HAEMATOLOGICAL AND BIOCHEMICAL CHARACTERISTICS OF VIETNAMESE DUCKS

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ABSTRACT

The study was conducted to investigate the haematological and biochemical parameters of four indigenous duck breeds in northern Vietnam. A total of 115 blood samples of Co, Pat Lai, Na Tau, and Troi ducks were collected from Ha Noi, Lang Son, Dien Bien, and Bac Ninh provinces, respectively, for the analyses of haematological parameters (red blood cells, white blood cells, and their indices) and biochemical parameters (total protein, albumin, and globulin). Most of the haematological parameters and all of the biochemical parameters were significantly different among the breeds (P <0.05). Particularly, red blood cells, hematocrit percentage, lymphocytes, and basophils in Co; mean corpuscular volume and mean corpuscular hemoglobin in Pat Lai; white blood cells in Pat Lai and Troi; and neutrophils in Na Tau and Troi ducks were found to be higher (P <0.05). Total protein and albumin were greater in the Co and Pat Lai breeds while globulin was observed to be lower in the Na Tau ducks (P <0.05). Significant effects of sex (P <0.05) were observed in most of the haematological and biochemical parameters except mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, and neutrophils. Interactions between breed and sex were observed for most of the haematological and biochemical parameters except red blood cells, white blood cells, lymphocytes, and eosinophil (P <0.05).

Keywords: Haematological parameters, biochemical parameters, indigenous ducks.

Sinh lý và sinh hóa máu của một số giống vịt bản địa Việt Nam

Nghiên cứu được tiến hành để đánh giá các chỉ tiêu sinh lý và sinh hóa máu của 4 giống vịt địa phương ở Miền Bắc Việt Nam. Tổng số 115 mẫu máu của vịt Cỏ, Pất Lài, Nà Tấu, Trời được thu thập từ các tỉnh Hà Tây, Lạng Sơn, Điện Biên và Bắc Ninh để xác định các chỉ tiêu nghiên cứu. Số liệu được phân tích bằng mô hình tuyến tính GLM và xử lý thống kê bằng phần mềm SAS. Hầu hết các chỉ tiêu sinh lý và tất các các chỉ tiêu sinh hóa có sự sai khác thống kê giữa các giống vịt (P <0,05). Cụ thể, số lượng, thể tích hồng cầu, bạch cầu lâm ba và ái kiềm ở vịt Cỏ; thể tích trung bình và khối lượng hemoglobin trong một hồng cầu ở vịt Pất Lài; số lượng bạch cầu ở vịt Pất Lài và vịt Trời, bạch cầu trung tính ở vịt Nà Tấu và vịt Trời được tìm thấy cao hơn so với các giống khác. Protein tổng số và hàm lượng albumin ở vịt Cỏ, Pất Lài và hàm lượng globulin ở vịt Nà Tấu cao hơn so với ở các giống vịt khác. Giới tính ảnh hưởng đến hầu hết các chỉ tiêu sinh lý và sinh hóa máu. Sự tương tác giữa giống và giới tính được quan sát thấy ở hầu hết các chỉ tiêu nghiên cứu (P <0,05).

Từ khóa: Sinh lý máu, sinh hóa máu, vịt địa phương.

1. INTRODUCTION

Vietnam is a country with the potential for supporting diverse populations of wild animals, but the livestock of indigenous origin are also very diverse. Indigenous ducks are raised throughout the country, but are most numerous in regions of high rainfall, riverine areas, deltas, and coastal districts. Even under adverse conditions such as high rainfall, high temperatures, excessive humidity, and poor housing, ducks have a better livability than

other animals (Ola, 2000). They also have the additional advantage of immunity to most prevalent disease problems (Aluyemi & Roberts, 1979). These are very valuable characteristics that have helped ducks survive for a long time, even during adverse conditions such as those due to current global climate changes. Currently, indigenous ducks are classified as being "in danger of extinction" because of changes in the livestock production systems in Vietnam (FAO, 2007). The importing and crowding of higher performing exotic breeds have led to a rapid decline in the number of indigenous duck breeds. Therefore, it is necessary to conserve and maintain the genetic diversity in indigenous breeds.

