within foraging groups of mountain goats (*Oreamnos americanus*) was studied both at and away from an artificial food bait for 2 winters in south-central Colorado. During this study, 3 frequently observed marked nannies belonged to separate, relatively stable groups of mostly female goats. Of these 3 nannies, the oldest and most dominant was most often seen at the bait, had the smallest home range, and was most likely to be near the bait site. Results suggested that social groups persisted within this population. We speculate that: the groups observed were matrilineal; there may have been resource partitioning among groups, and; groups led by older more dominant nannies achieved priority access to preferred resources.

Relations between social behavior and density-dependent population regulation in mountain goats are not understood. It is likely that social behavior influences population regulation in a K-selected species, such as mountain goats, by distributing goats in relation to the physical habitat and available food resources (Kuck 1977). On cliff winter ranges areas with optimum snow-shedding characteristics (Adams and Bailey 1980) are distributed patchily, as are food resources, which occur on benches or as scattered trees and shrubs. These patchy resources are used by small, stable groups of goats (Brandborg 1955, Smith 1976, Chadwick 1977), in which the rate of agonistic behavior among goats is high (Chadwick 1977, Dane 1977). Results of several studies cited below, indicate there are matrilineal relationships within these groups.

The social system of mountain goats has been described as a dominance hierarchy based upon defense of a mobile personal space (Chadwick 1977), and adult females appear dominant in winter (Chadwick 1977, Kuck 1977, Smith 1977). Female-subadult groups are common during summer and winter, and adult males use ranges separate from female-subadult groups (Geist 1964, 1974; Chadwick 1977; Kuck 1977; Stevens 1983; Risenhoover and Bailey 1985).

Mountain goat kids usually remain with their mothers for 10-11 months (Brandborg 1955, DeBock 1970, Foster and Rahe 1982, Chadwick 1983).

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and longer associations have been reported when the female does not produce a new kid (Hutchins and Hansen 1980). A prolonged nanny-juvenile bond could confer survival advantages to the offspring, and possibly increased reproductive fitness to the female (Trivers 1974, Hutchins and Hansen 1980, Clutton-Brock et al. 1982).

Density dependence has been observed in our study herd. Six mountain goats were introduced onto Sheep Mountain, in the Sawatch Range of Colorado, in 1950 (Rutherford 1972). Reproductive success (measured as kid:older animal ratios) of these goats declined by 47%, beginning in 1976, after the herd had doubled in size during 1970-1975 (Adams and Bailey 1982). We hypothesized that social mechanisms influenced this density-correlated decline in reproductive success.

We studied agonistic behavior of foraging mountain goats during 2 winters to explore social mechanisms of population regulation (Masteller 1987, Masteller and Bailey In Press). During this study, it appeared that goats wintering on the study area were members of distinct social groups. While the data were not conclusive, we are reporting our findings and proposing further research.

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STUDY AREA AND METHODS

Sheep Mountain is approximately 14 km west of Buena Vista, in south-central Colorado. Vegetation includes conifer forests, old burns with quaking aspen (Populus tremuloides), and mountain shrubs. Cliffs and outcrops dominate most south and southeast exposures. The geology, flora and vertebrate fauna have been described by Adams (1981).

Goat behavior at Sheep Mountain was observed during November-April, 1984-85 and 1985-86, with 10X50 binoculars and a 15-60X telescope. Observations were recorded on tape. Goats were classified by horn characteristics, rostrum length (relative to head size), urinating posture, size, and association with a kid (Brandborg 1955, Smith 1976, Chadwick 1977). Two and 3 collared females of known age were consistently present during the first and second winters respectively. For these goats, ages in 1986 and years when first collared and aged were: 9.5+years, 1979 (Goat no. 857); 9.5 years, 1979 (R96); 3.5 years, 1985 (Y8S).

A localized, potentially-defendable food resource (diameter = 1 m) was established near steep cliffs on Sheep Mountain in late November 1985. Data were collected at the site during January-April, 1986. When goats were seen at or away from the bait site, group size and composition, location, and presence of marked animals were noted. Goats were grouped into 10 classes; adult-female-with-kid (FK), or with no kid (F); adult male (AM); unidentified adult (U); 2-year-old male (2M), female (2F) or

unidentified (2U); yearling (Y); kid-with-female (KF), or without female (K). Interactions between marked females were used to determine dominance.

