ALASKA DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

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MOUNTAIN GOAT AERIAL SURVEY TECHNIQUE EVALUATION

By: Lyman Nichols

Project Progress Report
Federal Aid in Wildlife Restoration
Projects W-17-9 and W-17-10 (1st half)
Jobs 12.2R and 12.3R

(August 1978)

PROGRESS REPORT (RESEARCH)

State:	Alaska		
Cooperator:	Lyman Nichols		
Project Nos.:	W-17-9 & W-17-10	Project Title:	Big Game Investigations
Job No.:	12.2R	Job Title:	Evaluation of Mountain Goat Aerial Census Techniques
Job No.:	12.3R	Job Title:	Development of Aerial Mountain Goat Classification Techniques
Period Covered:	July 1, 1976 to December 31, 1977		

SUMMARY

Reconnaissance flights following the aerial marking in June 1977 of approximately 33 mountain goats near Grant Lake, Kenai Peninsula in Alaska revealed movements through and out of the previously selected study area. Replicate aerial surveys, conducted from a Piper PA-18-150 airplane in summer 1976, covered only the original study area, but those conducted in 1977 included the entire area known to be used by the herd. Total goat numbers counted in replicate aerial surveys flown under similar conditions were within 5 percent of each other both years, but varied by about 30 percent between poor and good counting conditions. Best conditions were found to be days with high overcast which produced soft light and few shadows. A total of 166 goats were found in the highest count during summer 1977. No helicopter survey was conducted and it is not known how close the total number counted was to the true population present. Unknown mid-summer movements made survey interpretation difficult.

Criteria for determining sex and age classes were described following close examination of goats from the ground. Those characteristics of goats which are easily visible and should serve for aerial classification include grouping, body size and stage of molt over time. More data are needed for confirmation. Percent snow cover, determined from sampling aerial photographs, increased between areas occupied by sheep only, sheep and goats together, and goats only, and was significantly greater during winter 1976-77 than winter 1975-76 on the sheep only area. Overwinter survival of sheep and goats appeared to be related to percent snow cover. Goat horn growth curves were prepared from measurements gathered from hunter-killed animals.

CONTENTS

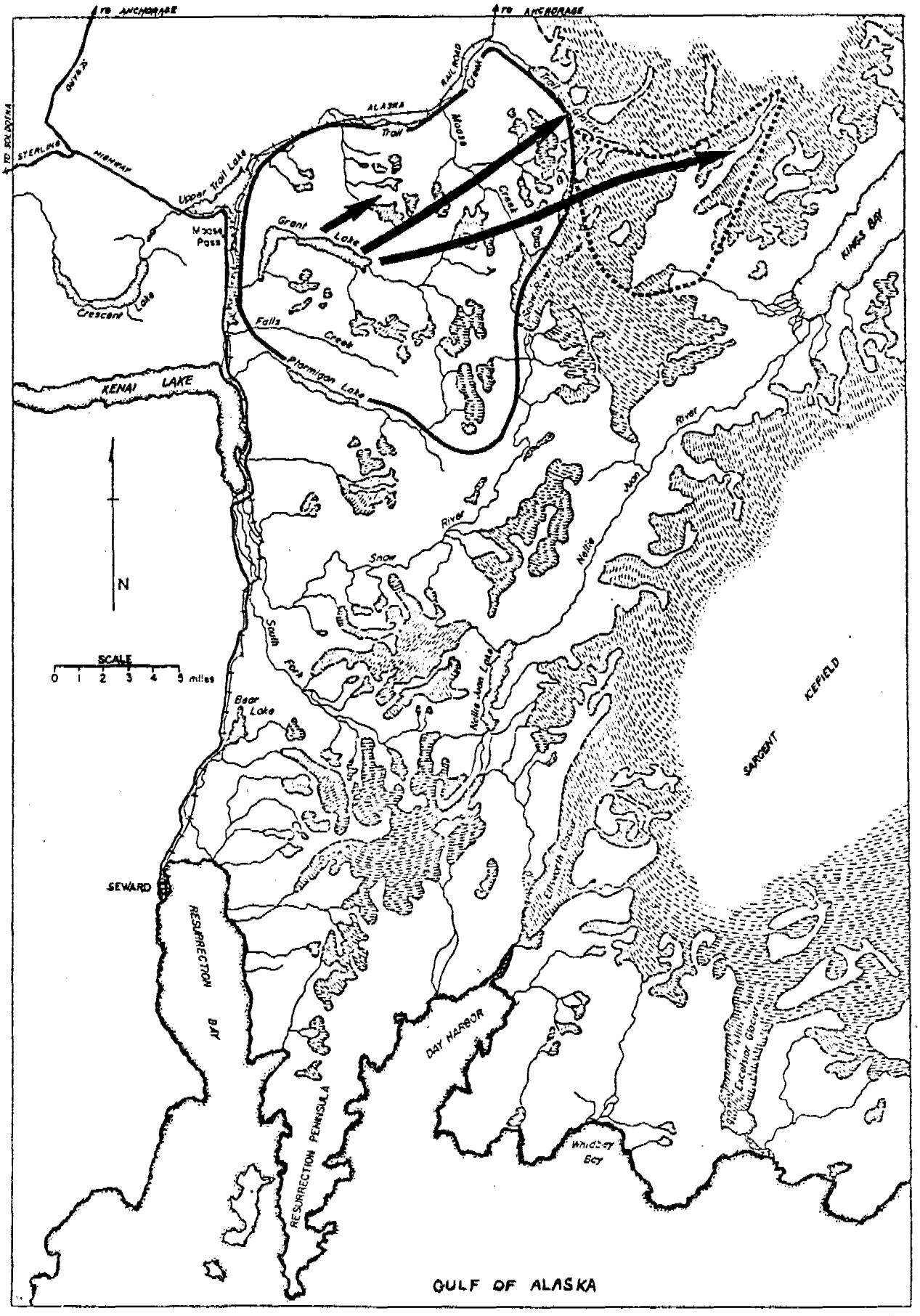
BACKGROUND

Little research has been conducted on Alaska's mountain goat (*Oreamnos americanus*) populations because it was assumed that inaccessibility and low hunter interest precluded the need for intensive management and related knowledge. Recently, however, hunting pressure has increased simultaneously with an apparent decline in some goat herds, particularly on the accessible Kenai Peninsula (Ballard 1977a). Whether these declines were the result of hunting harvest, severe winters, or other factors was unknown. It was, in fact, suspected that some apparent population changes were due to inconsistencies in survey accuracy.

The decision was made to conduct studies designed to determine the basic techniques needed to assess the status and dynamics of goat populations. Further studies could then be undertaken to learn the habitat requirements and basic life history of the mountain goat in Alaska, and to learn what factors limit goat distribution and abundance.

A goat herd suitable for study was selected under a previous research job (Nichols 1977). It occupies heavily glaciated mountains northeast of Moose Pass (Fig. 1), and was thought to be confined to the area between Trail Glacier, Snow River Glacier, Ptarmigan Lake, and Trail River. Dall sheep (*Ovis dalli*) share the range with goats south of Grant Lake, but are rarely found north of this drainage. Because the area is relatively distant from the ocean, the herd is considered an "interior" rather than a "coastal" herd.

Fig. 1. Study area boundaries and observed movements of marked goats, spring 1977.



Study area boundary 1976
Expanded area boundary 1977
Observed movements of marked goats

It has been generally accepted that the most practical way to census goats in remote areas is by means of aerial surveys (Couey 1951, Ballard 1975, Hibbs 1966, Lentfer 1955, and others). Ground surveys may result in more accurate classification of those seen, but they rarely are able to cover more than small portions of goat habitat (Ballard 1977b) and the problem of duplication is greater than for relatively "instantaneous" aerial counts. Although some researchers believe more accurate aerial counts can be obtained from a helicopter (Ballard 1975, 1977b; Hebert and Turnbull 1977; Quaedvlieg et. al. 1973), most concede that a slow-flying, maneuverable, fixed-wing airplane is more practical for general use over large areas because of the lower cost and less fearful reaction by goats (Ballard 1975; Chadwick 1973; Hibbs 1965, 1966).

Despite the fact that they are white in color and generally reside in an alpine or subalpine habitat, mountain goats are not always easy to locate from the air. In bright sunlight, their dingy-white coat blends with the many greyish-white boulders present; they often rest in the shade or on snowbanks in warm weather, and they frequently hide under bushes or overhanging ledges at the approach of a plane. Hibbs (1965), who worked extensively with goats in Colorado, considered it "more difficult to obtain accurate air counts for mountain goats than for any of the other big game species observed." Not the least of the difficulties presented is that they live in some of the most rugged and inhospitable mountain terrain in Alaska.

Although aerial goat counts have been conducted traditionally in Alaska and elsewhere, the accuracy of these counts is unknown. Observed population changes may be real or merely the result of counting errors. Lentfer (1955) compared aerial and ground counts, and several aerial counts of the same Montana goat herd, but did not determine the accuracy of either method. In Alaska, Ballard (1975, 1977b) attempted to assess the accuracy of aerial counting by comparing results of replicate counts of two herds by helicopter and fixed-wing airplane (primarily a Cessna 180 on floats). Results were inconclusive.

Previous aerial counts, with the exception of a few conducted at close range by helicopter (Hebert and Turnbull 1977), have provided numerical data only on the total number of animals counted, or on the relative proportions of kids to adults for use as an indicator of productivity. This is a poor measure of productivity, however, since the proportion of kids does not take into consideration the sex ratio of adults, the survival of previous kid crops, or the numbers of nonbreeding sub-adults present. As with most species of ungulates, annual production can be assessed accurately only if the proportion of young to breeding females can be determined, and assessment of population status requires a knowledge of year-to-year survival among sex and age classes. To date, no method has been devised to determine the sex and age of mountain goats from a fixed-wing airplane.

