Bulgarian Journal of Veterinary Medicine, 2015, **18**, No 4, 325–337
ISSN 1311-1477; DOI: 10.15547/bjvm.783

Original article

INTERSPECIES AND GENDER-RELATED VARIATIONS OF SOME HAEMATOLOGICAL PARAMETERS IN GALLIFORMES BIRD SPECIES

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Summary

Lashev, L., S. Atanasova & T. Dinev, 2015. Interspecies and gender-related variations of some haematological parameters in Galliformes bird species. *Bulg. J. Vet. Med.,* **18**, No. 4, 325–337.

An analysis of literature data about routine haematological parameters of avian species from the Galliformes order is made. Data for the following gallinaceous birds were included: wild and domesticated chicken breeds, common pheasant, quail, turkey, peafowl and guinea fowl. Data for red and white blood picture indices such as haemoglobin, red blood cells (RBC), packed cell volume (PCV), total and differential white blood cell (WBC) counts from the literature as well as own data were used. Gender-related differences were reported by most of authors for RBC, haemoglobin and PCV with higher values in male birds from the *Gallus gallus* species. Similar results were not found in other species of the order. In most of the cases no statistically significant interspecies or gender-related differences in WBC counts were registered. Tendencies for higher heterophil/lymphocyte ratios (H/L) in male birds were also registered. Differences related to the breed, result of various degree of domestication, were not identified.

Key words: birds, gallinaceous, haematology, interspecies and sex related differences

INTRODUCTION

The rearing of wild or domesticated bird species from the Galliformes order has been of considerable economical importance at all stages of the humankind development. The existing species and breeds provide information for the entire process of domestication that is especially clear for *Gallus gallus*. There are numerous studies and data about the condition of birds (especially domesticated species) and the factors influencing it. Haematological investigations are among the most widely used and easily available. The existing information about the different gallinaceous species varies considerably. The most numerous and detailed studies are about domesticated species – chickens, turkeys etc., whereas data about wild ones, including game species reared in aviaries, are rather limited (Mihailov *et al.*, 1999; Lashev *et al.*, 2007; Strakova *et al.*, 2010). The present research reports differences related to the species, age, season and gender in *Gallus gallus, Meleagris gallopavo, Phasianus colchicus, Coturnix coturnix* and others. So far, there are no studies summarising the data about gender-related differences in blood indices of species from the Galliformes order.

The purpose of the present paper was to analyse interspecies and gender-related differences in principal haematological parameters of gallinaceous birds on the basis of literature data and own results. We have also attempted to evaluate the influence of environmental factors as a result of domestication level and urbanisation on the most commonly analysed blood parameters of the *Gallus gallus* spp. using data for various breeds of this species.

MATERIALS AND METHODS

Data from haematological investigations of healthy representatives of both genders of gallinaceous bird species, published by various authors, were used. The references included in the analysis are cited in Tables 1 and 2. The following blood parameters were included in the analysis: red blood cells (RBC), haemoglobin (Hb), packed cell volume (PCV), total white blood cells (WBC) counts, differential WBC counts, heterophil/lymphocyte ratio (H/L). All blood analyses were standardised, allowing an unbiased comparison. The data are presented as they appeared in original publications, and in some instances were converted in uniform units for comparative purposes. Principal Component Analysis (PCA) was used for identifying patterns in data expressing them in a way such as to highlight their similarities and differences. A commercial software Pirouette Version 3.02 (Infometrics, Inc., Woodinville, WA, USA) was used.

RESULTS

The data for the haematological parameters showed variations among species and among different reports. With regard to RBC counts, haemoglobin content and PCV, different sources reported higher values in male birds with statistically significant differences mainly in wild and domestic chickens (Table 1). These tendencies did not exist in other analysed gallinaceous species. In an inter-species aspect quails and pheasants exhibited relatively higher values of red blood picture parameters as compared to other species included in the analysis. The chickens reared at unusually high altitudes as *Kashmir favorella* did not have higher levels of Hb or RBC count. The WBC counts were highly variable both within and among species. In most instances, female birds had higher lymphocyte and lower heterophil percentages (Table 2). Included birds demonstrated considerable variations of the H/L ratio which, in most instances, was higher in male birds. The absolute values and percentages of monocytes, eosinophils and basophils showed considerable intra- and inter-species variations in chickens, pheasants and quails, but were similar when both sexes of one species were compared. Extremely high monocyte counts were reported for *Kashmir favorella.* At a lesser extent, this was true for eosinophils.

