PESQUISA VETERINÁRIA BRASILEIRA
Brazilian Journal of Veterinary Research
ISSN 0100-736X (Print)
ISSN 1678-5150 (Online)

Pesq. Vet. Bras. 45:e07473, 2025
DOI: 10.1590/1678-5150-PVB-7473

Original Article
Wildlife Medicine

Hematological and biochemical parameters of free-living roadside hawks (*Rupornis magnirostris*) rescued in the state of Ceará[1]

Alicia F. Nunes[2]*, Felipe R. Oliveira[2], Francisco W.S. Alves[2], Carla R.S. Bezerra[2], Bruno P. Lima[3], Régis S.C. Teixeira[4], William C. Maciel[4] and Isaac N.G. Silva[2]

ABSTRACT.- Nunes AF, Oliveira FR, Alves FWS, Bezerra CRS, Lima BP, Teixeira RSC, Maciel WC, Silva ING. **Hematological and biochemical parameters of free-living roadside hawks (*Rupornis magnirostris*) rescued in the state of Ceará**. *Pesquisa Veterinária Brasileira 45:e07473, 2025*. Laboratório de Patologia Clínica Veterinária, Hospital Veterinário Dr. Sylvio Barbosa Cardoso, Universidade Estadual do Ceará, Rua Betel s/n, Itaperi, Fortaleza, CE 60714-100, Brazil. E-mail: alicia.f.nunes@gmail.com

Hematological and biochemical analysis of birds of prey serves as a valuable tool to assist in assessing the health status of individual animals when associated with clinical parameters. The scarcity of studies determining reference intervals for the roadside hawk (*Rupornis magnirostris*) interferes with the correct interpretation of the health status of these animals in captivity. In this study, blood samples were collected from 16 roadside hawks rescued in the state of Ceará to perform hematological analyses and serum biochemical measurements. Of this total, 10 (62.5%) birds were young hawks, and six (37.5%) were adults. All hawks underwent hematological analysis, while 12 of the 16 (75%) underwent biochemical analysis, of which eight (66.6%) were young, and four (33.3%) were adults. The values of the hematological parameters for all animals were as follows: red blood cells = 2.60 x 10^6/µL (± 0.58), hemoglobin = 10.26 g/dL (± 1.34), hematocrit = 38.94% (± 5.48), mean corpuscular volume = 154.05 fL (± 28.67), mean corpuscular hemoglobin concentration = 26.43% (± 1.26), leukocytes = 12.31 x 103/µL (± 6.75), heterophils = 5.56 x 103/µL (± 3.91), lymphocytes = 2.68 x 103/µL (± 2.38), eosinophils = 2.62 x 103/µL (± 2.29), basophils = 0.377 x 103/µL (± 0.52), monocytes = 1.06 x 103/µL (± 0.74) and total plasma proteins = 4.56 g/dL (± 0.77). The mean values obtained from serum biochemical measurements were as follows: uric acid = 14.69 mg/dl (± 9.40), aspartate aminotransferase = 218.13 UI/l (± 108.59), creatine kinase = 1,156 UI/l (± 892.71), albumin = 1.06 g/dl (± 0.18), total proteins = 3.57 g/dl (± 1.11), globulin = 2.5 g/dl (± 1.04), albumin/globulin ratio = 0.47 g/dl (± 0.21). The values obtained in this study are similar to those reported in previous studies for the same species. There was no significant difference in the hematological and biochemical parameters of the adult hawks versus the young hawks. Hematology and biochemistry associated with the clinical evaluation and monitoring of hawks are important factors in determining the health status of these birds when considering their suitability for reintroduction into their natural environment.

INDEX TERMS: Hematology, biochemistry, birds of prey, roadside hawk.

[1] Received on August 7, 2024.
Accepted for publication on August 27, 2024.

[2] Laboratório de Patologia Clínica Veterinária (LPCV), Hospital Veterinário Dr. Sylvio Barbosa Cardoso, Universidade Estadual do Ceará (UECE), Rua Betel s/n, bairro Itaperi, Fortaleza, CE 60714-100, Brazil. *Corresponding author: alicia.f.nunes@gmail.com

[3] Instituto Pró-Silvestre, Fortaleza, CE, Brazil.

[4] Laboratório de Estudos Ornitológicos (LABEO), Universidade Estadual do Ceará (UECE), Rua Betel s/n, Itaperi, Fortaleza, CE 60714-100, Brazil.

