FORAGING BEHAVIORS AMONG DIFFERENT AGE AND SEX CLASSES OF ROCKY MOUNTAIN
GOATS

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Abstract: Social and foraging behaviors of Rocky Mountain goats (Oreamnos
americanus) within nanny bands were studied on the alpine tundra of Mt.
Evans, Colorado from 19 July to 10 September 1987. Females and young (1
to 3 years) males were compared to investigate the possibility that
differential behaviors during feeding encourage these males to leave
nursery bands. Averaged over all group sizes, yearling males and females
were similar in feeding, alert and social time. Analyzed by group size,
however, yearling males' foraging time decreased with increased group
size, while adult females' foraging time increased. Alert time of
yearling males was higher in larger groups, while adult females' was
lower. Yearling females feeding and alert time was not correlated to
group size. Two and three-year-old males were similar to nannies and
barren females in feeding and alert time; however, these males spent
significantly more time in aggressive behavior than all other classes.
Social time was independent of group size for all classes. The increased
aggressive time of young males in nanny groups and the adverse effects of
larger group sizes specifically on yearling males encourages young males
leave the female bands. Further examination of group positioning within
these groups may explain the negative effects of increased groups size on
yearling males.

The social organization of mountain goats is characterized by the
formation of segregated male and female herds. This segregation seems to
occur after males are 2 years old. Typically there are separate nursery
bands, small bachelor male groups and solitary males. Why should this be
the case? There are many examples of species that live in mixed herds
(Estes 1974, Jarman 1974, Sinclair 1977).

Although segregation among mountain goats has not been studied in
depth, it has been examined in a number of other Northern ungulates.
There are four main theories for herd segregation:

(1) Parental-offspring competition.--Geist and Petocz (1977)
suggested that bighorn males leave nanny groups to limit competition with
their own offspring. However, male goats leave the nanny groups before
their first rut. These young males are not very successful in their first
ruts (Geist 1964); therefore, they do not begin contributing their own
offspring to the nanny groups until at least 2 years after leaving the
band. Competition with their own offspring is, therefore, non-existent or
minor for the young males that leave the nanny groups.

(2) Differential metabolic requirements of males and females.--In

general males and females have different metabolic needs due to size
dimorphism, differential reproductive activities and parental output
(Kleiber 1961; Gasaway and Coady 1974). Different metabolic requirements
are correlated with differential habitat use (Belovsky 1978). In order to
maximize intake, males and females must feed in different habitats. Adult
male and female goats have little size dimorphism; therefore, any
metabolic differences between them is mainly due to different reproductive
activities or parental output. Neither 2-year-old females nor 2-year-old
males engage in reproductive activities. Thus, the metabolic costs for
each should be similar, but young females stay in the group while males
leave. Barren older females also stay with the nanny groups. If
differences in metabolic needs are responsible for segregation, 2-year-old
females and barren females should also leave.

(3) Nanny-male competition.--Clutton-Brock et al. (1982) theorized
that red deer females expel young males to reduce competition for forage.
Mountain goat nannies drive males out of female bands in some instances
(Reisenhoover and Bailey 1985; Chadwick 1977). However, 2-year-old
females are not expelled; although, they also compete for forage.

(4) Male aggression.--It has suggested that nannies force young
males from the group because the males are more aggressive and increase
the danger to both females and kids. In the Mt. Evans population,
Risenhoover and Bailey (1985) found that nannies were the most aggressive.
Two-year-old males were no more aggressive than 2-year-old females.
Yearlings (male and female) directed 50% of their aggression toward other
yearlings, 34.3% toward 2-year-olds and only 13.8% to nannies and kids.
While 12.5% of nanny aggression was directed to other nannies. Therefore,
young males do not pose a greater threat than other females to nannies and
kids due to higher aggression.

