Physical Education, Health and Social Sciences
https://journal-of-social-education.org
E-ISSN: 2958-5996
P-ISSN: 2958-5988

Baseline Hemato-Biochemical Parameters for Health Monitoring of Homing Pigeon

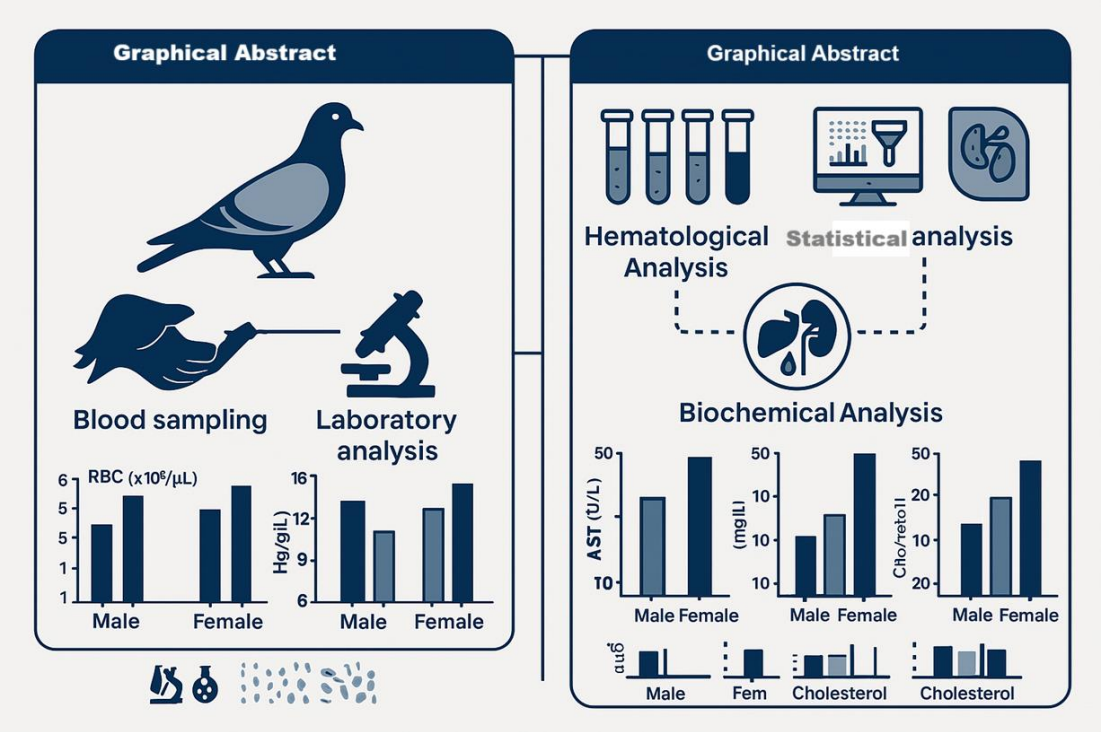
Farrukh Aziz [1], Komal Shahzadi [2], Hira Anjum [3], Sadia Nazir [4], Tayyaba Jamil [5], Ayesha Abdul Rasheed [6], Arooj Tahir [7], Rubab Kanwal [8], Zargul Ayman [9], Memona Aslam [10], Muhammad Waseem Aslam [11], Ali Umar [12*], Muhammad Zahir Tahir [13], Muhammad Saleem Khan [14*]

[1,2,3,4,5,6,7,8,9,10,11,12,13,14] Department of Zoology, Faculty of life sciences, University of Okara, Okara 56130, Pakistan. Email: samiikhan@uo.edu.pk
Corresponding author (*): M.S.K samiikhan@uo.edu.pk A.U. aumar2102@gmail.com

DOI: https://doi.org/10.63163/jpehss.v3i2.275

Abstract
This study was designed to establish the reference values of hematological, liver function (LFT), renal function (RFT), and cholesterol profiles in homing pigeons (Columba livia domestica) to provide baseline data for their health evaluation. Blood samples were collected from male and female homing pigeons during the breeding season in Okara, Pakistan. The hematological parameters revealed that hemoglobin (Hb) levels were 23.53±1.22 g/dL in males and 26.77±2.01 g/dL in females, while total RBCs were 3.63±1.39 $\times 10^6/\mu L$ in males and 2.73±0.70 $\times 10^6/\mu L$ in females. PCV was recorded as 58.10±1.59% in males and 61.63±1.35% in females. MCV was significantly higher in females (178±2.29 fL) than males (163.1±1.63 fL). In the biochemical analysis, serum total protein was 7.46±1.22 g/dL in males and 7.1±0.89 g/dL in females, while cholesterol levels were significantly higher in females (230.8±1.43 mg/dL) compared to males (220.7±2.05 mg/dL). Serum Urea levels were 18.33±2.05 mg/dL in males and 28±1.63 mg/dL in females, while serum creatinine was 0.9±0.24 mg/dL in males and 1.33±0.47 mg/dL in females. Highly significant differences ($p<0.01$) were found in WBCs, MCV, RDW-CV, MPV, eosinocytes, serum alkaline phosphatase, ALT, and serum urea values between male and female pigeons. In conclusion, the present study successfully provides baseline hematological and biochemical reference values for male and female homing pigeons, which can assist in their health monitoring and clinical assessments. It is recommended that future research should include larger sample sizes from different regions to develop a comprehensive health profile of Columba livia domestica for conservation and veterinary purposes.

