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CRITERIA FOR DETERMINING AGE AND SEX OF AMERICAN MOUNTAIN GOATS IN THE FIELD

BRUCE L. SMITH

Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, MT 59812
Present address: National Elk Refuge, P.O. Box C, Jackson, WY 83001

In the past, wildlife managers often based management prescriptions for mountain goats (*Oreamnos americanus*) primarily on harvest results from previous years (Hebert and Turnbull, 1977). Insufficient censusing and failure to classify observed goats by age and sex resulted in inadequate data on population composition with which to evaluate the status of populations and develop appropriate harvest strategies (Hebert and Turnbull, 1977; Johnson, 1977; Macgregor, 1977). The liberal hunting regulations that often resulted, combined with uneven distribution of harvests among individual goat herds, expanded road access to goat ranges, and the misconception that mountain goats could be managed by principles based upon experience and knowledge derived from other ungulates, led to widespread declines in goat populations in North America (Ballard, 1977; Hoefs et al., 1977; Johnson, 1977; Kuck, 1977; Phelps et al., 1976).

In a survey of professional mountain goat managers and researchers, development of inventory techniques ranked as the highest research priority (Eastman, 1977). Among techniques needed are standardized criteria for determining age and sex composition of populations. Improved evaluation of sex ratios, reproductive success, recruitment rates, and subadult survivorship—all of which require population composition data—is fundamental to management and conservation of mountain goats (Bailey and Johnson, 1977; Hebert and Turnbull, 1977; Macgregor, 1977). Standardizing criteria for collecting composition data will improve understanding of population dynamics, facilitate comparisons of populations, and enhance management efforts. This paper reviews existing techniques for age and sex determination of mountain goats, presents a quantitative justification for separating six age and sex classes in field surveys, and provides a verbal description of each class accompanied by illustrations.

Currently, three criteria are used to determine sex of free-ranging goats: 1) observation of genitals—the male's scrotum can be seen in summer but the goat's long pelage obscures the scrotum in winter, and the female's ($\geq$1 year old) black vulval patch is visible throughout the year when the tail is raised (Nichols, 1980); 2) urination posture—male goats "stretch" when urinating whereas females "squat" (Chadwick, 1983: 189–191); 3) horn morphology—two sexually dimorphic horn characteristics distinguish the sexes of animals $\geq$2 years of age (Brandborg, 1955; Hanson, 1950). Viewed laterally, horns of females are straighter than those of males, but sometimes have a prominent backward "crook" approximately 50–75 mm from the horn tip (coinciding with the slowing of horn growth during the first winter). Male horns display a greater curvature that is gradual throughout the length of the horn. Additionally, horns of males have a greater basal circumference than those of females. Sexual dimorphism of horns is poorly developed in goats <2 years of age.

TABLE 1.—*Sample sizes, means, 95% confidence intervals (CI), and ranges (in parentheses) for measurements (in mm), for 211 mountain goats, 139 from Montana (this study), and 72 from Idaho (Brandborg, 1955) and Montana (Casebeer et al., 1950).*

Character measured	Kid			Yearling			2-year-old ♂		
	n	$\bar{X}$ (Range)	95% CI	*n*	$\bar{X}$ (Range)	95% CI	*n*	$\bar{X}$ (Range)	95% CI
Horn length	13	69 (41–99)	57–80	21	149 (105–191)	141–158	16	201 (165–219)	192–211
Horn basal circumference	12	59 (44–71)	53–65	21	90 (73–114)	84–97	16	117 (114–127)	115–119
Rostral length	7	117 (111–121)	114–119	10	141 (130–156)	136–147	8	162 (159–171)	159–165
Ear length	11[a]	102 (89–119)	95–109	5	114 (114)	114–114	4	124 (122–127)	121–127
Horn : ear length	11	0.71 (0.45–0.94)	0.62–0.81	5	1.31 (1.22–1.33)	1.25–1.35	4	1.68 (1.60–1.77)	1.55–1.80
Beard length	5	(83–89)		2	(57–76)			—	
Beard-length dates		(28 Nov.–5 Apr.)			(30 Sep.–21 Oct.)			—	

[a] Data this study: $n = 8$, $\bar{X} = 97$, 95% CI = 93–101, range = 89–105; Casebeer et al. (1950) and Brandborg (1955) data combined: $n = 3$, $\bar{X} = 116$, 95% CI = 113–119, range = 114–119. The means of the two data sets are significantly different ($P < 0.01$).