RESUMO.- [Parâmetros hematológicos e bioquímicos de gaviões-carijós (*Rupornis magnirostris*) de vida livre resgatados no estado do Ceará.] A análise hematológica e bioquímica de aves de rapina serve como valiosa ferramenta de auxílio para avaliação do estado de saúde dos indivíduos quando associados aos parâmetros clínicos. A escassez de estudos que determinem intervalos de referência para a espécie gavião-carijó (*Rupornis magnirostris*) interfere na correta

interpretação do estado de saúde desses animais em cativeiro. Foram colhidas amostras sanguíneas de 16 indivíduos de gavião-carijó resgatados no estado do Ceará para realização de análises hematológicas e dosagens bioquímicas séricas. Deste total, 10 (62,5%) corresponderam aos indivíduos jovens e seis (37,5%) eram adultos. Todos os indivíduos realizaram análise hematológica, destes, somente 12/16 (75%) aves realizaram análises bioquímicas, sendo oito (66,6%) jovens e quatro (33,3%) adultos. Os valores dos parâmetros hematológicos para todos os animais foram: hemácias = 2,60 x 10^6/µL (± 0,58), hemoglobina = 10,26 g/dL (± 1,34), hematócrito = 38,94% (± 5,48), volume corpuscular médio = 154,05 µm^3 (± 28,67), concentração de hemoglobina corpuscular média = 26,43% (± 1,26), leucócitos = 12,31 x 10^3/µL (± 6,75), heterófilos = 5,56 x 10^3/µL (± 3,91), linfócitos = 2,68 x 10^3/µL (± 2,38), eosinófilos = 2,62 x 10^3/µL (± 2,29), basófilos = 0,377 x 10^3/µL (± 0,52), monócitos = 1,06 x 10^3/µL (± 0,74) e proteínas plasmáticas totais = 4,56 g/dL (± 0,77). Os valores médios obtidos das dosagens bioquímicas séricas foram: ácido úrico = 14,69 mg/dL (± 9,40), aspartato aminotransferase = 218,13 UI/L (± 108,59), creatina quinase = 1.156 UI/L (± 892,71), albumina = 1,06 g/dL (± 0,18), proteínas totais = 3,57 g/dL (± 1,11), globulina = 2,5 g/dL (± 1,04), relação albumina/globulina = 0,47 g/dL (± 0,21). Os valores obtidos neste estudo, de maneira geral, se assemelharam com estudos anteriores para a mesma espécie. Não houve diferença significativa nos parâmetros hematológicos e bioquímicos de adultos e jovens. A hematologia e bioquímica associados à avaliação e acompanhamento clínico dos indivíduos caracterizam-se como fatores importantes na determinação do estado de saúde desses animais para serem considerados aptos à reintrodução no seu ambiente natural.

TERMOS DE INDEXAÇÃO: Hematologia, bioquímica, aves de rapina, gavião-carijó.

INTRODUCTION

Predatory carnivorous avian species, commonly called birds of prey, have anatomical and physiological characteristics that make them adapted to hunting, such as greater visual capacity to search for prey, curved, sharp beaks, and claws with great gripping force. Raptors are divided into four orders: Falconiformes, Strigiformes, Cathartiformes, and Accipitriformes, the latter being represented, among other species, by the roadside hawk (*Rupornis magnirostris*), included in the Accipitridae family (Ferguson-Lees & Christie 2001).

The roadside hawk has a pattern of vertical stripes on the pectoral region and rectrices, alternating between light and dark gray or black bands. It is a medium-sized bird that does not present sexual dimorphism, except for the females being larger than the males (Santos & Rosado 2009).

This species has been reported from northern Mexico to Argentina and can be found throughout Brazilian territory. Due to anthropogenic changes that have led to the modification of its habitat, the roadside hawk is often found in urban areas and is considered well-adapted to this space. Their most common habitats include open fields, forest edges, rivers, lakes, and places where chickens are raised (Panasci & Whitacre 2002, Santos & Rosado 2009).

The clinical evaluation and diagnosis of these species are complex processes that involve a range of factors. For free-living birds, complete information about the animal's history, diet, and other data may be scarce. A complete physical examination and complementary tests, such as laboratory tests, provide important data regarding the individual animal's clinical condition (Joppert 2014).

Animals undergoing rehabilitation need to undergo several assessments and meet certain criteria to be considered fit for release. This is equally true for birds of prey, even though these animals tend not to present any signs of pathological processes. Thus, clinical symptoms in these individuals tend to appear in more advanced stages of the disease (Black et al. 2011).

In this context, hematological and biochemical parameters become valuable in assessing and monitoring the health status of these birds of prey. These values, however, are scarce for several species. In Brazil, where the roadside hawk is well adapted to urban environments and has a vast area of occurrence, the animal is commonly received in triage centers. As with other species, the clinical parameters of roadside hawks need to be evaluated and deemed adequate for them to be considered fit for release (Polo et al. 1992, Guerra et al. 2018).

The scarcity of hematological and biochemical reference values for this species makes it difficult to assess individual animals' health status accurately. Several factors interfere with these parameters, such as captivity stress, habitat changes, and diet changes, which can significantly affect the results of laboratory tests (Guerra et al. 2018).

In view of this, this study aims to determine the hematological and serum biochemical parameters for roadside hawks (*R. magnirostris*) rescued in the state of Ceará to aid in assessing the health status of this species.

