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Erythrogram, Leukogram and Blood cell measurement of Muscovy and Indian Runner Ducks – a comparison

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Abstract

The present study discusses and tries to compare hematological and morphometrical parameters of blood cells between Muscovy (MY) and Indian Runner (IR) ducks. Sample of blood were collected from forty adult birds (ten drakes and ten ducks belonging to each species). Hb%, TEC, heterophil %, Nucleus Breadth of lymphocytes, Nucleus: Cytoplasm ratio of lymphocytes and Cell Length/Cell Breadth ratio of heterophils significantly differs at p<0.05. But, percentages of monocytes, eosinophils and basophils, morphometric parameters of i. RBC (except Cell Length/Cell Breadth), ii. lymphocytes (except Nucleus Breadth and Nucleus: Cytoplasm), iii. monocytes, iv. eosinophils, v. heterophils (except Cell Length/Cell Breadth) and vi. Cell Breadth of basophils are significantly different at p<0.01 between individuals of two species and males, females of each species. Other parameters, except those mentioned above do not differ significantly.

Keywords: Erythrogram, leukogram, blood cells, Muscovy and Indian Runner.

Introduction

Order Anseriformes occupies all the habit and habitats in India and in the world. This order comprises three families, out of which family Anatidae is the largest family which include over 140 species of waterfowl such as ducks, geese, swans. With some exception, it is now widely believed that Anseriformes (water fowls) share most recent common ancestry with Galliformes (land fowls) forming a clade to as Galloanserae[1].

The waterfowls vary in size from pigmy geese to large swan. All species have strong legs and feet with comb-like lamellae in flattened bill. The plumage is water proof and varies from pure white to multihued to all black. The tongue is large and fleshy and serves in filter feeding. They feed on both plants and animals obtained by filtering, grazing and digging[2]. Family Anatidae includes certain birds which can be domesticated and are termed as poultry birds. Two of these, Muscovy (*Cairina Moschata domestica*) (exotic bird) and Indian Runner also known as Desi (*Anas platyrhynchos platyrhynchos*) (local bird) are considered in the present study.

Muscovy, a type of large duck, native to Mexico, Central to South America, belongs to tribe Cairinini. They are also known as perching ducks. These ducks are about 70cm in length and weighing up to 6.8kg. The birds are predominantly black and white colour, while the feathers are iridescent and glossy in male and drabber in females. These ducks bear long claws on their feet and have a wide tail. The drake weighs approximately 4.6 to 6.8kg while the hen is 2.7 to 3.6kg. The drakes have a patch of bare skin surrounded by pinkish caruncles which extends from the back of the eye to the bill. The hind limbs and the feet are greyish black and iris is yellowish brown[3]. The Indian Runner duck is a medium sized duck measuring about 70cm in length and weighing up to 6kg. The bird is off white in colour with stout orange coloured legs. They have head, bill, neck and body. The Indian Runner ducks are good layers and can produce high quality meat[4].

Haematology includes the study of aetiology, diagnosis, treatment, prognosis of blood diseases. It is very essential for analysing the birds' overall health. Expression of disease symptoms occurs late in case of many birds and which are very subtle and non-specific. To resolve the disease in time, haematology is one of the best ways[5]. Complete Blood Count (CBC) is used to reveal data about birds' general health. It is the single most important test to perform. If all parameters are normal on the CBC, then this is good indication that the bird is not currently fighting some type of generalised infection or inflammatory disease.

In this study haematological parameters comprise of Total erythrocyte count (TEC), Total leukocyte count (TLC), Differential leukocyte count (DLC), Packed cell volume (PCV), Haemoglobin percentage and erythrocyte indices which includes Mean corpuscular volume (MCV), Mean corpuscular haemoglobin (MCH) and Mean corpuscular haemoglobin concentration (MCHC) and cytomorphometry of blood cells.

Cytomorphometry means measurement of morphological features of cells. Morphometrical analysis is undertaken to measure the cellular and nuclear dimensions. It is a necessary

measure since it reveals certain facts regarding fragility. It helps to bring a comparative account on the basis of cell size between different taxon. Whether the cell is under functional or over functional can be diagnosed by morphometrical analysis. Cytomorphometry also discloses facts regarding diseases[6-9].

