MOOSE WEIGHTS AND MEASUREMENTS FROM ELK ISLAND NATIONAL PARK, CANADA

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ABSTRACT: During a herd reduction program at Elk Island National Park, Alberta, 151 moose (*Alces alces andersoni*) were collected. Whole weights, body measurements, fetal weights and measurements and ovarian weights were taken, providing an unusually large sample for *A. a. andersoni*. This paper reports these weights and measurements within sex and age subsamples.

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Weights and measurements of *A. a. andersoni* have been reported by Blood *et al.* (1967) and Haigh *et al.* (1980). Others describe those of *A. a. americana* (Quinn and Aho 1989, Crête 1983), and *A. a. gigas* (Franzmann *et al.* 1978) and *A. a. shirasi* (Doutt 1970). It is seldom possible to obtain whole weights of animals as large as moose. However, an opportunity occurred during 1-12 December 1980 when 151 moose (*A. a. andersoni*) were collected as part of a herd reduction program at Elk Island National Park (EINP), Alberta. Whole weights, body measurements, fetal weights and measurements and ovarian weights were taken from some animals. The results are presented and discussed in this paper.

STUDY AREA

EINP is 40 km east of Edmonton in central Alberta, Canada, within the recognized range of *A. a. andersoni* (Peterson 1955). It is characterized by gently rolling terrain and elevations of 710 to 755 m. Vegetation is dominated by trembling aspen (*Populus tremuloides*) and balsam poplar (*P. balsamifera*). Scattered upland and lowland meadows contribute to a mosaic of cover types.

The park includes 136-and 59 km^2 fenced portions separated by a highway. Moose numbers were believed at carrying capacity in 1980, but their body condition was good at the time of the reduction program as evidenced by abundant body fat deposits. The moose population in the park was estimated at 550 prior to the reduction (2.8/km^2). Browse surveys conducted by Park personnel during 1980 indicated that the number of ungulates had to be reduced to avoid possible starvation during the coming winter. Sport hunting to regulate ungulate numbers is not allowed in EINP and there are no natural predators, so it was decided that some moose and bison (*Bison bison*) be removed by slaughter and elk (*Cervus elaphus*) be trapped and transplanted to locations outside EINP. The objective of the reduction program was to reduce moose numbers by 150 to leave a wintering population of about 400 animals (2.0/km^2). Previous reduction programs occurred in 1960, 1963, and 1969. Winter die-offs and low reproductive rates were avoided through the periodic removal of surplus large ungulates. Other ungulates in the park were white-tailed deer (*Odocoileus virginianus*) and mule deer (*O. hemionus*). EINP is described in more detail by Blyth and Hudson (1987).

METHODS

Moose were shot by park wardens, bled, tagged, and trucked to the park abattoir where they were eviscerated, skinned and quartered (Blyth 1981). The meat was inspected by Agriculture Canada and placed in cold storage to await later distribution for human consumption. Body measurements were taken in the unloading area at the abattoir. Whole carcasses were weighed just prior to being eviscerated. Fetuses and ovaries were later weighed, labeled and preserved. Fetal measurements were also made later.

Whole carcasses were weighed to the nearest pound on a spring scale that was fastened to a rail hung from the ceiling of the abbatoir. Pounds were converted to metric prior to analysis. Body measurements were obtained using a metal metric tape (to the nearest .5 cm). Height measurements were taken from the tip of a front hoof to the top of the shoulder (scapula). Total length was measured from the top of the bare spot of the snout over the curves of the body to the tip of the tail. Heart girth was taken from the centre of the sternum immediately posterior to the front legs, around the chest area to the centre of the back. Hind foot measurements were from the tip of the straightened hoof to the heel. Fetuses and ovaries were weighed in the laboratory using an electronic scale to the nearest .01 g. Fetal measurements were taken using calipers (nearest mm). Moose fetal material was handled as described by Markgren (1969).

An incisor was removed from all but calves and sectioned for aging (Sargeant and Pimlott 1959, Gasaway *et al.* 1978). Student's t was used to compare weights and measurements between sex and age classes. Simple linear regression was used for testing the validity of using body measurements to predict whole weights.

