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Hematology and Serum Chemistry of Free-ranging Jaguars (*Panthera onca*)

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ABSTRACT: We collected and analyzed blood samples from 12 free-ranging jaguars (*Panthera onca*). Clinical examinations, hematology, and serum chemistry indicate the jaguars were in good overall health. Results may help as values for free-ranging jaguars under the same handling conditions.

Jaguars (*Panthera onca*) are the largest felids in the Americas. In the Brazilian Pantanal, habitat and prey base provide an appropriate environment for the long-term conservation of jaguars (Azevedo and Murray, 2007). However, 250 years of contact with livestock may be affecting jaguars' vulnerability to disease.

Although limited hematologic and serum chemistry data are available from captive jaguars (Hawkey and Hart, 1986; Deem, 2004), obtaining baseline reference values for free-ranging animals is important in assessing the health of the population, providing baseline values for future studies, and supporting conservation strategies (Dunbar et al., 1997). We present hematologic and serum chemistry reference values for free-ranging jaguars from a population in the Brazilian Pantanal and compare these values to data from captive jaguars.

Our study site was a working 100-km^2 cattle ranch and wildlife reserve in the southern part of the Pantanal (19°28′40′′S, 57°00′49′′W). Jaguars were captured by tracking them with trained dogs. Captured animals were immobilized with tiletamine hydrochloride and zolazepam hydrochloride (Zoletil, Virbac do Brasil, São Paulo, São Paulo, Brazil) at 10 mg/kg intramuscular (Azevedo and Murray, 2007). Animals were examined for clinical signs of disease, sex determined, weighed, and evaluated for reproductive condition and ectoparasites (Widmer el al., 2011). Age was estimated based on tooth wear. Animals were fitted with global positioning system radio collars (Followit Lindesberg AB, Stockholm, Sweden) and monitored from June 2008 to December 2010. Animal handling procedures were approved by the Brazilian Environment Institute and by a Bioethic Commission of the University of São Paulo.

Blood samples were collected from the cephalic or saphenous vein into a 5-mL ethylenediaminetetraacetic acid (EDTA) tube and a tube without additives. At the field base (1–8 hr after collection), blood without EDTA was centrifuged at 1,500 × G for 10 min. Serum was transferred into 1-mL cryogenic vials. Sera and EDTA whole blood samples were refrigerated until transport in a cool box to a commercial laboratory (Carlos Chagas, Corumbá, Mato Grosso do Sul, Brazil). The time between blood collection and delivery to the laboratory was <24 hr. Assessment of hematologic values was performed by an automated ABX micro 60 (Horiba Medical, São Paulo, São Paulo, Brazil) and confirmed by microscopic examination of blood smears stained with May Grunwald Giemsa. The serum chemistry profile was performed using an automated biochemistry and enzyme-linked immunosorbent assay machine (ChemWell, Awareness Technology, Palm City, Florida, USA).

Evaluated parameters are described in Table 1. For statistical analysis, we included all adult jaguars (>2 yr old; $n=11$).

TABLE 1. Mean hematologic and serum chemistry parameters for 11 free-ranging jaguar (*Panthera onca*) adults, 2–9 yr old (five males and six females), captured in 2008 and 2009 in the Brazilian Pantanal, and captive adult jaguars.