Regarding age, wildlife managers and researchers generally have classified mountain goats in the field as kids (0–12 months) and adults, or as kids, yearlings (13–24 months), and adults. Because goats seldom reach sexual maturity until 2.5 years of age and first reproduce at 3 years, identification of 2-year olds is also important (Smith, 1976:35). Yet, 2-year olds have been lumped with yearlings, adults, or both during censuses because criteria by which to identify them were lacking (Chadwick, 1983:13–14). Relative body size, horn length, pelage characteristics, and horn : ear-length ratios have been used to separate adults (≥3 years old) from subadult age classes (Brandborg, 1955; Foster, 1978; Nichols, 1980). However, quantitative data for discriminating among adults and the three subadult age classes, kid, yearling, and 2-year olds, remain lacking. This paper presents statistical justification for separating six age and sex classes of goats, and applicable criteria for their identification during field surveys. Mountain goats can be aged and sexed using these criteria from November through May when goats are in winter pelage, little change in horn and body growth occurs, and goat populations are concentrated, rather sedentary, and often separated into discrete, easily observed herds (Brandborg, 1955; Kuck, 1977; Smith, 1977).

From 1974 to 1980, measurements of horn lengths, horn basal circumferences, rostral lengths, ear lengths, and beard lengths were collected from 139 mountain goats. All five measurements were not obtained from each animal. Sex and age of each animal were recorded, based on genitalia or sexual dimorphism of horns and annuli of horns, respectively (Brandborg, 1955). Of the 139 goats, 119 were harvested by hunters in Montana between 15 September and 23 November, 1974–1979, and measured in the field or at Montana taxidermy shops. Measurements of 12 goats were from tranquilized animals, winter mortalities, and museum specimens from Montana. Five kid goats, sacrificed on 28 November 1978 in the National Bison Range (progeny of goats transplanted from Montana), also were measured. The remaiming three kids were pen-reared animals (progeny of goats transplanted to Colorado's Mount Shavano from Montana) measured on 25 April 1979 at Fort Collins, Colorado by T. Dailey. Thus, these data represent goats in developing or fully developd winter pelage and near completion of annual horn growth.

Horn length (outside curve) and basal circumference were measured on the right horn of each animal. The left horn was measured if the right one was broken. Rostral length was measured from the tip of the nose to the anterior corner of the eye. The standard measurement of ear length was used. The average length of the long guard hairs near the front of the beard was measured. Data sets of all five variables were tested for normality.

Student's *t*-tests were used to test sexual dimorphism of horn length and circumference, and rostral length within age classes. One-way analysis of variance and Duncan's multiple-range tests were used to examine differences in all measured characteristics for the four age classes (Sokal and Rohlf, 1969). The SPSS subprogram DISCRIMINANT was used to discriminate among the four age classes for the three variables (horn length and circumference, and rostral length) with sufficient sample sizes (Nie et al., 1975:434).

A second data set, obtained from 72 goats measured during autumn and winter (September–April) by Casebeer et al. (1950) and Brandborg (1955), consisted of horn lengths and circumferences, and ear lengths.

TABLE 1.—*Extended.*

2-year-old ♀			Adult ♂			Adult ♀		
n	$\bar{X}$ (Range)	95% CI	n	$\bar{X}$ (Range)	95% CI	n	$\bar{X}$ (Range)	95% CI
11	190 (168–210)	179–201	93	232 (200–295)	230–235	56	222 (178–295)	217–228
11	95 (80–105)	90–100	93	132 (114–149)	129–136	57	103 (86–127)	101–105
3	166 (162–171)	161–171	33	193 (171–225)	188–198	16	183 (171–216)	177–190
4	118 (114–122)	114–122	19	127 (114–140)	123–132	11	117 (114–127)	113–122
4	1.65 (1.58–1.73)	1.54–1.77	19	1.81 (1.60–2.11)	1.74–1.88	10	1.92 (1.70–2.11)	1.83–2.02
2	(95–102) (17 Oct.–25 Oct.)		20	(76–171) (15 Sep.–23 Nov.)		6	(76–114) (15 Sep.–25 Oct.)	

