INTRODUCED MOUNTAIN GOATS IN THE SNAKE RIVER RANGE, IDAHO: CHARACTERISTICS OF VIGOROUS POPULATION GROWTH

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ABSTRACT

Between 1969 and 1971, 12 mountain goats were translocated from northern Idaho to the Snake River Range of southeastern Idaho. Status and ecology of the resulting population was examined between March 1982 and December 1983. The 1983 estimated population of 142 animals has sustained a mean exponential rate of growth (r) of 0.20 since the last introduction; r was estimated at 0.26 for the period 1 July 1982 to 1 July 1983. Productivity was high during 1982 with 71% of adult females ($\geq$ 3-year-olds) producing young, and 25% of the sibling groups being twins. During 1983, 86% of adult females were observed with young, 33% with twins. Observed annual survival was also high between 1982 and 1983; kid survival was 88%, yearling survival was 95%, and average subadult/adult survivial was 93%. Yearling and 2-year-old sex ratios were not significantly different from unity, but observed adult goat ratios were heavily biased toward females. Mean and maximum group sizes were smallest during late spring, when solitary goats were most prevalent. The propensity for groups to cluster was highest and most variable during winter. High-quality habitat appears to be fully occupied before use of less-optimal habitat commences. Goats are now beginning to colonize the Teton Range, where their presence may threaten a resident bighorn sheep population. An aggressive management and research philosophy is proposed.

INTRODUCTION

The Snake River Range is located near the southern boundary of the historical distribution for mountain goats (Oreamnos americanus) (Rideout 1977). The Snake River Range and adjacent Teton Range are isolated by over 160 km of plains and desert from the nearest native population of goats--those of the Lemhi Range of central Idaho. Skinner (1926) explicitly described the Teton Range as an area for which there was no conclusive evidence for the existence of mountain goats.

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The Idaho Fish and Game Department initiated a transplant program in the Snake River Range with hopes to initiate a mountain goat population in lieu of the bighorn sheep population previously extirpated from the area (F. DeShon, pers. comm.). During early July of 1969, 1970, and 1971, a total of 12 mountain goats were relocated from northern Idaho into the Snake River Range at 2 sites (Figure 1, Table 1). Although neither area was fully censused for goats prior to this study, partial surveys and incidental observations indicated that the transplants were successful and the population had grown substantially (K. Neilson, pers. comm.).

Table 1. Composition of mountain goat transplants into the Snake River Range and Big Hole Mountains, Idaho.

Date	#Gts.	Composition	Source Population	Destination
July 1969	5	2 females, 1 male (age unknown)	Snow Peak, ID	Palisades Creek (Snake River Range)
		1 male, 1 female (age unknown)	Black Mtn., ID	
July 1970	3	3 yearling males	Black Mtn., ID	Black Canyon (Big Hole Mtns.)
July 1971	4	Adult female, Adult female with male kid, yearling male	Black Mtn., ID	Black Canyon (Big Hole Mtns.)

This study, conducted between March 1982 and September 1983, was initiated to determine the status and ecology of the mountain goats resulting from these introductions. The purpose of this paper is to present the population characteristics observed during the study, a period of rapid population growth not influenced by hunting. In addition, I hope to bring to attention a probable conflict between the goats originating in the Snake River Range and the bighorn sheep (Ovis canadensis) native to the Teton Range.

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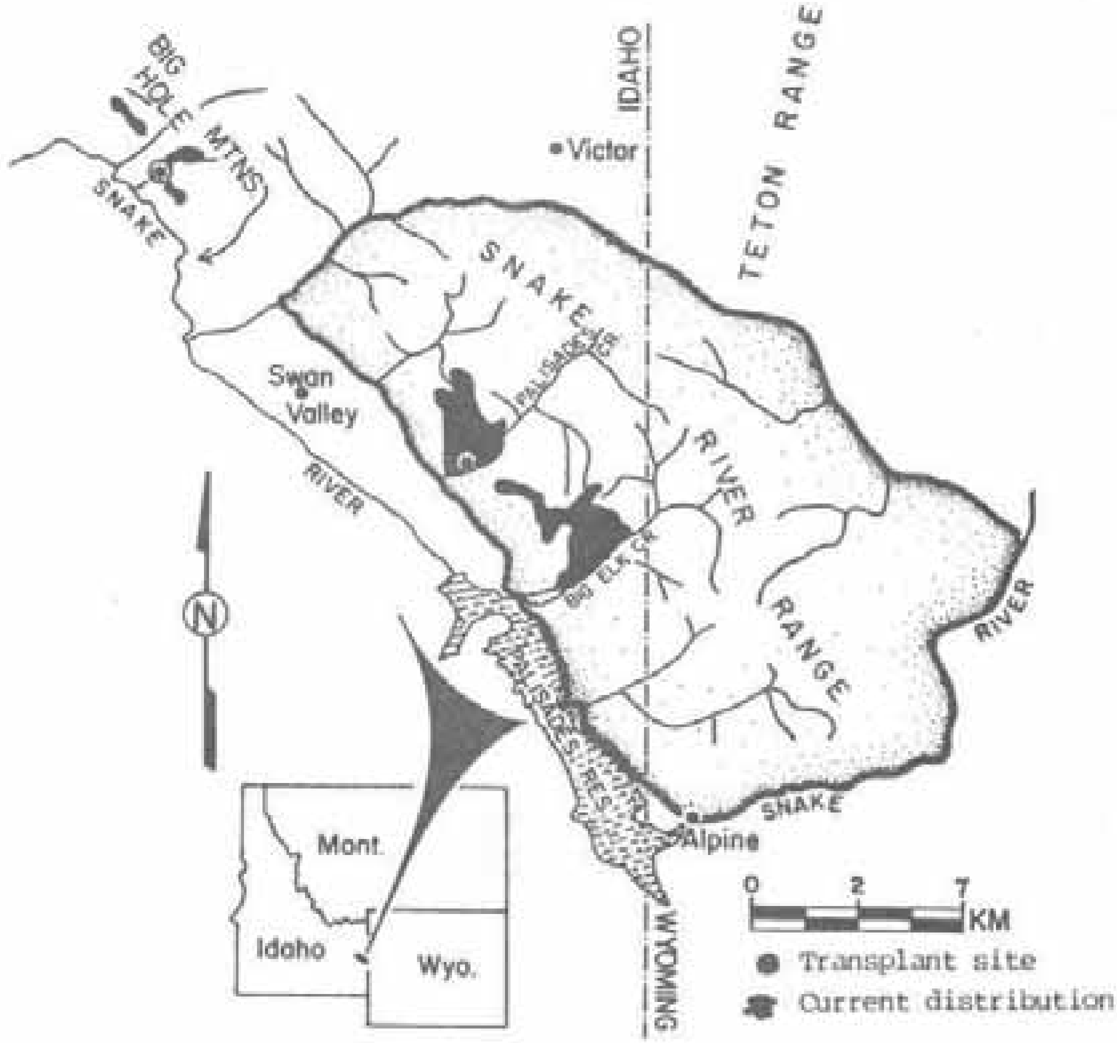
STUDY AREA