Group sizes were compared between marked nannies with a *t* test (Statistical Graphics Corporation 1985). Home ranges were calculated as minimum-area polygons (Mohr 1947). If goats were located more than once a day, only the first sighting was used in home range analysis.

RESULTS

Mountain goat groups were observed 1,111 times on Sheep Mountain during the 2 winters. Goats sometimes congregated at the bait site. No goat or group of goats continuously defended the bait from other goats (Masteller 1987, Masteller and Bailey in Press).

Grouping Behavior

In 1986, the 3 most frequently observed marked nannies appeared to belong to different social groups. Each of these females was most often seen in groups without either of the other marked nannies (Table 1), and the attraction of the bait appeared responsible for most instances when marked females were seen in the same group. Of 13 sightings including any 2 of these marked nannies, 62% were within 200 m of the bait site, and all 3 sightings including all 3 nannies were within 200 m of the site.

Average group size (excluding kids and groups with other marked nannies) was less for 1 nanny (Table 1), but variation in mean group size was similar among the 3 nannies. The most frequent group sizes were 7, 5 and 3 for B57, R96 and YBS, respectively (Fig. 1). Group composition of the most frequent group size of each female was relatively stable (Table 2). The 2 oldest nannies were most likely to have subadults (other than kids) in their groups, and were not seen with adult males. Comparing the 2 oldest nannies, the dominant (B57) had the highest average numbers of kids and adult females in her group.

Agonistic Behavior Among Marked Individuals

During January-April 1986, dominance relationships were established for the 3 marked nannies by observing interactions both at and away from the bait. B57 dominated both R96 (4 times) and YBS (3 times), and R96 dominated YBS (1 time). The oldest and most dominant goat, B57, was most often seen at bait, had the smallest home range, and was most likely to be nearest the bait site (Table 3). However, the home range of each female included the bait site (Fig. 2). It was not possible to establish dominance relations among other members of the 3 groups because the goats were not marked.

DISCUSSION

Matrilineal Groups

The social groups we found were mostly female, perhaps related, individuals. For mountain goat kids, metabolic weaning is usually

Table 1. Grouping behavior of the 3 most frequently observed marked nannies, January-April, 1986, Sheep Mountain, Colorado.

Nanny (S)	Age ^a	Rank	No. of sightings	Sightings without other marked female present (%)	Ave. group size without kids
B57	9.5+	1	34	72	4.1 (1.7)
R96	9.5	2	20	57	4.6 (2.3)
YBS	3.5	3	34	83	3.2 ^b (1.6)

^a Ages were determined when goats were collared in earlier years.

^b Significantly lower than both B57 and R96 ($P < 0.05$ and $P < 0.01$, respectively).

completed by 3-4 months of age; but complete behavioral weaning may not occur until 1 year (Brandborg 1955, DeBock 1970, Foster and Rahe 1982, Chadwick 1983). Hutchins and Hansen (1980) reported several cases of yearling and 2-year-old offspring being "retained" by female goats which had either lost their young-of-the-year or failed to conceive. These retained offspring maintained a close relationship, including close physical contact and some nursing, to their mother.

Females and their daughters (and sometimes sisters) have been shown to maintain matrilineal bonds in *Cervus* sp., *Capreolus* sp., and *Odocoileus* sp. (Clutton-Brock et al. 1982; Franklin and Lieb 1979; Bubenik 1965, reported in Lent 1974; Hawkins and Klimstra 1970; Dasmann and Taber 1956). There are similar indications in the little-studied *Nemorhaedus* sp., *Capricornus* sp. and *Rupicapra* sp. (Myslenkov 1978, Kishimoto 1981, Pachlatko and Nievergelt 1985), the closest relatives of *Oreamnos americanus*. In Africa, matrilineal groups occur in *Alcelaphus* sp. and *Loxodonta* sp. (Gosling 1969, review in Leuthold 1977). In most of these ungulates, associations are maintained between a mother and her young-of-the-year and female yearling, but in extensively-studied populations the association sometimes extends to older daughters and sisters (Clutton-Brock et al. 1982, Hawkins and Klimstra 1970).

