WEIGHTS AND MEASUREMENTS OF SELECTED BODY PARTS, ORGANS AND LONG BONES OF 11-MONTH-OLD MOOSE

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ABSTRACT: Summary data for selected body parts, internal organs/tissues, and long bones of twelve (6 female, 6 male), 11-month-old, captive moose (*Alces alces americana*) from Ontario are presented. These data characterize morphometry of moose which are approximately 6 months older than those killed legally as calves during autumn hunting seasons and which are 6 months younger than moose killed as yearlings. We describe how these data can be used to assess compliance to selective harvest regulations when investigating officers are presented with incomplete carcass evidence.

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Many resources management agencies employ selective harvest regulations as a means of attaining their wildlife population objectives. For example, in Ontario, only hunters possessing special permits can legally kill moose yearling age or older. To assess compliance, enforcement personnel require methods to distinguish between calves and older moose. If an entire carcass is available, it is a trivial matter to age the animal based on tooth wear/replacement characteristics, antlers, whole body mass, or general appearance. However, by the time officers are involved in a situation, there is usually little of the carcass left intact. Since considerable growth occurs between the ages of 6 and 18 months (Schwartz *et al.* 1987), summary statistics (mean, SD, etc.) for weights and measurements of various body parts can be used to distinguish between calf and yearling moose. However, descriptions of body parts of moose of known age remain limited despite published data on lengths of hind feet (Blood *et al.* 1967, Franzmann *et al.* 1978, Lynch *et al.* 1995), metatarsals (Peterson *et al.* 1982) and metacarpals (Bartosiewicz 1987).

In this paper we present data describing a variety of moose body parts which were collected from 11-month-old moose. These data are significant since they: 1) characterize moose which are as large as or larger than "legal" calves but too small to be misidentified as yearlings; and 2) relate to carcass attributes sometimes available to enforcement personnel after an animal has been moved from the kill site.

METHODS

Data were obtained from moose used to assess effects of winter tick (*Dermacentor albipictus*) on moose. Housing, handling and growth of these moose have been described in detail (Addison *et al.* 1983, Addison *et al.* 1994).

In April 1982, 12 moose were weighed alive and then killed with injection of T-61 (Hoechst Canada Inc., Montreal, Québec, Canada) into the jugular vein following immobilization with 300 mg of xylazine hydrochloride (Rompun, Haver-Lockhart Laboratories, Mississauga, Ontario, Canada). Selected body parts and internal organs/tissues were weighed and measured during necropsy (Tables 1 and 2). Long bones were cleaned (left to rot in water) and stored until measured (Table 3).

Table 1. Weights [kg] of selected body parts of 11-month-old, captive moose from Ontario.

Body Part	Female $\bar{x}$(SD)n [Max/Min]	Male $\bar{x}$(SD)n [Max/Min]	ALL $\bar{x}$(SD)n [Max/Min]
Live Mass[a]	205.8(21.57)6 [236.5/174.0]	228.9(30.53)6 [273.0/199.5]	217.4(29.30)12 [273.0/174.0]
Field Dressed Mass[b]	136.3(17.12)3 [152.2/118.2]	155.1(17.74)5 [183.3/138.4]	148.1(18.93) 8 [183.3/118.2]
Dressed Mass[c]	102.3(15.28)3 [117.0/ 86.5]	117.9(14.46)5 [140.0/103.5]	112.1(15.85) 8 [119.5/ 74.5]
Quartered Mass[d]	88.5(13.76)3 [102.0/ 74.5]	102.0(12.44)5 [119.5/ 89.0]	96.9(13.83) 8 [119.5/ 74.5]
Front Quarter[e]	24.4(3.75)3 [28.3/20.8]	28.2(3.73)5 [33.5/24.5]	26.8(3.98) 8 [33.5/20.8]
Hind Quarter[f]	19.8(3.15)3 [22.8/16.5]	22.8(6.76)5 [26.3/20.3]	21.7(3.01) 8 [26.3/16.5]
Neck[g]	6.9(1.02)6 [8.5/5.5]	8.9(2.86)6 [11.0/7.3]	7.9(1.76)12 [11.0/5.5]
Backbone[h]	8.0(0.95)6 [9.0/6.5]	7.6(1.43)6 [9.5/5.3]	7.8(1.38)12 [9.5/5.3]
Head[i]	9.5(1.00)6 [14.0/10.5]	10.1(1.07)6 [13.8/11.7]	9.8(1.03)12 [14.0/10.5]
Forefeet[j]	1.7(0.20)6 [2.0/1.5]	1.9(0.15)6 [2.2/1.8]	1.8(0.20)12 [2.2/1.5]
Hindfeet[k]	2.2(0.09)6 [2.3/2.1]	2.5(0.17)6 [2.7/2.3]	2.3(0.22)12 [2.7/2.1]
Hide[l]	17.8(1.13)6 [19.5/16.5]	19.0(2.19)6 [23.0/17.5]	18.4(1.79)12 [23.0/16.5]

