Growth and body weight of free-range reindeer in western Alaska

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Abstract: Total body weight of 9749 reindeer calves and 4798 adult reindeer were measured from 1984 to 1999 on the Seward Peninsula, western Alaska, USA. Growth rates of male and female calves, and annual growth patterns of adults were determined. Male calves grew faster than female calves. Reproductive females were lighter than non-reproductive females during summer but there was no effect of reproduction on average body weights the following winter. Adult males age 3-5 were heavier during summer than winter. Castrated males weighed the same as uncastrated males in summer, but were significantly heavier in winter, and did not display the large annual fluctuations in weight typical of reproductive males and females. Growth rates were higher and body weights greater in this herd than many other circumpolar reindeer populations. We suggest these kinds of physiological indices should be used to monitor the possible effects of spatial and temporal variation in population density and to evaluate changes in herding practices.

Key words: body mass, nutrition, *Rangifer tarandus,* reindeer husbandry.

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Introduction

Reindeer are an important livestock species in the circumpolar north. Currently there are approximately three million reindeer distributed across Russia, Scandinavia, Greenland, Iceland, Canada, and Alaska, with five hundred thousand animals slaughtered annually, producing over 20 000 metric tons of meat (Turi, 1998). The most widespread method used to increase production of the herds has been to increase density of animals on the grazing ranges. Densities have varied dramatically from 0.5/km^2 to 3/km^2 in Norway (Skogland, 1985), and 0.8/km^2 in Russia (Syroechkovskii, 1975). The majority of commercial production of reindeer in Alaska occurs on the Seward Peninsula. Currently there are 14 herds on 6 480 000 hectares of available rangeland with individual range permit areas averaging 405 000 hectares (Workman *et al.,* 1991). Herders employ an extensive management scheme where reindeer are allowed to range freely with infrequent herder contact and an absence of rotational grazing. The absence of close herd supervision requires that permit areas be stocked at low density to prevent localized overgrazing (Swanson & Pendelton, 1984). Since reindeer were first introduced to Alaska in 1891 (Stern *et al.,* 1980) it has been difficult to obtain estimates of densities on individual ranges. However, the total reindeer population on the Seward Peninsula has varied from a peak of 127 331 (2.2/km^2) reindeer during the 1930s (Stern *et al.,* 1980) to approximately 30 000 (0.53/km^2) during the early 1990s (Brown, 1997).

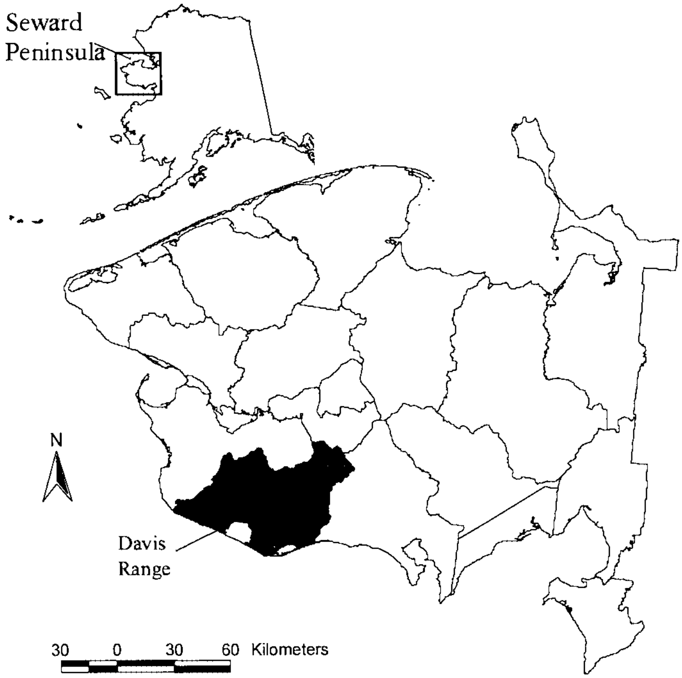

Fig. 1. Range of the Davis reindeer herd, Seward Peninsula, Alaska.

Most herds on the Seward Peninsula were undergoing good growth during the 1980s and early 1990s until many reindeer were lost to commingling and out-migration with the Western Arctic Caribou Herd (WACH), (Finstad *et al.*, in review).

