



## STUDY OF VARIATION OF HEMATOLOGICAL PARAMETERS AT *RATTUS NORGEVICUS*

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### ABSTRACT

**Background:** Hematological evaluation in animals is of capital interest in defining the diagnosis of many diseases. The variation of hematological parameters, i.e. the haemogram (red blood cells, white blood cells, haemoglobin, haematocrit, MCV, MCH, MCHC, platelets, neutrophils, lymphocytes and MXD) is an indicator of the state of health. **Materials and Methods:** Thus in this study, to be able to determine the normal values of the rats, a set of batches of male and female Wistar rats was formed and acclimatized for 2 months. Each batch set consisted of thirty-nine (39) rats. Each rat was weighed and then by caudal venipuncture to collect their blood in an EDTA tube. The EDTA tube was used to do the blood count. **Results:** The results of this study showed that some animals already had certain pathologies before the use of any beneficial or harmful substance on them. However, most of the animals used had normal hematological parameters, indicating good health status. **Conclusion:** These values of determined standard haematological parameters may form a basis for future tests.

**KEYWORDS:** Rats, hemogram, normal values.

### INTRODUCTION

Developing countries face enormous public health problems. Infectious diseases and malnutrition are the most prevalent despite the development of diagnostic tools. Clinical examinations are accompanied by biological analyses to guide or confirm the clinical diagnosis. Hematological and biochemical parameters are a reliable means for health and nutritional status assessment<sup>15</sup>. However, the interpretation of the results of these analyses is done by comparison with reference values of european populations provided by the manufacturer. As such, the diagnostic kits used in our laboratories are developed according to european or north american standards that do not necessarily reflect those of africans. In fact, studies made on the biological standards of africans are rare if not almost non-existent. Already, studies conducted by<sup>[30]</sup> in Côte d'Ivoire,<sup>[5]</sup> in Cameroon, and <sup>1</sup>in Congo have shown that there are differences between the mean values of some biological parameters of the african and the european.<sup>[25]</sup>

These differences would be due to nutritional and environmental variations, among others.<sup>[22,25]</sup> If we add the notion of intra- and inter-individual biological variations, we understand that the reference values cannot be transposed indifferently from one country to another. For this reason, during an international cooperative study on the transferability of reference values<sup>[26]</sup>, concluded that reference values adapted to geographical origin and taking into account the ethnic factor in Africa should be established.<sup>[25]</sup> So, the establishment of baseline values is of paramount importance for a given population in terms of scientific, diagnostic, and therapeutic aspects.<sup>[26,25]</sup> Therefore, before establishing baseline values for africans, it is essential to determine the biochemical and hematological parameters of animal models including rats. Indeed, haematological and biochemical characterization of animals is of particular interest for the diagnosis of many diseases,<sup>[20,18,17]</sup> especially subclinical forms, as well as for prognosis.<sup>[18,17]</sup> To do this, most pharmacological and toxicological experiments are performed on this small rodent. Thus, it is used as a study model in many areas

of biomedical research.<sup>[11]</sup> Although the rare work carried out on rats, i.e. the determination of their biochemical and hematological parameters, is only a means of verifying the effect of a substance on the rat organism, and even of establishing standard reference values for comparative studies<sup>[21,14]</sup> with reduced sampling. It is to remedy this situation that the present study was conducted.

Its objective was to study the variation in a few haematological parameters in *Rattus norvegicus*.

## MATERIALS AND METHODS

### MATERIALS

#### Animal material

The rats used in this study were *Rattus norvegicus*. They are 78 in number including 39 males and 39 females and were acclimatized for two months at the Animal Physiology Department of the University Jean Lorougnon Guédé (UJLoG) (Daloa, Côte d'Ivoire) in plastic jars with stainless steel covers. In each jar, there are 4 or 5 animals per group according to their sex. During this period, they were fed with pellets and subjected to controlled temperature and lighting conditions. The litter used was wood chips. It was renewed every two days during the entire experiment to ensure the good hygienic condition of the animals. Their age varied between 3 and 6 months. The males rats weighed between 75 and 175 g while the females weighed between 70 and 150 g.

#### Blood samples

Blood samples are taken by caudal venipuncture in rats. Whole blood from each rat was collected immediately in the purple tube (EDTA) and then transported in a cooler to the laboratory for the blood count.

## METHODS

### Method of analysis of haematological parameters: haemogram

For the analysis of the haemogram, after homogenization of the purple tube (EDTA) (repeated turning movement), it was placed under the suction nozzle of the device and then actuated. A volume of 12 to 15  $\mu\text{L}$  of blood was collected.<sup>[25]</sup> After the sample was taken, the results of the various haematological parameters were displayed on the screen of the device.

