INTRODUCTION

The Blue-fronted Amazon (Amazona aestiva, Linnaeus, 1758) stands out as the most popular parrot species on account of its reputation for sociability, intelligence, and ability to imitate human words (Sick, 1997). By placing this bird species in captivity, humans have restricted its environment, thereby promoting a reduction in its daily activities. The supplying of unbalanced diets, such as the use of a mixture of seeds with multiple nutrient deficiencies, facilitates the development of diseases and obesity (Saad and Machado, 2000; Saad et al., 2007).

Nutrition exerts great influence on the growth, reproductive capacity, and longevity of animals, besides acting on their ability to resist environmental stresses and pathogenic agents (Knapka et al., 1995). Propolis possesses biological (antimicrobial, antifungal, antiprotozoan, antiviral), therapeutic (antiinflammatory, cyto-restorative) and immunorestorative properties by activating granulocytes and T lymphocytes and through concentrations of immunoglobulins, a finding confirmed in mice (Sforcin et al., 2000; Fisher et al., 2008).

Hematological and biochemical parameters are important tools that aid in the elucidation of clinical problems. For this reason, the hemogram and biochemical analyses are of fundamental importance in the search to comprehend the physiological mechanisms related to blood (Goulart, 2006; Hawkins et al., 2006). In this context, the present study aimed to evaluate the effect of propolis on hematological and biochemical parameters of Blue-fronted Amazons (Amazona aestiva) kept in captivity.

MATERIALS AND METHODS

Birds and Location of the Study

The experiment was conducted at the Wildlife Medical and Research Center (CEMPAS) in the Depart-
The study was divided into 3 phases:

1) Phase I adaptation: for 15 d, the birds under the 3 treatments received the commercial ration Papagaio Mix (Biotron), without addition of propolis.

2) Phase II treatments: with duration of 30 d, the birds received one of the following 3 propolis levels added into their diet:
   - Treatment A: 0.0% propolis in the total diet,
   - Treatment B: 0.5% propolis in the total diet (0.30 g of propolis/60 g of ration),
   - Treatment C: 1.0% propolis in the total diet (0.60 g of propolis/60 g of ration).

3) Phase III posttreatments: the birds under the 3 treatments received ration without addition of propolis for 15 d.

The commercial ration Papagaio Mix (Biotron) contains 16% CP and 3,238.82 kcal/kg of ME.

Analyses

At the end of each phase, blood samples were collected for hematological and biochemical analyses.

**Hematological and Biochemical Analyses.** Blood samples were collected by venipuncture of a jugular vein using a needle (13 × 0.45 mm) and syringe (1.0 mL) indicated for small birds (Campbell, 2004). The samples were divided into 2 different tubes: one containing anticoagulant EDTA (3%) for hematological analysis, and the other tube without anticoagulant to obtain serum after centrifugation.

The analyses were divided into the following:

- **Biochemical:** serum (biochemical kits, Katal, Belo Horizonte, Minas Gerais, Brazil) and reading in an automated spectrophotometer (Cobas Mira) to determine the following parameters: aspartate aminotransferase (AST), lactate dehydrogenase (LDH), uric acid, and urea.
- **Hematological:** a hemogram was performed on the samples from tubes containing EDTA (3%): red blood cell (RBC) and white blood cell (WBC); differential count of leukocytes with mean of 200 cells; determination of hemoglobin concentration by the method of cyanometemoglobin; concentration of total plasma proteins; packed cell volume; mean corpuscular volume; and mean corpuscular hemoglobin concentration (MCHC; Jain, 1986).

**Statistical Analysis.** All data were expressed as mean ± SEM. The statistical analysis was conducted initially by the normality test of Shapiro-Wilk. Analysis of variance was used for the analyzed variables. When the difference presented significance, the test of Tukey for intergroup and intragroup means across time was applied. In all calculations, a critical level of 5% was fixed (P < 0.05), with the aid of the GLM procedure from SAS 9.00 (2002, SAS Institute Inc., Cary, NC). Data that presented CV of less than 50% were converted to log base 10, according to the following formula:

\[ FV = \log_{10} (D + 10), \]

where FV = final value used in the statistical program, and D = data obtained from the analyses performed.