Density-dependent effects, such as changes in growth rate and body weight, may arise as populations near ecological carrying capacity (Caughley, 1979; Skogland, 1983; Fox, 1999). Body weight of adult females in *Rangifer* influences conception rates (Dauphine, 1976; Ropstad *et al.*, 1991; Lenvik, 1988), calving time (Reimers, 1983; Cameron *et al.*, 1993), birth weights (Skogland, 1984), recruitment rate (Skogland, 1986; Post & Klein, 1999), and age at first reproduction (Leader-Williams & Rosser, 1983; Langvatn *et al.*, 1996; Prichard *et al.*, 1999). As population densities increase, a decline in growth rate and body weight (Skogland, 1983) will affect maximum sustained yield (Karter & Dieterich, 1989; Prichard & Finstad, 1999), and may indicate changes in range quality (Fox, 1999).

Presently, reindeer on the Seward Peninsula exhibit high productivity (Prichard & Finstad, 1999), but given the potential of overstocking, determination of growth rates and body weights of Alaskan reindeer can be used effectively to monitor the effects of spatial and temporal changes in population density and to evaluate changes in herding practices.

Study area

This study was conducted on the 3875 km^2 reindeer range of Lawrence Davis (Fig. 1), located on the Seward Peninsula, Alaska. Based on yearly handling records, the herd has increased in size from 4000 in 1987, to approximately 8000 animals in 1997, a rise in stocking rate of 0.9/km^2 to 2.1/km^2. Presently, the Davis range has the greatest stocking density on the Seward Peninsula. Overall, the range lichen biomass was estimated at 444 kg·ha^{-1} and a vascular plant biomass estimated at 866 kg·ha^{-1} (Swanson *et al.*, 1985). Predators include wolves (*Canis lupus*), wolverines (*Gulo gulo*), red foxes (*Vulpes vulpes*), and brown bears (*Ursus arctos;* Chetkiewicz, 1993). The mean monthly temperature for January is -15 °C, and for July temperature is 10.3 °C. Mean annual precipitation is 422 mm. Other large herbivores include moose (*Alces alces*), and muskox (*Ovibos moschatus*). Caribou from the WACH are not present on the Davis range.

Methods

Reindeer were herded into a corral located approximately 8 km north of Nome, Alaska (lat. 64°38'N, long. 165°20'W) biannually for censusing, velvet antler harvesting, castration, and veterinary care during the study period from 1984 to 1999. All calves received eartags with unique identification numbers. Weights to the nearest 0.5 kg were obtained by holding reindeer in a squeeze chute mounted on a Tru-test® livestock scale. Data were also collected on health of the animals, lactational status (the presence or absence of an udder in females; Bergerud, 1964), and date of castration for males. No supplemental feed was given. Relatively few castrated males (steers) were slaughtered pending completion of a slaughter and processing abattoir.

Between 1990 and 1999, a total of 9749 calves were weighed during summer handlings from 4

June through 8 July. In addition, 52 female and 36 male calf birth weights were collected in a separate study in 1991 and 1992 (Chetkiewicz, 1993). Gompertz growth curves (Seber & Wild, 1989) for each sex were fit to the mean weight for each handling date between birth and nine months of age using weighted nonlinear regression in Systat (SPSS, 1997). Mean values were weighted by the inverse of the standard errors. In addition, a linear regression was conducted on mean calf weights from summer handlings only (4 June to 8 July) to facilitate comparisons with other studies. Again, mean values were weighted by the inverse of the standard errors.

Adult weights were collected from 1984 to 1999 during summer (May to July) and from 1987 to 1992 during winter handlings (December and January). Comparisons between summer and winter weights were made using an Analysis of Variance (ANOVA) model for each sex separately. Female adult (age 1+) weights were analyzed in two groups, ages 1-3 and ages 4-10, due to varying effects of lactation status on young and mature reindeer. A total of 988 female weights, age 1-3 years, and a total of 1124 mature female weights, age 4-10 years, were used to analyze the effect of age, season (summer or winter), and presence of an udder. A total of 2088 castrated and non-castrated male (bulls) weights were used to analyze the effect of age (1-5), season (summer to winter), and castration.

