MORPHOLOGY OF THE BELL IN RELATION TO SEX AND AGE OF MOOSE (Alces alces)

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ABSTRACT: The bell is a conspicuous and unique structure hanging beneath the lower jaw of both male and female moose Alces alces L. Sexual dimorphism is seen in the shape and size of the bell. Males demonstrate the greatest development and variation with the longest bells found generally on bulls 2-4 years old. The dewlap portion of the male bell broadens and the tail portion shortens with increased age. These morphological changes result partially from the loss of all or a portion of the bell tail, probably by freezing. Females generally possess a shorter, less conspicuous bell than males. Bells on females older than 3.5 years change little in appearance with increasing age and are similiar morphologically to bells on yearling males. We suggest bell size and shape may be useful as an indicator of sex and relative age especially during the antlerless period.

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The bell on moose is a hair-covered fold of skin arising ventrally from the inter-mandibular area and hanging free from the throat region in both sexes (Gunderson and Beer 1953; Burt 1957; Cahalane 1961). It can be seen on all four races of moose in North America (*A. a. americana, A. a. andersoni, A. a. shirasi* and *A. a. gigas*) (see Seton 1929; Peterson 1955; Van Wormer 1972; Franzmann 1978).

The bell is also present on *A. a. alces* and *A. a. pfizenmayeri* in Europe and central and eastern Siberia respectively. However it is either absent or very poorly developed in *A. a. cameloides* in eastern Asia (Bubenik, unpublished). It is referred to as skegg or "beard" in Norwegian (J. Lykke, 7660 Vuku, Norway, personal communication to A. B. Bubenik, Ontario Ministry of Natural Resources, Southern Research Station, Maple, Ontario 1978), Bartzapfen or "cone-like-beard" in German (Zschetzsche 1959), and "pear with long, hair-like beard" in Chinese (pers. comm.; Peking Zoo, 1978). The distinctive appearance of the bell was even depicted in rock paintings of moose by neolithic hunters in the Lake Baikal area as long ago as three to four thousand years (Vereshchagin 1967) and by North American Indians in rock paintings in the Great Lakes Region (Dewdney and Kidd 1967).

Although much speculation has focused on the possible function of the bell (Fitzinger 1874; Herrick 1892; Seton 1929; Zschetzche 1959; Vereshchagin 1967; Timmermann 1979; Bubenik 1973, 1983), little has been published concerning its morphology and growth. The objective of the present study is to determine whether morphometric differences exist between bells of male and female moose of different ages.

MATERIALS AND METHODS

The heads of 427 (235 ♂♂, 192 ♀♀) moose killed by hunters and vehicles in the North Central Region of Ontario (between 48°00' - 52°00' N and 92°00' - 85°00' W) from 1975-78 were examined. The sample included animals of all ages (some whole fetuses) killed

throughout the year but detailed measurements of the bell were taken from only 338 (177 ♂♂, 161 ♀♀) specimens shot during the hunting season (October 4 - December 15) of 1976 and 1977. A reference number, sex, date killed and estimated wear-class age (Passmore *et al.* 1955) were recorded for each animal. A more precise age for most animals >0.5 yr was later determined by counting layers of cementum on central incisors (Sergeant and Pimlott 1959).

Heads, usually severed from the body between the atlas and axis, were placed left side down on a flat sheet of heavy white paper 1 m^2. The hair covering the bell was spread in a normal hanging position. A profile of the bell with hair (WH) was then drawn with a pencil or light felt marker. Four reference points including the angle of the lower jaw, tip of the lower lip, the location of the skin at the distal end of the bell, and tip of the longest hairs hanging from the distal end were included on the drawing (Fig. 1). The hair on the bell was removed by cutting to within 0.5 cm of the skin using heavy-duty electric clippers. The head was replaced on the original drawing and the profile of the clipped bell without hair (WOH) was traced. The bell was then cut from the head along the edge of the lower mandibles and examined for external scars, folds in the skin, growths or denuded patches and placed in 10% formalin.

A standard method of numerically computing and comparing bell morphology was established (Fig. 1). Measurements included jaw length (AB), bell length with hair (gD), bell length without hair (gC), bell tail length (oC), hair length (CD), dewlap length (go), area of bell profile with hair (AijDeA), area of bell profile without

