Factors affecting velvet antler weights in free-ranging reindeer in Alaska

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Abstract: Free-ranging reindeer on the Seward Peninsula in western Alaska are rounded up from late May to early July and antlers are removed. We used data collected from 1987 to 1997 to determine how velvet antler weights of males and females varied with age, year, reproductive status, Julian date, and body weight. Male antler weights increased with age up to age five years, and were lower in castrates than in bulls. There was a significant positive relationship between body weight and antler weight in both sexes. Female antler weights increased with age until at least age nine. Lactating females had lower antler weights than non-lactating females, but this effect is better explained by differences in body weight. Antler weight of individual reindeer at age two years was better predicted by their antler weights as yearlings than their body weight as yearlings.

Key words: *Rangifer tarandus,* reindeer husbandry.

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Introduction

Reindeer are an important livestock species in Western Alaska. Antler sales generated approximately $564 000 for local economies in 1996 (Alaska Agricultural Statistics Service, U.S., 1997). Reindeer on the Seward Peninsula are free-ranging and rounded up once or twice a year for censusing, inspections, and vaccinations. Harvest of growing (velvet) antlers for sale as a traditional Asian medicine occurs during summer round ups, typically held in June and early July. Factors affecting antler weight in *Rangifer* are economically important in semi-domestic reindeer and antler size and weight may influence population dynamics in reindeer and wild caribou. Antler size is a factor in male reproductive success in many cervids (Lincoln, 1972; Clutton-Brock, 1982; Lincoln, 1992). Antlers in female reindeer may be used for intraspecific competition for food in winter (Espmark, 1964; Henshaw, 1968).

Antler growth in cervids appears to be related to nutritional quality of the diet as well as genetic factors and age. Antlerless females occur in many *Rangifer* populations and the proportion of antlerless females in a population may be negatively correlated with habitat quality (Reimers, 1993). Male and female reindeer on reduced planes of nutrition had decreased body weights and antler lengths (Wika, 1980). McCorquodale *et al.* (1989) suggested that rapid antler growth in a colonizing population of elk (*Cervus elaphus nelsoni*) was due to favorable range conditions.

Scribner *et al.* (1989) found that antler growth in white-tailed deer (*Odocoileus virginianus*) showed no spatial variation but did show temporal variation and was related to genetic multilocus heterozygosity. Williams *et al.* (1994) found that the heritability of antler weight ranged from 0.71 to 0.86 for captive white-tailed deer, suggesting a strong genetic component to antler growth. Similarly van den Berg & Garrick (1997) found high heritabilities among red deer (*Cervus elaphus*). An implication is that selection for animals with superior velvet antler growth can increase future antler production.

We used antler weight data collected during semi-domesticated reindeer velvet antler harvests to investigate what factors influence antler weight. We attempted to determine the effects of age, reproduction, body weight, Julian date, and annual variation on the weight of antlers of both male and female reindeer. These results can be used to increase velvet antler production on the Seward Peninsula as well as providing benchmark levels for monitoring changes in antler production due to changes in herd density or environmental conditions.

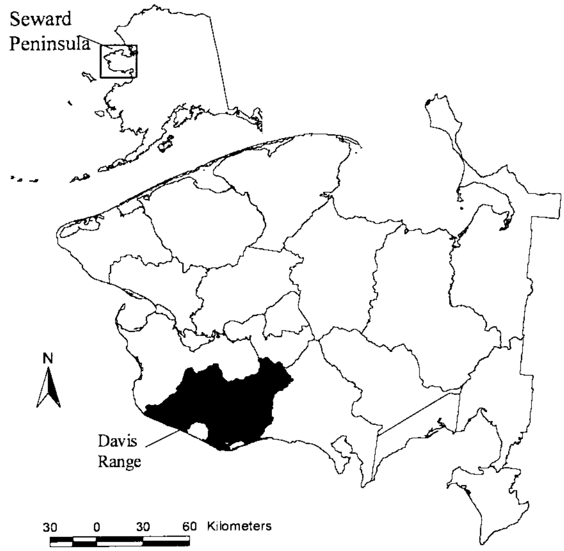

Fig. 1. Boundaries of Davis reindeer range on the Seward Peninsula, Alaska.

Methods

The Reindeer Research Program attended reindeer handlings conducted by herd owners and were allowed to weigh antlers after removal. Data consisted of 7155 observations from the reindeer herd of Lawrence Davis, that were handled in a corral located approximately 8 km north of Nome, Alaska (lat. 64°38'N long. 165°20'W). The herd has increased in size from about 3500 reindeer in 1987 to about 8000 reindeer in 1997. The range is 3875 km^2 stretching from coastline in the south to the Kigluaik Mountains in the north (Fig. 1).