Blood is a tissue that consists of a liquid part and cellular components; it is mainly responsible for capturing, transporting, and distributing nutrients in organisms through blood vessels. Haematological and biochemical blood data in animals provides a true reflection of their health status, immunity, and disease condition, and can be used to identify important physiological aspects that can be utilized for monitoring and managing animals. Haematological values can be modified by different factors including physiological, pathological, and treatment factors (Sabater & Forbes, 2015). Among these factors, species (Çelik, 2004; Elarabany, 2018), breed (Rath *et al.*, 2017; Ologbose & Dick, 2021), age (Ologbose & Dick, 2021), sex (Leonardi & Klempau, 2003; Ologbose & Dick, 2021), feed (Svetina *et al.*, 2002; Lim & Klesius, 2003), season (Oladele *et al.*, 2000; Langston *et al.*, 2002; Magill & Sayer, 2004), and stress (Cnaani *et al.*, 2004) have been frequently mentioned in previous studies.

The haematological and biochemical data of indigenous duck breeds may provide valuable references for the purpose of understanding the relationship of blood characteristics to the habitat and adaptability of the species to the environment (Fazio *et al.*, 2016); and assisting in the selection and improvement of indigenous genetic resources (Okeudo *et al.*, 2003; Pranoto & Nugrahalia, 2019; Ologbose & Dick, 2021). However, very limited research has been done and scanty information is available on these parameters in Vietnam. Therefore, to arrive at some baseline values with regards to the haematological and biochemical profiles of native duck breeds, the present work was carried out.

2. MATERIALS AND METHODS

2.1. Location of the study

Four indigenous duck breeds raised in the northern provinces of Vietnam were used to determine the haematological and biochemical parameters under small household farming conditions. Blood samples of Na Tau, Pat Lai, Co, and Troi ducks were collected from Dien Bien, Lang Son, Hanoi, and Bac Ninh provinces, respectively. The time to survey and collect the duck blood samples in the localities was from February to March 2022. Feed sources were local feed (banana stems, fresh cassava chips, rice bran, etc.) and commercial feed. The ducks were raised in housing and allowed to swim in the available water areas. The experimental animals had normal physiological statuses and were healthy.

2.2. Blood collection

A total of 85 blood samples of ducks from 10 to 12 weeks of age were collected, specifically 25 Na Tau (12 males and 13 females), 20 Pat Lai (10 males and 10 females), 20 Co (10 males and 10 females), and 20 Troi (10 males and 10 females). All the blood samples were taken in the morning before the ducks were fed. For each duck, a 2.5 ml blood sample was taken from the wing vein and then divided into two parts: (1) one part in a tube without anti-coagulant to allow for clotting in biochemical serum and (2) another part in a tube treated with ethylenediaminetetraacetic acid (EDTA) for haematological examination. After collection, the samples were transported in a thermor box with ice. The analyses were immediately carried out when the samples arrived at the laboratory.

2.3. Haematological analyses

The haematological parameters, namely total red blood cells (RBC), hemoglobin (HGB), hematocrit (HCT), the mean corpuscle volume

(MCV), the mean corpuscle haemoglobin (MCH), the mean corpuscle haemoglobin concentration (MCHC), white blood cells (WBC), monocytes, neutrophils, basophils, eosinophils, and lymphocytes, were analyzed by automatic machine (cell-dyn 3700) at the Laboratory of the Veterinary Hospital, Vietnam National University of Agriculture. The biochemical parameters (protein, albumin and globulin) were measured at the Medical Testing and Technology Company, Medlatec Hospital, Hanoi.

2.4. Statistical analysis

The data were subjected to ANOVA using the general linear model procedure (GLM) of the Statistical Analysis System (SAS) version 9.4. Pairwise comparisons between means were made using Tukey's test. The statistical model was as follows:

$$Y_{ijk} = \mu + Bi + Sj + B_i \times S_j + e_{ijk}$$

where Y_{ijk} is the haematological and biochemical blood values, μ is the overall mean of the records, B_i is the effect of the i^{th} breed, S_j is the effect of the j^{th} sex, $B_i \times S_j$ is the interaction effect between breed and sex, and e_{ijk} is the random error. The statistical parameters in the tables are the number of observations (n), Least Square Mean (LSM), and average standard error (avg s.e).