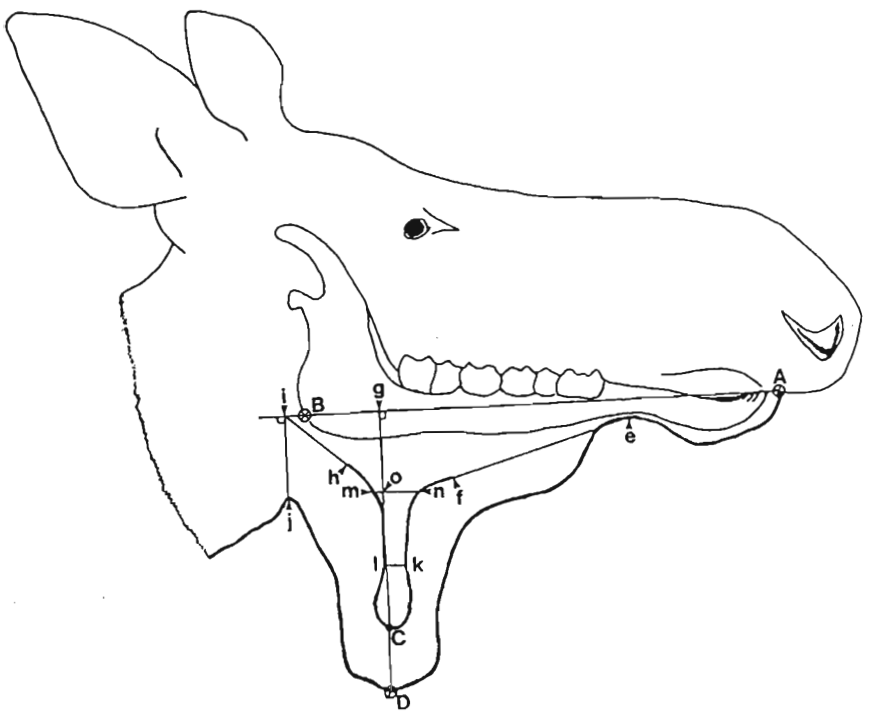


Figure 1. Bell of moose drawn in normal hanging position with hair (WH) and without hair (WOH) profile. The four points ⊗ (A, B, C, D) were used as reference marks. Eight additional arbitrary reference points (▲) facilitated morphometric analysis. These included; jaw length - AB; bell length (WH) - gD; bell length (WOH) - gC; dewlap length (WOH) - go; Tail length (WOH) - oC; hair length - CD; in centimeters and bell area (WH) - AijDeA; bell area (WOH) - AihmlCknfeA; tail area (WOH) - mlCkn; and dewlap area (WOH) - AihmonfeA in square centimeters.

hair (AihmlCknfeA), area of bell tail without hair (mlCkn) and area of dewlap without hair (AihmonfeA). The junction between dewlap and tail portions of the bell was arbitrarily defined as that point along its length (mn) where the bell was twice its minimum width (lk). Areas were measured from the drawings using an electronic planimeter (Electronic graphics calculator - Numonics Corp. Landsdale Pa. model 276-137). Sample sizes used in subsequent analyses varied to a small extent since all standard measurements could not be taken from every bell.

The rate of hair growth was investigated during the period 27 September - 30 December, 1978 using a captive male moose 1.5 years old. Hair at the tip of the bell was clipped to within 2 mm of the epidermis on 27 September. Samples of the growing clipped hair were extracted with hair bulbs attached at approximately 2 week intervals to 30 December. Control samples of unclipped growing hair in the adjacent tail area were also removed and their lengths compared to clipped samples.

A Duncan's multiple range test (Duncan 1955) was employed for each sex to separate and rank year classes for each of ten characters measured. A two-tailed F test (Nie *et al.* 1975) was used to assess similiarity of data of bells collected during different years.

The density of hair along the length of the tail portion of both long and short bells was investigated. Ten bells used for the study were all from 3.5-year-old males and had been stored in formalin. Hair was clipped from 2 skin samples (0.25 cm^2) cut from each of the proximal, mid and distal regions of the tail of the bell. Both the primary and secondary hairs clipped from skin samples were counted

in a gridded Syracuse glass using a dissecting microscope.

Scars visible grossly at the distal tip of bells were examined histologically. The tissue was fixed in buffered formalin, dehydrated in an ethanol series, embedded in paraffin and cut at a thickness of 5-14 µm. Lillie's a-b stain (Lillie 1954) was used routinely.

RESULTS

The bell of a developing fetus was visible as a small bud on the ventral surface of the neck as early as late November. By mid-term (February-March), the bell was still without hair and was 2-4 mm long. The bell of mid-term male fetuses was always longer than that of females ($P<0.05$). There was often considerable difference in the length of bells on twins of the same sex.

At birth, bells were fully haired and mean lengths were 35.5 ± 9.6 mm (WH), 25.6 ± 9.0 mm (WOH) and 13.3 ± 5.8 mm tail (WOH) on 8 males and 25.9 ± 5.8 mm (WH), 18.7 ± 5.1 (WOH) and 9.8 ± 3.3 mm tail (WOH) on 9 females. The jaw lengths of full term male and female fetuses were similar (21.0 ± 2.4 cm, $P>0.05$).

The bell of moose $\geq$ 0.5 yr is typically comprised of a loose hanging non-turgid sac-like dewlap and a narrower pendant tail (Fig.1). The spatula-shaped tail is most easily observed from late May to the end of July after the winter hair has been shed. By early fall the entire bell is covered with a dense insulating coat of winter hair and the tail becomes less conspicuous. The tail on bells clipped of hair narrows mid-way along its length and is frequently bulb-like in appearance at the distal end. The narrow isthmus on all tails

measured in side view had a mean width of 22.2 ± 4.7 mm and was 10 ± 2 mm thick. The distal bulb widened to 30.8 ± 4.7 mm.