	Free-ranging jaguars				Captive jaguars (Hawkey and Hart, 1986)			Captive jaguars (Deem, 2004)	
Parameter[a]	Mean (median)±SD	95% CI	Range	*n*	Mean±SD	Range	*n*	Mean±SD	*n*
Red blood cells (10^6/μL)	7.2 (7.2)±1.0	6.5–7.9	5.5–8.7	11	7.4±0.4	6.3–8.3	18	7.3±1.4	161
Hemoglobin (g/dL)*	10.68 (10.5)±1.2	9.8–11.4	8.8–12.5	11	12.8±1.0	11.0–15.0	18	11.8±2.3	166
Hematocrit (%)	35.4 (33.0)±4.2	32.6–38.3	30.0–43.0	11	38.0±4.0	33.0–48,0	18	34.8±5.7	199
MCV (fL)	49.3 (49.0)±2.8	47.4–51.1	46.0–55.0	11	49.0±5.0	42.0–62.0	18	48.8±9.3	159
MCH (pg)*	14.7 (15.0)±1.0	14.0–15.4	13.0–16.0	11	16.9±1.5	15.5–20.7	18	16.6±3.9	154
MCHC (g/dL)*	29.8 (30.0)±1.3	28.9–30.6	28.0–32.0	11	34.1±1.4	31.7–36.7	18	33.7±3.3	165
White blood cells (10^3/μL)*	20.8 (20.6)±4.8	17.6–24.0	15.1–29.0	11	9.3±2.2	4.2–12.4	18	12.0±4.1	191
Bands (10^3/μL)	1.4 (9.8)±1.2	0.6–2.3	0.4–4.6	11	—	—	—	0.8±1.6	77
Neutrophils (10^3/μL)*	14.4 (14.5)±3.0	12.4–16.4	10.5–19.2	11	7.2±2.0	3.4–10.6	18	8.6±3.9	179
Eosinophils (10^3/μL)*	0.4 (0.3)±0.3	0.2–0.7	0.0–1.0	10	0.2±0.1	0.0±0.5	18	0.3±0.3	135
Lymphocytes (10^3/μL)*	3.5 (2.9)±1.7	2.4–4.6	2.1–7.7	11	1.8±0.9	0.8–3.7	18	2.1±2.1	182
Monocytes (10^3/μL)*	0.9 (0.8)±0.4	0.6–1.1	0.3–1.4	11	0.1±0.1	0.0–0.3	18	0.3±0.4	142
Platelet count (10^3/μL)	232.4 (210.0)±81.3	177.9–287.0	128.0–420.0	11	217.0±51.0	109.0–306.0	18	273.0–107.0	37
Basophils (10^3/μL)	0.0	0.0	0.0	11	0.0	0.0	18	0.0±0.1	41
Urea nitrogen (mg/dL)*	106.4 (110.5)±24.0	86.3–126.5	70.0–130.0	11	—[b]	—	—	24.0±9.0	155
Creatinine (mg/dL)*	1.1 (1.0)±0.3	0.8–1.3	0.7–1.5	11	—	—	—	2.0±0.7	152
ALP (U/L)	44.9 (43.5)±24.0	24.8–64.9	19.0–80.0	11	—	—	—	33.0±33.0	147
AST (U/L)	42.0 (39.5)±10.4	34.6–49.4	28.0–60.0	10	—	—	—	35.0±16.0	150
ALT (U/L)	44.3 (44.5)±14.7	33.8–54.8	20.0–68.0	10	—	—	—	55.0±25.0	119
GGT (U/L)*,[c]	8.6 (8.0)±2.1	6.9–10.3	5.0–12.0	8	—	—	—	3.0±3.0	56
Total bilirubin (mg/dL)*	0.5 (0.5)±0.1	0.4–0.5	0.3–0.5	11	—	—	—	0.2±0.1	133
Direct bilirubin (mg/dL)*	0.3 (0.3)±0.1	0.2–0.3	0.2–0.3	11	—	—	—	0.0±0.1	45
Indirect bilirubin (mg/dL)*	0.2 (0.2)±0.0	0.2–0.2	0.1–0.2	11	—	—	—	0.1±0.1	45
CPK (U/L)	299.2 (237.5)±199.8	132.2–466.2	110.0–618.0	11	—	—	—	317.0±279.0	62
Total cholesterol (mg/dL)*	142.6 (84.5)±22.0	128.2–165.0	125.0–182.0	10	—	—	—	246.0±60.0	140
HDL (mg/dL)[c]	91.1 (84.5)±23.2	71.7–110.5	70.0–140.0	8	—	—	—	—	—
Triglycerides (mg/dL)	42.7 (39.0)±17.0	30.5–54.9	18.0–71.0	10	—	—	—	32.0±19.0	75
Uric acid (mg/dL)*	1.3 (1.1)±0.5	0.9–1.7	1.0–2.1	11	—	—	—	0.3±0.3	59
Total protein (g/dL)	7.5 (7.4)±0.4	7.2–7.8	7.1–8.2	11	—	—	—	7.3±0.6	142
Albumin (g/dL)*	2.4 (2.4)±0.2	2.2–2.6	2.0–2.7	11	—	—	—	3.4±0.4	114
Globulin (g/dL)	5.1 (5.10)±0.3	4.9–5.3	4.7–5.6	11	—	—	—	3.9±0.8	113

TABLE 1. Continued.

