

MOVEMENT AND HOME RANGE OF MOUNTAIN GOATS,
SHEEP MOUNTAIN-GLADSTONE RIDGE, COLORADO

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ABSTRACT

During summer 1979, 24 mountain goats (*Oreamnos americanus*) were marked with individually identifiable canvas collars and/or ear tags to determine movements and home ranges of goats on Sheep Mountain and Gladstone Ridge, Colorado. Marked goats were observed June-August 1979, January-March 1980, and June-August 1980. Greatest linear distance between any 2 observations of an individual was used as an index of home range size for each goat. During the 2 summers, there was no significant difference in average home range size between sexes. Summer home ranges averaged 8 times the size of winter home ranges. During both summers, home ranges expanded as forage turned green and snow disappeared at higher elevations. Goats frequently moved back and forth between salt licks on and near Sheep Mountain and alpine tundra areas on Gladstone Ridge and associated peaks, a distance of at least 5 km. During winter, goats remained within relatively small home ranges, although they were not limited to these areas by deep snow. Small home ranges may be an energy-conservation strategy in winter. During both seasons, females were reobserved more often than were males. This may have been due to males being in smaller and therefore less detectable groups, or to males having a greater tendency to disperse. One male dispersed from the study area and was seen in 1980 and 1981 on Mount Shavano, a linear distance of 16 km from Sheep Mountain.

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INTRODUCTION

Movements and home ranges of Rocky Mountain goats, particularly in winter, are little known due to the remoteness and rugged character of areas they inhabit. This facet of mountain goat ecology is particularly important in Colorado where mountain goats have been introduced outside their natural range and may compete with native bighorn sheep (Adams et al. 1982). Knowledge of seasonal home range size, movement patterns, relation of mineral licks to such patterns, and dispersal capabilities of mountain goats will be useful in assessing the potential for expansion of mountain goat populations onto ranges of existing bighorn herds.

The literature offers little information on movements and home ranges of mountain goats. Rideout (1974) radiocollared 16 goats in Montana and recorded their movements mainly from May to November with limited data collected during winter. Smith (1976) determined seasonal home ranges of 6 goats in the Bitterroot Mountains of Montana. The radio telemetry studies being conducted by Schoen (Unpub. Alaska Fed. Aid Prog. Rep. W-17-11-12.4R, 1979), Nichols (1982), and Smith and Raedeke (1982) are the most intensive investigations to date, but have been initiated recently with few results reported. Some information can be gleaned from occasional comments scattered throughout mountain goat literature, but these 5 studies represent the bulk of existing information on movements and home ranges of mountain goats.

Objectives of this study (Adams 1981) included determining home ranges and monitoring movements of 24 marked mountain goats on Sheep Mountain-Gladstone Ridge, in the Sawatch Range of central Colorado. We gratefully acknowledge the financial support of the International Order of Rocky Mountain Goats, the National Wildlife Federation, Colorado State University (CSU), the Hill Memorial Foundation, and the Colorado Division of Wildlife (CDOW). T. Dailey, J. Howlett, T. Spezze, H. Hood (CDOW), B. Trentlage, S. McCollough (CSU), and R. Smith (US Forest Service) assisted with the trapping and marking operations. We also acknowledge support provided by S. Ogilvie, D. Reed (CDOW), B. Lyons (US Forest Service), and E. Maben.

DESCRIPTION OF STUDY AREA

The study area is located 11 km west of Buena Vista, Colorado in the Arkansas River drainage. Boundaries of the area are the continental divide, Middle Cottonwood Creek, and South Cottonwood Creek. Major geographic features included Sheep Mountain (3640 m), Gladstone Ridge (4027 m), Jones Mountain (4031 m), and Mount Kreutzer (4000 m). Elevation ranged from 2775 m at the confluence of South and Middle Cottonwood Creeks to 4031 m at the summit of Jones Mountain (Fig. 1).