In order to maximize the number of animals in each age class (≥ 0.5 yr) for analysis, data collected in both 1976 and 1977 were combined. A meaningful comparison of bell measurements between the two years could only be done with animals in the age classes 0.5 - 4.5 for which there were sufficient moose examined each year. Bell measurements (Areas of bell WH, WOH, tail and dewlap and bell tail length) were similiar between animals of the same age and sex collected in the two years ($P>0.05$). The number of animals in older age categories was further increased by grouping 5.5- and 6.5-year-olds, 7.5- and 8.5-year-olds and all animals 9.5 years and older.

Jaw length is used here as an index of the relative size of each animal. It also influences bell measurements directly since the line AB, representing the jaw length on the head tracings, formed a portion of the profile used to calculate the area of the bell (Fig.1). Jaw lengths of males and females at the same age were similiar ($P>0.01$) as were the lengths of jaws of animals older than 0.5 yr ($P>0.05$) (data available in Timmermann 1979).

It was suspected that moose hair grows rapidly during the fall and early winter and could substantially influence bell measurements. The rate of hair growth at the end of the bell was examined on a 1.5-year-old captive male. The mean increase in length of clipped and unclipped hair during the 94 day period beginning 27 September was 4.3 cm. However, the hair grew 2.8 cm. from 4 October to 6 November, the period in which 77 percent of the bells were collected

in 1976 and 1977.

To determine if hair growth during the collection period influenced bell measurements taken from head tracings, the length of hair and area of bell with hair from animals taken early in the hunting season (4 October - 6 November) were compared with those taken later (7 November - 15 December). Subsamples from 1976 and 1977 for this comparison were of sufficient size (≥4) in only 4 age groups (0.5, 1.5, 2.5, 3.5). The length of the hair as measured from the tracings did differ ($P<0.05$) between early and late male calves in both 1976 and 1977, male yearlings in 1976 and female yearlings in both 1976 and 1977. The bell hair on some animals killed late in the season was 5 to 50 percent longer than hair on animals killed early. There was no difference in the hair length between early and late female calves or male yearlings taken in 1977. The mean length of the hair on the tip of the bell was similar in males and females of all ages tested (Table 1). The area of the bell with hair was different ($P<0.05$) between early and late male calves of both 1976 and 1977 (up to 50% increase), but not in female calves.

Increase in size of moose and seasonal growth of hair during the collection period both influenced bell measurements. The effect was undoubtedly greatest in calves yet the mean bell measurements of calves still remained distinct from other age groups. An arbitrary decision was made therefore, to ignore these increases in bell measurements during subsequent analysis of data.

The bell of male moose without hair was longer ($P<0.05$) than female bells except on animals older than 6.5 yr (Table 2). The longest bell measured was 60.7 cm from a 3.5-year-old male. The

TABLE 1. Length of hair at the distal end of the moose bell.

	Male		Female	
Age (yrs)	N	Mean (cm)*	N	Mean (cm)*
0.5	23	6.1± 1.6 (3.5- 9.3)	20	6.5± 1.8 (2.5-10.7)
1.5	52	7.0± 1.9 (1.9-10.6)	48	7.4± 1.8 (3.0-11.8)
2.5	30	8.0± 1.9 (4.0-11.5)	19	6.6± 1.8 (3.8-10.6)
3.5	25	7.2± 1.8 (4.1-11.2)	10	8.0± 2.5 (3.1-12.0)
4.5	6	8.2± 1.3 (6.5-10.0)	11	7.1± 1.0 (5.6- 9.1)
(5.5-6.5)	17	7.7± 1.6 (5.0-10.2)	15	7.3± 2.5 (3.0-12.2)
(7.5-8.5)	4	7.6± 2.1 (5.3-10.3)	9	8.0± 1.1 (6.2- 9.6)
9.5+	8	7.3± 1.5 (5.1- 9.2)	19	7.8± 2.5 (3.0-12.0)

* Mean, ± S.D. (range).

ANOVA (1 way) - Between age classes.

♂♂ Hair length F = 2.76 Range Test

0.5 1.5 3.5 9.5+ (7.5-8.5) (5.5-6.5) 2.5 4.5

♀♀ Hair length F = 1.38 Range Test

0.5 2.5 4.5 (5.5-6.5) 1.5 9.5+ 3.5 (7.5-8.5)

Note: Mean values for age classes arranged in ascending order of magnitude. Age classes underscored by the same line are not significantly different (P>0.05).

TABLE 2. Length of entire moose bell measured without hair.

