PATTERNS OF WEIGHT GAIN AND LOSS FOR GRIZZLY BEARS IN NORTHERN CANADA

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Abstract: Seasonal weight change in the grizzly bear (*Ursus arctos*) in two populations in northern Canada was studied by fitting growth curves to spring and fall weights. The spring weight of females levels off soon after the average age of first reproduction; that of males continues to increase through maturity and eventually reaches nearly twice that of females. Males lost in winter 22% of their fall weight, the fraction changing very little with age. The weight change in females is much larger, and continues to increase with age, the oldest females gaining in summer 70% of their spring weight and losing in winter 40% of their fall weight. Mature females gain and lose not only relatively, but absolutely, more weight than males.

The grizzly bear undergoes an annual cycle in weight, gaining in summer when it is active and feeding, and losing in winter when torpid (Pearson 1975). This weight gain and loss has not, to date, been quantified in free-ranging grizzly bears. Some information has been obtained by comparing weights when the same bear has been fortuitously captured at different times, but such recaptures are few: Pearson (1975) gave only 4 values for winter weight loss, and 2 for rate of gain in fall; Russell et al. (unpubl. rep. for Parks Can., Can. Wildl. Serv., Edmonton, 1979) gave 3 for each.

In this paper, seasonal changes in weight have been studied by comparing growth curves fitted to age-weight data for spring captures and for fall captures. Wood et al. (1962) used a similar method, fitting growth curves of the von Bertalanffy type to the seasonal extremes of weight in subspecies of *Odocoileus hemionus*.

The data used here were obtained from studies on the grizzly bear in the Arctic mountains of the northern Yukon Territory, and on the Tuktoyaktuk Peninsula and Richards Island on the coast of the District of Mackenzie, Northwest Territories. These studies were undertaken to establish population status and life history parameters with which to evaluate the effect of hunting, and to provide baseline data for environmental impact assessment. The full reports are in preparation (by Pearson et al. and by Nagy et al.).

METHODS

Study areas were selected in the northern Yukon and on the Tuktoyaktuk Peninsula. The latter is topographically homogeneous and of low relief. The northern Yukon study area is topographically more varied and of higher relief. However, grizzly bears have been shown, by radio-collaring, to range widely both here and elsewhere (Pearson 1975; Russell et al., unpubl. rep. for Parks Can., Can. Wildl. Serv., Edmonton, 1979) so the population can be treated as genetically homogeneous.

Bears were immobilized by injection of phencyclidine hydrochloride, and weighed to the nearest kilogram by being suspended in a net from the cargo hook of a hovering helicopter.

A premolar tooth was taken from each bear and fixed for later decalcification, sectioning, and staining (Mundy and Fuller 1964, Stirling et al. 1977). Ages were determined by counting cementum annulations in sections at 100× magnification. Bears handled in May and June were assigned ages of $n + 0.3$ years; in late August and September, $n + 0.7$ years. Data for bears captured in midsummer were not used in this analysis.

A weighted least-squares method (Kingsley 1979) was used to fit von Bertalanffy growth curves of the form

$$W = W_\infty \, [\, 1 - exp \, (-kt - x) \,]^3$$

where W = weight (kg) at age t (years), W_∞ = asymptotic weight (kg), k = relative growth rate (per year), and x = fitting parameter; and to derive the standard errors and error correlations of the parameter estimates.

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Table 1. Parameters of growth curves, $W = W_\infty [1 - exp(-kt - x)]^3$, fitted to data on ages and weights of grizzly bears from two northern Canadian populations.

Population	Sex	Season	Sample size	Fitted values (standard error)			Error correlations		
				W_∞ (kg)	k (per year)	x	$W_\infty - k$	$W_\infty - x$	$k - x$
N. Mackenzie	M	Spring	41	190.6(11.1)	0.283(0.026)	0.4072(0.0282)	−0.702	−0.054	−0.516
		Fall	10	258.3(44.7)	0.230(0.090)	0.6120(0.1525)	−0.834	0.297	−0.703
	F	Spring	45	105.0(5.7)	0.409(0.049)	0.5055(0.0374)	−0.684	−0.043	−0.421
		Fall	19	198.9(25.6)	0.146(0.049)	0.9009(0.0994)	−0.874	0.044	−0.442
N. Yukon	M	Spring	24	190.4(16.9)	0.226(0.058)	0.3474(0.1250)	−0.844	0.571	−0.848
		Fall	19	222.4(17.9)	0.296(0.101)	0.4737(0.2682)	−0.755	0.553	−0.929
	F	Spring	24	91.0(5.1)	0.412(0.096)	0.3742(0.1722)	−0.728	0.583	−0.925
		Fall	18	162.5(12.9)	0.205(0.050)	0.7836(0.0839)	−0.829	0.052	−0.399

The data were separated by sex, season, and population, and equations for growth in weight fitted to each set. Females were not separated by reproductive state because the condition of females handled in fall could not always be determined, and separate samples would have been too small to be usable.