### Method of statistical analysis

The statistical treatments were carried out on the data collected after the characterization of hematological parameters. This included a one-factor analysis of variance (ANOVA). When the difference is significant, a multiple comparison test (Turkey HSB) was conducted at the 5% threshold to separate the samples.

## RESULTS

### Results of hematological parameters analysis of males

The results of the analyses of hematological parameters in males rats are shown in Tables 1, 2 and 3.

The values of the parameters of males M1, M2, M5, M7, M9, M13, M14, M16, M18, M19, M31 and M39 obtained for WBC are not included in the reference value ( $12.58 \pm 3.6 \times 10^3 \mu\text{L}$ ) of Table 3.

RBC values obtained from males M3, M5, M7, M17, M23 and M25 are not included in the reference value ( $6.82 \pm 2.09 \times 10^6 \mu\text{L}$ ) in Table 3.

At the HGB level, the results obtained from males M6, M7, M11, M12, M22, M23, M25, M26, M27, M29 and M30 are outside the reference value ( $13.46 \pm 1.29 \text{ g/dL}$ ) of Table 3.

For HCT, its values obtained from males M3, M5, M7, M10 and M17 are not part of the reference value ( $41.32 \pm 11\%$ ) in Table 3.

The different MCV values for males M3, M5, M7 and M17 are outside the reference value ( $64.11 \pm 13.27 \text{ fL}$ ) of Table 3.

The results for MCH for males M3 and M17 obtained are not included in the reference value ( $20.72 \pm 9.13 \text{ pg}$ ) of Table 3.

The MCHC parameter of males M3, M10 and M17 is not included in the reference value ( $32.43 \pm 8.12 \text{ g/dL}$ ) of Table 3.

The PLT of the different males M2, M3, M5, M9, M10, M12, M17, M18, M20, M21, M29, M30 and M33 are outside the reference value ( $1118.08 \pm 257.04 \times 10^3 \mu\text{L}$ ) of Table 3.

Concerning LYM, the parameter values of males M5, M7, M11, M12, M14, M15, M16, M17, M24, M25 and M26 obtained are not included in the reference value ( $65.86 \pm 16.75\%$ ) of Table 3.

For MXD, the parameter values for males M5, M7, M9, M11, M13, M14, M15, M17, M22, M24, M26, M31 and M34 obtained are not part of the reference value ( $7.8 \pm 4.04\%$ ) in Table 3.

At the NEUT level, its values obtained from males M5, M11, M12, M14, M15, M16, M17, M24, M25, M26 and M39 are not included in the reference value ( $26.34 \pm 13.9\%$ ) of Table 3.

**Table 1: Hematological parameters of males in lot 1.**

Males Parameters	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22
WBC	<b>8.3</b>	<b>7.6</b>	9.4	12.5	<b>6.4</b>	9.9	<b>5.5</b>	11.1	<b>8.2</b>	11.1	11.2	15.6	<b>19.6</b>	<b>17.5</b>	13.8	<b>8.8</b>	10.8	<b>20</b>	<b>16.8</b>	13.2	14.4	12.9
RBC	7.27	6.27	<b>2.98</b>	6.63	<b>0.49</b>	6.19	<b>0.38</b>	7.71	6.5	4.91	6.01	5.75	7.91	7.75	8.56	7.93	<b>2.07</b>	7.93	7.64	6.69	6.64	7.2
HGB	14.5	12.6	12.4	13.7	12.4	<b>12</b>	<b>11.5</b>	13.7	14	12.8	<b>11.1</b>	<b>11.1</b>	14.6	14.2	14.4	14.9	14.3	13.8	14.9	12.3	12.2	12
HCT	47.5	40.6	<b>23.3</b>	42.3	<b>5.5</b>	37.9	<b>4.3</b>	45.5	41.8	<b>28.8</b>	38.6	38.5	48.3	47.5	48.3	49.7	<b>19.4</b>	48.3	50.3	41.4	40.5	41
MCV	65.3	64.8	<b>78.2</b>	63.8	<b>112.2</b>	61.2	<b>113.2</b>	59	64.3	58.8	64.2	67	61.1	61.3	56.4	62.7	<b>93.7</b>	60.9	61.9	61.9	61	56.9
MCH	19.9	20.1	<b>41.6</b>	20.7	26.8	19.4	28.2	17.8	21.5	26.1	18.5	19.3	18.5	18.3	16.8	18.8	<b>69.1</b>	17.4	18.3	18.4	18.4	16.7
MCHC	30.5	31	<b>53.2</b>	32.4	32.1	31.7	36	30.1	33.5	<b>44.4</b>	28.8	28.8	30.2	29.9	29.8	30	<b>73.7</b>	28.6	29.6	29.7	30.1	29.3
PLT	1158	<b>586</b>	<b>768</b>	1143	<b>1651</b>	917	1317	996	<b>665</b>	<b>674</b>	929	<b>441</b>	930	1205	1210	1357	<b>731</b>	<b>838</b>	957	<b>610</b>	<b>769</b>	1119
LYM	63.3	69.2	64.2	59.8	<b>27.4</b>	68.9	<b>47.2</b>	77.7	64.1	57.5	<b>38.4</b>	<b>26.8</b>	77.2	<b>86.1</b>	<b>94</b>	<b>83.4</b>	<b>85.9</b>	73.4	75.4	72.6	71	82.6
MXD	9.5	10.3	6.7	7.2	<b>17.9</b>	5.1	<b>18.5</b>	8.1	<b>13.4</b>	6.3	<b>13.2</b>	9.8	<b>2.7</b>	<b>3.7</b>	<b>1.1</b>	4.4	<b>2.1</b>	5.3	4.5	5.4	4	<b>3.4</b>
NEUT	27.2	20.5	29.1	33	<b>54.7</b>	25.9	34.3	14.2	22.5	36.2	<b>48.4</b>	<b>63.4</b>	20.1	<b>10.2</b>	<b>4.9</b>	<b>12.2</b>	<b>12</b>	21.3	20.1	22	25	14