	Male		Female	
Age (yrs)	N	Mean (cm)*	N	Mean (cm)*
0.5	23	17.1± 3.8 (10.2-25.2)	20	14.7± 2.5 (10.0-20.1)
1.5	51	25.4± 6.2 (12.0-41.2)	47	17.3± 4.4 (8.7-26.5)
2.5	29	27.8± 6.7 (10.5-41.9)	19	20.3± 4.3 (13.0-26.6)
3.5	26	32.0± 9.0 (17.7-60.7)	10	22.4± 4.6 (14.0-29.3)
4.5	6	31.5± 6.3 (22.6-40.8)	12	21.5± 2.9 (15.7-25.4)
(5.5-6.5)	18	27.6± 7.5 (16.3-42.0)	15	21.2± 3.3 (16.3-27.0)
(7.5-8.5)	3	26.9± 9.1 (19.0-37.0)	8	19.2± 4.0 (14.4-26.5)
9.5+	8	25.4± 5.8 (15.5-34.3)	18	22.4± 5.8 (13.2-32.0)

* Mean, ± S.D. (range).

ANOVA (1 way) - Between age classes.

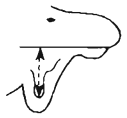
♂♂ Bell length F = 9.70 Range Test

0.5 9.5+ 1.5 (7.5-8.5) (5.5-6.5) 2.5 4.5 3.5

♀♀ Bell length F = 8.28 Range Test

0.5 1.5 (7.5-8.5) 2.5 (5.5-6.5) 4.5 9.5+ 3.5

Note: Mean values for age classes arranged in ascending order of magnitude. Age classes not underscored by the same line are significantly different (P<0.05).



longest bell on a female was 32.0 cm from a 12.5-year-old animal. The bell was progressively longer on males up to 4.5 yr but was shorter in older males. The length of the male bells measured with hair was similarly different from those of females (Timmermann 1979). The tail portion of the bell without hair became progressively longer on males and females up to 3.5 yr but was shorter in older males and changed little in length on older females (Table 3). The dewlap portion of the bell changed little in depth on females $\geq$ 3.5 yr (Table 4) but increased significantly in males $\geq$7.5 yr.

The profile area of the male bell measured both with hair and without hair was greater than the area of female bells in all age groups (Tables 5 and Timmermann 1979, respectively). The area of male bells increased with age, being greatest in older animals. The area of the dewlap portion of male bells also increased with age (Timmermann 1979) but the area of the tail decreased in males older than 3.5 yr (Table 6). The area of the bell increased on females up to 3.5 yr. and showed little further change in older animals (Table 5).

A summary of significant morphometric differences between the bells of male and female moose of all ages is shown in Table 7.

A single scar was found on the distal tip of some bells (Fig.2). Scars lacked hair and were slightly raised as a ridge of hardened tissue, 5-35 mm long ($\bar{X}$ = 13.7 ± 6.8) and 2-10 mm wide ($\bar{X}$ = 4.3 ± 3.0). They were not seen in moose less than 2.5-year-old and were more common on males (14.5%) than on females (2.6%). The frequency of scars was highest in old males (52% of animals > 4.5 yr). Bells with a terminal scar had a significantly shorter tail ($P<0.05$) than

TABLE 3. Length of the tail portion of the moose bell measured without hair

	Male		Female	
Age (yrs)	N	Mean (cm)*	N	Mean (cm)*
0.5	24	9.3± 2.2 (5.5-12.9)	20	8.1± 1.9 (5.3-13.4)
1.5	58	13.7± 4.2 (6.3-26.0)	50	9.3± 2.5 (4.5-14.3)
2.5	30	16.1± 4.5 (5.9-25.5)	19	11.3± 3.1 (5.8-17.5)
3.5	25	17.5± 5.9 (6.2-36.5)	11	11.3± 2.6 (6.9-16.1)
4.5	7	13.7± 5.9 (3.2-20.2)	13	11.5± 1.9 (8.4-14.4)
(5.5-6.5)	19	15.5± 4.9 (5.6-22.2)	15	11.9± 2.1 (8.5-15.5)
(7.5-8.5)	3	12.3± 3.0 (9.0-15.0)	9	11.3± 2.6 (7.2-16.2)
9.5+	4	11.4± 2.7 (9.1-14.8)	19	11.4± 2.9 (7.0-18.2)

* Mean, ± S.D. (range).

ANOVA (1 way) - Between age classes.

♂♂ Tail length F = 7.67 Range Test

0.5 9.5 (7.5-8.5) 4.5 1.5 (5.5-6.5) 2.5 3.5

♀♀ Tail length F = 6.05 Range Test

0.5 1.5 (7.5-8.5) 3.5 2.5 9.5+ 4.5 (5.5-6.5)

Note: Mean values for age classes arranged in ascending order of magnitude. Age classes not underscored by the same line are significantly different ($P<0.05$).

TABLE 4. Length of the dewlap portion of the moose bell measured without hair.