**RESULTS**

**Biochemical Analyses**

The biochemical results are presented in Table 1. Phase I (284.39 ± 46.1 IU·L⁻¹) presented higher values than those of phases II (187.25 ± 12.1 IU·L⁻¹) and III (191.99 ± 9.9 IU·L⁻¹) in general AST means, whereas the latter 2 did not differ from each other.

The difference in LDH concentrations occurred in treatment B, with phase I (498.43 ± 138.9 IU·L⁻¹) being superior to II (229.21 ± 57.1 IU·L⁻¹); the 2 did not differ from phase III (291.50 ± 68.8 IU·L⁻¹). In the general means of this variable, phase I (401.37 ± 58.7 IU·L⁻¹) was lower than phases II (245.71 ± 32.7 IU·L⁻¹) and III (243.83 ± 26.1 IU·L⁻¹). Phases II and III did not differ.
Treatment A presented a difference in the concentration of total plasma proteins between phases II and III; phase I was similar to both. In the general means, it was verified that phases I and II differed from phase III and were similar to each other.

The concentrations of uric acid did not present differences between phases I and II, but the 2 differed from phase III for treatment A. A difference was observed among treatment C birds between phases II and III, which did not differ from phase I. In the general means, phases I and II differed from phase III and were equal to each other. There was a decrease of the general means from phase II (7.33 ± 0.5 mg·dL⁻¹) to III (5.83 ± 0.6 mg·dL⁻¹) in the urea concentrations. Both phases were similar to phase I.

Hematological Analyses

The hematological data are displayed in Table 2. There was no effect from treatment or phase on packed cell volume and mean corpuscular volume.

For the variable hemoglobin concentration, it was observed that treatment B (16.03 ± 0.6 g·dL⁻¹) was superior to A (15.00 ± 0.2 g·dL⁻¹) in phase III; the 2 did not differ from phase I. In the general means, phases I and II differed from phase III and were equal to each other. There was a decrease of the general means from phase II (7.33 ± 0.5 mg·dL⁻¹) to III (5.83 ± 0.6 mg·dL⁻¹) in the urea concentrations. Both phases were similar to phase I.

Evaluation of Differential Leukocyte Counts

Table 3 displays the leukogram results. No differences were detected in the values of monocytes and basophils. The general means of lymphocyte values were higher in phase III (27.77 ± 1.1%) compared with phase I (9.99 ± 1.1%; phase II (15.06 ± 3.1 × 10⁴ µL⁻¹) did not differ from the prior ones.

There was no difference between phases II (14.03 ± 1.6 × 10⁵ µL⁻¹) and III (14.61 ± 1.9 × 10⁵ µL⁻¹) in the general means values of heterophils, whereas both were higher than phase I (9.02 ± 1.4 × 10⁵ µL⁻¹).

The eosinophil values presented a phase effect in treatment B and differences between the general means. In treatment B, the values presented in phase I (0.00 ± 0.0 × 10³ µL⁻¹) were lower than values for phases II (0.47 ± 0.2 × 10³ µL⁻¹) and III (0.33 ± 0.2 × 10³ µL⁻¹), without any difference between the latter two. The general means showed similarities between phases II (0.34 ± 0.1 × 10³ µL⁻¹) and III (0.45 ± 0.2 × 10³ µL⁻¹), and both were superior to phase I (0.10 ± 0.1 × 10³ µL⁻¹).

Discussion

Biochemical Analyses

Liver function is evaluated by determining concentrations of AST and LDH. Aspartate aminotransferase
is found in diverse bird tissues (liver, skeletal muscle, kidney, brain, and heart) and presents high activity in the liver. It is one of the tools for evaluating liver dysfunctions or muscular damage (Harris, 2000; Campbell, 2004). However, it is still little used for birds in veterinary medicine due to a lack of reference values (Schmidt et al., 2007).

