

Hematologic, biochemical, and endocrine characteristics of bobcats during a prey decline in southeastern Idaho

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We studied the hematology and blood chemistry of 33 adult bobcats (*Felis rufus*) captured from 1982 through 1985 in southeastern Idaho during a decline in lagomorphs, their major prey. Our objectives were to relate blood physiology of bobcats to sex, season, and a decline in abundance of black-tailed jackrabbits (*Lepus californicus*) and Nuttall's cottontail rabbits (*Sylvilagus nuttallii*). Males had higher ($P < 0.10$) erythrocyte counts (RBC) and hemoglobin levels (Hb) and lower ($P < 0.10$) insulin concentrations than females. Bobcats sampled during spring had higher ($P < 0.10$) mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and insulin levels, and lower ($P < 0.10$) Hb, packed cell volume (PCV), RBC, and cholesterol levels than bobcats captured in autumn. The decline in lagomorph prey abundance from 1982 to 1983 was reflected in bobcat blood by lower ($P < 0.10$) phosphorus and insulin levels and higher ($P < 0.10$) Hb, RBC, and PCV. Progesterone levels in females reflected field results indicating that reproduction was curtailed when prey was scarce.

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Nous avons étudié l'hématologie et la chimie du sang chez 33 Lynx roux (*Felis rufus*) adultes capturés entre 1982 et la fin de 1985 dans le sud-est de l'Idaho, au cours d'une période de déclin des populations de lagomorphes, leurs principales proies. Notre objectif était d'établir la relation entre la physiologie du sang des lynx d'une part, et, d'autre part, leur sexe, la saison, et la diminution d'abondance des Lièvres de Californie (*Lepus californicus*) et des Lapins de Nuttall (*Sylvilagus nuttallii*). Chez les mâles, le nombre d'érythrocytes (RBC) et la concentration d'hémoglobine (Hb) étaient plus élevés ($P < 0,10$) et la concentration d'insuline, plus faible ($P < 0,10$) que chez les femelles. Chez les lynx capturés au printemps, le volume moyen des globules (MCV), la concentration moyenne d'hémoglobine dans les globules (MCH) et la concentration d'insuline étaient plus élevés ($P < 0,10$), alors que la concentration d'hémoglobine, l'hématocrite (PCV), le nombre d'érythrocytes et la concentration de cholestérol étaient plus faibles que chez les lynx capturés à l'automne. La réduction de l'abondance de lagomorphes entre 1982 et 1983 se reflétait dans le sang des lynx : le phosphore et l'insuline étaient réduits ($P < 0,10$), alors que l'hémoglobine totale, le nombre d'érythrocytes et l'hématocrite étaient plus élevés ($P < 0,10$). La concentration de progestérone mesurée chez les femelles correspondait bien aux résultats obtenus en nature qui indiquaient que la reproduction était entravée par la réduction de l'abondance des proies.

[Traduit par la rédaction]

Introduction

Examination of blood profiles is included in ecological studies to determine the health and nutritional status of animals (Fuller et al. 1985; Franzmann and Schwartz 1988; DelGiudice et al. 1987a, 1987b; Hellgren et al. 1989) and to allow inferences to be made about the quality of the animals' environment (Seal et al. 1975; Seal et al. 1978; Messier 1987). Serum chemistry and hematology of wild felids are influenced by sex, age, capture method (Beltran et al. 1991; Iberian lynx, *Lynx pardina*), and erythroparasite load (Kocan et al. 1985; bobcat, *Felis rufus*).

Here we describe the physiological status of a free-ranging bobcat population in southeastern Idaho subjected to a decline in the prey base. The primary prey of bobcats in southeastern

Idaho, black-tailed jackrabbits (*Lepus californicus*), declined after a cyclic peak in 1981 at an annual finite rate of $\lambda = 0.08-0.53$; populations of Nuttall's cottontails (*Sylvilagus nuttallii*) also declined concurrently at $\lambda = 0.09-0.73$ (Knick 1990). Lagomorphs accounted for 63–76% of the bobcats' winter diet and 18–91% of their summer diet during this period (Knick 1990). Bobcats ceased reproduction and the population declined in response to prey shortage. As a further indication of stress, individuals made long-distance forays and 3 marked bobcats starved to death because few alternative prey were available to buffer the lagomorph decline (Knick 1990).