Keywords: Columba livia domestica, Hematology, Biochemical Profile, Health Assessment, Reference Values.



Graphical Abstract

Introduction

Understanding geographic distribution of birds is important and it plays a key role in conservation of particular species (Rohlf, 1993). To find its way home over extremely long distances, homing pigeon is a variety of domestic pigeons (Columba livia domestica) originate from the wild rock dove, selectively bred for its great ability . Birds participating in competitive pigeon racing have been seen to fly distances of up to 1800 km (1100 miles) (Walcott, 1996). Domestic Pigeon (Columba livia) is one of the few domesticated birds with an important economic value belonging to the Columbidae of Columbiformes , and usually considered as a sign of peace (Shapiro et al., 2013). Additionally, it serves as a model experimental bird species and is frequently used for behavioral or medical research (Oznurlu, Sur, Celik, & Ozaydin, 2012). In the field of hematology, at present studies on the basic biology of pigeons have been generally carried out, Khan et al. (2011) have reported various peripheral blood files of blue rock pigeons (Columba livia), and they argued that the serum and hematological biochemical parameter values could be used as indicators of stress response, which could reflect the health status of the animals. Subsequently, in this study a complete investigation on the cytochemistry and morphology of peripheral blood cells in domestic pigeons has been conducted, which provide basic data for health assessment and disease diagnosis of this species, which could enrich the knowledge of function and structure of peripheral blood cells in birds.

All over the Pakistan homing pigeons are distributed, but they are most common in the western and Northern provinces. In Pakistan the sport of pigeon racing is very popular, and the races are organized by many clubs and associations(Harry, 2012). For Many Purposes Pigeons are used, such as for hunting and messenger pigeons. In Pakistan there is a long tradition of pigeon racing. They are rather inexpensive to raise. Relatively it is easy to take care of pigeons(Lin, 2005). Male and female homing pigeons are identified in several ways. As compared to the females, male pigeons are usually heavier, larger and have thicker necks. Male pigeons also have shorter beaks and broader longer side toes, and less distance between their vent bones. Females have flatter heads, rounder eyes, slimmer necks, and smaller side toes. In contrast to the females, Male pigeons are more aggressive, territorial, and vocal. Male and female pigeons are identified accurately by DNA testing. For analysis blood sample or a feather sample taken

from the pigeon and send it to the laboratory. The gender of a pigeon could revealed by DNA testing with 100% certainty , but this method is also most expensive and offensive(Kadhim & Mohamed, 2015).

A serum profile is a blood test that measures and analyses the minerals proteins, and enzymes, that are present in our blood(Osvaldo Padilla 2022). It is used to diagnose or monitor a variety of conditions, such as, kidney disease, malnutrition, liver disease, inflammatory diseases and multiple myeloma (MedlinePlus, 2021). The test also measures the levels of phosphorus, alkaline phosphatase and calcium in the blood, which are related to bone health(Team, 2022). The levels of hormones produced by the thyroid gland is measured by thyroid function test and it can also help to diagnose thyroid disorders such as hyperthyroidism or hypothyroidism, Immunology test measures the levels of antigens or antibodies in the blood and can help diagnose disorders of immune system or infections (NHS, 2022). Serum reports are basically the results of serologic tests that measure the levels of antigens and antibodies in our blood. These reports used to identify and diagnose various conditions or diseases, such as, allergies, autoimmune disorders, infections, organ transplant rejection and cancer(Dublin, 2023). It also shows the normal values for different substances in your blood, such as hormones, enzymes, minerals and proteins. Serum reports can give us useful information about our immune system and overall health(Kimura et al., 2021).