Treeline occurs at about 3600 m depending on topography. Tundra vegetation consists mainly of grasses, sedges, and forbs with patches of Englemann spruce (*Picea englemanni*), bristlecone pine (*Pinus aristata*), and

willow (*Salix* spp.). Common plants include *Carex* spp., *Agropyron scribneri*, *Oreoxis alpina*, *Trifolium nanum*, and *Geum rossii*. Below treeline is a forested zone dominated by Englemann spruce, Douglas fir (*Pseudotsuga menziesii*), limber pine (*Pinus flexilis*), and bristlecone pine. Other major plants below treeline include *Muhlenbergia montana*, *Festuca arizonica*, *Artemisia frigida*, *Holodiscus dumosus*, and *Populus tremuloides*. Previous research on this area has been reported by Bailey and Johnson (1977), Johnson et al. (1978), Adams (1981), and Adams and Bailey (1980, 1982, 1983).

METHODS

In August 1978, an adult female mountain goat was collared on the study area. From May to July 1979, an additional 23 goats (19 adults, 4 yearlings) were captured and marked (Adams 1981). All goats were captured in Clover traps (Clover 1956) over artificial mineral licks at Cottonwood Lake and Porphyry Gulch (Fig. 1). Both licks were established at least 2 years in advance and were used regularly by goats prior to construction of traps on the sites.

Adults were collared with 10-cm wide colored and/or numbered vinyl-covered canvas collars and eartagged with numbered 5-cm Ritchey cattle eartags. Males were marked with green eartags and females with yellow eartags. Yearlings were eartagged by not collared. Kids were released unmarked.

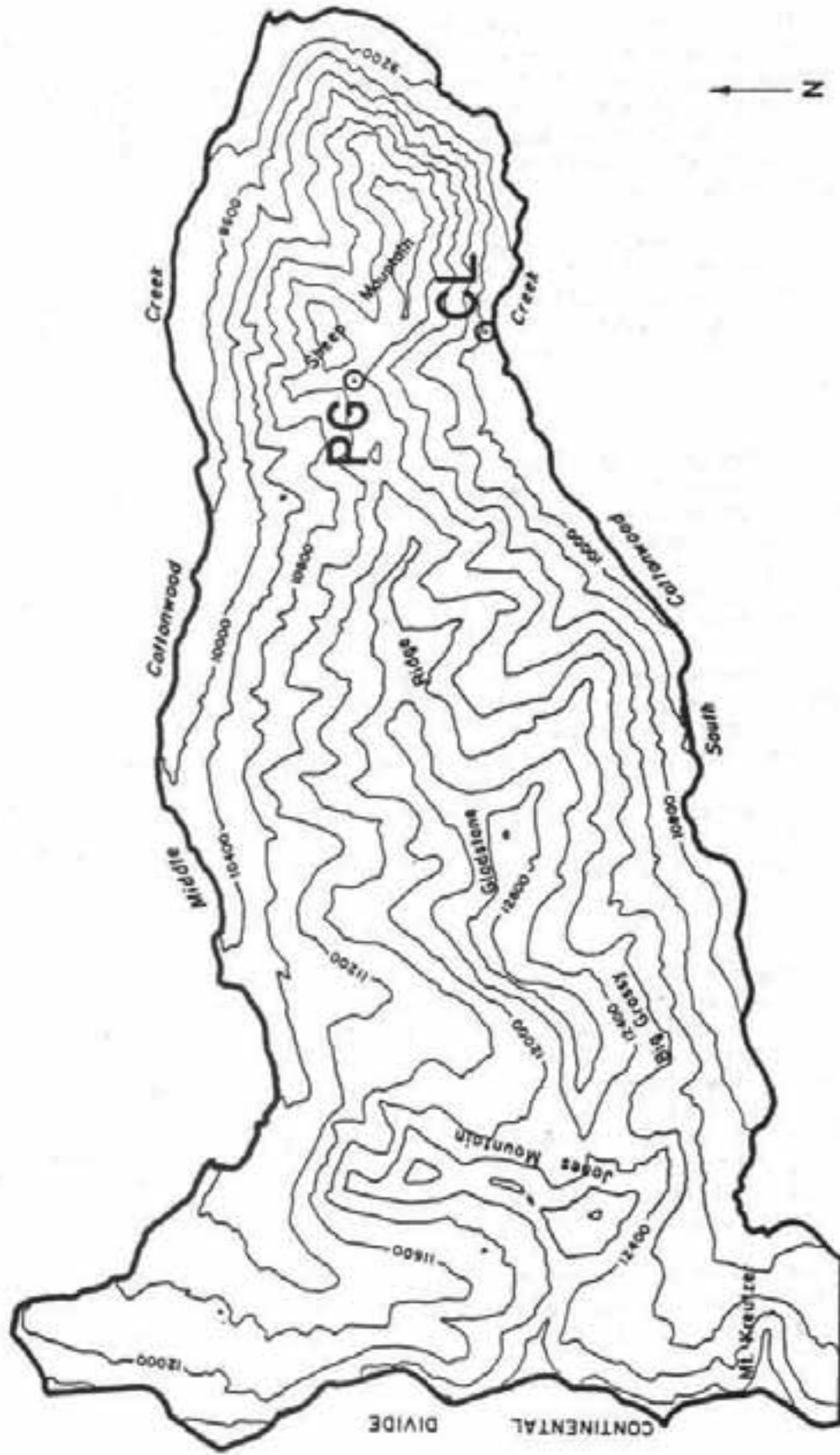
Marked goats were observed June-August 1979, January-March 1980, and June-August 1980. Observations were recorded to the nearest ha using a gridded 15-min U.S.G.S. topographic map (Adams 1981).