**Table 2: Hematological parameters for males in lot 2.**

Males Parameters	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39
WBC	11.3	13.9	9.4	9.8	13.9	12.6	12.4	15.4	<b>21.9</b>	13.2	13.1	11.1	11.7	12.5	13	14.6	<b>16.3</b>
RBC	<b>8.97</b>	8.82	<b>9.04</b>	8.85	8.81	8.22	8.49	8.47	7.12	7.25	7.2	6.98	6.95	7.44	7.34	7.66	7.04
HGB	<b>15.2</b>	14.5	<b>15.5</b>	<b>15.7</b>	<b>15.3</b>	14.4	<b>15.2</b>	<b>15.1</b>	12.9	12.3	12.8	12.8	12.4	13.1	12.8	13.2	12.4
HCT	49.2	47.8	50.6	50	51.1	46.6	49.5	49.7	43.9	44.4	43.7	42.1	42.3	43.1	42.8	44	41.3
MCV	54.8	54.2	56	56.5	58	56.7	58.3	58.7	61.7	61.2	60.7	60.3	60.9	57.9	58.3	57.4	58.7
MCH	16.9	16.4	17.1	17.7	17.4	17.5	17.9	17.8	18.1	17	17.8	18.3	17.8	17.6	17.4	17.2	17.6
MCHC	30.9	30.3	30.6	31.4	29.9	30.9	30.7	30.4	29.4	27.7	29.3	30.3	29.3	30.4	29.9	30	30
PLT	1148	1014	1232	1265	1227	1284	<b>1404</b>	<b>740</b>	1294	1035	<b>858</b>	916	1079	1067	1096	1047	1028
LYM	63.4	<b>30.3</b>	<b>42.1</b>	<b>38.4</b>	70.5	62.1	56.3	75.4	79.7	62.3	82.1	71.1	73.3	68.4	68.2	77.8	80.9
MXD	8.2	<b>13.2</b>	9.3	<b>13.2</b>	9.1	11.3	8.2	7.2	<b>3.2</b>	8.3	5.2	<b>11.9</b>	6.4	5.3	6.5	7.1	8.1
NEUT	28.4	<b>56.5</b>	<b>48.6</b>	<b>48.4</b>	20.4	26.6	35.5	17.4	17.1	29.4	12.7	17	20.3	26.3	25.3	15.1	<b>11</b>

\* *In bold, abnormal parameters*

**Table 3: Summary of hematological parameters for males of the two lots.**

Parameters	Maximum	Minimum	Average	Standard deviation	Reference values
WBC	21.9	5.5	12.58	3.6	<b>8.98-16.18</b> ×10 <sup>3</sup> μL
RBC	9.04	2.07	6.82	2.09	<b>4.73-8.91</b> ×10 <sup>6</sup> μL
HGB	15.7	11.1	13.46	1.29	<b>12.17-14.75</b> g/dL
HCT	51.1	4.3	41.32	11	<b>30.32-52.32</b> %
MCV	113.2	54.2	64.11	13.27	<b>50.84-77.38</b> fL
MCH	69.1	16.4	20.72	9.13	<b>11.59-29.85</b> pg
MCHC	73.7	27.7	32.43	8.12	<b>24.31-40.55</b> g/dL
PLT	1651	441	1118.08	257.04	<b>861.04-1375.12</b> ×10 <sup>3</sup> μL
LYM	94	26.8	65.86	16.75	<b>49.11-82.61</b> %
MXD	18.5	1.1	7.8	4.04	<b>3.76-11.84</b> %
NEUT	63.4	4.9	26.34	13.9	<b>12.44-40.24</b> %

WBC:(μL), RBC:(μL), HGB : hemoglobin (g/dL), HCT : hematocrit (%), MCV:(fL), MCH:(pg), MCHC:(g/dL), PLT : platelets (μL), LYM : lymphocytes (%), MXD:(%), NEUT : neutrophils (%)

#### Results of analyses of hematological parameters of females

Tables 4, 5 and 6 show the results of hematological parameters for females rats.