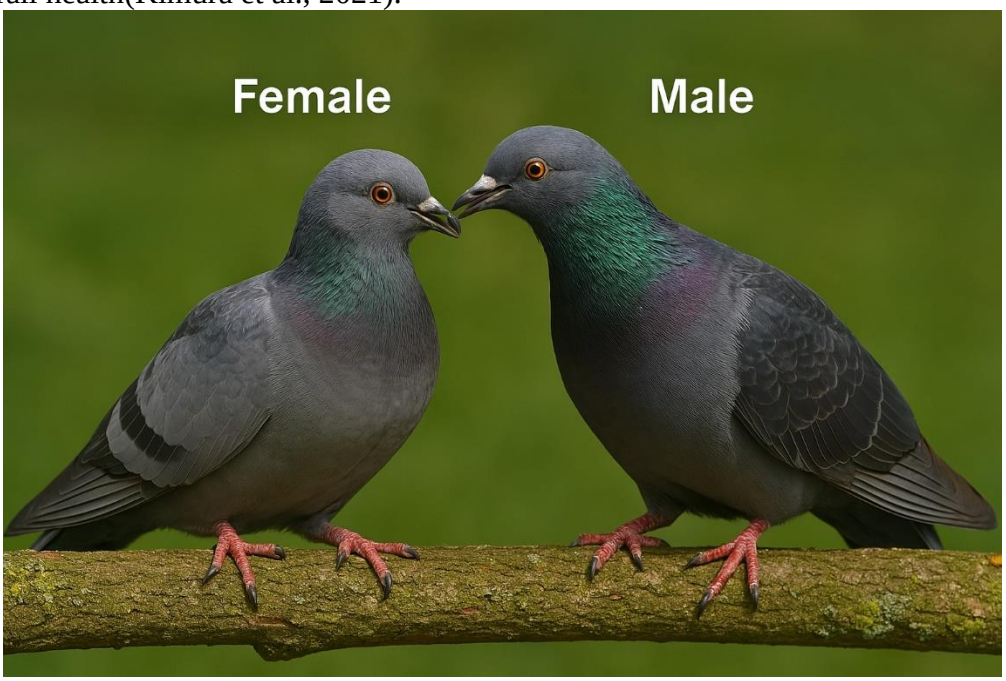


Figure 1: Male and Female homing pigeon

Many types of serum reports are used that can be done to measure different aspects of your blood. Complete blood count (CBC), that is used to measures the types and number of cells in the blood, such as platelets, white blood cells and red blood cells (Osvaldo Padilla 2022). Thyroid function tests examine the levels of antibodies and thyroid hormones in the blood. Immunofixation electrophoresis (IFE) is a test to measures the types and level of proteins in the blood. It can help diagnose conditions such as, lymphoma (a cancer of lymphocytes), multiple myeloma (a cancer of plasma cells), liver disease, inflammatory diseases and kidney disease(Shomon, 2022).

Hematology is a branch of medicine that deals with blood and the organs that make blood. It studies the causes, effects, treatments, and prevention of diseases that involve blood, such as bleeding disorders, blood clots, and blood cancers (kandola, 2020). They also perform laboratory tests on bone marrow blood samples and biopsies to monitor and diagnose many hematological conditions. (experts, 2023). The compounds that are examined in a serum profile

are known as the parameters. Blood cholesterol levels are measured by plasma total cholesterol (TC). Cholesterol functions as a structural component of cell membranes, a precursor to hormones, and a necessary ingredient in the formation of vitamin D. Albumin is a blood parameter that indicates how much albumin is present. Liver failure or drug-induced inhibition of bilirubin synthesis can both result in abnormally low levels of the bile pigment bilirubin (Osvaldo padlila, 2022). The liver and kidneys are essential organs that carry out several crucial bodily processes, such as the production of bile by the liver, which aids in the digestion of fats and the elimination of toxins. Additionally, the liver produces proteins, stores glycogen, controls blood clotting, and breaks down medications and hormones(Staff, 2021). It's important to keep an eye on the pigeons' cholesterol levels since that might affect their cardiovascular health and stamina.(Mehlhorn & Rehkämper, 2009).The possibility that pigeons have genetic variations that influence their cholesterol levels is another motivation for studying pigeons' unique lipid profiles. Finally, it would be interesting to see how homing pigeons' cholesterol levels stack up against those of other bird breeds and species to see whether there are any evolutionary adaptations or trade-offs associated to their superior navigational skills.(Esmailizadeh, Kharrati-Koopaee, & Nanaei, 2021)

2. Materials and Methods

2.1. Study Area

The present study was conducted on homing pigeon, for the analysis references values of Haematological, Cholesterol, LFT and RFT analysis. For the helping of present study homing pigeon blood samples were collected from the local pigeon farms.