This study was designed in an attempt to assess the accuracy of aerial counts from a fixed-wing airplane and to develop, if possible, a method for classifying goats from the air.

OBJECTIVES

To evaluate the accuracy of aerial goat surveys by fixed-wing aircraft.

To develop a method of sexing and aging mountain goats applicable to aerial surveys.

PROCEDURES

Replicate aerial surveys were conducted of the goat herd under study during summer 1976, using a wheel-equipped Piper PA-18-150 airplane. I flew all counts and recorded all observations in a tape recorder; two of the counts were flown alone, one with an observer. Locations and elevations above sea level of all goats seen were recorded as were the air temperatures and times of observations.

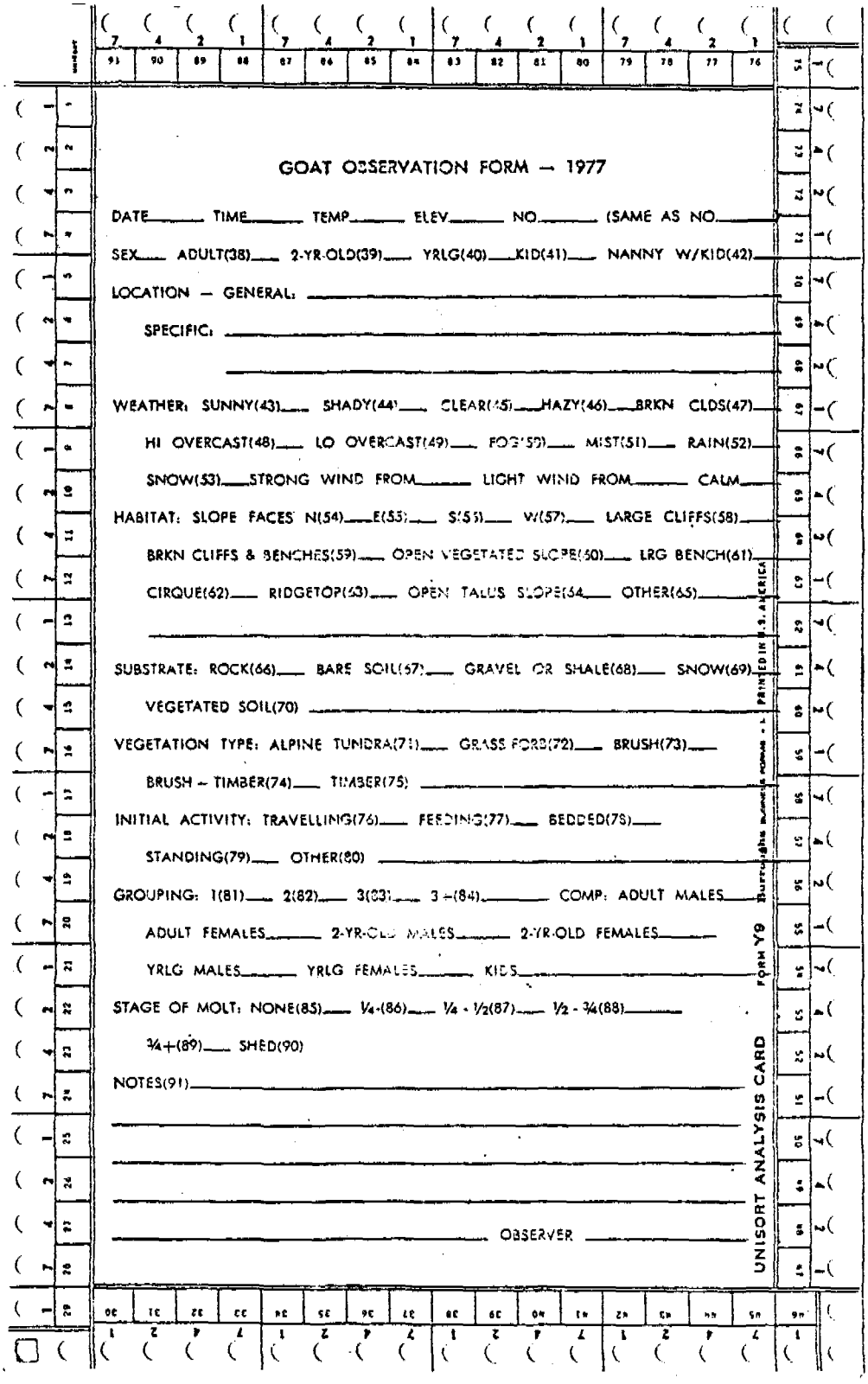
When it became apparent that extensive, but unknown, movements were taking place in spring as goats left winter range, I decided to mark a number of animals to ascertain whether the herd was remaining within the arbitrarily established study area and aerial counting boundaries. The method used to mark goats was a modification of that described by Simmons (1971) for aerially marking Dall sheep in Canada, and which I had used successfully on a previous sheep study (Nichols 1973). Red dye (Calcocid Scarlet 2RIL, American Cyanamid Co.) was mixed with water at a concentration of 10 lb. (4.5 kg) of dye per 40 gal. (151.4 l) of water. Up to 60 gal. (227 l) of this mixture are pumped into a modified Sorensen belly tank attached to a Piper PA-18-150 Supercub airplane. The tank was equipped with an electrically operated dump valve controlled by a trigger switch on the airplane's control stick. The valve opened and shut rapidly, and could be held open as long as desired. In practice, goats were located, then flown over at an altitude of 10-15 ft (3.0-4.6 m), whereupon dye was dumped on them in a drenching spray. Marking flights were conducted in June 1977, and follow-up flights were made to locate marked animals in June and July.

Further replicate aerial surveys were flown during late spring and summer 1977, three with an observer and three alone. The count area was expanded to include the drainage leading into King's Bay (Fig. 1).

Intensive ground observations of goats in portions of the study area were conducted during summers 1976 and 1977. Observers were moved to various locations by Supercub and helicopter, camps established, and goats at each site repeatedly observed and classified over time through binoculars and spotting scope. Each goat was identified as to sex and age class and various criteria were recorded on unisort punch cards (Fig. 2). Cards were then punched and sorted according to data categories of interest and the resulting data analyzed.

A mechanical weather station, established on the mountain north of Great Lake under a previous job, was maintained. Data have not yet been analyzed.

Fig.2. Goat observation form completed for each animal observed from the ground.



GOAT OBSERVATION FORM — 1977

DATE_____ TIME_____ TEMP_____ ELEV_____ NO_____ (SAME AS NO._____

SEX____ ADULT(38)____ 2-YR-OLD(39)____ YRLG(40)____KID(41)____ NANNY W/KID(42)____

LOCATION — GENERAL: _____

SPECIFIC: _____

_____

WEATHER: SUNNY(43)____ SHADY(44)____ CLEAR(45)____HAZY(46)____BRKN CLDS(47)____

HI OVERCAST(48)____ LO OVERCAST(49)____ FOG(50)____ MIST(51)____ RAIN(52)____

SNOW(53)____STRONG WIND FROM_____ LIGHT WIND FROM_____ CALM____

HABITAT: SLOPE FACES N(54)____E(55)____ S(56)____ W(57)____ LARGE CLIFFS(58)____

BRKN CLIFFS & BENCHES(59)____ OPEN VEGETATED SLOPE(60)____ LRG BENCH(61)____

CIRQUE(62)____ RIDGETOP(63)____ OPEN TALUS SLOPE(64)____ OTHER(65)_____

_____

SUBSTRATE: ROCK(66)____ BARE SOIL(67)____ GRAVEL OR SHALE(68)____ SNOW(69)____

VEGETATED SOIL(70) _____

VEGETATION TYPE: ALPINE TUNDRA(71)____ GRASS FORB(72)____ BRUSH(73)____

BRUSH — TIMBER(74)____ TIMBER(75) _____

INITIAL ACTIVITY: TRAVELLING(76)____ FEEDING(77)____ BEDDED(78)____

STANDING(79)____ OTHER(80) _____

GROUPING: 1(81)____ 2(82)____ 3(83)____ 3+(84)_____ COMP: ADULT MALES____

ADULT FEMALES_____ 2-YR-OLD MALES_____ 2-YR-OLD FEMALES_____

YRLG MALES_____ YRLG FEMALES_____ KIDS_____

STAGE OF MOLT: NONE(85)____ ¼-(86)____ ¼ - ½(87)____ ½ - ¾(88)_____

¾+(89)____ SHED(90)

NOTES(91)_____

_____

_____

_____

_____ OBSERVER _____

UNISORT ANALYSIS CARD FORM Y9 Burroughs business forms — PRINTED IN U.S.A.

A rapid and economical method was devised to assess gross snow cover during winter. Aerial photographs were taken in mid-winter of a number of mountain slopes in goat only, goat and sheep, and sheep only habitat. Transect lines were then drawn on the resulting enlarged prints, and the percent snow cover on the area estimated from the proportion of snow covered ground intercepted by the line transects. Percent snow cover was then compared statistically within and between areas and years.

Twenty horns from hunter-killed goats (14 male, 6 female) were examined and measured by Department personnel in fall 1977. Annual growth increments were plotted by sex and age to assess horn growth rates.