For WBC, the values of the parameters of females F4, F5, F7, F9, F10, F24, F25, F27, F28, F32, F33 and F37 obtained are not included in the reference value (12.09±3.8×10<sup>3</sup> μL or 8.29-15.89 ×10<sup>3</sup> μL) of Table 6.

RBC values obtained from females F4, F5, F6, F9, F10, F18, F20 and F22 are not included in the reference value (6.54±1.56×10<sup>6</sup> μL or 4.98-8.10×10<sup>6</sup> μL) in Table 6.

At the HGB level, the results obtained from females F6, F8, F11, F12, F13, F17, F19, F20, F22, F28 and F29 are outside the reference value (13.55±1.15 g/dL or 12.40-14.70 g/dL) of Table 6.

Concerning HCT, its values obtained from females F5, F6, F8, F9, F10, F18 and F20 are not part of the reference value (41.03±8.18 % or 32.85-49.21%) of Table 6.

The different MCV values for females F5, F6, F9, F10, F12, F13, F18, F23, F24, F26, F27 and F32 do not belong to the reference value (63.77±5.21 fL or 58.56-68.98 fL) of Table 6.

For MCH, the results for females F5, F6, F10 and F18 obtained are not included in the reference value (22.69±9.40 pg or 13.29-32.09 pg) of Table 6.

The MCHC parameter of females F5, F6, F10 and F18 is not in the reference value (34.95±11.26 g/dL or 23.69-46.21 g/dL) of Table 6.

The PLT of individual females F1, F2, F5, F6, F7, F8, F9, F18, F23, F24 and F35 are outside the reference value (849.92±195.08×10<sup>3</sup> µL or 654.84-1045.00×10<sup>3</sup> µL) of Table 6.

Concerning LYM, the values of the parameters of females F11, F12, F13, F14, F16, F18, F23 and F36 obtained are not within the reference value (71.64±13.82% or 57.82-85.46%) of Table 6.

For MXD, the parameters values of females F5, F6, F8, F9, F10, F12, F14, F15, F16, F18, F20, F21, F25, F27, F29 and F36 obtained are not part of the reference value (6.10±3.07% or 3.03-9.17%) of Table 6.

At the NEUT level, its values obtained from females F11, F12, F13, F16 and F37, are not included in the reference value (22.26±12.33% or 9.93-34.59%) of Table 6.

**Table 4: Hematological parameters of females in lot 1.**

Females Parameters	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22
WBC	10.5	11.5	12.8	<b>8</b>	<b>7.7</b>	8.4	<b>4.7</b>	10.1	<b>6.6</b>	<b>5.2</b>	13.4	15.8	11.8	11.1	11.4	11	8.9	8.3	13.2	10.9	11.6	13.7
RBC	5.48	6.36	7.01	<b>4.92</b>	<b>3.03</b>	<b>2.07</b>	6.2	7.76	<b>4.23</b>	<b>3.87</b>	6.08	5.71	5.4	6.39	7.79	7.63	7.82	<b>2.65</b>	7.96	<b>8.39</b>	7.21	<b>8.38</b>
HGB	12.8	13.1	13.2	12.9	13.6	<b>11.9</b>	13.5	<b>15.3</b>	13.2	13.9	<b>11.4</b>	<b>11.3</b>	<b>11.2</b>	13	14.6	14.6	<b>15.2</b>	14.2	<b>15.3</b>	<b>15.9</b>	13.6	<b>15</b>
HCT	37.6	41.8	43.9	33.8	<b>21.2</b>	<b>15.4</b>	42.2	<b>51.5</b>	<b>31.7</b>	<b>27.3</b>	41.8	40.2	37.7	42.2	48.1	46.6	48	<b>20.1</b>	47.7	<b>52.7</b>	43.8	49.2
MCV	68.6	65.7	62.6	68.7	<b>70</b>	<b>74.4</b>	68.1	66.4	<b>74.9</b>	<b>70.5</b>	68.8	<b>70.4</b>	<b>69.6</b>	66	61.7	61.1	61.4	<b>75.8</b>	59.9	62.8	60.7	58.7
MCH	23.4	20.6	18.8	26.2	<b>44.9</b>	<b>57.5</b>	21.8	19.7	31.2	<b>35.9</b>	18.8	19.8	20.7	20.3	18.7	19.1	19.4	<b>53.6</b>	19.2	19	18.9	17.9
MCHC	34	31.3	30.1	38.2	<b>64.2</b>	<b>77.3</b>	32	29.7	41.6	<b>50.9</b>	27.3	28.1	29.7	30.8	30.4	31.3	31.7	<b>70.6</b>	32.1	30.2	31.1	30.5
PLT	<b>385</b>	<b>633</b>	801	679	<b>515</b>	<b>1242</b>	<b>486</b>	<b>1092</b>	<b>463</b>	794	982	895	890	939	928	973	800	<b>654</b>	992	881	974	806
LYM	65.8	68.9	81.7	71.8	63.4	65.7	79.5	82.9	79	68.2	<b>39</b>	<b>28.7</b>	<b>31.2</b>	<b>56.1</b>	80.4	<b>91.5</b>	82	<b>87.3</b>	80.5	85	77.6	84.3
MXD	4.2	8	3.2	8.2	<b>11.3</b>	<b>12.6</b>	6.5	<b>2.1</b>	<b>10</b>	<b>9.3</b>	7.3	<b>10.2</b>	8.5	<b>11.2</b>	<b>2.6</b>	<b>1.2</b>	6	<b>2.7</b>	5.5	<b>2</b>	<b>2.4</b>	3.4
NEUT	30	23	15.1	20	25.3	21.7	14	15	11	22.5	<b>53.7</b>	<b>61.1</b>	<b>60.3</b>	32.7	17	<b>7.3</b>	12	10	14	13	20	12.3