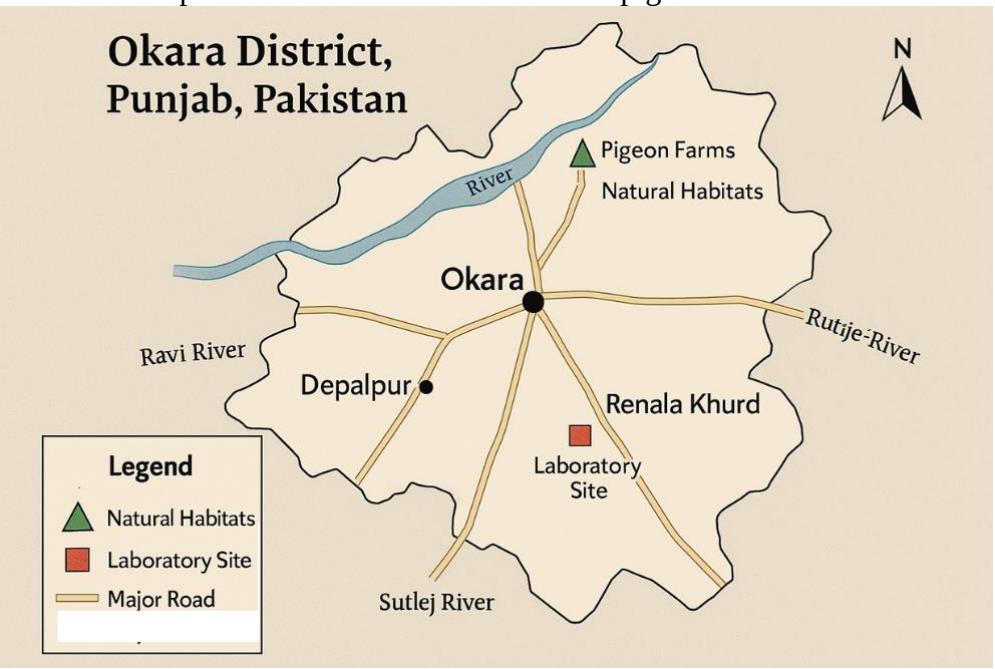


Figure 2: Map for study area

2.2. Sample collection

This study was conducted at okara area. In our study we have used homing pigeon Columba livia to collect information about the hematological and blood profile of this pigeon. One pair of homing pigeon (male and female) were used in our study and these are collected at breeding season. The pigeons were bred and cared at home. Sex was examined by observing their size and behavior. Blood sample was collected in May in breeding season. Blood was obtained from male and female to avoid any variations. Blood was extracted by using syringe washed by anticoagulant. Blood sample was stored in EDTA tube to avoid coagulation. Blood samples were sent to laboratory for experimental analysis.

2.3. Hematology method:

2.3.1. Blood Sample analysis

After experimental investigation, blood samples of Columba livia were taken from each group and were examined. The blood samples were used for studies of HGB, RBCs, WBCs, MPV, PDW, PCT, HCT and no of platelets.

2.3.2. Haemoglobin (HGB)

Haemoglobin, a protein present in RBCs, take oxygen from lungs to different tissues of body and carry the carbon dioxide back to the lungs.

2.3.3. White Blood Cells (WBC)

WBCs are involved in protecting body against foreign microorganisms and infectious diseases. Following formula was used for the measurement of WBCs:

$$\text{WBC}/\mu\text{L} = \frac{\text{Average of cells} \times \text{correction for dillution}}{\text{No. of squares} \times \text{Volume of one square}}$$

2.3.4. Total Red Blood Cells Count (TRBC)

RBCs are most occurring types of blood cells and are involved in delivering of oxygen to different tissues of body by blood circulation. TRBCs were measured by following:

$$\text{RBC (\%)} = \frac{50\ (\text{volume factor}) \times 200\ (\text{Dilution Factor}) \times \text{Number of cell counted}}{100}$$

2.3.5. Platelets (PLT)

Platelets are in involved in blood clotting and their total count was measured by following formula:

$$\text{Total Platelets Count (per Liter)} = \frac{\text{Cells count (N)} \times \text{Dilution Factor (20)} \times 10^6}{\text{Area (0.2 mm}^2\text{)}} \times \text{Volume coated (0.1 mm)}$$

2.3.6. Mean Platelet Volume (MPV)

Platelets are in involved in blood clotting and their total count was measured by following formula:

$$\text{Total Platelets Count (per Liter)} = \frac{\text{Cells count (N)} \times \text{Dilution Factor (20)} \times 10^6}{\text{Area (0.2 mm}^2\text{)}} \times \text{Volume coated (0.1 mm)}$$

2.3.7. Plateletcrit (PCT)

It is average volume of platelets in blood and is expressed in femtoliters (fL). The formula which was used to calculate Mean Platelet Volume (MCV) is:

$$\text{MPV (fL)} = \text{Plateletcrit (\%)}\text{Platelets count } \left(\times {}^{10^9}/_{\text{L}}\right) \times 10^5$$

Here, plateletcrit is the ratio between total platelet volume and complete blood volume.

2.3.8. Platelet Distribution Width (PDW)

It is actually involved in the measurement of different morphometric changes occurred in platelets, regarding activation and size. A histogram for each blood sample was used to measure the platelet distribution width.

2.3.9. Haematocrit (HCT)

It is the part of blood that is composed of packed RBCs and is expressed in percentage. Following formula was used to count it:

$$\text{HCT (\%)} = \text{RBCs count } (\times {}^{10^{12}}/_{\text{L}}) \times {}^{\text{MCV(fL)}}/_{10^6}$$

2.4. Statistical Analysis

Data was analysed through standard statistical method (mean, standard error of mean and range) using IBM SPSS (v 21). The significance of difference was test using unpaired t-test at 0.05 levels. Pearson correlation coefficient was calculated between different variables.