FINDINGS

Movements

During summer 1976, it became apparent that goats were moving from winter ranges along the north sides of Grant and Ptarmigan Lakes to summer ranges elsewhere. To learn the extent of these movements, aerial dye marking was undertaken in June 1977, before spring migrations began. Dye spraying was conducted on 8, 10 and 19 June along the north side of Grant Lake. In all, four belly tank loads of dye were used, resulting in the marking of at least 33 goats. More may have been marked by rubbing against aerially marked animals which were still wet. All of these animals were marked with red dye; marking ranged from almost completely red animals to those with smaller pink splotches.

Marked animals were located during follow up flights in late June and early July in the drainages north of Grant Lake as far north as Trail Glacier. Tracks were observed crossing the extensive upper Snow River Glacier icefield and subsequent searches revealed a number of marked and unmarked goats in the drainage leading into King's Bay (Fig. 1). This was a distance of over 15 airline miles (24 km) from the marking site and completely out of the study area boundary.

Other investigators have recorded similar movements from winter to summer range (Anderson 1940, Chadwick 1973, Lentfer 1955, Smith 1976), and several (Hibbs 1966, Hjeljord 1971) felt that goats were nonmigratory. Only Brandborg (1955) noted movements as great as 15 mi (24 km).

Although no dyed goats were observed after 8 July (most were shedding over their backs by then or had completely lost their winter coat which held the dye), both aerial and ground surveys suggested further movements from King's Bay in mid-August. It appeared that at least part of the early summer's population had moved elsewhere--possibly back across the ice field into the Trail Glacier area.

Following is a list of aerial and ground count results by date in King's Bay Valley alone. Movement into the valley during July, and out of it in August is implied.

Date	Total goats	Survey method
7/8/77	46	ground
7/18/77	53	air
8/1/77	58	ground
8/20/77	31	air
9/3/77	41	air
9/13/77	28	air
9/24/77	23	air

Both Casebeer (1950) and Kuck (1973) noted movements of goats out of early summer range in August. Much remains to be learned about mountain goat movements before it can be assumed that given herds will be found on given areas at any particular time and thus be usable in year-to-year trend counts.

Because of the movements noted, the area counted in replicate aerial surveys was expanded to include the valley of King's Bay in 1977. Therefore, I believe that most movements were included in the area counted, so the entire study area population was subjected to repeated aerial census. The possibility does exist for further movements out of the area which would certainly affect count results and their interpretation.

Aerial counts

Problems with weather and aircraft each summer made it impossible to conduct as many replicate surveys as desired. In 1977, heavy snow pack and late runoff left much of the area snow-covered until mid-summer. Consequently, survey flights (except for one preliminary count in late May on winter range) were delayed until late July and early August on the assumption that too many goats would be missed among the remaining snow banks. Helicopter surveys were not conducted either year because of funding and weather problems, nor were other pilot-observer teams made available to assist in the replicate fixed-wing aerial counts.

Aerial count results for both summers are summarized in Tables 1 and 2. In 1976, the two earliest counts of the entire study area from Trail Glacier to Ptarmigan Lake varied by only 5 percent. Both counts were made under less than ideal, but comparable, conditions without an observer. The third count, flown with an observer to help locate goats, resulted in a 19 percent increase in total counted when compared to the lowest earlier total.

It would appear at first glance that the addition of the observer was responsible for the observation of more animals. However, upon examination of the counts by sub-area, it can be seen that all three were fairly similar (11 percent different from lowest to highest) in the Grant Lake to Ptarmigan Lake segment with no significant increase in late summer. In the Trail Glacier to Grant Lake segment, the total rose 25 percent from lowest to highest. At the time, nothing was known of the movements into and out of King's Bay, nor was that area included in the surveys. It is probable that at least some of the variation can be attributed to the movement of animals back from King's Bay into the Trail Glacier to Grant Lake segment, since a similar movement appeared to have taken place in August 1977.

Table 1. Results of replicate aerial goat counts by total and sub-areas counted, 1976 and 1977.

Date	Area	Sub-area	Observer	Counting Conditions	Total goats	Percent kids
7/18-24/76	Trail Gl.-Ptarmigan L.		No	Poor - bright sun, glare, stark shadows, late P.M.	137	26
7/18		Trail Gl.-Grant L.	No	Poor - bright sun, glare, stark shadows, late P.M.	86	24
7/24		Grant L.-Ptarmigan L.	No	Poor - bright sun, glare, stark shadows, late P.M.	51	29
8/4-23/76	Trail Gl.-Ptarmigan L.		No	Poor - bright sun, glare, stark shadows, late P.M.	131	26
8/4		Trail Gl.-Grant L.	No	Poor - bright sun, glare, stark shadows, late P.M.	85	27
8/23		Grant L.-Ptarmigan L.	No	Poor - bright sun, glare, stark shadows, late P.M.	46	24
9/5/76	Trail Gl.-Ptarmigan L.		Yes	Fair - bright sun, some new snow on peaks, A.M. - mid P.M.	156	25
9/5		Trail Gl.-Grant L.	Yes	Fair - bright sun, some new snow on peaks, mid A.M. - noon	106	25
9/5		Grant L.-Ptarmigan L.	Yes	Fair - bright sun, some new snow on peaks, early - mid P.M.	50	24
5/21-28/77	Trail Gl.-Ptarmigan L.		No	Poor - partly cloudy, much snow remaining	109	16[1/]
5/21		Grant L. only[2/]	No	Poor - high overcast, much snow remaining	68	18[1/]
5/28		Trail Gl.-Ptarmigan L.[3/]	No	Poor - partly cloudy, much snow remaining	41	12[1/]

Date	Area	Sub-area	Observer	Counting Conditions	Total goats	Percent kids
7/28/77		Grant L.-Ptarmigan L.	No	Poor - sunny, hot, stark shadows, glare, late P.M.	53	30
8/16-20/77	King's Bay-Ptarmigan L.		Yes+No	Excellent - high overcast, calm, no glare or deep shadows, P.M. except King's Bay, clear, hot sun, late A.M.; no observer	166	-[4]
8/16	Trail Gl.-Ptarmigan L.		Yes	Excellent - high overcast, calm, no glare or deep shadows, P.M.	135	25
8/16		Trail Gl.-Grant L.	Yes	Excellent - high overcast, calm, no glare or deep shadows, P.M.	73	25
8/16		Grant L.-Ptarmigan L.	Yes	Excellent - high overcast, calm, no glare or deep shadows, P.M.,	62	26
8/20		King's Bay	No	Good - clear, hot sun, late A.M.; no observer	31	-[4]
9/3/77	King's Bay-Ptarmigan L.		Yes	Poor - bright sun, glare, hot, smoke haze, mid A.M. - late P.M.	120	-[4]
9/3	Trail Gl.-Ptarmigan L.		Yes	Poor - bright sun, glare, hot, smoke haze, mid A.M. - late P.M.	79	18
9/3		Trail Gl.-Grant L.	Yes	Poor - bright sun, glare, hot, smoke haze, mid A.M. - late P.M.	30	10
9/3		Grant L.-Ptarmigan L.	Yes	Poor - bright sun, glare, hot, smoke haze, mid A.M. - late P.M.	49	22
9/3		King's Bay	Yes	Poor - bright sun, glare, hot, smoke haze, mid A.M. - late P.M.	41	-[4]

Date	Area	Sub-area	Observer	Counting Conditions	Total goats	Percent kids
9/13/77	King's Bay-Ptarmigan L.		Yes	Excellent - high overcast, calm, no glare or deep shadows, midday	158	22
9/13	Trail Gl.-Ptarmigan L.		Yes	Excellent - high overcast, calm, no glare or deep shadows, midday	130	21
9/13		Trail Gl.-Grant L.	Yes	Excellent - high overcast, calm, no glare or deep shadows, midday	78	18
9/13		Grant L.-Ptarmigan L.	Yes	Excellent - high overcast, calm, no glare or deep shadows, midday	52	25
9/13		King's Bay	Yes	Excellent - high overcast, calm, no glare or deep shadows, midday	28	25
9/24-26/77	King's Bay-Ptarmigan L.		No	Fair - high overcast, no glare, but new snow present, midday	126	-4/
9/24-26	Trail Gl.-Ptarmigan L.		No	Fair - high overcast, no glare, but new snow present, midday	103	-
9/24		Trail Gl.-Grant L.	No	Fair - high overcast, no glare, but new snow present, midday	55	-
9/26		Grant L.-Ptarmigan L.	No	Fair - high overcast, no glare, but new snow present, midday	48	-
9/24		King's Bay	No	Fair - high overcast, no glare, but new snow present, midday	23	-

1/ Yearling percent; kidding incomplete

2/ Goats still on winter range

3/ All study area counted except Grant L.

4/ Kids not classifed

Table 2. Summary of aerial goat counts by sub-areas counted 1976,1977.