[a]Live Mass - intact, live animal.

[b]Field Dressed Mass - carcass less viscera (abdominal and thoracic organs and fat), and blood.

[c]Dressed Mass - whole carcass with head (removed at occipital condyles/atlas junction), viscera, blood, feet and skin removed (front feet removed at junction of carpals and metacarpal, hind feet removed at junction of tibia and tuber calcis/tarsus).

[d]Quartered Mass - 4 skinned quarters combined, bone in.

[e]Front Quarter Mass - average of skinned left and right front quarters, bone in, front feet removed at junction of carpals and metacarpals; 7 vertebrae removed between front and hind quarters.

[f]Hind Quarter Mass - average of skinned left and right hind quarters, bone in, hind feet removed at junction of tibia and tuber calcis/tarsus.

[g]Neck Mass - skinned neck, between occipital condyles - atlas junction and last cervical vertebra.

[h]Backbone Mass - all lumbar vertebrae with associated muscles.

[i]Head Mass - skinned head.

[j]Forefeet Mass - mean of right and left feet removed at junction of carpals and metacarpals, skin and hooves attached.

[k]Hindfeet Mass - mean of right and left feet removed at junction of tibia and tuber calcis/tarsus, skin and hooves attached.

[l]Hide Mass - skin with tail but not including skin left on fore and hind feet.

RESULTS AND DISCUSSION

Two questions arise regarding use of our data to age wild moose. The first question is 'Why use data from 11-month-old moose?'. Undoubtedly, data from both wild calf and yearling moose harvested during normal autumn hunting seasons would be most useful. However, for most body parts, no such data have been published.

The utility of data from 11-month-old moose becomes apparent when one considers the following. Growth of wild moose calves decreases in the autumn and ceases during the winter months (Franzmann *et al.* 1978, Schwartz *et al.* 1987, Cederlund *et al.* 1991). Wild moose do not begin growing significantly again until 12-13 months of age. Growth in the second summer results in wild yearlings during autumn in most studies being 65-118% larger than calves in autumn (Blood *et al.* 1967, Schladweiler and Stevens 1973, Peterson 1974, Franzmann *et al.* 1978, Saether 1983, Schwartz *et al.* 1994, Adams and Pekins 1995, Lynch *et al.* 1995)(Table 4). Even in other studies with fewer than 11 moose used for comparisons, yearlings have been 47-57% larger than calves (Blood *et al.* 1967, Timmermann 1972). Thus 11-month-old moose would be much smaller than legally harvested yearlings yet as large or larger than legally harvested calves. If a hunter claims to have shot a calf but tissues or organs from the kill site are much larger than tissues from known age 11-month-old moose, we can conclude that the harvested moose was not a calf.

The second question that arises is 'Can we justify using size of young captive moose to estimate age of wild moose?'. Caution must be applied when doing this since many factors may influence growth differentially between captive and wild moose calves. Husbandry and nutrition may lead to slower growth in young calves in captivity due to volume of food consumed or digestive disorders (Addison *et al.* 1983, Welch *et al.* 1985, Lankester *et al.* 1993). However, there may be more rapid growth in captive as compared to wild calves in the autumn when many of the artificial rations used have greater energy and protein content than would food of wild calves. This has led to an extended growing season beyond the time of leaf fall for some captive calves (Lankester *et al.* 1993, Addison *et al.* 1994). However, even in captive moose on high quality diets, growth slows by late autumn (Lankester *et al.* 1993) and ceases by early to mid-winter (Addison *et al.* 1994).