RESULTS

Whole weights (less blood) were obtained for 59 male and 66 female moose (Table 1). No difference was detected between male and female yearling (1.5 - year-olds) weights ($P<.05$; $n=6$). Yearling males and females weighed less than 2.5 - year-old males and females respectively (both $P>0.05$). Weights of 2.5-year-olds (both sexes) did not differ from weights of older moose ($P<0.05$).

Moose body measurements taken included those for height, total length, and hind foot. Height measurements were obtained for 61 male and 67 female moose (Table 1). There was no difference between male and female moose heights within the nine age groups analyzed ($P<0.05$). Calves were significantly less in height than yearlings ($P>0.01$), but in yearling and older moose there was no difference in height between age groups or between the sexes.

There was little difference in total lengths from the yearling age class on. There was no difference in length between male and female calves, but calves (both sexes) were not as long as yearlings ($P>.01$)(Table 1). In our sample, 2.5-year-old cows were longer than yearling cows and 5.5-year-old males were longer than 5.5-year-old females.

Hind foot length of 61 males and 67 females was measured (Table 1). There was no difference in means of hind foot of male versus female calves. Means of calves were different than those of yearlings ($P>.05$), but from yearlings on there was no difference in means of hind foot measurements between age groups or between males and females ($P<.05$).

Neck circumference measurements of a species is an important consideration when designing telemetry collars. We measured the neck circumference of 32 male and 33 female moose (Table 1). Necks of calves (both sexes) were smaller than those of yearlings. Means of neck circumference measurements of males older than 7.5 (the oldest age class) were greater than those of the other

Table 1. Weights and measurements of moose from Elk Island National Park in 1980.

	Males				Females			
	n	Mean	S.D.	Range	n	Mean	S.D.	Range
Whole Weight (kg)								
Calves	13	197.11	23.82	149.7-226.8	12	170.83	21.63	131.5-226.8
Yearlings	6	325.40	28.22	281.2-362.8	8	278.06	51.38	176.9-331.1
2.5	6	393.43	49.57	356.0-498.9	7	347.90	53.33	272.1-403.6
3.5	3	397.57	25.55	374.1-433.1	7	400.06	65.45	340.1-521.5
4.5	8	438.21	25.02	403.6-476.2	10	414.96	20.42	369.6-451.2
5.5	4	430.28	43.99	385.5-498.9	4	403.08	43.20	351.5-464.9
6.5	6	446.35	20.52	408.2-464.9	8	395.43	31.47	351.5-464.9
7.5	6	487.87	56.01	430.8-578.2	5	413.60	27.30	362.8-444.4
>7.5	7	468.40	33.23	430.8-521.5	5	440.80	18.54	417.2-464.9
>1.5	40	441.61	49.21	356.0-578.2	46	400.72	47.91	272.1-521.5
Height (cm)								
Calves	13	157.73	5.76	145.0-167.0	13	154.88	4.46	145.0-162.0
Yearlings	7	180.64	6.12	168.0-188.0	8	179.56	9.10	158.5-188.0
2.5	6	185.00	4.56	179.5-192.5	7	184.36	6.91	171.0-193.5
3.5	3	192.00	6.16	185.0-200.0	7	185.50	5.91	176.0-196.0
4.5	8	193.19	6.94	182.0-201.0	10	191.35	3.47	183.0-195.0
5.5	4	191.00	6.04	181.0-197.0	4	189.75	5.81	182.0-197.5
6.5	6	193.17	5.90	182.0-200.0	8	188.75	6.62	178.5-200.0
7.5	6	198.17	5.46	188.0-205.0	5	194.40	3.79	190.5-201.0
>7.5	8	199.38	6.00	192.0-212.5	5	195.60	3.26	190.0-200.0
>1.5	41	193.62	7.52	179.5-212.5	46	189.60	6.51	171.0-201.0
Total Length (cm)								
Calves	12	199.13	14.71	178.0-225.0	12	195.88	7.19	184.0-210.0
Yearlings	7	242.93	11.02	226.5-263.0	8	227.81	14.75	198.0-245.0
2.5	6	253.50	8.92	243.0-267.0	7	248.86	12.09	234.0-271.0
3.5	3	258.33	8.96	246.0-267.0	7	250.07	6.57	238.0-258.0
4.5	8	265.31	18.33	224.0-289.0	10	257.95	9.56	247.5-275.0
5.5	4	279.50	10.64	265.0-292.0	4	251.25	10.13	240.0-266.0
6.5	6	259.17	12.79	241.0-275.0	8	255.38	8.57	247.5-271.5
7.5	6	261.58	6.21	255.0-272.0	5	263.20	2.66	260.5-268.0
>7.5	8	265.88	11.99	252.0-290.0	5	258.30	11.40	243.0-270.0
>1.5	41	263.12	14.08	224.0-292.0	46	254.95	10.31	234.0-275.0
Hind Foot Length (cm)								
Calves	13	72.08	2.51	68.0-78.0	13	69.92	2.30	63.0-73.0
Yearlings	7	79.79	0.96	78.0-81.5	8	78.75	3.46	70.0-82.0
2.5	6	79.67	2.34	75.5-83.5	7	78.57	2.15	76.0-82.0
3.5	3	82.67	1.44	81.0-84.5	7	80.71	1.25	78.5-82.5
4.5	8	82.26	3.30	78.0-88.0	10	80.70	1.90	77.5-83.5
5.5	4	81.13	3.63	75.0-84.5	4	80.38	2.56	77.5-84.5
6.5	6	82.17	1.57	80.0-85.0	8	80.75	1.54	77.5-83.0
7.5	6	84.08	2.17	80.0-87.0	5	81.50	1.76	78.5-84.0
>7.5	8	82.63	2.22	79.5-87.0	5	83.30	1.33	82.0-85.5
>1.5	41	82.12	2.83	75.0-88.0	46	80.73	2.18	76.0-85.5