**Table 5: Hematological parameters of females in lot 2**

Females Parameters	F23	F24	F25	F26	F27	F28	F29	F30	F31	F32	F33	F34	F35	F36	F37	F38	F39
WBC	11.2	<b>17.1</b>	<b>16.5</b>	13.8	<b>22.1</b>	<b>15.90</b>	13.6	13.5	11.8	<b>16.4</b>	<b>21.1</b>	15.4	13	14.7	<b>7.5</b>	9.9	11.6
RBC	7.16	7.81	6.93	7.32	7.42	8.08	8.04	7.09	6.81	7.23	6.67	7.05	6.26	7.12	6.93	6.99	7.64
HGB	12.8	13.9	13	12.9	12.6	<b>15.3</b>	<b>15.3</b>	13.5	13	12.9	13.2	14	12.6	13.7	13.1	13.9	14
HCT	41.9	44.6	41.1	42.6	43	48.5	<b>49.6</b>	43.8	40.7	41.8	41.1	44.1	40.2	44.1	40.6	42.6	45.5
MCV	<b>58.5</b>	<b>57.1</b>	59.3	<b>56.7</b>	<b>58</b>	60	61.7	61.8	59.8	<b>57.8</b>	61.6	62.6	64.2	61.9	58.6	60.9	59.6
MCH	17.9	17.8	18.8	18.2	17	18.9	19	19	19.1	17.8	19.8	19.9	20.1	19.2	18.9	19.9	18.3
MCHC	30.5	31.2	31.6	29.7	29.3	31.5	30.8	30.8	31.9	30.9	32.1	31.7	31.3	31.1	32.3	32.6	30.8
PLT	<b>1113</b>	<b>1107</b>	934	827	790	1030	1017	1029	829	850	835	966	<b>564</b>	783	686	938	1045
LYM	16.5	83	74.6	72.4	70.5	80.2	64.3	72.4	75.9	71.8	70.6	73.8	69.8	<b>87</b>	60.6	67.5	72.6
MXD	3.2	5	<b>2.3</b>	7.4	<b>9.2</b>	7.5	<b>9.2</b>	8.6	4.1	6.1	8.3	5.2	3.2	<b>2</b>	4.5	6.4	7.2
NEUT	20.3	12	23.1	20.2	20.3	12.3	26.5	19	20	22.1	21.1	21	27	11	<b>34.9</b>	26.1	20.2

\* *In bold, abnormal parameters*

**Table 6: Summary of haematological parameters for females of the two lots.**

Parameters	Maximum	Minimum	Average	Standard deviation	Reference values
WBC	22.1	4.7	12.09	3.80	<b>8.29-15.89 ×10<sup>3</sup> μL</b>
RBC	8.39	2.07	6.54	1.56	<b>4.98-8.10×10<sup>6</sup> μL</b>
HGB	15.9	11.2	13.55	1.15	<b>12.40-14.70 g/dL</b>
HCT	52.7	21.2	41.03	8.18	<b>32.85-49.21 %</b>
MCV	75.8	56.7	63.77	5.21	<b>58.56-68.98 fL</b>
MCH	57.5	17.0	22.69	9.40	<b>13.29-32.09 pg</b>
MCHC	77.3	27.3	34.95	11.26	<b>23.69-46.21 g/dL</b>
PLT	1242	385	849.92	195.08	<b>654.84-1045.00×10<sup>3</sup> μL</b>
LYM	91.5	28.7	71.64	13.82	<b>57.82-85.46 %</b>
MXD	12.6	1.2	6.10	3.07	<b>3.03-9.17 %</b>
NEUT	61.1	10	22.26	12.33	<b>9.93-34.59 %</b>