3. RESULTS

3.1. Haematological parameters

The erythrocyte indices of the four indigenous duck breeds of Vietnam are presented in Table 1. Total red blood cells ranged from 2.89 to 3.18 (10^6/μl). The significant effects ($P < 0.05$) of breed were observed in most of the erythrocyte parameters except HGB and RDW. The results revealed that Co had higher values in RBC and HCT, Pat Lai had higher values in MCV and MCH, and Na Tau and Troi had greater MCHC values than the other breeds.

Effects of the interaction between breed and sex were found ($P < 0.05$) except for RBC ($P > 0.05$). The HBG of Co, Pat Lai, and Troi males; the HCT and RDW of Co and Pat Lai males; and the MCV and MCH of Co males were higher than these parameters in females of the same breed while the parameters were not significantly different between sexes for the other breeds not listed. The MCH and MCHC values of Na Tau females were greater than in males but these parameters were not in parallel for the three other duck breeds.

Most of the haematological values were significantly different between males and females ($P < 0.05$) except MCV, MCH, and MCHC ($P > 0.05$). Males had greater values of RBC, HGB, and HCT, and lower values of RDW than females.

Aspects of the leukocyte indices of the four indigenous duck breeds of northern Vietnam are presented in Table 2.

The total white blood cells of the four indigenous duck breeds in this study ranged from 14.70 to 22.89 (10^3/μl). In the present study, the total white blood cells of the ducks was influenced by both breed and sex ($P < 0.001$), however an interaction between the two factors was not observed ($P > 0.05$). The total white blood cell values were higher in Pat Lai and Troi than the two other breeds; and were higher in the females as compared with the males.

For the leukocyte differential, the percentage of lymphocytes was the highest and was followed by neutrophils. Among the breeds, neutrophils, lymphocytes, and basophils were significantly different ($P < 0.05$). The neutrophil percentages of Na Tau and Troi were higher than Co ($P < 0.001$), whilst the lymphocyte percentage of Co was higher than Troi ($P < 0.05$). The basophil percentages of Co and Pat Lai were significantly higher than Na Tau and Troi ($P < 0.001$). Regarding the sex of the birds, neutrophils were not different between males and females ($P > 0.05$) but lymphocytes were higher ($P < 0.001$) in females; and monocytes ($P < 0.05$), eosinophils ($P < 0.01$), and basophils ($P < 0.05$) were greater in males. Interactions between breed and sex were observed for neutrophils, monocytes, and basophils. The neutrophil percentage of Pat Lai females was higher than that in males while this parallel was not found in the Co, Na Tau, and Troi duck

breeds. The monocyte percentage of Co males was greater than that in females while this parameter was not significantly different between the sexes of the three other breeds. The basophil percentage of Pat Lai males was higher than that in females but this parallel was not found in the other three other duck breeds.

3.2. Biochemical parameters

The results of the biochemical parameter measurements of the four indigenous duck breeds are shown in Table 3. The results indicated that the values of total protein, albumin, and globulin of the four studied duck breeds ranged from 44.71 to 59.38 (g/l); from 16.19 to 23.06 (g/l); and from 28.96 to 36.85 (g/l), respectively. All the factors, namely breed, sex, and the interaction between breed and sex, significantly affected ($P < 0.05$) all the biochemical values. Co and Pat Lai had higher total protein values as compared with Na Tau. The albumin values found in Co and Pat Lai were higher as compared with Na Tau and Troi. The globulin values were observed to be lower in Na Tau and greater in the three other breeds. The interaction between breed and sex showed that Co and Pat Lai females had higher total protein and albumin values than males while no significant differences were observed between the sexes for these two parameters in Na Tau and Troi. Globulin of females was greater than that in males for Pat Lai but not for Co, Na Tau, and Troi.