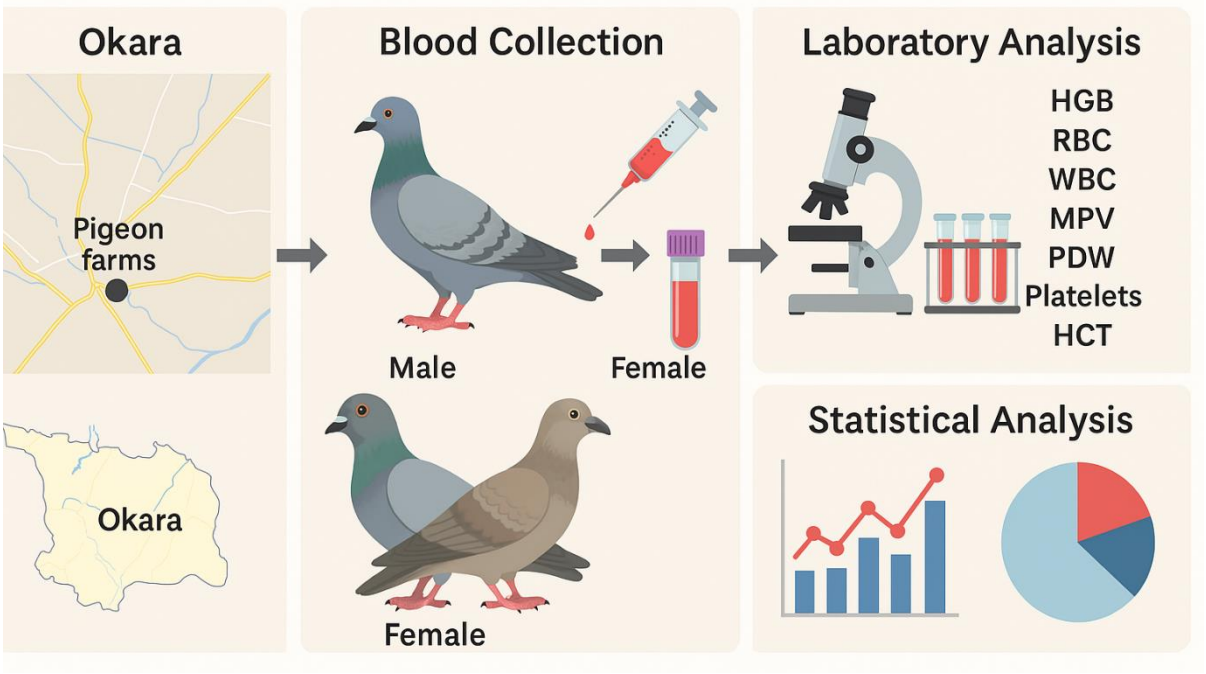


Figure 31: Study design

Results

3.1. Hematological study

The concentration of HB is greater in female 23.5±1.22(22-25) and 26.7±2.01(24.5-29.4) respectively, the concentration of Total RBCs in male and female is 3.63±1.39(2-5.4) and 2.73±0.70(1.8-3.5) respectively, the concentration of HCT/PCV in male and female is 58.1±1.59(56.1-60) and 61.6±1.35(59.9-63.2) respectively, the concentration of MCHC in male and female is 66.2±1.51(64.5-68.2) and 45.2±2.28(65.9-71.4) respectively observes as non-significant difference.

The concentration of Platelets in male and female is 2.3±0.84(1.5-3.5) and 3.23±1.51(1.5-5.2) respectively, the concentration of PDW in male and female is 4.7±2.02(3.5-5.5) and 4.7±2.02(2.5-7.4) respectively, the concentration of Neutrophils in male and female is 1.3±0.49(0.9-2) and 2.20±0.83(1.3-3.32) respectively, and the concentration of lymphocytes in male and female is 91.9±1.67(89.9-94) and 95.1±2.69(91.9-98.5) respectively observes as non-significant difference.

The concentration of MCHC in male and female is 40±1.89(37.5-42.1) and 45.2±1.71(43.2-47.4) respectively, the concentration of RDW-SD in male and female is 64.2±1.74(61.9-66.1) and 71.7±2.69(68.4-75) respectively, the concentration of monocytes in male and female is 1.08±0.31(0.75-1.5) and 5.3±2.05(3-8) respectively observes as significant difference.

The concentration of WBCs in male and female is 165.7±3.68(161-170) and 143.6±2.14(140.8-146) respectively, the concentration of MCV in male and female is 163.1±1.63(161-65) and 178±2.29(175.3-180.9) respectively, the concentration of RDW-CV in male and female is 11.6±1.30(10.3-13.2) and 32.3±2.01(30-34.9) respectively, the concentration of MPV in male and female is 4.7±0.69(3.9-5.6) and 30.2±2.78(27-33.8)

respectively, the concentration of eosinocytes in male and female is 152.7±2.05(150-155) and 111.3±2.86(108-115) respectively observes as highly significant.