Area	Date	Non-kids	Kids	Total
Trail Gl.-Ptarmigan L.	7/18-24/76	101	36	137
Trail Gl.-Ptarmigan L.	8/4-23/76	97	34	131
Trail Gl.-Ptarmigan L.	9/5/76	117	39	156
Trail Gl.-Grant L.	7/18/76	65	21	86
Trail Gl.-Grant L.	8/4/76	62	23	85
Trail Gl.-Grant L.	9/5/76	79	27	106
Grant L.-Ptarmigan L.	7/24/76	36	15	51
Grant L.-Ptarmigan L.	8/23/76	35	11	46
Grant L.-Ptarmigan L.	9/5/76	38	12	50
King's Bay-Ptarmigan L.	8/16-20/77	-	-	166
King's Bay-Ptarmigan L.	9/3/77	-	-	120
King's Bay-Ptarmigan L.	9/13/77	124	34	158
King's Bay-Ptarmigan L.	9/24-26/77	-	-	126
Trail Gl.-Ptarmigan L.	5/21-28/77	109	-	109
Trail Gl.-Ptarmigan L.	8/16/77	101	34	135
Trail Gl.-Ptarmigan L.	9/3/77	65	14	79
Trail Gl.-Ptarmigan L.	9/13/77	103	27	130
Trail Gl.-Ptarmigan L.	9/24-26/77	-	-	103
Trail Gl.-Grant L.	8/16/77	55	18	73
Trail Gl.-Grant L.	9/3/77	27	3	30
Trail Gl.-Grant L.	9/13/77	64	14	78
Trail Gl.-Grant L.	9/24/77	-	-	55
Grant L.-Ptarmigan L.	7/28/77	37	16	53
Grant L.-Ptarmigan L.	8/16/77	46	16	62
Grant L.-Ptarmigan L.	9/3/77	38	11	49
Grant L.-Ptarmigan L.	9/13/77	39	13	52
Grant L.-Ptarmigan L.	9/26/77	34	14	48
King's Bay	8/20/77	-	-	31
King's Bay	9/3/77	-	-	41
King's Bay	9/13/77	21	7	28
King's Bay	9/24/77	-	-	23

In 1977, the two best counts of the Trail Glacier to Ptarmigan Lake area, both flown with an observer under almost ideal conditions, were only 4 percent apart. During both surveys, goats were very visible, standing out readily against their backgrounds in the soft light. I felt that the areas were covered completely and that little could have been gained by counting from a helicopter. Unfortunately this assumption could not be confirmed. The two surveys, which included King's Bay Valley and which were flown under good light conditions, were similar to those flown over the Trail Glacier to Ptarmigan Lake segment. The total number of goats counted was 5 percent higher in the earlier survey. King's Bay was counted without an observer on the first flight.

Variation within segments on these two surveys was greater than that between counts of the total area. It is not known whether this was caused by movements from the Grant Lake - Ptarmigan Lake segment into the Trail Glacier - Grant Lake segment (no indication of such movements was noted in late summer 1976), or reduced count accuracy in the southern segment being balanced by an influx into the northern segment from King's Bay.

The Grant Lake - Ptarmigan Lake segement was surveyed without an observer and under poor light conditions (bright sun and glare) on 28 July 1977, then again with an observer under slightly worse conditions on 3 September 1977. The total number of goats counted was 8 percent lower in the second count despite the presence of the observer. Whether this change was due to unseen animals or to possible egress from the segment is unknown.

The King's Bay segment, alone, may have been surveyed with greater accuracy than the other segments on all counts. This valley runs generally north and south so the observer is not subject to the intense glare and stark shadows which occur when searching north facing slopes, nor was any haze present there on 3 September. The valley is relatively open and the goats were concentrated in a comparatively small part of it where they were easily found. Despite variations in counting conditions, the herd in that valley declined steadily from a high of 53, counted on a reconnaissance survey on 18 July, to 23 on 24 September, suggesting a gradual drifting of goats out of the valley. Occasionally tracks were seen crossing the icefield between King's Bay Valley and the Trail Glacier segment.

In comparing the lowest count, made under very poor light conditions, with two highest counts, made under good light conditions, the total number of goats counted in the Trail Glacier to Ptarmigan Lake area increased by 65 to 71 percent, and in the entire area from King's Bay to Ptarmigan Lake by 28 to 32 percent. The greatest variation was in the Trail Glacier to Grant Lake segment, where the lowest to highest counts varied by 143 to 160 percent. In the Grant Lake to Ptarmigan Lake segment, variation was 6 to 27 percent. The difference between segments may be related in part to the movement of animals from King's Bay into the Trail Glacier area.

A survey was flown in late May 1977, to determine the percentage of yearlings in the herd. Despite remaining heavy snow cover at medium and

high elevations, a surprisingly high count was obtained. Most goats seen had moved low on the slopes below snow line (apparently seeking succulent new forage) and were very visible. The total counted in this survey is not comparable with totals counted in later surveys, however, since it did not include the north side of Trail Glacier where a number of goats winter. Some of these goats apparently moved south of the glacier into the study area in June.

The percentage of kids observed in the herd remained quite stable throughout both summers, declining from 26 to 25 percent in 1976, and from 25 to 21 percent in 1977. Both declines could be the result of counting inaccuracies and/or summer mortality.

In an attempt to compare accuracy of ground versus aerial counts, the best estimates of several local populations which were within reach of the ground observers were compared with aerial surveys of the same area (Table 3). In all counts where a reliable ground estimate was obtained, except King's Bay Valley, more animals were located in aerial counts. The extreme ruggedness of terrain limited the amount of any given area which could be covered or observed by ground personnel in a short time. Ground searches over a several-day period resulted in an unknown number of duplicate observations, making population estimates unreliable. In King's Bay Valley, the terrain and animal concentrations were such that an observer on the ground could view almost the entire habitat used by goats during a period of a few hours. I believe the ground count there was accurate for the date conducted. It was 9 percent higher than an aerial count made 2 weeks earlier. It is possible the higher ground count was due, at least in part, to an influx of goats in July, and that both aerial and ground counts were accurate on the days surveyed.

Average air temperatures taken on aerial surveys were compared statistically with the number of goats counted to see whether any relationships existed between temperature and count accuracy. No significant trends could be discerned in the number of goats counted relative to temperature.

Regressions were also calculated for the relationships between number of goats counted on a given count segment and the time spent making the count. No significant relationships were found; i.e., a longer, more intensive count did not necessarily result in more goats observed. All counts included were made with appropriate dilligence. It is probable that an accuracy-time relationship could be demonstrated by comparing quick, careless counts with longer, more carefully conducted flights.

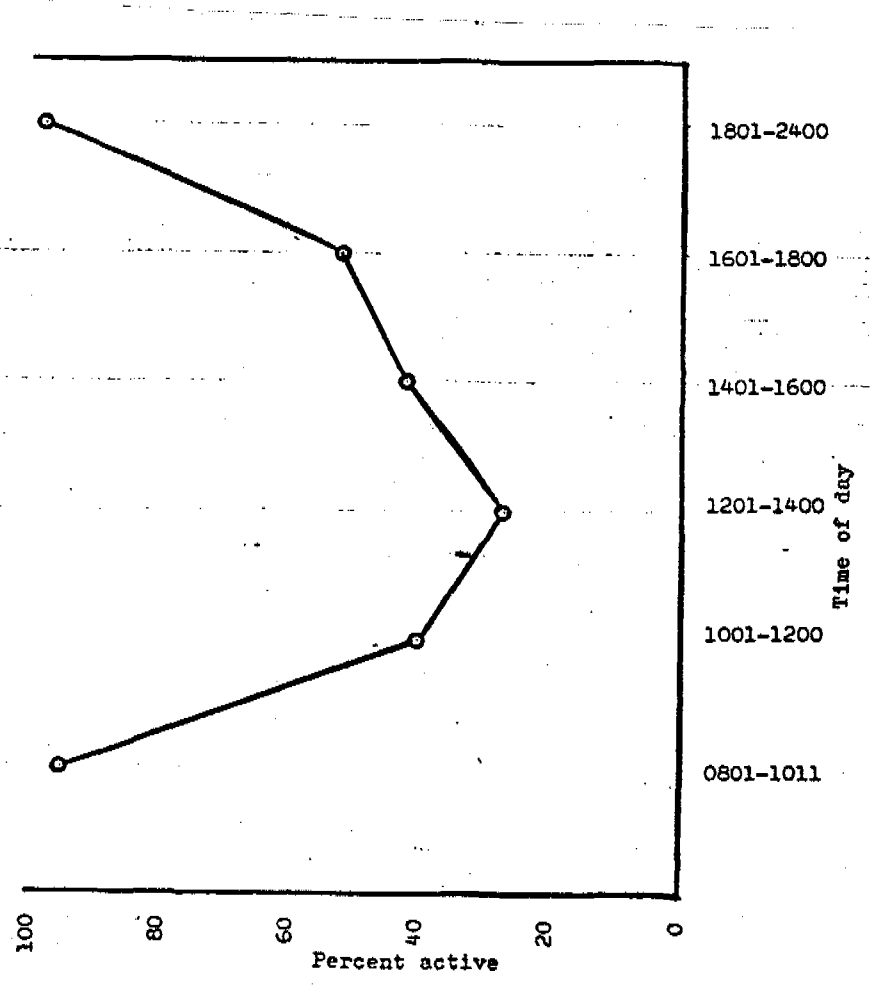
Daily activity pattern

It has been reported that mountain goats are active early in the morning and late in the afternoon. During mid-day, most may be found bedded and resting or ruminating (Anderson 1940, Brandborg 1955, Chadwick 1973, Lentfer 1955, Rideout 1974). The observed activity pattern in this study confirmed these findings (Fig. 3). No difference could be discerned between daily activity patterns in 1976 and 1977. Most morning activity occurred before 1000 hours, and most afternoon activity after 1800 hours.

Table 3. Aerial vs. ground estimates for selected goat herds.

Area	Year	Type estimate	Adults	Kids	Total
Ptarmigan Valley	1976	Best aerial count	24	9	33
	1976	Best ground estimate	23	8	31
	1977	Best aerial count	29	11	40
	1977	Best ground estimate	27-37	8-13	35-50
Trail Glacier	1976	Best aerial count	21	8	29
	1976	Best ground estimate	20	4	24
	1977	Best aerial count	18	5	23
	1977	Best ground estimate	11	4	15
King's Bay Valley	1977	Best aerial count	-	-	53
		Best ground count	-	-	58

Figure 3. Percent of goats active by time of day.