The sizes of matrilineal groups in ungulates may depend on: 1) age of the female, 2) sex of previous young, 3) dominance of the female, and 4) habitat characteristics such as visibility and forage continuity (Estes 1974, Jarman 1974, Owen-Smith 1977, Clutton-Brock et al. 1982). There are apparent limits on matrilineal group size, however. In red deer (*Cervus elaphus*), "clusters" were usually less than 4 related animals, but clusters up to 7 occurred (Clutton-Brock et al. 1982). Hawkins and Klimstra (1970) reported that 8 white-tailed deer (*Odocoileus virginianus*) was the maximum number found together. Our oldest, most dominant nanny,

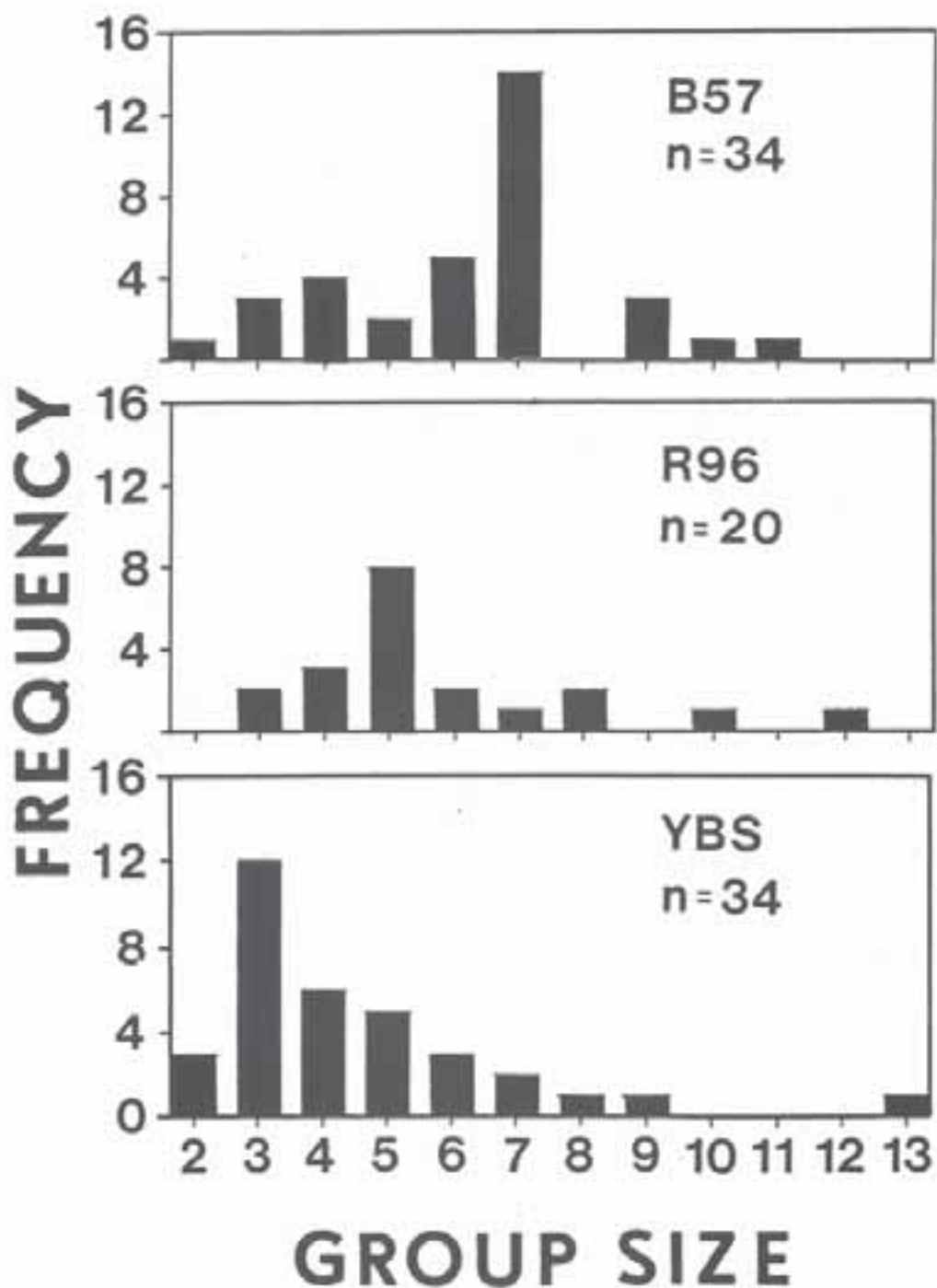


Figure 1. Frequency distributions of group sizes for the 3 mountain goat nannies of known rank, January-April, 1986, Sheep Mountain, Colorado. The rank order was B57 > R96 > YBS.