Each animal was given a unique six-digit ear tag as a calf. Ear tag numbers, date, and reproductive status (castrated, not castrated for males; presence of a distended udder for females) were recorded. Some bulls were castrated, usually as yearlings. Adult animals were weighed to the nearest 0.5 kg using a Numak® pneumatic animal crush mounted on Tru-test® load bars. Age was calculated from individual capture records. Only known age animals were included in the analyses.

Velvet antlers were cut approximately 3 cm above the coronet during summer handlings and weighed using an O'Haus® balance. Weights were recorded ±10 g immediately after cutting. Handlings occurred from 23 May to 5 July, the mean date for all years was 21 June. Antlers from males were typically harvested earlier (mean date 13 June) than from females (mean date 26 June). Unless otherwise stated, all tests were run on log transformed antler weights of the form ln(antler weight + 1/6) (Mosteller & Tukey, 1977). Procedures for animal use conducted by University of Alaska personnel have been reviewed and accepted by the University of Alaska Animal Care and Use Committee.

Results

Male Antlers

Effect of age and date

The natural log of (antler weights + 1/6) kg from non-castrated males age 1 to 7 years old from the Davis herd (n = 1872) were analyzed using an Analysis of Covariance (ANCOVA) model with age as a categorical variable and Julian date and Julian date squared as covariates. Julian date squared was included to account for potential decrease in antler weight as ossification progressed. R^2 was 0.70, there were significant differences with age, Julian date, and Julian date squared ($P < 0.0001$; Fig. 2). The equation for antler weight as a function of Julian date for an average age of 2.64 years was:

$$\ln(\text{antler weight} + 1/6) = -11.3489 + 0.1312\,\text{Julian Date} - 0.000348\,\text{Julian Date}^2$$

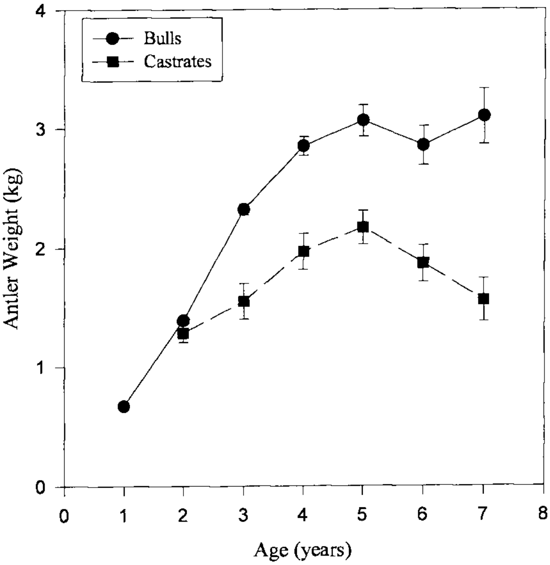

Fig. 2. Mean antler weights (± 1 standard error of the mean) from bulls and castrates on the Seward Peninsula Alaska.

According to this equation the maximum weight of antlers occurs at 7 July. Because this is two days after the last date of harvest, we have no evidence of decreases in antler weight as ossification occurs. Weights increased with age until age 5, but there was little increase in antler weight after age 4 (Fig. 2; Table 1).

Effects of castration

A Genetal Linear Model (GLM) was used to assess the effects of castration on subsequent antler weights. Age (2-7), reproductive status (castrated, non-castrated), and the interaction of the two were included as factors, and Julian date and Julian date squared were included as covariates (n = 1500).

Table 1. Mean weight (kg) of antlers from reindeer males age 1-7 years. All weights adjusted to mean date of harvest (13 June). L.C.L. and U.C.L. are lower 95% confidence limit and upper 95% confidence limit of the mean respecrively.

Age	Mean Wt. (kg)	L.C.L	U.C.L	n
1	0.504	0.482	0.527	524
2	1.335	1.288	1.383	501
3	2.297	2.214	2.383	437
4	2.759	2.627	2.898	235
5	2.868	2.658	3.094	97
6	2.717	2.452	3.009	54
7	2.962	2.541	3.448	24

Castrates had consistently lower antler weights than bulls of the same age after adjusting for date of harvest ($P < 0.0001$). There was also a significant interaction effect ($P < 0.0001$; $R^2 = 0.445$) most likely due to the high antler weights of castrated two year olds (Fig. 2).

Annual variation

Antler weights from male reindeer age 1 to 7 years from the Davis Herd were compared for nine years between 1987 and 1997. A GLM model was run using Julian date, and Julian date squared as covariates, year and age as factors. There were significant differences in male antler weight among years (n = 1869, $R^2 = 0.709$, $P < 0.0001$).