Differences were observed between the general mean phases for AST. Phase I was superior to phases II and III, with the latter two falling within the acceptable

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Level</th>
<th>Phase</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>A</td>
<td>11.75 ± 0.3</td>
<td>10.43 ± 2.1</td>
<td>15.00 ± 0.2^B</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>12.38 ± 0.4</td>
<td>17.78 ± 2.6</td>
<td>16.03 ± 0.6^A</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>11.53 ± 0.6</td>
<td>15.60 ± 2.1</td>
<td>15.20 ± 1.0^A</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>11.89 ± 0.3^B</td>
<td>14.60 ± 1.5^A</td>
<td>15.41 ± 0.4^A</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>A</td>
<td>43.00 ± 1.1</td>
<td>50.33 ± 5.0</td>
<td>46.75 ± 3.8</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>47.75 ± 3.8</td>
<td>43.25 ± 2.3</td>
<td>47.50 ± 2.9</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>39.75 ± 3.7</td>
<td>45.75 ± 2.9</td>
<td>47.00 ± 3.1</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>43.50 ± 1.9</td>
<td>46.09 ± 1.9</td>
<td>47.08 ± 1.7</td>
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<tr>
<td>RBC (× 10^3)/µL</td>
<td>A</td>
<td>2,088.75 ± 254.7</td>
<td>2,421.25 ± 233.6</td>
<td>2,038.75 ± 242.1</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>2,352.50 ± 276.4</td>
<td>3,213.75 ± 747.7</td>
<td>1,856.67 ± 160.5</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>2,041.25 ± 78.8</td>
<td>2,418.75 ± 68.6</td>
<td>2,321.75 ± 58.6</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>2,154.17 ± 122.0</td>
<td>2,684.58 ± 269.6a</td>
<td>2,092.73 ± 146.4b</td>
</tr>
<tr>
<td>MCHC (%)</td>
<td>A</td>
<td>27.33 ± 0.4</td>
<td>30.45 ± 5.6</td>
<td>32.71 ± 2.6</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>26.34 ± 1.9</td>
<td>41.37 ± 6.5</td>
<td>33.97 ± 1.6</td>
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<tr>
<td></td>
<td>C</td>
<td>29.65 ± 2.8</td>
<td>33.98 ± 3.2</td>
<td>32.35 ± 0.2</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>27.77 ± 1.1b</td>
<td>35.27 ± 3.1a</td>
<td>33.01 ± 0.9a</td>
</tr>
<tr>
<td>MCV (fL)</td>
<td>A</td>
<td>214.95 ± 26.6</td>
<td>156.46 ± 35.5</td>
<td>232.35 ± 9.2</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>217.38 ± 39.3</td>
<td>156.13 ± 32.4</td>
<td>201.55 ± 69.4</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>195.06 ± 16.9</td>
<td>189.31 ± 11.5</td>
<td>213.99 ± 34.8</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>209.13 ± 15.5</td>
<td>167.30 ± 15.6</td>
<td>215.96 ± 23.9</td>
</tr>
</tbody>
</table>

Means followed by different uppercase letters indicate differences between treatments within an experimental phase, and those followed by different lowercase letters represent treatment differences between phases. P < 0.05.

Table 3. Leukogram (mean ± SE) from Blue-fronted Amazons (Amazona aestiva), in distinct treatments and experimental phases