Though data on haematology as well as morphometry of blood cells are available in other vertebrates and aves, but with respect to different species and sex of ducks are inadequate, inconsistent and nonconsolidated, therefore, present authors have attempted to analyse the influence of species and sex on haematological and cytomorphometrical parameters in two species of duck available commercially.

Materials and methods

For this work, two species of ducks, namely, Muscovy (*Carina moschata*) and Indian Runner (*Anas platyrhynchos platyrhynchos*) were considered. Blood samples were collected from these ducks, available commercially at Karadapalli village, Tigiria, Odisha, India. A total of 40 birds were sampled (20 Muscovy and 20 Indian Runner). Out of these, 10 males and 10 females from each type were sampled. Also, they were abbreviated as MY for Muscovy and IR for Indian Runner for convenience of work and reporting. Sterile 2ml syringes attached to 25 gauge needle were used to take out blood from the metatarsal vein of the ducks hygienically. Samples were kept in anticoagulant vials having EDTA in the month of June when temperature was approximately 37-40°C and relative humidity was 70%. The morning hours (10.00am to 11.00am) were chosen for sample collection. The collected samples in EDTA vials were placed in ice box and transported to the laboratory for further analysis, though blood smears were made on slides at the site and fixed with methanol for further procedures and analysis.

All parameters of CBC, namely Hb%, TEC, TLC, MCV, MCH, MCHC, DLC and cytomorphometry were performed. Sahli's acid haematin method was used to study Hb%[10]. Haemocytometer having Neubauer's chambers were used for studying TEC (Hayem's fluid used) and TLC (Turk's fluid used). For estimating PCV, blood from each sample was taken in Wintrobe haematocrit tube and centrifuged at 3,500rpm for 15 minutes. The erythrocyte indices (as mentioned earlier) were calculated as sper previous researchers[11]. DLC and cytomorphometry of blood cells were done with the help of stained blood smears on slides and photomicroscope. For measuring dimensions of cells and nuclei, 30 observations per type of cell were considered, except basophils, because of its less number. All these were done by using microscope eyepiece digital camera which attached to computer having software for cell measurement. Finally, for statistics, Paleontological Statistics (PAST) Version 2.17 was used and ANOVA was calculated followed post-hoc analysis (Tukey's pairwise comparison test). Significant differences among and between groups were studied at $p<0.01$ and $p<0.05$.

Results and discussion

Overall significant differences ($p<0.05$) exists in case of Hb and TEC. IR ducks differ among themselves but not with other birds in case of Hb. Regarding TEC differences among and between the groups is not reflected. Rest parameters are not significantly different among and between the groups (Table-1).

TLC and lymphocyte percentage from DLC reflect insignificant variation within and between above the birds under consideration. Percentages of monocytes, eosinophils and basophils are significantly different ($p<0.01$) and heterophils at $p<0.05$. Monocytes and basophils of MY male and female differ with IR ducks. Eosinophils and heterophils of MY male differ with both sexes of IR (Table-2).

Table-1: Erythrogram of exotic and local ducks.

Breed/ Parameter	Muscovy		Indian Runner		Analysis of Variance
	Males (10)	Females (10)	Males (10)	Females (10)	
Hb (%)	12.69±1.08	12.00±0.78	13.91±0.20[a]	10.05±1.05 [a]	3.53* ($p<0.05$)
TEC (millions/mm³)	2.06±0.22	1.99±0.28	2.69±0.18	1.90±0.10	2.92*($p<0.05$)
PCV (%)	36.40±3.67	34.60±2.89	35.70±2.85	33.60±2.91	0.15
MCV (µ³)	254.20±85.00	228.42±49.71	192.27±19.36	129.71±13.52	1.02
MCH (pg)	64.44±3.44	66.43±5.79	54.33±6.56	53.41±3.00	1.86
MCHC (%)	46.44±13.48	38.94±5.81	28.90±2.51	44.96±4.69	0.62

All morphometrical parameters of erythrocytes significantly differ at $p<0.01$ except ratio of cell length to breadth. Length and area of erythrocytes shows similar significant differences between the two species of ducks. In case of breadth of erythrocytes male MY ducks are different with both sexes of IR whereas, female MY is different with male IR only. Nuclear length, breadth and area of RBC and Nucleus:Cytoplasm ratio differs among MY drakes and ducks. But nuclear length to breadth ratio of MY male differs with males from other group and also with its female. Also, females of both species differ in this respect (Table-3).