The greatest linear distance between any 2, not necessarily consecutive, observations of an individual was used as an index of home range size for each goat. This was appropriate since the study area is linear in shape (Fig. 1).

RESULTS

SUMMER

During summer, marked mountain goats were observed ranging over large portions of the study area. Goats observed on Sheep Mountain during June stayed in that area until the end of the month, then moved on to other parts of the study area (Fig. 2). Marked goats moved erratically over much of the study area during the rest of the summer (Fig. 3). An adult female, R46, was observed to move 8.6 km, between Gladstone Ridge and a mineral lick on Sheep Mountain in 24 hours or less.



Scale: 1 cm = 0.7 km

Fig. 1. Major geographic features and trapsites, Sheep Mountain-Gladstone Ridge, Sawatch Range, Colorado. PG=Porphyry Gulch trapsite, GL=Cottonwood Lake trapsite.

The greatest linear distances across the home ranges averaged 6.4 km for the 2 summers (Table 1). There was no significant difference in average home range size between sexes. Males were less apt to be reobserved than were females. Of 14 adult females collared by July 1979, 13 were reobserved an average of 1.8 times that summer (Table 2). Four of 6 collared adult males were reobserved an average of 1.3 times each that summer after release. Similar trends occurred in 1980 (Table 2).

One adult male, G2, was not observed during any of the 3 field seasons after he was collared. One unidentified green-collared male (presumably G2 but possibly G1 or G3) was observed during summer 1980 and 1981 on Mount Shavano, 16 km linear distance from Sheep Mountain. The probable dispersal route along the continental divide was over 30 km.

WINTER

Marked goats were more sedentary in winter than in summer. Typical winter movements were exemplified by 2 adult females (Fig. 4). Only 3 goats were observed to move more than 1.3 km. These goats were in a group observed on Mount Kreutzer during a helicopter survey on 22 January 1980. Goats were not observed in that area after the flight. It is possible that these long movements resulted from helicopter-related disturbance and are not characteristic of mountain goats in winter.

If the movements off Mount Kreutzer are ignored, the greatest linear distance covered by goats in winter averaged 0.7 km, based on 9 female goats (Table 3). However, if the movements off Mount Kreutzer are included, the average greatest linear distance covered was 1.7 km.

In winter as in summer, average number of reobservations for males was less than that for females (Table 2). Nine female goats were reobserved an average of 1.8 times, whereas of 3 males observed, only 1 was reobserved.

DISCUSSION

In summer, home ranges of mountain goats expanded as the season progressed and encompassed large areas. In June, goats observed on Sheep Mountain inhabited small areas (Fig. 2). During this time, forage was turning green at the lower elevations of the study area and these goats may have remained in the area to utilize succulent forage. These goats were also near mineral licks that may have attracted them. The rocky, broken terrain of southern Sheep Mountain is characteristic of kidding areas and goat G (Fig. 2) was observed with a small kid in the area on 25 June 1979. She was last observed on Sheep Mountain 3 days later, then was seen subsequently on Gladstone Ridge.

