Appendices

**Appendix I. Avian Hematologic Reference Ranges**

<table>
<thead>
<tr>
<th>Determination</th>
<th>African grey</th>
<th>Amazon</th>
<th>Budgerigar</th>
<th>Canary</th>
<th>Cockatiel</th>
<th>Cockatoo</th>
<th>Conure</th>
<th>Eclectus</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC x 10³/µl</td>
<td>5-11</td>
<td>6-11</td>
<td>3-8.5</td>
<td>4-9</td>
<td>5-10</td>
<td>5-11</td>
<td>4-11</td>
<td>4-10</td>
</tr>
<tr>
<td>RBC x 10⁶/µl</td>
<td>2.4-3.9</td>
<td>2.4-4</td>
<td>2.4-4</td>
<td>2.5-3.8</td>
<td>2.2-3.9</td>
<td>2.4-4.2</td>
<td>2.5-4.1</td>
<td>2.4-3.9</td>
</tr>
<tr>
<td>Hets (%)</td>
<td>55-75</td>
<td>55-80</td>
<td>50-75</td>
<td>50-80</td>
<td>55-80</td>
<td>55-80</td>
<td>55-75</td>
<td>55-70</td>
</tr>
<tr>
<td>Eos (%)</td>
<td>0-2</td>
<td>0-1</td>
<td>0-2</td>
<td>0-2</td>
<td>0-2</td>
<td>0-2</td>
<td>0-2</td>
<td>0-1</td>
</tr>
<tr>
<td>Baso (%)</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-2</td>
<td>0-2</td>
</tr>
<tr>
<td>Monos (%)</td>
<td>0-3</td>
<td>0-3</td>
<td>0-2</td>
<td>0-2</td>
<td>0-2</td>
<td>0-2</td>
<td>0-2</td>
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<table>
<thead>
<tr>
<th>Determination</th>
<th>Jardine’s</th>
<th>Lory</th>
<th>Lovebird</th>
<th>Macaw</th>
<th>Parakeet</th>
<th>Pionus</th>
<th>Quaker</th>
<th>Senegal</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC x 10³/µl</td>
<td>4-10</td>
<td>4.5-8.5</td>
<td>3-8.5</td>
<td>6-12</td>
<td>4.5-9.5</td>
<td>4-11.5</td>
<td>4-10</td>
<td>4-11</td>
</tr>
<tr>
<td>RBC x 10⁶/µl</td>
<td>2.4-4.2</td>
<td>2.5-4.1</td>
<td>2.3-3.9</td>
<td>2.4-4.2</td>
<td>2.2-3.9</td>
<td>2.4-4</td>
<td>2.3-4.1</td>
<td>2.4-4.1</td>
</tr>
<tr>
<td>Hets (%)</td>
<td>55-75</td>
<td>50-70</td>
<td>55-80</td>
<td>58-78</td>
<td>50-75</td>
<td>50-75</td>
<td>55-80</td>
<td>55-75</td>
</tr>
<tr>
<td>Eos (%)</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
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<tr>
<td>Baso (%)</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
<td>0-1</td>
</tr>
<tr>
<td>Monos (%)</td>
<td>0-2</td>
<td>0-2</td>
<td>0-3</td>
<td>0-3</td>
<td>0-2</td>
<td>0-2</td>
<td>0-3</td>
<td>0-2</td>
</tr>
</tbody>
</table>

*Provided by University of Miami Avian and Wildlife Laboratory: RBC and WBC count by Unopette method from blood collected in EDTA; Spun HCT; Diff based on 100-cell count using smear made at the time of sample acquisition.*
Appendix II. Avian Hematologic Reference Ranges for Clinically Normal Psittacines**

In an attempt to establish ranges for clinically normal birds of various psittacine species, the following criteria were used to determine the acceptability of individual values for incorporation into the following statistics:

1) The bird was presented for a wellness examination, at which time the sample was obtained.

2) At least one previous CBC was performed and documented at the same hospital, utilizing the same techniques, and was also performed during a wellness examination.

3) No other concurrent disease was detected or treated, with the exception of behavioral concerns.

4) The total WBC did not vary more than 25% between the two values.