Blood characteristics of captive animals indicate lowered metabolic activity (lower serum triiodothyronine (T_3) concentration) and hemoconcentration (higher hemoglobin level (Hb), higher erythrocyte count (RBC), and higher packed cell volume (PCV)) in response to food deprivation (Harlow and Seal 1981; DelGiudice et al. 1987b; Eales 1988). We expected to find similar responses in the blood profiles of the bobcats in our study. In addition, we examined the blood characteris-

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TABLE 1. Indices of lagomorph abundance from 1982 through 1985 in southeastern Idaho

Year	Spotlight counts of jackrabbits (no./km)	Fecal pellet plots (no./ha)	
		Jackrabbits	Cottontails
1982	0.30–1.34	1.20–2.76 ^a	
1983	0.05–0.47	0.57–0.91	2.44–10.86
1984	0.00–0.04	0.16–0.67	1.41–9.04
1985	0.00–0.03	0.12–0.27	0.61–2.98

NOTE: Spotlight counts were of jackrabbits only. Lagomorph densities were estimated from numbers of fecal pellets by conversion factors (Knick 1990). Cottontail rabbit densities were not determined for 1982. Results are from Knick (1990) except where noted.

^aData from Gates (1983) and Grant (1987).

tics of bobcats relative to sex and season of the year. Concurrence of field and captive results would support the role of blood studies in evaluating the physiological status of free-ranging populations.

Methods

Study area

We studied bobcats and their prey in the grounds of the Idaho National Engineering Laboratory (INEL) (43°, 112°W) and surrounding desert in southeastern Idaho from 1982 to 1985. The habitat was primarily sagebrush (*Artemisia tridentata*) flats punctuated by craters, collapsed lava tubes, lava flows, rock outcrops, and buttes of volcanic origin (Nace et al. 1975; McBride et al. 1978). Mean winter (December–March) temperatures during our study were –6°C in 1981–1982, –4°C in 1982–1983, –8°C in 1983–1984, and –12°C in 1984–1985. Maximum snow depths were 14 cm in 1981–1982, 25 cm in 1982–1983, 37 cm in 1983–1984, and 44 cm in 1984–1985. Winter weather in 1984–1985 consisted of longer periods of deeper snows and more extensive low temperatures relative to winters 1981–1982 through 1983–1984 (Knick 1990, p. 10).

Capture and blood sampling

We sampled blood from 18 bobcats (8 females (F), 10 males (M)) in 1982, 17 (7 F, 10 M) in 1983, and 7 (3 F, 4 M) in 1984–1985. All bobcats were >11 months of age (estimated mean birth date 1 May) at time of sampling and were independent hunters (determined from radiotelemetry).

We livetrapped bobcats using unpadding No. 2 coil-spring leg-hold traps from January 1982 through March 1985. Traps were checked daily before 12:00, and no serious trap-related (\geq class III; van Ballenberghe 1984) injuries resulted. In spring 1984 and 1985, blood was sampled from 2 bobcats captured in box traps and 1 bobcat that was manually restrained.

Captured bobcats were anesthetized with an intramuscular injection of 11 mg/kg body weight of ketamine hydrochloride and 0.05 mg/kg body weight of promazine hydrochloride administered via a pole syringe. Captured bobcats were sexed, weighed, and ear-tagged, and individuals >8 kg were radio-collared.

Blood was drawn from each captured bobcat via the brachial or femoral vein into one 5-mL tube containing EDTA anticoagulant, and one or two 10-mL tubes without anticoagulant for serum analyses. Mean time of blood sampling was 33.1 ± 2.3 (SE) min ($n = 42$) after the drugs were first administered. Each bobcat received an intramuscular injection of 300 000 units benzathine penicillin and 300 000 units penicillin G procaine to reduce potential infection from capture activities after blood was taken.