Other factors that could result in differential growth between captive and wild calves include winter severity (Cederlund *et al.* 1991), summer weather influencing quality of summer food (Saether 1985) and presence of parasites or diseases such as infestations with winter ticks (*Dermacentor albipictus*) (Addison *et al.* 1994). Lankester *et al.* (1993) also suggested that differences in birth dates, birth weights, the age and condition of the cow, differences between subspecies and individual genetic fitness may influence size of calves. The most important consideration is not if, but to what extent, these factors affect growth differentially between wild and domestic calves.

In general, effects of a second summer season during which to grow are large in comparison with the influence of other factors on growth of young moose. For example, differences in body mass of six-month-old calves between those being from a cow bred in the first as compared to the second oestrus was 27 kg (18%)(Schwartz *et al.* 1994). In contrast, the difference in body mass between six-month-old calves and autumn yearlings was 150 kg (82%) for calves from first oestrus breedings and 167 kg (108%) for calves from second oestrus breedings in the same study (Schwartz *et al.* 1994). In another example, maximum annual variation in mean mass of Norwegian yearling moose for a period of more than 15 years was 14-27% for three study areas (Saether 1985). In a second

Table 2. Organ/internal tissue weights and measures for 11-month-old, captive moose from Ontario.

Body Part	Female $\bar{x}$(SD)n [Max/Min]	Male $\bar{x}$(SD)n [Max/Min]	ALL $\bar{x}$(SD)n [Max/Min]
Whole Viscera Mass[a] (kg)	46.4(3.22)6 [50/41]	50.9(6.93)6 [64/43]	48.6(5.94)12 [64/41]
Trachea Length[b] (cm)	47.2(2.60)6 [51/44]	49.4(2.62)6 [53/47]	48.3(2.73)12 [53/44]
Oesophagus Length[c] (cm)	99.1(5.12)6 [109/94]	98.3(4.97)6 [107/93]	98.7(4.83)12 [109/93]
Lung Mass [d](g)	1939(395.9)6 [2673/1570]	2086(296.1)6 [2460/1590]	2012(342.0)12 [2673/1570]
Lung Volume[e] (dm^3)	3.2(0.46)6 [3.7/2.6]	3.4(0.72)6 [4.5/2.6]	3.3(0.61)12 [4.5/2.6]
Heart Mass[f] (g)	1471(130.4)6 [1589/1300]	1617(101.8)6 [1760/1460]	1544(135.2)12 [1760/1300]
Diaphragm Mass[g] (g)	1246(218.2)6 [1515/1000]	1351(152.5)6 [1580/1210]	1298(187.7)12 [1580/1000]
Spleen Mass[h] (g)	1291(751.1)6 [2670/ 560]	785(280.3)6 [1056/ 400]	1038(601.6)12 [2670/ 400]
Liver Mass[i] (g)	4114(655.4)6 [5043/3380]	4372(621.7)6 [5500/3800]	4243(623.8)12 [5500/3800]
Kidney Mass [j](g)	349(57.35)6 [430/288]	378(63.12)6 [456/300]	363(59.44)12 [456/288]
Small Intestine Length [k](m)	31.2(1.99)6 [34/29]	30.4(1.46)6 [32/28]	30.8(1.71)12 [34/28]
Large Intestine Length[l] (m)	15.2(1.78)6 [17.5/13.2]	14.6(1.79)6 [16.8/12.4]	14.9(1.73)12 [17.5/12.4]
Caecum Length[m] (cm)	47(5.39)6 [57/42]	45(5.57)6 [56/40]	46(5.36)12 [57/40]
Pancreas Mass [n] (g)	364(84.17) [470/250]	344(53.67)5 [390/260]	355(69.32)11 [470/250]
Testes Mass[o] (g)	--(----)-	22(4.90)6 [28/13]	--(----)--
Ovaries Mass[p] (g)	2(0.30)4 [2.0/1.3]	--(----)-	--(----)--
Thyroid Mass[q] (g)	6.1(0.99)6 [7.5/5.0]	6.6(1.75)6 [9.5/4.5]	6.4(1.38)12 [9.5/4.5]
Adrenal Mass[r] (g)	6.2(1.05)6 [7.5/4.5]	6.1(0.87) [6.9/5.0]	6.2(0.92)12 [7.5/4.5]

[a]Whole Viscera Mass - all abdominal and thoracic organs, diaphragm, mesentery, and fat.

