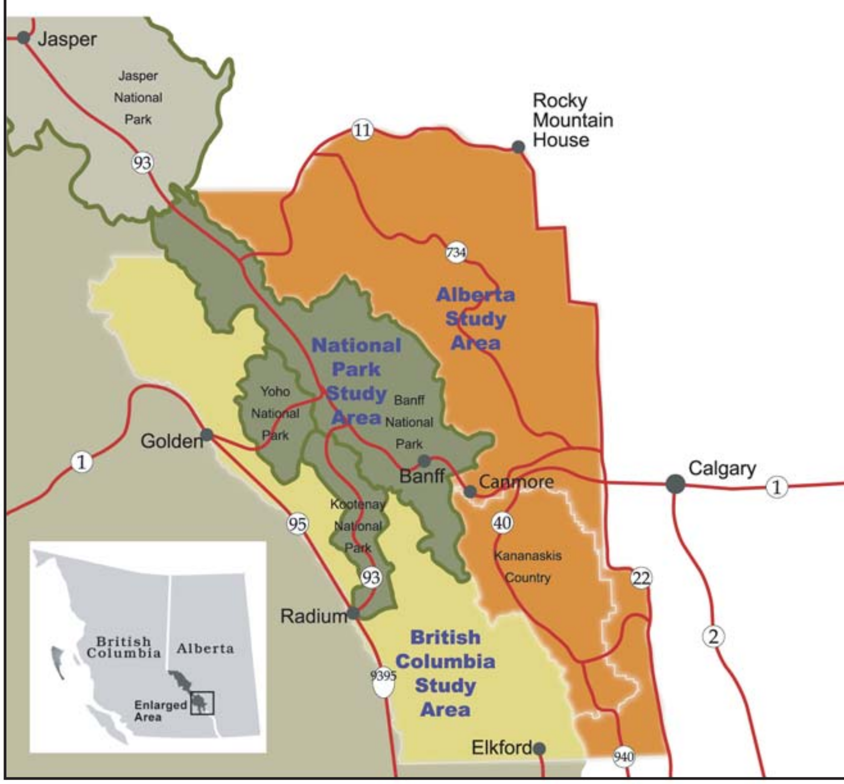
CHAPTER 8

NUTRITIONAL AND HORMONAL STATUS OF SOME EASTERN SLOPES GRIZZLY BEAR PROJECT BEARS AND POSSIBLE LINKS TO LOW REPRODUCTIVE OUTPUT



8.1 NUTRITIONAL AND HORMONAL STATUS OF SOME EASTERN SLOPES GRIZZLY BEAR PROJECT BEARS AND POSSIBLE LINKS TO LOW REPRODUCTIVE OUTPUT

Stephen Herrero

INTRODUCTION

In the absence of other constraints the population density of grizzly bears in a given area is predicted to increase as a linear function of landscape productivity (Senft et al. 1987). Bears' rate of reproduction varies across their range with varying availability of food (Ferguson and McLoughlin 2000). High seasonality of food availability and variation in foods available between years characterize bear populations found at high altitude or latitude. If reproductive success varies significantly between individuals and years then Ferguson and McLoughlin (2000) state that bet-hedging theory predicts a reduction in reproductive effort per year in order to live longer and reproduce more times, thereby sampling a larger number of reproductive conditions and increasing the number of offspring born in good conditions. Among interior populations of grizzly bears in North America, vegetational productivity (indexed by evapotranspiration), accounts for >90% of variation in age of first cub production with bears found in less productive areas first reproducing at later age (Ferguson and McLoughlin 2000).

Grizzly bears have one of the lowest reproductive rates of any terrestrial mammal (Bunnell and Tait 1981). For bears, reproductive output is directly related to body mass in the fall (Rogers 1976, Blanchard 1987, Stringham 1990, Schwartz and Franzmann 1991). With abundant nutritious foods supporting sufficient body mass litter sizes tended to be larger, age of first reproduction earlier, and intervals between litters shorter (Rogers 1977, 1987, Bunnell and Tait 1981, Stringham 1990). Mass needed for successful reproduction by female grizzly bears ranged between 95 and 200 kg (Stringham 1990). Heavier bears typically had the highest rates of reproduction. It is difficult for grizzly bear females to attain large mass if they fatten primarily on berries. Unless berry densities are high there may not be enough foraging time in a day to ingest sufficient berries to attain a large enough mass to reproduce (Welch et al. 1997). A high carbohydrate (berry), low protein diet also increases energy metabolism and this limits weight gain (Rode and Robbins 2000). Optimal weight gains for grizzly bears appear to occur with a diet where primary fattening foods include a combination of fruits, nuts and animal protein but not fruits alone (Mattson 1999, Rode and Robbins 2000, Felicetti et al. 2003).