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continued Table 1.

	Males				Females			
	n	Mean	S.D.	Range	n	Mean	S.D.	Range
Neck Circumference (cm)								
Calves	6	59.67	5.31	54.0-70.0	7	55.14	5.38	48.0-63.0
Yearlings	6	71.17	5.01	65.0-78.0	4	65.00	1.73	62.0-66.0
2.5	3	74.50	7.97	65.0-84.5	4	71.50	3.64	67.0-76.0
3.5	2	74.50	1.50	73.0-76.0	2	75.00	4.00	71.0-79.0
4.5	2	84.50	7.50	77.0-92.0	4	80.50	6.34	70.0-87.0
5.5	4	78.75	7.40	70.0-90.0	2	72.50	7.50	65.0-80.0
6.5	2	85.50	6.50	79.0-92.0	5	69.80	2.79	67.0-75.0
7.5	0	-	-	-	7	5.33	1.25	74.0-77.0
>7.5	6	90.83	2.61	87.0-95.0	2	70.50	2.50	68.0-73.0
>1.5	20	82.73	8.57	65.0-95.0	22	73.59	5.76	65.0-87.0
Heart Girth (cm)								
Calves	13	148.69	6.81	140.0-164.0	13	144.46	11.31	132.0-166.0
Yearlings	7	173.00	7.43	162.0-182.0	8	165.38	9.01	144.0-174.0
2.5	6	180.00	9.87	160.0-190.0	7	181.86	7.61	171.0-192.0
3.5	3	188.00	18.83	170.0-214.0	7	185.29	7.42	176.0-196.0
4.5	8	192.38	6.36	182.0-200.0	10	189.30	10.41	180.0-214.0
5.5	4	191.25	5.45	182.0-196.0	4	190.00	5.66	182.0-198.0
6.5	6	196.00	3.61	190.0-199.0	8	181.81	9.41	159.0-192.0
7.5	6	191.00	5.26	184.0-198.0	5	192.60	11.79	180.0-214.0
>7.5	8	199.63	7.18	190.0-210.0	5	191.60	8.24	182.0-206.0

age classes except 4.5 and 6.5-year-olds. Measurements were taken in December, approximately nine weeks after the peak in the rut.