[b]Trachea Length - from epiglottis to junction with bronchi.

[c]Oesophagus Length - from junction with trachea to rumen.

Table 2. Continued

[d]Lung Mass - all lung tissue with bronchi from bifurcation with trachea.

[e]Lung Volume - as determined by water displacement.

[f]Heart Mass - heart with pericardium removed and vena cava, aorta, pulmonary artery and vein, removed flush with heart.

[g]Diaphragm Mass - muscle removed as close as possible to walls of body cavity.

[h]Spleen Mass - spleen with associated blood vessels cut close to organ.

[i]Liver Mass - entire organ with associated blood vessels removed close to surface.

[j]Kidney Mass - mean of right and left kidneys; ureters and blood vessels trimmed close to organ; external fat removed.

[k]Small Intestine Length - from junction with abomasum to junction with large intestine.

[l]Large Intestine Length - from junction with small intestine to anus.

[m]Caecum Length - from junction with small intestine to distal tip.

[n]Pancreas Mass - entire gland with ducts cut flush with surface.

[o]Testes Mass - mean of right and left testes, epididymis removed.

[p]Ovaries Mass - mean of right and left ovaries, ligaments trimmed off close to surface.

[q]Thyroid Mass - mean of right and left glands.

[r]Adrenal Mass - mean of right and left glands.

study there was no significant difference in between year variation in carcass mass of moose calves among 14 populations spread throughout Sweden and measured annually for a period of 4 years (Sand and Cederlund 1996). These measures of the effect of differences in annual growing seasons on growth were of small magnitude compared to differences in size between sympatric calves and yearlings. Yearlings have been 65-118% heavier than calves in studies representing many different years, a wide variety of areas across North America and in Norway, and for a number of subspecies of moose (Blood *et al.* 1967, Schladweiler and Stevens 1973, Peterson 1974, Franzmann *et al.* 1978, Saether 1983, Schwartz *et al.* 1994, Adams and Pekins 1995, Lynch *et al.* 1995)(Table 4).

In short, there are no data at this time to suggest that data from captive 11-month-old moose would be inappropriate for distinguishing between wild calves and yearlings. This conclusion is supported by comparison of whole body mass from calves in this study with whole body mass from wild calves. Despite different subspecies, locations and times of collection of data between October and April, our calves raised in captivity (see Addison *et al.* 1994)(n=18) were of similar mass at the same age to wild calves in Alaska (Franzmann *et al.* 1978)(n=192) and in Alberta during 1960 and 1963 (Blood *et al.* 1967)(n=9) and during 1980 (Lynch *et al.* 1995)(n=25)(Table 4).

Summary data for selected body parts, internal organs/tissues and long bones are presented in Tables 1, 2, and 3. Though similarities among the sexes were evident, data are presented separately since circumstances often demand that the most specific data available be applied to the animal under investigation. Data combined from both sexes are presented since the sex of the animal is sometimes unknown.

Body mass of calf and yearling moose differ sufficiently to allow delineation of age based on that criterion (Table 4). Using data from various carcass yields for ageing moose

Table 3. Lengths[cm] of selected long bones of 11-month-old, captive moose from Ontario

