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MOUNTAIN GOAT MOVEMENTS STUDY

By

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Period Covered: July 1, 1981 through June 30, 1982

SUMMARY

Of 34 goats radio-collared at the beginning of this report period, 32 were still alive and broadcasting at its end. No new collars were installed after June 1981. Radio tracking during summer 1981 was limited due to weather and lack of aircraft. Eight tracking flights were made during the report period, with all collared goats relocated during each flight. Movements between and within seasons have been variable; more data are needed before any conclusions about range fidelity or predictability can be reached. A herd of 218 goats is estimated in the study area based on spring and summer aerial counts. Known movements suggest increasing the size of the study area to include those goats on the north side of Trail Glacier as part of the study herd. Mortality in the collared sample of goats was light during the comparatively mild winter of 1981-82. It is recommended that this study continue for at least 3 more years to make full use of radio collar life and to obtain sufficient data for reasonable management recommendations.

Key words: fidelity, mountain goat, season, seasonal movements.

CONTENTS

BACKGROUND

One of the major concerns of game managers in Alaska is the difficulty in counting mountain goats (Oreamnos americanus) accurately from the air, making the assessment of populations and population changes highly questionable. Previous studies have shown that acceptable accuracy can be obtained from aerial counts conducted under suitable conditions (Ballard 1975, Nichols 1980a). However, on the Kenai, it was found that goats moved considerable distances between seasonal ranges, and in so doing, crossed count areas or hunting Unit boundaries. Furthermore, it was strongly suspected that at least some goats moved from area to area during midsummer when aerial counts were most practicable.

Gross movement studies were attempted by aerially dye-marking goats for identification. While the marking was relatively inexpensive and successful, the method was useful only for detecting gross movements; individuals could not be identified or tracked. In addition, the dyes used so far have proven too short-lived for serious movement study.

If goats do move during the summer counting season, it is apparent that counting inaccuracies will result when unknown movements occur between count areas. Increases or decreases in count results can reflect unknown movements rather than real population changes. Thus, the management biologist does not know the true population sizes within the Units for which he issues hunting permits.

Therefore, it is of immediate concern to learn whether such movements are random or predictable; whether the same herds or subherds can be expected on a given area during part of the year; or whether their seasonal or intraseasonal movements can be predicted. If movements are predictable, censuses can be interpreted properly; if unpredictable, it will be necessary to establish larger count areas to include such movements. Otherwise, Unit management will have to be conservative and take into account the possibility of serious counting errors.

This job has been designed to determine the fidelity of goats to particular areas by time, and hence the predictability of given animals being in a given area at a given season where they may be counted each year. It has also been designed to discover major seasonal movements by the various subsegments of the Ptarmigan Lake/Trail Glacier/King's Bay herd which has been under study, and to learn whether goats move into and out of the study area boundaries. Additional information obtained will indicate mortality causes and rates, home range size of individuals, winter range sizes, and should provide an additional check on the accuracy obtained in aerial censuses.

During the 1st report period, 20 goats were collared with radio-collars and relocated during each of 18 subsequent tracking flights (Nichols 1980b). One collar failed shortly after installation. Of the 19 remaining collared animals, 14 survived the severe winter and avalanches of 1979-80 and continued to be tracked into the next report period, during which 24 additional tracking flights were made. In the 1980-81 report period, 21 more goats were captured and fitted with radio collars (Nichols 1981).

OBJECTIVES

To determine the seasonal movements of mountain goats in the Kenai Mountains, and to assess the fidelity of goats to given areas within seasons and between years.

PROCEDURES

Tracking and plotting procedures have been described previously (Nichols 1980b, Nichols 1982, Schoen and Kirchhoff 1981). In addition, a detailed paper on capturing and radio telemetry techniques was prepared and presented at the biennial conference of the Northern Wild Sheep and Goat Council in Fort Collins, Colorado in March 1982 (Appendix A).

Because of problems with the Department of Administration, no airplane was available on contract for radio tracking from 1 July to 14 September 1981. Only 1 tracking flight was conducted during that period utilizing a short-term, rented aircraft. Seven more flights were made throughout fall and winter until the time of this writing. Bad weather hampered tracking flights most of the year.