WBC:(μL), RBC:(μL), HGB : hemoglobin (g/dL), HCT : hematocrit (%), MCV:(fL), MCH:(pg), MCHC:(g/dL), PLT : platelets (μL), LYM : lymphocytes (%), MXD:(%), NEUT : neutrophils (%)

### Results of the statistical analysis

Statistical calculations are often useful to biologists for the determination of normal values or, more precisely, reference values, as well as for the evaluation of precision and analytical accuracy.<sup>[3,24,4]</sup>

The result of the statistical analysis of hematological parameters for males and females is shown in Table 7.

**Table 7: Statistical study of hematological parameters by gender (ANOVA).**

Parameters	WBC	RBC	HGB	HCT	MCV	MCH	MCHC	PLT	LYM	MXD	NEUT
Sex											
Males	12.58 ± 3.6 <sup>a</sup>	6.82 ± 2.09 <sup>a</sup>	13.46 ± 1.9 <sup>a</sup>	41.32 ± 11.00 <sup>a</sup>	64.11 ± 13.27 <sup>a</sup>	20.72 ± 9.13 <sup>a</sup>	32.43 ± 8.12 <sup>a</sup>	1018.08 ± 257.04 <sup>b</sup>	65.86 ± 16.75 <sup>a</sup>	7.8 ± 4.04 <sup>b</sup>	26.34 ± 13.90 <sup>a</sup>
Females	12.09± 3.80 <sup>a</sup>	6.54± 1.56 <sup>a</sup>	13.53± 1.15 <sup>a</sup>	41.03± 8.18 <sup>a</sup>	63.77± 5.21 <sup>a</sup>	22.69± 9.40 <sup>a</sup>	34.95± 11.26 <sup>a</sup>	849.92± 195.08 <sup>b</sup>	71.64± 13.82 <sup>a</sup>	6.10± 3.07 <sup>b</sup>	22.26± 12.33 <sup>a</sup>
P	0.562799	0.494663	0.753409	0.897198	0.878890	0.352843	0.260794	<b>0.001698</b>	0.100345	<b>0.039267</b>	0.174025

$P < 0.05$  sex has an influence on the hematological parameter studied.

$P > 0.05$  has no influence on the hematological parameter studied.

## DISCUSSION

### Analysis of hematological parameters of males and females

Analysis of the parameters of the haemogram, in particular white blood cells or WBC, showed that the values of males M1, M2, M5, M7, M9 and M16 and females F4, F5, F7, F9, F10 and F37 were below their respective reference values by  $12.58 \pm 3.6 \times 10^3 \mu\text{L}$  ( $8.98-16.18 \times 10^3$ ) and  $12.09 \pm 3.80 \times 10^3 \mu\text{L}$  ( $8.29-15.89 \times 10^3 \mu\text{L}$ ). According to<sup>[19,8,9,7]</sup>, this decrease would correspond to leukopenia. This would mark an immunodepression. There may sometimes be an association of leukopenia from one lineage-leukocytosis from another lineage. This is the case in a stress situation: the leucogram is modified according to a formula called "de stress". The stress pattern is characterized by moderate neutrophilia, lymphopenia, eosinopenia and variable monocyte counts. Thus, the above-mentioned individuals on top would correspond to this state of affairs. As for the values of the males M13, M14, M18, M19, M31 and M39 and those of the females F24, F25, F27, F28, F32 and F33, they have values higher than their respective reference values. According to<sup>[13,12]</sup>, this increase would indicate hyperleukocytosis. This would indicate a general

inflammatory state. According to<sup>[2,12]</sup>, this general inflammation could be at the origin of the stimulation of the immune system leading to these increases. Therefore, previous individuals would obey this principle. Statistical analysis ( $p > 0.05$ ) shows that gender has no influence on white blood cells.