MATERIALS AND METHODS

Ethical approval. This research was submitted and approved by Ceará State University's Ethics Committee for Animal Use under number 110128646/2022.

Study area. The study took place at the "Laboratório de Estudos Ornitológicos" (Ornithological Studies Laboratory – LABEO) and the "Laboratório de Patologia Clínica Veterinária" (Veterinary Clinical Pathology Laboratory – LPCV) of the "Hospital Veterinário Dr. Sylvio Barbosa Cardoso" (Dr. Sylvio Barbosa Cardoso Veterinary Hospital – HVSBC), both located at "Universidade Estadual do Ceará" (UECE), in the city of Fortaleza, Ceará, Brazil. The specimens in the study were rescued in the state of Ceará by civilians, the fire department, the environmental police battalion, or a non-governmental organization called "Instituto Pró-Silvestre" and sent to LABEO.

Sample period and collection. Blood samples were collected from *Rupornis magnirostris* specimens from November 2022 to October 2023. The animals were rescued and underwent rehabilitation for eventual release. Initially, the birds were physically restrained with leather gloves while clinical and physical examination was performed. Each bird was evaluated according to the following parameters: inspection of feathers, skin, mucous membranes, and oral cavity; palpation of bones and joints; body condition score (1 to 5); presence of ectoparasites; mental state (active, prostrate, calm, agitated, aggressive); and auscultation of the cardiorespiratory system (Goulart 2015). Regarding age, the birds were classified according to their plumage as chicks, young birds, and adults. Each bird was fed daily by rats or mice equivalent to 10% of its body weight.

Venipuncture was performed after asepsis of the site with cotton soaked in 70% alcohol, using sterile 1- or 3-mL syringes and 24 G or 26 G needles. The syringe size and the needle gauge were chosen according to the size of the bird and the visibility of the blood vessel to be punctured. A blood volume of approximately 0.5 to 2 mL was collected, not exceeding the maximum amount of 1% of the bird's body weight. The preferred collection site was the jugular or brachial vein, and blood smears were immediately made after collection. The remaining blood was stored in microtubes with ethylenediaminetetraacetic acid additive and microtubes with clot activator to evaluate the hematological and biochemical profile, respectively. The blood samples were stored in slide-holder bottles, and the samples in microtubes were refrigerated in a Styrofoam box with recyclable ice. All these materials were forwarded to the LPCV on the same day for processing.

Hematological analysis. Initially, the samples were homogenized for five minutes in a homogenizer (AP 22, Phoenix, Araraquara, Brazil). Hematological parameters included red blood cell count (RBC), hematocrit (Ht), hemoglobin concentration (Hb), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), white blood cell count (WBC) and differential, blood parasite screening, evaluation of erythrocyte and leukocyte morphology, thrombocyte count, and total plasma protein (TPP) measurement.

The red blood cell, leukocyte, and thrombocyte counts were performed using a hemocytometer (Global Trade Technology Mirrored Neubauer Chamber) and Natt-Herricks diluent according to the methodology of Dias (2010) with modifications. The fluid proportion used was 1:100 (10 µL blood + 1000 µL Natt-Herricks). The solution was homogenized manually, and the Neubauer chamber was filled with 20 µL of this solution for counting under an optical microscope (Olympus Cx21led, Tokyo, Japan) at 400x magnification. The erythrocytes were counted in the five small squares located in the central quadrant, and the value was multiplied by the multiplying factor 5,000. Leukocytes and thrombocytes were counted in the 25 small squares in the central quadrant, and the value was multiplied by the multiplying factor of 1,000.

Hematocrit determination was performed using the microhematocrit technique, where approximately two-thirds of a microcapillary tube was filled for each sample. The tube was sealed using a blowtorch and placed in a microhematocrit centrifuge at 11,000 revolutions per minute (RPM) for five minutes. Subsequently, the reading was performed using a graduated ruler to read the microhematocrit levels. From the capillary, it was broken in the region between the plasma volume and the cellular components, and the plasma was deposited in a refractometer instrument, with the TPP reading performed in the left column of the device (Dias 2010).

Hemoglobin concentration was determined using the cyanmethemoglobin method (Labtest kit, Lagoa Santana, Minas Gerais, Brazil) measured in a spectrophotometer (Mindray BA-88A, Shenzhen Mindray Bio-Medical Electronics Co., Ltd., Shenzhen, China) after centrifugation (Campbell 2015). The hematimetric indices (MCV and MCHC) were calculated according to Wintrobe's (1932) formulas.

The previously prepared blood smears were stained with May Grunwald-Giemsa (Newprov laboratory products Ltda., Paraná, Brazil) according to the manufacturer's recommendations, and a differential leukocyte count was performed on a total of 100 leukocytes, as well as the morphological evaluation of these cells under optical microscopy, using 100x magnification (oil immersion).