<table>
<thead>
<tr>
<th>Determination</th>
<th>African greys (n = 150)</th>
<th>Amazon sp. (n = 150)</th>
<th>Budgerigars (n = 50)</th>
<th>Cockatiels (n = 200)</th>
<th>Umbrella cockatoos (n = 100)</th>
<th>Aratinga conures (n = 50)</th>
<th>Eclectus parrots (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC x 10³/µl</td>
<td>8-11</td>
<td>7.5-12.5</td>
<td>2.5-6.5</td>
<td>4.0-8.8</td>
<td>7.11.5</td>
<td>7.0-11.7</td>
<td>7.0-11.8</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>42-50</td>
<td>44.49</td>
<td>42-53</td>
<td>45-57</td>
<td>38.48</td>
<td>42-49</td>
<td>41-49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Determination</th>
<th>Lovebirds (n = 25)</th>
<th>Macaws (n = 100)</th>
<th>Pionus sp. (n = 25)</th>
<th>Quaker (monk) parakeets (n = 50)</th>
<th>Senegal parrots (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC x 10³/µl</td>
<td>4.5-9.0</td>
<td>8.5-15.5</td>
<td>7.0-11.5</td>
<td>5.5-12.5</td>
<td>6.5-12</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>39-51</td>
<td>39-52</td>
<td>44.51</td>
<td>38.48</td>
<td>37.48</td>
</tr>
</tbody>
</table>

** Compiled 1989-2001 by Teresa L. Lightfoot, DVM, Dipl ABVP-Avian: All calculations were done using the Eosinophil Unopette method; an average of the total WBC counts for the two or more CBCs that were performed was used to develop the above ranges.
Appendix III. Avian Biochemistry Reference Ranges

<table>
<thead>
<tr>
<th>Determination</th>
<th>African grey</th>
<th>Amazon</th>
<th>Budgerigar</th>
<th>Canary</th>
<th>Cockatiel</th>
<th>Cockatoo</th>
<th>Conure</th>
<th>Eclectus</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALT (U/L)</td>
<td>5-12</td>
<td>5-11</td>
<td>5-10</td>
<td>5-11</td>
<td>5-11</td>
<td>6-12</td>
<td>5-13</td>
<td>5-11</td>
</tr>
<tr>
<td>AST (U/L)</td>
<td>100-365</td>
<td>130-350</td>
<td>145-350</td>
<td>145-345</td>
<td>95-345</td>
<td>145-355</td>
<td>125-345</td>
<td>120-370</td>
</tr>
<tr>
<td>Amylase (U/L)</td>
<td>210-530</td>
<td>205-510</td>
<td>200-500</td>
<td>190-485</td>
<td>205-490</td>
<td>200-510</td>
<td>100-450</td>
<td>200-645</td>
</tr>
<tr>
<td>BUN (mg/dL)</td>
<td>3-5.4</td>
<td>3.1-5.3</td>
<td>3.5-2</td>
<td>3-5</td>
<td>2.9-5</td>
<td>3-5.1</td>
<td>2.8-5.4</td>
<td>3-5.5</td>
</tr>
<tr>
<td>Ca (mg/dL)</td>
<td>8.5-13</td>
<td>8.5-14</td>
<td>6.5-11</td>
<td>5.5-13.5</td>
<td>8-13</td>
<td>8-13</td>
<td>7-15</td>
<td>7-13</td>
</tr>
<tr>
<td>Chol (mg/dL)</td>
<td>160-425</td>
<td>180-305</td>
<td>145-275</td>
<td>150-400</td>
<td>145-355</td>
<td>125-345</td>
<td>120-400</td>
<td>130-350</td>
</tr>
<tr>
<td>Creat (mg/dL)</td>
<td>0.1-0.4</td>
<td>0.1-0.4</td>
<td>0.1-0.4</td>
<td>0.1-0.4</td>
<td>0.1-0.4</td>
<td>0.1-0.4</td>
<td>0.1-0.4</td>
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<td>CPK (U/L)</td>
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<td>90-300</td>
<td>55-350</td>
<td>30-245</td>
<td>95-305</td>
<td>35-355</td>
<td>220-345</td>
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<tr>
<td>Glu (mg/dL)</td>
<td>1-10</td>
<td>1-12</td>
<td>1-10</td>
<td>1-14</td>
<td>1-30</td>
<td>1-45</td>
<td>1-15</td>
<td>1-20</td>
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<tr>
<td>GGT (U/L)</td>
<td>190-350</td>
<td>190-345</td>
<td>190-390</td>
<td>205-435</td>
<td>200-445</td>
<td>185-355</td>
<td>200-435</td>
<td>200-425</td>
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<tr>
<td>Lipase (U/L)</td>
<td>35-350</td>
<td>35-225</td>
<td>30-300</td>
<td>29-255</td>
<td>30-280</td>
<td>25-275</td>
<td>30-290</td>
<td>35-275</td>
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<tr>
<td>Phos (mg/dL)</td>
<td>3-5.4</td>
<td>3.1-5.5</td>
<td>3.0-5.2</td>
<td>2.9-4.9</td>
<td>3.2-4.8</td>
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<td>2.9-6.5</td>
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<td>Potassium (mmol/L)</td>
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<td>2.4-6.7</td>
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<td>3.5-4.3</td>
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<td>Sodium (mmol/L)</td>
<td>157-165</td>
<td>125-155</td>
<td>139-165</td>
<td>135-165</td>
<td>130-153</td>
<td>130-153</td>
<td>135-149</td>
<td>130-145</td>
</tr>
<tr>
<td>Total bili (mg/dL)</td>
<td>0.0-0.1</td>
<td>0.1-0.1</td>
<td>0.0-0.1</td>
<td>0.0-0.1</td>
<td>0.0-0.1</td>
<td>0.0-0.1</td>
<td>0.0-0.1</td>
<td>0.0-0.1</td>
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<td>Total protein (g/dL)</td>
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<td>3-5.2</td>
<td>2.5-4.5</td>
<td>2.8-4.5</td>
<td>2.4-4.1</td>
<td>3-5</td>
<td>3.4-2</td>
<td>2.8-3.8</td>
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<tr>
<td>Trig (mg/dL)</td>
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<td>49-190</td>
<td>105-265</td>
<td>60-265</td>
<td>45-200</td>
<td>45-205</td>
<td>50-300</td>
<td>70-410</td>
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<td>Uric acid (mg/dL)</td>
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<td>4.5-14</td>
<td>4-12</td>
<td>3.5-10.5</td>
<td>3.5-10.5</td>
<td>2.5-11</td>
<td>2.5-11</td>
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</table>