4. DISCUSSION

There is a dearth of information on the indigenous ducks of Vietnam. Both haematological and biochemical parameters have been frequently used as useful and non-invasive indicators to evaluate the general condition of many species of animals (Jenni & Schwilch, 2001; Sanchez-Guzman *et al.*, 2004). In this study, the results showed that significant effects of breed and sex were observed in most of the haematological and biochemical profiles of the ducks. The differences among breeds may be in response to differences in the adaptations of these duck breeds as there are overlaps among the different adaptations in animals to meet the requirements of their given environment; and genetic modifications can happen in animal populations in response to environmental challenges to shape their unique characteristics in an adaptive manner (Horton, 2005). The influence of sex on several of the haematological parameters and all of the biochemical parameters could be due to hormonal differences. Interactions between breed and sex were observed for most of the haematological and biochemical parameters. This results on the interactions between the two studied factors could indicate that it is better to assess blood parameters by sex within breed rather than by breed only.

4.1. Haematological parameters

Red blood cells transport and distribute oxygen and carbon dioxide in the body (Scanes, 2015). The value of RBC counts varies depending on the animal's physiological state, nutrition, age, sex, breed, and diseases (Schmidt *et al.*, 2007; Sabater & Forbes, 2015). According to Ologbose & Dick (2021), the number of red blood cells of poultry ranges from 2.85 to 5.63 x 10^6/mm^3, which indicates that the four indigenous duck breeds in this study were in normal health. Previous studies on native ducks reported that red blood cell counts of Co ducks at 70 days of age were 2.77 x 10^6/mm^3 (Nguyen Thi Minh, 2001), Dom ducks were 2.56 x 10^6/mm^3 (Dang Vu Dang Vu Hoa, 2015), Xiem ducks raised in Vinh Long province were 3.18 x 10^6/mm^3 (Chau Thi Huyen Trang *et al.*, 2014), and indigenous ducks of southeastern Nigeria were 3.22 x 10^6/mm^3. The red blood cell value of Co ducks was found to be higher than the three other duck breeds and it was also higher than the values of previous studies. These differences may occur among breeds due to the body metabolic rate and nutritional diet of each breed (McKechinie, 2007).

Table 1. Least square means according to breed, sex, and breed*sex interaction of the erythrocyte parameters

Variable	Breed				Sex		Breed*Sex								Avg s.e	Level of significance			R^2
	Co	Pat Lai	Na Tau	Troi	Male	Female	Co* Male	Co* Female	Pat Lai * Male	Pat Lai* Female	Na Tau* Male	Na Tau* Female	Troi* Male	Troi* Female		Breed	Sex	Breed* Sex	
N	20	20	25	20	42	43	10	10	10	10	12	13	10	10		85	85	85	
RBC	3.18^{a}	2.89^{b}	2.95^{b}	2.96^{b}	3.16^{a}	2.83^{b}	3.28	3.07	3.11	2.67	3.06	2.83	3.18	2.74	0.059	***	***	ns	0.46
HGB	166.8	158.1	159.3	159.3	172.11^{a}	149.65^{b}	178.00^{a}	155.60^{bcd}	179.20^{a}	137.00^{d}	161.33^{abc}	157.31^{bc}	169.90^{ab}	148.70^{cd}	3.499	ns	***	***	0.51
HCT	35.40^{a}	33.51^{ab}	32.96^{b}	32.66^{b}	35.89^{a}	31.37^{b}	37.66^{a}	33.14^{bc}	37.38^{a}	29.64^{c}	34.06^{ab}	31.87^{bc}	34.46^{ab}	30.85^{bc}	0.758	*	***	*	0.47
MCV	111.40^{bc}	119.60^{a}	112.47^{b}	109.40^{c}	114.04	112.40	114.80^{bc}	108.00^{d}	120.40^{a}	118.80^{ab}	112.25^{cd}	112.69^{cd}	108.70^{d}	110.10^{cd}	0.953	***	ns	**	0.58
MCH	52.49^{b}	56.50^{a}	54.10^{b}	53.26^{b}	54.5	53.69	54.28^{bc}	50.70^{d}	57.66^{a}	55.34^{abc}	52.52^{cd}	55.68^{ab}	53.53^{bcd}	53.02^{bcd}	0.589	***	ns	***	0.46
MCHC	471.20^{b}	472.10^{b}	484.79^{a}	490.45^{a}	481.7	477.6	472.60^{c}	469.80^{c}	478.80^{bc}	465.40^{c}	475.67^{c}	493.92^{ab}	499.60^{a}	481.30^{abc}	3.725	***	ns	***	0.40
RDW	10.7	10.4	10.87	10.89	10.46^{b}	10.97^{a}	10.04^{bc}	11.36^{a}	9.78^{c}	11.02^{a}	11.21^{a}	10.53^{abc}	10.81^{ab}	10.97^{ab}	0.177	ns	***	***	0.39