For red blood cells: erythrocytes or RBC, males M3, M5, M7 M17 and females F4, F5, F6, F9, F10, F18 have respective values below their norm ( $6.82 \pm 2.09 \times 10^6 \mu\text{L}$  i.e. ( $4.73-8.91 \times 10^6 \mu\text{L}$ ) and  $6.54 \mu\text{L} \pm 1.56 \times 10^6$  i.e. ( $4.98-8.10 \times 10^6 \mu\text{L}$ )). According to<sup>[7]</sup>, an abnormally low red blood cell count is often a sign of anemia. It could result from a defect of erythropoiesis, or from a destruction of the circulating red blood cells. It is thus possible to deduce that males M3, M5, M7 M17 and females F4, F5, F6, F9, F10, F18 would correspond to this observation. As for males M23 and M25, and females F20 and F22, they have values above their respective standards. According to<sup>[7]</sup>, an abnormally high number of red blood cells is called polyglobulia. It can be primary, for example in a hematopoietic bone marrow stem cell tumor, or secondary, for example in chronic hypoxia. So the males M23 and M25, and the females F20 and F22

could indicate this. Statistical analysis ( $p > 0.05$ ) reveals that sex has no influence on red blood cells.

In terms of hemoglobin, males M6, M7, M11, M12 and M22 and females F6, F11, F12 and F13 had values below their respective standards of  $13.46 \pm 1.29$  g/dl (12.17-14.75 g/dl) and  $13.55 \pm 1.15$  g/dl (12.40-14.70 g/dl). Males M23, M25, M26, M27, M29 and M30 and females F8, F17, F19, F20, F22, F28 and F29 gave values above their respective standards. For<sup>[7]</sup>, an abnormally low value would be a sign of anemia and an abnormally high value would be a sign of hemoconcentration. Consequently, all of the above-mentioned individuals could obey each situation previously defined. Statistical analysis ( $p > 0.05$ ) indicates that gender has no influence on hemoglobin.

The hematocrit (HCT) levels of males M3, M5, M7, M10, M17 and females F5, F6, F9, F10, F18 are lower than their respective reference values by  $41.32 \pm 11$  % (30.32-52.32 %) and  $41.03 \pm 8.18$  % (32.85-49.21 %). However, in F20 and F29 females, this rate is above their reference value. <sup>7</sup>says the measurement of hematocrit would make it possible to objectify a possible anemia and would allow the evaluation of blood hemoconcentration: the hematocrit would be increased in case of dehydration or in case of polyglobulism. As a result, the different individuals mentioned above would correspond to each predefined state of health. The statistical analysis ( $p > 0.05$ ) states that gender does not influence hematocrit.

The rate of MCV obtained in males M3, M5, M7 and M17, and females F5, F6, F9, F10, F12, F13, F18 are superior to their respective norms by  $64.11 \pm 13.27$  fL (50.84-77.38 fL) and  $63.77 \pm 5.21$  fL (58.56-68.98 fL). Nevertheless, in females F23, F24, F26, F27 and F32, it is under the norm. According to<sup>[10,7]</sup>, the MCV would qualify the erythrocyte population as normocytic when the MCV is within the reference values; as microcytic when it is below the reference values : this is the case in ferripritic anemias; and macrocytic when it is higher than the reference values: this can for example be observed in regenerative anemia with the massive arrival in the blood of immature red blood cells whose size is greater than the mature red blood cells. Thus, the individuals mentioned above would indicate one of the predefined states. Statistical analysis ( $p > 0.05$ ) indicates that gender has no influence on MCV.

For MCH and MCHC, with the exception of M10 where the only MCHC value is above  $32.43 \pm 8.12$  g/dl (24, 31-40.55 g/dl), the values obtained in males M3 and M17, and females F5, F6, F10 and F18 are above the standards by  $20.72 \pm 9.13$  pg (11.59-29.85 pg) and  $32.43 \pm 8.12$  g/dl (24.31-40.55 g/dl), respectively; and by  $22.69 \pm 9.40$  pg (13.29-32.09 pg) and  $34.95 \pm 11.26$  g/dl (23.69-46.21 g/dl), respectively.<sup>[7]</sup> suggests that they would make it possible to determine whether the red blood cell population is: normochrome, i.e. red blood cells contain

a normal amount of hemoglobin; hypochrome, i.e. red blood cells contain a decreased amount of hemoglobin, as may be the case in iron deficiency anemia. Therefore, the above-mentioned individuals can probably obey these conditions. Statistical analysis ( $p > 0.05$ ) shows that gender has no influence on the MCH and MCHC.