The current theories on ungulate herd segregation do not adequately
explain sexual segregation in mountain goats. This suggests that there
are other factors causing segregation. To investigate interactions
influencing the social structure of male and female goats, this study
examined the foraging behaviors and group spacing of different classes of
mountain goats in order to determine if the classes behave differently
within nanny bands. Such differences, if present, will help uncover the
benefits and disadvantages that different goats derive from being in a
group. Conversely, they will also indicate the advantages or
disadvantages to females of males being within nanny groups. The effects
of group size on the different goat classes was examined because group
size was shown to have a large impact on goat behavior (Risenhoover and
Bailey 1985).

their hospitality and assistance. Without their technical support the field work would have been difficult if not impossible.

STUDY AREA AND METHODS

Mount Evans (4346 m) is in the Colorado Front Range approximately 45 km west of Denver, Colorado. The peaks of Epaulet Mountain and Rosalie Mountain were also in the study area. The vegetation in the study area is open alpine tundra.

Although the herd is hunted, the goats are habituated to people as the alpine areas are accessible via a paved road and there is heavy traffic along the road during the summer. This provided an excellent opportunity to study goat behavior as the goats could be approached quite closely (within 20 m). Foraging behavior of goats within nanny groups has been previously described on Mt. Evans although not analyzed by goat age or sex (Risenhoover and Bailey 1985).

From 25 July 1987 to 26 August 1987, 130 foraging mountain goat nanny groups were videotaped for 5 min periods. Nanny groups were defined as any group containing at least 1 nanny and kid. Filming occurred throughout the day in various weather conditions. Filming locations were mainly open alpine areas, but also in rocky (not cliffs) and wet alpine areas at a distance of 20 to 200 m. Group composition and the class of individual goats were identified in field. Goats were separated into five classes: nannies, barren adult females (no kid), yearling females, yearling males and adult males (2 years or older) using horn character- istics, external genitalia, urination posture and nanny-kid association. Individual goats were filmed in different groups on different days.

From the tapes, the time spent in feeding, alert, social behavior (Table 1) and the foraging steps per minute during the observation period (4 to 5 min) were recorded. The class of and distance to the nearest- neighbor at 1 min intervals were also recorded. Data were taken for 2 to 10 goats per group and if possible, at least 2 goats in each class were observed. For each group, the data for each class were then averaged. Data were not recorded for kids although they were counted in the total group size.

Table 1. Classification of mountain goat behavior (adapted from Risenhoover and Bailey 1985).

Type	Description
Feeding	Ingesting forage; looking at forage; moving toward forage. Head oriented toward the ground.
Alter	Surveying surroundings. Head upright. Often in alarm posture (head fully upright and rigid body).
Social	Interactions among goats; play; aggression; display; looking at other goats; moving toward other goats.

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The feeding, alert and social behaviors were recorded as the percent of the observation period spent in each behavior. Overall differences between the 5 classes were determined with planned comparisons (from ANOVA analysis) and Scheffe's comparisons (unplanned) after the percentages were normalized with an arcsin transformation. A non-parametric test (Friedman-Rafsby test) was also performed on the foraging behaviors data. For each class, these behaviors were then tested for correlation with group size by calculating the correlation coefficient (Sokol and Rohlf 1981).