<table>
<thead>
<tr>
<th>Determination</th>
<th>African grey</th>
<th>Amazon</th>
<th>Budgerigar</th>
<th>Canary</th>
<th>Cockatiel</th>
<th>Cockatoo</th>
<th>Conure</th>
<th>Eclectus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bile acids (µmol/L)</td>
<td>13-90</td>
<td>18-60</td>
<td>15-70</td>
<td>23-90</td>
<td>20-85</td>
<td>25-87</td>
<td>15-55</td>
<td>10-61</td>
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<tr>
<td>T₄ (µg/dL)</td>
<td>0.2-1.5</td>
<td>0.1-1.1</td>
<td>0.3-1.5</td>
<td>0.3-1.8</td>
<td>0.4-1.9</td>
<td>0.3-1.8</td>
<td>0.3-1.9</td>
<td>0.3-2.0</td>
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<td>Pre-albumin (g/dL)</td>
<td>0.03-1.35</td>
<td>0.35-1.05</td>
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<td>0.35-0.98</td>
<td>0.8-1.6</td>
<td>0.24-1.18</td>
<td>0.18-0.98</td>
<td>0.05-0.74</td>
</tr>
<tr>
<td>Albumin (g/dL)</td>
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<td>1.9-3.52</td>
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<td>0.81-1.23</td>
<td>0.7-1.8</td>
<td>1.8-3.1</td>
<td>1.9-2.6</td>
<td>2.3-2.6</td>
</tr>
<tr>
<td>Alpha-1 (g/dL)</td>
<td>0.02-0.27</td>
<td>0.05-0.32</td>
<td>0.08-0.21</td>
<td>0.08-0.16</td>
<td>0.05-0.30</td>
<td>0.05-0.18</td>
<td>0.04-0.23</td>
<td>0.09-0.19</td>
</tr>
<tr>
<td>Alpha-2 (g/dL)</td>
<td>0.05-0.25</td>
<td>0.07-0.32</td>
<td>0.05-0.16</td>
<td>0.05-0.22</td>
<td>0.05-0.30</td>
<td>0.04-0.36</td>
<td>0.08-0.26</td>
<td>0.11-0.21</td>
</tr>
<tr>
<td>Beta (g/dL)</td>
<td>0.35-0.66</td>
<td>0.38-0.76</td>
<td>0.35-0.75</td>
<td>0.3-0.71</td>
<td>0.3-0.78</td>
<td>0.35-0.82</td>
<td>0.38-0.77</td>
<td>0.35-0.62</td>
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<tr>
<td>Gamma (g/dL)</td>
<td>0.11-0.71</td>
<td>0.17-0.76</td>
<td>0.15-0.55</td>
<td>0.16-0.63</td>
<td>0.11-0.53</td>
<td>0.21-0.65</td>
<td>0.32-0.61</td>
<td>0.22-0.51</td>
</tr>
<tr>
<td>A/G ratio</td>
<td>1.6-4.3</td>
<td>1.9-5.0</td>
<td>1.5-4.1</td>
<td>1.3-4.5</td>
<td>1.5-4.3</td>
<td>2.0-4.5</td>
<td>2.2-4.3</td>
<td>2.6-4.1</td>
</tr>
</tbody>
</table>