Body Part	Female x(SD)n [Max/Min]	Male x(SD)n [Max/Min]	ALL x(SD)n [Max/Min]
Right Pelvis[a]	19.8(0.80)5 [21.1/19.0]	19.9(0.53)6 [20.7/19.4]	19.9(0.64)11 [21.1/19.0]
Left Pelvis[a]	19.7(0.61)5 [20.5/19.0]	19.9(0.52)6 [20.6/19.2]	19.8(0.54)11 [20.6/19.2]
Left Femur[b]	36.9(1.43)6 [39.6/35.6]	38.0(0.98)6 [38.8/36.2]	37.4(1.31)12 [39.6/35.6]
Left Tibia[c]	42.4(1.65)5 [45.2/40.8]	43.4(1.02)6 44.8/42.0]	43.0(1.36)11 [45.2/40.8]
Right Tibiotarsus[d]	8.4(0.08)6 [8.5/ 8.3]	8.9(0.15)5 [9.1/ 8.7]	8.7(0.28)11 [9.1/ 8.3]
Left Tibiotarsus[d]	8.4(0.11)6 [8.5/ 8.2]	8.9(0.23)6 [9.1/ 8.5]	8.6(0.32)12 [9.1/ 8.2]
Right Fibular Tarsus[e]	14.1(0.24)6 [14.5/13.8]	14.7(0.27)6 [15.0/14.3]	14.4(0.38)12 [15.0/13.8]
Left Fibular Tarsus[e]	14.1(0.24)6 [14.5/13.9]	14.6(0.19)6 [14.8/14.3]	14.4(0.40)12 [14.8/13.9]
Right Metatarsus[f]	36.5(0.68)6 [37.6/35.8]	37.7(0.50)6 [38.2/36.8]	37.1(0.82)12 [38.8/35.8]
Left Metatarsus[f]	36.6(0.63)6 [37.6/36.0]	37.2(1.26)6 [38.0/34.8]	36.9(1.00)12 [38.0/34.8]
Right Hind Foot Right Third Phalanx[g]	6.5(0.21)6 [6.9/ 6.4]	6.5(0.12)6 [7.0/ 6.4]	6.5(0.17)12 [7.0/ 6.4]
Right Hind Foot Right Second Phalanx[g]	6.5(0.08)6 [6.6/ 6.4]	6.6(0.15)6 [6.7/ 6.4]	6.5(0.12)12 [6.7/ 6.4]
Right Hind Foot Right First Phalanx[g]	8.6(0.08)6 [8.7/ 8.5]	8.9(0.23)6 [9.2/ 8.6]	8.7(0.21)12 [9.2/ 8.5]
Right Scapula[h]	31.9(0.69)5 [33.0/31.4]	32.9(0.71)6 [33.4/31.6]	32.5(0.84)11 [33.4/31.4]
Left Scapula[h]	32.0(0.63)6 [33.0/31.6]	32.8(0.61)6 [33.2/31.6]	32.4(0.73)12 [33.2/31.6]
Right Humerus[i]	33.2(1.16)5 [35.0/31.8]	34.6(0.71)6 [35.8/33.8]	34.0(1.16)11 [35.8/31.8]
Left Humerus[i]	33.1(1.04)6 [35.0/32.0]	34.6(0.66)6 [35.6/33.8]	33.8(1.15)12 [35.6/32.0]
Right Radius[j]	36.9(1.03)5 [38.6/35.8]	38.4(0.76)6 [39.6/37.2]	37.7(1.13)11 [39.6/35.8]
Left Radius[j]	36.8(0.96)6 [38.6/35.8]	38.4(0.61)6 [39.6/37.2]	37.6(1.12)12 [39.6/35.8]

Table 3. Continued

Body Part	Female x(SD)n [Max/Min]	Male x(SD)n [Max/Min]	ALL x(SD)n [Max/Min]
Right Ulna[k]	38.2(1.13)5 [40.2/37.2]	39.4(0.81)6 [40.6/38.6]	38.8(1.10)11 [40.6/37.2]
Left Ulna[k]	38.2(0.98)6 [40.0/37.0]	39.5(0.59)6 [40.4/38.8]	38.9(1.04)12 [40.4/37.0]
Right Third Metacarpus[l]	31.2(0.42)5 [31.8/30.8]	32.5(0.45)6 [33.0/31.8]	31.9(0.81)11 [33.0/30.8]
Left Third Metacarpus[l]	31.4(0.54)6 [32.2/30.8]	32.5(0.49)6 [33.0/31.8]	32.0(0.75)12 [33.0/30.8]
Right Front Foot Right Third Phalanx[g]	7.8(0.10)6 [7.9/ 7.7]	8.2(0.21)6 [8.5/ 7.9]	8.0(0.27)12 [8.5/ 7.7]
Right Front Foot Right Second Phalanx[g]	5.8(0.04)6 [5.8/ 5.7]	6.0(0.18)6 [6.2/ 5.8]	5.9(0.17)12 [6.2/ 5.7]
Right Front Foot Right First Phalanx[g]	7.8(0.10)6 [7.9/ 7.7]	8.2(0.23)6 [8.5/ 7.8]	8.0(0.25)12 [8.5/ 7.7]

[a]Pelvis Length - most anterior extent of ilium to anterior edge of acetabulum.