RESULTS

Foraging and Alertness

Foraging behaviors were recorded for 60 nanny groups ranging in size from 2 to 39 goats. Averaging all groups together, adults (nannies, barren females and adult males) were significantly more alert than yearlings (male and female). Nannies were more alert than barren females but not more than adult males. Yearling females and males were not significantly different. Adult males were significantly more aggressive than all other classes (Table 2, Figs. 1-3).
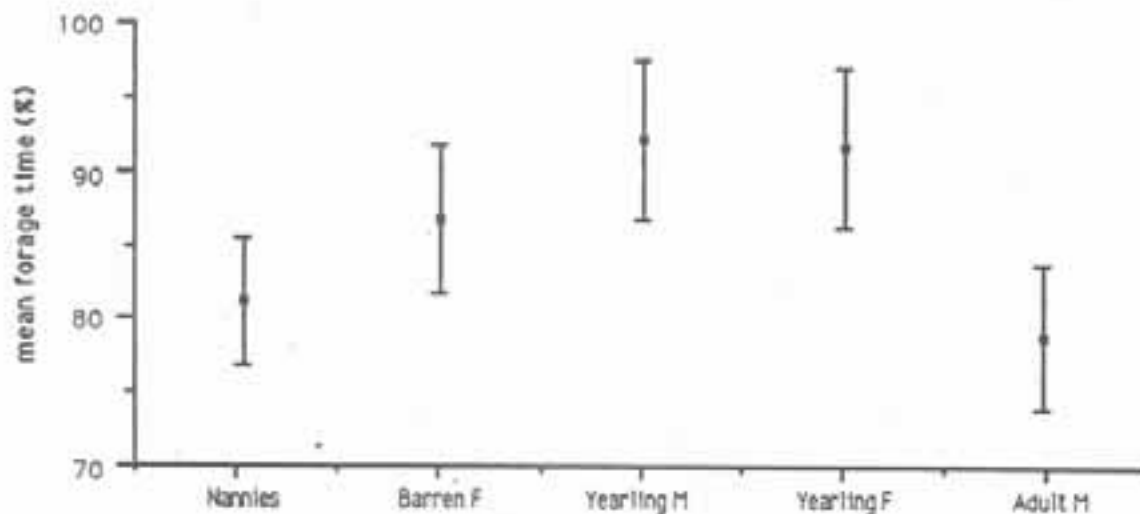

Figure 1. Mean percent of time spent in foraging during 130 five min observations on Mt. Evans, Colorado, late July to early September 1987. Data was averaged over all group sizes. Figure includes the standard error of the mean.