Measurements of these 72 goats from Montana and Idaho were used as a second population for discriminant analysis and also were combined with the author's 139 goats for Student's t- and one-way ANOVA tests.

Based on means of each variable measured and photographs of mountain goats of known age and sex, pen and ink drawings (Figs. 1–3) were made of the six age and sex classes of mountain goats: kid, yearling, 2-year-old male, 2-year-old female, adult male, and adult female.

Measurements of goats within age and sex classes were similar in the two data sets except for ear length of kids (Table 1). Tests of the five variables measured revealed a lack of sexual dimorphism in kids. Although horn basal circumference was significantly greater ($P < 0.001$) in yearling males than yearling females, the difference was small ($\bar{X} = 19$ mm) and horn curvature was not consistently sexually dimorphic. On 2-year olds, only horn circumference was significantly different ($P < 0.001$) between the 16 males ($\bar{X} = 117$ mm) and 11 females ($\bar{X} = 95$ mm). Among adults, horn length and circumference of 93 males ($\bar{X} = 232$ mm, $\bar{X} = 132$ mm, respectively) were significantly greater ($P < 0.005$ and $P < 0.001$, respectively) than for 57 females ($\bar{X} = 222$ mm, $\bar{X} = 103$ mm). Adult rostral length also was significantly greater ($P < 0.05$) in males ($\bar{X} = 193$ mm) than in females ($\bar{x} = 183$ mm). Because of the small percentage of difference in horn length (4.5%) and rostral length (5.5%) between adult males and females, I consider only horn circumference and horn curvature to be sexually dimorphic characteristics of 2-year-olds and adults during field surveys.

Horn length and basal circumference, and rostral length, were all significantly different ($P < 0.001$) among all four age classes of mountain goats. However, rostral length was consistently most age-specific with only 2-year olds and adult classes showing overlap (Table 1). Ear length was not significantly different ($P > 0.05$) between adjacent age classes. The ratio of horn : ear length was useful for separating kids ($\bar{X} = 0.71$) from yearlings ($\bar{X} = 1.31$). The largest horn : ear length for a kid was 0.94; the smallest for a yearling was 1.22. The differences in the ratio between yearlings and 2-year olds ($\bar{X} = 1.66$) and 2-year olds and adults ($X = 1.85$) were smaller, and there was considerable overlap between adjacent age classes (Table 1).

Differences in beard length of the four age classes could not be tested because of small sample sizes and because the beard pelage was still developing during the autumn hunting season when most beard measurements were collected. Beard length of 20 adult males harvested between 15 September and 23 November was positively correlated ($r = 0.93$, $P < 0.01$) with date of harvest. Field observations indicated that winter-pelage development probably was completed by early December. Although useful in distinguishing age classes during winter and spring, beard development (including fullness and shape as well as length) was not a reliable characteristic for aging goats before mid-November. Mean beard length of five kids ($\bar{X} = 84$ mm, $SD = 3$ mm) collected on 28 November was not significantly different ($t = 0.23$, $d.f. = 14$, $P > 0.05$) from that of 11 adult goats ($\bar{X} = 91$ mm, $SD = 12$ mm) killed by hunters during the first 2 weeks of Montana's hunting season (15–28 September).

Using the variables horn length and basal circumference, discriminant analyses accurately predicted the age class of 78% of the 139 mountain goats in my data set, 85% of the 72 goats in the combined Brandborg (1955) and Casebeer et al. (1950) data set, and 80% of the 211 goats in both data sets. The 2-year age group was most often aged incorrectly (54%, 35%, and 44% incorrect) using these variables. Applying the discriminant analysis to mountain goats for which horn length and basal circumference, and rostral length, were

TABLE 2.—*Predicted ages of known-aged mountain goats from discriminant analysis based on horn lengths and rostral lengths of 77 goats from Montana.*

Actual age class	Sample size	Predicted age class (%)			
		Kid	Yearling	2-year old	Adult
Kid	7	7 (100.0)	0	0	0
Yearling	10	1 (10.0)	7 (70.0)	2 (20.0)	0
2-year old	11	0	1 (9.1)	10 (90.9)	0
Adult	49	0	0	3 (6.1)	46 (93.9)

known ($n = 75$), 88% of the mountain goats were aged correctly. Yearlings and 2-year olds were most often misclassified (20% and 18%), exclusively with each other.