One aerial census of the entire study area was conducted on 30 and 31 July 1981. Bad weather precluded any ground classification surveys in 1981.

FINDINGS

Radio Tracking

The main objective of this study is to obtain information on goat movements during summer when aerial census is practical. With no aircraft available for tracking during most of summer 1981, nearly all potential movement data for that critical period were lost. During the 1 flight in late July and in subsequent flights from late September to late April 1982, all collared goats were located. Most could be tracked until visual verification; however, when they were using heavy timber in winter, some animals could only be radio-located. All were plotted as described previously, and additional information on their habitat and companions was recorded.

Of the 34 goats with operating collars at the beginning of this report period, 32 were still alive and broadcasting in late April 1982. One adult female died of unknown causes in September 1981. She was over 10 years old at the time and appeared weak when last observed alive. When captured in fall 1979, it was noted that her incisor teeth were loose and some were missing. She may have been unable to eat despite abundant summer forage and died of malnutrition. The 2nd animal to die was a 13-year-old male which apparently was caught in a narrow canyon by a winter avalanche. Two of the collared goats' kids died during summer 1981. The remainder survived throughout the following winter.

Movement Analysis

Plots of all goats radio-located during the 1st year of this study were digitized and entered into a computer at the end of that report period. A printout of this data has recently been received. Preliminary examination has indicated considerable individual variation in movements between summer and winter ranges and in the size of both. Some animals moved long distances during the year; some were relatively sedentary. It was not possible to draw any conclusions from this 1st printout. The computer analysis needs modification to better show seasonal movements, and more years of data must be included. Additional locations will be entered and plotted after the coming summer's data have been obtained.

Aerial Survey Results and Population Estimates

One complete aerial survey of the study area was flown under good conditions (i.e., light overcast, calm winds) on 29 and 30 July 1981. This survey was designed to cover the area completely and to obtain an estimate of total goats and total kids present. Because no survey could be flown in early July, no estimate of herd composition could be obtained (Nichols 1980*a*). Results of this survey and of one conducted in May 1981 are shown in Table 1.

Nichols (1980*a*) found that a careful survey by fixed-wing aircraft under good conditions resulted in about 90% of all goats being observed. Thus, the observed totals divided by 0.90 give an estimate of the actual total number of goats present.

By combining results of the May survey (from which a percentage of yearlings was obtained) with the July survey, an estimate of the number of adults, yearlings, and kids may be obtained (Table 2). Although not as satisfactory as a complete classification which provides ratios of kids and yearlings/100 breeding-age females, percentages of adults, yearlings, and kids do provide an estimate of reproductive success. Overwinter mortality also can be estimated by comparing these percentages between years.

Reproductive success, as indicated by kids:100 adults by year, was similar between the collared sample of the herd and the entire herd (Table 3). Overwinter mortality compared between the collared sample and entire herd for the winters of 1979-80 and 1980-81 was similar for total losses, but not for kid-to-yearling losses (Table 4).

Effects of the severe winter of 1979-80 were apparent in the high overwinter mortality and reduced reproductive success the following summer. Conversely, the milder winter of 1980-81 caused little mortality while reproductive success increased in the following summer. The winter of 1981-82, as indicated by snowfall (Clagett et al. 1982), was much milder than the previous one.

Mortality in the collared sample of goats was low, both in the total sample and in the kid-to-yearling portion. Postparturition aerial counts have not yet been flown, so no overwinter mortality estimates for the entire herd are available.

Although no overwinter mortality was observed between 1980 and 1981 in the population as a whole (Tables 2, 4), at least 1 collared adult and her kid were known to have died. The apparent increase from kids to yearlings would be impossible in a closed herd. An error in estimating the number of yearlings present in 1981--possibly caused by too small a sample size in estimating yearling percent during the spring aerial census--could have been responsible for this anomaly. However, radio tracking has shown that this herd is not as closed as formerly believed. At least some goats move freely across the Trail River Glacier boundary during fall and winter. An influx into the study area would influence population estimates. Examination of aerial count results over the 2 years showed that no overwinter mortality was evident in the King's Bay portion of the study area; a 13% loss was noted in the Ptarmigan Lake to Grant Lake segment; and a 14% gain appeared in the Grant Lake to Trail Glacier portion. This gain further suggests an influx from the north side of Trail Glacier. Future aerial counts should include that portion of the herd as an integral part of the entire herd under study.