Parameter[a]	Free-ranging jaguars				Captive jaguars				
					(Hawkey and Hart, 1986)			(Deem, 2004)	
	Mean (median)±SD	95% CI	Range	n	Mean±SD	Range	n	Mean±SD	n
Iron (μg/dL)*	141.9 (111.0)±102.1	56.5–227.3	52.0–345.0	11	—	—	—	84.0±20.0	15
Magnesium[c]	2.3 (2.2)±0.9	1.5–3.0	0.5–3.8	9	—	—	—	2.7±0.5	5

[a] MCV = mean cell volume; MCH = mean cell hemoglobin; MCHC = mean cell hemoglobin concentration; ALP = alkaline phosphatase; AST = aspartate aminotransferase; ALT = alanine aminotransferase; GGT = gamma glutamyl transpeptidase; CPK = creatine phosphokinase; HDL = high-density lipoprotein.

* t-test: statistically significant differences ($P<0.05$).

[b] — indicates that data are not available;

[c] Because of a laboratory mistake, these tests were not performed for all samples.

Captive jaguar data were obtained from Hawkey and Hart (1986) and Deem (2004). Statistical analyses were performed using SPSS software (SPSS, Inc., Chicago, Illinois, USA). The distribution for each parameter was tested for normality using the normal probability plot and the Kolmogorov-Smirnov test. Outliers (values exceeding 2 SD from the mean) were removed from the analyses. Excluded outliers were female 01 from eosinophil analysis (1.75×10^3/μL) and male 08 from aspartate aminotransferase (AST; 160.0 U/L) and alanine aminotransferase (ALT; 140.0 U/L) analyses. Female 03 was excluded from triglycerides (157.0 mg/dL) and cholesterol analysis (171.0 mg/dL) because of lipemia. When data were normal we used a two-sample independent t-test to compare hematologic parameters between our data and data from captive jaguars and for comparisons between male and female free-ranging jaguars. We used a Kruskal-Wallis one-way analysis of variance for data violating the assumptions of normality and homogeneity.

Blood samples were collected from 11 adult (six females and five males) and one juvenile (female, 6 mo old) free-ranging jaguars. All animals were in good overall health based on physical evaluation. The results of the hematologic and serum chemistry tests are given in Tables 1 and 2. Two females were pregnant (03, 06) and one was lactating (09). One male (08) presented a long anesthetic recovery (7 hr to total recovery).

Among the 13 hematologic parameters used for comparisons between free-ranging and captive jaguars, eight were significantly different from results of Hawkey and Hart (1986) and five from those of Deem (2004). We observed higher values of white blood cells, neutrophils, lymphocytes, monocytes, and eosinophils in free-ranging jaguars than in captive jaguars described by Hawkey and Hart (1986) and higher values of white blood cells, neutrophils, lymphocytes, and monocytes in free-ranging jaguars than in captive jaguars

TABLE 2. Mean hematologic and serum chemistry parameters for 11 free-ranging jaguar (*Panthera onca*) adults, 2–9 yrs old (five males and six females), and hematologic and serum chemistry values for 1 juvenile (female, 6 mo old) captured in 2008 and 2009 in the Brazilian Pantanal, categorized according to sex.