When foraging data were correlated to group size, nannies' foraging time increased with increasing group size up to approximately 15 goats/ group after which it levelled near 95% foraging time. Nannies in 2 large groups (32 and 38 animals) foraged less (Fig. 4A). Similarly barren females increased feeding time in larger groups, however, without the
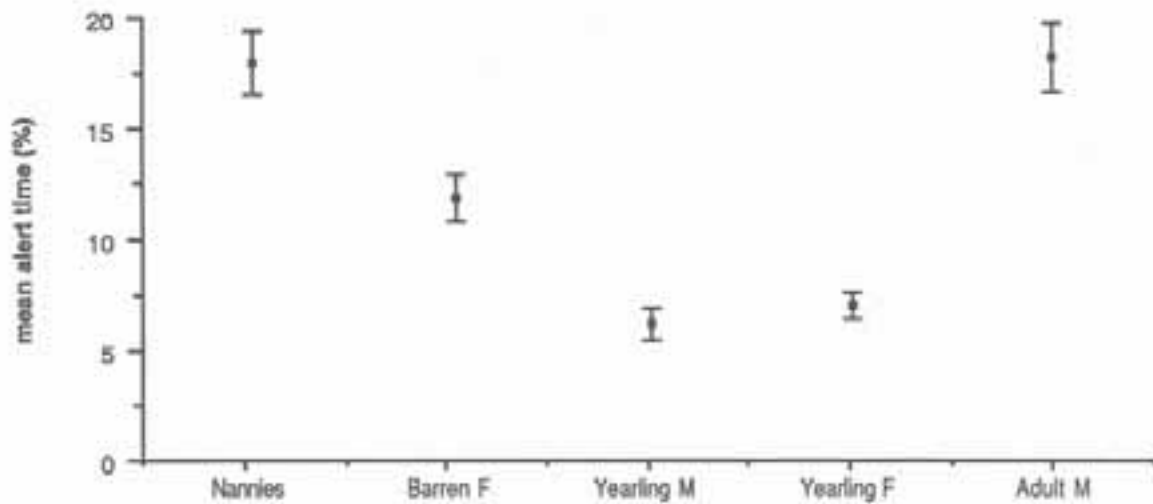
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Figure 2. Mean percentage of time spent in alertness during 130 five-min observations on Mt. Evans, Colorado, late July to early September 1987. Data was averaged over all group sizes. Figure includes the standard error of the mean.
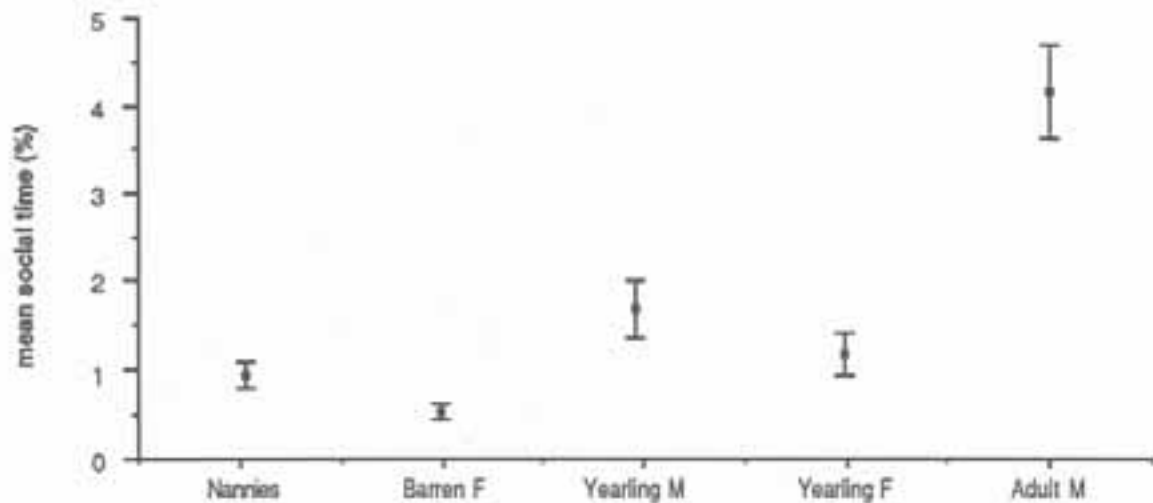