RECOMMENDATIONS

1. Future aerial counts of this study herd should include the north side of Trail Glacier.

2. No management recommendations regarding goat movements or home range fidelity can be made until further data have been gathered and analyzed.

3. I recommend that this study continue at least 3 more years to fully utilize data from radio-collared goats in determining range use fidelity over a series of seasons.

4. In view of the critical need for summer movement data, every effort should be made to assure availability of an aircraft for telemetry work during this period.

ACKNOWLEDGMENTS

I would like to express my appreciation to Danny Anctil for his assistance in the preliminary digitizing and computer analysis of movement data. Thanks also go to Karl Schneider for his continuing support of this program, and to Rosie Thompson and other staff members who worked to pry an aircraft lease from a reluctant and snail-slow Department of Administration.

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Table 1. Results of aerial surveys conducted on study area in 1981.

Date	Total	Total adults[a]	Yearlings	Kids
5/8, 5/25/81	97	97	20 (21% of TA)	--
7/29-7/30/81	196	149	--	47 (32% of TA)

[a] Total Adults (TA) = Total non-kids-of-the-year.

Table 2. Estimated population models for study area during summers 1979, 1980, and 1981, and calculated mortalities.

Year	Total[a]	Total adults	Yearlings	Kids
1979	246	191	25	55
	-6[b]			
	240	185	25	55
	-41%		-56%	
1980	171	141	24	30
	-5[b]			
	166	136	24	30
	-0%		+13%	
1981	218	166	34	52

[a] Totals corrected for count error: total actually counted ÷ 0.90 = estimated total (Nichols 1980<u>a</u>).

[b] Reported hunter harvest in study area.

Table 3. Kids:100 adults in the population model and the radio-collared sample by year.

Year	Population model	Collared sample
1979	29	34
1980	21	18
1981	32	29

Table 4. Overwinter mortality as indicated by the population models and radio-collared samples of the study area.

Winter	Est. adult mortality[a]		Est. kid mortality[b]	
	Pop. model	Collared sample	Pop. model	Collared sample
1979-80	-41%	-42%	-56%	-100%
1980-81	0	-6%	+13%	-33%
1981-82	c	-14%	c	-20%

a Based on total kids in fall, yearlings in spring.

b Based on total adults fall to spring.

c Unknown until estimates are made from postparturition aerial counts.

APPENDIX A.

CAPTURE AND RADIO TELEMETRY OF MOUNTAIN GOATS IN ALASKA[1]

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ABSTRACT

Between August 1979 and June 1981, 41 mountain goats (*Oreamnos americanus*) were captured and radiocollared in the Kenai Mountains, Alaska. Capture was by drugged darts fired from a helicopter, using the drug M99 (etorphine hydrochloride). The method was efficient and selective. No goats were killed or seriously injured during capture. Drug effects appeared more consistent and predictable in early summer than in late summer when goats were fat. Goats were equipped with color-coded radio collars and subsequently relocated periodically by means of a Piper Super Cub fixed-wing aircraft equipped with directional antennas and scanning receiver. Except for 1 collar that failed initially and 8 goats that subsequently died, all collars were still functioning in January 1982.

[1] Nichols, Lyman Jr. 1983. Capture and radio telemetry of mountain goats in Alaska. *In* James A. Bailey and Gene G. Schoonveld (eds.) Proc. Northern Wild Sheep and Goat Conf., Colo. State Univ., Ft. Collins (in prep.).