Running from northwest to southeast, the Snake River Range spans the Idaho/Wyoming border. Adjacent to the northeast lies the Teton Range, a larger, more rugged range, with elevations to 4197 m. The Snake River Range is small, only about 1200 square km, but elevations range from approximately 1735 to 3060 m. The northwestern 1/3 of the range is known as the Big Hole

Figure 1. Map of the Snake River Range study area, including transplant sites and areas of current distribution (1982-1983).



Mountains, and has a maximum elevation of only 2748 m. The South Fork of the Snake River and Palisades Reservoir form the southern boundary of the Snake River Range (Figure 1).

Peaks of the range are connected by a central axial divide. Cirque basins, common especially throughout the central portion of the range, frequently retain snow through late July (L. Merrill, pers. comm.). Cliff strata are made up almost entirely of a hard, gray limestone.

No true alpine or krummholz areas exist in the Snake River Range. High elevation areas are characterized by large, dry meadows scattered with Engelmann spruce (Picea engelmannii), subalpine fir (Abies lasiocarpa), limber pine (Pinus flexilis), and an occasional Douglas fir (Pseudotsuga menziesii). At the southeastern end of the range, meadows are much larger, and herbaceous vegetation is more lush than elsewhere.

At low elevations, closed stands of Douglas-fir, mixed with bigtooth maple (Acer grandidentata), Rocky Mountain maple (A. glabrum), serviceberry (Amalanchier alnifolia), limber pine, and ninebark (Physocarpus malvaceus), dominate cool exposures between cliff bands. Warm exposures are dominated by old-growth curl-leaf mahogany (Cercocarpus ledifolius) and Utah juniper (Juniperus osteosperma).

Early seral stages characteristic of debris chutes were typified by bigtooth and Rocky mountain maples, along with scattered shiny-leaf ceanothus (Ceanothus yelutinus), chokecherry (Prunus virginiana), and/or red osier dogwood (Cornus stolonifera).

METHODS

FIELD TECHNIQUES

Identification of Sex and Age

Goats were examined through a 15-60x telescope. The identification of genitalia was infrequent. Sexes were classified on the basis of horn curvature and basal width (Brandborg 1955, Lentfer 1955). Additional features provided clues for classification: the association with a kid, general social behavior and timing of the molt (Chadwick 1973), and coat color during the rut (Brandborg 1955). I found it difficult to distinguish the sex of yearlings before midsummer.

When possible, goats were classified as kid, yearling, 2-year-old, or adult. Ages were estimated largely on the basis of rostrum length (Smith 1976), as well as on beard and horn length (Brandborg 1955). Body size, social behavior (Chadwick 1973), pantaloon development (Smith 1976), timing of the molt, and coat color during the rut (Brandborg 1955) provided additional clues for estimating age.

Census Techniques

The entire Snake River Range was censused a minimum of once every 3 weeks between 27 March and 15 September 1982, and between 18 June and 15 August 1983.

Full censuses were also flown periodically during winter 1982. When a group of goats was sighted, I marked their location and age/sex composition on a 7.5 minute topographic map. The time, weather, general behavior of the group, age/sex composition of the group, and incidental observations were recorded in a notebook. During aerial censuses a cassette recorder was used in lieu of the notebook. Standard routes were followed during each census, although minor deviations were necessary to assist in classification.

Ground Censuses. Classification of goats to age-class 2 was possible only during ground censuses. Goats were located and identified by scanning with 8 x 30 binoculars and a 15-60x telescope. All drainages in the area were censused during composition counts, with additional attention given to the Palisades and Big Elk Creek drainages, the 2 major centers of mountain goat activity.

Aerial Censuses. During 1982, 3 aerial censuses were conducted to help assess seasonal distribution and numbers of goats. A Hiller-Soloy helicopter was used to census winter ranges on 10 April and 8 December, when goats were concentrated on winter or winter/transitional ranges. A Bianca Scout plane was used to survey summer ranges on 21 and 22 July. Two aerial censuses were completed during 1983. A Cessna 180 was used to survey summer range on 25 June, 20 July, and 21 July. A helicopter census on 9 December was aborted due to severe weather.

During the helicopter surveys drainages were systematically investigated for goats and goat tracks. Each drainage was divided into several segments by subdrainage. Each segment, typically from 1 to 1.5 km in length, was flown from top to bottom at contour intervals of approximately 60 m. During the April 1982 census, my second week in the field, I was only able to classify goats as kids or non-kids. During the December census, I was also able to distinguish yearlings and the sex of adults from the air.

Because the summer range was so large, and because there was little snow for tracking, the plane censuses were more extensive than intensive. All drainages, including low-elevation cliffs and winter ranges, were flown from top to bottom. Long, high-altitude ridgetops were flown first, in segments of approximately 2 km. Due to the relief of the area and the reconnaissance nature of the fixed-wing flights, drainages associated with each segment of ridge were flown at 120 m contour intervals. Narrow drainages were flown by side-slipping and slowly gliding back and forth straight down the drainage. The minimum speed of the plane (85 km/hr) proved too swift for me to reliably classify goats other than to kids or non-kids.

ANALYTICAL TECHNIQUES

Calculation of Demographics

The discrete nature of the Snake River Range population allowed application of the cohort completion method (Smith 1976) to surveys throughout the year. By this method, identifiable age/sex categories were repeatedly counted, and the highest count was assumed to be closest to the true size of that category. The summation of all age/sex categories (including unknowns) thereby represents the minimum calculated population size. These counts were assumed to reflect the population immediately following the kidding season. Back-calculation of age/sex categories to previous years provided additional information. All demographics reported are taken from the populations resulting from the cohort completion method. A basic assumption behind this method is that goats are properly classified, and the classification to each category is equally reliable. Although this method does not assume equal observability between age/sex categories, it does assume that differences in observability are not extremely disparate.