Figure 3. Mean percentage of time spent in social behavior during 130 five-min observations on Mt. Evans, Colorado, late July to early September 1987. Data averaged over all group sizes. Figure includes the standard error of the mean.

Table 2. Mean proportion of time spent in foraging, alert and social behavior for each goat class. In order to normalize the data, the proportions were arcsin transformed (x = arcsin(proportion)); thus, the proportions do not sum to 1.0. Significance is based on results from planned comparisons and Scheffe's comparisons (in parentheses) Scheffe's test is a conservative test to account for making ma. /comparisons.

Class	n	Mean proportion of observed time		
		Foraging	Alert	Social
Nannies	75	.999	.185	.007
Barren females	47	1.112	.121	.006
Yearling females	44	1.240	.062	.017
Yearling males	65	1.200	.069	.012
Adult males	13	.963	.186	.042

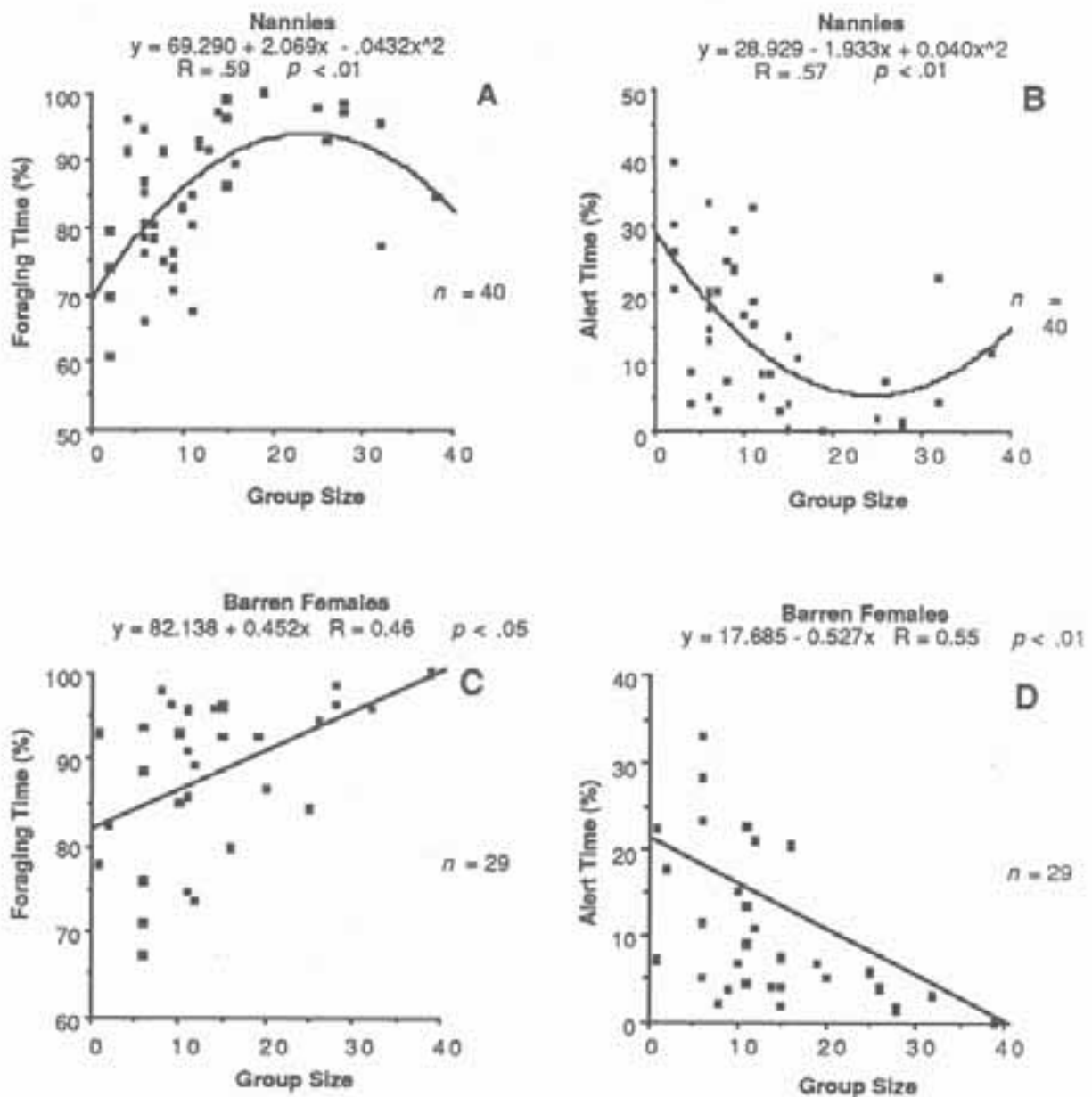| Comparisons:	Significance (p <)		
Adult vs yearlings	ns (ns)	.005(.01)	.75 (ns)
Nannies vs barrens	ns (ns)	.05 (ns)	.75 (ns)
Yearling males vs females	ns (ns)	.75 (ns)	.75 (ns)
Adults females vs males	ns (ns)	.75 (ns)	.001(.10)
Adults w/o kids vs nannies	ns (ns)	.10 (ns)	.50 (ns)
Nannies vs yearlings	ns (ns)	.005(.01)	.50 (ns)
Adult males vs yearlings	ns (ns)	.025(.10)	.50 (ns)
Adult males vs barrens	ns (ns)	.25 (ns)	.001(.10)

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Figure 4. Foraging and alert behavior of nanny and barren female mountain goats in relation to group size on Mount Evans, Colorado, late July to early September 1987. Foraging and alert behavior expressed as the average percent of time spent in each behavior during the observation period. Each point is the average of all the goats of the specified class in that group. On graph A, a linear regression to the points has R = .46 (p < .05).

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decline in foraging time in larger groups (Fig. 4B). The increase in feeding time in larger groups corresponded to the decrease in alert time with increased group size for nannies and barren females (Figs. 4C and D).

Although yearling male and female foraging behaviors were not different when averaged over all group sizes, they did show differences when correlated to group size. Foraging times of yearling males declined with increased group size (Fig. 5C). This decline corresponded to higher alertness in larger groups (Fig. 5D). On the otherhand, yearling females did not significantly increase in foraging within larger groups. Alert time of yearling females was lower in large groups compared to smaller groups, but this was not significant (Figs. 5A and B).