Results

Calves

Three parameter Gompertz growth curves were of the form Weight (kg) = $A*\exp\{-e^{-K(age-I)}\}$ (Fig. 2). The parameters A, K, and I represent the asymptotic weight, the growth constant, and the inflection point, respectively. The partial derivative with respect to age is equal to $K*A/e$ at the inflection point, this represents the maximal rate of growth in kg·day^{-1} (Seber & Wild, 1989). Asymptotic weights were 56.7 kg for females and 61.0 kg for males (Table 1). The maximum growth rate ($K*A/e$) was 0.43 kg·day^{-1} for males and 0.37 kg·day^{-1} for females, occurring when animals were approximately 40 days old (41.7 for males, 40.7 for females).

In addition, we fit linear regressions to calf weights measured during summer handlings only (4 June to 8 July). Sex, age (days), and an interaction term were included in the model. Male growth rates (0.41 kg·day^{-1}, $s_{\bar{x}}$=0.017) were significantly (P=0.042) greater than female growth rates (0.36 kg·day^{-1}, $s_{\bar{x}}$=0.016). The model explained 84.0% of the variation in calf weight.

Females age 1-3

Body weight was analyzed using a three-factor ANOVA model including all two-way interactions. Age was treated as a categorical variable (1, 2, or 3). A total of 988 weights were included in the analysis. All terms were highly significant (P<0.005) except season*lactational status (P=0.062) and lactational status (P=0.316). Body weight was significantly higher in winter than in summer, although the difference decreased with increasing age (Fig. 3). The effect of lactational status changed with age. At age 1, lactating females were heavier than nonlactating females (P<0.001), at age 2 there was no difference (P=1.00), and at age three lactating females were lighter than nonlactating females (P=0.042; Bonferroni Multiple Comparison). The model explained 64.9% of the variance.

Females age 4-10

Body weights of females, age 4-10, were analyzed using age as a continuous variable due to small sample sizes of older females. A total of 1124 weights were included in an Analysis of Covariance (ANCOVA) model using lactational status, season, the

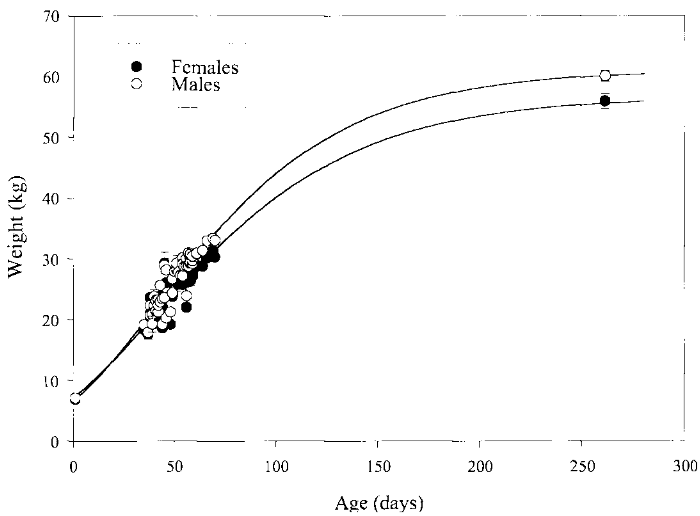

Fig. 2. Body weights ($\pm s_{\bar{x}}$) of male and female reindeer calves in western Alaska. Curve was fit using a Gompertz growth curve.

Table 1. Parameter estimates and asymptotic standard errors (A.S.E.) of Gompertz growth curves fit to weight data for reindeer calves from birth to age 8.5 months. A is asymptotic weight (kg), K is growth rate, and K*A/*e* is the maximum growth rate at the inflection point (kg·d^{-1}).

	A (kg)		K		Maximum Growth Rate (kg·d^{-1})	
	Estimate	A.S.E.	Estimate	A.S.E.	Estimate	A.S.E
Females	56.65	3.21	0.01792	0.0014	0.374	0.018
Males	61.00	2.59	0.01924	0.0013	0.432	0.020

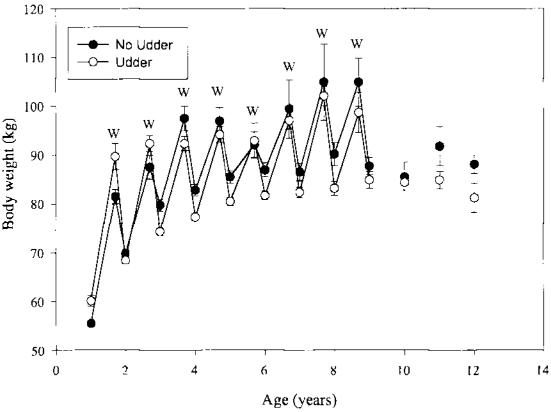

Fig. 3. Summer and winter body weights (+$s_{\bar{x}}$) of female reindeer based on presence or absence of an udder during summer handlings. "W" indicates winter weights.