Blood analysis

Whole blood was analyzed for Hb by the spectrophotometric cyanmethemoglobin method, RBC was determined by means of an auto-

TABLE 2. Blood characteristics of bobcats sampled in southeastern Idaho that were affected by sex, season, or year interactions

Interaction	RBC ($10^6/\mu\text{L}$)			PCV (%)			MCH (pg)		
	N	Mean	SE	N	Mean	SE	N	Mean	SE
Females \times spring	9	6.8	0.2	9	38.2	1.5	8	18.6	0.2
Males \times spring	8	8.1	0.3	8	44.9	1.9	8	17.6	0.3
Females \times fall	5	8.2	0.3	5	43.6	1.3	4	17.2	0.5
Males \times fall	12	8.4	0.2	12	43.5	1.4	11	17.3	0.3

NOTE: RBC, red blood cells ($F = 6.51$, $P = 0.01$); PCV, packed cell volume ($F = 4.54$, $P = 0.04$); MCH, mean corpuscular hemoglobin ($F = 3.18$, $P = 0.09$).

mated cell counter (Coulter ZBI, Coulter Instruments, Hialeah, FL 33012, U.S.A.), and PCV by a microhematocrit technique (Seal and Mech 1983). Hematological indices (mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC)) were also calculated (Benjamin 1981). We analyzed serum for urea nitrogen (SUN), triglycerides, calcium, phosphorus, T_3 , total cholesterol, and insulin levels. Progesterone levels were measured in females. Laboratory methods are described elsewhere (Seal et al. 1972; Seal et al. 1975; Seal 1978; Kreeger et al. 1990). Cortisol, glucose, creatine kinase, and white blood cell data were not included in our analyses because of sensitivity to capture stress (Kreeger et al. 1990). Our inability to determine length of time in the trap, amount of trap resistance, or level of stress would further confound our interpretation of stress-related variables.

Prey base

Indices of jackrabbit numbers were obtained from night spotlighting counts along routes driven monthly on the grounds of the INEL and in an adjacent region. Densities of jackrabbits and cottontail rabbits were determined from fecal pellet plots (Neff 1968) and were presented by Gates (1983), Grant (1987), and Knick (1990). We grouped prey results into three periods that represented high (1982), medium (1983), and low (1984–1985) lagomorph densities (Table 1). May–October estimates of total biomass of jackrabbits and cottontail rabbits declined from 12.7 to 2.2 kg/ha in lava flows, from 6.3 to 3.0 kg/ha in buttes and craters, and from 3.5 to 0.7 kg/ha in sagebrush habitats between 1983 and 1985 (Knick 1990). Counts of jackrabbits obtained during spotlight surveys in another study on the INEL decreased $>250\times$ from 1981 to 1984 (Anderson and Shumar 1986).

Statistical analysis

We analyzed blood results for differences between sex, season, and periods of differing prey abundance. Collection periods for spring samples were 21 February – 17 April 1982 (4 F, 2 M), 26 February – 21 April 1983 (5 F, 6 M), 27 February – 17 April 1984 (3 M), and 6 February – 7 March 1985 (2 F), and for fall samples were 13 September – 14 December 1982 (4 F, 8 M), 18 August – 8 October 1983 (2 F, 4 M), and 6 October – 15 November 1984 (1 F, 1 M).

Our trapping success declined from 1 capture/88 trap-nights in 1982 to 1 capture/654 trap-nights in 1984–1985, despite similar trapping intensity among years (Knick 1990, p. 14). Thus, samples collected during the period of minimum lagomorph abundance ($n = 5$ in 1984 and $n = 2$ in 1985) were of inadequate size to include in the statistical analysis. Data from 1984–85 were pooled and presented descriptively for comparison with results from 1982 and 1983.

Multiple captures of individuals within a season (3 bobcats were recaptured 2 times) were averaged for the season, and mean values were used in analyses. Individuals recaptured in different seasons (7 bobcats were recaptured in spring and fall seasons; 1 bobcat was recaptured in one fall and two spring seasons) were treated as independent samples.

