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Hematological Profiles of the Formosan Black Bear (*Ursus thibetanus formosanus*)

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Geng-Ruei Chang, Frank Chiahung Mao, Chieh-Chung Yang, and Fang-Tse Chan (2006) Hematological profiles of the Formosan black bear (*Ursus thibetanus formosanus*). *Zoological Studies* **45**(1): 93-97. Seasonal changes and sex differences in hematological values of 5 adult Formosan black bears, kept at the Low Altitude Experimental Station, Taichung County were evaluated from Apr. 2000 to Aug. 2003. Total erythrocyte counts, hemoglobin, hematocrit, and mean corpuscular volume were statistically higher in autumn-winter than in spring-summer but did not differ between sexes. Mean corpuscular hemoglobin was significantly higher in males than females but did not differ between seasons. Female total leucocyte counts and lymphocyte were statistically higher in spring-summer than autumn-winter, while monocytes showed the opposite response. This indicates that the innate immunological defense decreased with decreasing temperature. The other leucocyte differential count parameters, mean corpuscular hemoglobin concentration and total platelet count, did not differ among seasons or between sexes. These results suggested that from autumn to winter, erythrocytes are replaced by larger, more-numerous cells that increase oxygen transport, required for producing more energy. Baseline parameters established in this study will help evaluate diagnostic medicines that can be applied as guidelines for future management and preservation of Formosan black bears in the field. http://zoolstud.sinica.edu.tw/Journals/45.1/93.pdf

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The Formosan black bear (*Ursus thibetanus formosanus*) belonging to the family Ursidae is distributed in the Central Mountain Range of Taiwan from broadleaf forests as low as 200 m to coniferous forests as high as 3500 m (Hwang et al. 2000, Chang et al. 2004). Field studies suggest that Formosan black bears do not hibernate, but migrate from high to low elevations where food remains available throughout the winter (Hwang et al. 2000). The Formosan black bear is endemic to Taiwan and is the largest carnivore on the island. In the past few decades, habitat destruction and over-hunting have rapidly reduced its distribution range, threatening the population with extinction (Wang 1990, Yang et al. 2003). In accordance with wildlife conservation laws, the Taiwan Council of Agriculture listed it as an endangered species in 1989. Since then, hunting, trading, possession, and killing of the Formosan bear have been prohibited.

Hematological characters and serum chemistry are becoming increasingly important diagnostic tools for physiological and taxonomic studies of the Ursidae. Results are helpful for fighting diseases in wild bear populations (Seal et al. 1967, Hissa 1997). Previous studies showed that elevation, climate, species, sex, age, and reproductive status affect the hematological values of bears (Svihla et al. 1955, Matula et al. 1980, Palumbo et al. 1983, Huber et al. 1997). Seasonal variations in hematological characters have been documented for captive American black bears (*Ursus americanus*) in Michigan (Erickson and Youatt 1961) and North Carolina (Hellgren et al. 1989), and for

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wild brown bears (*Ursus arctos horribilis*) in Canada (Pearson and Halloran 1972).

Evidence for a stress response due to being captured was provided by Brannon (1985), which illustrated that blood values of wild and enclosed grizzly bears (*Ursus arctos*) in central and northeastern Alaska differ. Hellgreen et al. (1989) showed that several blood characters, including hematocrit, hemoglobin, and red blood cells, of the American black bear in North Carolina differ with sex and age. Interestingly, each character shows a similar annual rhythm, decreasing from the time of denning to summer and increasing from summer to the time of denning. Alternatively, white blood cell counts of grizzly bears in Alaska (Brannon 1985) and hematological values of brown bears in Canada (Pearson and Halloran 1972) did not significantly differ between sexes in any season.

Hematological values of Ursidae animals vary individually and climatically (Seal et al. 1967, Brown et al. 1971). Therefore, the present study did not compare differences of normal hematological values between Formosan black bears and other Ursidae animals. Furthermore, observations on the distribution and activity of Formosan black bears in natural environments are limited (Chang et al. 2004), and almost no data have been collected on their hematology and serum chemistry. This study was an attempt to determine the seasonal changes and sexual differences in hematological characters of the Formosan black bear which can serve as a useful reference for the development of medicine, conservation, and management practices.

MATERIALS AND METHODS

Experimental animals

Two male and 3 female adult Formosan black bears were used as experimental animals. Their ages were estimated based on body size when captured. They were housed individually in covered outdoor enclosures (9 x 5 m) under ambient conditions in Taichung County at the Low Altitude Experimental Station of the Endemic Species Research Institute (120°56'52.47"E, 24°16' 24.39"N). The institute is situated at 1000 m and provides a climate that simulates natural breeding conditions. An appropriate diet was provided according to Yang et al. (2001). The reproductive condition and physical status were observed and recorded by technicians. No external or internal parasitic infections were diagnosed during the time of the study.