Statistical Analysis

The DECSYSTEM 20 time-sharing computer at the University of Montana was used in data analysis. Basic descriptive statistics and file manipulation were made easier through use of the 1022 Database Management System program (Jackson 1982). The SPSS Program (Nie et al. 1975, Hull and Nie 1981) was used for more advanced descriptive statistics and non-parametric analysis of density indices. For the analysis of ratios, the G-test (Sokal and Rohlf 1981) was used in lieu of the Chi-square test because of better reliability and ease of calculation. Simple FORTRAN programs were written by the author to calculate harmonic statistics (See Neft 1966), and to perform G-tests. These programs are available upon request.

Calculation of Population Parameters

The instantaneous, exponential rate of growth (r) for the population was estimated according to the following formula:

$$r = \frac{\ln(N_t/N_0)}{t}$$

where, r = estimate of the exponential rate of increase;
N_t = population size at time t;
N_0 = population size at time zero; and,
t = time period length

Population birth and death rates were calculated for each segment of the population from the composite population for 1 July of each year (following the kidding season).

Analysis of Grouping

Grouping was analyzed according to Adams and Bailey (1980) for each drainage and for the entire population. Similar to the method employed by Chadwick (1977), a goat was considered to belong to a specific group if within 50 m and currently or recently engaged in similar activities. Areal concentration of groups was analyzed by examining the distance between groups. Sample size necessitated the lumping of drainages. Straight arithmetic comparisons of the distance between groups are sensitive to the dispersal of even a few individuals, and not to concentration or clustering, and therefore do not make a good measure of concentration. By transforming the distance between groups (or individuals) in a harmonic or inverse manner (DIST ==> 1/DIST) this problem is circumvented (See Neft 1966). Harmonic transformations have been used with individual animals to help describe home ranges (Dixon and

Chapman 1980, Samuel et al. 1983), and have appropriate applications in the analysis of populations.

The average (harmonically-transformed) distance from 1 location (group) to all others, represented as H_d, was calculated according to the following formula:

$$H_d = \frac{n}{\sum_{i=1}^{n} \sum_{j=2}^{n} \frac{1}{M_j}}$$

Where, H_d = the harmonic mean distance from the "anchor" location to all other locations;
n = the total number of locations, and;
M_j = the distance from the "anchor" location (i) to the "object" location (j)

The average H_d among the population of locations is known as H_p, which provides a measure of concentration directly comparable to that of other areas, or to the same area, but at different times (See Neft 1966).

The broken topography of mountain goat habitat severely hinders H_p comparisons, and in fact, detracts from the application of mean harmonic measures (as with any present measure of seasonal or home range). However, a more indirect application of harmonic mean measures yields information on the relative dominance of the clustering effect within an area, and how this changes with time (Neft 1966).

The location of the point on the map with the smallest distance to all other locations is known as H_c, and its value is represented by H_r (which equals the H_d for that point). The ratio of H_p to H_r indexes the dominance of the clustering exhibited by the population of locations--but is not a measure of concentration (as is H_p by itself).

The location of H_c and the associated value of H_r can be estimated by overlaying an artificial grid on the map of locations, and evaluating the H_d associated with each grid intersection. This is the general method used by Dixon and Chapman (1980) and Samuel, Pierce, Garton, Nelson, and Dixon (1983) to map harmonic home ranges. Except when sample sizes are small, or locations very widely scattered relative to the desired degree of precision, the coordinates of the location with the smallest H_d can be used as a reasonable estimate of the location of H_c, and that H_d can similarly be used to approximate H_r.

Neft (1966) considered a H_p/H_r ratio of over 2.0 to represent a strong clustering effect, and a ratio below that to indicate poor or no clustering. The theoretical range for this ratio is from 0 to infinity, but in practice, it normally ranges from 0 to 6, and is rarely over 15.

RESULTS

Two major concentrations of goats were found in the Snake River Range. The primary center of activity was in the Palisades Creek drainage, and a secondary center was in the Big Elk Creek drainage (Figure 1). Near the site of the first release, the Palisades Creek herd comprised about 2/3 of the total population during the study. Most of the remaining goats were found near Mount Baird, the highest peak of the range. A maximum of only 5 goats were seen near the site of the 1970 and 1971 release site, at Black Canyon, in the northwestern portion of the range.

The minimum observed population size was 103 goats in 1982, and 142 goats in 1983. The calculated population was 109 goats in 1982, and 142 goats in 1983. Using the calculated populations, the r-value was estimated at 0.26 for the change from 1982 to 1983. Censusing was intensive during this study, and I feel reasonably confident that the population-segment estimates (Table 2) are within 10% of their true size.

Because transplant demographics were obviously very skewed from that of a reasonable population structure, and because the goats were transplanted in more than 1 year, I took the growth of the adult female (≥ 3 years old) segment of the population at the time of the last release to be a more true indicator of overall population growth. In 1971, a maximum of only 4 adult females was possible. The r-value for this segment of the population to 1983 was 0.20.

Productivity was high during both 1982 and 1983 (Table 3). No significant differences in productivity were found between 1982 and 1983, or between drainages in either year (G-test, $P>0.10$). By 28 May 1982, I had not observed any neonates, but a severe snowstorm on that date severely hindered visibility. On 30 May, I found 5 kids (including 2 sets of twins) among 6 non-kids in the same area. By 21 June, the kid crop was apparently complete. The population was not examined during the 1983 kidding season.

During early summer 1982, 21 of 29 adult females (72%) were observed with kids, and 5 of 21 sibling groups (24%) were twins. During the same period in 1983, 30 of 35 adult females (86%) were observed with kids, and 10 of 30 sibling groups (33%) were twins.

In terms of precipitation from November through March, the 1981-82 winter was the most severe since 1957 (when those records were first kept at Palisades dam). The 1982-83 winter ranked 6th among the preceding 26 years. Despite these severe winters, the calculated survival rate for the population including unclassified goats was 94% between 1982 and 1983. Survival was estimated at 92% for the classified population for this period, with no significant differences between kid, yearling, and average subadult/adult rates (G-test, $P>0.95$). Observed kid survival was 88%, yearling survival was 95%, and the average subadult/adult survival was 93%.

The age structure of the population was extremely broad-based, with less than 2/5 of the classified population in the adult category during either year. There was no significant difference in age structure between 1982 and 1983 (G-test, $0.30>P>0.20$) (Figure 2).

Table 2. Composition of mountain goats in the Snake River Range, Idaho using the cohort completion method (Smith 1976).