	Male		Female	
Age (yrs)	N	Mean (cm)*	N	Mean (cm)*
0.5	23	7.7± 2.6 (3.6-12.5)	20	6.5± 2.1 (3.1-10.2)
1.5	51	11.6± 4.0 (3.5-18.8)	47	8.0± 3.2 (1.4-17.2)
2.5	29	12.2± 4.6 (3.8-22.8)	19	9.0± 2.7 (5.3-13.7)
3.5	26	15.2± 4.7 (6.1-24.5)	10	11.0± 2.4 (7.1-14.0)
4.5	5	16.1± 4.4 (12.7-24.1)	12	9.7± 2.2 (5.9-12.0)
(5.5-6.5)	18	13.2± 5.4 (5.5-24.0)	15	9.3± 2.3 (5.5-14.7)
(7.5-8.5)	3	22.6± 3.2 (19.0-24.7)	8	8.1± 2.3 (5.2-10.5)
9.5	8	19.7± 5.9 (10.4-30.0)	18	11.8± 4.8 (4.0-23.5)

* Mean, ± S.D. (range).

ANOVA (1 way) - Between age classes.

♂♂ Dewlap length F = 11.9 Range Test

0.5 1.5 2.5 (5.5-6.5) 3.5 4.5 9.5+ (7.5-8.5)

♀♀ Dewlap length F = 5.6 Range Test

0.5 1.5 (7.5-8.5) 2.5 (5.5-6.5) 4.5 3.5 9.5+

Note: Mean values for age classes arranged in ascending order of magnitude. Age classes not underscored by the same line are significantly different (P<0.05).

TABLE 5. Profile area of the entire moose bell with hair.

	Male		Female	
Age (yrs)	N	Mean (cm)*	N	Mean (cm)*
0.5	24	439±126 (215-716)	20	401±100 (258-611)
1.5	51	662±146 (331-971)	47	541±124 (306-795)
2.5	29	699±193 (324-983)	20	589±152 (367-903)
3.5	25	803±191 (473-1146)	10	700±187 (403-1006)
4.5	7	830±143 (661-1041)	11	626±148 (442-843)
(5.5-6.5)	18	783±171 (543-1085)	15	617±162 (342-935)
(7.5-8.5)	3	1039±185 (904-1249)	8	648±146 (460-897)
9.5+	8	834±134 (661-981)	18	652±177 (226-939)

* Mean, ± S.D. (range).

ANOVA (1 way) - Between age classes.

♂♂ Profile area F = 14.74 Range Test

0.5 1.5 2.5 (5.5-6.5) 3.5 4.5 9.5+ (7.5-8.5)

♀♀ Profile area F = 7.08 Range Test

0.5 1.5 2.5 (5.5-6.5) 4.5 (7.5-8.5) 9.5+ 3.5

Note: Mean values for age classes arranged in ascending order of magnitude. Age classes not underscored by the same line are significantly different (P<0.05).

TABLE 6. Profile area of the tail portion of the moose bell measured without hair.

	Male		Female	
Age (yrs)	N	Mean (cm)*	N	Mean (cm)*
0.5	24	21.6± 5.2 (10.7-31.4)	19	18.4± 5.1 (7.9-31.4)
1.5	58	36.3±12.5 (11.2-72.4)	50	22.0± 6.7 (7.5-39.8)
2.5	30	43.9±13.9 (15.5-67.5)	19	26.4± 6.7 (10.6-37.6)
3.5	25	43.9±13.9 (18.7-82.2)	11	28.5± 5.6 (19.3-36.9)
4.5	7	39.5±17.3 (15.0-68.9)	13	26.5± 4.9 (18.7-35.1)
(5.5-6.5)	19	38.8±11.5 (14.9-57.0)	15	26.6± 6.5 (18.9-40.4)
(7.5-8.5)	3	24.6±11.9 (15.0-38.0)	9	28.8± 6.8 (19.7-40.7)
9.5+	4	31.1±12.9 (14.8-44.4)	19	27.1± 8.1 (14.2-42.5)

* Mean, ± S.D. (range).

ANOVA (1 way) - Between age classes.

♂♂ Profile area F = 8.56 Range Test

0.5 (7.5-8.5) 9.5+ 1.5 (5.5-6.5) 4.5 3.5 2.5

♀♀ Profile area F = 5.65 Range Test

0.5 1.5 2.5 4.5 (5.5-6.5) 9.5+ 3.5 (7.5-8.5)

Note: Mean values for age classes arranged in ascending order of magnitude. Age classes not underscored by the same line are significantly different (P<0.05).

TABLE 7. Summary of morphometric differences in the bell of male and female moose.