Weather related activity pattern

Goats have been found to be more active following storms or rainy periods than on clear, hot days (Casebeer 1950, Fox 1977, Richardson 1971, Saunders 1955). Goats observed in this study during 1976 and 1977 were classified as active (feeding, moving) or inactive (bedded, standing). Comparing activity by weather (Fig. 4) shows that they were somewhat more active on overcast days than on clear or partly cloudy days, and much more active during rain than under any other conditions. Few were active in fog.

During August, when most goats were beginning to grow a heavier coat following the molt and were thus unable to lose heat readily, Chadwick (1973) and Peck (1972) found that they preferred shade for all activities, and were more prone to use cooler, north facing slopes. I did not attempt to quantify activity as to use of shaded or open habitat. The terrain involved did not permit ground observers to obtain sufficient observations to quantify goat use by direction of slope. During aerial surveys, it was apparent that goats were more difficult to find on hot, clear days in August, and many of those seen were in the shade of rocks, cliffs, overhanging snowbanks, or glacial crevasses. Many were observed lying on snowbanks or glaciers. On cooler, overcast days goats were more conspicuous and appeared to be more in the open.

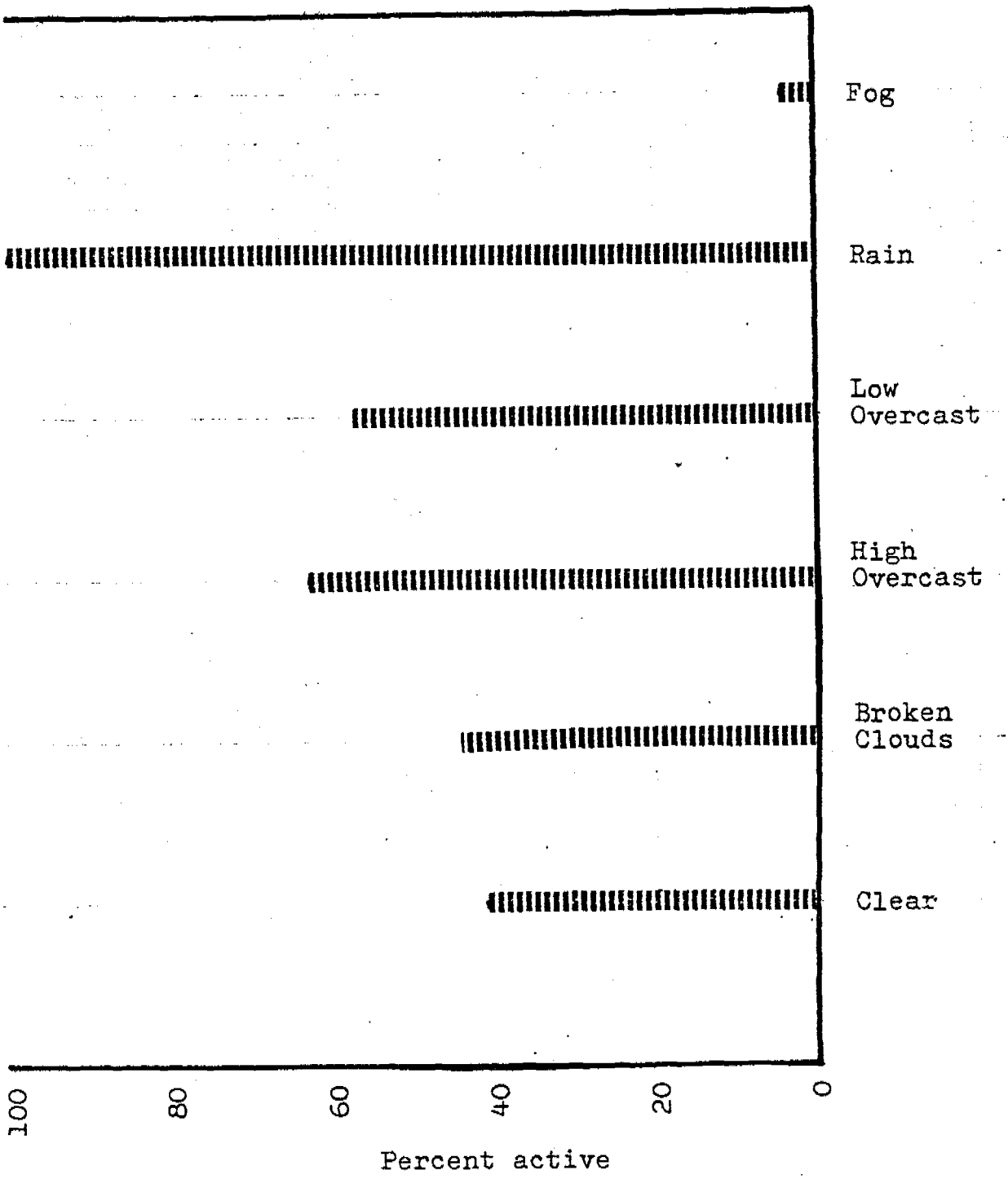
Sex and age criteria

Most goats observed from the ground were identified as to sex and age class. Kids-of-the-year were not sexed, nor were some yearlings. Age classes used were: kid (those animals born during the current summer), yearling (animals born during the previous summer), 2-year-old (animals 24 months old on or about 1 June), and adult (all animals over 36 months of age).

This classification system appears logical from the standpoints of reproductive ability and assessment of population dynamics. Nearly all investigators agree that goats do not first breed until approximately age 2 1/2 years (Chadwick 1973, Foss 1962, Holroyd 1967, Lentfer 1955, Peck 1972). Thus, animals older than 36 months can be considered adults, and those younger than 36 months can be considered sub-adults when observed during the summer.

During summer 1976, we used urination posture (Brandborg 1955, Hibbs and Denney 1965) and direct observations of the genitalia for positive sex identification and to confirm identification based on more readily visible criteria such as horn shape and body size and shape. Others have noted the difference in thickness and shape of the horns between sexes in adults (Brandborg 1955, Casebeer 1950, Cowan and McCrory 1970, Klein 1953, Lentfer 1955, Vaughan 1975). Horns of adult males are more massive, thicker at the base, and follow a smoother curve from base to tip than those of adult females. The latter have horns which have smaller bases, are relatively narrow, are somewhat straighter for approximately the lower 2/3 of their length, then curve rearward with a more angular appearance, and usually are more divergent than those of males.

Fig. 4. Percent of goats active by weather conditions.



Goat horns taken in the 1976 hunting season were measured by Department personnel and summarized by mean circumference at the base, mean length, sex and age (Alaska Dept. of Fish and Game files, unpub.). I compared mean base circumferences and mean lengths between sexes by age using the paired t-test. Mean circumference at all age levels was significantly greater in males than in females ($t = 14.18$, $p < .001$), but length was no different. A rough approximation of the mean basal diameter was obtained by assuming the bases to be circular (not exactly true since goat horns are roughly oval in cross section) and dividing each mean circumference by Pi. The mean basal diameter for females was 21 percent less than that for males.

We found that horns, alone, were nearly always an adequate criterion for determining the sex of 2-year-old and adult goats. When horns were clearly visible and sex was not in doubt, we later dropped our initial requirement of viewing urination posture or genitals for sex identification.

Body shape and size are also useful criteria for sex determination for adult goats. Hibbs (1966) found that adult nannies were generally 10-20 percent smaller than adult billies. Lentfer (1955) was able to group kids, yearlings, 2-year-olds, and adults on the basis of shoulder height. Our observations agreed with theirs. In addition, we noted that nannies usually had thinner necks and less massive shoulders than billies.

Females goats always exhibit black vulval patches when the tail is raised but no similar dark area is visible on males. In summer, the males' scrotums are readily visible, those of adults being obviously much larger than those of 2-year-olds. In winter, long hair generally covers these organs; however, adult males nearly always have a dirt-smeared rump in winter, while females and young goats have clean coats.

Table 4 summarizes external, visible characteristics which may be used to classify goats by sex and age when viewed from the ground. We were able to classify them from a distance of a mile or more using a Questar telescope on days with few heat waves.