The equations relating weight to age were standardized by dividing by W_∞ for spring females, and compared between populations by multivariate T tests (Cooley and Lohnes 1971, Kingsley 1979). There being no significant differences, the weight data were standardized in the same way, the two populations were pooled, and a single curve was determined for each sex and season. The spring curves were assumed to represent growth in basal weight, and fall basal weights were interpolated. Components of weight were identified as: annual growth (next spring weight minus spring weight), winter maintenance (fall weight minus next spring weight), and the sum of these: summer weight gain (fall weight minus spring weight). These components were plotted against fall age. The allocation of summer weight gain to growth and winter maintenance, and comparisons of summer weight gain to spring weight, and of winter weight loss to fall weight, were also calculated and plotted.

RESULTS AND DISCUSSION

Bears of the Tuktoyaktuk Peninsula population were heavier, age for age, than bears from the Northern Yukon for both sexes in both seasons (Table 1) ($P \leqslant 0.01$ for spring females; $P \leqslant 0.05$ for spring males; $P \geqslant 0.05$ for both sexes in fall). However, the two populations showed very similar growth curves when weights were stan-

dardized (the highest F value was 1.67, the others less than 1.0), so pooling was unexceptionable. Growth curves for pooled data are shown in Fig. 1.

The sexes had quite different patterns of growth as shown by spring weight. The asymptotic spring weight, W_∞, for males was nearly twice that for females (Table 2), but males took 14 years to reach 95% of W_∞, against 9 years for
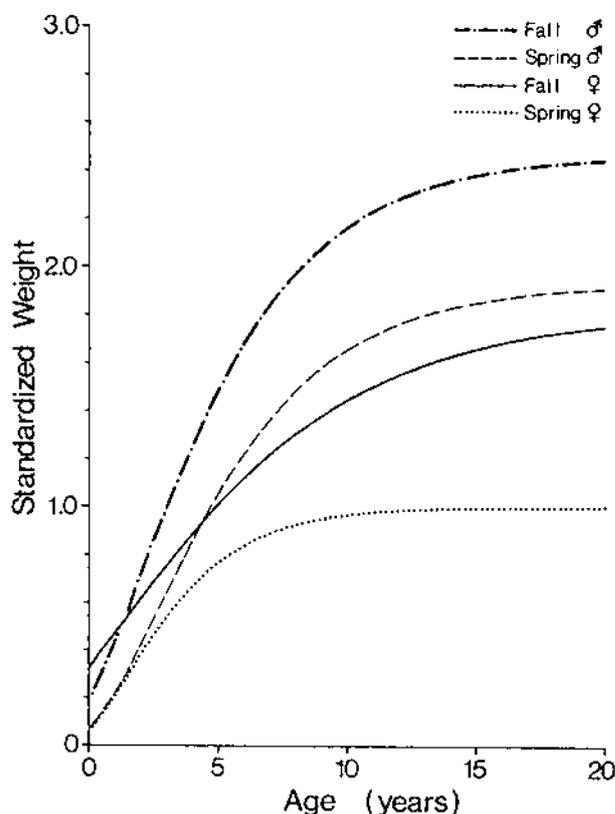

Fig. 1. Growth curves fitted to pooled standardized data on weights and ages of northern Canadian grizzly bears.

Table 2.   Parameters of growth curves, $W = W_\infty \left[1-exp(-kt-x) \right]^3$, fitted to pooled standardized[a] data on weights and ages of grizzly bears from northern Canada.

Sex	Season	Sample size	Fitted values			Standard errors			Error correlations		
			W_∞	k (per year)	x	W_∞	k (per year)	x	$W_\infty - k$	$W_\infty - x$	$k - x$
M	Spring	37	1.932	0.2587	0.4073	0.0837	0.0212	0.0266	−0.701	0.098	−0.621
	Fall	29	2.468	0.2595	0.5562	0.1746	0.0552	0.1204	−0.777	0.427	−0.839
F	Spring	69	1.004	0.3905	0.5103	0.0395	0.0356	0.0325	−0.687	0.005	−0.465
	Fall	37	1.820	0.1791	0.8320	0.1206	0.0344	0.0684	−0.844	0.157	−0.545

[a] All weights for each population were divided by W_∞ for spring females (Table 1) and populations pooled.

females (Table 3). The maximum rate of increase in basal weight was similar for the two sexes. These differences were similar to those found for polar bears (*Ursus maritimus*) (Kingsley 1979): males had much larger values for W_∞ and the age at which they reached 95% of W_∞, and the age for females to reach 95% of W_∞ was somewhat greater than the age of first reproduction. When females divert resources into reproduction, they stop growing; but large size is an advantage to males in intraspecific conflicts, and their size is limited only by resource availability for their own needs, so they continue to grow.