As summer progressed and vegetation turned green and snow dissipated at higher altitudes, mountain goat home ranges expanded (Fig. 3). Goats began utilizing alpine tundra summer range on Gladstone Ridge, but moved between



Fig. 2. Movements of adult female mountain goat, G, summer 1979. Sheep Mountain-Gladstone Ridge, Sawatch Range, Colorado. Solid line represents movements during June.

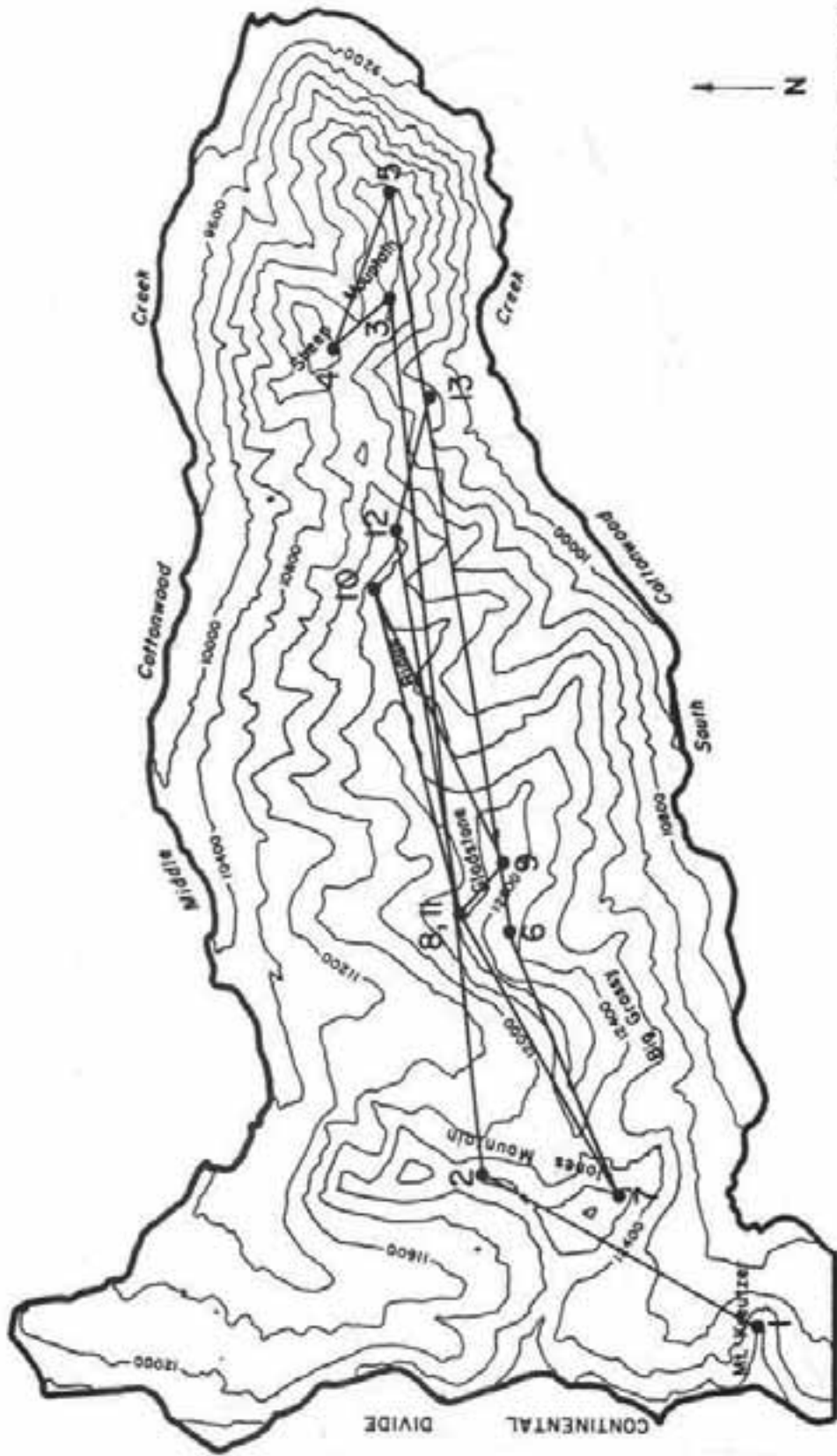


Fig. 3. Movements of adult female mountain goat, B59, summer 1980, Sheep Mountain-Gladstone Ridge, Sawatch Range, Colorado.