Parameter[a]	Males			Females			Juvenile
	n	Mean (median)±SD	Range	*n*	Mean (median)±SD	Range	
Red blood cells (10^6/μL)	5	6.71 (6.4)±0.95	5.5–8.1	6	7.67 (7.85)±0.94	6.4–8.7	6.8
Hemoglobin (g/dL)	5	9.86 (9.50)±1.01	8.8–11.5	6	11.18 (11.00)±1.00	10.0–12.5	9.5
Hematocrit (%)	5	33.20 (33.00)±3.49	30.0–39.0	6	37.33 (37.00)±4.08	33.0–43.0	34.0
MCV (fL)	5	50.00 (49.00)±3.53	46.0–55.0	6	48.67 (48.00)±2.06	47.0–52.0	50.0
MCH (pg)	5	14.89 (15.00)±0.84	14.0–16.0	6	14.67 (14.50)±1.21	13.0–16.0	14.0
MCHC (g/dL)	5	29.60 (29.00)±0.89	29.0–31.0	6	29.83 (30.00)±1.60	28.0–32.0	28.0
White blood cells (10^3/μL)	5	22.82 (21.00)±4.8	17.8–29.0	6	19.12 (17.95)±4.49	15.1–24.5	16.0
Bands (10^3/μL)	5	1.81 (1.42)±1.63	0.5–4.6	6	1.13 (0.87)±0.79	0.4–2.5	0.3
Neutrophils (10^3/μL)	5	15.05 (15.75)±2.48	11.0–17.4	6	13.91 (12.90)±3.53	10.5–19.2	5.3
Eosinophils (10^3/μL)	5	0.52 (0.39)±0.31	0.3–1.0	5	0.36 (0.3)±0.39	0.0–1.0	0.2
Lymphocytes (10^3/μL)	5	4.31 (3.56)±2.23	2.10–7.74	6	2.83 (2.67)±0.61	2.26–3.91	9.0
Monocytes (10^3/μL)*	5	1.12 (1.33)±0.38	0.6–1.4	6	0.66 (0.67)±0.26	0.30–0.98	1.3
Platelet count (10^3/μL)	5	235.80 (216.00)±33.67	208.0–275.0	6	229.66 (190.00)±110.81	128.0–420.0	428.0
Basophils (10^3/μL)	5	0.00	0.0	6	0.00	0.0	0.0
Urea nitrogen (mg/dL)	5	93.60 (84.00)±29.78	64.0–130.0	6	108.17 (115.0)±32.28	58.0–144.0	68.0
Creatinine (mg/dL)	5	1.00 (0.90)±0.35	0.7–1.5	6	1.03 (0.95)±0.29	0.8–1.5	0.5
ALP (U/L)	5	42.40 (23.00)±32.30	13.0–80.0	6	40.50 (43.50)±20.75	15.0–68.0	192.0
AST (U/L)*	4	33.75 (34.00)±5.56	28.0–39.0	6	47.50 (48.00)±9.16	35.0–60.0	39.0
ALT (U/L)	4	40.25 (42.50)±10.34	26.0–50.0	6	47.00 (49.00)±17.42	20.0–68.0	33.0
GGT (U/L)[b]	4	8.25 (8.00)±2.87	5.0–12.0	4	9.00 (9.00)±1.15	8.0–10.0	12.0
Total bilirubin (mg/dL)	5	0.48 (0.50)±0.45	0.4–0.5	6	0.45 (0.45)±0.10	0.3–0.6	0.5
Direct bilirubin (mg/dL)	5	0.28 (0.30)±0.04	0.2–0.3	6	0.27 (0.25)±0.08	0.2–0.4	0.3
Indirect bilirubin (mg/dL)	5	0.20 (0.20)±0.00	0.2–0.2	6	0.18 (0.20)±0.04	0.1–0.2	0.2
CPK (U/L)*	5	166.20 (146.00)±65.62	110.0–280.0	6	400.33 (358.50)±172.35	195.0–618.0	958.0
Total cholesterol (mg/dL)	5	134.25 (133.00)±8.84	125.0–146.0	5	159.00 (161.50)±25.41	131.0–182.0	154.0
HDL (mg/dL)[b]	4	82.25 (84.50)±8.81	70.0–90.0	4	100.00 (94.00)±31.12	72.0–140.0	140.0
Triglycerides (mg/dL)	5	39.60 (37.00)±17.47	18.0–63.0	5	45.80 (41.00)±17.96	25.0–71.0	41.0
Uric acid (mg/dL)	5	1.62 (1.70)±0.51	1.0–2.1	6	0.94 (1.00)±0.25	0.5–1.1	1.6
Total protein (g/dL)	5	7.45 (7.40)±0.30	7.2–7.8	6	7.48 (7.30)±0.44	7.1–8.2	7.1
Albumin (g/dL)	5	2.30 (2.25)±0.32	2.0–2.7	6	2.44 (2.40)±0.11	2.3–2.6	3.2
Globulin (g/dL)	5	5.15 (5.15)±0.06	5.1–5.2	6	5.04 (4.90)±0.36	4.7–5.6	3.9

