Hematologic and Biochemical Indices in the East African Baboon

By Henry Foy, Athena Kondi and Verstistine Mbaya

The baboon (Papio anubis and Papio sinocephalus) is becoming an increasingly important animal for laboratory investigation. On account of its greater size and the ease with which large quantities of blood can be withdrawn and multiple marrow and other biopsies taken, it is replacing the rhesus monkey (Macaca mulatta). Its temperament is equable and the animals are more reliable than the smaller vervet monkey (Cercopithecus aethiops). They are readily tamable and quickly become accustomed to handling, even when brought in as adults from the bush.

During the past years, these baboons have been used extensively in this laboratory for dietary, hematologic and other studies. It is therefore thought worthwhile to record the basic hematologic and other blood values.

Some of the captive animals were fed on a more or less natural diet consisting of fresh bananas, maize, paw-paw, sugar cane, carrots, green leaves, supplemented now and again with an egg and perhaps some grubs. Others in captivity were fed an experimental diet consisting of sucrose, vitamin-free caseine (General Biochemicals, Chagrin Falls, Ohio) corn oil, all the necessary mineral salts and added vitamins supplying 1000 to 2000 calories daily according to size and appetite. In their wild state they eat small birds, rodents, lizards, locusts, grubs, eggs, and have been known to kill and eat small gazelle, lambs as well as carrion, but to what extent is unknown, and although their natural diet may be more varied, it could be calorically inadequate.

The nutritional state of wild baboons varies considerably according to the area which they inhabit and the season of the year, whether wet or dry. Some animals brought in are in a very poor nutritional condition. On their natural diet in captivity and particularly on the experimental diet, they increase in weight rapidly and there is a general improvement in their condition, the coat becoming smooth and close, the eyes bright and alert, the skin of the face and abdomen supple and of good color and the animals active and enquiring. Since many of them are not fully grown when caught, the meaning of actual weight gain is not easy to determine.

The animals were kept either singly in large circular wire cages, 2½ metres high and 1 metre in diameter, or in groups of 2–4 in houses, 4 metres by 4 metres, divided into a day and night compartment. They were brought from their large houses into the cages when required for experimental purposes.
HEMATOLOGIC, BIOCHEMICAL INDICES IN E. AFRICAN BABOON

Table 1.—Peripheral Blood: Wild and Captive Animals (70)

<table>
<thead>
<tr>
<th></th>
<th>Hb. Gm./100 ml.</th>
<th>PCV %</th>
<th>MCHC %</th>
<th>WBC cu. mm.</th>
<th>Polys %</th>
<th>Lymphs %</th>
<th>Eos %</th>
<th>Platelets cu. mm.</th>
<th>Retics %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>12.8</td>
<td>42</td>
<td>32</td>
<td>7200</td>
<td>47</td>
<td>50</td>
<td>3.0</td>
<td>300,000</td>
<td>0.6</td>
</tr>
<tr>
<td>Range</td>
<td>8.9–16.7</td>
<td>37–49</td>
<td>26–34</td>
<td>3900–</td>
<td>28–72</td>
<td>28–78</td>
<td>0–12</td>
<td>26000–</td>
<td>0–1.2</td>
</tr>
</tbody>
</table>

**Serum Proteins Gm./100 ml.**

<table>
<thead>
<tr>
<th>Total Protein</th>
<th>Albumin</th>
<th>α₁</th>
<th>α₂</th>
<th>β</th>
<th>γ</th>
<th>T.G.</th>
<th>Wt./kilo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>6.7</td>
<td>3.1</td>
<td>0.3</td>
<td>0.8</td>
<td>1.0</td>
<td>1.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Range</td>
<td>5.0–7.6</td>
<td>1.9–4.3</td>
<td>0.2–0.6</td>
<td>0.5–1.0</td>
<td>0.6–1.2</td>
<td>1.1–2.7</td>
<td>2.9–4.7</td>
</tr>
</tbody>
</table>

**Materials and Methods**

Seventy observations were made on recently caught baboons, and 60 on captive ones. They were anesthetized with Sernyl (Phencytidine—Parke Davis) 1 mg./kilo/body weight. This is an excellent parenteral anesthetic with a wide safety margin which can be given repeatedly without any apparent ill effects. Blood, 5 to 25 ml., was taken from the femoral or external saphenous vein into heparinized, sequestrinized or plain tubes according to need. It was never necessary to use cardiac puncture.