Social Behavior

The percent of time spent in social behavior was not correlated with group size for any class; however, because goats were only studied for 5 min periods, little social behavior was recorded for individual goats.

Nearest-Neighbors

Adult males stayed the farthest from other goats in nanny bands, averaging 3.5 m from their nearest-neighbor. Other classes' average nearest-neighbor distances were 1.9 to 2.9 m. The distance to their nearest-neighbor did not significantly differ (p > .05) between nannies, barren females and yearlings. Differences between goat classes, however, were seen in the class of the nearest neighbor. The nearest-neighbor of adult males was most often a nanny. Nannies and barren females were equally likely to be near each class. Yearling males and females were mostly likely found near another yearling (Fig. 6, Table 3). Nearest-neighbor distances were not correlated to group size for any class.
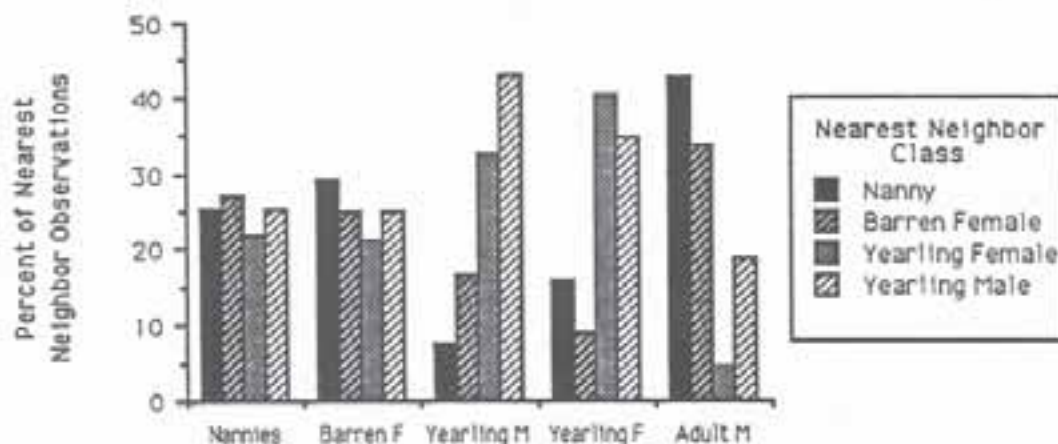

