HEMATOLOGICAL AND BLOOD CHEMISTRY VALUES IN A SEMI-FREE POPULATION OF WHITE-NOSED COATIS *(NASUA NARICA)* IN LA VENTA TABASCO, MEXICO

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ABSTRACT. Clinical analyses of Procyonidae groups are extremely limited. The aim of this work was to obtain gender baseline data on the blood chemistry and hematological values of *Nasua narica*, in conditions of semi-freedom. For this, 14 males adults and 30 females adults were sedated with ketamine hydrochloride and captured. The blood was collected from the femoral artery, and conventional techniques were used to analyze the samples. Males showed statistical differences in hemoglobin, hematocrit and erythrocytes, compared to females. The females on the other hand having higher platelet counts than the males. For blood chemistry, the females showed higher concentrations of magnesium compared with the males. On the other hand, the males showed higher values in Albumin/Globulin relation with respect to the females. These results could be useful as reference values for adult individuals of *Nasua narica*, in order to develop future criteria regarding the health-disease processes of this species.

Key words: *Nasua narica*, biometry, serum biochemistry, reference values, male, female.

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RESUMEN. Los análisis clínicos a grupos de Procyonidos son muy limitados. El objetivo principal del presente trabajo fue obtener valores basales de química sanguínea y biometría hemática de *Nasua*

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narica, en condiciones de semi-libertad. Para esto, 14 machos y 30 hembras adultos fueron sedados con hidrocloruro de ketamina y capturados. La sangre se colectó de la arteria femoral; fueron utilizadas técnicas convencionales para analizar las muestras. Los machos mostraron diferencias estadísticas en hemoglobina, hematocrito y eritrocitos comparado con las hembras. Las hembras, por su parte tuvieron mayor número de plaquetas que los machos. Para química sanguínea, las hembras mostraron mayores concentraciones de magnesio en comparación con los machos. Por otro lado los machos mostraron valores más elevados en la relación Albumina/Globulina, con respecto a las hembras. Estos resultados podrían ser útiles como valores de referencia para los individuos adultos de *Nasua narica*, a fin de desarrollar futuros criterios en relación con los procesos de salud-enfermedad de esta especie.
Palabras clave: *Nasua narica*, biometría, química sanguínea, valores de referencia, machos, hembras.

INTRODUCTION

Understand and investigate the diseases of free-living individuals are vital aspects in management wildlife programs. Also the need to conserve several wild animal species in semi-free-range has attracted attention to the potential transmission of infectious microorganisms, their impact on the health of individuals and groups of the wild animals and their effect on conservation programs (Russel 1992). Animals kept in captivity or bred in semi-free-range areas, such as zoological gardens or parks may become infected with pathogens in their enclosures (Taema *et al.,* 2008). It is therefore fundamental to know the health conditions of captive animals in order to guarantee their wellbeing (Wirz *et al.,* 2008). A method for determining animal health is blood sampling and analysis. Haematological and serum biochemical values can obtain easily and are useful in determining the health or general condition of wild fauna (Riviello & Wirz 2001; Flabian *et al.,* 2008). In fact, the constituents of blood as well as many of the chemicals it carries provide fundamental information for medical diagnosis of disease (Morrison 1999; Moore 2000; Wirz *et al.,* 2008).

For some animal species, standard values of hematological variables are well defined. However concerning the Procyonidae, published date have often been based on few species, on small numbers of individuals, or derived from a single sample per animal, or reported values combined for all age groups or both sex or infected with a parasite.

The white-nosed coati (*Nasua narica*) is a Carnivore with great plasticity of behavior, which is an important factor in the success of the species within its wide geographical distribution, which extends from northeastern Colombia to southern Arizona and New Mexico (Gompper 1995). In Mexico, in particular, it is mainly distributed in the tropical forests of both oceanic slopes (Valenzuela 1998).