Table 1:. The comparisons of hematological parameters between male and females

Parameters	Gender	Mean	SD	SE	t value	P value
Hb	Male	23.53	1.22565	0.70763	1.93	0.12
	Female	26.77	2.01715	1.1646		
WBCs	Male	165.7	3.68179	2.12568	7	0.001**
	Female	143.6	2.14838	1.24037		
Total RBCs	Male	3.633	1.39124	0.80323	0.816	0.46
	Female	2.733	0.70396	0.40643		
HCT/PCV	Male	58.1	1.59374	0.92015	2.391	0.07*
	Female	61.63	1.35236	0.78079		
MCV	Male	163.1	1.63911	0.94634	7.45	0.00**
	Female	178	2.29395	1.32442		
MCH	Male	66.23	1.5195	0.87729	1.47	0.23
	Female	45.23	2.28959	1.3219		
MCHC	Male	40	1.89912	1.09646	2.89	0.04*
	Female	45.23	1.71723	0.99145		
Platelets	Male	2.333	0.84984	0.49065	0.73	0.5
	Female	3.233	1.5195	0.87729		
RDW-CV	Male	11.6	1.3064	0.75425	12.24	0.00**
	Female	32.33	2.00721	1.15886		
RDW-SD	Male	64.23	1.74611	1.00812	3.3	0.02*
	Female	71.73	2.69485	1.55587		
PDW	Male	4.733	2.02375	1.16841	0	>0.99
	Female	4.733	2.02375	1.16841		
MPV	Male	4.767	0.69442	0.40093	12.57	0.00**
	Female	30.27	2.78249	1.60647		
Neutrophils	Male	1.3	0.49666	0.28674	1.31	0.25
	Female	2.207	0.83751	0.48354		
Lymphocytes	Male	91.97	1.67398	0.96648	1.41	0.23
	Female	95.13	2.69609	1.55659		
Monocytes	Male	1.083	0.31181	0.18002	2.89	0.04*
	Female	5.333	2.05481	1.18634		
Eosinocytes	Male	152.7	2.05481	1.18634	16.57	<0.00**
	Female	111.3	2.86744	1.65552		

4.2. LFT, RFT and Cholesterol study

The concentration of serum total bilirubin in male and female is 0.79±0.14(0.65-1) and 0.92±0.05(0.87-1) respectively, the concentration of AST(SGPT) in male and female is 33±1.63(31-35) and 37±1.63(35-39) respectively observed as non-Significant difference.

The concentration of serum total Protein in male and female is 7.46±1.22(6-9) and 7.1±0.89(6-8.2) respectively, the concentration of serum albumin in male and female is 4.3±1.06(3-5.6) respectively observes as non-Significant difference.

The concentration of serum globulin in male and female is 2.75±1.13(1.25-4) and 2.66±1.14(1.2-4) respectively, the concentration of serum creatinine in male and female is 0.9±0.24(0.6-1.2) and 1.33±0.47(0.9-2) respectively, the concentration of A/G ratio in male and female is 1.5±0.40(1-2) and 1.5±0.40(1-2) observes as non-Significance difference. The concentration of Serum BU in male and female is 8.46±1.22(7-10) and 13±0.81(12-14) respectively, the concentration of cholesterol in male and female is 220±2.05(218-223) and 230.8±1.43(229-232.5) respectively observes as significant difference.

The concentration of serum alkaline phosphate in male and female is 459.7±1.24(458-461) and 541.3±2.05(539-544) respectively, the concentration of serum ALT(SGPT) 39±1.63(37-41) and 48±1.24(47-50) respectively, the concentration of serum Urea 18.3±2.05(16-21) and 28±1.63(26-30) respectively observes as highly significant difference.

Table 2: The comparisons of LFT paraments between male and female

Parameters	Gender	Mean	SD	SE	t value	P value
Serum Total Bilirubin	Male	0.797	0.148	0.086	1.163	0.3
	Female	0.927	0.054	0.031		
SerumAlkaline phosphate	Male	459.7	1.247	0.72	48.05	<0.001**
	Female	541.3	2.055	1.186		
Serum ALT(SGPT)	Male	39	1.633	0.943	6.424	0.001**
	Female	48.33	1.247	0.72		
AST(SGOT)	Male	33	1.633	0.943	2.449	0.07
	Female	37	1.633	0.943		
Serum Total proteins	Male	7.467	1.226	0.708	0.341	0.75
	Female	7.1	0.898	0.519		
Serum Albumin	Male	4.33	1.062	0.613	0.245	0.81
	Female	4.1	0.829	0.478		
Serum Globulin	Male	2.75	1.137	0.656	0.073	0.94
	Female	2.667	1.147	0.662		
A/G Ratio	Male	1.5	0.408	0.236	0	0.99
	Female	1.5	0.408	0.236		

Table 3: The comparisons of RFT and Cholesterol paraments between male and female.

Test	Parameters	Gender	Mean	SD	SE	t value	P value
Serum cholesterol	Cholesterol	Male	220.7	2.055	1.186	5.738	0.0001***
		Female	230.8	1.434	0.828		
RFT	Serum Urea	Male	18.33	2.055	1.186	5.209	0.001***
		Female	28	1.633	0.943		

Serum Creatinine	Male	0.9	0.245	0.141	1.14	0.31
	Female	1.333	0.478	0.276		
Serum BUN	Male	8.467	1.226	0.708	4.383	0.01*
	Female	13.03	0.818	0.472		

Discussion

The overall mean PCV recorded for the homing pigeons in the present study (58.10±1.59%) was comparable to and slightly higher than that reported by(Ihedioha, Anyogu, & Chibuezeoke, 2016)for domestic pigeon (44.54 ± 4.73 %).It was however relatively higher than the (49.36 ± 6.40 %) reported for street rock pigeons by (Khan, Ali, Saeed, Asghar, & Iqbal, 2011)