*Note: Avg s.e: average standard error; ns: non-significant; *: P <0.05; **: P <0.01; ***: P <0.001; Values in each row of each breed with different superscripts are significantly different (P <0.05); R^2: Determined coefficient; Red blood cells (RBC, 10^6/mm^3), hemoglobin (HGB, g/l), hematocrit (HCT,%), mean corpuscular volume (MCV, fl), mean corpuscular hemoglobin (MCH, pg), mean corpuscular hemoglobin concentration (MCHC, g/l), red cell distribution width (RDW,%)*

Table 2. Least square means of breed, sex, and breed*sex interaction of the leukocyte parameters

Variable	Breed				Sex		Breed*Sex								Avg s.e	Level of significance			R^2
	Co	Pat Lai	Na Tau	Troi	Male	Female	Co* Male	Co* Female	Pat Lai* Male	Pat Lai* Female	Na Tau* Male	Na Tau* Female	Troi* Male	Troi* Female		Breed	Sex	Breed *Sex	
N	20	20	25	20	42	43	10	10	10	10	12	13	10	10		85	85	85	
WBC	14.75^{b}	22.89^{a}	14.70^{b}	21.38^{a}	15.06^{b}	21.79^{a}	11.12	18.38	17.96	27.82	12.78	16.62	18.40	24.35	1.581	***	***	ns	0.44
Neutrophils	34.24^{b}	46.10^{ab}	49.10^{a}	54.20^{a}	47.96	43.86	43.80^{bc}	24.67^{c}	36.76^{c}	55.44^{ab}	51.23^{ab}	46.97^{ab}	60.03^{a}	48.36^{ab}	3.819	***	ns	***	0.39
Lymphocytes	53.74^{a}	45.2^{ab}	46.74^{ab}	40.74^{b}	41.07^{b}	52.17^{a}	41.80	65.68	44.20	46.31	43.38	50.10	34.89	46.60	3.577	*	***	ns	0.22
Monocytes	4.70	4.46	2.44	3.53	4.62^{a}	2.95^{b}	7.22^{a}	2.18^{b}	4.17^{ab}	4.76^{ab}	3.22^{ab}	1.67^{b}	3.86^{ab}	3.20^{ab}	0.817	ns	*	*	0.22
Eosinophils	0.25	0.22	0.37	0.29	0.34^{a}	0.23^{b}	0.25	0.26	0.30	0.14	0.49	0.24	0.32	0.27	0.051	ns	**	ns	0.21
Basophils	7.06^{a}	8.49^{a}	1.26^{b}	1.23^{b}	6.02^{a}	3.00^{b}	6.91^{ab}	7.22^{ab}	14.59^{a}	2.39^{b}	1.67^{b}	0.85^{b}	0.90^{b}	1.57^{b}	1.495	***	*	**	0.40

*Note: Avg s.e: average standard error; ns: non-significant; *: P<0.05; **: P<0.01; ***: P<0.001; Values in each row of each breed with different superscripts are significantly different (P< 0.05); R^2: Determined coefficient ; White blood cells (WBC, $10^3/mm^3$), neutrophils (g/l), lymphocytes (%), monocytes (%), eosinophils (%), basophils (%), platelet (PLT, $10^3/mm^3$).*