There has been little study of nutrient availability for grizzly bears living in the ESGBP study area. Detailed study of seasonal availability of energy through foods can be used to understand reproduction and other aspects of grizzly bear ecology (Mattson 1999). Food habits of grizzly bears in the Cascade Valley portion (Rocky Mountain Front Ranges) of the ESGBP research area were studied 1976-1980 (Hamer 1985, Hamer and Herrero 1987a). The foraging season was short, reflecting a continental climate. High energy foods on which to fatten appeared restricted primarily to one berry species (*Shepherdia canadensis)* and the occasional availability of elk or other ungulates. Food availability may be better to the west of the Cascade Valley in the Rocky Mountain Main Ranges portion of the ESGBP study area. However, nutrient availability and significant seasonal fluctuation of nutrients throughout the year and year to year, probably limit reproductive potential and keep population densities relatively low (Wielgus and Bunnell 1994, Proctor 1998). Fire suppression in the Cascade Valley region was suggested to have resulted in decreased nutrient availability for grizzly bears (Hamer and Herrero 1987b). Since then prescribed fire may have improved habitat quality somewhat (Hamer 1996, 1999).

Other factors in addition to nutritional state are also thought to constrain reproduction in grizzly bears. Female grizzly bears must live to reproductive age and then survive through their reproductive years. For Rocky Mountain grizzly bear populations that were stable or increasing there was an adult female survival rate of at least 0.92 (McLellan 1989, Wielgus and Bunnell 1994, Eberhardt et al. 1994, Weaver et al. 1996, Garshelis et al. 2005). Another possible constraint on reproductive output is competition between sexes whereby males may displace adult females from productive habitat (Wielgus and Bunnell 1994, Mattson

1999). Female grizzly bears have also been shown to underutilize productive habitat as a result of its proximity to people's developments or activities (Mattson et al. 1987, McLellan and Shackleton 1988, Kasworm and Manley 1990, Mace et al. 1996, Gibeau 2000).

ESGBP research was conducted 1994- 2002. Reproductive data were obtained from 30 female bears aged 6–27 years old. The project accumulated 143 bear-years of reproductive information on adult-age animals, and was able to back-fill another 12 bear-years. Demographic analysis showed this population had one of the lowest reproductive outputs of any population studied in North America (Garshelis et al. 2005). Average age of first reproduction of a surviving cub litter was 8.4 years, average litter size 1.84. Age of first reproduction is considered to be a reproductive parameter particularly sensitive to local conditions for bears (Noyce and Garshelis 1994, Ferguson and McLoughlin 2000). The combination of long inter-litter intervals (4.4-4.5 years) and small litter sizes gave a reproductive rate of 0.17 female offspring reaching independence per female per year. Considering also the effects of delayed age of first birthing, bears in this population had the lowest potential lifetime cub production of any *Ursus arctos* population yet studied (Garshelis et al. 2005). Low body mass for ESGBP females (mean 96 kg, Chapter 4, this report) probably contributed to low reproductive output (Stringham 1990).

In this section of the ESGBP final report we present preliminary findings regarding nutrition. We used a Body Condition Index (BCI) (Cattet et al. 2002) and reproductive hormone levels to compare the nutritional status of ESGBP bears with a more productive population found in and east of Jasper National Park in the Foothills Model Forest grizzly bear study area, northwest of the ESGBP population, along the eastern portion of Jasper National Park and the adjacent foothills (G. Stenhouse. Alberta Sustainable Resource Development, Hinton, Alberta, Canada, personal communication, 2003). We also used stable isotope analysis of hair to estimate the percentage contribution of plants and animals to grizzly bear diet.