When ln(body weight) was included in the model both body weight and year were significant (n = 508; $R^2 = 0.780$; $P < 0.0001$) indicating that the annual variation in antler weight could not be entirely explained by differences in body weight.

Effect of Body Weight

Antler weights of non-castrated male reindeer age 1-6 years were compared for animals of known body weight at the time of antler harvest (n = 505). Age (categorical) and Julian date and ln(body weight) (continuous) were included in a GLM to determine the effects of age and ln(body weight) on male antler weights. Both variables were highly significant ($P < 0.0001$). Body weight was positively related to antler weight even after accounting for differences in age and date of harvest. The model explained 76.1% of the variation in the data. The interaction between age and ln(body weight) was not significant ($P = 0.56$) and therefore not included in the model. Including year in the model did not change the results (see above). The estimated model ignoring age differences was:

$$Y = 0.0000348 * X^{2.3599}$$

Where Y is antler weight in kg, and X is body weight in kg. This equation is adjusted to the mean harvest date of 13 June.

Female Antlers

Effect of age and date

Antler weights of females increased with age and Julian date. A GLM with age (categorical), Julian Date, and Julian date squared was conducted on ln(antler wt + 1/6). All three variables were highly significant ($P < 0.0001$), the model explained

Table 2. Mean weight (kg) of antlers from female reindeer age 1-10 years. All weights adjusted to mean date of harvest (25 June). L.C.L. and U.C.L. are lower 95% confidence limit and upper 95% confidence limit of the mean respectively.

Age	Mean Wt. (kg)	L.C.L	U.C.L	*n*
1	0.371	0.357	0.386	549
2	0.453	0.435	0.471	476
3	0.519	0.496	0.542	349
4	0.581	0.557	0.606	357
5	0.647	0.613	0.683	212
6	0.660	0.622	0.701	172
7	0.698	0.651	0.747	129
8	0.707	0.662	0.755	140
9	0.763	0.719	0.810	164
10	0.760	0.697	0.827	80

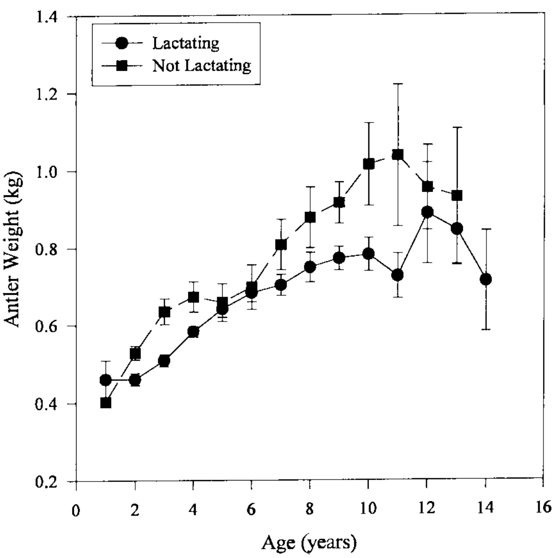

Fig. 3. Mean antler weights (± 1 standard error of the mean) of lactating and non-lactating female reindeer on the Seward Peninsula, Alaska.

29.0% of the variation (n = 2628). Antler weights appeared to continue increasing at least until age 9 (Fig. 3; Table 2). Antler weights also continued to increase until the last date of harvest (5 July). The interaction between age and Julian Date was not significant (P = 0.676) and therefore was not included in the model.

Difference Between Lactating and Non-lactating Females

Antler weights were lighter for lactating females than non-lactating females (Fig. 3; n = 2401, R^2 = 0.337; P < 0.0001) even when adjusting for age, Julian date, and year. Lactating females had significantly lighter body masses than non-lactating females after adjusting for age, and year (n = 789; P < 0.0001). Including ln(body weight) in the model for antler weight indicated that differences in antler weight were better explained by differences in body weight than differences in lactational status (Table 3).

Annual variation

The effect of year was compared for Davis herd females using a GLM with age and year as factors and Julian date and Julian date squared as covariates. There were significant differences in female antler weights among years (n = 2 618; R^2 = 0.315; P < 0.0001). If ln(body weight) and lactational status are both included in the analysis as covariates, year is still significant (Table 3), this indicates that the yearly differences can not be accounted for by differences in body weight or proportion lactating alone.

Effect of Body Weight

The effect of body weight on natural log of antler weight was estimated using a GLM with age (1-10) as a categorical variable, and Julian Date, Julian date squared, and weight as continuous variables (n = 855). The interaction of age and weight was not significant (P = 0.17) therefore it was not included in the model. Both age and body weight were highly significant (P < 0.0001). Body weight was positively related to antler weight even after controlling for differences in age and date of harvest. Similarly there were significant differences in antler weight

Table 3. Analysis of variance on ln(antler weights +1/6), for female reindeer from the Davis herd (n = 789; R^2 = 0.451). Results indicate that differences in antler weight for lactating reindeer can be explained by differences in body weight.