Grouping by sex and age

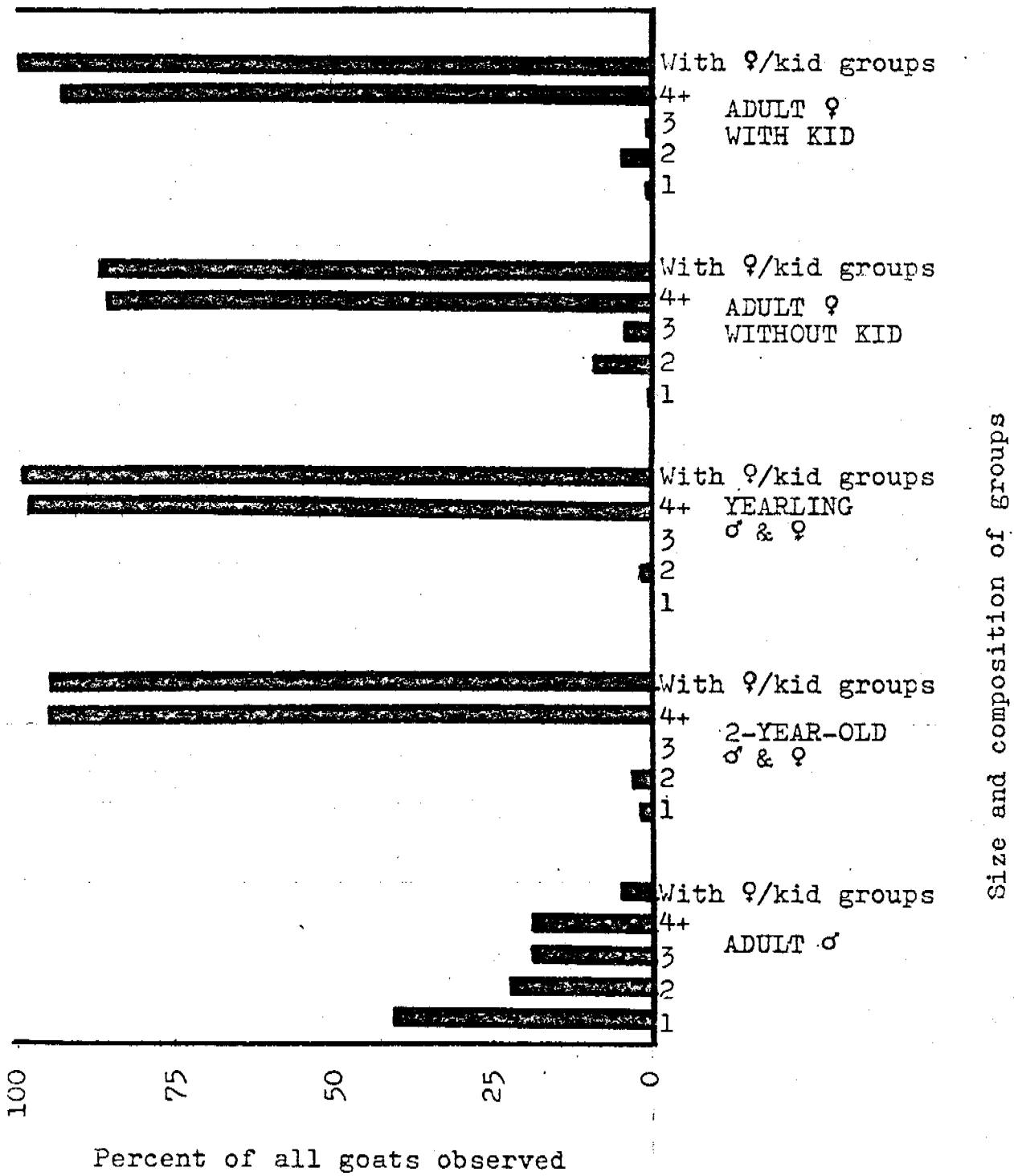
Male goats are usually solitary in summer, or are found in small groups of 1-5 (Brandborg 1955, Casebeer 1950, Chadwick 1973, Hibbs 1965, Holroyd 1967, Lentfer 1955). They normally remain segregated from the adult female, 2-year-old, yearling, kid groups, although they do occasionally mingle with them for a short time. However, they are not actually a part of these groups when they do so, and go their separate way at the slightest disturbance (Hebert 1967). Young males remain with the female groups until after they reach 2 1/2 years of age when they begin a relatively solitary existence (except during the rut) (Chadwick 1973, Hibbs 1965).

The grouping of all goats classified in summer 1976 and 1977 was noted (Fig. 5). About 95 percent of all adult billies were found in male-only groups; the remaining 5 percent were seen in association with female groups. However, this association appeared temporary and the

Table 4. Useful criteria for sexing and aging mountain goats.

Age Class	Sex	Characteristics
Kid		Small size obvious; horns barely visible early summer to less than 1/2 ear length by fall; face very juvenile in appearance.
	Male:	Urination posture: stands or stretches during urination.
	Female:	Urination posture: squats during urination.
Yearling		Size larger than kid, considerably smaller than adult female; horns in early summer less than ear length to about ear length by fall; face still juvenile in appearance.
	Male:	Urination posture; scrotum visible; horn bases becoming heavier, though sometimes not easily distinguished.
	Female:	Urination posture; horn bases thinner; black vulval patch becoming visible under tail.
2-year-old		Size smaller than adult female, larger than yearling; horns longer than ears; face no longer juvenile, but not quite as long and angular in muzzle as adults; difficult to distinguish from adults in late summer.
	Male:	Urination posture; scrotum visible in summer, but comparatively small; horn bases thicker than females' with less space between bases as seen frontally, smoother curve from base to tip as seen laterally; body appears somewhat heavier over neck and shoulders than females'.
	Female:	Urination posture; black vulval patch easily visible under tail; horns thinner and slightly more angular (not always) than males' as viewed laterally, more space between bases as viewed frontally; neck and shoulders not quite as massive.
Adult		Full grown animals; faces long and angular; horns longer than ears.
	Male:	Urination posture; scrotum visible in summer and much larger than in sub-adults; rump usually dirt-smeared in winter; horns heavy at bases with space between horns usually less than width of horn bases when viewed frontally; horns tapering and curving rearward smoothly from base to tip, often curving inwards near tips when viewed frontally; neck and shoulders massive with crest line forming nearly smooth, convex curve from back of head to lumbar region; body larger than females'.
	Female:	Urination posture; may be with kid; black vulval patch under tail; horns appear thinner than males' and more angular, horns often diverge in "V" shape; space between horn bases wider than bases; "ewe-necked" before molt is complete with less massive shoulder hump; after molt, dorsal crest line appears slightly concave or less convex than males'; shoulders and entire body less massive than adult males'; rump clean in winter.

Fig. 5. Group sizes of mountain goats by sex and age class.



adult billies would usually leave the female groups in a short time or when disturbed. Only rarely were adult males found in groups as large as four or five; 82 percent were found in groups containing three or less.

Ninety-five percent of all 2-year-old male and female goats were found in groups of four or more and in groups with adult nannies and kids. Ninety-nine percent of yearlings were in groups containing adult females with kids, and 98 percent were in groups larger than three.

Molt by sex and age

In early to mid-summer, goats molt their heavy winter coats, a process that is very obvious because of the contrasting portions of their bodies covered with either thick or very thin pelage. During this molt, patches of loose hair adhere to the animals, flopping in the breeze or during movement. Contrast is very marked between cleanly shed and unmolted animals.

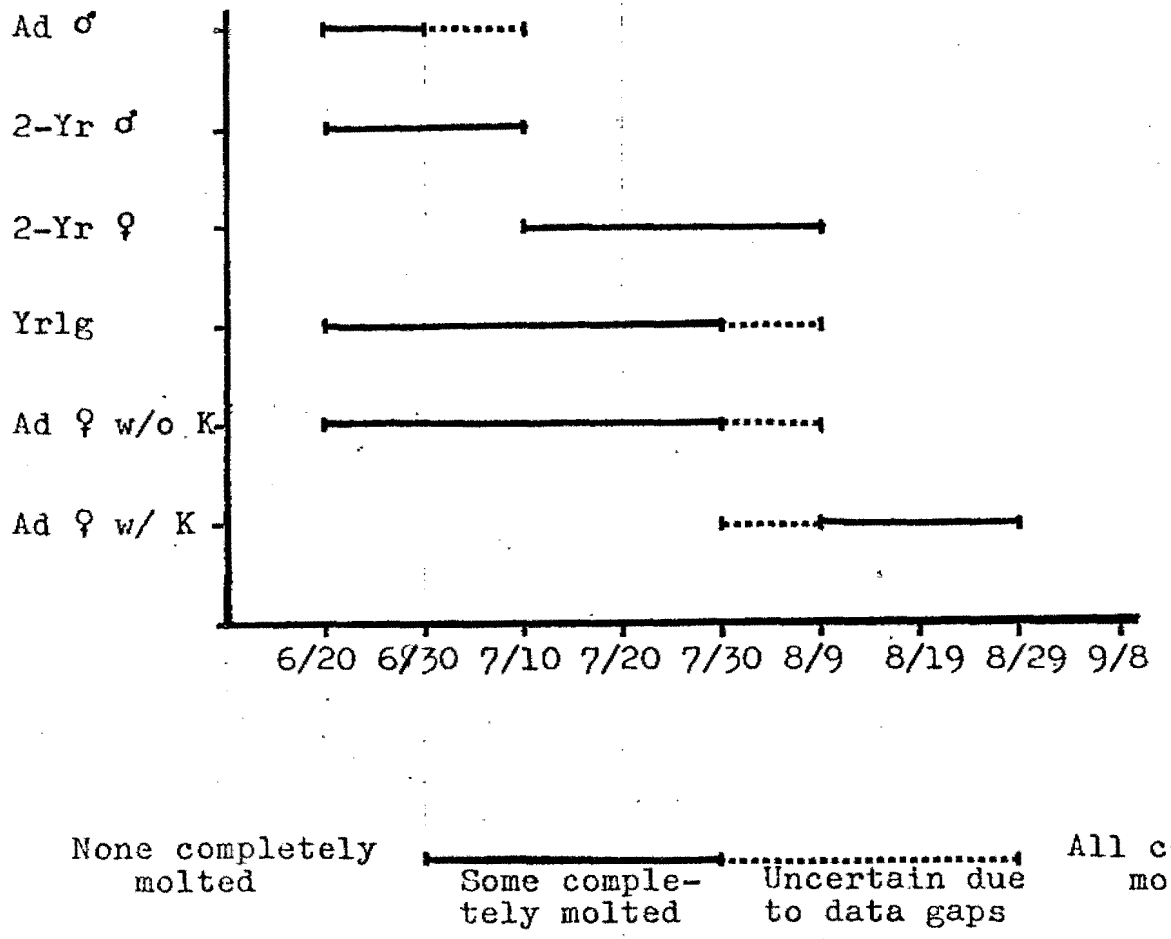
Molting does not take place during the same time frame for all sex and age classes, a distinction noted by other researchers. Most agree that adult males complete their molt first, and adult females with kids last. However, Holroyd (1967) believed that yearlings were the first to molt in British Columbia, whereas Hibbs (1966) and Casebeer (1950) reported that yearlings were the last to molt in Colorado and Montana. Chadwick (1973) and Hebert (1967) found that adult males molted first, adult females without kids and young animals (presumably 2-year-olds) next (with young females slightly later than young males) and adult females with kids much later. Hebert (1967) believed that the molt pattern and sequence by sex and age class was a fixed physiological process.