Blood sample collection and analyses

Blood samples were collected monthly between Apr. 2000 and Aug. 2003 from the jugular vein. Prior to collection, the animals were anesthetized with Zoletil 50® (10 mg/kg; Virbac, Taipei, Taiwan), except during times of pregnancy, lactation, or illness. All blood samples were collected within 10 min of immobilization. Ethylenediaminetetraacetic acid (EDTA) was added as an anticoagulant. Samples were placed on ice following 2-3 min at room temperature. Samples were then sent to the Apex' Medical Laboratory in Taichung for analyses using an automatic cell counter (SE-9000, Sysmex, New Jersey, USA).

Six hematological parameters were measured for each sample: 1) total erythrocyte counts (RBC); 2) hemoglobin (Hb); 3) hematocrit (Hct); 4) RBC indices including mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC); 5) total platelet count (PLT); and 6) total leukocyte count (WBC). Differential leukocyte values were calculated from microscopic examination of blood smears. Percentages included band cells, segmented cells, eosinophil cells, basophil cells, lymphocytes, and monocytes. WBC and leukocyte differential counts for adult males during the spring-summer season were not compared due to an insufficient sample size.

Statistical analysis

Data were sorted by sex and season: spring-summer (Mar. - Aug.), autumn-winter (Sept.- Feb.). All hematological values were expressed as the mean ± SE and compared between seasons and sexes by analysis of variance (ANOVA), while seasonal groups of WBC and leucocyte differential counts were compared using *t*-tests.

RESULTS

RBC, Hb, Hct, and MCV showed significant differences ($p < 0.05$) between seasons, while differences between sexes were not significant (Table 1). Results indicated a significant increase in autumn-winter compared with values in spring-summer. Female WBC and lymphocyte counts were significantly higher ($p < 0.05$) in spring-summer than in autumn-winter. Monocyte counts illustrated the opposite response (Table 2). Differences between sexes were only found to be significant for MCH values ($p < 0.05$).

Although the difference was not significant, MCH and MCHC values were slightly higher in autumn-winter than during the other seasons for both sexes. Female band cell, segmented cell, eosinophil cell, and basophil cell measures did not significantly differ across seasons, while changes in PLT were irregular. Female PLT values were higher in autumn-winter, while males showed the opposite response. No basophil cells were detected except in males during autumn-winter.

DISCUSSION

Seasonal variations

Results of our study indicated that RBC and RBC indices of both sexes of Formosan black bears increased in autumn-winter (Table 1). This result is similar to reports for European brown bears (Hissa et al. 1994) and American black bears in North Carolina and northern Michigan (Erickson and Youatt 1961, Hellgren et al. 1989). On the other hand, a study by Person and Halloran (1972) found this response for RBC levels of brown bears in Canada but observed the opposite for the RBC indices.

During the autumn-winter, a decrease in sunlight causes a gradual decrease in temperature. These changes may correspond with seasonal changes in physiological conditions (Franzmann and Schwartz 1988, Hellgren et al. 1989), and may relate to an increase in the demand for oxygen transport imposed by higher energy demands at lower temperatures.

In this study, a similar response was observed for Hb (Table 1). Hb is a major constituent of erythrocytes which function in oxygen transport and can therefore be used to evaluate the physical condition of an animal. Numerous studies examining Ursidae Hb level responses to climate have indicated a trend for Hb to increase with decreasing temperature (Hellgreen et al. 1989). Furthermore, American black bears in Michigan (Erickson and Youatt 1961) had higher levels during hibernation compared to other seasons.

Our study showed that Formosan black bear Hct values decreased during spring-summer and increased in the colder months (Table 1). This result is similar to that described for the brown bear in Canada (Pearson and Halloran 1972), and the American black bear in North Carolina (Hellgren et al. 1989). Similar to Hb, lower temper-

Table 1. Comparison of hematological values (mean ± SE, n = 21, 10 each for females and males) between sexes and season for adult Formosan black bears

Blood parameter	Sex	Season	
		Spring-summer	Autumn-winter
RBC[a] ($10^6/\mu l$)	F	5.96 ± 0.16	6.80 ± 0.18
	M	6.35 ± 0.18	7.15 ± 0.50
Hb[a] (g/dl)	F	13.93 ± 0.33	15.58 ± 0.43
	M	14.90 ± 0.09	17.96 ± 1.01
Hct[a] (%)	F	38.80 ± 0.98	44.60 ± 1.68
	M	41.60 ± 1.55	49.00 ± 2.17
MCV[a] (fl)	F	61.90 ± 1.06	66.00 ± 1.25
	M	61.70 ± 3.11	69.60 ± 1.76
MCH[b] (pg)	F	22.00 ± 0.49	23.20 ± 0.09
	M	23.60 ± 0.31	24.30 ± 0.07
MCHC (g/dl)	F	35.31 ± 0.91	35.60 ± 0.35
	M	34.60 ± 0.31	35.80 ± 0.10
PLT ($10^3/\mu l$)	F	196.00 ± 42.30	229.00 ± 47.70
	M	311.00 ± 22.40	258.00 ± 65.20

[a]Blood values significantly differed ($p < 0.05$) between seasons.
[b]Blood values significantly differed ($p < 0.05$) between sexes. RBC, total erythrocyte count; Hb, hemoglobin; Hct, hematocrit; MCV, mean corpuscular volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; PLT, total platelet count.

atures are thought to cause the substantial increase in Hct (Hissa et al. 1994), in correspondence with an increase in circulating RBC.