INTRODUCTION

Several methods have been used with varying degrees of success to capture, mark, and relocate Rocky Mountain goats. In the early 1950's, goats were captured in Alaska for a transplant while swimming or by commercial trappers. Attempts to catch them by foot traps, baited corral-traps, lassooing, and running down newborn kids met with poor success (Burris and McKnight 1973). Rideout (1974a) successfully captured goats in Montana with baited Clover traps; he tried drop nets and darts drugged with phencyclidine hydrochloride (Sernylan, Parke-Davis Co.), but had limited success.

Hebert et al. (1980) captured goats in Canada with Clover and corral traps. These methods were slow, inflexible, required considerable manpower, and time, and resulted in losses from capture myopathy. Cannon-netting was used by Thompson and McCarthy (1980), but, while successful, was cumbersome, slow, and also required a fixed, baited site.

Quaedvlieg et al. (1973) utilized Clover traps in Alberta, but then immobilized the captured goats with the drug etorphine hydrochloride (M99, D-M Pharmaceuticals) for ease in handling. Free-ranging goats were captured by Kuck (1977) utilizing M99 and darts fired from the ground and from a helicopter.

This technique and/or drug has been used on numerous wildlife species in Africa (Young 1975) and in America on moose (*Alces alces*) (Ballard and Gardner 1980, Gasaway et al. 1978, Lynch 1981, Roussel and Patenaude 1975), bighorn sheep (*Ovis canadensis*) (Thorne 1971), pronghorn antelope (*Antilocapra americana*) (Autenrieth et al. 1981), woodland caribou (*Rangifer tarandus*) (Fuller et al. 1981), black bears (*Ursus americanus*) (Beeman et al. 1974), Sitka black-tailed deer (*Odocoileus hemionus*) (Schoen et al. 1981), and others.

Schoen (1978) tried snares and helicopter-dropped nets, but finally settled on the drugged dart fired from a helicopter as the best method to date of capturing free-ranging goats in Alaska. He used 2.5-3.0 mg of M99 per goat injected intramuscularly with a Cap-chur gun (Nasco-west, Modesto, Ca.) from a Hiller 12 E helicopter. Of 8 goats hit, 5 were captured; no losses occurred. He captured these goats in winter in deep snow to avoid losses caused by falling from precipitous terrain.

Installation of radio collars has proven one of the best methods by which captured animals can be identified and relocated as needed. Relocating collared goats was initially accomplished by use of fixed directional antennas and triangulation or by hand-held directional antennas (Rideout 1974b). More commonly, free-ranging animals have been relocated by utilizing directional antennas mounted on aircraft, either fixed-wing or helicopter (Ballard et al. 1979, Hoskinson 1976, Inglis 1981, Mech 1974). Schoen (1979) used double, 3-element Yagi antennas mounted on a

Helio Courier for locating collared goats with excellent success in Southeastern Alaska.

This paper presents updated and detailed methodology and results utilizing these highly successful techniques on mountain goats in Alaska. The capturing, collaring, and radio-tracking work was part of a larger study on goat movements.

METHODS

CAPTURING AND COLLARING

Twenty goats were captured in the Kenai Mountains, Alaska, in August 1979; 3 in August 1980; and 18 in June 1981. The same technique was used in all 3 sessions with but minor variations. Habitat was generally goat summer range consisting of very rugged, heavily glaciated mountains. All goats were captured in the alpine between elevations of about 762 m (2500 ft) and 1372 m (4500 ft); some on open tundra or fell fields, some on snowbanks, glaciers, or icefields, and some on precipitous slopes or cliffs. No serious injuries or fatalities occurred.

A Bell 206 B Jet Ranger helicopter was used in all operations. The crew consisted of 3 men: pilot, shooter, and assistant, except that only the pilot and shooter were present in 1980. Crew size, which was adequate, was limited to 3 to reduce weight and allow more maneuverability of the helicopter in dangerous terrain. Communication between crew members was enhanced by use of a 3-way, portable intercom system (Genie Electronics Engineering, Inc., Red Lion, Pa.) which allowed continuous conversation and direction.

Etorphine (M99) was used for all capturing. It was fired in darts from a standard Cap-chur gun using green (intermediate-range) propellant charges. Dart needles were modified by cutting off most of the barb and shortening needles to just ahead of the barb attachment. Less tissue damage resulted from the shorter darts which were then easier to remove with the smaller barbs. A dosage of 4 mg (4 cc) of M99 was used on all but the largest adult males, some of which were given 5 mg. However, 4 mg was used on all goats from yearlings to adult males in the June 1981 operation.