We attempted to correlate body weight with heart girth, height, total length and hind foot length. Linear correlations (with sex and age groups combined) were made with weight as the dependent variable and girth, height, length, and hind foot length as independent variables (Table 2). Best r^2 values were obtained for girth/weight (r^2=0.616) and hind foot length/weight (r^2=0.743).

Antler burl circumference was considered a possible indicator of moose age. We measured burl circumference of 21 individuals (Table 3). When age was regressed on burl circumferenc, the resulting r^2 value was 0.56 and the linear equation was Age= -4.647 + (0.407 x burl circumference).

Table 2. Linear correlations between body measurements and whole weights of moose.

Parameter	r^2	Linear Equation	Std Err of Est
Girth (n=125)	0.616	Whole Weight= -637.983+(0.616 x girth)	73.233
Height (n=100)	0.380	Whole Weight= -799.619+(6.349 x height)	67.283
Length (n=100)	0.237	Whole Weight= -258.353+(2.603 x total length)	74.614
Hind Foot (n=125)	0.743	Whole Weight= -1118.64+(18.721 x hind foot length)	54.630

Table 3. Antler burl circumferences of 21 moose from Elk Island National Park in 1980.

Age	n	Mean (cm)	S.D.
Yearling	5	18.00	2.98
2.5	4	17.63	2.77
4.5	6	23.00	1.66
5.5	3	23.83	1.03
6.5	2	24.00	1.00
8.5	1	25.00	-

Forty five fetuses from 44 pregnant cows were weighed and measured (Table 4). Two small fetuses were judged to be second estrus fetuses and were not included in the calculations. Their weights were 1.28 and 1.37 g and respective crown lengths were 20.0 and 25.0 mm. There was no difference between male and female fetus weights, crown length and hind foot measurements ($P<0.01$). The mean weight of all fetuses (n=43) was 44.95 g (range 15.20 - 79.50, S.D. 18.760). The mean crown length was 95.09 mm (range 64.0 - 120.0, S.D. 15.028), and mean hind foot length was 25.72 mm (range 15.0 - 35.0, S.D. 5.640).

A total of 131 (45 right, 46 left) ovaries were collected and weighed (Table 5). Ovaries were grouped into three categories for analysis; from pregnant cows; non-pregnant cows; and calves. Eighty seven ovaries from pregnant cows were examined. Only one of the 44 pregnant cows was a yearling. The others ranged in age from 2.5 to 10.5. There was no difference in weights of right and left ovaries from pregnant cows ($P<0.01$). The mean weight of all ovaries from pregnant cows was 3.83 ± 0.21 g (S.D. 1.246).

There were 11 pairs of ovaries from non-pregnant cows. Non-pregnant cows included seven yearlings, two 2.5-year-olds, one 3.5-year-old, and one 6.5-year-old. There was no difference between right and left ovaries within this group ($P<0.01$). The overall mean ovary weight was 2.21 ± 0.26 g. The 6.5-year-old cow in this group had ovary weights well below the mean (right 1.24 g, left 1.87 g). Ovaries from 11 calf moose were also analyzed. Again, there was no difference between weights of right and left ovaries ($P<0.01$). The overall mean ovary weight from calves was 1.38 ± 0.20 g. Mean weights of ovaries from pregnant cows were greater than those of non-pregnant cows and calves ($P>0.01$). Ovaries from calves weighed less than those from either of the other two groups.

Only 1 of 8 yearling females was pregnant (12.5 %). Forty-three of 47 females older than yearlings were pregnant (92 %). Only one of 44 pregnant cows was carrying twin fetuses (2.3 %). As expected, none of the female calves were pregnant. The sex ratio in the unhunted moose population at EINP is even (Blyth 1981).

Table 4. Weights and measurements of 21 male and 22 female moose fetuses.