The hematological parameters of the Red blood cells in male (3.633±1.39)and female (2.73±0.70) and PCV in male(58.10±1.59%) and female(61.63±1.35) of homing pigeons obtained in this study were higher than the feral pigeons as recorded by(Pavlak, Vlahović, Jerčić, Dovč, & Župančić, 2005) and other scientists (Schummer, 1973),(Amand, 1986)

The calculated MCH and MCHC values (64.5-68.2) ,(37.5-42.1) respectively were in higher range than the values reported by the (Kasprzak, Hetmański, & Kulczykowska, 2006) that is (39–42 pg) and (22–25 g/dl), (Peinado, Polo, Celdrán, Viscor, & Palomeque, 1992; Polo, Celdran, Peinado, Viscor, & Palomeque, 1992); (Seiser et al., 2000); (Gayathri, Shenoy, & Hegde, 2004).

The mean values of Red blood cells and white blood cells recorded in the male(3.633±1.39), (165.7±3.68), and female(2.73±0.70),(143.6± 2.14) respectively of homing pigeon compared with the values recorded by(Gayathri & Hegde, 1994) ♂(2.64±0.13),(12.81±0.67) and ♀(2.28±0.12),(11.69±0.59). According to these values of homing pigeon were higher. In other words Red blood cells and white blood cells counts , blood of pigeon resembles that of chicken and ducks(Gayathri & Hegde, 1994)

The values of the Hemoglobin in male (23.53±1.22), female (26.77±2.01) and MCV in male (163.1±1.63), female (178.0±2.293) in homing pigeon compared with the values of the feral pigeon. The values of the homing pigeon both Hemoglobin and MCV are higher than the feral pigeon suggest an iron deficiency anemia in young birds (Pavlak et al., 2005).

The minimum and maximum values of the lymphocytes (89.9-94), monocytes (0.75-1.5), eosinocytes (150-155) of homing pigeon compared with domestic pigeon present in Nsukka agro-ecological zone, Enugu State, Nigeria recorded the range of lymphocyte (32.00-58.00), monocytes (5.00-19.00) and eosinophils (4.00-17.00), It shows that the range of lymphocytes and eosinocytes in homing pigeon is higher than the domestic pigeon but the range of monocytes in homing pigeon is lower than the domestic pigeon.

The parameters such as RDW-SD, RDW-CV, MPV, Platelets, Neutrophils and PDW which are new parameters studied in our research that are not discussed in previous researches.

The overall mean Serum Total Protein was recorded in present study (7.4±1.22) which was slightly higher than the Anas clypeata (6.975 ± 0.42) and A. crecca (7.1 ± 0.29). The overall mean AST was recorded in present study (33±1.63) which was slightly higher than the Anas clypeata (16 ± 2.55) and slightly lower in A. crecca (34 ± 3.94*). The overall mean Albumin was recorded in present study (4.3±1.06) which was slightly higher than the Anas clypeata (1.325 ± 0.08) and A. crecca (1.35 ± 0.11). The overall mean creatinine was recorded in present

study (0.9±0.24) which was slightly higher than the Anas clypeata (0.475 ± 0.11) and A. crecca (0.53 ± 0.11). The overall mean Serum Urea was recorded in present study (18±2.05) which was slightly lower than the Anas clypeata (20.5 ± 3.84) and A. crecca (21.5 ± 1.12). The overall mean Cholesterol was recorded in present study (220±2.05) which was slightly lower than the Anas clypeata (391.67 ± 23.61*) and A. crecca (321.25 ± 22.73). Our these all findings were supported by the (Elarabany, 2018).

The parameters such Serum Total Bilrubin, Serum Alkaline Phosphate, Serum ALT, Serum Globilin, A/G Ratio and Serum BU which are new parameters studied in our research that are not discussed in previous researches.

References

Amand, W. (1986). Avian clinical hematology and blood chemistry. In M. E. Fowler (Ed.), Zoo and wild animal medicine (2nd ed., pp. 264–276). WB Saunders.

Dublin. (2023). Serum global market report 2023: Rising awareness about age-related skin issues drives growth. GlobeNewswire. https://www.globenewswire.com/news-release/2023/05/24/2675422/28124/en/Serum-Global-Market-Report-2023-Rising-Awareness-About-Age-related-Skin-Issues-Drives-Growth.html

Elarabany, N. (2018). A comparative study of some haematological and biochemical parameters between two species from the Anatidae family within migration season. The Journal of Basic and Applied Zoology, 79(1), 31. https://doi.org/10.1186/s41936-018-0044-4

Esmailizadeh, A., Kharrati-Koopaee, H., & Nanaei, H. A. (2021). Whole genome resequencing data for rock pigeon (Columba livia). BMC Research Notes, 14(1), 305.

Experts, Mayo Clinic Hematology. (2023). Hematology. Mayo Clinic. https://www.mayoclinic.org/departments-centers/hematology/sections/overview/ovc-20201283

Gayathri, K., & Hegde, S. (1994). Sexual differences in blood values of the pigeon, Columba livia. Comparative Biochemistry and Physiology Part B: Comparative Biochemistry, 109(2–3), 219–224.