The fall weight of males was simply related to spring weight by a 28% increase in W_∞, with k and x being unchanged (Table 2), and winter maintenance stayed remarkably constant at 22% of fall weight (Figure 2). Weight more than tripled during the first summer; thereafter, the relative weight gain in summer fell continuously with
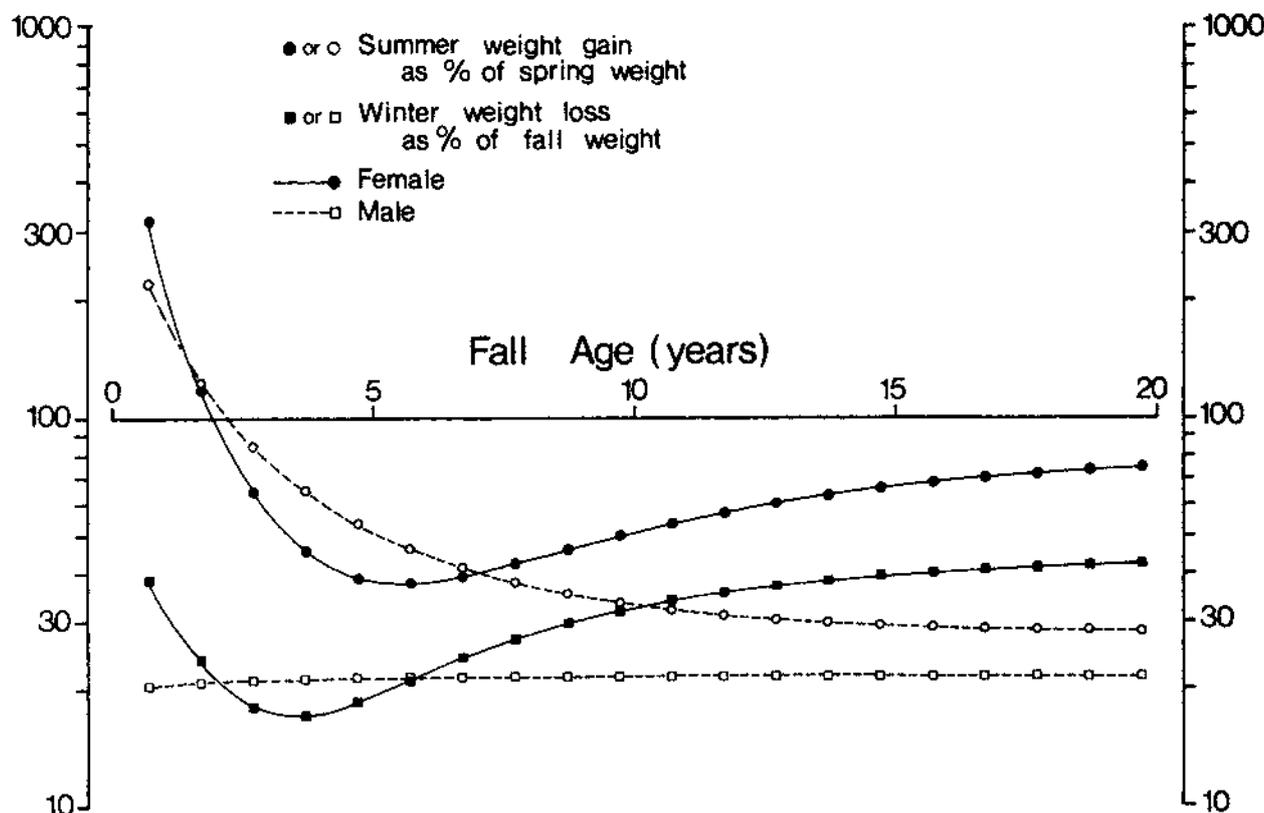