A final discriminant analysis included only the horn and rostral lengths ($n = 77$). Horn basal circumference was deleted because the sexually dimorphic variation was believed to be reducing the predictive capability of the discriminant function (horns in adult females averaged less than those of 2-year-old males; Table 1). The result was a 91% predictive accuracy of age (Table 2). Three yearlings and one 2-year old were misclassified, each because its horn length, not rostral length, was larger or smaller than expected for its age class. The same was true for two of the three misclassified adults. Age classification accuracies exceeding 91% are likely when observations of beard development and social behavior supplement estimations of horn and rostral lengths.

As previously reported by Hoefs et al. (1977) and Nichols (1980), basal circumference of horns in adult males is significantly greater in than in adult females; I also found a significant difference between 2-year-old males and females. Viewed frontally, Nichols (1980) noted that the space between horn bases is less in relation to the basal horn widths in males than in females (Figs. 2, 3). Horn curvature, as described by Hanson (1950) and Brandborg (1955), is consistently sexually dimorphic for goats 2 years of age.

Rostral and horn lengths discriminate among the four age classes. Horn length is a less age-specific character than rostral length, probably because of the variable annual growth achieved in accordance with severity of winter and spring weather (Smith, 1984). Field observations and limited empirical data indicate that beard development (length and shape) also is age specific. The horn : ear length ratios average less than one for kids (0.71) and greater than one for yearlings (1.31) and older animals as also reported by Foster (1978) and Nichols (1980).

Six age and sex classes of mountain goats are distinguishable from autumn through spring. Reliable identification of age and sex requires both frontal and lateral views of the head. Except at close range, spotting scopes or binoculars are necessary to distinguish subtle differences in horns, facial characteristics, and pelage. Under conditions of good visibility, age and sex of mountain goats during ground censuses can be determined at distances $\leq$800 m with a 15–45× or 15–60× spotting scope.

Data in this study are from the range of *O. a. missoulae*, the southeastern most of the four subspecies listed by Anthony (1928). Although Cowan and McCrory (1970) found clinal variation in skull and horn sizes of mountain goats (northern populations were largest and southern smallest), they found no taxonomic basis for subspecies in *O. americanus*. Therefore, criteria for field classification described herein may apply throughout the species' range. Formal field testing of this technique on goats of known age and sex should be conducted throughout the range of *Oreamnos*.

Using the following descriptions and Figs. 1–3, an observer can learn with practice to classify mountain goats. This is a self-teaching tool applicable to ongoing management surveys and research programs. For those states and provinces desiring to implement or refine age and sex harvest restrictions, this also may provide a basis for a hunter-information pamphlet.

Kids.—Because kids grow slowly and generally do not exceed 20 kg (Brandborg, 1955; Casebeer et al., 1950), body size distinguishes them from older animals. The face is foreshortened with rostral lengths of 120 mm or less ($\bar{X} = 117$). A diminutive beard, less than 90 mm in length ($\bar{X} = 84$), augments the rounded facial appearance. Horn sheaths become obvious at about 2.5 months of age and, in winter, appear as 45–90 mm conical spikes. Horn : ear length ratios average 0.71 in autumn, winter, and early spring. Horns may reach 115 mm at 12 months of age, approximating ear length. The pantaloons (long guard hairs of the upper forelegs) are poorly developed and appear as a gradual thickening of the forelegs above the radio-carpal articulation.

Yearlings.—Yearlings are 1.5 times as large as kids; however, separation from older animals is unreliable on the basis of size alone. Rostral lengths range from 130–155 mm ($\bar{X} = 141$), so yearlings retain a somewhat kid-like appearance. Horn growth is greatest during the second summer. Horn lengths of yearlings are 125–