* University of Miami Avian and Wildlife Laboratory: All reference ranges obtained from heparinized plasma samples; regular chemistry performed on Ortho (Kodak Ektahem) 700XR; TP by non-temperature compensated refractometer; bile acids and T₄ by RIA; EPH by Beckman Paragon SPEP II gels; represent adult ranges.
### Determination

<table>
<thead>
<tr>
<th>Jardine’s</th>
<th>Lory</th>
<th>Lovebird</th>
<th>Macaw</th>
<th>Parakeet</th>
<th>Pionus</th>
<th>Quaker</th>
<th>Senegal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alk phos (U/L)</td>
<td>80-156</td>
<td>75-155</td>
<td>10-90</td>
<td>20-230</td>
<td>20-120</td>
<td>80-290</td>
<td>70-300</td>
</tr>
<tr>
<td>ALT (U/L)</td>
<td>5-12</td>
<td>5-13</td>
<td>5-13</td>
<td>5-12</td>
<td>5-12</td>
<td>5-12</td>
<td>5-11</td>
</tr>
<tr>
<td>AST (U/L)</td>
<td>150-278</td>
<td>150-350</td>
<td>110-345</td>
<td>100-300</td>
<td>145-395</td>
<td>150-365</td>
<td>150-285</td>
</tr>
<tr>
<td>Amylase (U/L)</td>
<td>100-425</td>
<td>90-422</td>
<td>90-400</td>
<td>150-550</td>
<td>150-525</td>
<td>200-500</td>
<td>100-400</td>
</tr>
<tr>
<td>BUN (mg/dL)</td>
<td>2.8-5.6</td>
<td>2.7-5.7</td>
<td>2.8-5.5</td>
<td>3-5.6</td>
<td>3.1-5.3</td>
<td>3.5-4</td>
<td>2.9-5.4</td>
</tr>
<tr>
<td>Ca (mg/dL)</td>
<td>7-13</td>
<td>6.5-13</td>
<td>8.14</td>
<td>8.5-13</td>
<td>5.5-13.5</td>
<td>7.13-5</td>
<td>7-12</td>
</tr>
<tr>
<td>Chol (mg/dL)</td>
<td>70-290</td>
<td>70-300</td>
<td>70-300</td>
<td>70-300</td>
<td>70-300</td>
<td>70-300</td>
<td>70-300</td>
</tr>
<tr>
<td>Creat (mg/dL)</td>
<td>0.1-0.4</td>
<td>0.1-0.4</td>
<td>0.1-0.4</td>
<td>0.1-0.4</td>
<td>0.1-0.4</td>
<td>0.1-0.4</td>
<td>0.1-0.4</td>
</tr>
<tr>
<td>GGT (U/L)</td>
<td>1-15</td>
<td>1-16</td>
<td>2.5-18</td>
<td>1-30</td>
<td>1-12</td>
<td>1-18</td>
<td>1-15</td>
</tr>
<tr>
<td>LDH (U/L)</td>
<td>199-348</td>
<td>199-348</td>
<td>199-348</td>
<td>199-348</td>
<td>199-348</td>
<td>199-348</td>
<td>199-348</td>
</tr>
<tr>
<td>Lipase (U/L)</td>
<td>30-255</td>
<td>30-255</td>
<td>30-255</td>
<td>30-255</td>
<td>30-255</td>
<td>30-255</td>
<td>30-255</td>
</tr>
<tr>
<td>Phos (mg/dL)</td>
<td>7-13</td>
<td>6.5-13</td>
<td>8-14</td>
<td>8-14</td>
<td>8-14</td>
<td>8-14</td>
<td>8-14</td>
</tr>
<tr>
<td>Total bili (mg/dL)</td>
<td>0-0.1</td>
<td>0-0.1</td>
<td>0-0.1</td>
<td>0-0.1</td>
<td>0-0.1</td>
<td>0-0.1</td>
<td>0-0.1</td>
</tr>
</tbody>
</table>