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Level</th>
<th>Phase</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>WBC1 (× 10^3)/µL</td>
<td>A</td>
<td>21.00 ± 2.4</td>
<td>25.50 ± 3.1</td>
<td>37.25 ± 4.2</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>16.25 ± 1.5</td>
<td>46.75 ± 18.6</td>
<td>33.25 ± 1.7</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>22.00 ± 3.7</td>
<td>27.50 ± 4.6</td>
<td>38.50 ± 4.2</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>19.75 ± 1.6b</td>
<td>33.25 ± 6.5ab</td>
<td>36.33 ± 2.0a</td>
</tr>
<tr>
<td>Lymphocytes (× 10^3)/µL</td>
<td>A</td>
<td>9.93 ± 2.2</td>
<td>12.53 ± 3.0</td>
<td>19.83 ± 1.8</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>9.79 ± 1.5</td>
<td>21.45 ± 8.2</td>
<td>20.36 ± 2.7</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>10.25 ± 2.5</td>
<td>11.19 ± 2.6</td>
<td>21.13 ± 5.4</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>9.99 ± 1.1b</td>
<td>15.06 ± 3.1ab</td>
<td>20.44 ± 1.9a</td>
</tr>
<tr>
<td>Heterophils (× 10^3)/µL</td>
<td>A</td>
<td>10.32 ± 1.1</td>
<td>12.50 ± 1.5</td>
<td>16.02 ± 4.9</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>5.90 ± 0.3</td>
<td>14.25 ± 3.4</td>
<td>11.65 ± 2.8</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>10.82 ± 3.8</td>
<td>15.40 ± 3.6</td>
<td>16.16 ± 1.2</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>9.02 ± 1.4b</td>
<td>14.03 ± 1.6a</td>
<td>14.61 ± 1.9b</td>
</tr>
<tr>
<td>Eosinophils (× 10^3)/µL</td>
<td>A</td>
<td>0.00 ± 0.0</td>
<td>0.11 ± 0.1</td>
<td>0.70 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.00 ± 0.0b</td>
<td>0.47 ± 0.2a</td>
<td>0.33 ± 0.0a</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.16 ± 0.2</td>
<td>0.44 ± 0.1</td>
<td>0.31 ± 0.1</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.10 ± 0.1b</td>
<td>0.34 ± 0.1a</td>
<td>0.45 ± 0.2a</td>
</tr>
<tr>
<td>Monocytes (× 10^3)/µL</td>
<td>A</td>
<td>0.66 ± 0.1</td>
<td>0.26 ± 0.3</td>
<td>0.41 ± 0.1</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.44 ± 0.1</td>
<td>0.31 ± 0.2</td>
<td>0.53 ± 0.2</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.55 ± 0.3</td>
<td>0.27 ± 0.1</td>
<td>0.60 ± 0.4</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.55 ± 0.1</td>
<td>0.28 ± 0.1</td>
<td>0.61 ± 0.1</td>
</tr>
<tr>
<td>Basophils (× 10^3)/µL</td>
<td>A</td>
<td>0.01 ± 0.1</td>
<td>0.11 ± 0.1</td>
<td>0.30 ± 0.1</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>0.12 ± 0.0</td>
<td>0.32 ± 0.2</td>
<td>0.08 ± 0.1</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>0.22 ± 0.0</td>
<td>0.20 ± 0.1</td>
<td>0.31 ± 0.1</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.15 ± 0.0</td>
<td>0.21 ± 0.1</td>
<td>0.23 ± 0.1</td>
</tr>
</tbody>
</table>

Means followed by different lowercase letters represent treatment differences between phases. P < 0.05.

1WBC: white blood cell.
reference standards (Lumeij, 1987; Lumeij and Overduin, 1990; Fudge, 2000), and corroborated only Fudge (2000), indicating that propolis may act as a regulator of AST values. There are no studies that correlate AST with propolis, but in general propolis is known for its hepatoprotective action, acting on another parameter: LDH (El-Khatib et al., 2002).

Found in cardiac and skeletal muscle, as well as liver, kidney, bones, and RBC, LDH is one of the tools employed to aid in the diagnosis of hepatocellular diseases. Furthermore, through its presence in RBC, elevated blood levels of LDH can, consequently, indicate hemolysis (Campbell, 2004).

In treatment B, the birds tended to present high LDH values, whereas propolis apparently reduced these levels, approximating the reference levels (Lumeij, 1987). This result interfered directly on the general means, presenting a difference in which phase I was superior to the subsequent phases, suggesting that propolis reduced LDH values.

In studies without challenges, mice that had received different levels of propolis did not present differences in concentrations of AST or LDH (Sforcin et al., 2002), a finding also reported by Mani et al. (2006) who worked with different types of solvents (extracts of aqueous and alcoholic propolis) with the same animal species.

Elevated concentrations of total plasma proteins (TPP) may indicate chronic or acute inflammatory conditions, by increase of globulins and decrease of albumin. Dietary protein content, or a state of dehydration, can also influence concentrations of TPP, especially albumin (Schmidt et al., 2007).