Table 1. Values of selected red blood indices in species from the Galliformes order

Sex	n	Red blood cells T/L	Haemoglobin (g/L)	Packed cell volume (L/L)	Source
Gallus gallus gallus					
♂	17	4.7±0.16^{a}	144.6±5.4^{a}	0.44±0.002^{a}	Aengwanich & Tanomtong,
♀	16	4.11±0.14^{b}	126.5±5.4^{b}	0.38±0.001^{b}	2007
Kashmir favorella					
♂	30	3.20±0.07^{a}	132.1±3.9^{a}	0.41±0.001^{a}	Pampory & Iqbal, 2007
♀	55	2.98±0.08^{b}	113.2±1.9^{b}	0.35±0.001^{b}	
Gallus gallus domesticus					
♂	20	2.32±0.31	92.7±14.2^{a}	0.33±0.004	Simaraks *et al.*, 2004
♀	20	2.19±0.26	85.2±8.5^{b}	0.31±0.004	
♂	55	2.58±0.51^{a}	93.8±7.7^{a}	0.31±0.003^{a}	Uko & Aaja, 1996
♀	57	2.42±0.48^{b}	88.2±10.6^{b}	0.29±0.004^{b}	
♂	18	2.39	85.8	0.31	Orawan & Aengwanich,
♀	18	2.36	84.1	0.30	2007
♂	15	6.24±0.1^{a}	128.9±3.4	–	Mihailov *et al.,* 1999
♀	15	5.55±0.28^{b}	116.6±5.3	–	
♂	31	3.05±0.73^{a}	125.4±18.7^{a}	0.39±0.009^{a}	Emoke, 2005
♀	157	2.43±0.41^{b}	83.2±8.7^{b}	0.29±0.005^{b}	
♂	20	3.37±0.3^{a}	94.8±3.8^{a}	0.33±0.007^{a}	Sharmin & Myenuddin,
♀	20	2.48±0.25^{b}	82.9±3.9^{b}	0.31±0.001^{b}	2004
♂	10	2.3±0.15	123±10	0.35±0.001	Mushi *et al.*, 1999
♀	90	2.0±0.10	104±10	0.33±0.002	
♂	15	3.07±0.11	–	0.31±0.001	Hako Touko *et al.*, 2009
♀	15	2.92±0.15	–	0.29±0.001	
♂	40	3.3±0.4^{a}	10.1±1.1	0.36±0.005^{a}	Albokhadaim, 2012
♀	40	2.9±0.2^{b}	95±9	0.28±0.004^{b}	
Phasianus colchicus					
♂	101	3.58±0.78	115±20.5	0.38±0.004	Hauptmanova *et al.*, 2006
♀	96	3.47±0.77	104±21.5	0.38±0.003	
♂	96	4.09±0.65	141±18	0.44±0.005	Hauptmanova *et al.*, 2006
♀	94	3.3±0.47	117.6±15	0.38±0.004	
♂	88	3.90±0.73	116±14.7	0.37±0.003	Hauptmanova *et al.*, 2006
♀	87	3.98±0.63	124±15.6	0.39±0.004	
♂	15	2.72±0.13	159.6±11	0.44±0.001^{a}	Schmidt *et al.*, 2007
♀	15	2.37±0.12	167.4±10.7	0.39±0.001^{b}	
♂	7	2.55±0.5	94±16	0.35±0.005	Kececi & Gol, 2010
♀	8	2.67±0.5	97±15	0.36±0.005	
Coturnix coturnix japonica					
♂	25	4.14±0.07	158±2	0.53±0.001	Nirmalan & Robinson,
♀	30	3.87±0.09	146±3	0.49±0.001	1971
♂	15	5.86±0.11	111.3±7	–	Mihailov *et al.*, 1999
♀	15	5.71±0.24	104±8.9	–	
♂	40	3.26±0.04	114.4±10.0	0.45±0.001	Aydin *et al.*, 2008
♀	40	2.39±0.05	94.1±9	0.36±0.002	

Table 1 (cont'd). Values of selected red blood indices in species from the Galliformes order