Fig. 2.   Annual weight gain and loss in grizzly bears as percentages, respectively, of spring weight and fall weight.
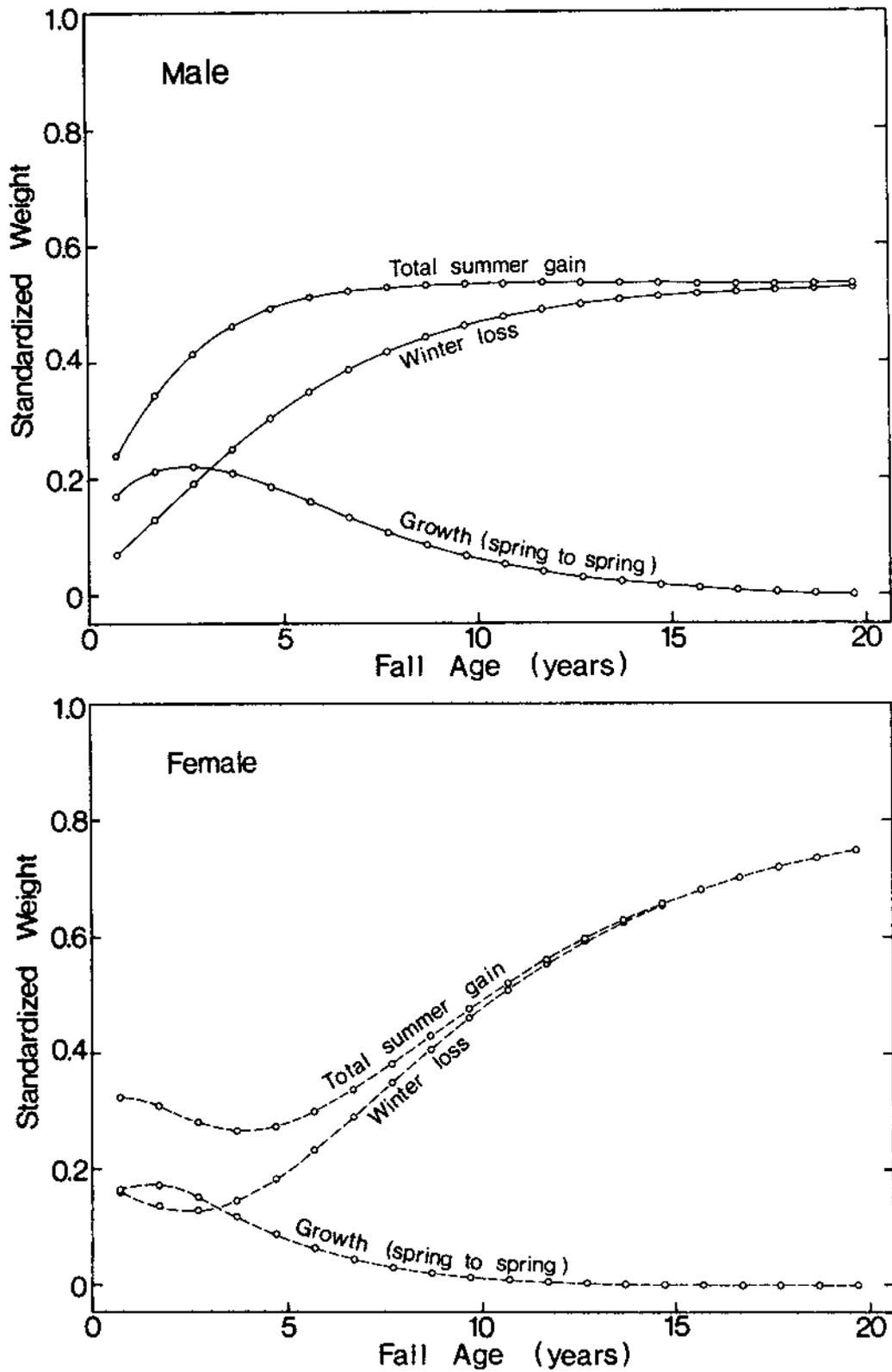
Fig. 3. Magnitude and allocation of summer weight gain in grizzly bear males (a) and females (b).

Table 3. Ages (in years) at which northern Canadian grizzly bears reached 95% of asymptotic weight, W_∞.

Sex	Season	Age (standard error)
Male	Spring	14.18(1.10)
	Fall	13.57(2.51)
Female	Spring	9.13(0.78)
	Fall	18.12(3.28)

age (Figure 2), although the absolute gain and loss both continued to increase (Figure 3a).

Mature females cycled more weight than males, both absolutely (Figure 3b) and relatively (Figure 2); and the gain and loss continued to increase through maturity, until the oldest females were cycling 70% of their spring weight. The 95% age for the fall weight of females (Table 3) and the low k value (Table 2) both reflected this. The relative weight gained and lost by females exceeded that for males from the age of first reproduction onwards. That females should have a bigger weight fluctuation than males was not surprising, since they are liable for energy costs of reproductive processes.

The continuing increase, throughout maturity, of the amplitude of the female weight cycle was hard to explain. It shows (Table 2) as a large difference in k between spring and fall, which was statistically significant at 0.1%. When the populations were analyzed separately, they agreed very closely in this, so it was probably not an artifact,

nor due to sampling error. Increasing knowledge and experience could have accounted for the increasing summer gain — but males also get more experienced, and they showed a steady *decrease* in relative summer gain. And if younger adult females had been prevented by inexperience from building up necessary reserves, then their rates of successful reproduction should have been low — which they were not.

In both sexes, the winter weight loss started to exceed the annual growth a year after the young became independent (Figure 3a, b). Young denning with their mother can to some extent use her body heat for warmth, and allocate more resources to growth.

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