Treatment A presented distinct values in TPP concentrations among the phases, with a reduction occurring between II and III, with both being similar to phase I. These results were reflected in the general means with a drop in the values of phase III. In comparison with the literature (Schmidt et al., 1999), the values of treatment A were normal in phases I and III and elevated in phase II, suggesting that the alteration may be attributable to a normal daily variation in ration consumption or an individual variation already demonstrated by other authors as a problem for standardizing biochemical parameters in birds (Lumeij and Overduin, 1990). The concentrations under all the treatments in phase III were also within the range of normality, whereas the TPP differences produced by treatment A were reflected in the general means.

The birds are uricotelic, with uric acid being the main catabolite of nitrogen metabolism. The determination of blood concentrations of nitrogen is used as a tool for diagnosing kidney diseases and dehydration, but may vary with diet, especially with the consumption of protein-bearing foods (Campbell, 2007).

In phases I and II, the concentrations of uric acid under all the treatments (including the general means between the phases) exceeded only the levels reported by Lumeij and Overduin (1990) and corroborated the values found by Lumeij (1987) and Fudge (2000) for the genus Amazona sp. There was a reduction in the uric acid concentration among the birds in treatments A and C, between phases II and III, suggesting an alteration attributable to nutrition, namely to the supply of a balanced diet. For this parameter, the general mean of phase III was lower than that of phase II. The phase III result is in agreement with the literature consulted (Lumeij, 1987; Lumeij and Overduin, 1990; Fudge, 2000).

Comparing treatment A with the other treatments found no difference, indicating the possibility that there was no effect of propolis on this parameter.

From the subproducts of the proteins, urea is synthesized in the liver and excreted by glomerular filtration. For this reason, its concentration is influenced by protein ingestion and is useful for testing prerenal azotemia (Campbell, 2004; Schmidt et al., 2007).

Urea differences were found in the general means: phase III was inferior to phase I and similar to II. Phase III was also the only period that corroborated all the reference values (Lumeij, 1987; Fudge, 2000), suggesting that these alterations were due to the consumption of feed with 16% protein for this period and not influenced by propolis consumption.

**Hematological Analyses**

In contrast to the use of EDTA in the present study, the studies consulted in the literature used heparin as the anticoagulant (Polo et al., 1998; Goulart, 2006; Paula et al., 2008). For this reason, possible differences between the present findings and those of the prior studies may be a consequence of this variation in the hematological analyses.

Fudge (2000) and Campbell (2007) referred to the genus Amazona sp.; all the other citations (Polo et al. 1998; Schmidt et al., 1999; ISIS, 2002; Goulart, 2006; Paula et al., 2008) referenced the Blue-fronted Amazon (Amazona aestiva).

**Erythrogram.** Hemoglobin is responsible for transporting oxygen in the erythrocytes. In birds, the bond between hemoglobin and oxygen is less stable than in mammals, thus enabling oxygen to become available to the tissues more rapidly. A decrease in its concentration, added to low values of RBC count and hematocrit, may indicate anemia (Benjamin, 1978; Campbell, 2004).

Treatment B presented higher values than treatment A in phase II, indicating that the use of propolis at lower levels influenced hemoglobin levels positively. Although different results were found by Çetin et al. (2010), in which hens treated with propolis did not present altered hemoglobin concentrations, Haro et al. (2000) found results similar to those of the present study of propolis-treated rats, in which there was efficient regeneration of hemoglobin as a consequence of better utilization of the iron supplied by feed.

The values found in the general hemoglobin means also varied: the lowest was observed in phase I; phases
II and III did not differ from each other. Despite the differences, all the values corroborate the literature consulted (Polo et al., 1998; Schmidt et al., 1999; Fudge, 2000; ISIS, 2002; Campbell, 2004; Goulart, 2006; Paula et al., 2008).

The total counts of erythrocytes revealed a difference in the general means. Phase II was superior to III and both were similar to phase I, with the values produced in phase II being more satisfactory compared with the references, corroborating 2 prior studies (Polo et al., 1998; Campbell, 2007) and presenting higher values than another study (Schmidt et al., 1999). This result may indicate an improvement in phase II from the use of propolis, as evidenced by summing the results obtained in treatments B and C and shown in the general means.