Its diet consists mainly of fruits and terrestrial invertebrates (Kaufmann 1962; Russell 1982; Saénz 1994; Gompper 1996; Valenzuela 1998). When fruits are scarce, however, it is reported that bands focus more on leaf -litter fauna and the males forage for larger prey, among which are some small vertebrates (Smythe 1970; Rusell 1981; 1982; 1983). Moreover, in captivity the coati's diet is modified and may include al-

most any kind of food. Currently, the coati is cataloged in a position of least concern (LC) according to IUCN (Samudio *et al.,* 2008).

The objective of present study is to establish reference values for biometric and blood chemistry in male and female adults of *Nasua narica* in semi-free conditions. These parameters will be critical in implementing conservation and management programs for this species, because will be used as reference to compare such values with other populations in the wild and in captivity. This is very important as will help us to detect and also, develop strategies in order to solve health problems with the aim to contribute to the conservation and survival of this species.

MATERIALS AND METHODS

Geographical location. The individuals in this study are located in Museum Park "La Venta", a protected natural area of the state government of Tabasco, where ecotourism is being developed. Located in downtown Villahermosa, Tabasco, México (18°20'N, 93°18') at a height of only10 m above sea level, the park covers an area of 8.0 ha, of which 6.0 ha have heterogeneous vegetation, both native and introduced. Its climate is warm-humid, with an average annual rainfall of 1600-2000 mm and a temperature of 22-26 °C (Fuentes *et al.,* 2003).

The vegetation consists of elements of high and medium evergreen forest, with secondary vegetation introduced (Capello & Alderete 1986). The lower middle stratum has trees 12 to 15 m in height. In the lower strata there are abundant herbaceous plants and thorny shrubs 2 to 8 m high. Some species present are: *Sapindus saponaria* (soap), *Byrsonima crassifolia* (nance), *Mangifera indica* (mango), *Gliricidia sepium* (cocoite) *Haematoxylum campechianum* (red stick), *Chrisophyllum caimito* (star apple), *Coccoloba barbadensis* (uvero) *Partmentiera edulis* (cuajilote), *Pouteria sapota* (mamey zapote), *Acrocomia mexicana* (cocoyol), *Tabernaemontana alba* (milky) and *Tamarindus indica* (tamarind) (Capello & Alderete 1986). *Mangifera indica* and *Pouteria sapota* were recorded in the diet of the coatis in this area (Fuentes-Anaya in preparation). In addition, daily eggs, bread, oatmeal and bananas are provided for them.

Experimental Design

Anesthesia and Capture. This study was approved by the institutional guidelines of the Universidad Veracruzana, the Federal Government of Mexico's Secretariat of Environment and Natural Resources (SEMARNAT; official permits # 09/GS-2132/05/10), and the Management Unit for Conservation of Wildlife (UMA) 2000, Museum Park "La Venta" INE/CITIES/DGVS/ZOO-E-002-97-TAB.

During the period from November 30 to December 2, 2009, 44 adult individuals were captured within the park: 30 females and 14 males. Each individual was

sedated by using a 3-ml syringe and darts made with 3x32mm needles, which were fired through a blowgun, approximately two to five meters from the trigger. Each dart contained a dose of 10-15 mg/kg (0.5 ml – Modified from Kreeger & Ameno 2007) of ketamine hydrochloride (Inoketam® 1000 Virbac, S.A. Lab. Guadalajara, Jal. Mexico). When the dart had hit its mark, the individuals were weighed in a hanging scale (LightLine® Spring Scales, Forestry Suppliers, Inc. Jackson MS, USA).

After the last blood sampling, each was placed temporarily in an individual cage until complete recovery from the anesthesia. Thereafter, they were returned to the site of capture and observed until they rejoined their social group.

Blood Sampling. A syringe (BD-Vacutainer® 21Gx 32mm, México, DF) was used to extract 2.5 ml of blood from the femoral artery. Each blood sample was then split into various fractions as follows:

Hematic biometry. For hematic biometry, 0.5 ml was placed in tubes (Microtainer® Brand Becton Dickinson, Franklin Lakes, New Jersey, USA), in which ethylendiaminotetracetic acid (EDTA) was included as an anticoagulant. This was mixed gently and maintained at ambient temperature in continuous agitation for 30 minutes. Then it was stored at 4ºC for less than 8 hours, for subsequent laboratory analysis.