Variables were tested for normality (PROC UNIFORM; SAS Institute Inc. 1988); variables with non-normal distributions were \log_{10} -trans-

TABLE 3. Differences in blood characteristics between male and female bobcats sampled in southeastern Idaho from 1982 and 1983

Blood characteristic	Males			Females			F test	
	N	Mean	SE	N	Mean	SE	F	P
Hb (g/dL)	20	14.4	0.3	14	13.0	0.4	3.19	0.09
RBC ($10^6/\mu\text{L}$)	20	8.3	0.2	14	7.3	0.2	3.97	0.05
PCV (%)	20	44.1	1.1	14	40.1	1.2		
MCV (fL)	20	53.3	0.9	14	55.4	0.7		
MCHC (g/dL)	20	32.3	0.4	14	32.4	0.4		
MCH (pg)	19	17.4	0.2	12	18.1	0.3		
Cholesterol (mg/dL)	20	121.1	5.4	13	103.4	6.7		
Triglycerides (mg/dL)	19	25.2	2.1	13	21.8	1.2		
SUN (mg/dL)	19	30.1	0.9	13	32.9	3.5		
Calcium (mg/dL)	20	10.1	0.3	13	9.7	0.3		
Phosphorus (mg/dL)	20	4.5	0.3	14	4.5	0.5		
T ₃ (ng/dL)	20	56.2	5.9	13	41.2	7.0		
Insulin ^a (IU/mL)	20	14.5	1.5	13	18.4	1.7	3.68	0.07

NOTE: Three males and two females were sampled twice in different seasons or years. Significance values are presented from full three-way (sex \times season \times year) interaction ANOVA.

^aAnalysis was performed on log-transformed data.

TABLE 4. Seasonal differences in blood characteristics of bobcats sampled in southeastern Idaho from 1982 and 1983

Blood characteristic	Spring			Fall			F test	
	N	Mean	SE	N	Mean	SE	F	P
Hb (g/dL)	17	13.4	0.4	17	14.3	0.3	4.20	0.05
RBC ($10^6/\mu\text{L}$)	17	7.4	0.3	17	8.3	0.2	12.90	0.01
PCV (%)	17	41.4	1.4	17	43.5	1.0	3.45	0.08
MCV (fL)	17	55.9	0.6	17	52.4	0.9	6.10	0.02
MCHC (g/dL)	17	32.2	0.3	17	32.4	0.5		
MCH (pg)	16	18.1	0.2	17	17.3	0.3	5.22	0.03
Cholesterol ^a (mg/dL)	16	101.0	5.0	17	126.5	5.8	3.46	0.08
Triglycerides (mg/dL)	16	23.6	2.0	16	24.0	0.9		
SUN (mg/dL)	16	34.1	2.0	16	28.3	1.1		
Calcium (mg/dL)	16	9.5	0.1	17	10.3	0.3		
Phosphorus (mg/dL)	17	4.4	0.4	17	4.7	0.3		
T ₃ (ng/dL)	16	48.7	7.3	17	51.8	6.0		
Insulin ^a (IU/mL)	16	17.3	1.7	17	14.9	1.6	7.68	0.01

NOTE: One bobcat was sampled in fall in both 1982 and 1983. Five bobcats were sampled in both spring and fall. Significance values are presented from full three-way (sex \times season \times year) interaction ANOVA.

^aAnalysis was performed on log-transformed data.

formed and then used in subsequent statistical analyses. A three-way analysis of variance (ANOVA) (PROC GLM; SAS Institute Inc. 1988) was conducted, with sex, season (spring, fall), and year (1982, 1983) as main factors. All two-way interactions were also included. Significance was reported from the Type III sum of squares in the full interaction model. Because of small cell sample sizes in a three-way interaction model, we chose a significance level (α) of 0.10 to identify all variables that may have changed. We also recognize the increased probability of falsely rejecting null hypotheses. Tukey's Studentized range test was used to identify significantly different group means at $\alpha = 0.10$ (Steele and Torrie 1980).

Results

Masses of adult males (≥ 1.5 years) (12.2 ± 0.4 (SE) kg, $n = 16$) were significantly greater ($P = 0.003$) than those of females (10.2 ± 0.3 kg, $n = 15$). However, masses did not vary ($P > 0.1$) by year or season between 1982 and 1983.

Blood characteristics

Sex \times season interactions were significant for RBC, PCV, and MCH (Table 2). Females sampled in spring had lower RBC ($P = 0.03$) and PCV ($P = 0.07$) and higher MCH ($P = 0.09$) values than females sampled in fall or males sampled in either season. No other two-way interactions (sex \times year, season \times year) were significant.