Hemoparasite search. Blood smears were evaluated for the presence of hemoparasites under an optical microscope at 400x and 1,000x magnification. Each slide was read for at least 30 minutes, according to the recommendations of Fallon & Ricklefs (2008). The Woo test (Woo 1969) was also used, where the plasma/cell interface of the microcapillary was examined under an optical microscope at 100x magnification and the presence or absence of hemoparasites was observed through movement. Subsequently, the microcapillary was broken near the buffy coat region and then inserted into a glass slide, and the smear was conducted to determine the presence of hemoparasites. The staining, time, and magnifications of the reading of the buffy coat smears were the same as those used for the blood smears.

Biochemical evaluation. Biochemical analyses of aspartate aminotransferase (AST), uric acid, creatine kinase (CK), total proteins and fractions (albumin and globulin), and albumin/globulin ratio were performed using commercial kits (Labtest kit, Lagoa Santana, Minas Gerais, Brazil) and an automatic Labmax Plenno biochemical analyzer (Labtest, Lagoa Santana, Minas Gerais, Brazil), previously calibrated with a commercial calibrator and level I and II controls, all in accordance with the manufacturer's recommendations.

Inclusion criteria. The hematological and biochemical reference values established in this research were determined using birds considered healthy in the clinical evaluation, based on the parameters evaluated in the physical examination and which did not present hematological alterations such as the presence of significant erythroid precursors, hypochromia, toxic heterophils, reactive lymphocytes, and activated monocytes, in addition to negative results in the hemoparasite search. Samples with significant hemolysis and/or lipemia were also not included in the study.

Statistical analysis. Statistical analyses were performed using IBM SPSS Software (Statistical Package for the Social Sciences). The Shapiro-Wilk test was used to assess the normality of the variables. Subsequently, to assess whether the variables were significant between adults and young birds, parametric (Student's t-test) and non-parametric (Mann-Whitney U test) tests were applied to the values of variables with normal and abnormal distributions, respectively. Values were considered significant when $P < 0.05$.

RESULTS

Of the 28 birds evaluated, 16 met the research inclusion criteria. The 16 hawks were considered clinically healthy, with no apparent injuries and clinical parameters within normal limits. Of the 16 birds, 10 (62.5%) were young hawks, and six (37.5%) were adults. It was not possible to determine the sex of the birds. Biochemical analyses were performed on only 12 of the 16 (75%) birds due to difficulty in collecting blood or insufficient blood samples. Of these 12, eight (66.6%) were young, and four (33.3%) were adults. The values of hematological parameters and biochemical assays obtained in this study are detailed in Table 1.

Morphologically, the cells presented typical characteristics described for the species. Mature erythrocytes had an elliptical shape, pinkish-red cytoplasm, regular edges, an elliptical nucleus, dense chromatin, and were basophilic. Immature erythrocytes had slightly basophilic cytoplasm and a more rounded shape, with loose chromatin.

Leukocyte morphology was also typical for the species. Heterophils presented cytoplasm full of elliptical granules and pink coloration, eosinophils presented rounded pink granules, and basophils had basophilic granules. Monocytes were characterized as the largest leukocytes, with round to amoeboid cytoplasm and a round to lobed nucleus (Fig.1). The

lymphocytes had rounded cytoplasm, with a round nucleus, possibly with a slight indentation, and chromatin with a reticulated pattern. At the same time, the thrombocytes had round to oval nuclei and cytoplasm and densely agglutinated chromatin (Fig.2).

The most predominant leukocytes were heterophils (5.56 ± 3.91 x 10^3/µL). In order of predominance, the other leukocyte types were lymphocytes, eosinophils, monocytes, and basophils.

Using the Shapiro-Wilk test for variables that presented P > 0.05, the Student›s T-test was performed for two independent samples. The only variables that presented P < 0.05 were the values for heterophils, lymphocytes, eosinophils, and basophils, which were then submitted to the Mann-Whitney U test for two independent samples (Table 2). None of the variables presented significant values between the young and adult birds.

Regarding the total thrombocyte count, only three of the 16 (18.75%) birds included in the study did not present morphological alterations, with thrombocyte aggregates reported in all other animals. Therefore, this parameter was not included in the statistical analyses.

DISCUSSION

The animals selected for the present study came from rescue actions, with the main objective of reintroducing these birds to their original environment. Monitoring the physical evolution associated with hematological and biochemical parameters served as a highly relevant factor for assessing the health status of each specimen. The scarcity of comparative values for free-living animals makes interpretation difficult, highlighting the importance of studies on animals living in natural environments to understand how they develop hematological responses to different stimuli and conditions (Santos et al. 2017).