Table 2. Group composition of the most frequent group size for marked females, January-April, 1986, Sheep Mountain, Colorado. Most frequent group size was 7 for B57, 5 for R96, and 3 for YBS.

Nanny (no. groups)	Average number present with marked nanny (range) ^a							
	AF	2M	2F	Y	K	2U	U	AM
B57 (14)	1.92 (1-2)	1.00 (1)	0.92 (0-1)	0.17 (0-1)	2.00 (2)	0 (0)	0 (0)	0 (0)
R96 (8)	0.37 (0-1)	0 (0)	0.25 (0-1)	0.62 (0-2)	1.12 (1-2)	0.25 (0-1)	1.37 (0-3)	0 (0)
YBS (12)	0.58 (0-1)	0 (0)	0.08 (0-1)	0 (0)	1.00 (1)	0 (0)	0.17 (0-1)	0.17 (0-1)

^a AF=Adult female, 2M=2-year-old male, 2F=2-year-old female, Y=yearling, K=kid, 2U=2-year-old unidentified, U=unidentified adult, AM=adult male.

★ = BAIT SITE

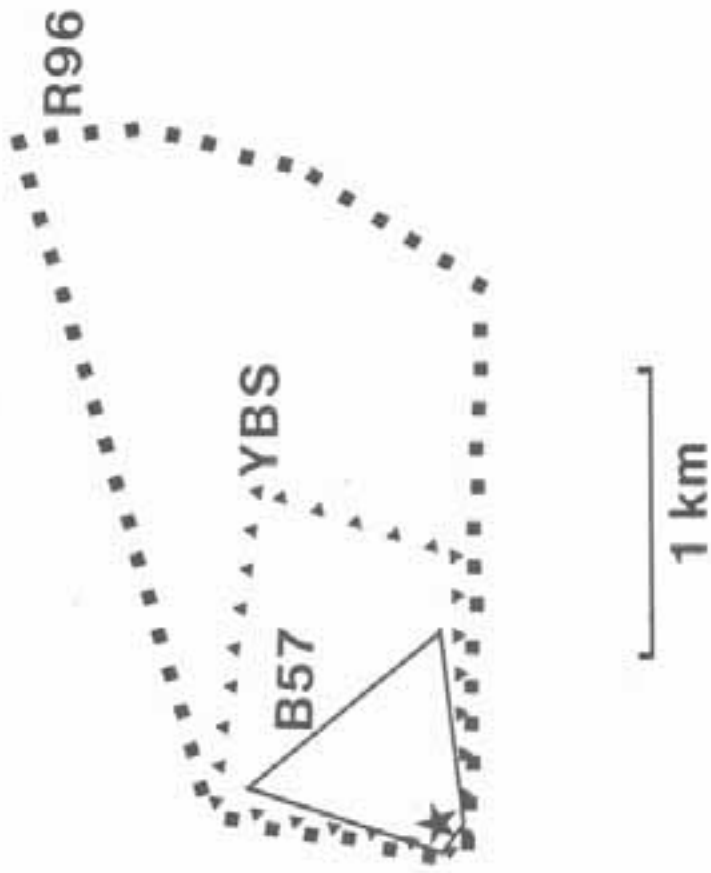


Figure 2. Winter home ranges of 3 marked mountain goat nannies of known rank, January-April, 1986, Sheep Mountain, Colorado. The rank order was B57 > R96 > YBS.