Gayathri, K., Shenoy, K., & Hegde, S. (2004). Blood profile of pigeons (Columba livia) during growth and breeding. Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology, 138(2), 187–192.

Ihedioha, J. I., Anyogu, D. C., & Chibuezeoke, K. J. (2016). Haematological profile of the domestic pigeon (Columba livia domestica) in Nsukka agro-ecological zone, Enugu state, Nigeria. Animal Research International, 13(1), 2368–2377.

Kadhim, K. H., & Mohamed, A. A. (2015). Comparative anatomical and histological study of the esophagus of local adult male and female homing pigeon (Columba livia domestica). Veterinary Medical Science, 14(1), 80–87.

Kandola, A. (2020). What to know about hematology. Medical News Today. https://www.medicalnewstoday.com/articles/hematology

Kasprzak, M., Hetmański, T., & Kulczykowska, E. (2006). Changes in hematological parameters in free-living pigeons (Columba livia f. urbana) during the breeding cycle. Journal of Ornithology, 147(4), 599–604.

Khan, B. Y. A., Ali, F., Saeed, M. Q., Asghar, M., & Iqbal, F. (2011). A study on serum biochemistry and hematological profiling of blue rock pigeon (Columba livia) in Multan (Punjab, Pakistan). Pakistan Journal of Zoology, 43(5), Article 5.

Kimura, Y., Nakai, Y., Shin, J., Hara, M., Takeda, Y., Kubo, S., ... & Moriyama, K. (2021). Identification of serum prognostic biomarkers of severe COVID-19 using a quantitative proteomic approach. Scientific Reports, 11(1), 20638.

Lin, E. (2005). Production and processing of small seeds for birds. Food and Agriculture Organization of the United Nations.

MedlinePlus. (2021). Immunofixation (IFE) blood test. U.S. National Library of Medicine. https://medlineplus.gov/lab-tests/immunofixation-ife-blood-test/

Mehlhorn, J., & Rehkämper, G. (2009). Neurobiology of the homing pigeon—a review. Naturwissenschaften, 96, 1011–1025.

NHS. (2022). Blood tests—Examples. https://www.nhs.uk/conditions/blood-tests/types/

Padilla, J. A. O. (2022). Blood tests: Normal values. MSD Manual. https://www.msdmanuals.com/professional/resources/normal-laboratory-values/blood-tests-normal-values

Oznurlu, Y., Sur, E., Celik, I., & Ozaydin, T. (2012). Hematology and enzyme histochemistry of peripheral blood lymphocytes in domestic pigeon (Columba livia f. domestica). Biotechnic & Histochemistry, 87(5), 340–345.

Pavlak, M., Vlahović, K., Jerčić, J., Dovč, A., & Župančić, Ž. (2005). Age, sexual and seasonal differences of haematological values and antibody status to Chlamydophila sp. in feral and racing pigeons (Columba livia forma domestica) from an urban environment (Zagreb, Croatia). European Journal of Wildlife Research, 51, 271–276.

Peinado, V. I., Polo, F. J., Celdrán, J. F., Viscor, G., & Palomeque, J. (1992). Hematology and plasma chemistry in endangered pigeons. Journal of Zoo and Wildlife Medicine, 23(1), 65–71.

Polo, F., Celdran, J., Peinado, V., Viscor, G., & Palomeque, J. (1992). Hematological values for four species of birds of prey. The Condor, 94(4), 1007–1013.

Rohlf, F. J., & Marcus, L. F. (1993). A revolution in morphometrics. Trends in Ecology & Evolution, 8(4), 129–132.

Schummer, A. J. (1973). Anatomie der Hausvögel. Parey Verlag.

Seiser, P. E., Duffy, L. K., McGuire, A. D., Roby, D. D., Golet, G. H., & Litzow, M. A. (2000). Comparison of pigeon guillemot (Cepphus columba) blood parameters from oiled and unoiled areas of Alaska eight years after the Exxon Valdez oil spill. Marine Pollution Bulletin, 40(2), 152–164.

Shapiro, M. D., Kronenberg, Z., Li, C., Domyan, E. T., Pan, H., Campbell, M., ... & Vickrey, A. I. (2013). Genomic diversity and evolution of the head crest in the rock pigeon. Science, 339(6123), 1063–1067.

Shomon, M. (2022). Reading your thyroid blood test results. Verywell Health. https://www.verywellhealth.com/interpret-your-thyroid-test-results-3231840

Staff, Mayo Clinic. (2021). Liver function tests. Mayo Clinic. https://www.mayoclinic.org/tests-procedures/liver-function-tests/about/pac-20394595

Team, Manual. (2022). What is the bone profile blood test? All you need to know. Manual. https://www.manual.co/health-centre/daily-health/bone-profile-blood-test

Walcott, C. (1996). Pigeon homing: Observations, experiments and confusions. Journal of Experimental Biology, 199(1), 21–27.