Character measured (cm,cm²)	Age (yrs) 0.5	1.5	2.5	3.5	4.5	(5.5-6.5)	(7.5-8.5)	9.5+
Jaw length	-	-	-	-	-	-	-	-
Bell length (WH)	-	X[1,2]	X	X	X	X	-	-
Bell length (WOH)	X	X	X	X	X	X	-	-
Bell tail length	-	X	X	X	-	X	-	-
Bell dewlap length	-	X	X	X	X	X	X	X
Bell hair length	-	-	X	-	-	-	-	-
Bell area (WH)	-	X	X	-	X	X	X	X
Bell area (WOH)	-	X	-	X	-	X	X	X
Bell tail area	X	X	X	X	X	X	-	-
Bell dewlap area	-	X	-	-	-	X	X	X

1. X indicates significant differences (P<0.05 - 't' test) between means (♂ > ♀)

2. Sample sizes (N) tested are listed in tables 1 to 6.

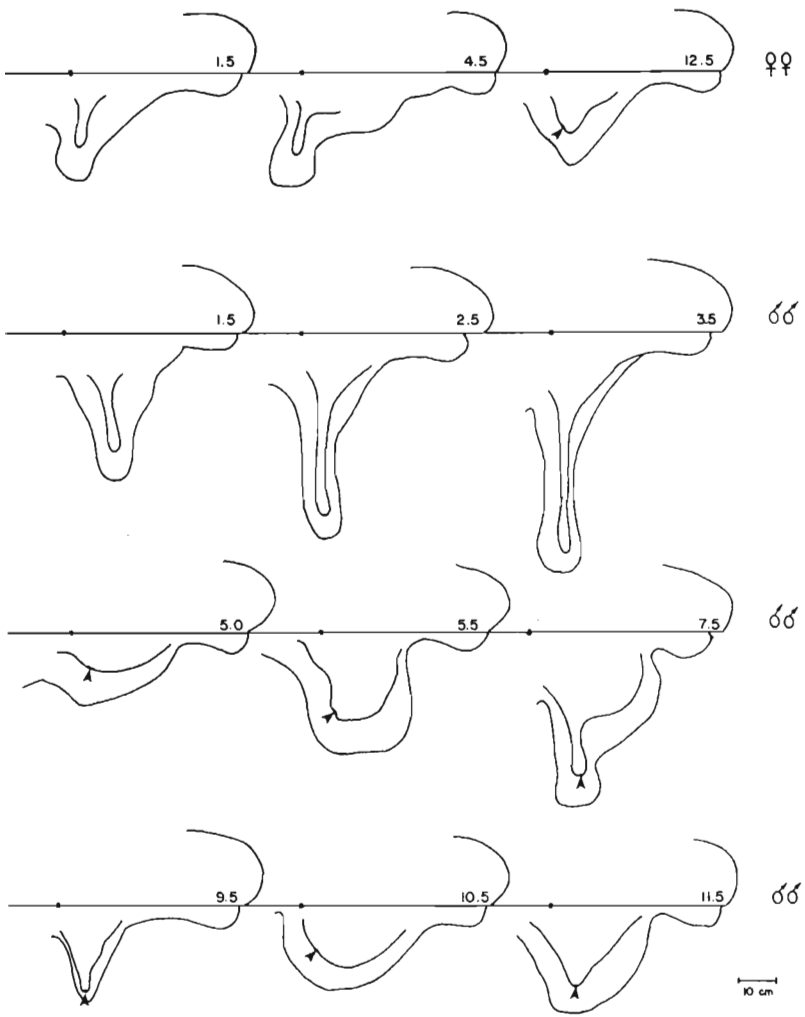


Figure 2. Selected profiles of the bell of mail (♂♂) and female (♀♀) moose drawn with and without hair (▲ indicates location of scar).

those without a scar with the exception of one fairly long scarred, 2.5-year-old female (Table 8). Some bells with a scar had completely lost the tail portion and appeared sac-shaped. Such bells were almost exclusively a male phenomenon (Table 9). Only one female (12.5 yr) in a total of 161 fall specimens examined, had a bell completely lacking a tail. Conversely 8 of 177 males (4.5%) aged 2.5 to 10.5 yr had a sac-shaped bell. Eight additional sac-shaped bells from males 2.5 to 15.5 yr were examined incidental to the main study. Each had a terminal scar and no tail.

Histologically, scars consisted of glassy, elongated collagen fibres orientated at right angles to fibres in the adjacent undamaged dermis. The keratinized layer over the scar was thickened. Dermal ridges were more numerous and there appeared to be a greater concentration of melanin granules in the stratum germinativum than in undamaged skin. Hair follicles were absent and the superficial dermis was often infiltrated with eosinophils.

Bare patches or small, sparsely-haired areas were commonly seen in the mid-region of the tail of long bells. The density of winter hair on the bell tail of ten, 3.5-year-old males was examined. None of the bells had a scar on the distal tip. Hair densities were similiar in the mid-region of the 5 shortest (810±198cm^2) and 5 longest bells (808±161). Densities in the mid-region of the combined sample (809±176) were lower ($P<0.05$) than in either distal (1148±186) or proximal locations (970±210). The density of hair in the mid-region of the tail decreased slightly, but not significantly, with increasing tail length ($r = -.245$). No changes in density were found in either the distal or proximal regions with increasing tail length. The

TABLE 8. The incidence of scars on the distal end of moose bells.