[b]Femur Length - from most proximal extent of greater trochanter diagonal to distal extent of medial condyle.

[c]Tibia Length - proximal extent of intercondylar eminence to distal extent of medial malleolus.

[d]Tibiotarsus Length - maximum measured on diagonal.

[e]Fibular Tarsus Length - maximum with calcaneal tuber attached.

[f]Metatarsus Length - proximal extent of metatarsus to distal extent of condyles.

[g]Hind and Front Foot Phalanx Length - maximum measured on diagonal.

[h]Scapula Length - scapular tuberosity straight line distance along spine to distal extent of scapula.

[i]Humerus Length - proximal extent of greater tubercle to distal extent of capitulum.

[j]Radius Length - proximal tuberosity to distal extent of styloid process.

[k]Ulna Length - proximal extent of ulna (olecranal tuberosity removed) to distal extent of styloid process.

[l]Metacarpus Length - proximal tuberosity to distal extent of condyles.

Table 4. Weights [kg] of calf and yearling moose reported in the literature.

Measurement	Age	Female	Male	All	Source/Location/Comments
Whole Body	Calf	174, n=4[a] [193/156][b]	197, n=5 [206/193]		Blood *et al.* (1967), Alberta, Canada, animals killed between 24 Nov. and 6 Jan.
	Yearling	336, n=4 [355/305]	310, n=2 [329/292]		
Dressed Weight[c]	Calf	94, n=27 [112/ 70]	95, n=21 [110/ 70]		
	Yearling	162, n=28 [186/128]	153, n=34 [193/115]		
Field Dressed[d]	Calf	157, n=3 [186/138]	140, n=7 [170/109]		Timmermann (1972), Ontario, Canada, autumn killed
	Yearling	231, n=7 [272/213]	255, n=19 [336/200]		
Whole Body	Calf		156(10.6)4[e]		Franzmann and Arneson (1973), Alaska, USA, calves captured in November and December
Field Dressed	Calf	84, n=14 [102/ 54]	99, n= 9 [116/ 82]		Schladweiler and Stevens (1973), Montana, USA
	Yearling	164, n=15 [187/126]	171, n=28 [208/125]		
Field Dressed	Calf	109, n=26	120, n=19		Peterson (1974), Québec,
	Yearling	203, n=34	204, n=51		Canada, autumn killed
Whole Body	Calf			160	Franzmann *et al.* (1978), Alaska, USA, animals collected throughout the year,
	Yearling			275	weights interpolated from Fig. 3
Whole Body	Yearling	245, n=1			Crichton (1979), Manitoba, Canada,
Field Dressed	Yearling	164, n=1			autumn killed
Whole Body	Yearling	297(14.8)4			Crichton (1980), Manitoba, Canada,
Field Dressed	Yearling	163, n=1	206(11.1)4		autumn killed
Dressed Weight	Calf	66.7(12.7)53	71.0(13.5)63		Saether (1983), Norway, animals killed
	Yearling	144(17.5)123	152(19.7)211		between 10 September and 20 October