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8.2 STUDY AREA AND TRAPPING LOCATION

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The ESGBP study area was the 41,000 km^2 Central Rockies Ecosystem (CRE), an area straddling the continental divide of Alberta and British Columbia (Komex 1995). All trapping of grizzly bears was done within the major eastern slopes portion of the study area, the Bow River Watershed of Alberta (Gibeau 2000). The climate is continental with long, cold winters and short, cool summers (Janz and Storr 1977). Vegetation development goes through major seasonal variations driven by snow cover during winter. Most of the landscape falls into relatively high elevation major ecoregions: montane (1300-1600 m), subalpine (1600-2300m) and alpine (>2300m). Topographic features include mountains with substantial unvegetated portions. Forty-eight percent of the Banff National Park portion of the study area was unsuitable for grizzly bear foraging, primarily because it was covered with rock, ice, water or bare soil (Gibeau et al. 2001). Less unusable habitat was found in Alberta portions of the study area such as Kananaskis Country (21% unusable). Major valley bottoms are the most productive areas and many of these have development such as highways, railway, and settlement. Additional details regarding the ESGBP study area can be found in Chapter 2 of this final report and Gibeau (2000).

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8.3 COMPARISON OF SELECT HEALTH DATA BETWEEN THE EASTERN SLOPES (ESGBP) AND THE FOOTHILLS MODEL FOREST GRIZZLY BEAR PROJECTS (FMFGBP)

Marc Cattet, Nigel Caulkett, Mike Gibeau, Stephen Herrero, Janice Bahr, Judith Van Cleef, and Gordon Stenhouse

In effort to seek potential explanations for low cub production by Eastern Slope grizzly bears, a comparison of select health parameters was made between Eastern Slopes and Foothills Model Forest Grizzly Bear Project bears. The parameters considered were body condition as a reflection of nutrition and reproductive hormone levels as a reflection of reproductive function. The working hypothesis was that reduced reproductive output in Eastern Slopes grizzly bears is a result of low energy uptake causing diminished reproductive function.

Using the definition of body condition as the “combined mass of fat and skeletal muscle in an animal relative to its body size”, we estimated and compared the body condition of grizzly bears captured in both projects by the Body Condition Index or BCI (Cattet et al. 2002). BCI values are calculated as the standardized residuals from the regression of total body mass against a linear measure of size, body length, and range in value from –3.00 to +3.00. Eastern Slopes grizzly bears tended to be in poorer body condition than FMF grizzly bears captured at the same time of year, a difference that was most notable among adult males (Table 1).

Table 1. Comparison of Body Condition Index (BCI) values between the Eastern Slopes and Foothills Model Forest Grizzly Bear Projects for grizzly bears captured during either May or June.

	Body Condition Index[A] (mean ± SE; [*n*])		
Sex (Age Class)	**ESGBP**	**FMFGBP**	**Statistical Significance[B] (*p*)**
Female (all ages)	-0.43 ± 0.13 [22]	-0.13 ± 0.13 [37]	0.14[ns]
- subadult (< 5 yrs)	-0.59 ± 0.38 [6]	-0.25 ± 0.25 [16]	0.48[ns]
- adult (≥ 5 yrs)	-0.37 ± 0.11 [16]	-0.04 ± 0.13 [21]	0.08[ns]
Male (all ages)	-0.16 ± 0.23 [21]	+1.00 ± 0.22 [23]	< 0.001***
- subadult (< 5 yrs)	-0.45 ± 0.35 [9]	+0.47 ± 0.29 [10]	0.06[ns]
- adult (≥ 5 yrs)	+0.05 ± 0.31 [12]	+1.41 ± 0.29 [13]	0.004**

[A] Mean BCI values were compared between studies using a *t*-test for two independent samples.
[B] Statistical significance was assigned when the probability of a Type I error was equal to or less than 0.05. Non-significant = ns, $p \leq 0.001$ = **, and $p \leq 0.001$ = ***.