		Classification[1]														
Year	Location	AF	AM	AU	2F	2M	2U	2+F	2+M	2+U	YF	YM	YU	K	U	TOTAL
1982	Palisades	15	4	0	4	5	0	0	1	0	5	6	2	12	4	58
	Big Elk	13	4	0	1	2	0	1	3	1	2	1	5	13	0	46
	Other	1	1	0	1	1	0	0	0	0	0	0	0	1	0	5
	Total	29	9	0	6	8	0	1	4	1	7	7	8	26	4	109
1983	Palisades	23	7	0	7	9	1	0	0	0	4	4	11	24	2	92
	Big Elk	12	11	0	1	1	2	0	1	0	1	2	1	16	1	49
	Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	35	18	0	8	10	3	0	1	0	5	6	13	40	3	142

[1] A:adult; 2:age class 2; 2+: 2 years or older; Y:yearling; K:kid; U:unknown; M:male; F:female.

Table 3. Natality in mountain goats of the Snake River Range, Idaho; 1982-1983.

	1982			1983		
	No. Adult Females[1]			No. Adult Females[1]		
No. Kids Produced	Palisades	Big Elk	Total[2]	Palisades	Big Elk	Total[2]
0	6	2	8	4	1	5
1	6	9	15	14	6	20
2	3	2	5	5	5	10
	15	13	28	23	12	35
Productivity	0.87	1.00	0.90	1.04	1.33	1.14
Proportion of AF's without a kid	0.04	0.15	0.28	0.17	0.08	0.14
Proportion of twins per AF	0.20	0.15	0.18	0.22	0.42	0.29
Proportion of twins per productive AF	0.33	0.18	0.25	0.26	0.45	0.33

[1]Adult females are 3 years of age or older.
[2]Includes observations from other portions of the range

Figure 2. Comparison of sex ratios in the Snake River Range mountain goat population when subadult cohorts are included with older goats.

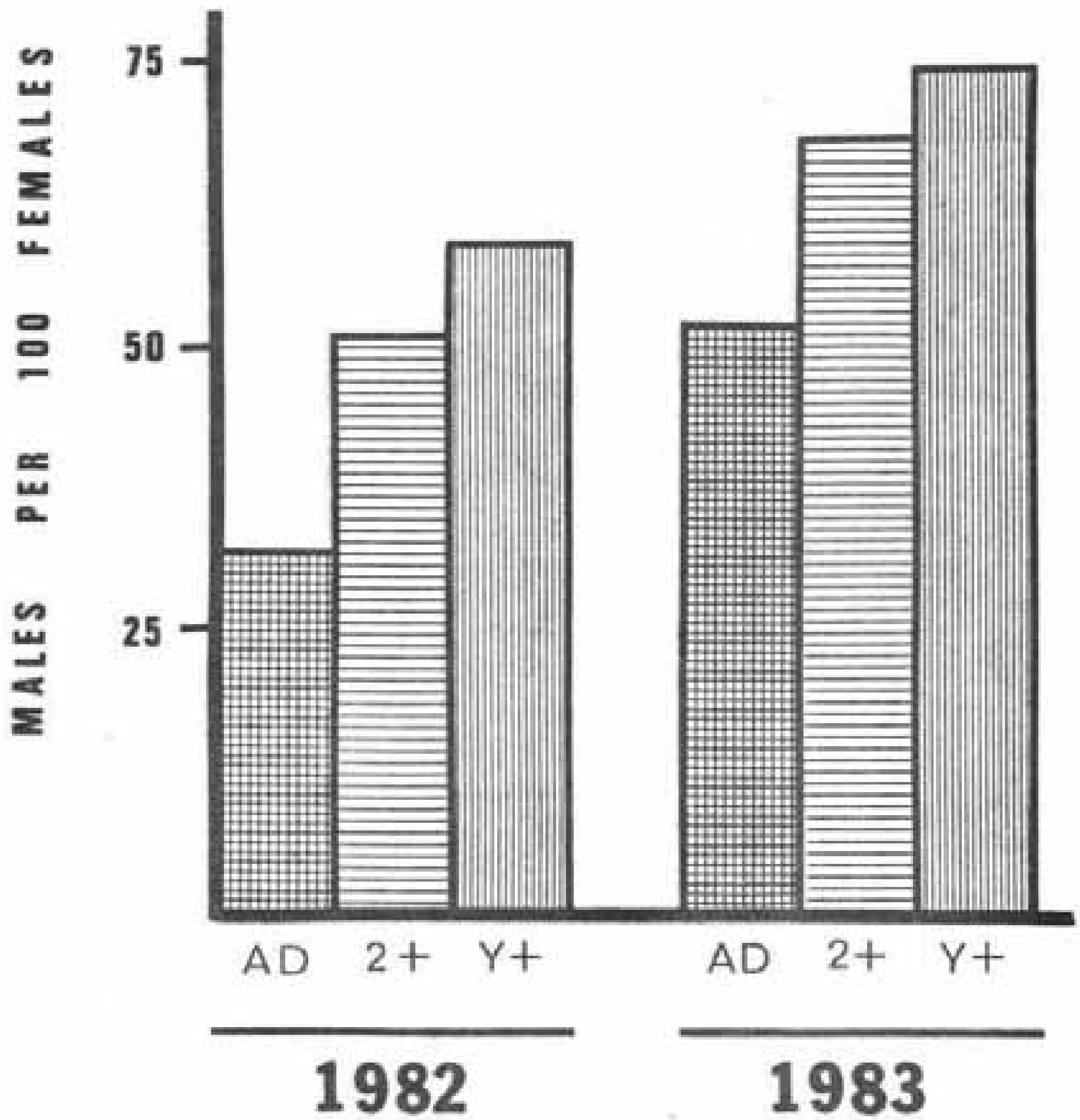


Figure 3. Age structure of mountain goats from complete surveys in the Snake River Range, Idaho, 1982-1983.