All parameters except width of nucleus and nucleus to cytoplasmic ratio ($p<0.05$) of lymphocytes differ significantly at $p<0.01$. Lymphocytes' length, breadth and area of MY male and female differ with both sexes of other species but not among themselves. Nuclear length and area of female MY ducks differ with male and female IR. Nuclear breadths of lymphocytes differ at $p<0.05$ among MY ducks with respect to sexual dimorphism and MY female differ with IR female in this aspect. In case of ratio of cell length to cell breadth, IR ducks differ among them only and not with other group. Nuclear length to breadth ratio of lymphocytes of MY male differs with all other groups irrespective of sexual dimorphism. Significant difference is observed among male and female MY ducks with respect to nucleus to cytoplasm ratio at $p<0.05$ (Table-4).

All parameters (MY drakes and ducks differ with both sexes of IR ducks but intra species difference is absent) are significantly different at $p<0.01$ (Table-5).

Table-2: Leukogram of exotic and local ducks.

Breed/ Parameter	Muscovy		Indian Runner		Analysis of Variance
	Male (10)	Female (10)	Male (10)	Female (10)	
TLC (thousands/mm^3)	14072.90 ±2331.26	14071.00 ±2593.86	9856.00 ±1720.92	9541.40 ±1594.03	1.44
L (%)	38.50±2.44	38.50±4.10	46.80±5.71	43.70±5.3	0.80
M (%)	14.10 ± 1.30^{a}	15.30 ± 2.10^{b}	$5.30\pm1.82^{a,b}$	$5.20\pm1.33^{a,b}$	10.67^{**} ($p<0.01$)
H (%)	12.90 ± 2.70^{a}	25.70±8.74	38.80 ± 7.01^{a}	40.10 ± 6.47^{a}	3.71^{*} ($p<0.05$)
E (%)	29.80 ± 3.38^{a}	16.60±3.91	7.40 ± 2.51^{a}	9.30 ± 3.93^{a}	8.49^{**} ($p<0.01$)
B (%)	4.70 ± 0.20^{a}	3.90 ± 0.58^{b}	$1.70\pm0.44^{a,b}$	$1.70\pm0.47^{a,b}$	11.61^{**} ($p<0.01$)

Table-3: RBC morphometry of exotic and local ducks.

Breed/ Parameter	Muscovy		Indian Runner		Analysis of Variance
	Males (30)	Females (30)	Males (30)	Females (30)	
Cell Length(µm)	12.61 ± 0.29^{a}	11.34 ± 0.27^{a}	11.81 ± 0.24^{a}	11.59 ± 0.28^{a}	4.00^{**} ($p<0.01$)
Cell Breadth(µm)	9.93 ± 0.24^{a}	9.42 ± 0.16^{b}	$9.36\pm0.19^{a,b}$	9.34 ± 0.20^{a}	1.89^{**} ($p<0.01$)
Nucleus Length(µm)	6.21 ± 0.20^{a}	7.39 ± 0.27^{a}	6.83±0.24	6.85±0.24	3.91^{**} ($p<0.01$)
Nucleus Breadth (µm)	4.11 ± 0.27^{a}	5.93 ± 0.38^{a}	5.30±0.33	4.88±0.33	5.31^{**} ($p<0.01$)
Cell: Length/Breadth	1.27±0.01	1.20±0.02	1.26±0.00	1.24±0.02	2.44
Nucleus: Length/Breadth	1.58 ± 0.03^{a}	$1.32\pm0.04^{a,b}$	1.35 ± 0.03^{a}	1.49 ± 0.04^{b}	8.61^{**} ($p<0.01$)
Cell Area(μm^2)	100.28 ± 4.62^{a}	$84.98\pm3.45^{a,b}$	$88.34\pm3.89^{a,b}$	86.44 ± 4.06^{a}	2.99^{**} ($p<0.01$)
Nucleus Area(μm^2)	21.47 ± 2.38^{a}	36.97 ± 3.38^{a}	30.46±2.93	28.24±2.85	4.81^{**} ($p<0.01$)
Nucleus:Cytoplasm	0.24 ± 0.03^{a}	0.47 ± 0.04^{a}	0.38±0.04	0.36±0.04	4.67^{**} ($p<0.01$)

Table-4: Lymphocyte morphometry of exotic and local ducks.