	Parameter	Mean	S.D.	Range	95% C.L.
Males	Weight(g)	45.85	17.595	15.2-79.5	6.143
	Crown Length(mm)	95.29	13.746	65.0-120.0	4.799
	Hind Foot Length(mm)	25.76	5.117	15.0-33.0	1.787
Females	Weight(g)	44.08	19.769	15.7-72.2	6.902
	Crown Length(mm)	94.91	16.155	64.0-120.0	5.640
	Hind Foot Length(mm)	25.68	6.115	15.0-35.0	2.135
Both	Weight(g)	44.95	18.760	15.2-79.5	6.550
	Crown Length(mm)	95.09	15.028	64.0-120.0	5.247
	Hind Foot Length(mm)	25.72	5.640	15.0-35.0	2.135

Table 5. Mean weights of ovaries from moose collected at Elk Island National Park in 1980.

	n	Mean	S.D	Range	C.L.
Pregnant Cows					
Right	43	3.89	1.176	1.60-6.56	0.287
Left	44	3.77	1.308	1.70-7.23	0.316
Both	87	3.83	1.246	1.60-7.23	0.214
Non-pregnant Cows					
Right	11	2.08	0.765	1.13-3.93	0.369
Left	11	2.33	0.745	1.53-4.26	0.360
Both	22	2.21	0.766	1.13-4.26	0.261
Calves					
Right	11	1.40	0.592	0.79-2.90	0.286
Left	11	1.36	0.565	0.51-2.60	0.272
Both	22	1.38	0.579	0.51-2.90	0.197

DISCUSSION

Blood *et al.* (1967) reported whole weights of 35 moose collected at EINP during winter herd reduction programs in 1960 and 1963. Their male and female calf mean weights fell within our 95% confidence interval for male and female calves respectively. Their yearling male weights were also within our confidence interval, but their yearling female mean weight (335.29 kg, n=4) was above our 95% confidence interval. Blood *et al.* (1967) suggested that yearling and 2.5-year-old females were heavier than males of the same age. We found the opposite in our sample, where 6 yearling males averaged 325.40 kg and 8 yearling females averaged 278.06 kg. Six 2.5-year-old males and 7, 2.5-year-old females averaged 393.4 and 347.9 kg respectively. Their mean weights for 2.5-year-old males and females fell within our confidence interval for that age group. Blood *et al.* (1967) had few older bulls (n=3) or cows (n=6) in their sample. Our mean weight of 40 males older than 1.5 was 441.61 kg, compared to 412.22 kg (n=3) for males 3.5 and older reported by Blood *et al.* (1967). Our mean weight of 46 females older than yearlings was 400.72 kg, compared to 416.74 kg for 6 females 3.5 years and older reported by Blood *et al.* (1967). The heaviest male in our sample was a 7.5-year-old at 578.20 kg. Our heaviest female was a 3.5-year-old that weighed 521.50 kg.

We also compared our moose whole weights to those of 71 male and 70 female moose collected at EINP during a herd reduction in 1969 (Canadian Wildlife Service, unpublished data). Their moose were aged by tooth replacement and wear and all moose older than 3.5 were grouped together. Mean weights (kg) of 12 male and 7 female calves was 174.33 (S.E. 8.06) and 173.53 (S.E. 1.14) respectively. Mean weights of male calves fell below our 95% confidence limits for that group, but mean weights of female calves were within our confidence limits. Mean weights of 4 yearling males and 4 yearling females in 1969 were 269.65 and 251.18 kg respectively. Means of 5 male and 12 female 2.5-year-olds were 335.66 and 330.26 kg respectively. Respective mean weights of 13 male and 9 female 3.5-year-olds was 399.63 and 365.68 kg. Thirty seven older males averaged 476.61 kg (S.E. 9.16) and 38 older females averaged 402.53 kg (S.E. 8.56). All mean weights for females

from the 1969 herd reduction fell within our 95% confidence limits, but weights of yearling and 2-year-old males were below our confidence limits.

Haigh *et al.* (1980) reported weights of 6 male and 12 female *A. a. andersoni* from Alberta and Saskatchewan. The moose were chemically immobilized in the field and weighed using a scale suspended from a helicopter. The males, all older than 36 months, had a mean weight of 527 kg (range 475-570 kg). Twelve females older than 36 months averaged 422 kg (range 325 - 515 kg). Haigh *et al.* (1980) took their weights between October and February.