interaction between lactational status and season, and age and age squared (Fig. 3). All terms were significant (P<0.016). Weight varied seasonally. Lactating females ($\bar{x}$=80.8 kg, s=10.3) were lighter than nonlactating females ($\bar{x}$=85.8 kg, s=10.4, P<0.0001) in summer but not in winter ($\bar{x}$=97.9 kg, s=11.0, P=1.00; Bonferonni Multiple Comparison). The model explained 29.7% of the variance.

Males

A total of 2088 weights were included in a three-factor ANOVA model using castration status (bull or steer), season (summer and winter), and age (1, 2, 3, 4, or 5) on body weight in males. All interaction terms were included. All terms were significant (P<0.0001) except the two-way interaction between age and castration status (P=0.647). Weights of both steers and bulls increased with age. After age 3, bulls lost weight from summer to winter, presumably due to the effect of the fall rut, while steers gained weight from summer to winter (Table 3, Fig. 4.). The model explained 74.3% of the variation. Steers age 3-5 were significantly heavier than bulls during the winter (P<0.0001) but not during the summer (P=1.00; Bonferroni Multiple Comparison).

Discussion

Growth rates and body weights of animals in this study were generally higher than those of other circumpolar adult reindeer (Reimers, 1983; 1985). This suggests that this range was providing good nutrition at the stocking densities existing during this study. Estimates of mean weights of adults in this study are probably a conservative estimate because reindeer are not corralled and weighed on the Seward Peninsula during the peak of body weight in autumn (Nichols, 1999).

Calf growth rates observed in this study were higher than those found on high quality Scandinavian ranges (Reimers, 1997). Winter calf weights observed were high, 60.1 kg for males, compared to male calf autumn weights reported for Scandinavian reindeer herds, 31.6-54.5 kg, (Reimers, 1997); and 55.9 kg for females compared to female calf winter weights from reindeer introduced onto South Georgia (41-48kg), (Leader-Williams Leader-Williams & Ricketts, 1982). Male calves had higher rates of growth than female calves in accordance with other studies (Haukioja & Salovaara, 1978; Lenvik *et al.,* 1988).

Growth rate of calves may be a good predictor of future changes in productivity due to heavy stocking levels or climate change. We fit a Gompertz growth curve to the data and then calculated the maximum daily weight gain. While this requires weight data to be gathered over a longer period of time, maximum growth rates among herds can be compared directly. We also estimated the linear growth rate over a short period of time to facilitate comparison with other studies. Because this is a sigmoidal relationship the rate of growth measured linearly will be negatively biased. Comparisons

Table 2. Weight gain in kg from summer handling in 1988 to winter handlings in January of 1989, of female reindeer with an udder and without an udder during the summer handling.

	No Udder			Udder		
Age	Wt gain (kg)	$s_{\bar{x}}$	*n*	Wt gain (kg)	$s_{\bar{x}}$	*n*
1.7	23.88	±1.49	24	25.67	±1.36	3
2.7	23	±1.33	9	26.88	±1.69	17
3.7	23.5	±1.88	6	19.48	±1.05	21
4.7	12.25	±4.64	4	18.71	±1.95	14
Total	22.56	±1.13	43	21.91	±0.96	55

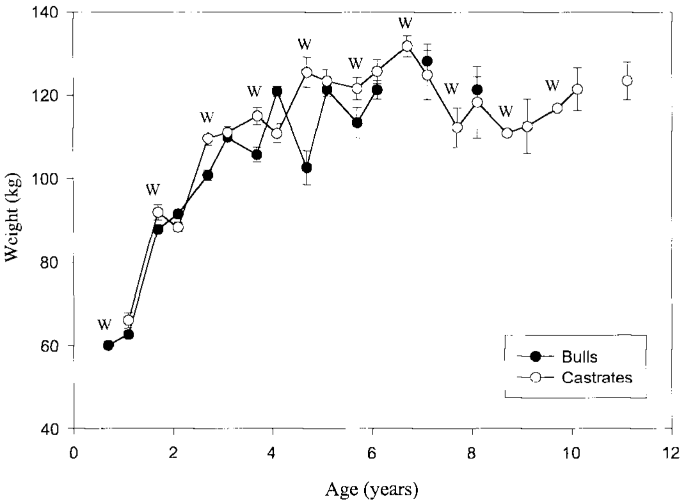

Fig. 4. Summer and winter body weights (±$s_{\bar{x}}$) of bull, and steer reindeer in Western Alaska. "W" indicates winter weights.

among herds using linear growth rate should only be made if data was collected at similar ages. As expected, growth rate measured linearly was smaller than the estimated maximal growth rate at the inflection point.