Breed/ Parameter	Muscovy		Indian Runner		Analysis of Variance
	Males (30)	Females (30)	Males (30)	Females (30)	
Cell Length (µm)	12.45 ± 0.30^{a}	11.31 ± 0.31^{b}	$9.39\pm0.33^{a,b}$	$9.59\pm0.33^{a,b}$	20.41^{**}(p<0.01)
Cell Breadth (µm)	10.35 ± 0.18^{a}	9.93 ± 0.16^{b}	$8.17\pm0.26^{a,b}$	$8.13\pm0.26^{a,b}$	26.30^{**}(p<0.01)
Nucleus Length(µm)	7.83 ± 0.37	8.36 ± 0.28^{a}	6.93 ± 0.24^{a}	6.91 ± 0.26^{a}	5.76^{**}(p<0.01)
Nucleus Breadth(µm)	5.83 ± 0.41^{a}	$7.08\pm0.37^{a,b}$	5.99 ± 0.19	5.83 ± 0.26^{b}	3.47^{*}(p<0.05)
Cell: Length/Breadth	1.19 ± 0.00	1.13 ± 0.01	1.15 ± 0.02^{a}	1.18 ± 0.02^{a}	1.78^{**}(p<0.01)
Nucleus: Length/Breadth	1.42 ± 0.04^{a}	1.24 ± 0.04^{a}	1.15 ± 0.02^{a}	1.21 ± 0.03^{a}	10.16^{**}(p<0.01)
Cell Area(μm^2)	103.04 ± 4.33^{a}	89.83 ± 4.10^{b}	$62.37\pm3.86^{a,b}$	$63.19\pm3.72^{a,b}$	25.25^{**}(p<0.01)
Nucleus Area (μm^2)	39.47 ± 4.10	49.16 ± 3.55^{a}	33.8 ± 2.16^{a}	33.21 ± 2.58^{a}	5.34^{**}(p<0.01)
Nucleus:Cytoplasm	0.43 ± 0.05^{a}	0.60 ± 0.04^{a}	0.55 ± 0.02	0.54 ± 0.03	2.88^{*}(p<0.05)

Table-5: Monocyte morphometry of exotic and local ducks.

Breed/ Parameter	Muscovy		Indian Runner		Analysis of Variance
	Males (30)	Females (30)	Males (30)	Females (30)	
Cell Length (µm)	10.50 ± 0.16^{a}	10.53 ± 0.14^{b}	$10.83\pm0.22^{a,b}$	$10.66\pm0.32^{a,b}$	0.44^{**}(p<0.01)
Cell Breadth (µm)	8.80 ± 0.20^{a}	8.90 ± 0.18^{b}	$8.63\pm0.20^{a,b}$	$8.78\pm0.20^{a,b}$	0.30^{**}(p<0.01)
Cell: Length/Breadth	1.20 ± 0.01^{a}	1.19 ± 0.01^{b}	$1.26\pm0.02^{a,b}$	$1.21\pm0.03^{a,b}$	1.64^{**}(p<0.01)
Cell Area(μm^2)	73.61 ± 2.68^{a}	74.49 ± 2.43^{b}	$74.51\pm3.04^{a,b}$	$74.87\pm3.57^{a,b}$	0.03^{**}(p<0.01)

Table-6: Eosinophil morphometry of exotic and local ducks.