Marrow was taken from the sternum or iliac crest and stained with Leishman and Giemsa and examined as thin smears for cytology. The red cell precursors were estimated as a percentage of the total nucleated red cell population. Marrow hemoglobin was determined by the direct method of Rath and Finch. Hemoglobin was estimated spectrophotometrically as cyanometheiiioglobin, the packed cell volume by the microhematocrit method. Peripheral white cell counts and differentials, reticulocytes and platelets, as well as marrow precursors and differentials, were done by the usual technics used for man. The serum proteins were determined by the biuret method and the globulin precipitated with 26.5 per cent sodium sulphate at 37 C. The globulins were separated by conventional electrophoresis using 0.02 ml. of serum seeded on to Whatman No. 4 paper, 5 cm. wide, and run for 22 hours in barbiturate buffer pH 8.6, ionic strength 0.05, both being kept constant to ensure that any movement of the A₂-globulin into the albumin fraction was uniform. The papers were then dried at 100 C. for 15 minutes and stained in bromocresol blue for 15 minutes, washed until the background was clear and then scanned. Gaussian curves were built by the square counting technic. The agreement between the electrophoretic and chemical albumin was generally within 0.2 of a gram.

The results for 70 peripheral blood examinations are given in table 1 and for 60 bone marrow examinations in table 2.

**Results and Discussion**

Baboons, coming in from the bush, invariably had a slightly lower hemoglobin level than those in captivity. The mean Hb level for recently caught baboons was 12.4 Gm./100 ml. (range 8.9–15.5); whereas for those that had been in captivity for from 1 to 3 years, the mean Hb level was 14.1 Gm./100 ml. (range 12.3–16.7). The baboons in the Nairobi colony were either caught at sea level or 3000 feet. Nairobi itself is 5600 feet and doubtless this increase in altitude was a factor in the higher hemoglobin levels of those in captivity. There was no significant difference between the mean and range of the hemoglobin in the male and female baboons. During menstruation the perineal swelling in the female lowers the plasma volume tending to increase.
Table 2.—Bone Marrow: Wild and Captive Animals (60)

<table>
<thead>
<tr>
<th></th>
<th>Early Erythro-blasts</th>
<th>Late Erythro-blasts</th>
<th>Normoblasts</th>
<th>Total red cell precursors</th>
<th>Blasts</th>
<th>Promyelocytes</th>
<th>Myelocytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td></td>
<td>2.4</td>
<td>12.0</td>
<td>21.0</td>
<td>36</td>
<td>0.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Range</td>
<td>1.6–3.0</td>
<td>10–15</td>
<td>20–22</td>
<td>32–39</td>
<td>0–2.0</td>
<td>0.5–1.0</td>
<td>2–9</td>
</tr>
<tr>
<td>Meta-myelms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polys</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lymphs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plasma</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.E.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.0–10.0</td>
<td>21–43</td>
<td>11–34</td>
<td>1.0–6.0</td>
<td>0–7.0</td>
<td>0–4</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>3.0</td>
<td>30</td>
<td>20</td>
<td>3.0</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

the Hb value and raise the PCV. Hemosiderin was present in the marrow (grade 1–4,18) usually as large aggregates, but sometimes as fine pepper-like granules.

More than half the animals had *Hepatocysis kochi* in their blood when captured. The presence of these parasites no doubt depends on the season of the year as well as the area from which the animals come, being commoner in the coastal baboon than in those caught at higher altitudes. Intestinal parasites included *Strongyloides spp*, *Oesophagostoma spp*, *B. hertiella*, *Physaloptera spp*, Tape worms *spp*, *Oxyurids spp*, *Ancylostomes spp*, *Trichostrongyloidea spp*, *Schistosomes spp*, *Amoeba spp*, *Balantidium spp*, most of the animals having multiple infections. The marrow of baboons is easily obtainable, resembling closely that of man, stains well with Romanowsky stain and shows none of the differences described by Winter18 in sheep. In determining marrow activity we have counted the number of red cell precursors as a percentage of the total red cell population and like Fruhling and Dourov7 found it entirely satisfactory and agrees with the activity as estimated by red cell uptake of Fe59. Megaloblasts were found in the marrow of only 1 animal and this was not anemic. Giant stab cells were found in 8. The significance of these giant stab cells is not fully understood; in man they are thought to be related to folic acid deficiency.3,4 In baboons they were present in recently caught animals, usually the anemic ones, which have high serum folic acid levels and low B12 values.