Male bobcats had higher ($P < 0.10$) Hb and RBC and lower ($P = 0.07$) insulin levels than females (Table 3). Bobcats sampled during spring had lower Hb, RBC, PCV, and cholesterol levels and higher MCV, MCH, and insulin levels than those captured during fall (Table 4).

The decline in abundance of jackrabbits and Nuttall's cottontails (Table 1) was reflected in lowered ($P < 0.10$) insulin and phosphorus concentrations in 1983 compared with 1982 (Table 5). Hb, RBC, and PCV were elevated ($P < 0.10$) in 1983 compared with 1982.

TABLE 5. Differences in blood characteristics of bobcats sampled during periods of differing prey abundance in southeastern Idaho in 1982 (abundant) and 1983 (medium)

Blood characteristic	Lagomorph abundance									F test	
	Abundant (1982)			Medium (1983)			Scarce (1984–1985)				
	N	Mean	SE	N	Mean	SE	N	Mean	SE	F	P
Hb (g/dL)	18	13.5	0.3	16	14.2	0.5	6	14.3	0.6	3.21	0.09
RBC ($10^6/\mu\text{L}$)	18	7.7	0.2	16	8.0	0.3	6	8.3	0.5	3.74	0.06
PCV (%)	18	40.9	1.1	16	44.1	1.4	6	41.8	2.7	4.42	0.04
MCV (fL)	18	52.9	0.8	16	55.5	0.7	6	50.2	1.8		
MCHC (g/dL)	18	32.6	0.4	16	32.0	0.3	6	34.7	1.7		
MCH (pg)	15	17.5	0.2	16	17.9	0.3	6	17.3	0.4		
Cholesterol (mg/dL)	17	120.2	5.8	16	107.8	6.6	7	103.1	9.5		
Triglycerides (mg/dL)	16	23.2	2.0	16	24.4	1.9	7	109.6	90.8		
SUN (mg/dL)	16	29.2	1.2	16	33.2	2.7	7	41.8	2.7		
Calcium (mg/dL)	17	10.1	0.3	16	9.7	0.2	7	10.6	0.3		
Phosphorus (mg/dL)	18	5.0	0.4	16	3.9	0.2	7	4.4	0.4	3.59	0.07
T ₃ (ng/dL)	17	55.1	7.8	16	45.3	4.7	7	40.4	7.2		
Insulin ^a (IU/mL)	17	19.4	1.7	16	12.5	1.0	7	11.8	1.7	16.24	<0.01

NOTE: Results from 1984–1985, when jackrabbits were scarce, were not included in the statistical analysis because of sparse samples and are presented for descriptive purposes only. Four bobcats were sampled in both spring and fall of the same year. Two bobcats were sampled in both 1982 and 1983. Significance values are presented from full three-way (sex \times season \times year) interaction ANOVA.

^aAnalysis was performed on log-transformed data.

TABLE 6. Mean values of blood characteristics of emaciated bobcats that died 3–21 days after sampling that were >2 SD from those of bobcats sampled during 1982 (high prey abundance)

Blood characteristic	Bobcat 3 (♀)	Bobcat 49 (♀)	Bobcat 92 (♂)	1982		
				N	Mean	SD
PCV (%)			32	18	40.9	4.5
MCV (fL)			42	18	52.9	3.6
MCHC (g/dL)			43	18	32.6	1.9
SUN (mg/dL)	41.4	39.3	78.2	16	29.2	4.9
Triglycerides (mg/dL)	67		654	16	23.2	8.1
Cholesterol ^a (mg/dL)	64			17	120.2	23.7

NOTE: Hematology values were not available for bobcat 3.

^aAnalysis was performed on log-transformed data.

The 1984–1985 sample included blood from 2 starving bobcats (captured in box traps) that subsequently died 2–18 days after spring captures in 1985 and 1 emaciated bobcat (captured by manual restraint) that was assumed to have starved after his capture in spring 1984 (Knick 1990). Each bobcat had been previously captured, radio-collared, and blood sampled in 1982 or 1983. At the final capture, each bobcat was 64–69% of a previous capture weight.