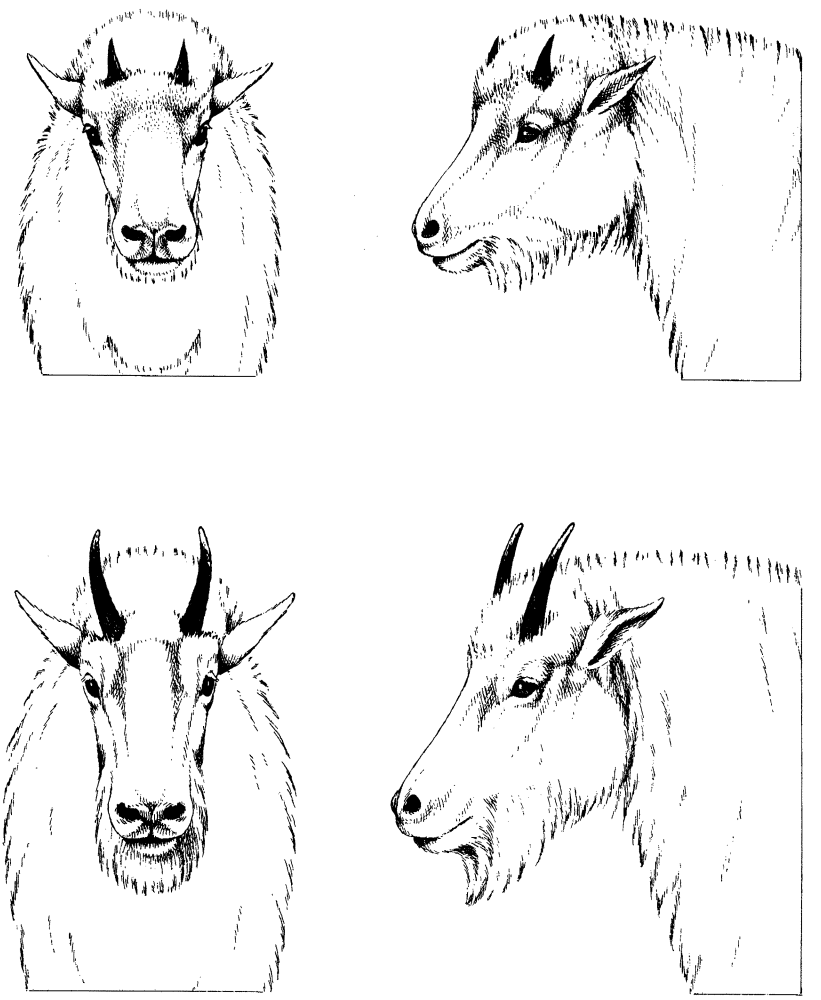

FIG. 1.—Frontal and lateral views of kid (above) and yearling mountain goats. Horns are shorter than the ears in kids but longer than the ears in yearlings; rostral lengths of kids average 117 mm compared to 141 mm for yearlings.

165 mm ($\bar{X}$ = 149) by mid-autumn, and seldom exceed 175 mm at 24 months of age. Horn : ear length ratios in this study averaged 1.3 compared to 1.4 in British Columbia (Foster, 1978) and 1.5 in Alaska (Nichols, 1980). Yearlings' beards grow more from the sides of the mandible, rather than primarily from the underside of the mandible as in kids, but are shorter (about 100 mm) and less full than in older animals.

Two-year olds.—Two-year-old males and females are the most difficult classes to identify in the field. Their horn, body, and pelage development are intermediate between yearlings and adults. Rostral length ranges from 159–171 mm and is the most reliable characteristic for separating 2-year olds from yearlings (130–156 mm) and adults (171–225 mm). Horns range from 165–219 mm ($\bar{X}$ = 197) in length and overlap those of yearlings little and those of adults considerably. Horn : ear length ratios for 2-year olds average 1.66 but because of variation in both dimensions, this criterion is not reliable for separating 2-year olds from adults. The shoulder hump, shaggy pantaloons, and dense beard, all characteristics of adult goats, are discernible in 2-year olds but are less fully developed. The shoulder hump, a result of long guard hairs growing along the dorsal ridge, is less pronounced than in adults. The beard has not yet reached maximum length and fullness. Although no fully developed beards of 2-year olds were measured, they probably average 115–135 mm in length. Beards of 2-year olds originate higher on the side of the face than in yearlings. Horn