We estimated the concentration of eleven different constituents: Hemoglobin Concentration, Hematocrit, Red Blood Cells, Mean Corpuscular Volume, Mean Corpuscular Hemoglobin, Mean Corpuscular Hemoglobin Concentration and Platelets, White Blood Cells, Monocytes, Lymphocytes, and Granulocytes. These were quantified with Beckman Coulter equipment ACT-5-DIF (Beckman Coulter de Mexico S.A. de C.V.) by means of the cyanmethemoglobin spectrophotometry methodology, mathematical ratio and electrical impedance.

Serum biochemistry. For the blood biochemistry test, 2 ml of blood were emptied into a tube (BD-Vacutainer® SST^{TM}) with a gel to separate it from the serum. This was centrifuged at 1,096 g for 10 min. (COLE -PARMER®; Equipar S.A. de C.V. México), and then the serum was collected and placed in clean vials. These were transported at 4ºC and stored at -20ºC for less than 8 hours, for subsequent analysis. For blood chemistry, we determined the concentration of eighteen different parameters: Glucose, Blood Urea Nitrogen, Urea, Uric Acid, Total Protein, Albumin, Globulin, Albumin/Globulin Ratio, Creatinine, Cholesterol, Triglycerides, Alkaline Phosphatase, Calcium, Phosphorus, Magnesium, Chloride, Potassium and Sodium, which were quantified with a Johnson & Johnson Vitros 250 Chemistry Analyzer (Johnson & Johnson de México, S.A. de C.V.) by means of the reflectance spectrophotometry methodology and direct potentiometry.

The hemolyzed, icteric or lipemic samples were discarded to avoid analytical interferences.

Statistical analyses. Thereafter, a descriptive statistic (Me ± SD) was applied in order to obtain the mean weights of the specimens, to determine gender differences in

the weights applied a one-way ANOVA. The Kolmogorov-Smirnoff test was applied to these data to establish whether the distribution was normal. Finally a Mann-Whitney test was applied to determine the differences among the values in each parameter of chemistry and hematic biometry between males and females, with $p<0.05$ being considered as significant. Moreover was performed a Pearson correlation between the weight of individuals and hematology and blood chemistry values was made. The analyses were carried out in the statistic package SIGMA STAT 3.5 (SYSTAT®, Charter Oak, CA. USA).

RESULTS

The average weight of the males was significantly higher ($F = 61.944$, $p<0.0001$) than that of the females (5.6 ± 0.23 *vs*. 4.0 ± 0.06 kg). There was no significant correlation between weight and hematological values; however, there was negative correlation between weight of females ($r = -0.43$) and males ($r = -0.71$) with alkaline phosphatase and a positive correlation between the weight of the males and the values of potassium and creatinine ($r = 0.76$ and $r = 0.65$ respectively).

Hematic biometry. This shows the mean, standard deviation and range values of each hematological parameter for males and females. As the values failed the normality test (Kolmogorov-Smirnov), was applied the Mann-Whitney test, the males showed significant differences compared to those found in the females, within the parameters of hemoglobin ($U = 80$; $p = 0.001$), hematocrit ($U = 108.5$; $p = 0.011$), and red blood cell count ($U = 119$; $p = 0.021$). However, the females showed a difference in platelets ($U = 129$; $p = 0.023$) compared with the males, all other parameters showing no significant differences between the genders (Table 1).

Serum Biochemistry. The males showed significant differences in albumin/globulin relation ($U = 38$; $p = 0.001$) and creatinine ($U = 53.5$; $p = 0.027$) compared to the females; whereas in the parameter of magnesium, the females showed significant differences ($U = 53.5$; $p = 0.009$), compared to the males. The other parameters showed no significant differences between the genders (Table 2).