Table 4. Continued

Measurement	Age	Female	Male	All	Source/Location/Comments
Whole Body	Yearling	246(53.5)8 [330/200]	289(61.7)4 [360/230]	260(57.5)12 [360/200]	Quinn and Aho (1989), Ontario, Canada, Males weighed without antlers, animals killed throughout the year
Dressed Weight	Calf	67(9.6)25	71(13.6)27		Cederlund *et al.* (1991), Grimso, Sweden, calves killed between October and May
Whole Body	Calf			141(4.7)5	Lankester *et al.* (1993), Ontario, Canada, captive animals weighed in mid-October
Whole Body					Schwartz *et al.* (1994), Alaska, USA, captive bred and reared.
	Calf			170(15)12	October - from 1st estrus breeding
				140(15)12	October - from 2nd estrus breeding
				229(18)12	May - from 1st estrus breeding
				209(21)12	May - from 2nd estrus breeding
	Yearling			332(29)8	October - from 1st estrus breeding
				322(22)7	October - from 2nd estrus breeding
				370(54)8	May - from 1st estrus breeding
				355(22)7	May - from 2nd estrus breeding
Whole Body	Calf	128(5.6)8	144(15.5)10		Addison *et al.* (1994), Ontario, Canada, captive animals weighed during first week in October, same moose as in 11-month-old sample (this paper)
Field Dressed	Calf	108(23.4)23	112(18.7)23		Adams and Pekin (1995), New Hampshire, Maine, Vermont, USA, autumn killed
	Yearling	216(32.0)65	199(40.7)139		
Whole Body	Calf	171(21.6)12 [227/132]	197(23.8)13 [227/150]		Lynch *et al.* (1995), Alberta, Canada, killed and bled, December
	Yearling	278(51.4)8 [331/177]	325(28.2)6 [363/281]		

[a] mean, sample size.
[b] [Maximum/Minimum].
[c] whole carcass with head, viscera, blood, feet and skin removed.
[d] whole carcass with viscera and blood removed.
[e] $\bar{x}$(SD)n.

has proven more difficult. However, Blood *et al.* (1967) determined that carcass yields are similar among different age classes of moose. Using this information in conjunction with the data on 11-month-old moose (Table 1), one can calculate for calves probable expected mass of various carcass components leading towards cut and wrapped meat.

Data we report have been used to assess compliance with selective harvest regulations. The following are two examples.

Example 1

It is claimed that a moose with quartered mass (hide off) of 160 kg and a heart mass of 2.0 kg was a calf moose. Although mass of quarters is much smaller than field dressed mass (Table 1), quartered mass of the moose in question exceeds field dressed or dressed mass of 126 calves from Montana, Alberta, Ontario, and Québec (Table 4). The heart of the moose in question was 30% heavier than the average heart mass of 11-month-old moose and 14% heavier than the largest heart of 11-month-old moose (Table 2). It is concluded based on the comparative mass of hanging quarters and the heart that the tissues examined must be from a moose older than a calf.

Example 2

It is claimed that 115 kg of cut and wrapped meat were produced from a male calf shot during the legal hunt in October. From Table 4 it is clear that this amount of meat weighs more than field dressed male moose calves from Montana (99 kg) and slightly less than the average field dressed mass of calves from Québec (120 kg). The quartered mass (i.e. not yet cut and wrapped) from 11-month-old Ontario moose averaged 102 kg and represented a carcass yield equal to 66% of field dressed mass (Table 1). Assuming that carcass yield is the same for 5 to 6-month-old calves as for 11-month-old moose, which it should be according to Blood *et al.* (1967), then quartered mass for Montana, Ontario, and Québec calves should equal 65 kg, 92 kg, and 79 kg respectively. The quartered mass for 11-month-old moose averaged 87 % of dressed mass. Applying this conversion to dressed mass for Alberta calves, quartered mass of Alberta calves ready for butchering would weigh 83 kg. It seems highly improbable that a calf moose could produce 115 kg of cut and wrapped meat, when estimates of quartered mass of calves were significantly lighter. Further, our data indicate that the mean quartered mass from 11-month-old moose should occur between 85 kg and 109 kg, 95 times out of 100 (95% confidence). Since the measured amount of meat exceeds the upper 95% confidence limit, it seems likely that the meat came from a yearling age or older moose.

The preceding examples demonstrate how anatomical data can be used in resource management. Although these data will be helpful in many cases, they should not be expected to provide easy differentiation between calf and yearling moose under all circumstances. Unfortunately, the literature to date does not report many data relating to organ mass or long bone measurements for comparative purposes. Clearly there is a need to collect and present various types of body measurement data so that greater use can be made of the limited evidence usually available to enforcement officers.