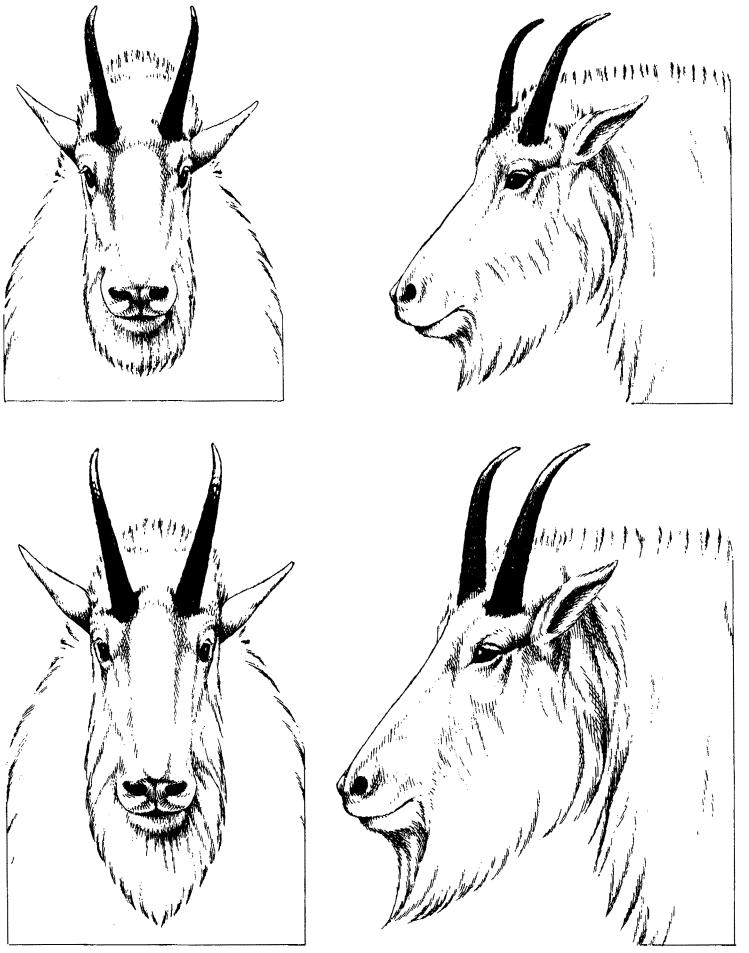

FIG. 2.—Frontal and lateral views of 2-year-old female (above) and adult female. Rostral lengths and horn lengths average 166 mm and 190 mm, respectively, for 2-year olds and 183 mm and 222 mm, respectively, for adults; the beard is more fully developed in adults.

curvature and basal circumference separate sexes of 2-year olds. Horn curvature of 2-year-old males is typically distributed along the horns' entire length. Horns of 2-year-old females are comparatively straight, but often display a distinctive backward "crook" 50–75 mm from the horn tip. Basal horn circumference of 2-year-old males averages 22 mm greater than for females of the same age (7 mm difference in frontal diameter).

Adults.—Adults do not attain maximum size until 4 or 5 years of age (Brandborg, 1955; Cowan and McCrory, 1970) but 3-year olds are not distinguishable in the field from older individuals. Rostral length is the most discrete and reliable criterion for separating adults from 2-year olds. In adults, rostral length ranges from 171–222 mm ($\bar{X}$ = 190). Horn lengths of adults generally are 205–260 mm ($\bar{X}$ = 228) long and overlap considerably with those of 2-year olds, that may reach 219 mm in length. Beards of adults grow thicker on the sides of the face than those of 2-year olds. Consequently, beards of adults appear broader when viewed frontally. Beard length reaches 155–180 mm in adults. Likewise, flowing pantaloons of guard hair, exceeding 170 mm in length (Brandborg, 1955), and a prominent dorsal ridge, are distinctive characteristics of the winter pelage. A rostral length exceeding 170 mm accompanied by a horn length exceeding 200 mm (both criteria are best judged in profile) signifies an adult rather than a 2-year old. If the horns appear as long as those of an adult, but the rostral length is borderline, length and fullness of the beard, and the overall size and pelage characteristics of the animal, may be considered to decide its age class. As described for 2-year olds, horn curvature is sexually dimorphic in adults. Basal horn diameters (best judged frontally) of adult