Oxnard15 and Krohn, Oxnard and Chalmers12 say that in recently caught rhesus monkeys, the mean serum B12 level is 271 µg./ml. (range 110–680) compared with a mean of 43 µg./ml. (range 20–70) in animals that have been in captivity for 2 to 10 years. These authors attributed the fall to changes in diet perhaps due to the absence of such things as locusts and meal worms; they do not mention giant stab cells.

Deo and Ramalingaswami12 observed that rhesus monkeys suffered a fall in their serum B12 levels when on a low protein diet which returned to normal when additional protein was given.

Serum protein levels fluctuated fairly widely (table 2), but did not seem to be affected by captivity, unless the animals were on a riboflavin-deficient diet.5

Blood volume, red cell iron uptake, T¹⁄₂ and protein turnover studies were
done on a few animals using Fe\textsuperscript{59} and I\textsuperscript{131} labelled human albumin with ion exchange resin.\textsuperscript{9,10} The protein catabolic rate in three baboons was 20.4 per cent, 21.3 per cent and 24.8 per cent daily measured by the radioactivity appearing in urine and faeces. The protein turnover rate was 250, 279 and 246 mg./kilo/daily. These figures are high compared to those of Cohen\textsuperscript{1} who reported values of 2–14 per cent for the catabolic rate. The turnover rate is similarly high. These high figures may have been due to the selective destruction of the human albumin.\textsuperscript{13,14} The work is being repeated using labeled baboon albumin.

**Summary**

Hematologic values for peripheral blood and marrow, serum proteins, B\textsubscript{12} and folic acid levels are given for recently caught and captive baboons (P. anubis and P. sinocephalus) in Nairobi.

The hemoglobin levels were higher in captive than in wild animals. There was no change in the serum proteins unless the animals were on a riboflavin-deficient diet.

Marrow activity as estimated by counting red cell precursors as a percentage of the total nucleated red cell population agreed with that of red cell uptake of Fe\textsuperscript{59} ferric chloride.

Hemosiderin was present in the marrow in all the animals.

Protein turnover studies using I\textsuperscript{131}-labeled albumin with ion exchange resins indicated that the protein catabolic rate and turnover was high. This may have been due to the selective destruction of the human albumin in the baboon.

**Summario in Interlingua**

Le valores hematologic pro sanguine peripheric e medulla si ben como le concentrationes seral de proteinas, vitamina B\textsubscript{12}, e acido folic es reportate pro babuinos (Papio anubis e P. cynocephalus) recentemente capturate o vivente in captivitate in Nairobi.

Le nivellos de hemoglobina esseva plus alte in animales captive que in animales salvage. Nulle alteration eseva notate in le proteinas seral excepte quando le animales recipeva un dieta con carentia de riboflavina.

Le activitate medullari, estimate per le contation de precursores erythrocytic como procentage del total population de nucleate erythrocytos, eseva de accordo con illo estimate a base del acceptation erythrocytic de chloruro ferric a Fe\textsuperscript{59}.

Hemosiderina eseva presente in le medulla de omne le animales.

Studios del metabolismo de proteina, utilisante albumina marcate a I\textsuperscript{131} con resinas de excambio de iones, indicava que le catabolismo proteinic eseva intense. Isto eseva possibilemente le efecto de un destruction selective de albumina human in le babuino.

**REFERENCES**

2. Deo, M. G., and Ramalingaswami, V.: Absorption of Co\textsuperscript{58} labelled cyano-cobalamin in protein deficiency: An
Hematologic and Biochemical Indices in the East African Baboon
HENRY FOY, ATHENA KONDI and VERSTISTINE MBAYA