Source	SS	df	MS	F-ratio	*P*
Julian Date	0.498	1	0.498	5.943	0.015
Age	4.198	9	0.447	5.334	0.000
Lactation	0.072	1	0.072	0.854	0.356
Year	3.473	9	0.386	4.609	0.000
ln(Body Weight)	14.910	1	14.910	178.06	0.000
Julian Date^2	0.479	1	0.479	5.726	0.017
Error	64.140	766	0.084		

due to age independent of body weight. The estimated model ignoring age differences was:

$$Y = 0.00095*X^{1.487}$$

Where Y is antler weight in kg, and X is body weight in kg. This equation is adjusted to the mean harvest date of 27 June.

Correlation between Antler Weights in Consecutive Years
Antler weights from 698 females and 427 males were collected in two consecutive years. The Pearson Correlation between antler weight in $year_i$ and $year_{i+1}$ was 52.7 and 57.3 for females and males respectively, both were significantly different from zero ($P < 0.001$).

We also compared antler weight of individuals and body weight at one year of age to antler weight at two years of age. We used a GLM with ln(body weight age 1) and Julian date, and also a GLM with ln(antler weight age 1) and Julian date to predict ln(antler weight age 2). For females lactational status at age 2 was included as a variable. For males only antler weight was a significant, but only fair predictor ($n = 103$; $R^2 = 0.216$; $P = 0.0003$), Body weight at age one was not a good predictor of antler weight the following year ($n = 49$; $R^2 = 0.135$; $P = 0.585$). In females both antler weight at age one ($n = 94$; $R^2 = 0.215$; $P = 0.0006$), and body weight at age one ($n = 49$; $R^2 = 0.259$; $P = 0.047$) were significantly related to antler weight at age 2.

Discussion

We conclude, from other studies, that factors affecting antler weight and length are important for breeding success in male reindeer and foraging success in female reindeer. They are also of economic importance for reindeer herders of the Seward Peninsula. Determining the antler weights for each sex and age, as well as determining the effects of castration, lactation, and nutrition on antler growth can contribute to management decisions for future production.

Our results for antler weight changes with age are consistent with previous results for the same herd (Blodgett *et al.,* 1994). Antler weights of lactating females were significantly lighter than non-lactating females, this could be due to the energetic costs of pregnancy and lactation, hormonal changes due to pregnancy, or differences in date of initiation of growth. The fact that body weight was a better predictor of differences in antler weight than lactational status supports a nutritional explanation.

Castrated males had much lower subsequent antler weights. Lincoln & Tyler (1992) showed that the removal of gonads 1-2 weeks after birth does not block subsequent growth of antlers in either sex. In female reindeer, oestradiol induces the normal development of antlers (Lincoln & Tyler, 1999). Skjenneberg & Slagsvold (1968) reported that castrated males had antlers as large or larger than intact males. This difference may be due to different dates of initiation of antler growth or differences in ages (Fig. 2). If managing for high antler weights, males should only be castrated if scheduled for slaughter, although other factors such as potential increased range fidelity may make castration preferable.

Because antler weight increased with Julian date to July 5, harvest dates should be as late as possible while accounting for changes in antler quality, and ease of removal. Declining antler quality due to increased ossification may make early antler harvest necessary (Goss, 1983). Some variation in weights may be due to differences in harvesting practices with date. Typically as antlers grow and ossification progresses, antlers need to be cut higher on the beam, introducing a small negative bias with Julian date.

Antler weights showed annual variation not entirely explained by changes in body weight or Julian date. This could be caused by variation in resource availability (Scribner *et al.*, 1989) or diet composition caused by variation in date of green-up, or spring foraging locations. Mineral levels in the diet may be limiting antler growth (Ullrey, 1983) while not influencing summer body weight.

Moore *et al.* (1988) reported that antler weight at age two years was a better predictor of antler weights in red deer age 3-5 years than any measurements of body weight. However, a combination of 15-month liveweight and spike antler length was the best predictor of antler length. Selection of animals with low antler weights or low body weights for slaughter should increase the productivity of the herd. Based on our results, if selecting for heavier antlers, it is better to select for one year olds with heavy antlers than one year olds with high body weights. Because reindeer are also harvested for meat, selection should occur for both high antler weights and high body weights. In practice, antler size may be the most logistically practical indicator of genetic superiority. Accurate estimates of antler weight changes due to age structure, management practices, and environmental factors allows managers to improve predictions of effects of management decisions on antler production. Estimates presented here can be used to assess the effect of different harvest levels on future antler and meat production.

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