Table 3. Least square means of breed, sex, and breed*sex interaction on the biochemical parameters

Variable	Breed				Sex		Breed*Sex								Avg s.e	Level of significance			R^2
	Co	Pat Lai	Na Tau	Troi	Male	Female	Co* Male	Co* Female	Pat Lai* Male	Pat Lai* Female	Na Tau* Male	Na Tau* Female	Troi* Male	Troi* Female		Breed	Sex	Breed *Sex	
N	12	20	12	12	28	28	6	6	10	10	6	6	6	6		56	56	56	
Protein (g/l)	59.38^{a}	55.81^{a}	44.71^{b}	52.72^{ab}	49.04^{b}	57.28^{a}	50.38^{b}	68.38^{a}	45.14^{b}	66.48^{a}	41.08^{b}	48.33^{b}	59.54^{ab}	45.91^{b}	2.946	**	**	***	0.58
Albumin (g/l)	23.06^{a}	20.59^{a}	16.19^{b}	17.65^{b}	18.09^{b}	20.66^{a}	18.85^{bc}	27.27^{a}	18.20^{c}	22.98^{ab}	15.17^{c}	17.21^{c}	20.13^{bc}	15.17^{c}	0.874	***	**	***	0.69
Globulin (g/l)	36.85^{a}	35.90^{a}	28.96^{b}	35.08^{a}	31.51^{b}	36.89^{a}	31.75^{bc}	41.95^{ab}	28.24^{c}	43.56^{a}	26.30^{c}	31.63^{bc}	39.76^{ab}	30.41^{bc}	2.145	*	**	***	0.53

*Note: Avg s.e: average standard error; ns: non-significant; *: P <0.05; **: P <0.01; ***: P <0.001; Values in each row of each breed with different superscripts are significantly different (P <0.05; R^2: Determined coefficient.*

Hemoglobin is a metalloprotein that contains iron, and is an oxygen-transporter protein attached to the red blood cells of all vertebrates (Sidell & O'Brien, 2006; Etim *et al.*, 2014). The physiological function of hemoglobin is to deliver O_2 into animal tissues to oxidize the consumed food to produce ATP which will be utilized for other biological processes as well as to transport CO_2 out of the animal's body (Omiyale *et al.*, 2012). A low hemoglobin concentration leads to inactivity in animals. Kuhl *et al.* (1928) found hemoglobin levels in poultry averaged 156 g/l and ranged from 129 to 182 g/l. Nguyen Ba Mui *et al.* (2018) indicated the value of hemoglobin in Co Lung ducks was 123.6 g/l. In this study, the value of hemoglobin was in the normal range from 158.10 to 166.80 g/l and there were non-significant differences among the breeds.

Hematocrit reflects the volume occupied by red blood cells relative the whole blood volume (Galvez *et al.*, 2009). Hematocrit plays a vital role in carrying O_2 and absorbed nutrients (Isaac *et al.*, 2013). A high level of hematocrit causes a decrease in circulating plasma volume and eventually results in polycythemia. Nguyen Ba Mui *et al.* (2018) found the hematocrit percentage of Co Lung ducks was 44.52%. Sanchez *et al.* (2021) found that the hematocrit percentages of sport birds, common geese, Mexican domestic ducks, Aztec ducks, turkeys, and broiler chickens were 19.4%, 27.8%, 27.6%, 31.7%, 25.7%, and 22.4%, respectively. Soliman *et al.* (1966) observed hematocrit in the range of 30 to 35%, and averaging 33% for forty healthy ducks from six to ten months old. In this study, the percentages of hematocrit of the four native ducks ranged from 32.96 to 35.40%, and a higher percentage was found in the Co breed. It is possible that the hematocrit value may be different among breeds due to differences in their metabolic rate (McKechnie, 2007).