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REFERENCES

ADAMS, K.P., and P.J. PEKINS. 1995. Growth patterns of New England moose: yearlings as indicators of population status. Alces 31:53-59.

ADDISON, E.M., R.F. MacLAUGHLIN, and D.J.H. FRASER. 1983. Raising moose calves in Ontario. Alces 18:246-270.

_____, R.F. McLAUGHLIN, and J.D. BROADFOOT. 1994. Growth of moose calves (*Alces alces americana*) infested and uninfested with winter ticks (*Dermacentor albipictus*). Can. J. Zool. 72:1469-1476.

BARTOSIEWICZ, L. 1987. Metacarpal measurements and carcass weight of moose in central Sweden. J. Wildl. Manage. 51: 358-359.

BLOOD, D.A., J.R. McGILLIS, and A.L. LOVAAS. 1967. Weights and measurements of moose in Elk Island National Park, Alberta. Can. Field-Nat. 81:263-269.

CEDERLUND, G.N., H.K.G. SAND, and A. PEHRSON. 1991. Body mass dynamics of moose calves in relation to winter severity. J. Wildl. Manage. 55:675-681.

CRICHTON, V.F.J. 1979. An experimental moose hunt on Hecla Island, Manitoba. Proc. N. Am. Moose Conf. Workshop 15:245-279.

_____. 1980. Manitoba's second experimental moose hunt on Hecla Island. Proc. N. Am. Moose Conf. Workshop 16:489-526.

FRANZMANN, A.W., and P.D. ARNESON. 1973. Moose research centre studies. Alaska Department of Fish and Game Juneau, Alaska. Volume XIV, Project Progress Report, Federal Aid in Wildlife Restoration, Project W-17-5, Jobs 1.1R, 1.2R, 1.3R and 1.7R.

_____, R.E. LERESCHE, R.A. RAUSCH, and J.L. OLDEMEYER. 1978. Alaskan moose measurements and weights and measurement-weight relationships. Can. J. Zool.56:298-306.

LANKESTER, M.W., T. WHEELER-SMITH, and S. DUDZINSKI. 1993. Care, growth and cost of captive moose calves. Alces 29:249-262.

LYNCH, G.M., B. LAJEUNESSE, J. WILLMAN, and E.S. TELFER. 1995. Moose weights and measurements from Elk Island National Park, Canada. Alces 31:199-207.

PETERSON, R.L. 1974 . A review of the general life history of moose. Naturaliste can. 101:9-21.

PETERSON, R.O., J.M. SCHEIDLER, and P.W. STEPHENS. 1982. Selected skeletal morphology and pathology of moose from the Kenai Peninsula, Alaska and Isle Royale, Michigan. Can. J. Zool. 60:2812-2817.

QUINN, N.W.S., and R.W. AHO. 1989. Whole weights of moose from Algonquin Park, Ontario Canada. Alces 25:48-51.

SAETHER, B. 1983. Relationship between mandible length and carcass weight of moose in Norway. J. Wildl. Manage. 47:1226-1229.

_____. 1985. Annual variation in carcass weight of Norwegian moose in relation to climate along a latitudinal gradient. J. Wildl. Manage. 49: 977-983.

SAND, H., and G. CEDERLUND. 1996. Individual and geographical variation in age at maturity in female moose (*Alces alces*). Can. J. Zool. 74: 954-964.

SCHLADWEILER, P., and D.R. STEVENS. 1973. Weights of moose in Montana. J. Mammal. 54:772-775.

SCHWARTZ, C.C., W.L. REGELIN, and A.W. FRANZMANN. 1987. Seasonal weight dynamics of moose. Swedish Wildl. Res. Suppl. 1:301-310.

_____, K.J. HUNDERTMARK, and E.F. BECKER. 1994. Growth of moose calves conceived during the first versus second estrus. Alces 30:91-100.

TIMMERMANN, H.R. 1972. Some observations of the moose hunt in the Black Sturgeon area of northwestern Ontario. Proc. N. Am. Moose Conf. Workshop 8:223-239.

WELCH, D.A., M.L. DREW, and W.M. SAMUEL. 1985. Techniques for rearing moose calves with resulting weight gains and survival. Alces 21:475-491.