Each emaciated bobcat that subsequently starved to death had 1–5 blood characteristics that were >2 SD of the mean values for bobcats sampled in 1982 (high prey density) (Table 6). All 3 bobcats had elevated SUN, 2 had elevated triglyceride levels, and 1 had a lowered cholesterol level.

Progesterone levels in 2 females captured during the breeding or gestation period (February–April) (120.0 and 68.0 ng/mL) that subsequently raised kittens and 1 female with 5 uterine placental scars (20.0 ng/mL) were higher (one-way ANOVA; $F = 13.32$; 2,22 df; $P = 0.0002$) than in spring samples of 6 subadults (<9 months of age; mean = 4.18 ± 1.30 ng/mL) or 16 samples from nonbreeding adults in spring or fall (mean = 12.56 ± 3.42) (Fig. 1). The lowest progesterone levels (0.78, 1.80 ng/mL) of any adults were obtained from 2

emaciated females (one 3.5 years old, marked as a kitten, and the other 4.5 years old, age determined from tooth cementum annuli; Crowe 1972), captured during the 1985 breeding season, that subsequently died 1–21 days after sampling.

Discussion

In response to decreased prey levels, bobcats in southeastern Idaho curtailed reproduction, expanded individual home ranges, and made long forays during winter to areas that contained prey (Knick and Bailey 1986; Knick 1990). We hypothesized that the blood characteristics of bobcats would also reflect a food shortage. Although blood profiles obtained in our study were consistent with responses observed in captive animals, not all trends were significant ($\alpha = 0.10$). Notably, we did not detect significance in the observed decline in T₃ levels, indicating hypothyroid status and lowered metabolic activity (Harlow and Seal 1981; DelGiudice et al. 1987b).

Insulin concentrations decreased in sampled bobcats, from the peak in prey abundance in 1982 to years of lower prey numbers. Decreased serum insulin and cholesterol levels associated with lower prey densities are consistent with predictions

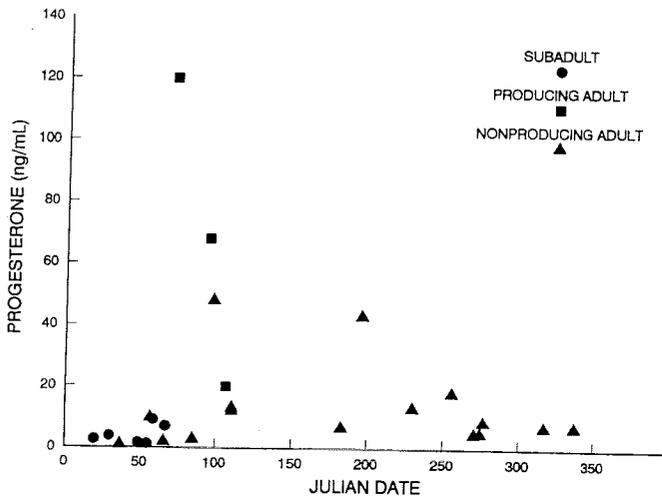


FIG. 1. Progesterone levels in 12 female bobcats captured in south-eastern Idaho from 1982 through 1985.

from previous research (Messier 1987). Following a meal, absorbed glucose enters the circulation, triggering pancreatic release of insulin to promote transport and storage of glucose (McGilvery 1983, pp. 520–521). Insulin also promotes fatty-acid synthesis from glucose, storage of fat in the form of triglycerides, and hepatic production of cholesterol (McGilvery 1983). With decreased densities of prey and presumably fewer and more widely spaced meals, insulin levels declined in Idaho bobcats. Cholesterol levels also declined with decreased prey densities, although the difference was not significant.

Elevated SUN and triglyceride levels coupled with lowered cholesterol levels indicate that 3 emaciated bobcats were catabolizing body proteins and fat reserves (Mech et al. 1984). These starving bobcats died 3–21 days after sampling.