As an index of reproductive function, blood serum concentrations of various reproductive hormones were compared between grizzly bears captured in the two studies (Tables 2 and 3). In both sexes, luteinizing hormone (LH) concentrations were significantly lower in Eastern Slopes bears than in FMF bears. In mammals, LH is secreted from cells of the anterior pituitary gland and stimulates development of the ovaries in females and the testes in males. Further, LH stimulates secretion of sex steroids from the gonads – estrogens (including estradiol) from the ovaries and testosterone from the testes. Diminished secretion of LH can result in failure of gonadal function which manifests in females as cessation of reproductive cycles and in males as failure in production of normal numbers of sperms. Although information is lacking on normal serum concentrations of LH in grizzly bears, these results cannot be used to rule out the possibility of diminished reproductive function in Eastern Slopes bears, especially when considered in conjunction with body condition results (Table 1). In mammals, the function of the reproductive system is dependent on the availability of energy in the environment. In several species, fasting and caloric restriction have been shown to cause the suppression of LH secretion, a mechanism that probably prevents energy being wasted for reproduction (Caprio et al. 2001, Gong 2002).

Table 2. Comparison of reproductive hormone concentrations between the Eastern Slopes and Foothills Model Forest Grizzly Bear Projects for female grizzly bears captured by leg-hold snare during either May or June.

	Serum Concentration[A] (mean ± SE)		***Statistical***
Hormone (Units)	**ESGBP (*n* = 14)**	**FMFGBP (*n* = 29)**	**Significance[B] (*p*)**
Progesterone (ng/ml)	2.54 ± 0.63	2.82 ± 0.35	0.67^{ns}
Estradiol (pg/ml)	10.6 ± 1.2	13.5 ± 1.0	0.11^{ns}
Luteinizing hormone (ng/ml)	0.13 ± 0.05	0.39 ± 0.08	0.006**
Testosterone (ng/ml)	0.28 ± 0.05	0.29 ± 0.04	0.89^{ns}

[A] Mean hormone concentrations were compared between studies using a *t*-test for two independent samples.
[B] Statistical significance was assigned when the probability of a Type I error was equal to or less than 0.05. Non-significant = ns and $p \leq 0.01$ = **.

Table 3. Comparison of reproductive hormone concentrations between the Eastern Slopes and Foothills Model Forest Grizzly Bear Projects for male grizzly bears captured by leg-hold snare during either May or June.

	Serum Concentration[A] (mean ± SE)		***Statistical***
Hormone (Units)	**ESGBP (*n* = 16)**	**FMFGBP (*n* = 17)**	**Significance[B] (*p*)**
Luteinizing hormone (ng/ml)	0.07 ± 0.04	0.33 ± 0.09	0.01*
Testosterone (ng/ml)	0.85 ± 0.26	0.91 ± 0.22	0.86^{ns}

[A] Mean hormone concentrations were compared between studies using a *t*-test for two independent samples.
[B] Statistical significance was assigned when the probability of a Type I error was equal to or less than 0.05. Non-significant = ns and $p \leq 0.05$ = *.

Results from a comparison of body condition and reproductive hormone concentrations between Eastern Slopes and FMF bears cannot be used to disprove the hypothesis that reduced reproductive output (long interval between litters and low reproductive rate) in Eastern Slopes grizzly bears is a result of low energy uptake (especially in males) causing diminished reproductive function. Future research directions should include the assessment of body condition in a larger sample of bears, especially adults, and the assessment of reproductive function in female and male adult bears. Ideally, assessment of reproductive function should involve ultrasonographic examination of the gonads of both female and male bears, and spermatologic examination of semen samples collected from males. This data should be evaluated in relation to circulating concentrations of reproductive hormones measured in blood serum samples taken at the time of examination.

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8.4 DIET OF SOME EASTERN SLOPES GRIZZLY BEAR PROJECT BEARS AS DETERMINED USING STABLE ISOTOPE ANALYSIS

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Isotopic analysis of ESGBP grizzly bear hair was conducted to further comment on the hypothesis that low reproductive output might be due to low energy intake. Analysis of stable isotopes of carbon and nitrogen present in hair indicate the dietary contribution of plant versus animal tissue. Since hair is replaced each year in bears the values reflect the diet consumed during growth of the hair.