In this study, all animals classified by sex and age class were also classified as to stage of molt to see whether the sequence could be quantified and used as a criterion for determining the sex of goats during aerial surveys. The sequence appeared to be similar in both summers, so data were combined (Fig. 6). Both adult and 2-year-old males completed their molt by 20 July. Adult males may have finished by 11 July, but sufficient data to confirm this were not obtained. Two-year-old females began molting later and were not completely shed until 9 August or possibly 19 August. Yearlings of both sexes apparently began molting earlier than 2-year-old females, but were not all completed until the same date. However, lack of observations leaves the date by which all were shed somewhat questionable. At least some adult females without kids had completed their molt as early as some adult and young males, but 97 percent of all those observed had not begun nor completed their molt until the 30 July to 9 or 19 August period. None of the nannies with kids were cleanly shed before 9 August, but all had completed their molt by 8 September.

Snow cover

Mean percentages of snow cover were compared within areas each year by one-way analyses of variance. In winter 1975-76, no significant differences existed within the areas classified as sheep only and sheep

Fig. 6. Time periods before which no goats of given sex/age class have completely molted, and after which all have molted. Combined 1976-77 observations grouped by 10-day periods.



and goats mixed. In the area inhabited by goats only, a statistically significant within-area difference was detected ($F = 6.89$, $p < .01$). Further analysis by Student-Newman-Keuls' test showed that only one sub-area differed significantly from the others, but in general, the areas were homogeneous within each type. Between-area testing showed that each was significantly different from the other ($F = 46.03$, $p < .025$). Mean percentages of snow cover in 1975-76 were:

Sheep only area	$\bar{x}$ = 41 percent snow covered
Sheep and goats mixed	$\bar{x}$ = 64 percent snow covered
Goats only area	$\bar{x}$ = 81 percent snow covered.

In winter 1976-77, each area had significant within-area differences (sheep only $F = 3.65$, $p < .01$; sheep and goats $F = 3.34$, $p < .05$; goats only $F = 2.96$, $p < .05$). However, within each area snow cover on only one sub-area was different from the remainder in that area. Between the areas, a significant difference in snow cover was found ($F = 5.12$, $p < .01$). Snow cover on sheep only and sheep and goat areas was similar; that on the goat only area was significantly higher. Mean percentages of snow cover in 1976-77 were as follows:

Sheep only area	$\bar{x}$ = 86 percent snow covered
Sheep and goats area	$\bar{x}$ = 89 percent snow covered
Goat only area	$\bar{x}$ = 96 percent snow covered

Snow cover was also compared between the two winters by area and found only to be significantly greater in winter 1976-77 on the sheep only area ($t = 3.609$, $p < .01$).

Goat horn growth

Horns taken in the 1977 Kenai Peninsula permit hunt were measured by annual increments. No annulus can be found at the end of the kid's first summer, but cessation of growth can be estimated very roughly by a change in horn surface texture from smooth and shiny to a rougher texture. Hence, estimated length of growth during the first summer is only a rough approximation compared to length of growth segments during later years when clearly defined annuli are present. Lengths of horns by age and sex are plotted in Figs. 7 and 8.

DISCUSSION

Preliminary movement studies showed that an unknown number of goats move from winter/spring range on the north shore of Grant Lake through the study area to Trail Glacier and across the head of Snow River Glacier into the Valley of King's Bay. Since most goats were marked prior to their spring molt, markings were lost with the shedding of winter hair and could not be used to indicate further movements in late summer. Nevertheless, observed population build up and decline in King's Bay Valley suggested movements out of this valley in August by at least some animals. Whether goats crossed Trail Glacier to the north or otherwise left the study area is unknown. No marked goats were found elsewhere. These movement patterns, poorly understood at present, make the interpretation of replicate aerial counts in the study area difficult.

Fig. 7. Male goat horn length by age, 1977 data.

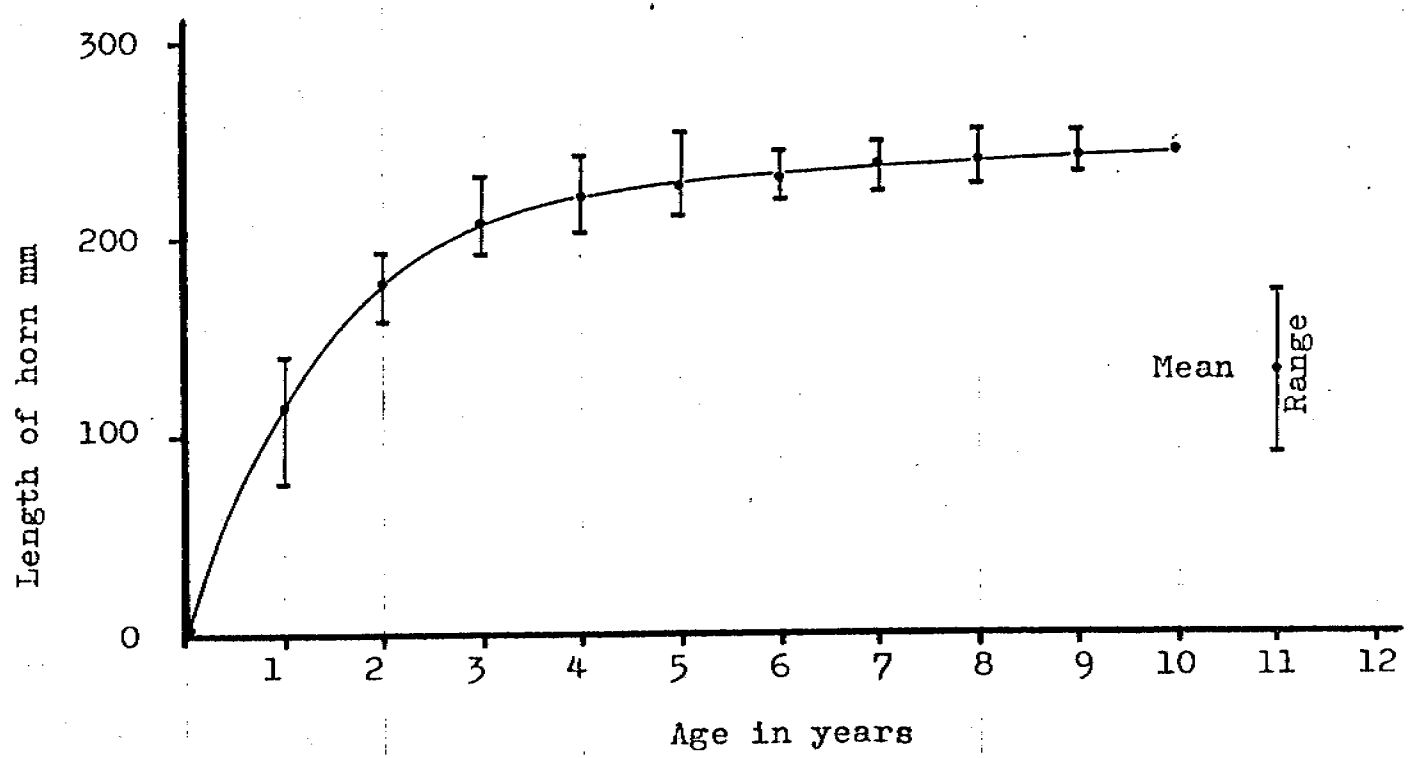
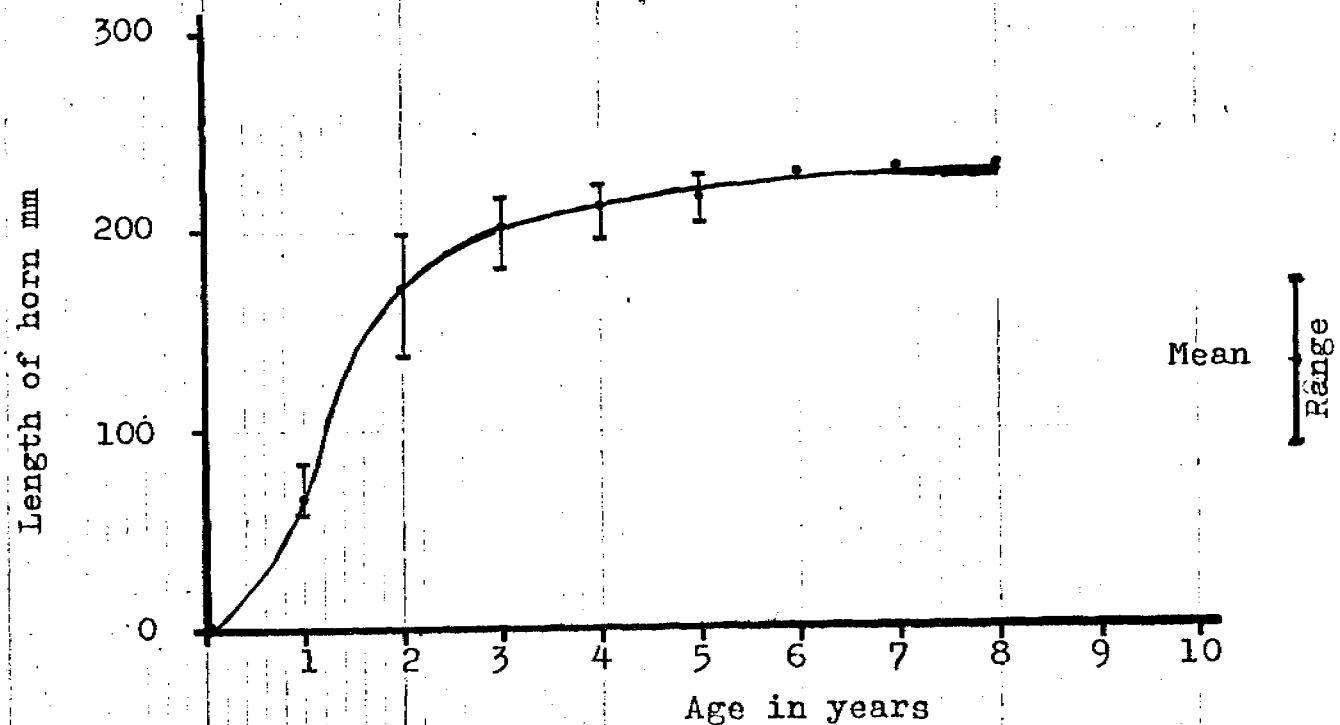


Fig. 8. Female goat horn length by age, 1977 data.