DISCUSSION

The results of blood counts between genders showed that the females were found to have lower values than the males in three parameters (hemoglobin, hematocrit and red blood cells); this may be due to the sexual dimorphism presented, which is consistent with other reports on mammals (Samonds *et al.,* 1974; Abouheif & Fairbairn 1997; Larsson *et al.* 1999; Riviello & Wirz 2001; Suardiaz *et al.,* 2004; Miller *et al.,* 2009; Mikniene *et al.,* 2010).

When comparing these three parameters with those reported for *Nasua nasua* by (Sampaio *et al.*, 2001), our animals showed higher values in these parameters. How-

Table 1. Hematological values (mean ± SD), maximum and minimum range of 44 male and female adults white-nose coatis (*Nasua narica*). Hemoglobin, hematocrit and red blood cell count were significantly higher in males than females. Platelets were significantly higher in female than males. Mann-Whitney test, $p < 0.05$.

Parameters	Male n = 14	Máx Mín	Female n = 30	Máx Mín	U-test
Hemoglobin (g/dL)	10.71 ± .43	13.9-8.7	9.21 ± .18	12.7-7.6	.001*
Hematocrit (%)	31.84 ± 1.48	44.3-25.2	27.86 ± .61	39.1-22.5	.011*
Red Blood Cell count ($\times 10^6$/uL)	6.54 ± .27	8.86-5.3	5.81 ± .13	8.39-4.3	.021*
Mean Corpuscular Volume (fl)	48.64 ± .72	54-45	48.03 ± .36	52-45	.540
Mean Corpuscular Hemoglobin (pg)	16.42 ± .31	19.3-15.2	15.87 ± .11	17.7-14.8	.141
Mean Corpuscular Hemoglobin Concentration (g/dl)	33.79 ± .34	36.1-31.4	33.13 ± .17	34.7-31	.093
Platelet ($\times 10^3$/uL)	512.71 ± 19.55	636-393	595.43 ± 22.07	904-385	.023*
White blood cell ($\times 10^3$/uL)	9.48 ±.84	14.7-5.20	8.61 ± .43	15.3-5.1	.668
Monocyte ($\times 10^3$/uL)	2.42 ± .27	4.0-1.1	2.13 ± .10	3.2-1.1	.605
Lymphocyte ($\times 10^3$/uL)	3.37 ± .33	5.8-2.1	2.72 ± .15	5.8-1.5	.089
Garanulocytes ($\times 10^3$/uL)	3.69 ± .39	6.3-1.7	3.76 ± .30	10.3-1.8	.899

ever with respect to that reported by *Pimentel* (1994, cited by Silva *et al.*, 1999) for same specie in captivity conditions, *Nasua narica* shows lower values in red blood cells and hematocrit, and similar ones in hemoglobin, whereas a slight increase is shown over that reported for *Nasua nasua* infected with *Trypanosoma evansi* (Silva *et al.*, 1999). Regarding the white blood cell values, we found a lower concentration of these in respect to *Nasua nasua* in both conditions. These results allow us to suggest that our individuals are not sick (Silva *et al.*, 1999) or stressed as a result of immobilization and handling during the capture (Wallace & Oppenheim 1996). On the other hand, we must take into account that there may be large variations in the blood levels of wild populations in regard to both intrinsic (inflammatory responses, immunological investment, aerobic capacity) and extrinsic factors (environmental and host factors - Beldomenico *et al.*, 2008).

In regard to platelet count, we found that females showed a greater number of them compared to males. Platelets play an important role in the response to vascular damage and are also involved in the inflammatory response (Roitt *et al.*, 1998), increasing in number when injuries occur (Semple *et al.*, 2002). We suggest that this difference is probably related to the greater social activity presented by females, as observed in the bands that they form (Gommper 1996; Valenzuela, 1998) they also

Table 2. Blood biochemistry values (mean ± SD), maximum and minimum range of 44 male and female adults white-nose coatis (*Nasua narica*). Albumin/Globulin relation, creatinine was significantly higher in males than females. Magnesium was significantly higher in female than males. Mann-Whitney test, $p < 0.05$.