### Bile acids (µmol/L)

<table>
<thead>
<tr>
<th>Jardine’s</th>
<th>Lory</th>
<th>Lovebird</th>
<th>Macaw</th>
<th>Parakeet</th>
<th>Pionus</th>
<th>Quaker</th>
<th>Senegal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tₐ (µg/dL)</td>
<td>0.2-1.5</td>
<td>0.3-1.2</td>
<td>0.2-2.3</td>
<td>0.2-1.9</td>
<td>0.4-1.8</td>
<td>0.5-1.9</td>
<td>0.4-2.1</td>
</tr>
<tr>
<td>Pre-albumin (g/dL)</td>
<td>0.18-0.32</td>
<td>0.48-0.76</td>
<td>0.6-1.2</td>
<td>0.05-0.7</td>
<td>0.6-1</td>
<td>0.19-0.93</td>
<td>0.48-1.13</td>
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<tr>
<td>Albumin (g/dL)</td>
<td>1.85-2.23</td>
<td>1.26-1.96</td>
<td>2.2-8</td>
<td>1.24-3.11</td>
<td>1.9-3</td>
<td>2.19-3.29</td>
<td>1.26-2.52</td>
</tr>
<tr>
<td>Alpha-1 (g/dL)</td>
<td>0.07-0.15</td>
<td>0.04-0.14</td>
<td>0.08-0.21</td>
<td>0.04-0.25</td>
<td>0.06-0.16</td>
<td>0.1-0.19</td>
<td>0.04-0.25</td>
</tr>
<tr>
<td>Alpha-2 (g/dL)</td>
<td>0.08-0.15</td>
<td>0.04-0.23</td>
<td>0.08-0.25</td>
<td>0.04-0.31</td>
<td>0.07-0.20</td>
<td>0.08-0.15</td>
<td>0.05-0.28</td>
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<tr>
<td>Beta (g/dL)</td>
<td>0.38-0.66</td>
<td>0.35-0.58</td>
<td>0.34-0.68</td>
<td>0.48-0.68</td>
<td>0.22-0.45</td>
<td>0.30-0.60</td>
<td>0.41-0.63</td>
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<tr>
<td>Gamma (g/dL)</td>
<td>0.26-0.51</td>
<td>0.13-0.29</td>
<td>0.2-0.48</td>
<td>0.2-0.5</td>
<td>0.19-0.30</td>
<td>0.18-0.42</td>
<td>0.13-0.48</td>
</tr>
<tr>
<td>A/G ratio</td>
<td>2.9-3.5</td>
<td>2.3-4.0</td>
<td>2.5-4.6</td>
<td>1.6-4.3</td>
<td>4.5-3</td>
<td>3.4-5.0</td>
<td>2.2-3.2</td>
</tr>
</tbody>
</table>

* University of Miami Avian and Wildlife Laboratory: All reference ranges obtained from heparinized plasma samples; regular chemistry performed on Ortho (Kodak Ektachem) 700XR; TP by non-temperature compensated refractometer; bile acids and Tₐ by RIA; EPH by Beckman Paragon SPEP II gels; represent adult ranges.

For assistance on biochemistry conversions: [www.vin.com/scripts/labquest/converterhtml.pl](http://www.vin.com/scripts/labquest/converterhtml.pl)
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