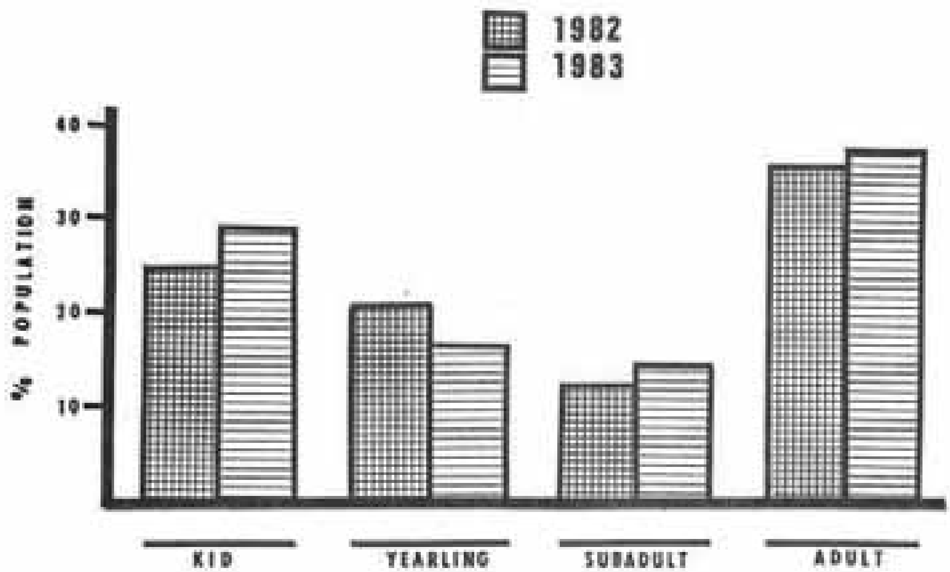
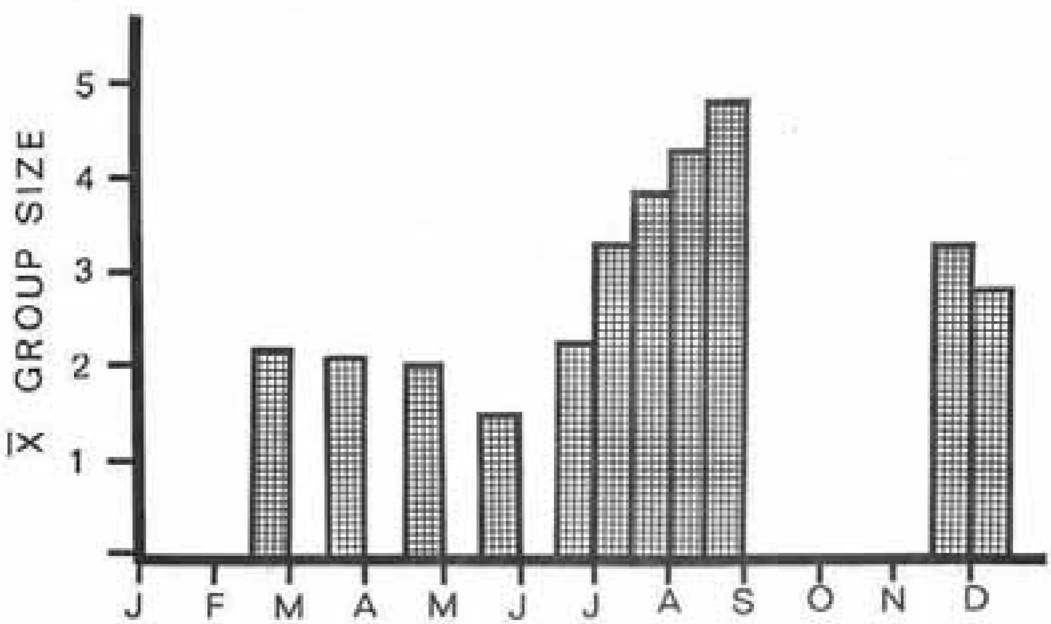


Figure 4. Bimonthly group mean group sizes of mountain goats observed during full surveys of the Snake River Range, Idaho. Data are from 1982 and 1983 (combined).



The sex ratio was even among yearlings (G-test, 0.90>P>0.80) and 2-year-olds (G-test, 0.6>P>0.5). Adult sex ratios, however, were heavily biased toward females (G-test, P<0.001). Inclusion of yearling and 2-year old cohorts in sex ratios for the population (Figure 3) therefore masked the relative proportion of sexually mature males to sexually mature females (G-test, 0.10>P>0.05).

Mean group size was smallest during mid-May and highest during mid-July (Figure 4, Table 4). The proportion of goats that were solitary animals was lowest during mid-summer. The standard error of groups was smallest during late-winter/early spring.

Seasonal H_p/H_r ratios calculated for the Snake River Range (Table 5) indicate a strong clustering effect (according to Nef's 1966 criterion), especially during winter. Analysis of the variation of these ratios between summer and winter indicated a difference that was not quite significant statistically (Kruskal-Wallis test, P=0.15), but the sample size for each season was small (N_1 = 4, N_2 = 5), thereby limiting the power of the test. It appears that winter concentration ratios may be more variable than summer ratios, perhaps a reflection of the variability of winter conditions versus the relative stability of summer conditions. Sample size was too small to permit comparisions between years.

DISCUSSION

With regard to the characteristics discussed by Pianka (1970), mountain goats may be viewed as a very 'k'-selected species. Where mountain goats are found in small, semi-isolated populations, management should be precise and based on accurate information. Unfortunately, the general lack of knowledge about population structure, age-specific rates of productivity and survivorship, and the influence of social behaviour confound such a management scheme. Consequently, management has been, at best, based on an extrapolation of much more general data.

Perhaps the most important factor contributing to this management approach is the difficulty in counting and classifying mountain goats. Accurate sex ratios are difficult to determine because males and females look very similar and males are frequently more dispersed than females. Many researchers classify goats only as kids or non-kids, although some identify the yearling cohort. Several researchers have classified 2-year-olds also (Chadwick 1973, 1977, Smith 1976, Dane 1977, Nichols 1980, Risenhoover and Bailey 1982, Smith 1982), despite problems inherent with variation in horn growth (Foster 1982) and other aging criteria.

In many areas, goats can only be classified as kids and non-kids for practical or economical reasons. Where more detailed breakdowns of age-structure are possible however, the analysis of population dynamics is made easier.

Bias From Differences in Population Structure

The structures of recently-introduced populations (those that have not yet achieved a near-stable age distribution and growth rate) are difficult to

Table 4. Grouping characteristics of mountain goats in the Snake River Range, Idaho. Data are from full surveys of drainages only.