Parameters	Male n = 14	Máx Mín	Female n = 30	Máx Mín	U-test
Glucose (mg/dL)	80.09 ± 8.70	133-39	74.36 ± 4.28	114-45	.789
Blood Urea Nitrogen (mg/dL)	16.27 ± 2.09	29-7	17.40 ± 0.76	29-11	.321
Urea (mg/dL)	34.82 ± 4.48	62.1-15.0	37.25 ± 1.64	62.1-23.5	.328
Ureic Acid (mg/dL)	1.15 ± 0.9	2.0-0.9	1.15 ± 0.9	1.5-0.9	.293
Total Protein (g/dL)	7.02 ± .22	8.2-6.2	7.05 ± .14	8.3-5.7	.647
Albúmin (g/dL)	3.09 ± .10	3.6-2.8	2.90 ± .06	3.5-2.4	.244
Globulin (g/dL)	3.93 ± .13	4.7 - 3.4	4.15 ± .09	5.1-3.2	.187
Albumin/Globulin relation (mg/dL)	0.78 ± .01	0.85 - 0.63	0.69 ± .01	0.81-0.60	.001*
Creatinine (mg/dL)	1.17 ± .06	1.5-0.9	0.99 ± .02	1.2-0.8	.027*
Cholesterol (mg/dL)	173.0 ± 13.57	259 -102	197.09 ± 6.69	258-143	.163
Triglyceride (mg/dL)	28.90 ± 3.35	55-20	27.36 ± 1.08	35-20	.688
Alkaline Phosphatase (U/L)	50.27 ± 5.52	79-28	46.13 ±2.07	75.0-34.0	.703
Calcium (mg/dL)	8.67 ± .15	9.5-8.0	8.34 ± .11	9.2-7.3	.117
Phosphorous (mg/dL)	5.17 ± .23	6.2-3.9	5.13 ± .12	6.3-4.2	.939
Magnesium (mmol/L)	1.87 ± .07	2.4-1.6	2.08 ± .04	2.4-1.7	.009*
Chloride (mmol/L)	114.81 ± 1.32	122.0-108.0	115.04 ± 1.06	125-105	.746
Potassium (mmol/L)	4.58 ± .10	5.2-4.2	4.64 ± .08	5.5-4.1	.745
Sodium (mmol/L)	142.27 ± 1.70	152-136	141.90 ± 1.35	154-129	.984

have greater individual interactions during coalitions periods with the young (Hirsch 2007; Fuentes-Anaya, in preparation).

Other authors mention that these differences in females may be due to cyclical secretion of gonadal hormones (Emms & Lewis 1985). However, our sampling was carried outside this reproductive period (Gommper 1995).

The results of blood chemistry showed significant gender differences, the males having higher concentrations in the albumin/globulin relation and in creatinine as compared to the females, while the latter showed a higher concentration of magnesium ions. A clinical laboratory test for humans reports an albumin/globulin relation in a range of 3.3-5.9 g/ml and plasma magnesium between 1.5 and 2 mmol/L, neither being reported by gender (Morrison 1999). The same range applies to the values for the coatis. As to the statistical difference in the concentration of creatinine, this may

be related to the body mass of individuals, its concentration being the result of muscle metabolism (Morrison 1999).

In general, all values in hematology and blood chemistry reported in this study, were within the ranges shown in the ISIS database. The differences in minimum and maximum values of blood cells, is likely due to ISIS values include analysis of young individuals, while our results only represent adult organisms. It is reported that young individuals mammals have hematologic differences from adults because the young are growing and developing (Sealander 1963; Franzmann & Schwartz 1988; Flaiban *et al*., 2008).

It is important to note that most of the reports on the hematological values in different species of Procyonidae are made using individuals in captivity, either because they are subject to investigation or enclosed in zoos. To our knowledge this is the first report for blood test in *Nasua narica* under semi-freedom conditions in Southeastern of Mexico, and our findings underline the differences between genders in hematology test and blood chemistry. Therefore, our results could be useful as reference values for adult individuals of *Nasua narica*, in order to develop future criteria regarding the health-disease processes of this species.

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