The mean values of the total erythrocyte count and hematimetric indices (MCV and MCHC) obtained in this

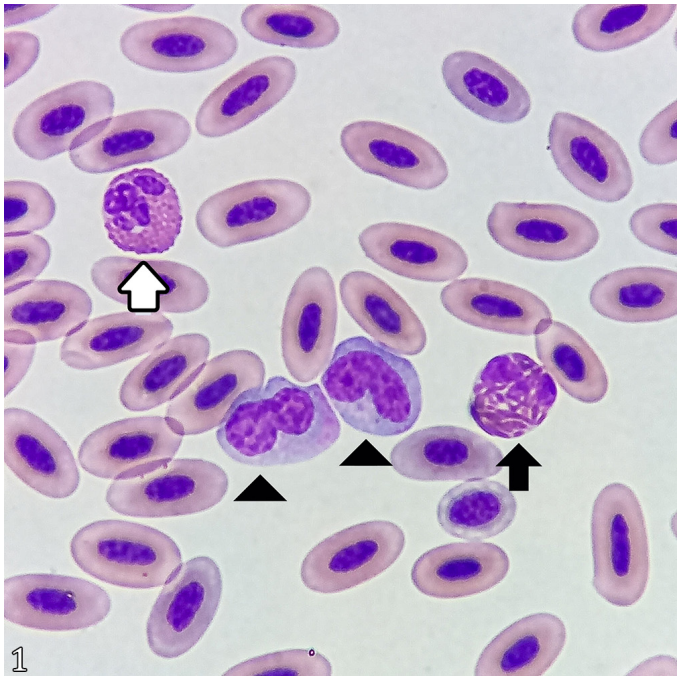

Fig.1. Blood cells of *Rupornis magnirostris*, indicating an eosinophil (white arrow) with round granules, heterophil (black arrow) with elongated and elliptical granules, and monocytes (arrowheads). A young red blood cell may be seen below the indicated heterophil. May-Grunwald Giemsa stain, 1000x magnification. Fortaleza/CE, 2023.

Table 1. Hematological and biochemical values obtained from roadside hawks (*Rupornis magnirostris*) rescued in the state of Ceará. Fortaleza/CE, 2023

Parameters (unit)	N	Mean	SD ±	Median	Min-Max (CI: 95%)
Red blood cells (x10^6/µL)	16	2.60	0.58	2.44	2.30-2.91
Hemoglobin (g/dL)	16	10.26	1.34	10.55	9.5-11.0
Hematocrit (%)	16	38.94	5.48	38.50	36-41
VCM (fL)	16	154.05	28.67	160.15	138.8-169.3
CHCM (%)	16	26.43	1.26	26.25	25.7-27.1
Leukocytes (x10^3/µL)	16	12.31	6,75	11.0	8.7-15.9
Heterophiles (x10^3/µL)	16	5.56	3.91	4.0	3.47-7.64
Lymphocytes (x10^3/µL)	16	2.68	2.38	1.98	1.4-3.9
Eosinophils (x10^3/µL)	16	2.62	2.29	1.38	1.4-3.8
Basophils (x10^3/µL)	16	0.377	0.52	0.20	0.09-0.65
Monocyte (x10^3/µL)	16	1.06	0.74	1.11	0.67-1.46
TPP (g/dL)	16	4.56	0.77	4.80	4.1-4.9
Uricacid (mg/dL)	12	14.69	9.40	12.2	8.7-20.6
AST (UI/L)	12	218.13	108.59	210.50	149.1-287.1
CK (UI/L)	10	1,156	892.71	846.7	517.7-1,794
Albumin (g/dL)	10	1.06	0.18	1.10	0.9-1.1
TP (g/dL)	10	3.57	1.11	3.30	2.7-4.3
Globulin (g/dL)	10	2.5	1.04	2.3	1.75-3.24
A/G ratio (g/dL)	10	0.47	0.21	0.40	0.31-0.62

N = number of individuals, SD = standard deviation, Min = minimum, Max = maximum, CI = confidence interval, MCV = mean corpuscular volume, MCHC = mean corpuscular hemoglobin concentration, TPP = total plasma proteins, AST = aspartate aminotransferase, CK = creatine kinase, TP = total proteins, A/G ratio = albumin/globulin ratio.

study remained within the values previously established by Sanches et al. (2005) and Dias (2010). The number of red blood cells (2.56 ± 0.560 x 10^6/µL) was also similar to other studies involving hawks, such as those reported by Dias (2010) (2.22 ± 0.4360 x 10^6/µL; n = 13), obtained from animals in the process of recovery and adaptation. The counts were also similar to those reported by Santos et al. (2017) (2.62 ± 0.4860 x 10^6/µL; n = 20) and Sanches et al. (2005) (2.96 ± 1.4960 x 10^6/µL; n = 9).

Most studies of the species *Rupornis magnirostris* have made comparisons between male and female hawks, with little data on comparative hematological and biochemical parameters between juveniles and adults. Although no significant difference was observed in the current study, the mean values of hematological parameters were lower in the young hawks than in the adults. Other factors influencing the erythrocyte and MCV values of avian species include sex, hormones, environmental factors, and diseases (Campbell 2015).