Heart girth has been correlated to whole weights in many species including moose (Haigh *et al.* 1980, Blood *et al.* 1967), white-tailed deer (Smart *et al.* 1973, Weckenly *et al.* 1987), bison (Kelsall *et al.* 1978), elk (Blood and Lovaas 1966), mountain goat (*Oreamnous americanus*) (Rideout and Worthen 1975), Stone's sheep (*Ovis dalli stonei*) (Seip and Bunnell 1984), grizzly bear (*Ursus arctos*) (Nagy *et al.* 1984), and black bear (*U. americanus*) (Cherry and Pelton 1976, Patrick 1961). Talbot and McCulloch (1965) correlated heart girth and body weight in nine species of East African mammals. Haigh *et al.* (1980) correlated certain body measurements and whole moose weights. They found that girth squared provided the best estimate of body weight with the lowest standard error (S.E. 13.6). We used the statistic r^2 to show the strength of relationships between girth and weight, height and weight, body length and weight, and hind foot length and weight. Our r^2 values of 0.616 for girth and weight and 0.743 for hind foot length and weight were compared to those of others who used regression analysis to predict animal weights. Smart *et al.* (1973) reported r^2 values of 0.69 and 0.73 respectively for fawn and adult white-tailed deer. Kelsall *et al.* (1978) reported r^2 values of 0.82 for male and 0.61 for female bison weight regressed on girth. Seip and Bunnell (1984) reported 0.96 for 15 Stone's sheep. Nagy *et al.* (1984) reported 0.95 and 0.92 in two study areas respectively for grizzly bear weight and chest girth. Talbot and McCulloch (1965) reported r^2 values when chest girth was used to estimate weight of several East African ungulates. Cherry and Pelton (1976) used chest girth and weight to get r^2=0.88 in female black bear (0.91 for males). In Tennessee, Weckerly *et al.* (1987) calculated linear regression equations for whole body weight and chest girth in white-tailed deer. Their r^2 values ranged from 0.46 to 0.74 within sex and age groups and at different seasons. They speculated that low r^2 values were due either to a small sample size or a higher amount of variation in deer from Tennessee. Haigh *et al.* (1980) suggested that inaccuracies are likely to occur where a measurement over areas of heavy pelage and "over the curves" requires the tape to be held or moved in a series of steps, such as occurs with a total length measurement. The animals' position and degree of relaxation affect the consistency of measurements. Differences in body condition and rumen fill can cause further variation. Leg lengths or height at the shoulder are difficult measurements to reproduce consistently (Peterson 1974). In our study body measurements were difficult to reproduce because dead moose were crowded into various positions on the floor of the abattoir when measurements were taken.

We obtained our highest r^2 with the hind foot length measurement and weight (r^2=-0.743). However, for field studies, heart girth would probably better reflect seasonal fluctuations in body weight. We were also able to compare our hind foot lengths to those collected from EINP in 1969 by the Canadian Wildlife Service (Canadian Wildlife Service, unpublished data). Mean hind foot lengths (cm) of male moose in 1969 were calves, 70.59 (n=12), yearlings, 76.85 (n=4), 2.5-year-olds, 78.74 (n=5), 3.5-year-olds,

81.10 (n=13), and older than 3.5-year-olds, 81.65 (n=37). The same age groups of females were measured to yield mean hind foot lengths of 70.41 (n=7), 76.50 (n=4), 78.68 (n=12), 79.30 (n=9), and 79.84 (n=38) respectively. All hind foot measurements recorded in 1969 were similar to those we report in 1980 at EINP.

The 1969 data (Canadian Wildlife Service, unpublished data) included girth measurements that were also similar to those we report in 1980. Their means of girth measurements (cm) in calf, yearling, 2.5-year-old, 3.5-year-old, and older than 3.5-year-old categories were: males; 151.25 (n=12), 168.60 (n=4), 176.28 (n=5), 184.55 (n=13), and 193.49 (n=37) respectively, and females; 155.84 (n=7), 170.53 (n=4), 181.94 (n=12), 183.32 (n=9), and 191.90 (n=38) respectively.

Our data, together with that cited from other sources, provides a substantial information base on the weights and measurements of *A. a. andersoni*. We believe that this information will be of use to others in the future when large-scale herd reductions are unlikely to occur.

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