In practice, goats were located in terrain where it appeared we had a good chance to effect a capture before darted animals could reach extremely precipitous areas where they might become injured by falling when narcosis occurred. An animal or group was selected and the helicopter maneuvered in a slow hover behind the target until a favorable shot was presented. Goats usually reacted to close pursuit in one of three ways: if in sloping terrain, they would frequently climb; when rock outcrops were present, they often would flatten against the downhill side; on relatively level ground, they would run straight away. If they reached dangerous terrain, the chase was abandoned. Their deliberate and relatively predictable flight pattern allowed close approach from the rear or side in most cases, and with patience, easy shots of under 15 m (49 ft) could be obtained. Continuing voice communication between shooter and pilot via the intercom contributed substantially to efficiency and success.

When dart placement was confirmed, the helicopter would back off to avoid unnecessary harassment, and the goat would be observed from a distance until it went down. Only if it began running for dangerous cliffs would attempts to herd it be made. Usually, goats would respond to herding until the drug began taking effect, after which, they would go their own way regardless of helicopter approach.

When the goat became and remained prostrate, the helicopter would land nearby and the crew could proceed with their equipment to the goat. However, in steep terrain where the helicopter could not land, it was often necessary for the shooter and assistant to jump from the hovering machine to be picked up later.

The anesthetized goat was sexed, aged from horn annuli, weighed and measured, and biological samples taken. Weight was obtained from slinging the goat beneath a portable 300 lb (136 kg) capacity spring scale suspended from a stout pole which was then lifted by 2 men. We found it impossible for 2 men to lift full-grown males high enough for weighing by this method.

A numbered ear tag (Rototag, Nasco-West, Modesto, CA) was installed, and finally a color-coded radio collar was fastened to the drugged goat. Radio collars (Model MKVM, configuration 5 B with mortality-sensing option, Telonics, Inc. Mesa, Ariz.) were individually color-coded for visual identification by wrapping with various colors of plastic electrical tape in different patterns. The collars used were in the frequency range 150.000 to 152.000 MHz.

When work with the goat was completed, an injection of the antagonist diprenorphine hydrochloride (M50-50, D-M Pharmaceuticals) was given intravenously in an amount equalling the original injection of M99. Injection site was commonly the radial vein which was raised for easy access by using a lightweight, surgical-rubber-tubing tourniquet proximal to the site.

RADIO LOCATING

A Piper PA-18-150 Super Cub has been the vehicle used in this project for all relocating of radio-collared goats. It has been used on wheels in spring and fall, floats in summer, and skis in winter with equal success. A pair of Hy-gain model RA-3 (Telonics, Inc.) 3-element Yagi antennas are mounted 1 on each side of the airplane on the lift struts. Mounting is similar to that described by Inglis (1981) except that the antennas point outward at 90 degrees to the axis of the fuselage rather than forward as in his description. Thus, the loudest signals are heard directly off either wing. The antennas lead via coaxial cables down the wing lift struts and through the control cable openings into the interior of the cockpit. They are connected to a Telonics TAC II right-left-both toggle switch, which in turn is connected to a Telonics mated TR-2 receiver and TS-1 scanner. Earphones can be plugged into the receiver. However, since I both fly the plane and operate the receiving electronics, I have found it more convenient to connect the telemetry receiver to an intercom system (Telonics model TADS-2) which integrates this system with the aircraft's avionics through 1 headset, as well as allowing a passenger with a second headset to hear all incoming signals and to communicate with me vocally.

In use, frequencies of collars to be located are programmed into the scanner and the antenna switch is set on "both." When a signal is heard, the scanner is locked on, and the antenna switch moved to "right" or "left" for the loudest signal and to determine which direction to fly. If the goat appears to be at some distance away, the airplane can be turned slowly until a signal of equal strength from each antenna is heard. It is then pointing toward the collared animal. Because of the topography inhabited by mountain goats, this usually entails flying directly toward a mountain and is the main reason for not using Inglis' (1981) forward-pointing antennas and search method for final transmitter location.