Breed/ Parameter	Muscovy		Indian Runner		Analysis of Variance
	Males (30)	Females (30)	Males (30)	Females (30)	
Cell Length (µm)	10.58 ± 0.17^{a}	$9.20\pm0.27^{a,b}$	$11.50\pm0.27^{a,b}$	$10.63\pm0.38^{a,b}$	10.97^{**}(p<0.01)
Cell Breadth (µm)	8.80 ± 0.22^{a}	8.00 ± 0.25^{b}	$8.63\pm0.22^{a,b}$	$8.69\pm0.21^{a,b}$	2.35^{**}(p<0.01)
Cell: Length/Breadth	1.21 ± 0.02^{a}	1.15 ± 0.01^{b}	$1.33\pm0.01^{a,b,c}$	1.22 ± 0.03^{c}	5.55^{**}(p<0.01)
Cell Area(μm^2)	74.24 ± 2.97^{a}	59.63 ± 3.63^{b}	$79.71\pm3.84^{a,b}$	$74.26\pm4.06^{a,b}$	10.51^{**}(p<0.01)

All parameters are significantly different at p<0.01.Cell length of eosinophil of male MY differ with all other groups and that of female MY with IR. Cell breadth and area of male and female MY don't differ among them but interspecific difference is observed. Eosinophil length to breadth ratio of MY male and female don't differ among them but differ with male IR which itself differs intra-specifically (Table-6).

Length of heterophils of male MY differ among them and both sexes of IR and that of female MY differ with female IR at p<0.01. Male MY differs with all other groups regarding breadth of heterophils (p<0.01), Female MY and male IR differ with respect to heterophil length to breadth ratio at p<0.05.MY ducks differ intra-specifically as well inter specifically with IR ducks with respect to heterophil area (Table-7).

Table-7: Heterophil morphometry of exotic and local ducks.

Breed/ Parameter	Muscovy		Indian Runner		Analysis of Variance
	Males (30)	Females (30)	Males (30)	Females (30)	
Cell Length (µm)	6.11±0.59[a]	9.43±0.61[a,b]	10.83±0.22[a]	10.66±0.35[a,b]	20.90[**](p<0.01)
Cell Breadth (µm)	5.08±0.43[a]	8.28±0.38[a]	8.63±0.20[a]	8.73±0.21[a]	28.80[**](p<0.01)
Cell: Length/Breadth	1.22±0.05	1.11±0.02[a]	1.26±0.02[a]	1.22±0.03	2.96[*](p<0.05)
Cell Area(μm^2)	29.76±6.44[a]	66.93±6.76[a,b]	74.51±3.04[a,b]	74.64±3.83[a,b]	16.54[**](p<0.01)

Table-8: Basophil morphometry of exotic and local ducks

Breed/ Parameter	Muscovy		Indian Runner		Analysis of Variance
	Males (12)	Females (12)	Males (12)	Females (12)	
Cell Length (µm)	8.87±1.06	7.34±0.53	6.04±0.90	6.19±0.99	2.10
Cell Breadth (µm)	7.95±0.66[a]	7.31±0.41	5.82±0.53	5.04±0.60[a]	5.66[**](p<0.01)
Cell: Length/Breadth	1.09±0.07	1.01±0.05	1.00±0.07	1.23±0.09	1.88
Cell Area (μm^2)	60.89±12.34	43.60±5.50	31.56±7.85	29.19±9.51	2.50

Out of four morphometrical parameters related to basophils of two species of ducks, three are not significantly different among and between the groups. Male MY and female IR differ in case of cell breadth at p<0.01.

Hb%, TEC, TLC, lymphocyte count from DLC, Cell Length of erythrocyte and basophil, Cell Breadth of lymphocyte and basophil, Cell Length/Cell Breadth of RBCs, lymphocytes, heterophils, monocytes, eosinophils and basophils, Cell Area of basophil, Nucleus Length and Nucleus Breadth of erythrocytes, Nucleus Breadth of lymphocytes, lymphocytic Nucleus Length/Nucleus Breadth and lymphocytic Nucleus:Cytoplam of the birds considered here are similar with adult Khaki Campbell from our previous study as all these birds are in same age group, sex and similar environment. All similarities in parameters between IR and adult Khaki Campbell duck from our previous report may be present due to their similarity up to species level and difference is limited to sub-species level[12].

Hb% of adult MY ducks considered in this study differ with that of one week Muscovy ducks from Indonesia studied during dry and wet season. The cause of this difference may be difference in age, geographical location and environmental conditions. But PCV and lymphocytes of adult female and male MY of this study corroborates with that of one week old female and male Muscovy ducks from Indonesia which may be due to similar sex and similar dry season when samples were collected[13]. TEC and PCV of 24 weeks old indigenous ducks (control group) from rural area of Sylhet, Bangladesh corroborates with that of adult female Indian Runner duck which is also reared in rural areas of India having similar environmental conditions[14].