Age (yrs)	Males N	Males No. with scars (%)	Males Length of bell tail (cm)* with scar	Males Length of bell tail (cm)* without scar	Females N	Females scars (%)	Females Length of bell tail (cm)* with scar	Females Length of bell tail (cm)* without scar
0.5	24	0 (0)	-	9.3 (15.5-12.9)	20	0 (0)	- -	8.1 (5.3-13.4)
1.5	58	0 (0)	-	13.7 (6.3-26.0)	50	0 (0)	- -	9.3 (4.5-14.3)
2.5	30	4 (13)	10.5 (0-18.5)	17.1 (5.9-25.5)	20	1 (5)	17.3 17.3	10.9 (5.8-17.5)
3.5	25	3 (12)	9.3 (0-21.2)	18.6 (6.2-35.5)	11	2 (18)	9.5 (8.4-10.5)	11.7 (6.9-16.1)
4.5	7	2 (29)	9.5 (3.2-15.7)	15.3 (8.1-20.2)	13	0 (0)	- -	11.5 (8.4-14.4)
(5.5-6.5)	20	8 (40)	13.3 (0-20.3)	15.6 (5.6-22.2)	15	0 (0)	- -	11.9 (8.5-15.5)
(7.5-8.5)	5	3 (60)	4.3 (0-12.8)	12.3 (9.0-15.0)	9	0 (0)	- -	11.3 (7.2-16.2)
9.5+	8	6 (75)	3.1 (0- 9.5)	13.7 (12.5-14.8)	23	1 (4)	0.0 -	11.4 (7.0-18.2)
Total	177	26 (14.5)			161	4 (2.5)		

* Mean length of bell tail and (range)

TABLE 9. The frequency and morphology of sac-type bells in moose examined.

Age (yrs)	Sex	Frequency of sack type bells in 1976 & 1977*	Bell length (cm) WH**	Bell length (cm) WOH***	Bell area (cm²) WH	Bell area (cm²) WO	Scar size (mm)
2.5	♂	1/30	29.0	21.9	794	505	9 x 2
2.5	♂	*	24.0	16.0	526	328	12 x 5
3.5	♂	1/25	27.4	18.5	623	385	13 x 4
3.5	♂	*	27.3	16.5	772	432	14 x 5
3.5	♂	*	29.9	20.4	868	460	15 x 4
3.5	♂	*	31.0	22.5	830	476	10 x 4
5.0	♂	*	20.2	10.6	660	366	15 x 5
5.5	♂	1/9	34.0	24.0	1085	538	11 x 14
7.5	♂	1/2	27.0	19.0	904	545	12 x 7
7.5	♂	*	30.8	22.0	1064	562	25 x 5
8.5	♂	1/2	30.0	24.7	963	587	12 x 2
10.5	♂	1/2	24.5	15.5	719	402	24 x 4
10.5	♂	*	24.4	17.5	801	535	12 x 4
10.5	♂	*	36.0	27.2	1083	654	21 x 4
11.5	♂	1/1	31.0	23.5	975	532	18 x 4
12.5	♀	1/1	26.5	18.0	678	389	8 x 3
12.5	♂	1/2	38.0	30.0	981	692	21 x 3
15.5	♂	*	26.0	17.5	743	459	15 x 4

* Incidental bells examined.

** WH = With hair.

*** WOH = Without hair.

ratio of guard (primary) hair to underfur (secondary) was similiar in short and long bells in all three sample locations.

DISCUSSION

In northwestern Ontario, the bell on male moose is usually longer and has a greater profile area than that on females (Fig.3). The longest bells were found on males 2.5-3.5 yr old. In older males, a sac-shaped bell without a tail was common. A scar was present at the distal end of all sac-shaped bells suggesting a tail had once been present but was lost.

Similiar observations have been made on moose elsewhere. On Sibley Peninsula, east of Thunder Bay, Ontario, moose were photographed while frequenting salt licks during spring and summer (D. Frazer, Ont. Min. Nat. Res., Maple, Ont., pers. comm. 1979). Sac-shaped bells or bells with a very short tail (<3 cm) were seen on 13 of 21 male moose estimated to be 3 yr or older. Younger males (N=24) and all females (N=44) had a bell with a conspicuous tail portion. In Newfoundland, the bells of moose killed by vehicles were measured (E. Mercer, Newfoundland Department of Tourism, St. John's, Newfoundland, pers. comm. 1978). The bell on males (N=92) was consistently longer than that on females (N=35) and the longest bells occurred on males 3-5 yr old. A small sample of bells from *A. a. gigas* collected near Soldotna, Alaska were sent to the author by A. Franzmann, Alaska Department of Fish and Game, Soldotna, Alaska. The bells of 7 females (0.5-14 yr) and 2 males (2 yr) were similiar in shape and size to those on moose in northwestern Ontario and all