METHODS

Samples of hair were collected from all bears captured and sedated as part of the ESGBP. A sample of these was sent to Dr. Charles T. Robbins' lab at Washington State University, Pullman, for isotopic analysis. Sample size was small, 5 adult female and 4 adult male bears. Isotope signatures vary geographically (Garten 1993, Chamberlain et al 1997) hence a herbivore baseline was required for the Eastern Slopes Grizzly Bear Project (ESGBP) ecosystem. Hair samples from ungulates killed 2001 to 2003 in Banff National park were provided by Parks Canada with the help of Dr. Todd Shury. The ungulates sampled included mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*) and elk (*Cervus elaphus*). The isotope signatures of the ungulate hair were then used to develop herbivore baselines for the ESGBP study area.

Hair samples were treated with a 2:1 chloroform:methanol solution to remove oils, dried, and ground into a fine powder in liquid nitrogen (Hilderbrand et al. 1996). Samples were weighed into tin boats and analyzed for $\delta^{15}N$ by continuous flow methods using a Carlo Erba NC2500 elemental analyzer coupled to either a Micromass Optima mass spectrometer or a Finnigan Delta Plus XL mass spectrometer (Fry et al. 1992). $\delta^{13}C$ was not analyzed as all samples were expected to have a uniform, terrestrial, C_3-based signature. Results are reported as per mil ratios (‰) relative to atmospheric N ($\delta^{15}N$) with internal laboratory standards calibrated against US Geological Survey 25 ($\delta^{15}N$ = -30.4‰), and USGS 26 ($\delta^{15}N$ = 53.7‰) values. Internal reproducibility based on hundreds of standards run over the last 5 years is $\pm$ 0.2‰.

Dietary meat calculations are as in Hilderbrand et al. (1996) in which each $\delta^{15}N$ is solved for the respective bear signature that would occur if that species had been consumed as the entire diet. The trophic enrichment (4.3 if consuming deer and 4.4 for elk) was then used to estimate the percent meat represented by the difference in each bear's $\delta^{15}N$ above the herbivore baseline represented by the mean ungulate signature.

RESULTS AND DISCUSSION

The ungulates had significantly different $\delta^{15}N$ signatures (mule and white-tailed deer = 5.6±1.2, n=15; elk = 3.6±1.2, n=9). When using the deer baseline, the grizzly bear population is estimated to be entirely herbivorous (Table 1). When using the elk baseline, meat is a more significant percent of the assimilated diet (Table 1).

Table 1: Male and female grizzly bear isotopic values and their implications regarding percentage composition of plant and animal matter in diet.

ESGBP #	ESGBP Bear Information	$\delta^{15}N$	Deer – based[1]		Elk – based[2]	
			% Meat	% Plant	%Meat	% Plant
10	Adult male grizzly #10. April 19, 1997	4.6	0	100	23	77
12	Adult male grizzly #12. May 17, 1994	5.7	2	98	48	52
14	Adult male grizzly #14. June 1994	5.7	2	98	48	52
42	Adult male grizzly #42. June 15, 1997	4.7	0	100	25	75
	Male Mean ± 1 SD	5.2±0.6	1±1	99±1	36±14	64±14
28	Adult female grizzly #28	4.7	0	100	25	75
30	Adult female grizzly #30. May 26, 1997	5.3	0	100	39	61
33	Adult female grizzly #33. August 30, 2000	3.7	0	100	2	98
36	Adult female grizzly #36.	3.7	0	100	2	98
59	Adult female grizzly #59. June 23, 2001	3.6	0	100	0	100
	Female Mean ± 1 SD	4.2±0.8	0	100	14±17	86±17
	Total Mean ± 1 SD	4.6±0.8	0	100	23±19	77±19

[1] Deer based herbivore baseline. Deer hair $\delta^{15}N$ mean ± 1 SD = 5.6 ±1.2 (n=15).
[2] Elk based herbivore baseline. Elk hair $\delta^{15}N$ mean ± 1 SD = 3.6 ±1.2 (n=9).

The higher estimated mean meat percentage in the assimilated diet of male versus female grizzly bears when using the elk baseline is typical of interior grizzly bear populations. Although the baseline signatures of deer and elk differed, the isotope values indicate that this grizzly bear population depends on plant matter for the bulk of its nourishment. The low reproductive output of the population probably reflects this relatively low energy diet. The small number of grizzly bears sampled suggests caution with the results.

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