Although the search method used is roughly similar to that described by Mech (1974) and others, the mountainous terrain necessitates some special techniques. Upon reaching the general area of the collared goat (indicated by an increasingly loud signal), the plane is flown close to and parallel with the mountain slope with the receiver volume turned low and tuned to the antenna facing the mountain. A rapid buildup and peak in sound level indicates the vertical plane occupied by the goat, but not the elevation. When the plane is flown close to the slope and the volume is loudest from the antenna facing the mountain, the target transmitter is either just off the wing tip or above the flight level. If it is of equal strength from both antennas at peak level, the transmitter is directly below; if stronger from the antenna facing away from the mountain, the goat is downslope.

Once the goat has been located, or its location approximated with appropriate precision, its position may be plotted on a map. I use clipboard-sized segments of U.S.G.S. 1:63,360 topographical maps with mylar plastic overlays. Four clipboards cover my study area. Further data on companions, habitat, etc., may be recorded on other forms or recorded in a small cassette recorder slung from my neck for that purpose.

RESULTS AND DISCUSSION

CAPTURING AND COLLARING

Because of their behavior when closely pursued by helicopter and their favorable response to etorphine, mountain goats are well suited to this method of capture. Efficiency of capture was high in all 3 collaring sessions to date. In the first, with no previous crew experience in capturing goats, and despite inclement weather, 19 goats were successfully captured with 22 hits. One more adult male was captured, but, because of an initial underdose, took 4 more darts before he could be caught. Thus, 20 were captured in a 5-day period. Three others were hit but not captured. One of these, a yearling, climbed into the clouds before narcosis occurred. It was seen the next day, apparently fully recovered. Another yearling vanished into a jumble of rocks after being hit, but apparently recovered; no carcass could be found later. An adult female, hit in the flank with injection directly into the rumen probable, showed no effect of the drug and escaped beneath a glacier.

During the second attempt in August 1980, 3 goats were captured with 3 hits in 1 afternoon. Eighteen goats were captured in the final operation in June 1981, with 19 darts (every shot hit) in 4 days. One adult male received only a partial injection, and escaped into unsuitable terrain without complete narcosis. No mortalities occurred out of the 45 goats darted. Although several animals fell or slid considerable distances, no serious injuries resulted.

Recovery of anesthetized goats occasionally was hazardous due to terrain. Ice axes were used to good advantage on steep slopes and snowbanks. Rock climbing equipment, although always carried, was required only once when it was found necessary to rappel down to an animal on a cliff ledge. A major contribution to success was the skill and interest displayed by the helicopter pilot, as well as the ability of the machine to perform as required.

Mean weights of goats captured and dosage levels of etorphine are listed in Table 1 by month of capture (August 1979 and August 1980 are combined), sex, and age class. Because most adult males could not be weighed, listed dosage levels for that class are biased on the high side. Dosage levels and animal weights were compared between month and class by standard t-tests. In almost all cases, dosages used resulted in deep anesthesia and ease of handling with no struggling or obvious awareness.

Statistically significant differences between mean weights and dosages in mg/kg of M99 were found between June and August in "adult" females (those older than 1 year). Animals were lighter in early summer; consequently, dosage rates were higher. Suggestive differences ($P < 0.10$) were found in weights and dosage levels between June and August in yearlings, while no significant difference ($P > 0.10$) could be detected for these parameters in "adult" males. The latter 2 anomalies were probably results of small sample size. Had more yearlings and adult males been captured, and more of the latter weighed, significant differences probably would have been found.

When all sexes and ages were combined, significant differences ($P \leq 0.05$) between June and August weights and dosage levels were noted, as they were between adult males and adult females when months were combined. Thus, goats generally received higher per kg dosages of M99 in early summer when they were lighter in weight, and adult males received lighter dosages than adult females. The range overall in dosage levels was between 0.0304 mg/kg for a large adult male (and possibly lower for larger, unweighed males), and 0.1176 mg/kg for a small yearling. The overall mean dosage level for all animals and both seasons was 0.0680 mg/kg (SD = 0.0185, N = 32).