In their study of different owl species, Montolio et al. (2017) observed a difference between young and adult owls in hematocrit values, total red blood cell count, and hemoglobin concentration, with young owls having the lowest values. The study associated the higher values in adult owls with an adaptation mechanism due to the increased oxygen demand for flight activities.

Regarding total leukocyte count, Montolio et al. (2017) observed significantly higher values in young owls compared to adults, suggesting that young owls may have a more responsive immune system than adults, or that young owls may be more sensitive to stress than older ones. In another study carried out with vultures, Hernández & Margalida (2010) observed lower leukocyte values in chicks compared to free-living adults. Likewise, in the present study, the mean values of total leukocytes were higher in adult hawks.

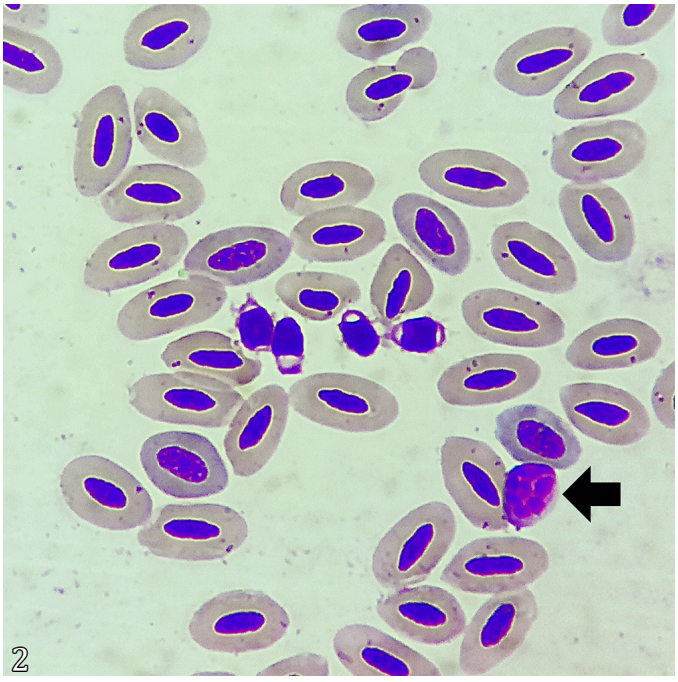

Fig.2. Photomicrograph showing thrombocytes (center) and lymphocytes (black arrow) of *Rupornis magnirostris*. May Grunwald-Giemsa stain, 1000x magnification. Fortaleza/CE, 2023.

Table 2. Mean values of hematological parameters and biochemical assays of young and adult roadside hawks (*Rupornis magnirostris*) rescued in the state of Ceará. Fortaleza/CE, 2023

Parameters (unit)	Young				Adults				P
	N	Mean	SD ±	MD	N	Mean	SD ±	MD	
Red blood cells (x10^6/µL)	10	2.56	0.5	2.47	6	2.69	0.8	2.41	0.681[a]
Hemoglobin (g/dL)	10	10.1	1.4	10.5	6	10.4	1.3	10.4	0.745[a]
Hematocrit (%)	10	38.0	5.8	38.5	6	40	4.9	38.5	0.396a
MCV (fL)	10	151.0	25.0	153.8	6	159.1	36.0	170.8	0.598a
MCHC (%)	10	26.8	1.2	26.5	6	25.7	1.0	25.2	0.083a
Leukocytes (x103/µL)	10	10.6	4.4	10.0	6	15.1	9.3	14.0	0.200a
Heterophiles (x103/µL)	10	4.56	2.2	3.8	6	7.21	5.6	5.8	0.448b
Lymphocytes (x103/µL)	10	2.23	2.5	1.3	6	3.43	2.0	2.5	0.065b
Eosinophils (x103/µL)	10	2.56	2.3	1.2	6	2.72	2.5	1.8	0.447b
Basophils (x103/µL)	10	0.30	0.3	0.1	6	0.52	0.8	0.2	0.663b
Monocytes (x103/µL)	10	0.92	0.6	1.11	6	1.27	0.9	0.9	0.409a
TPP (g/dL)	10	4.5	0.8	4.8	6	4.5	0.8	4.6	0.912a
Uric acid (mg/dL)	8	13.3	7.3	12.2	4	17.4	13.5	12.2	0.503a
AST (UI/L)	8	190.7	118.6	172.5	4	272.8	66.5	261.5	0.233a
CK (UI/L)	8	1,313	935	1,052	2	527	239	527.5	0.291a
Albumin (g/dL)	8	1.0	0.2	1.1	2	1.1	0.1	1.1	0.752a
TP (g/dL)	8	3.6	1.2	3.4	2	3.3	0.1	3.3	0.725a
Globulin (g/dL)	8	2.6	1.1	2.4	2	2.2	0.3	2.2	0.676a
A/G ratio (g/dL)	8	0.4	0.2	0.4	2	0.5	0.1	0.5	0.837a

N = number of individuals, SD = standard deviation, MD = median, Min = minimum, Max = maximum, MCV = mean corpuscular volume, MCHC = mean corpuscular hemoglobin concentration, TPP = total plasma proteins, AST = aspartate aminotransferase, CK = creatine kinase, TP = total proteins, A/G ratio = albumin/globulin ratio; [a] Values obtained through Student's t-test of two independent samples, [b] values obtained through Mann-Whitney U test for two independent samples.