Interestingly, the results of the RBC indices did show that MCV responded to seasonal changes with a decrease in spring-summer followed by an increase in autumn-winter (Table 1). However, no significant seasonal changes in MCV were found for European brown bears (Hissa et al. 1994). In the Formosan black bear, an increase in MCV may accompany higher RBC and Hct levels. Therefore, the RBC indices reflect seasonal shifts in RBC, Hb, and Hct in accordance with larger and more-numerous RBCs that contain more Hb during the autumn-winter.

No statistical differences were observed for PLT values (Table 1), as has been reported for female European brown bears (Hissa et al. 1994). An increase was observed from spring-summer to autumn-winter for females, while the opposite was observed for males. To date, very limited PLT information has been obtained for Ursidae animals. It appears that ambient temperature may affect PLT production, yet the influence of an inherent circannual metabolic rhythm on the PLT cycle is still unknown.

Female WBC counts were significantly higher in spring-summer (Table 2), as has been reported for American black bears (Erickson and Youatt 1961, Matula et al. 1980, Hellgren et al. 1989). This implies a lower immunological defense requirment during winter. However, seasonal changes in WBC levels vary, and many factors can influence it (Schalm 1975). Leukocyte differential counts were similar to those for black and brown bears as reported by Hock (1966) and Pearson and Halloran (1972). Female blood parameters of leukocyte differential counts were higher in autumn-winter with the exception of lymphocytes and segmented cells (Table 2). We found no allergies, microorganisms, or phagocytosis in our study animals and therefore could not associate wounds or parasitic infections with an increase in eosinophil cell levels as found by previous studies (Pearson and Halloran 1972, Schalm 1975).

In summary, the above data indicate that seasonal shifts are responsible for changing hematological values of Formosan black bears. The increase in RBC, Hb, and Hct levels most often observed before and during the winter suggests that cells are more numerous and larger erythrocytes. Furthermore, this may be adaptive by increasing erythrocyte surface area relative to erythrocyte mass, thus increasing oxygen exchange. Ambient temperature may affect partial blood values, since annual changes reflect hematopoietic

Table 2. Comparison of leucocyte counts (mean ± SE, n = 22, 7 each for females and males) and differential counts of leucocytes in percentage (mean ± SE, n = 16, 7 each for females and males) between sexes for adult Formosan black bears

Blood parameter	Sex	Season	
		Spring-summer	Autumn-winter
Total leukocyte counts	F	10.20 ± 0.51	7.81 ± 0.69*
($10^3/\mu l$)	M	ND	8.33 ± 1.19
Band cells (%)	F	1.00 ± 0.55	1.20 ± 0.39
	M	ND	5.60 ± 2.50
Segmented cells (%)	F	62.25 ± 5.82	62.20 ± 4.12
	M	ND	55.00 ± 3.78
Eosinophil cells (%)	F	0	5.30 ± 1.60
	M	ND	7.60 ± 2.23
Basophile cells (%)	F	0	0
	M	ND	0.20 ± 0.20
Lymphocytes (%)	F	42.80 ± 8.87	20.30 ± 3.50*
	M	ND	22.20 ± 5.31
Monocytes (%)	F	3.20 ± 0.86	10.80 ± 2.67*
	M	ND	9.40 ± 3.36

*Female blood values significantly differed ($p < 0.05$) among seasons. ND, No samples were determined.

function as it relates to energy demands of Formosan black bears.

Sex differences

There were no significant differences in blood values between sexes with the exception of MCH. Similar results have been shown for brown bears in Canada (Pearson and Halloran 1972) as well as for 34 species of wild mammals across the US and Canada (Sealander 1964).

Results of this study showed that male and female blood parameters responded similarly. This suggests that hematological physiology between female and male Formosan black bears is comparable. However, variable differences between sexes have been reported for black bears in Pennsylvania (Matula 1980) and black bears in Alaska (Franzmann and Schwartz 1988). Inconsistencies among Ursidae animals make it difficult to interpret the reason for hematological changes in the present study.

In conclusion, the present study provides important hematological information that can be applied to the management and assessment of Formosan black bears in the field. Further studies considering nutritional intake, stress, and health, and comprising larger sample sizes are needed to refine the application of blood parameters to assess the body condition of Formosan black bears in the field.

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