Figure 3. Typical profiles of female and male moose (top to bottom-calves, 0.5 yr; yearling ~2.5 yr; prime, 5.5-10 yr) showing bell development and degree of pigmentation (after Bubenik et al. 1977)

had a tail portion. However, sac-shaped bells are commonly seen on older bulls in Alaska and a tissue scar can be seen on the distal edge of such bells (A. Franzmann, pers. comm. 1979). Sokolov (1964) mentioned that the longest bell on *A. a. alces* in central Soviet Union occur on males 3-4 yr and the bell is shorter and broader on older males. Although most workers agree that old male moose generally have short broad bells, long bells are occasionally seen. The tail portion of a bell from a 11.5-year-old male killed near Geraldton, Ontario measured 29.0 cm (C. Greenwood, Ont. Min. Nat. Res. Geraldton, Ont., pers. comm. 1978).

The length and morphology of the bell may vary on moose in different parts of their range. C. H. D. Clarke (former chief Fish and Wildlife Branch, Ont. Min. Nat. Res. Toronto, Ont., pers. comm. 1977) mentioned that moose in the Rocky Mountain Parks of Western Canada generally had longer bells than he had seen on moose elsewhere in Canada. Some moose in the Interlake Region of central Manitoba have exceptionally long bells (some exceeding 76 cm) and were believed by Crichton (Manitoba Department of Mines, Resources and Environmental Management, Winnipeg, Manitoba, pers. comm. 1978) to be 15-20 cm longer than bells seen on moose in other parts of Manitoba. The longest bell reported in the literature (96 cm excluding hair) was from a female shot in eastern Manitoba in 1903 (Seton 1929). It is interesting to note that long, tail-like bells are rarely seen on moose (*A. a. alces*) in eastern Europe. Bells on moose in Norway were described by Lykke (7660 Vuku, Norway, pers. comm. to A. Bubenik, 1978) as pad-like and not usually conspicuous on females. Moose in Sweden are also reported to have short inconspicuous bells (Lonnberg

1923). Sokolov and Chernova (1985) report that bells are tassel-shaped in the mountain population of east Siberia and broad and wedge-shaped in the flatter plains.

Sac-shaped bells seen commonly on older males in the present study were without a pendulous tail. There is some evidence that the tail portion may be lost as a result of freezing. During January and February of 1953, the Ontario Department of Lands and Forests collected a number of moose on Big Island in Lake of the Woods, northwestern Ontario. The tip of the bell was described as "frozen stiff" on several moose examined immediately after being shot (R. Hepburn, Ont. Min. Nat. Res. Maple, Ont., pers. comm. 1979). In mid-winter, 1978, a Manitoba Provincial Park employee found what appeared to be the terminal tail portion of a moose bell which was about 15 cm long in an open area on a moose trail. There was no blood at the site or anything on which the bell might have been caught and been torn off (V. Crichton, pers. comm. 1978). Similiarly J. Davis reported a 30 cm piece of bell tissue at the moose research centre, Soldotna, Alaska. He believed the hair covered tail portion was shed about 1 November 1980, just after the first hard freeze (W. Gasaway, Alaska Dept. Fish and Game, pers. comm. 1981). A. Bubenik, (pers. comm. 1977) has spoken to trappers in Alberta who claim to have found pieces of frozen moose bells during winter. In the Soviet Union, Knorre (1959), Sokolov (1964) and Kozhukhov, (1965) reported that the bell of moose may freeze and fall off during the first or second year of life and leave either a shortened tail or a broad fold of skin, depending on the original length of the bell.

The likelihood of the bell tail being lost by freezing or other causes may be related to its length. In the present study, the tail portion of the bell was generally longer on males than on females and loss of all or part of the tail was much more prevalent in males than in females. Histological examination and latex injections gave the impression that the narrow isthmus of the bell tail was less vascularized than either the proximal or distal regions (Timmermann 1979). Hair was also less dense in the mid-region of the tail and sparsely-haired patches were commonly seen on the tail of exceptionally long bells. Suitable skin temperature may not be maintained as the bell tail increases in length making long tails more susceptible to freezing in cold weather. Alternatively moose winter tick (*Dermacentor albipictus*) was suggested by Timmermann and Lankester (1980) as a possible factor in the loss of bell extremities in Ontario moose.

In summary, we suggest knowledge of bell size and shape may be a useful secondary indicator of sex and relative age especially among bulls during the antlerless period. Although considerable individual variation exists, the following general guidelines may be useful:

1. calves (0.5 yr) have a small less conspicuous bell;
2. bells increase in size with age;
3. bulls have larger bells than cows of the same age;
4. cows tend to have a narrow tail-like bell subtended from a short or non descript dewlap portion at all ages;
5. long narrow tail-like bells are commonly found in younger bulls 2.5-3.5 yr;

6. prime bulls (5.5-10.5 yr) frequently display a large sac-shaped bell which may or may not be subtended by a narrow tail portion.

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