In the present study, the hawks' predominant leukocytes were heterophils, followed by lymphocytes, corroborating the findings of Goulart (2015). Araujo et al. (2022) observed a predominance of heterophils and eosinophils in *R. magnirostris* and *Parabuteo unicinctus*, highlighting that these leukocyte types may present similar morphologies, which makes it challenging to differentiate between them. The present study employed May Grunwald-Giemsa staining to characterize heterophil and eosinophil granules to facilitate cell differentiation.

Avian thrombocytes consist of nucleated cells with round to oval cytoplasm and nucleus and densely agglutinated chromatin, which serve hemostatic and phagocytic functions. These cells tend to clump together in blood smears (Campbell 2015). The presence of thrombocytic aggregates in most of the hawks in the present study (13 out of 16) prevented a reliable assessment of this parameter since the aggregates make it difficult to determine the concentration of these cells and their morphological assessment. This is why few studies provide values for this cell type (Hernández & Margalida 2010).

There are few studies focused on serum enzyme levels for the species *R. magnirostris*. The results obtained from the animals included in this study were compared with the values reported by Goulart (2015). Compared to those findings, the present study found slightly higher values for uric acid (14.69 mg/dL ± 9.40), AST (218.13 UI/L ± 108.59), total proteins (3.57 g/dL ± 1.11), albumin (1.06 g/dL ± 0.18), and globulin (2.5 g/dL ± 1.04); however, it should be noted that the Goulart (2015) study used fewer animals. In comparison with another species, a study carried out by Neri Júnior (2018) with Harris's hawk (*P. unicinctus*) revealed that uric acid values in young birds were higher than in adults, while albumin and total proteins values were higher in adult birds, and that the average AST and CK values were 406.66 IU/L (± 199.18 UI/L) and 578.4 IU/L (± 527.72 UI/L), respectively. In the present study, young hawks presented lower values of uric acid (13.3 mg/dL ± 7.3), AST (190.7 UI/L ± 118.6), albumin (1.0 g/dL ± 0.2), and albumin/globulin ratio (0.4 g/dL ± 0.2) compared to adults. It should be noted, however, that most of the biochemical measurements were obtained from only two adult hawks (except for uric acid and AST, which were obtained from four adult hawks), which may mean that the assessment was not as accurate.

CONCLUSIONS

The values obtained for the hematological and biochemical parameters of *Rupornis magnirostris* in this study were similar to those reported in previous studies of the same species. Adult and young hawks did not present significant differences in the parameters evaluated. There are few comparative studies between parameters and dosages between young and adult birds, making further investigation between these two groups necessary, considering that age is one of the factors that can interfere in quantifying these values.

Obtaining hematological profile values and biochemical dosages for roadside hawks associated with the clinical evaluation and monitoring of individuals are important factors in determining the health status of these animals and in assessing their suitability for reintroduction into their natural environment.

Acknowledgments.- This study was possible with the support of the team from the "Laboratório de Patologia Clínica Veterinária" (Veterinary Clinical Pathology Laboratory – LPCV) and the "Laboratório de Estudos Ornitológicos" (Ornithological Studies Laboratory – LABEO), of the "Hospital Veterinário Dr. Sylvio Barbosa Cardoso" (Dr. Sylvio Barbosa Cardoso Veterinary Hospital – HVSBC), and "Universidade Estadual do Ceará" (UECE), as well as rescue actions by the fire department, the environmental police battalion, and the "Instituto Pró-Silvestre".

Conflict of interest statement.- The authors declare that they have no conflict of interest.

Credit author statement.- Alicia F.N.: collected samples, participated in the entire methodology, carried out research, and wrote the manuscript. Felipe R.O.: collected samples, participated in the entire methodology, offered research support, and wrote and reviewed the manuscript. Francisco W.S.A.: participated in the hematological and biochemical processing of samples and reviewed the manuscript. Carla R.S.B.: participated in the hematological and biochemical processing of samples. Bruno P.L.: conducted the rescue and rehabilitation of animals used in the methodology and helped collect samples. Régis S.C.T.: helped obtain animals and collect samples. William C.M.: helped obtain animals. Isaac NGS: provided guidance throughout the methodology and wrote and reviewed the manuscript.