Date	# of Goats	Range in Group Size	Mean Group Size	Standard Deviation	Standard Error	% Groups as Singles	% Goats as Singles
15[1] February	70	1-6	2.19	1.42	0.65	41	19
15 March	135	1-8	2.08	1.63	0.78	52	25
15 April	120	1-9	2.03	1.67	0.82	56	28
15 May	78	1-6	1.50	1.18	0.79	79	53
1 June	76	1-9	2.23	2.00	0.90	53	24
15 June	326	1-15	3.36	2.99	0.89	30	9
1 July	146	1-22	3.84	4.16	1.08	37	10
15 July	295	1-24	4.54	4.45	0.98	34	7
1 August	122	1-14	4.36	3.98	0.91	29	7
15 August	135	1-17	4.82	4.10	0.85	18	4
15 November	130	1-14	3.33	3.19	0.96	44	13
1 December	206	1-9	2.82	2.25	0.80	42	15

[1] The first half of a given month is represented by a 1 and the second half by a 15.

Table 5. Harmonic mean measures of distribution of groups of mountain goats in the Snake River Range, Idaho (see Neft 1966).

Season	Date[1]	H_p	SE	H_r	H_p/H_r[2]	No. Groups
Winter	11/15	71.59	0.37	38.02	1.9	12
	12/00	203.54	0.89	61.86	3.3	62
	2/15	122.54	0.81	27.66	4.4	25
	3/15	205.05	0.98	35.38	5.8	47
	4/15	111.07	0.43	49.18	2.3	47
	Average	142.76	****	42.42	3.4	
Summer	7/00	169.27	0.46	67.52	2.5	21
	7/15	230.50	0.74	94.78	2.4	12
	8/00	98.12	0.59	39.42	2.5	21
	9/00	102.87	0.59	47.94	2.1	10
	Average	150.19	****	62.42	2.4	

[1]For the day, 00 indicates the first half of the month, and 15 indicates the second half.

[2]Indexes the dominance of the clustering within the distribution.

compare except grossly because of the many complications involved. Population structures of recently-introduced populations vary from one locale to the next because of differences in the size and demographics of the transplants, timing between transplants, number of transplants, and variability of genetic potential.

These factors, in conjunction with the amount of time elapsed between the transplant(s) and the study of the population, make a clear analysis unrealistic. The progressive, rippling instabilities of the structure of introduced populations are further complicated by factors that often make the comparisons between established populations difficult. Such factors include:

1. study procedures/data reliability;
2. seasonal strategies of habitat use (e.g. winter survival on high vs. low elevation ranges);
3. inherent habitat constraints (e.g. browse vs. graminoid/forb winter ranges);
4. variable sources of natural mortality;
5. the influence of local climate;
6. variable hunting regimes and other direct influences of man; and,
7. indirect influences of man (e.g. mining near kidding areas.

Each age-class of a population contributes to population parameters in a particular manner. The best comparison of parameters between populations is by using age-specific rates. However, the construction of such tables for mountain goats is rarely feasible except for kid, yearling, and in more intensive studies, the 2-year-old age-classes. Comparisons of lumped rates between populations are possible only if population structures are similar, but much information is still lost.

Age-specific fecundity schedules have not been developed for mountain goats. As found, for example, with mule deer (Robinette and Gashwiler 1950, Robinette et al. 1955), fecundity during the first year of sexual maturity can probably be expected to be lower than that of the next few age-classes, and a gradual drop in fecundity can be expected in the oldest age-classes. Under these conditions, the productivity exhibited by a population with a young age-structure would be different than that of a population of the same size, but with an old age-structure, even if they were on identical ranges. This influence should be kept in mind when interpreting productivity rates and other parameters from this and other recently-introduced populations.

Habitat Colonization

The strong affinity for cliffed areas by mountain goats is well-documented. Kuck (1977), during his study of a rapidly-declining goat population in the Pahsimeroi Range of Idaho, found that the value of a cliff or cliff complex appeared to be more related to physiographic characteristics than to vegetative characteristics.

The Palisades Creek and Big Elk Creek drainages have the steepest low-elevation base slopes in the range. In the Palisades Creek drainage, the tier-like arrangement of cliffs and the abundance of curl-leaf mahogany, a high-quality browse, makes this area an especially lucrative winter range for mountain goats. The Big Elk drainage, with very good regeneration of mahogany and many large cliffs, appears to have good potential. Beyond these 2 areas, however, cliff areas of the Snake River Range are decidedly smaller and more isolated.

Another large drainage of the range, Indian Creek, contains a fair number of low-elevation cliffs with ample forage, but the base slope itself is noticeably much more shallow. Here, at the southeastern end of the range, snowfall seems to be heavier than elsewhere, as prevailing winds from the southwest pick up moisture from Palisades Reservoir before dumping it as snow in the mountains. Thus, in addition to less effective snow-shedding properties, heavier snowfalls make this a less desirable winter range.

In general, there are many areas in the Snake River Range that are comparable vegetatively to occupied areas, but no areas are nearly similar physiographically. Mountain goats in the Snake River Range appear to be colonizing and filling the high-quality habitat of the Palisades Creek and Big Elk Creek drainages well before colonizing less-optimal habitat in other portions of the range. The high densities of goats in these 2 primary areas indicate that there may be a large difference in quality between that of the currently-occupied habitat and that of the next best (and as yet unoccupied) habitat.

Population Dynamics

The mean r-value for the first 12 years of the Snake River goat population is comparable to the 20-year rate calculated by Guenzel (1980) for transplants into the Selkirk Mountains of Idaho, and the Black Hills of South Dakota. Only the transplants into the Crazy Mountains, Montana, and the Gore Range, Colorado exhibited faster growth.

The high growth rate found in this population is probably related to good forage quality and quantity. The abundance of curl-leaf mahogany, and additional composite of juniper, Douglas-fir, maples, ceanothus, etc. form an excellent browse-based winter range. Goats in the Snake River Range have not been present in large numbers for an extended period of time, and the winter vegetative communities have not approached the zootic disclimax typical of most browse-based ranges.

Heavily-impacted winter ranges with poorly-sprouting browse species (such as curl-leaf mahogany) do not have the inherent ability to quickly recover. Subsequently, a substantial lag may follow a herd reduction before the vegetation can recover enough to increase productivity and survival. Similarly, high-elevation ranges, because of their short growing seasons and more harsh environment, usually cannot recover quickly either. J. Swenson (pers. commun.) notes that in situations where the vegetation can quickly recover, a more compensatory response to goat hunting may be expected. In any case, the 2 year lag between birth and sexual maturity makes any compensatory response a slow one.

Productivity

Productivity observed during this study was high relative to other populations (Table 6). This appeared primarily to be the result of a high rate of twinning despite a substantial number of females observed without kids.

Even age-specific productivity rates rarely reflect parturition accurately. Use of a productivity rate implies that we have knowledge of the actual number of young being produced, when in fact, we derive this as an estimate some time after birth of the young. Thus, early juvenile mortality is incorporated with both non-conception and non-parturition of successfully bred females in the statistic, and productivity statistics should be interpreted with this in mind.