Figure 6. Standardized frequencies of the nearest-neighbor classes for nanny, barren female, yearling feamle, yearling male and adult male mountain goats, Mount Evans, CO, Summer 1987. The observed frequency of a certain class being the nearest-neighbor was standardized by the observed proportions of each class in the study groups (35.6% nannies, 21.5% barren females, 24.8% yearling females, 14.1% yearling males, 4% adult males). Not enough data was available to include adult males.
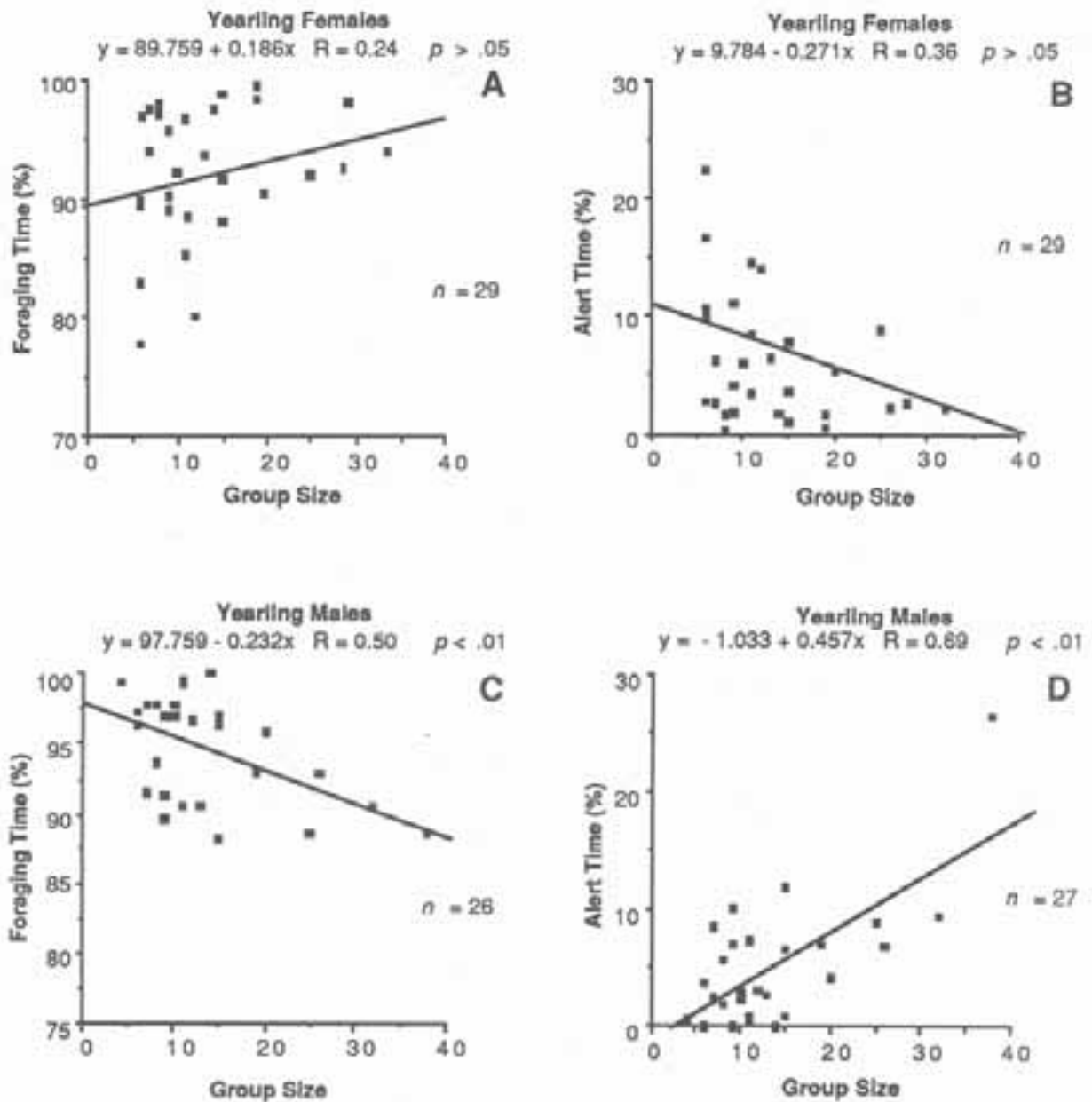
Figure 5. Foraging and alert behavior of yearling male and female mountain goats in relation to group size on Mount Evans, Colorado, late July to early September 1987. Foraging and alert behavior expressed as the average percent of time spent in each behavior during the observation period. Each point is the average of all the goats of the specified class in that group. If the high alertness data point on graph D (group size 38) is removed, R = .45. This is significant at the .05 level.

Table 3. Class composition of the nearest neighbor data for nannies, barren females, yearling females, yearling males and adult males, Mt Evans, CO, Summer 1987. For example, nannies' nearest neighbors were other nannies in 25.4% of the observations, were barren females in 30.0%, etc. Data were standardized by the frequency of each class in the observations. For a given class, I compared the frequency that one class was the nearest neighbor as opposed to another class. For instance, for yearling males, the frequency of their nearest neighbor being a yearling and it being another class are significantly different ($p < .01$).