Data availability statement.- The data supporting the findings of this study are available within the article and upon request from the corresponding authors, Isaac N.G.S and William C.M., since the animals, at the time the study was carried out, were in the process of rehabilitation in a non-governmental, non-profit organization, in order to preserve the work of the institution.

REFERENCES

Araujo ST, Campos SDE, Cunha DM, Pires JR, Pimentel Junior ACA, Toma HK, Souza AM, Almosny NRP. Caracterização morfológica e citoquímica de células sanguíneas de rapinantes da ordem Accipitriformes apreendidos ou resgatados no bioma Mata Atlântica do Rio de Janeiro (Sudeste do Brasil). Res Soc Develop 2022; https://doi.org/10.33448/rsd-v11i10.32508

Black PA, McRuer DL, Horne L-A. Hematologic parameters in raptor species in a rehabilitation setting before release. J Avian Med Surg 2011; https://doi.org/10.1647/2010-024.1, PMid:22216719

Campbell TW. Hematologia das aves, p.205-238. In: Thrall MA, Weiser G, Allison RW, Campbell TW. Hematologia e bioquímica clínica veterinária. 2ª ed. Rio de Janeiro: Roca, 2015.

Dias TMZS. Hematologia, pesquisa de hemoparasitos e mensuraçao da atividade de Colinesterases plasmáticas em Falconiformes e Strigiformes do estado de São Paulo, Brasil. Dissertação de Mestrado, 2010; https://doi.org/10.11606/D.10.2010.tde-15122011-143316

Fallon SM, Ricklefs RE. Parasitemia in PCR-detected *Plasmodium* and *Haemoproteus* infections in birds. J Avian Biol 2008; https://doi.org/10.1111/j.0908-8857.2008.04308.x

Ferguson-Lees J, Christie DA. Raptors of the World. New York: Houghton Mifflin, 2001. 992p.

Goulart MDA. Parâmetros hematológicos, bioquímicos e pesquisa de cepas produtoras de ESBL e carbapenemases em aves de rapina em cativeiro no Brasil. Dissertação de Mestrado, Universidade Federal do Paraná, Paraná, 2015. 153p.

Guerra RR, Dias GF, Bernadino MGS, Junior NAN, Guerra MFVF, Satake F. Hematological standards, hormonal indexes and gonadal morphology of roadside Hawks (*Rupornis magnirostris*). Arch Vet Sci 2018;23(1):63-76.

Hernández M, Margalida A. Hematology and blood chemistry reference values and age-related changes in wild bearded vultures (*Gypaetus barbatus*). J Wildl Dis 2010; https://doi.org/10.7589/0090-3558-46.2.390, PMid:20688632

Joppert AM. Accipitriformes, Falconiformes e Strigiformes (gaviões, águias, falcões e corujas), p.527-597. In: Cubas ZS, Silva JCR, Catão-Dias JL. Tratado de Animais Selvagens. Vol.1. 2ª ed. São Paulo: Roca, 2014.

Montolio SA, López RM, Cray C, González SL, Francisco ON, Sánchez IM, Casas-Díaz E, Valera RC. Hematologic reference intervals and age effect in European Strigiformes. Vet Clin Pathol 2017; https://doi.org/10.1111/vcp.12516, PMid:28712138

Neri Júnior NA. Estudo hematológico e bioquímico de gavião-asa-de-telha *Parabuteo unicinctus* (Temminck, 1824) utilizados para falcoaria. Trabalho de Conclusão de Curso (Bacharel), Universidade Federal da Paraíba, Paraíba, 2018. 57p.

Panasci TA, Whitacre DA. Roadside hawk breeding ecology in forest and farming landscapes. The Wilson Bulletin 2002; https://doi.org/10.1676/0043-5643(2002)114[0114:RHBEIF]2.0.CO;2

Polo FJ, Celdran JF, Peinado VI, Viscor G, Palomeque J. Hematological values for four species of birds of prey. The Condor 1992; https://doi.org/10.2307/1369300

Sanches TC, Joppert AM, Gattamorta MA, Matushima ER. Perfil hematológico de falconiformes de vida livre na cidade de São Paulo. IX Congresso e XIV Encontro da Associação Brasileira de Veterinários de Animais Selvagens, São José do Rio Preto, p.49. 2005.

Santos AA, Joppert AM, Egami MI. Valores hematológicos do gavião carijó *Buteo magnirostris* (Gmelin, 1788) (Ave, falconiforme). Acta Scient Biol Res 2017; https://doi.org/10.19141/2526-169X.actascientiae.v2.n1.p43-54

Santos WM, Rosado FR. Dados preliminares da biologia do gavião-carijó (*Rupornis magnirostris*, Gmelin, 1788) na região Noroeste do Paraná. Revista Agronegócio Meio Ambiente 2009;2(3): 21-430.

Woo PTK. The haematocrit centrifuge for detection of trypanosomes in blood. Can J Zool 1969; https://doi.org/10.1139/z69-150, PMid:5343381