Caughley (1977) notes that the age of fecundity is often lower in rapidly-growing populations than those with no (positive) growth. Stevens and Driver (1978) observed "several" 2-year-old nannies accompanied by kids in the introduced population of the Olympic Peninsula, Washington. They also reported that no adult female observed during their study was seen without a kid at her side. In the Snake River Range population, the age of sexual maturity was approximately 2.5 years for the first breeding. Several times during late-summer 1982, I observed what appeared to be an age-class 2 female with a kid. Confirmation of the nanny's age was not possible, however, and she may have merely been a "low-quality" 3-year-old.

Maturation of young goats continues through winter, but at a slower rate than during the remainder of the year. Most age-class 2 goats were distinguishable from other age-classes through mid-winter, and a few individuals were distinguishable through early spring. Although age-class 3 goats were not readily discernible during June, behavioral cues and impressions of slightly smaller body sizes, rostrum lengths, and horn size often hinted that certain animals were likely 3 years of age.

I was not able to reliably age age-class 3 goats in either year of the study. However, of those nannies that I felt were likely to be 3-year-olds, none had twins. I suspect that the twinning rate (and by inference, parturition rate) among 3-year-old females is much lower than that of older females.

During the collection of behavior data during late June 1983, a nanny with what appeared to be a set of triplets was observed for extended periods of time over a 4-day period. Suspected triplets were not observed during any census, however, and so are not included in the productivity summary. Lentfer (1955) reported the only other cases of suspected triplets, in the rapidly-growing, introduced population of the Crazy Mountains, Montana. Of 311 kids observed during the 2 years of his study, Lentfer classified 3 sibling groups as triplets and felt he had evidence for 3 additional sets.

Caution is necessary in the interpretation of multiple birth statistics. On 19 August 1982, I witnessed 2 kids to leave a nanny in one group and join a different group. Disturbed by my presence, a group of 9 goats slowly crossed the hillside away from me. One kid became separated from the rest of the group and began bleating loudly, whereupon the second kid broke from the group and ran back to the first kid. The remainder of the group continued across the

Table 6. Comparison of productivity estimates between selected studies. All estimates expressed as the number of kids per 100 females ≥3 years of age or older.

Location	Source	Year	Kids per 100 mature females	Population Size
Montana	Chadwick 1973	1971	44	25
		1972	73	29
		1973	89	31
Montana	Smith 1976	1974	40	132
		1975	39	110
Montana	Chadwick 1977	1974	56	314
		1975	55	300
		1976	57	232
British Columbia	Dane 1977	1968	13	36
		1969	27	18
		1970	35	36
		1971	50	32
		1972	50	37
British Columbia	McFetridge 1977	1974[1]	75	32
		1974[1]	27	23
		1975[2]	69	39-42
		1975[2]	80	31-33
Alaska	Nichols 1980	1977[3]	108	45
		1977[4]	70	58
		1978[3]	79	41
		1978[4]	54	59
		1979[3]	77	42
		1979[4]	87	37
Colorado	Rissenhoover and Bailey 1982	1981	100	118
Idaho	This study	1982	90	109
		1983	114	142

[1] Mt. Hamell.
[2] Goat Cliffs.
[3] Ptarmigan Lake.
[4] King's Bay.

hill and out of sight. Neither the nanny or any other goats showed c oncern over the absence of the 2 kids. Meanwhile, both kids took up bleating loudly and were answered by a kid in a group of 3, also including a nanny and a 2-year-old male.

The 2 kids then joined the new group, and after a 10-15 minute period of acquaintance and play, bedded next to the nanny. I observed this new group for the next 40 minutes, and the kids appeared to be well-accepted into the group.

Foster and Rahs (1982) concluded that the separation of a nanny and her kid was not an uncommon phenomenon, and that orphaned kids will often join a foster group. They supported Rideout's conclusion (1974, as cited by Foster and Rahs) that nanny/kid separations do not always lead to the kid's death, and note that metabolic dependency on nursing is probably complete before mid-August under normal circumstances.

Among bighorn sheep, Hass (1984) documented nursing of lambs on females other than their mother in a low winter-stressed population on the National Bison Range, Montana. This type of behavior would increase the chances for survival of orphaned young during summer. It is not reported if this allo-mothering extended to protection and care of the "stranger's" lambs, which would increase orphan survival well beyond the nursing stage. Cooperative nursing and other forms of allo-mothering have not been described among mountain goats. It appears most likely that orphan survival and health is largely a function of the orphan's own resources and its ability to join a foster group.

Survivorship

Productivity for introduced mountain goats is higher than that of native or established populations as indexed by the proportion of kids to females 2 years of age or older (Bailey and Johnson 1977). The high survivorship observed in the Snake River Range supports the hypothesis that survivorship, the second important determinant of population growth, can be expected to follow the same pattern.

The opportunity for a goat to die by an accident is probably less here than on most winter ranges. The cliffs themselves are relatively small, and avalanches are not abundant--possibly because of shallow base slopes.

Golden (Aquila chrysaetos) and bald (Haliaetus leucocephalus) eagles are frequently observed in the Snake River Range. Both species nest within or adjacent to these mountains. Coyotes (Canis latrans) are abundant and bobcats (Lynx rufus) are also present. Mountain lions (Felis concolor) are common in the range, and tracks were observed almost on a daily basis on the Palisades Creek winter range during late winter and early spring. The low mortality rate for the goats reflects the low influence of predation on the population, at least outside the neonatal period.

Poaching has been identified as a major source of adult mortality in other areas, and has apparently affected this population also. On 27 March 1982, during the first survey of the study, I found the headless carcass of a large adult billy. Apparently left within the previous 3 weeks, the carcass had been caped and left on a hiking trail below a winter range cliff. The caped carcass of another adult billy was found in the southeastern part of the range during a Wyoming elk hunt during September 1983 (G. Roby, pers. commun.). Casual reports from local residents indicate that one resident may have taken up to 4 illegal goats from this population, and there are rumors of illegal guided hunts. How much poaching has affected the growth of the Snake River Range population remains unknown. My presence in the range probably lessened the degree of poaching during the study.

Juvenile Mortality

The lower productivity observed in 1982 likely incorporates early juvenile mortality. In terms of total winter precipitation, the winter preceding the 1982 kid crop was the most severe in the previous 25 years. This may have weakened at least the smaller (and presumably younger) nannies, and affected the fetus.