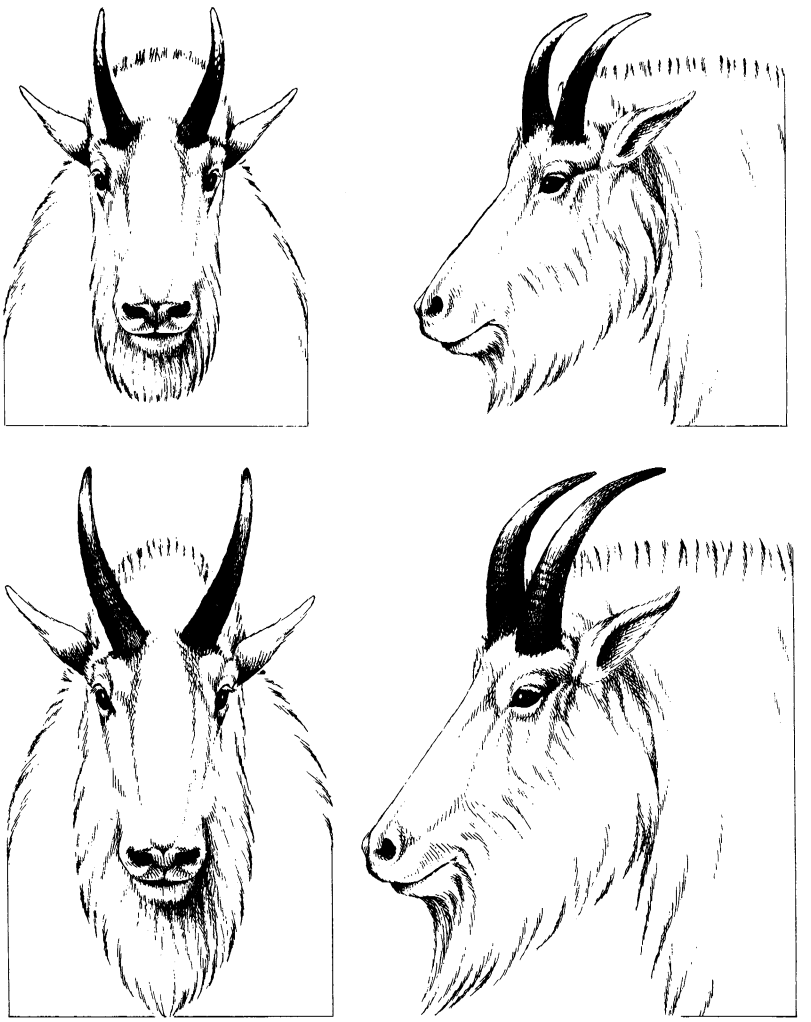

FIG. 3.—Frontal and lateral views of 2-year-old male (above) and adult male. Rostral lengths and horn lengths average 162 mm and 201 mm, respectively, for 2-year olds and 193 mm and 232 mm, respectively, for adults; the beard is more fully developed in adults.

males average 42 mm, or 10 mm greater than for adult females (32 mm in frontal diameter). Viewed frontally, the space between the horn bases is less in relation to basal horn widths in males than in females. The bridge of the rostrum in adult males generally is broader in appearance than in adult females. Occasionally, adult males appear "Roman-nosed" in profile.

Reliability of age and sex decisions depends upon the conditions of observation, experience of the observer, and time to evaluate several criteria. The important distinguishing characteristics of the four age classes are statistically distinct. Nevertheless, any one characteristic may not be diagnostic because of poor visibility, the observed animal's position or background, or the adjacency of a characteristic's size to its possible minimum or maximum size. As the number of discriminating characteristics evaluated increases, so will the reliability of age classifications. Likewise, the reliability of sex determinations increases as both horn curvature and basal circumference, bolstered by observations of sexually dimorphic behavior (Chadwick, 1983; Geist, 1964), are evaluated.

Several authors reported the superiority of ground censuses for obtaining total counts and classifications (Ballard, 1977; Johnson, 1983:65–69; Nichols, 1980; Smith, 1976). Ground censuses of goat populations often are not made because of funding and manpower limitations (Ballard, 1977). However, periodic ground

censuses of representative herds ultimately may prove cost effective if incorporation of detailed herd-composition data produces management programs that maintain optimum goat populations.

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