Regarding the red blood cell indices, namely MCV, MCH, and MCHC, higher levels of MCV and MCH were observed in Pat Lai ducks and higher levels of MCHC were found in Na Tau and Troi ducks. Several previous studies have reported these computed values in ducks. Nguyen Ba Mui *et al.* (2018) reported the values of MCV, MCH, and MCHC in Co Lung ducks to be 158.60 fl, 43.44 pg, and 279.8 g/l, respectively. Elarabany (2018) found the values of MCV in migratory Northern shovelers and Eurasian teals were 88.07 and 91.52 fl; the values of MCH were 28.75 and 29.38 pg; and the values of MCHC were 335 and 326.6 g/l, respectively. Pranoto & Nugrahalia (2020) found the values of MCV were 94.62 fl for males and 146.24 fl for females; and the values of MCH were 30.68 for males and 45.67 for females. When comparing these values in Indonesian native chickens and broilers, Muneer *et al.* (2021) found the MCV values ranged from 118.76 fl to 126.75 fl; and the MCH values ranged from 31.71 pg to 32.29 pg for broilers and Indonesian native ducks and chickens, respectively. A study was carried out focusing adult birds from a range of different species of poultry viz. Guineafowl, turkey, Japanese quail, Kadakanath, Nicobari, Aseel, Rhode Island Red, white Leghorn, and geese maintained at the Institute of Poultry Production and Management, Tamil Nadu Veterinary and Animal Sciences University, Chennai. The study's authors showed the values of MCV, MCH, and MCHC ranged from 84.81 to 142.04 fl; 34.63 to 50.24 pg; and 312.3 to 45.58 g/l, respectively (Durai *et al.*, 2012). Our findings showed the values of MCV, MCH, and MCHC to be similar to the above studies.

White blood cells are the defense cells of the body, and their levels have a great influence in the immune responses and the ability of animals to fight infection (Schalm *et al.*, 1975). Animals with low WBC counts have a higher risk of disease infection while those with high counts are capable of generating antibodies in the process of phagocytosis, have a high degree of resistance to disease (Soetan *et al.*, 2013), and have enhanced adaptability to indigenous environmental and disease prevalent conditions (Kabir *et al.*, 2011). The present findings showed that WBC ranged from $14.70 \times 10^3/mm^3$ to $22.89 \times 10^3/mm^3$, and the values were higher

in Pat Lai and Troi ducks. The values for WBC obtained in this study were in the range of the reference values of 10.2 to 30 (× 10^3/mm^3) reported by Jain (1993). The four indigenous duck breeds were found to be healthy without any signs of illness suggesting that the blood cells were still effectively performing their phagocytic and immune functions. Previous studies in native ducks showed higher levels of WBC than our findings. When studying Dom and Co Lung ducks, various authors showed the values of WBC were 43.12 × 10^3/mm^3 (Dang Vu Hoa, 2015), and 38.55 × 10^3/mm^3 for males and 40.98 x 10^3/mm^3 for females (Nguyen Ba Mui *et al.*, 2018). However, our results are in agreement with previous studies for the value of WBC. Soliman *et al.* (1966) reported WBC in ducks ranged from 15 to 30 × 10^3/mm^3; and Olayemi & Arowolo (2009) indicated that WBC in Nigerian ducks ranged from 24.53 to 32.8 × 10^3/mm^3. Mulley (1980) observed WBC with the range of 19.7 to 23.58 × 10^3/mm^3.

For the WBC differential, the present findings are in agreement with previous studies about the percentages of lymphocytes and neutrophils being predominant in domestic ducks (Olayemi & Arewwolo, 2009; Gladbach *et al.*, 2010; Imouokhome & Orheruata, 2019). The predominance of neutrophils and lymphocytes is associated with stressors, infections, inflammation, or toxicity (Davis *et al.*, 2008; Jones, 2015). The dominant behavior of the species can keep it under constant stress (Valdebenito *et al.*, 2021). The lymphocyte percentages were higher in Co ducks as compared with the others. The basophil percentages of Co and Pat Lai were greater than the two other breeds. Variations in lymphocytes and basophils might occur due to the involvement of genetic factors (Simaraks *et al.*, 2004; Karbi, 2011).