One adult male, estimated to weigh well over 136 kg (300 lb) was insufficiently dosed with the first 4 cc dart at a dosage level of about 0.0294 mg/kg or less. He subsequently took 4 more darts (one did not inject) for a total of 15.5 mg of M99 (approximately 0.1140 mg/kg) before capture. Although this required considerable harrassment during pursuit, he recovered with no apparent ill effects.

No differences in mean induction time could be detected between months or sex/age classes. The mean induction time was 7.5 minutes, with a range of 2.0 to 15.0 minutes. Not all induction times were recorded; however, it appeared that these were more uniform and capture more certain in June when the animals were lighter and dosage rates in mg/kg higher at 4.0 mg/dart.

Quaedvlieg et al. (1973) reported a mean dosage level of 0.0375 mg/kg and induction time of 3.3 minutes for trapped goats, but lost one, presumably from underdosing and consequent excitement. Schoen (1978, 1979) first used 2.5-3.0 mg/goat in capturing free-ranging animals for a mean induction time of 15 minutes. Increasing dosage to 3.5 mg/goat decreased his mean induction time to 12 minutes. In this study, the average dosage of 4.0 mg/goat further reduced mean induction time to 7.5 minutes. Reduced induction time, obviously, is advantageous in preventing escape and reducing exertion in darted animals. Autenrieth et al. (1981), working with pronghorns, and Lynch (1981), working with moose, both felt underdosing with M99 was more dangerous than overdosing due to the prolonged preinduction excitement and exertion. I agree, and believe that a safe and workable dosage for mountain goats is 4.0 mg/goat in early summer (3.0 mg/yearling probably would be adequate, but 4.0 mg appears safe), and 4.0 to 4.5 mg/goat in fall except that adult males should be given at least 5.0 mg in fall.

Kuck (1977) and Quaedvlieg et al. (1973) gave the antagonist M50-50 at double the rate of M99 in the capture dose. Schoen (1978) gave it at equal dosage intramuscularly and reported a mean recovery time of 8 minutes. In this study, M50-50 was given at the same dosage as M99 but intravenously. Mean recovery time was 1.5 minutes, with a range of 0.5 minutes to 4.0 minutes. The 1 male given 15.5 mg of M99 was given 10 mg of M50-50 and recovered in 2.3 minutes. No differences in mean recovery time could be found between sex/age class or month of capture. Recovery typically was sudden with the animal up and walking off within seconds of first opening its eyes. Although most appeared disoriented at first, their sense of balance returned rapidly and no falls occurred during recovery. Two animals which inadvertently received their antagonist intramuscularly took over 15 minutes each to recover. Thus, intravenous is the preferred route for the antagonist where rapid recovery is desirable.

The cost of capturing 18 mountain goats in June 1981 (exclusive of manpower) included the following:

Helicopter	20 hours @ $381.00/hr	$ 7620.00
Darts	19 @ $9.24 (many were recovered)	175.56
Drugs (M99 and M50-50)		484.50
Collars	18 @ $262.20	4719.60
	Total	$ 12,999.66

The cost per goat captured was $722.20. Ballard and Spraker (1979) estimated the cost of capturing wolves (Canis lupus) by helicopter and dartgun at $578.00 per wolf, exclusive of collar and manpower. Including a radio collar would have brought their cost up to about $840.00 per wolf. In 1953, the State of Alaska paid trappers $100.00 per male goat and $400.00 per female for a transplant (Burris and McKnight 1973), and had difficulty obtaining enough animals. The present method is cheaper (allowing for inflation), more selective, and much more efficient.

RADIO LOCATING

Locating radio-collared mountain goats by the method described has proven relatively simple and certain. On nearly every search, all goats have been located, although not always visually. During summer, it has been easier actually to see the animals than during winter when they blend in with the numerous snowbanks or are under tree canopies. Even when the collared goat could not be spotted, it has been possible to narrow its location to a circle of about 100 m (300 ft) in diameter or less by careful flying and search. During hot summer days, goats have been found by persistent search even when under snowbanks or in shallow caves.