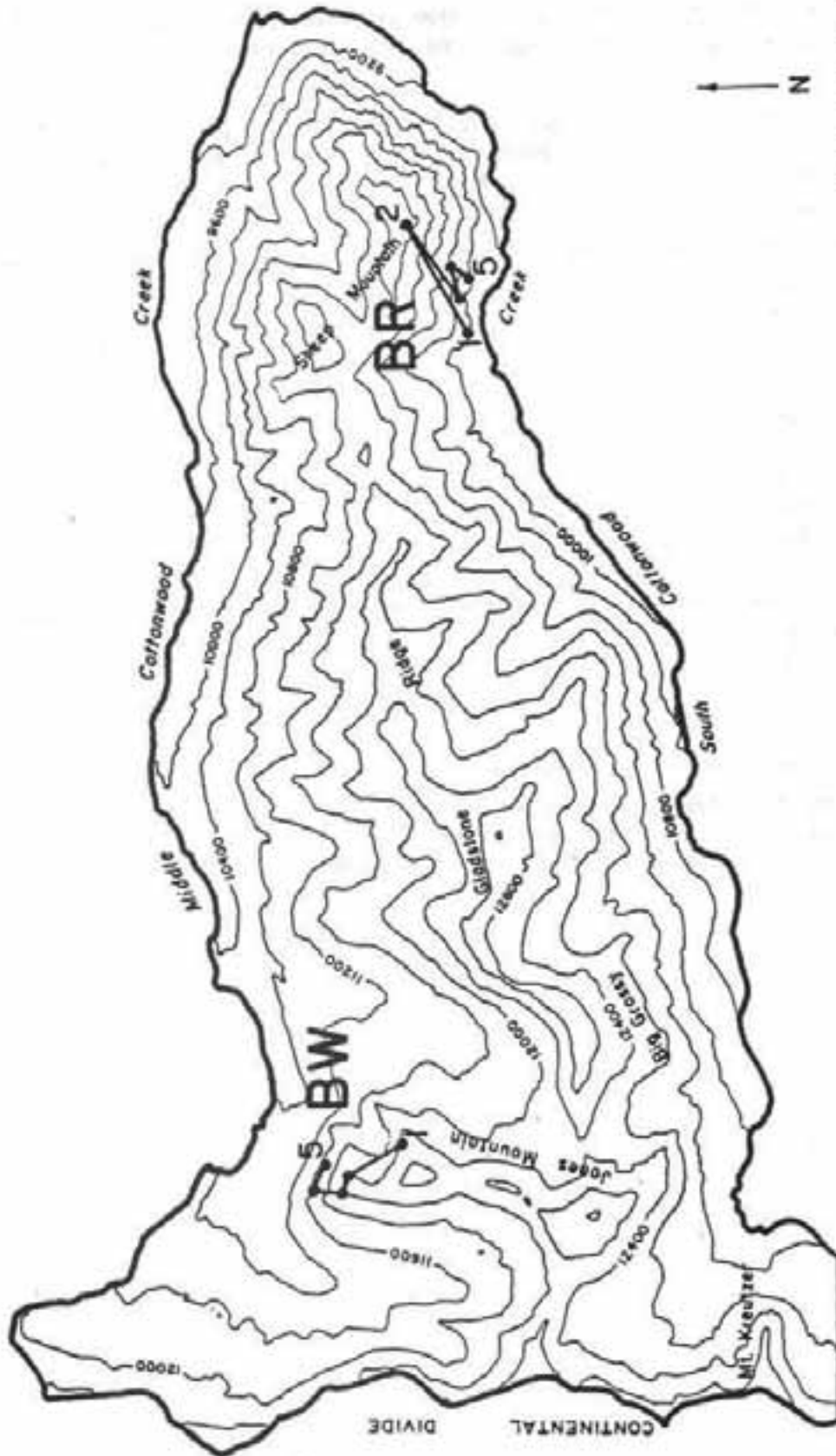
Table 1. Greatest linear distance between any 2 observations during summer for each goat, Sheep Mountain-Gladstone Ridge, Colorado.