There was a difference between phases I and II, both of which were similar to phase III for MCHC, in relation to the general means of the phases. This difference reflects an increase of hemoglobin concentrations that presented the same variation.

By simultaneously analyzing the results for erythrocytes, hematocrit, and hemoglobin, it can be inferred that, despite some differences, the birds did not present anemia in the distinct phases and treatments and propolis acted in a positive manner on 2 (erythrocytes and hemoglobin) of the 3 parameters used to evaluate anemia.

**Leukogram.** Immunomodulation can be carried out through the potentiation or suppression of elements of the immune system (Kirkley, 1999). Propolis exerts this effect, which may occur in a contradictory manner, probably due to, among other factors, the variety of its chemical components (Fischer et al., 2008).

The action of propolis depends on the concentration, period, and route of administration (Sforcin, 2007). The proliferation of mouse lymphocytes in vitro can be inhibited by one of the chemical components of propolis (Sá-Nunes et al., 2003). Another experiment on mice in vivo demonstrated that high concentrations of nitric oxide (NO) harm the proliferation of T cells (Gherardi et al., 2000). The number of T cells can also be reduced through the action of an active compound of propolis, the caffeic acid phenethyl ester (Park et al., 2004). Two recent studies on rats have reported that propolis exerts antiinflammatory (Orsatti et al., 2010a) and proinflammatory action (Orsatti et al., 2010b).

The WBC count is used as a tool for evaluating the health and welfare of birds. In the general means for lymphocytes, despite phase I having presented the lowest value in phase III with phase II being intermediate, all the phases produced values above the reference levels consulted (Polo et al., 1998; Schmidt et al., 1999; Fudge, 2000; ISIS, 2002; Goulart, 2006; Campbell, 2007). There were no differences between the treatments, whereas the results of general means are similar to those found in the total leukocyte count, because lymphocytes represent up to 83.5% of the total count (Polo et al., 1998).

Heterophils participate in an organism’s first line of defense and represent up to 46.6% of the total leukocyte count (Coles, 1997). They are extremely efficient in the process of engulfing a bacterium, leaving to monocytes the task of processing dead tissues (Tizard, 2009). In all the treatments and phases, the heterophil values did not differ. There was a difference only in the general means, in which phase I was the lowest whereas phases II and III were the highest and similar to each other.

The heterophil count is also reflected in the results of the total leukocyte count, because the differences in both counts were similar: phase I presented lower values than phases II and III. However, only one reference corroborates the general mean values found in phase I (ISIS, 2002), whereas all the others are higher than the references. Leukocytosis and the respective heterophilia are characterized when reaching values $10^{9}\text{L}^{-1}$ higher than the reference (Coles, 1997). Despite the finding of values above the reference, leukocytosis cannot be inferred. Therefore, the increase in leukocytes was displayed in a positive form, characterizing immunomodulation by propolis, because after the treatment phase in most birds (phase II and III), there was a better response from the birds.

The responses of eosinophils in sick birds are rarely mentioned given the difficulty of differentiating these cells, although the indication of eosinopenia is sometimes apparent (Latimer and Bienzle, 2010).

When compared with the literature on the genus *Amazona* sp. (Fudge, 2000; Campbell, 2007), phases I and II of treatment A, phase I of treatment B, and the general means were in agreement, whereas the other treatments and phases presented higher values. In comparison with the literature referring to Blue-fronted Amazons, only phase I of treatments A and B corroborate Polo et al. (1998), Schmidt et al. (1999), and Goulart (2006). The rest of the treatments and phases exceeded the reference values cited by these authors and agree with one citation only (ISIS, 2002).

The increase in the eosinophil values between phases I and II of treatment B indicated possible immunomodulatory action of propolis. However, eosinophils do not have a defined function in birds (Campbell, 2007). In humans, they are stimulated by NO (Silva et al., 2004). Thus, it could be inferred that the elevation of the eosinophil values occurred by means of propolis immunomodulation driven by an increase of NO.

It may be concluded that the inclusion of propolis (0.5%) in the ration of Blue-fronted Amazons interferes in the hematological and serum biochemical parameters. It is suggested that the eosinophil values are increased by the immunomodulatory action of Brazilian propolis.

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REFERENCES