Table 3. Dominance, home range, and access-to-bait for the 3 most frequently observed marked females, January-April, 1986, Sheep Mountain, Colorado.

Goat	Age ^a	Dominance Order	No. Times seen at bait	Home Range (ha) ^b	Average Distance (m) of all sightings to bait site (N)
B57	9.5+	1	15	34	208 ^c (41)
R96	9.5	2	10	219	768 ^d (31)
YBS	3.5	3	5	85	374 (37)

^a Ages were determined as 3.5 or 3.5+ when goats were collared in earlier years.

^b Calculated with minimum-area polygon method.

^c Lower than both R96 and YBS ($\underline{P} < 0.001$ and $\underline{P} < 0.01$, respectively).

^d Greater than YBS, $\underline{P} < 0.05$.

B57, was most frequently found in a group of 7 (Fig. 1), which was the largest modal group size for the 3 marked nannies.

Resource Partitioning

There were indications of resource partitioning between the mountain goats we observed. The dominant nanny was most often seen at bait, had the smallest home range, and was most likely to be near the bait site (Table 3). However, this may be an artifact of the bait location. If the bait was placed within the home range of only 1 nanny, other nannies would have to extend their home ranges to visit the bait and may therefore be seen at bait less often.

Resource partitioning may vary with environmental conditions such as snow depth (Petocz 1973). During an unusually harsh week-long snowstorm in February 1986, the 3 nannies (and the unmarked goats associated with them) remained separate and were especially sedentary, with the 2 oldest nannies in the steepest cliffs. B57 and her group used the cliffs directly below the bait site during this storm. Kuck (1977) felt that dominant nannies occupied the best habitat (steep, snow-shedding slopes), and that when these nannies were removed subordinate nannies moved from marginal habitats to replace them.

The ancestors to mountain goats were probably territorial (Chadwick

1983). Indeed, mountain goats wintering on native ranges exhibit territorial-like behavior (Walther et al. 1983): fidelity to small home ranges (Smith 1976, Rideout 1977, Kuck 1977), high rates of aggression (Chadwick 1977, Dane 1977), small group sizes (Smith 1976, Brandborg 1955), and dispersal of young (Rideout 1977, Smith and Raedeke 1982). Additionally, serow (*Capricornis crispus*) and goral (*Nemorhaedus caudatus*) exhibit territoriality (Kishimoto 1981, Myslenkov 1978). Resource partitioning among social groups of goats on winter ranges could be a manifestation of territorial ancestry.

Our results suggest there may be distinct social groups of goats on this wintering area, and the literature suggests these groups may be matrilineal groups. While not conclusive, there is some supporting evidence from a non-native goat population in Washington (Hutchins and Hanson 1980).

Our results further suggest resource partitioning among these social groups, similar to that described for black-tailed deer (*O. h. columbianus*) by Miller (1974). Although no group of goats continuously defended the food resource, there were indications that one group had priority access to it (Table 3). If social groups exist in mountain goats, understanding population regulation in this species will require studying both inter- and intra-group variation in reproduction, survival and dispersal (Clutton-Brock and Albon 1985). Knowledge of these group relations may be necessary for evaluating impacts of harvests, especially of females, upon goat populations.

Differential resource partitioning among groups has implications for possible supplemental feeding of goats during winter. Goats readily accepted the food bait (once they found it), but in a concentrated supplemental feeding situation the subordinate goats most in need of food would have least access to it. Espmark (1974) described similar problems among roe deer at winter feeding stations in Sweden.

The work of Hutchins and Hansen (1980), Stevens (1983), Clutton-Brock et al. (1982), and Lent (1974) represent important first steps in the study of social groupings among goats and other ungulates. While Chadwick (1977) and Singer and Doherty (1985) found no strong evidence of extended associations between individual mountain goats, determining existence of associations such as matrilineal groups requires a large number of marked animals (see Clutton-Brock et al. 1982:189) and long-term research.

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