One problem encountered occasionally has been signal echos in certain valleys. These indicate false positions and sometimes require considerable searching to overcome. They appear more prevalent in narrow canyons in winter.

I do not know the maximum range of these collars. Sharp signals have been received from as far away as 25 km (15 mi). However, most searching is done in valley systems where ranges are much less and unwanted signals from adjacent valleys are blocked out by high ridges. Valley-by-valley searching acquires signals only from those animals within the valley and assures the operator that any signals heard emanate from nearby animals.

Another minor problem encountered has been signal drift, particularly in cold weather. However, this drift has been less than 1.0 KHz and only by a few transmitters. Since no collar frequencies have been spaced closer than 10.0 KHz, there has been no confusion created in identification, but merely a requirement to program the scanner 1.0 KHz to one side or the other of the listed frequency on a few collars.

Transmitter longevity has been very satisfactory. Except for 1 complete failure initially, all collars have functioned as advertised. Expected life upon installation was 2 years. All collars put on in August 1979 and on still-living goats (13) were functioning in January 1982--29 months later. One collar on a goat killed by an avalanche in early winter 1979, and buried under tons of packed snow all that winter, all the next, and part of the third, finally ceased to function in December 1981. All this time, it had been operating on "mortality mode" at twice the normal pulse rate, resulting in a higher battery drain. Other collars continued to operate under avalanches and after the goat carcasses had been eaten later by scavengers and the collars much chewed, even by grizzly bears (*Ursus arctos*). This speaks well for their construction. In fact, all the electronic equipment purchased from Telonics, Inc., has performed remarkably well under adverse conditions.

Time required to radio locate 34 collared goats--the maximum number operating at any time--on a study area of approximately 609 km^2 (235 mi^2), was about 7 to 8 flying hours, including about 1 hour of ferry time to and from the area. This required 2 flights in a Super Cub and could be accomplished in 1 day during summer, but took 2 in winter when days are short. More goats could be located visually in summer than in winter.

Color-coding collars makes it possible to identify individuals visually, an advantage when several collared animals are in the same group. Individual identification is necessary, for example, to determine which collared females are accompanied by kids in a group with several radio collars. Bright collars also make it easier to sight a collared goat. Color-coding by plastic electrical tape has worked well, although sometimes it has been necessary to fly rather close to identify certain patterns. Collars so marked in 1979 were still recognizable in January 1982.

Flight performance of the airplane used in radio tracking mountain goats is of great importance to both efficiency and safety.

I have found the Piper Super Cub to be an excellent vehicle, especially when flying and tracking alone. It is simple, may be flown slowly with safety, and has the tight turning radius necessary to search small valleys. Schoen (1979) used the Helio Courier, an aircraft of similar performance, with good success. Kuck (1977) used a Cessna 182 for radio-locating mountain goats in Idaho; I believe such a fast, heavy aircraft would be both inefficient and dangerous for this work in the rugged mountainous terrain of Alaska's goat habitat.

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Table 1. Mountain goat weights and dosages of M99 by month of capture, sex, and age class.[1]

Month	Sex	Age class	N	Mean weight in kg	Difference significant?	Mean dosage mg/kg	Difference significant?
June	both	yrl.	3	38.4	no; $P > 0.10$	0.1042	no; $P > 0.10$
August	both	yrl.	2	50.4		0.0794	
June	F	2+	10	52.9	yes; $P < 0.001$	0.0759	yes; $P < 0.001$
August	F	2+	12	73.1		0.0577	
June	M	2+	2	70.3	no; $P > 0.01$	0.0600	no; $P > 0.10$
August	M	2+	3	97.8		0.0417	
Both	F	2+	22	63.9	yes; $P < 0.01$	0.0660	yes; $P < 0.025$
Both	M	2+	5	86.8		0.0500	
June	Both	1+	15	52.3	yes; $P < 0.001$	0.0796	yes; $P < 0.001$
August	Both	1+	18	74.8		0.0566	

1 Exclusive of all animals which were not weighed.