Class	Nearest neighbor observations by class (% of total)				Comparisons of nearest neighbor classes (significance level α)					
	nanny	barren female	yearling female	yearling male	nannies vs others	barren females vs others	yearling females vs others	yearling males vs others	yearlings vs adults	yearling males vs females
Nannies	25.4	30.0	22.1	25.5	.75	.75	.75	.75	.75	- - -
Barren F	28.8	24.9	21.4	24.8	.75	.75	.75	.75	.75	- - -
Yearling F	7.7	16.4	32.8	43.0	.001	.05	.05	.001	.001	- - -
Yearling M	15.9	8.8	40.4	34.7	.2	.001	.001	.1	.001	.75
Adult M	42.8	33.7	4.6	18.9	.5	.75	.1	.75	.05	.75

DISCUSSION

Foraging Behaviors

This study found that larger group size had a positive or at least neutral effect on the foraging time of females but had a negative effect on the foraging time of yearling males. This was due to increased alert time for yearling males and decreased alertness for females in large groups.

This adverse effect of large group size on yearling males may lead to segregation by encouraging young males to leave large nanny bands. Young males cannot avoid large nanny bands if they stay with the same individual females. Fidelity to one set of goats was seen in females in this population and in the Gladstone Ridge population of the Sawatch range. Throughout the course of a day or number of days, a group of females on Mt. Evans will combine with other groups to form larger foraging bands and that new group may later combine with another to form an even larger band. Unless male goats leave goat groups whenever they become too large, they must forage in different size groups at different times. The disadvantage of foraging within large groups encourages yearling males to either shift from small group to small group or to leave the nanny groups altogether. In this situation the young males must spend a large segment of their time outside of female bands after they have left a band that became too large and before they have found another smaller group.

Why is there a differential effect of group size on male and female behavior? The advantages of large groups for predator defense and detection are well known for many animals (Bertram 1978) including ungulates (Berger 1978 and 1983, Halls 1984, Underwood 1976). Increased security allows decreased individual alert time and increased foraging time. Female goats with kids are more vulnerable and at the same time have higher forage intake and quality needs while lactating. Foraging in large groups increases their security, allowing them to feed in open areas with more abundant forage. Competition increases and social interactions also increase, however, resulting in a higher likelihood of injury. Goats are dangerously equipped with sharp horns and violent contact causes significant damage (Geist 1964).

For nannies, the risk of injury is evidently outweighed by the need for increased foraging opportunities. Barren females do not have higher metabolic needs due to lactating; therefore, increased foraging opportunities are not as important while the risk of injury is still increased. This risk, however, is diminished for both nannies and barren females due to established dominance hierarchies that serve to reduce the chances for violent contact.

While increase foraging and decreased alert time was observed for nannies and barren females, yearling females showed only a slight (not significant) increase in foraging time due to lowered alert time. Yearling females have lower metabolic needs than adult females due to their smaller size (Kleiber 1961). This may account for the lack of a greater increase in foraging in the larger group sizes.

A strong foraging time to group size relationship is not expected for yearling males because like yearling females they have lower metabolic requirements but this could not cause a negative relationship. There are three factors that could have caused the increase in alertness:

1) Yearling males feed on the periphery of nanny bands. In the open areas where large groups feed, the periphery is the most vulnerable and higher alertness is expected for these periphery goats. The relative position of yearling males in foraging bands can easily be examined. In this study, the few adult males observed foraged on the periphery groups, generally far from their nearest-neighbor. Such positioning was not clear for yearling males and could not be quantitatively studied because the position of goats relative to the group was not directly examined.

2) The distance to escape terrain not the group size causes the increase in alert time. The relationship, if any, between distance to escape terrain and alertness can be easily tested by measuring escape distance for different foraging bands.

3) The alert behavior of yearling males in large groups is not actually "alert" behavior, but relations to other goats that are indistinguishable from scanning the area for danger. While observing goat bands at close range, I found goats very vocal and continually making small body and head motions to which other goats respond. These vocal responses and small motions cannot be detected except a few feet from a group. The increased alertness of yearling males may actually be such responses. In this case, the alert behavior is not scanning the area for danger from without but scanning the group for danger from other goats.

This is only one look at sexual segregation in mountain goats. Obviously other factors such as male aggression and forage preferences most likely play a role in segregation. It does indicate, however, that differences in the foraging behaviors of yearling males and females encourage segregation.

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