The high plane of nutrition available on this range apparently allows maintenance of adequate body weight even under the simultaneous energetic costs of reproduction and growth. In a number of caribou herds the energetic cost of lactation has been suspected to cause pauses in reproduction in multiparous females (Dauphine, 1976; Cameron, 1994). We were unable to detect any negative effect of lactation on weight gain from summer to winter or on body weight the following year. Females acquired enough nutrition during spring and summer to both successfully rear a calf and deposit sufficient stores for subsequent conception and fetal growth. This is consistent with findings that lactation in yearlings has no apparent negative effect on subsequent reproduction or weight gain in this herd (Prichard *et al.*, 1999).

The observed patterns of seasonal weight fluctuations in adults agree with previous studies (Leader-Williams & Ricketts, 1981). Females are much lighter in summer than in winter while males are heavier in summer than in winter. In females, increased expenditure of resources occurs during the early spring and summer to maintain fetal development and lactation. Daily maintenance energy requirements are twice as high for lactating females as for non-lactating females (Chan-McLeod *et al.*, 1994). In contrast, mature males expend considerable body reserves during rut in the fall and early winter (Hadwen, 1942; McEwan, 1968). Castrated males who are not allocating resources to reproduction showed a dampened seasonal fluctuation in weight similar to females. The contrast in seasonal weight fluctuation between bulls, steers, and females may influence the foraging strategy of each reproductive class. Partitioning of food resources occurs among species of markedly different body size in the Arctic (Klein & Bay, 1994) and may be extended to the level of a sexual dimorphism in foraging strategy among reindeer (Leader-Williams & Ricketts, 1981).

Table 3. Average total body weights in kg of male reindeer age 1-5 in western Alaska.

	Bulls				Steers			
Age	Summer (*s*)	*n*	Winter (*s*)	*n*	Summer (*s*)	*n*	Winter (*s*)	*n*
1	62.7 (11.2)	526	87.8 (9.2)	185	66.1 (10.2)	31	91.9 (7.5)	17
2	91.5 (12.6)	343	100.9 (11.2)	83	88.4 (11.1)	86	109.7 (10.1)	42
3-5	115.2 (15.4)	483	105.9 (13.2)	68	113.8 (14.8)	152	119.0 (15.4)	72

Reproductively active male and female reindeer may utilize different range resources at different times of the year as a result of this and other factors such as differences in predator and insect avoidance strategies.

A characteristic common to most *Rangifer* populations is increasing numbers on high quality ranges, followed by a decline due to density-dependent food limitation (Skogland, 1985). Overgrazed ranges may take decades to fully recover (Klein, 1987; Jefferies *et al.,* 1992). Avoiding range degradation, which compromises future animal growth, is patamount to the land manager and herd owner. Growth rates and body weights reported here suggest that the Davis range has provided good nutrition at stocking rates existing early in the study. Monitoring growth rate and body weight is important in detecting warning signs of a population that may be nearing ecological carrying capacity. Furthermore, the herd owner can use individual growth rate and body weight information to select for faster growing and larger body sized animals. Slower growing and smaller animals can be identified and selectively harvested out of the population. The herd owner can also use the predicted body weight of known age animals to determine the optimal demography of the herd and slaughtering schedule to maximize meat yield (Prichard & Finstad, 1999).

A number of reindeer herds on the Seward Peninsula are currently threatened by the expansion of the WACH (Finstad *et al.,* in review). Reindeer are being displaced from much of their traditional range to isolated refugia. Competition for forage by migrating caribou and harassment by the predators that follow them, as well as increased herder intervention will cause reindeer to increase expenditure of body reserves during fall and winter. Growth rates and body weight may decline as a result. Stocking densities and grazing pressure will also increase as animals are held on smaller grazing inclusions. Monitoring trends in reindeer weights will be useful for quantifying the possible effect of caribou range expansion on the productivity of Seward Peninsula reindeer.

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