Concerning the effects of sex on the haematological parameters, the RBC counts, HGB, HCT, and MCV were higher in males than females. These results are in line with many previous studies (Olayemi & Arowolo, 2009; Elarabany, 2018; Pranoto & Nugrahalia, 2020; Muneer *et al.*, 2021), which indicated that RBC counts and HGB values in males were higher than females. According to Khan & Zafar (2005), high estrogen levels caused decreases in the values of RBC and hemoglobin. *Vander el al.* (1990) insisted that the hormone testosterone stimulates erythropoietin release, which acts to stimulate the proliferation and maturation of erythrocytes in bone marrow, while estrogen inhibits erythropoietin. Other authors have indicated that differences between sexes can reflect the body condition of individuals (Whittow, 1999; Campbell and Ellis, 2007; Clark *et al.*, 2009; Campbell *et al.*, 2010).

For WBC counts and the WBC differential, higher WBC counts and lymphocytes were measured in females than males while higher monocytes, eosinophils, and basophils were observed in male ducks. These findings are in agreement with several previous studies. Nguyen Ba Mui *et al.* (2018) exhibited that female Vietnamese indigenous Co Lung ducks had higher WBC counts than males. Simaraks *et al.*, (2004) showed the percentages of lymphocytes and eosinophils in females were higher than in male chickens.

The results of the greater HGB and HCT values in Co males and Pat Lai males could be explained by the effects of the nutritional, metabolic, or ecological conditions of each breed.

4.2. Biochemical parameters

The values of total protein, albumin, and globulin of the four indigenous duck breeds in this study were higher than other indigenous duck breeds found by previous studies in Vietnam but similar to other studies from other parts of the world. Nguyen Ba Mui *et al.* (2018) found the values of total protein and albumin in Co Lung duck were 34.12 g/l and 17.61 g/l, respectively. Dang Vu Hoa (2015) reported the values of these parameters were 33.92 g/l and 18.30 g/l. When studying the total protein, albumin, and globulin of Muscovy ducks in Nigeria at 8 weeks of age, the values were 54.66 g/l, 27 g/l, and 26 g/l, respectively; and

these values in 8 week-old Mallard ducks were 64.33 g/l, 34.50 g/l, and 29.83 g/l, respectively. The values of total protein, albumin, and globulin in Co and Pat Lai ducks were greater than the other breeds. These value were influenced by genotype, breed, age, and nutrition (Chen *et al.*, 2016; Rath *et al.*, 2017; Sinha *et al.*, 2017).

In this study, total protein in males was lower than in females. Higher values of the three biochemical parameters in female poultry have been reported by numerous previous studies (Okeudo *et al.*, 2003; Nguyen Ba Mui *et al.*, 2018; Ologbose & Dick, 2021). The increase in total protein was influenced by estrogen (Hochleithner, 1994) and was responsible for the high content of globulins. In addition, greater values of albumin and globulin in females could be explained by the physiological process needed for the reproductive functions of the adult ducks, which requires higher levels of these substances.

In regard to the interaction between breed and sex, it was found that Co and Pat Lai females were superior to males in total protein and albumin, but this trend was not observed in Na Tau and Troi ducks. Globulin in Pat Lai females was superior to males of the same breed. The probable explanation for the mostly higher biochemical parameters in females than males across breeds could be due hormonal differences. Female hormones are usually associated with high metabolic activities resulting in higher values of biochemical parameters (Shumaila *et al.*, 2012).

5. CONCLUSIONS

The four examined breeds of indigenous ducks (Co, Pat Lai, Na Tau, and Troi) had some differences in the haematological and biochemical parameters of RBC, HCT, MCV, MCHC, WBC, neutrophils, lymphocytes, basophils, total protein, albumin, and globulin. The sex of the ducks affected most of the haematological and biochemical parameters except MCH, MCHC, and neutrophils. The influence of breed on the blood parameters was involved with the effect of sex. Information on the haematological and biochemical values of the four indigenous ducks in Northern Vietnam provide important reference data for planning breeding programs of these indigenous duck breeds.

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