Variations in numbers counted under comparable conditions from the air within segments of the study area may well have been caused, at least in part, by between-segment movements. When the entire area was covered in each count, or when a large part of it was covered in two counts made over a relatively short time span as in 1976, variation between counts conducted under similar conditions was small - about 5 percent. Variation in total goats counted between fair to poor and excellent counting conditions was about 30 percent when the entire area was taken as a whole in 1977. Thus, it appears that when made under similar conditions, results of aerial counts may be closely comparable but not necessarily indicative of the true population size. Surveys conducted under good conditions (i.e., high overcast; soft, even light) resulted in the highest total counts. It remains to be learned whether these totals are close to the true numbers present, but the importance of counting under good light conditons is apparent.

Since animals moving and feeding are easier to observe and hence more likely to be counted from the air than those resting, surveys on clear days probably should be conducted during early morning or late afternoon activity peaks. This does not seem as important on overcast days when activity is more uniform. Periods of clear weather immediately following bad weather also appear to be a time when goats are active and observable.

Regardless of animal activity patterns, it was found that early mornings and late afternoons on clear, sunny days in late July, August and September had the worst conditions of glare and deep shadow because of the sun's low angle. It was very difficult to see anything when looking into shadowed slopes against the bright glare of the low sun. Conversely, goats were not as readily distinguished from light colored rocks or snow banks on brightly lit, sunny slopes. Under the soft, even light produced by a high, thin overcast, goats were much more visible and obvious in all habitats, and chances of missing them were much lower.

Surveys were not conducted in early summer (late June, early July) because of the many large snow banks present and the assumed risk of missing many goats among them. Despite the presence of snow cover, the one spring survey did produce a high count of goats and may have produced a total comparable to the best summer counts (exclusive of kids) had the total area occupied by the herd been covered. Late summer (late August, early September) surveys undertaken on clear, sunny days encountered the problem of goats seeking relief from the heat under cover and on snowbanks. Thus, they were much harder to locate. It is possible that the long post-sunset or pre-sunrise twilight hours of clear, early summer days might provide conditions as suitable as on days of high overcast in spite of the heavier snow cover.

No census as such was attempted in winter, but a number of reconnaissance surveys made it obvious that few goats could be found in the brushy, timbered habitat occupied at that season. Tracks, not goats, were the best indicators of winter distribution.

In the type of extremely rugged, glaciated mountains occupied by mountain goats in this part of Alaska, attempts to census them from the ground appear impractical. In all but one of the compared aerial vs. ground surveys conducted here, more goats were seen from the air and these were under the best terrain conditions for ground survey that could be found. Ground observers could not even reach or search much of the occupied habitat, nor could they cover enough area in a short time to avoid duplicate sightings caused by goat movements.

Data gaps preclude definitive conclusions at this time, but it appears to be possible to at least partially classify goats by sex and age from the air on the basis of body size, grouping and stage of molt. Sex and age classifications needed for productivity and survival computations are primarily adult females of breeding age, kids of the year, and yearlings. The necessary ratios of kids to breeding females and yearlings to breeding females can then be obtained. It is also advisable to obtain the ratio of adult males to breeding females. To determine the number of breeding females present (including adult females without kids as well as those with kids), other age classes must be eliminated.

The proportion of yearlings in the herd may best be determined by surveying in late April or early May before kidding has begun and when animals are visible on the lower slopes below the receding snowline. Only total numbers and yearlings need be enumerated at this time; the object is to determine only the proportion of yearlings in the herd, not total numbers. A count including a large proportion of goats in the herd is necessary, but it is not necessary to find total numbers.

A second survey should be conducted between 20 July and 9 August to classify new kids, adult males, and mixed yearlings, 2-year-olds, adult females without kids, and females with kids. If conditions are suitable, an attempt to count total goats in the herd may also be made at the same time. During such a count, most large, cleanly shed goats observed separately from groups including kids, and usually in groups of 3 or less, may be assumed to be adult males. Some adult females without kids, and a few 2-year-olds may be in such small groups (but not with the adult males), but over 90 percent of animals seen in these isolated groups will be adult males. By making one or more close passes, an observer may be able to improve identification even further by observing horns, body shape or genitalia.

In mixed groups, new kids may be recognized easily by their size. Large, unshed goats will be adult females accompanying the kids. They will, of course, be equal in number to the kids, except where rare twins are present. Other goats present will include both shed and unshed yearlings, 2-year-olds, and adult females without kids. The approximate number of yearlings present may be calculated from the previously obtained ratio of yearlings to total goats, excluding kids. Left unclassified are the 2-year-olds and adult females without kids.

It is particularly desirable to be able to identify those females without kids so that effective productivity - the ratio of kids to breeding age females can be calculated. However, more data are needed

before it can be determined whether this can be done from the air. Should this prove possible, two aerial surveys as described each year could provide all necessary data on adult sex ratios, productivity, survival from kids to yearlings and yearlings to 2-year-olds, and total herd size.

The method of assessing snow cover from transect-sampled aerial photographs proved economical and simple; accuracy appears to be adequate for the information needed. Although snow cover could be estimated at only one point in time (mid-winter) from the photographs taken, the method also could be used to assess changes in cover throughout the winter if desired by taking a series of photographs at regular time periods.

The difference in percent snow cover was striking in winter 1975-76 between areas occupied by sheep only, sheep and goats together, and goats only. Winter snow cover may be one of the most important factors limiting the expansion of sheep into range generally occupied by goats; if this is true, the cline in snow cover as found would be as expected. In winter 1976-77, which was a winter of record snow fall (Clagett 1977), percent snow cover was not significantly different between sheep-only, and sheep-and-goat areas, but was significantly greater on goat-only areas. The apparent tolerance by goats to deeper snow than that tolerated by Dall sheep was again suggested.

Comparisons of the two winters showed a statistically significant increase in percent snow cover in 1976-77 only on the sheep-only area despite an apparently greater snow fall on all areas. During that winter, mortality was high among sheep on the sheep-only areas; over 50 percent were lost. The only exception noted was the Broadview Cliffs which are the wintering ground of the Cooper Landing Closed Area sheep herd. This herd suffered a mortality of about 30 percent (Nichols, unpub. data). Only on this mountain was snow cover significantly lower than that on the remainder of the sheep-only habitats.

Percent snow cover on the areas occupied by sheep and goats, and goats only, was not significantly greater than in the previous winter. Mortality among the goats was approximately 13 percent in the Trail Glacier to Ptarmigan Lake portion (highest total count in 1976 to highest in 1977), while that among the sheep in this same area was about 8 percent. In the sheep-only areas, mortality was about 24 percent in the Cooper Landing Closed Area, and 49-54 percent in the remainder (mortality estimates which include the second year's kid/lamb production as calculated here, are not good estimates of actual mortality, but are used here for comparative purposes, only, because lamb and yearling data are not available for sheep in the area occupied by both sheep and goats). Thus, high overwinter mortality of sheep appears related to the significantly greater percent snow cover found on the sheep-only areas in winter 1976-77, while lower mortality among both goats and sheep occupying the other areas may well be related to the insignificant difference in snow cover between years.

RECOMMENDATIONS

Further studies of goat movements throughout summer and early fall are badly needed. Without a better knowledge of such movements, and knowledge of goat fidelity to given ranges at given seasons, interpretation of aerial survey results will always be questionable.

The two jobs covered in this report need to be continued over at least one more field season to enable further replicate aerial counts to be made, backed up by at least two helicopter counts. A better estimate of actual goat numbers present in the study herd must be obtained to compare with results from fixed-wing aircraft aerial counts made under variable conditions. Also, time gaps in sex and age classification studies need to be filled in an attempt to learn whether more detailed classification from the air is practicable.

Additionally, sex and age classification observations over time should be made on another goat herd, preferably in coastal habitat, to learn whether the same criteria for aerial classification apply.

Winter snow studies should be continued to evaluate the type of winter conditions encountered by goats.

Range and food habits studies are needed to determine the adaptability of goats to their available food supply, and the amount of competition occurring between sheep and goats where ranges overlap.

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PREPARED BY:

Lyman Nichols
Game Biologist

APPROVED BY:

Acting Director, Division of Game

SUBMITTED BY:

Karl Schneider
Regional Research Coordinator

Research Chief, Division of Game