MARKED GOAT	AGE (in 1979)	SUMMER 1979			SUMMER 1980		
		LENGTH OF OBSERVATION PERIOD ^a (days)	NUMBER OF OBSERVATIONS ^b	GREATEST LINEAR DISTANCE (km)	LENGTH OF OBSERVATION PERIOD ^a (days)	NUMBER OF OBSERVATIONS	GREATEST LINEAR DISTANCE (km)
FEMALES							
BR	3	69	4 ^c	3.7	46	12	8.0
G	3	67	7	9.3	-	-	-
R92	2	26	6	1.6	47	6	6.1
YR	2	64	4	6.3	66	19	8.2
BW	2	42	5	7.2	62	13	9.4
R96	3	41	3	9.0	33	9	6.2
Y6	1	34	3	3.1	55	7	2.1
R95	3	31	4	5.0	66	12	6.4
R97	3	17	2	3.4	46	7	8.3
B60	3+	34	5	6.2			
G4	3+	24	3	9.3	48	16	8.2
R46	2	22	3	8.6	66	12	6.7
Y12	1	18	2	2.0	-	-	-
B55	3	-	1	0.7	44	11	11.0
B57	3+	12	2	0.7	48	11	8.3
B59	2	12	2	3.1	59	15	11.2
				mean = 5.2 ± 1.5 ^d			mean = 7.7 ± 1.3 ^d
				Overall Mean = 6.4 ± 1.1 ^d			
MALES							
WG	3+	47	4	7.4			
B56	2	15	2	9.2	63	8	6.6
93	1	-	1	-	14	2	3.7
B58	3+	-	1	-	6	2	0.5
G2	2	-	1	-	-	-	-
96	1	-	1	-	70	4	5.9
G1	3	6	2	9.2	-	-	-
G3	3+	32	5	9.2	-	-	-
				mean = 8.8 ± 0.9 ^d			mean = 4.2 ± 2.7 ^d
				Overall Mean = 6.5 ± 2.2 ^d			

^aPeriod between first and last observation. ^bIncludes trapping. ^cTrapped in 1978. ^d±2S.E.

Table 2. Reobservations of marked adult mountain goats, summer 1979-1980, and winter 1980, Sheep Mountain-Gladstone Ridge, Colorado.

SEX	MARKED ADULT GOATS	SUMMER				WINTER	
		(9 June-21 August) NUMBER OBSERVED IN SEASON	REOBSERVATIONS PER GOAT	(3 June-19 August) NUMBER OBSERVED IN SEASON	REOBSERVATIONS PER GOAT	(17 January-11 March) NUMBER OBSERVED IN SEASON	REOBSERVATIONS PER GOAT
FEMALES	14	13	1.8	12	11.9	9	1.8
MALES	6	4	1.3	2	5.0	3	0.8



Scale: 1 cm = 0.7 km

Fig. 4. Movements of 2 adult female mountain goats, BW and BR, winter 1980, Sheep Mountain-Gladstone Ridge, Sawatch Range, Colorado.

Table 3. Greatest linear distance between any 2 observations during winter 1980 for each goat, Sheep Mountain-Gladstone Ridge, Colorado.

MARKED GOAT	LENGTH OF OBSERVATION PERIOD ^{a,b} (days)	NUMBER OF OBSERVATIONS ^b	GREATEST LINEAR DISTANCE ^b (km)
FEMALES			
BR	34	5	1.3
R92	-	1	-
YR	9(50)	2(3)	0.2(4.7)
BW	50	5	1.1
y6	22	3	1.1
R97	2	3	0.4
G4	6	4	0.9
B55	9(50)	2(3)	0.2(4.7)
B57	10	2	0.4
B59	10	2	0.4
			mean= 0.7 ± 0.3^c
MALES			
B56	-	1	-
B58	-(16)	1(2)	(1.8)
G1	-	1	-

^aPeriod between first and last observation.

^bNumbers in parentheses include data from goats on Mt. Kreuzer disturbed by helicopter and not included in mean.