Bobcats in our study had lower Hb and RBC and higher MCV in spring than in fall, although no change in mass was observed. These changes in hematologic variables reflect results obtained from wolf pups during changes in population density (DelGiudice et al. 1991). Lowered Hb values were also evident in wolf pups sampled in an area of low prey density (Messier 1987). Lowered RBC coupled with increased MCV in bobcats in spring suggests a macrocytic anemia (Benjamin 1981) caused by decreased food intake.

Higher Hb, RBC, and PCV in bobcats sampled in 1983 indicate hemoconcentration and are similar to results for fasted wolves (DelGiudice et al. 1987b) and badgers (Harlow and Seal 1981) caused by decreased water intake. Although bobcats were using alternative food sources after 1982 (Knick 1990), decreased phosphorus levels suggest reduced food intake.

Endogenous rhythms could also influence the seasonal change in bobcat hematology. Although circannual patterns in serum chemistry and hematology in wild felids are not available for comparison, hematologic variables in captive wolves provided with food ad libitum exhibited consistent circannual patterns, with a peak in winter and a nadir in summer (Seal and Mech 1983). Free-ranging black bears also had similar circannual rhythms, with Hb, PCV, and RBC increasing from early summer to late fall and denning (Franzmann and Schwartz 1988; Hellgren et al. 1989). A similar endogenous rhythm may also explain our observed seasonal changes in Hb, PCV, and RBC in bobcats.

Low progesterone concentrations in adult females in 1984–1985 supported field data which indicated that reproduction

was curtailed (Knick 1990) and females may not have achieved estrus. In 1983 (a moderate prey year) adult females had progesterone concentrations indicative of luteal activity (48 and 43 ng/mL) and may have bred but did not raise kittens. The producing female with 5 placental scars was never seen with kittens but appeared to be pregnant at capture and showed denning tendencies for several days.

The annual pattern in serum progesterone concentration for females in our study paralleled profiles of captive and wild bobcats in Mississippi (Woshner 1988). In Mississippi, average progesterone concentrations were 7–9 ng/mL during the anestrus and estrus periods, 39–60 ng/mL during the luteal phase and early to midpregnancy (March–April), and 22.5 ng/mL during late pregnancy (April–May).

Adult predators, such as bobcats, that are solitary and hunt independently may initially suffer greater consequences during declines in the prey base than cooperatively hunting social predators. We detected physiological changes in adult bobcats hunting alone in intrasexually exclusive territories (Bailey 1974; Knick 1990). Conversely, prey density did not influence the physiology of adult wolves (Seal et al. 1975; Messier 1987) because the wolves' social structure buffered adults of higher status against nutritional stress (Mech 1977). However, wolf pups in a population of high but declining density and, later, of low density were anemic relative to pups from the same population at a time of stable, medium density (Messier 1987; DelGiudice et al. 1991).

The effects of the food decline were compounded by the energetic consequences of severe winter weather. During the winter with lowest prey level (1984–1985), average temperatures were lower and average maximum snow depth was greater than in all other years of the study (Knick 1990, p. 10). Because average temperatures were lower than the lower critical temperature in winter (-2.2°C) for bobcats (Mautz and Pekins 1989), energetic needs were increased during a time of limited prey resources and reduced mobility in deep snow. Bobcats that previously remained within territories were forced to make extraterritorial forays during the second winter of the lagomorph decline to highly localized aggregations of jackrabbits (Knick 1990, p. 34). Ultimately 3 bobcats starved to death, and bobcat densities declined at least 9-fold between 1982 and 1985 (Knick 1990).

Our data on metabolic activity and endocrine levels are consistent with expected changes in the physiological condition of bobcats relative to changes in energetic demands and behavior associated with the decline in prey availability. Although statistically significant at $\alpha = 0.10$, our results indicate that the prey base (or our ability to measure it) was not strongly correlated with the variation in these characteristics, as was also reported for free-ranging wolf (*Canis lupus*) populations (Seal et al. 1975; Messier 1987; DelGiudice et al. 1991).

Our conclusions were influenced by our capture methods and success and illustrate the difficulty of using blood studies to evaluate the physiological status of free-ranging populations. Recent innovations, such as the capture collar (Mech and Gese 1992), will permit better sampling design and stronger conclusions concerning the relationship between the prey base and blood physiology of free-ranging predator and prey populations.

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