Table 2. Continued.

Parameter[a]	Males			Females			Juvenile
	n	Mean (median)±SD	Range	n	Mean (median)±SD	Range	
Iron (µg/dL)	5	200.50 (190.50)±117.31	76.0–345.0	6	78.60 (60.00)±34.24	52.0–135.0	139.0
Magnesium (mg/dL)[b]	4	2.20 (2.25)±1.36	0.5–3.8	5	2.32 (2.30)±0.35	2.0–2.9	3.3

[a] MCV = mean cell volume; MCH = mean cell hemoglobin; MCHC = mean cell hemoglobin concentration; ALP = alkaline phosphatase; AST = aspartate aminotransferase; ALT = alanine aminotransferase; GGT = gamma glutamyl transpeptidase; CPK = creatine phosphokinase; HDL = high-density lipoprotein.

* t-test: statistically significant differences ($P<0.05$).

[b] Because of a laboratory mistake, these tests were not performed for all samples.

described by Deem (2004). The relative leukocytosis in our free-ranging jaguar data might be explained by stress during capture. Although we believe stress during capture of free-ranging and captive wild animals is difficult to compare, a similar pattern of leukocytosis with neutrophilia has been reported for other wild felids (Weaver and Johnson, 1995; Marco et al., 2000). Mean values of hemoglobin, mean cell hemoglobin, and mean cell hemoglobin concentration were lower in free-ranging jaguars compared with captive jaguars described by Hawkey and Hart (1986). The last two parameters' values were also lower when compared to captive jaguars described by Deem (2004).

Although total protein values were similar between captive and free-ranging jaguars, free-ranging animals had lower albumin and higher globulin values. The mild hypoalbuminemia and hyperglobulinemia could be related to gastrointestinal parasitism in this population (Thrall, 2004), because there are some indications that gastrointestinal parasites are often found in free-ranging neotropical felids (Patton et al. 1986). Free-ranging jaguars had lower values of creatinine and higher values of urea nitrogen, uric acid, and iron than captive animals, which are probably effects of recent intake of rich protein meals by the free-ranging animals (Thrall, 2004). Within free-ranging jaguars, males had more monocytes and lower AST and creatinine phosphokinase mean values than females (Table 2).

The high values of eosinophils observed for animal 01 were probably due to intense infestation by *Tunga penetrans* (Widmer and Azevedo, 2012). The high values of transaminases (AST and ALT) activity with apparently normal values for creatine phosphokinase, alkaline phosphatase, and gamma glutamyl transpeptidase in male 08 suggest hepatocellular damage (Thrall, 2004), which might explain the long anesthetic recovery of this animal, because both tiletamine and zolazepam are metabolized by the liver (Maddison

and Page, 2008). This male was the oldest animal sampled, with an estimated age of 9 yr; it died 3 mo after capture of unknown causes (Widmer et al. 2011). Clinical examination, hematologic and biochemical results, and monitoring after capture indicate that these jaguars were in good overall health, except for animal 08. Despite the interference caused by capture stress and anesthesia, these results can be used as reference values for individual jaguars under similar handling conditions. We suggest that jaguar health researchers include analyses of hematologic and biochemical parameters to better evaluate and monitor individual and population health.

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