Hb% of adult Muscovy ducks and Indian Runner male duck corroborates with adult black duck. Also TEC of male Indian Runner is close to that of black duck as both of them belong to same age group and the same genus to which Indian Runner and Black duck belong[15]. Adult male Canvasback ducks caught near Mississippi River during mid-migration period and near Chesapeake Bay during early winter period have closer RBC count and MCV value respectively like that of adult male Indian Runner duck. MCH values observed in this study about all ducks are in accordance with all Canvasback ducks. Adult female Canvasback ducks caught near Mississippi River during mid-migration period and Chesapeake Bay during late winter have closer MCHC value like that of adult male Indian Runner duck[16]. Hb%, MCV and MCHC of mallards corroborates with that of Indian Runners which may be due to same age, sex and similar genus and species[17].

Hb% and TEC of caged and free-roaming White Peking ducks show similarity with IR ducks whereas PCV don't have any resemblance. These similarities may occur because both are *Anas platyrhynchos.* Also, length of RBC of caged and free-roaming White Peking ducks has similarity with the birds considered in this study which may be due to similar age[18]. Haematology of different types of gulls studied by earlier authors reports likely MCH values and length of RBC as that of adult *Cairina moschata domestica* and all birds mentioned here

respectively[19]. Hb% of adult geese from Tamil Nadu and adult IR female resembles each other[20]. This similarity indicates towards approximately similar temperature, rainfall, food habit, habitat, etc.

PCV of 30-32 week old and basophils of 19-23 week old turkey shows similarity with that of male MY which may be due to large size of both categories of bird and physiological stress[21]. Hb content and lymphocytes of MY and IR ducks respectively matches with that of Nigerian local turkey and that of IR duck with turkey reared at Zaria, Nigeria which may be due to higher temperature prevailing in both places[22,23]. Hb of female 119 days old B.U.T 6 hybrid turkey corroborates with female IR which may be due to same sex[24]. MCH of adult helmeted guinea fowl matches with that of adult IR[25].

Erythrocytic parameters are comparatively higher in males than females in this study which is also supported by earlier studies[26]. PCV and heterophil count of Thai indigenous chicken are in accordance with IR duck (which is also indigenous species) and male MY duck respectively[27]. Indigenous chicken from Bangladesh have similar PCV value with that of IR duck which is also an indigenous species[28]. Similarities in haematological parameters between chicken and ducks might occur because because Order Galliformes and Anseriformes belong same clade Galloanserae as mentioned in introduction part of this study.

Hb percentage of goose, duck and pintail duck, lymphocytes of goose and neutrophils of pintail ducks from Bangladesh studied by are alike to that of IR ducks considered in this study[29]. This similarity may happen because of similar climatic conditions in India and Bangladesh. MCH of IR ducks and domestic fowls of Nera Black strain (blood sample collection time 10.00am) reflects likeliness which may be due to same age – groups and approximately same time of sample collection[30].

Hb% observed in this study among and between the two species of ducks (exotic and indigenous) are in accordance with the range reflected by American Black duck, Canvas-back duck, Red Head, Canada goose, Aleutian Canada goose and Embden goose. Similarly, TEC values of above birds and others mentioned in the normal range of parameters (hematology of selected Anseriformes) matches with this study. Also, MCH of Wood duck and Canada goose by same author is similar with MCH of IR ducks. Other parameter like, MCHC of Canvas-back duck, Canada goose and Trumpeter Swan from reference values mentioned in the work of the same author have resemblance with our study. The TLC observed in case of MY ducks is within the reference value of total WBC recorded in case of Canada goose. Heterophils of adult male Indian Runner matches with the reference value for post-reproductive adult mallard[31].