For PLT (platelets), its values in males M2, M3, M9, M10, M12, M17, M18, M20, M21, M30 and M33, and females F1, F2, F5, F7, F9, F18, F35 are under their respective reference values of  $1118.08 \pm 257.04 \times 10^3$   $\mu$ L ( $861.04 - 1375.12 \times 10^3$   $\mu$ L) and  $849.92 \pm 195.08 \times 10^3$   $\mu$ L ( $654.84 - 1045.00 \times 10^3$   $\mu$ L). This, according to<sup>[27,7]</sup>, would reflect thrombocytopenia, i.e. an abnormally low number of platelets, which could be due to insufficient synthesis: when the bone marrow is damaged, for example; excessive loss: through haemorrhage or excessive consumption of platelets, as in the case of Disseminated Intravascular Coagulation (DIC). Thus, the individuals mentioned above could comply with this principle. Therefore, the individuals mentioned above could respect this principle. As for males M5 and M29, and females F6, F8, F23 and F24, the values obtained are above their respective standards. According to<sup>[23,27,7]</sup>, this would indicate thrombocytosis, i.e. an abnormally high number of platelets, with different artifactual origins: cell fragments from erythrocytes or leukocytes can lead to pseudothrombocytosis or physiological thrombocytosis : It corresponds to the circulation of platelets normally sequestered in the spleen, by contraction of the spleen, or secondary thrombocytosis: thrombopoiesis is stimulated in an exaggerated way by cytokines, in an inflammatory or neoplastic context. Therefore, these individuals must match this state. Statistical analysis ( $p < 0.05$ ) reveals that gender has an influence on platelets.

LYM (lymphocyte) values for males M5, M7, M11, M12, M24, M25, M26 and females F11, F12, F13, F14, F23 respectively are  $65.86 \pm 16.75$  % (49.11-82.61 %) and  $71.64 \pm 13.82$  % (57.82-85.46 %) below baseline. According to<sup>[6]</sup>; lymphopenia being a decrease in blood lymphocytes would be found in certain pathologies of the immune system called immunodeficiencies. Apart from thymectomy and chylothorax, there is another important cause of lymphopenia: exudative enteropathy. Previous individuals may therefore be consistent with this state of health. As for the values of M14, M15, M16 and M17 and those of females F16, F18 and F36, they are above their respective reference. According to<sup>[29,7]</sup>; an increase in lymphocytes would reflect lymphocytosis: lymphoid neoplasia, sometimes following exposure to an antigen. Therefore, the individuals mentioned above may be in compliance with this principle. Statistical analysis ( $p > 0.05$ ) reveals that gender does not influence lymphocytes. For MXD, the values for males M13, M14, M15, M17, M22 and M31 and females F8, F15, F16, F18, F20, F21, F25 and F36 were  $7.8 \pm 4.04$  % (3.76-11.84 %) and  $6.10 \pm 3.07$  % (3.03-9.17 %) below the respective references. Males M5, M7, M9, M11, M13, M24, M26 and M34, and females F5, F6, F9, F10, F12,

F14, F27 and F29 are above their respective references. Statistical analysis ( $p < 0.05$ ) indicates that gender influences MXD.

At the NEUT (Neutrophil) level, the values of males M14, M15, M16, M17 and M39 and female F16 are  $26.34 \pm 13.9\%$  (12.44-40.24 %) and  $22.26 \pm 12.3\%$  (9.93-34.59 %) below baseline. M5, M11, M12, M24, M25 and M26 males and F11, F12, F13 and F37 females are higher than their respective standards. According to<sup>[28,16]</sup>, under stress, the release of glucocorticoids can induce neutrophilia associated with lymphopenia; this is a "stress formula". The latter individuals could obey this state of affairs. Statistical analysis ( $p > 0.05$ ) states that gender has no influence on neutrophils.

### CONCLUSION

The results of this study showed that most of the animals had normal hematological parameters. The values of these individuals allowed the determination of standards in rats with a more representative sampling. Nevertheless, some individuals had fluctuating hematological parameters. Variations in these parameters can be the cause of many pathologies. Thus, these pathologies are observed in a particular way at the level of.

- 6 males out of 39 and 6 females out of 39 with leukopenia.
  - 6 out of 39 males and 6 out of 39 females with hyperleukocytosis.
  - 4 out of 39 males and 6 out of 39 females with anemia due to low red blood cell count.
  - 5 out of 39 males and 4 out of 39 females had problems with anemia due to low hemoglobin.
  - 2 out of 39 males and 2 out of 39 females who had polyglobulia.
  - 6 out of 39 males and 7 out of 39 females showed signs of hemoconcentration.
  - 5 out of 39 males and 5 out of 39 females had low hematocrit values that could indicate anemia and 2 out of 39 females had high hematocrit values that could also indicate hemoconcentration.
  - 4 out of 39 males and 7 out of 39 females had macrocytic problems and 5 out of 39 females had microcytic problems;
  - 11 out of 39 males and 7 out of 39 females who had thrombocytopenia.
  - 2 out of 39 males and 4 out of 39 females with thrombocytosis.
  - 7 out of 39 males and 5 out of 39 females who had lymphopenia.
  - 4 out of 39 males and 3 out of 39 females who had lymphocytosis.
- Statistical analysis of the various hematological parameters revealed that gender has an influence on platelets and MXD.

On the basis of the standard hematological parameters obtained, it would be plausible to test certain substances

*in vivo* in order to determine their harmful or beneficial effects on vital organs and thus extend it to humans.

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