^c ± 2 S.E.

these areas and the lower slopes of Sheep Mountain throughout the summer. These movements appear to be due to the attraction of mineral licks on and near Sheep Mountain. The longest movement by a goat within 24 hours, a distance of 8.6 km, was from alpine tundra on Gladstone Ridge to a salt lick on eastern Sheep Mountain. On 4 August 1979, an adult female, YR, was observed to travel from Dead Can Gulch to the lick at Porphyry Gulch trap site, a distance of 4.5 km, in less than 2 hours. Such strong attractions to mineral licks have been reported elsewhere for mountain goats (Hebert and Cowan 1971, Singer 1977, Hutchins and Stevens 1981).

Greatest linear distance covered by goats from June to August averaged 6.4 km for goats on this area. Schoen (Unpubl. Alaska Fed. Aid Rep. W-17-11-12.4R, 1979) reported a comparable 6 km as the mean yearly home range length for goats in Alaska.

During winter, mountain goats restricted their movements to small areas within the boundaries of their summer home ranges. Winter home ranges averaged 11% the sizes of summer home ranges. Smith (1976) reported similar differences between summer and winter home ranges for goats in Montana. Brandborg (1955) mentioned 10 goats remaining on 81 ha for 3 months during winter in Idaho. Schoen (Unpubl. Alaska Fed. Aid Rep. W-17-11-12.4R, 1979) reported that a majority of 20 radio-collared goats near Juneau, Alaska occupied smaller areas in winter than in summer, but the opposite was true for some of the goats.

Such characteristically small home ranges may be due to snow conditions that do not allow animals to move far. However, this does not appear to have been the case on Sheep Mountain-Gladstone Ridge. Although deep snow in the forested portions of Gladstone Ridge did not permit travel between alpine ranges and subalpine ranges, the goats were not as restricted as their movements indicated. Much of the study area above treeline was relatively snow-free and available to goats wintering on the tundra, but only a small portion of it was used. Long movements of goats off of Mount Kreuzer following the 22 January helicopter survey illustrate the ability of mountain goats to travel long distances through snow if necessary.

Small winter home ranges may be an energy conservation strategy. If adequate forage was available in areas that provided escape terrain, resting cover, and the other required resources, there would be no reason to move from those areas. On Sheep Mountain-Gladstone Ridge, mountain goats appeared to select and remain in areas that offered a combination of foraging areas with plentiful vegetation, interspersed with cliffy terrain (Adams and Bailey 1980).

Male mountain goats were less apt to be observed than were females regardless of season. Males seem to have a greater tendency to disperse than females, which may account for this difference. Dispersal of an adult male to Mount Shavano supports this theory. Rideout (1974) reported that marked male goats were never observed on his study area the year following their capture. Four of 8 males trapped on this study area in summer 1979

were not observed again during that summer. Two more marked males were not observed on the area during the following winter or summer. In comparison, only 1 female of 16 collared was not observed during summer 1979, after her release, but she was seen during winter 1980.

Male goats may also aggregate into smaller, hence less detectable, groups than do females. This has been reported by several authors (Brandborg 1955, Holroyd 1967, Chadwick 1977) and may account for their reduced observability.

Information presented here has implications for management of goats. First, since goats are capable of moving long distances in relatively short periods, aggregating several daily ground surveys of different portions of the area would be questionable for estimating the minimum population size. Surveying the entire area in 1 day with several ground crews or by helicopter, is preferable.

Second, when using the Petersen estimate (Caughley 1977) with mountain goats, a survey of the population to estimate the marked:unmarked ratio will not be a random sample if adult males are less observable than are adult females, as suggested above. Consequently, adult males and females should be marked in proportion to their occurrence in the herd.

More information on home range fidelity in mountain goats would be useful in determining the potential for dispersing animals to establish new populations. Schoen (Unpul. Alaska Fed. Aid Rep. W-17-11-12.4R, 1979) suggested some fidelity to home ranges being expressed by females, albeit from limited data. If female goats usually return to the same winter ranges, establishment of new satellite populations would be slowed. Harvest data from Colorado (Denney 1977) suggest this may be true. On areas between the Mount Shavano population, introduced in 1948, and the Sheep Mountain-Gladstone Ridge population, introduced in 1950, only males were harvested until 1974. Determination of home range fidelity could affect the amount of concern over and management strategies for limiting expansion of existing mountain goat populations in Colorado. Additional information on movement patterns, home range dynamics and fidelity, dispersal rates, and factors that trigger dispersal will aid the Colorado Division of Wildlife in making timely decisions on management of the state's mountain goat populations.

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