Hb%, PCV, MCHC and heterophils values reflected by this study have resemblance with the reference value of mallard ducks and Canada goose[32]. Hb%, TEC, MCV, lymphocyte, eosinophil and basophil percentages of Indian Runner duck from our previous study approximately matches with the same birds considered in this study because of similar environment, age-group, feeding etc[33]. Eight to ten month old Bali ducks reflect similar count of basophils with that of adult Indian Runner ducks[34]. Heterophils of captive Puna Ibis, water dwelling bird and MY ducks are in accordance with each other as both belong to same habitat[35]. Eosinophils of flightless cormorants from Galapagos islands show higher value like that of ducks in this study because both are aquatic birds or because of attack of parasites[36].

Apart from these analyses, DLC reflects heteropenia and basophilia in Muscovy ducks, eosinophilia in both species with more impact on MY. But, according to some author, higher numbers of lymphocytes than heterophils are typical for order Anseriformes. Monocytosis reflected in this report may be due to acute or chronic parasitic or microbial infection or may be due to dietary deficiencies. Astonishingly high number of eosinophils may occur due to type IV hypersensitivity. Along with that basophilia is also reflected which reflects stress, infectious and disease condition of the water birds. These above mentioned conditions indicate serious physiological and pathological discomforts resulting strong action of immune system as per earlier workers, since these birds are kept in commercial condition where care is very little[37].

Erythrocyte and heterophil length of adult IR and eosinophil length of adult MY female resembles with adult Japanese quail[38]. Ratios of nuclear length to breadth of adult farmed ostriches are similar to adult male MY for the same parameter[39]. Length of RBC, lymphocytes and eosinophils of adult MY male, female and IR male respectively in this report corroborates with that of adult male ostrich[40]. Erythrocyte breadths of Brazilian ostriches belonging to 22-30 months age are nearly same when compared to birds of present study because both are adults[41].

Diameter of large lymphocyte and morphometry of eosinophils of female Eastern Sarus Crane is approximately and exactly similar to breadth of lymphocytes of male and female IR ducks respectively. Similarly, morphometry of heterophils and basophils of Eastern Sarus Crane is similar to that of Muscovy ducks. Length of erythrocytes of pheasants shows similarity with length of erythrocytes of *Cairinamoschata* and *Anasplatyrhynchos platyrhynchos*[42].

Nuclear length of erythrocytes of adult ducks studied here reflects some similarity with that of four species of adult birds of prey[43]. Similarly, morphometrical parameters of erythrocytes of Lycian salamander (urodele species) were compared with the subjects of this work. But comparison shows that amphibians' RBC are very large compared to avian RBC. Like RBCs, lymphocytes, monocytes, eosinophils, heterophils and basophils of Lycian salamanders are also very large compared to ducks of

this study though both type of animals spend their maximum time in water[44]. These large differences are present because amphibians have largest blood cells among vertebrates.

Comparison of all parameters related to RBC morphometry of 19 amphibian species and 4 turtle species show larger value than these two duck species. Similarly, anurans and urodeles have larger lymphocytes but testudines from the same study reflect similarity in dimensions of lymphocytes. But, urodeles have very large eosinophils but anurans and testudines show similar size of eosinophils like that of IR ducks. Also, aquatic species among Turkish herpetofauna has larger monocytes, heterophils and basophils compared to the ducks considered here[45]. Dimensions of lymphocytes of endangered sea turtles also show some similarity with these birds[46]. Resemblance in structure of blood cells between reptiles and aves may be the cause.

Interestingly, the fish, *Diodonhystrix*, have smaller RBC, lymphocytes, monocytes compared to aquatic birds aken in this study but erythrocytic Nucleus Length/Nucleus Breadth, Nucleus: Cytoplasm ratio and lengths of heterophils shows some likeliness. This is just opposite to that of comparison with amphibians, since fishes have smaller blood cells[47]. Capture and culture Asian eel have similar length and breadth of RBC like that of MY and IR ducks, though nuclear dimensions are very small compared to these birds[48]. Actually, fishes have circular RBC and its nucleus in contrast to avian oval RBC and its nucleus. Basophilic dimensions of MY duck are in accordance with that of Sunbleak fish, since, both have aquatic habitat[49].

Conclusion

Significant differences exists between the two sexes of Muscovy (exotic) and Indian Runner (local) ducks for most of the parameters considered in this study which may be due to difference in genetic factors and some similarities are also found among them which may be because of similar rearing conditions and environment.

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