On 28 May 1982, a heavy, wet snow fell, and the weather remained very cold and wet through 7 June. This is the first, and perhaps crucial, part of the kidding season in the Snake River Range. The combination of a harsh winter and a cold, wet kidding season probably contributed to early juvenile mortality, and might have been incorrectly interpreted as poor production.

Additionally, I may have directly contributed to the mortality of a set of twins. During an exploratory survey on 30 May 1982, I rounded a rocky outcrop and came face-to-face with a nanny and 2 very young kids. Hoping the nanny would lead the kids away, I froze. Instead, she stamped her feet several times and left the vicinity, but the kids could not keep up. Immediately leaving and circumventing any area I thought visible to the unseen nanny, I retraced my path back to a hidden vantage point about 750 m from the kids. The abandonment took place at about 1500. Although the kids bleated frequently, the nanny did not return by 2030, at which time I couldn't see any more. I did not find evidence of the kids upon my return to the area on 1 June. These kids were extremely small and were probably less than 2 days old. Unless the nanny returned soon after I left, it is doubtful the kids survived that night because of the inclement weather.

Grouping

One manner in which the analysis of a population may be augmented is by examining the density of the population. A major drawback in the calculation of densities is that it is often difficult to empirically define the boundary of the area under consideration in a biologically meaningful manner. There is also a difficulty in predicting what habitat is suitable (or tolerable) to mountain goats, i.e. which areas within the general boundary may be included. Broad demarcations tend to include large amounts of area not suited to mountain goats. The steepness of the base slope and other topographical considerations contribute to the amount of "preferred" area estimated. Comparisions of densities are generally useful only within a specific locale from year to year, and the interpretation of changes in these densities is limited.

In lieu of examining density, examining grouping patterns infers much about the same relationships. As noted by Adams and Bailey (1980), average group size is a function of many factors, including season, population size relative to available resources, physiography, vegetation structure. Other factors include population structure, reproductive success, survivorship, winter severity, and continuity of the habitat. Needless to say, it is extremely difficult to attribute differences in patterns of grouping to any one or certain combination of specific factors.

The seasonal group size and annual pattern of grouping of goats in the Snake River Range population was typical of populations that winter at low elevations. The mean group size during summer was slightly larger than those compiled by Adams (1981) for subalpine-wintering goats, and the mean group size during winter fell in the middle of the range of means he compiled. Goats in the Snake River Range appear to fragment into slightly smaller groups during winter, and coalesce into slightly larger groups during summer. Adams and Bailey (1980) theorized that larger group sizes could be expected in recently-introduced populations because of a lack of severe competition. The range of group sizes, percent groups as singles, and percent of goats that were singles also compare most closely with those reported for Colorado goats wintering on subalpine ranges (Adams and Bailey 1980, Adams 1981).

Dispersal

In this study, as found with most other mountain goat populations, immature goats of both sexes and adult billies were less centralized on seasonal ranges than adult females. It was not uncommon to find yearling and 2-year old females associated with adult males during late spring and early summer. This type of association would facilitate the permanent colonization of new locales.

Mountain goats have been observed annually during summer in the Teton Range since 1975, and have recently been observed wintering there (M. Whitfield, pers. commun.). Recently, the composition and timing of the sightings indicate that their presence in the Tetons is becoming less ephemeral in nature. The establishment of a permanent goat population in the Tetons may already have begun. A nanny and kid were observed in Webb Canyon, in the northernmost end of the Tetons during late June 1983 (M. Whitfield, pers. commun.). The Tetons are still well-covered by snow through this period, and it is unlikely that these animals travelled the 57 km length of the range (and a portion of the Snake River Range) in less than 2 weeks--especially in light of the age of the kid. It is not known if this female wintered in Webb Canyon or nearby. Historically, this area has been used by bighorn sheep as a lambing area, but not as a winter range (Whitfield 1983).

During late winter in the Tetons, the high-elevation patches of bighorn winter range become ice-capped forcing sheep onto the cliffs (Whitfield 1983). Thus, although bighorns and mountain goats normally tend to segregate on a physiographic basis, the presence of goats in the Tetons would probably lead to sheep competing with goats for forage and space, and possibly to 2-way competition, because of this critical, late-winter habitat is more typical of that to which the mountain goat has adapted.

CONCLUSIONS AND RECOMMENDATIONS

The Snake River Range population is currently growing extremely rapidly and may be approaching the carrying capacity of the occupied habitat. This rapid growth has been made possible by an abundance of browse on winter ranges, which has received minimal use until the recent past. The distribution of the population infers that the primary habitat of the range has been occupied, and further range expansion will be to areas of much lower quality. It is likely, therefore, that density regulation will begin to play a major role in population dynamics in the near future. As goats disperse into less-optimal habitat, expansion into the Teton Range can be expected--with probable detrimental effects to the bighorn sheep population of that range.

It appears that agressive management of the goat population at this time could mitigate a severe overshooting of the carrying capacity of the Snake River Range. The first hunt on this population was conducted during November 1983 and included 6 permits: 3 in the Palisades Creek drainage and 3 in the Big Elk Creek drainage. For fall 1984, the hunt was expanded to 5 permits in each area. To effectively slow population growth to a rate that would allow the early stabilization of population size, 10 to 13% of the population (currently 15 to 20 goats) should be harvested over the next 2 to 5 years to allow the vegetation to achieve the zootic disclimax that will ultimately determine population characteristics. Harvest need not be concentrated on billies during this period, and, in fact, should include mature females. Intensive aerial and ground trend and composition surveys are necessary each year to evaluate the status of the population during this critical period to allow the evolution of a more conservative management scheme as density regulation commences. This close monitoring is key to a successful management plan.

When future trend and composition analyses infer that density regulation is beginning to play a major role in population dynamics, the harvest should be reduced substantially. The current Idaho standard of a 4 or 5% harvest for mountain goats would be more appropriate at this time. If the harvest were concentrated more on the male segment of the population, a slightly higher harvest would be possible.

Careful monitoring and further study of this population is also recommended for more universal reasons. This population presents a rare opportunity to examine a relatively isolated population at various levels of density regulation. An ecological study by Hayden (unpubl. data) prior to the hunting of this population, and an ongoing behavioral study by Whitfield and Hayden (unpubl. data) provide baseline material for more indepth, longterm studies exploring the concepts of habitat colonization and selection, the role of social behavior, population dynamics, the effectiveness of aggressive management with introduced populations, and other ecological concepts.

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