Sex	n	Red blood cells T/L	Haemoglobin (g/L)	Packed cell volume (L/L)	Source
♂		2.63±0.10	110.5±60	0.33±0.002	Farahat *et al.*, 2010
♀		2.84±0.13	117.1±5.2	0.34±0.001	
Meleagris gallopavo					
♂	13	1.30±0.2	167±1.8	0.39±0.005	Schmidt *et al.*, 2009
♀	40	1.13±0.23	162±20	0.37±0.005	
♂	22	0.96±0.27	172±17	0.36±0.003	Schmidt *et al.*, 2009
♀	35	1.05±0.27	176±19	0.37±0.004	
♂	10	1.99±0.38	137.9±26.6	0.40±0.004	Azeez *et al.*, 2011
♀	10	2.26±0.28	130.9±22.2	0.40±0.004	
♂	15	2.42±0.2	112.2±6	0.42±0.002	Lazar *et al.*, 2012
♀	15	2.82±0.9	100.7±9	0.43±0.001	
Meleagris ocelata					
♂	2	2.35±1.24	134.5±32.4	0.40±0.008	Ortiz, 2004
♀	9	2.37±0.28	134.3±8	0.40±0.008	
Numida meleagris					
♂	41	3.45±0.62	106.8±11.6	0.36±0.001	Uko & Ataja, 1996
♀	37	3.40±0.64	105.1±10.4	0.33±0.006	
♂	49	2.65±0.09	142±5.4	0.41±0.007	Nalubamba *et al.*, 2010
♀	40	2.44±0.1	124±2.9	0.38±0.005	
Pavo cristatus					
♂	17	3.54±0.3	115.1±15	–	Lashev *et al.*, 2013
♀	19	3.42±0.4	101.2±12	–	

RBC– red blood cells, PCV– packed cell volume, n – number of birds; [a, b] means in the same column with different letters are significantly different (P<0.05).

The Principal Component Analysis was applied separately for RBC and WBC data. When data for RBC were transformed into Principal Components, the first principal component (RBC values) explained 87.6% of total variations in the data, the second principal component (haemoglobin values) explained 11.2% and the third personal component (PCV values) – 1.2% respectively. Principal component 1 correlated mainly with the variable PCV (r=0.946), the second: with haemoglobin (r=0.928), and the third – with RBC (r=0.976).

The distribution of tested species in the space of the first two principal components is presented on Fig. 1. Quails formed a relatively separate group. Points corresponding to other species did not form a separate group.

The results of principal component analysis, applied for WBC data are presented in Table 3. Distribution of tested species in the space of principal component 1 (WBC count) and principal component 2 (lymphocytes) is presented on Fig. 2. No bird species was found to form a separate group.

DISCUSSION

The results included in the present analysis were obtained by different researchers, in different laboratories, latitudes and cli-

Table 2. White blood cells picture in different species of Galliformes order

Sex	n	White blood cells , G/L	Lymphocytes (%)	Heterophils (%)	H/L	Monocytes (%)	Eosinophils (%)	Basophils (%)	Source
Gallus gallus domesticus									
♂	55	22.71±2.04	51.8±7.3	34.2±5.5	0.66	9.1±1.3	3.6±0.2	1.3±0.1	Uko & Ataja,1996
♀	57	23.37±3.27	56.2±6.7	29.2±3.8	0.52	8.8±1.6	4.3±0.5	1.5±0.1	
♂	20	20.5±3.9	60.3±5.33	25.40±5.12	0.42	4.35±3.15	7.35±2.91	2.7±2.13	Simaraks *et al.*, 2004
♀	20	20.5±5.3	67.05±11.49	22.0±8.78	0.33	4.05±3.39	4.30±3.59	2.60±2.16	
♂	18	11.7	73.74	17.31	0.23	3.79	3.60	2.29	Orawan &
♀	18	11.6	72.64	17.31	0.24	3.59	4.20	2.57	Aengwanich, 2007
♂	20	19.13±0.43[a]	62.0±2.85[a]	22.8±1.06[a]	0.37	1.65±0.49[a]	3.15±0.75[a]	1.0±0.0	Sharmin & Myenuddin,
♀	20	20.68±0.54[b]	70.6±0.88[b]	19.4±0.60[b]	0.27	2.75±0.79[b]	1.80±0.52[b]	0.85±0.37	2004
♂	15	27.88±1.03	75.12±0.86	21.3±0.7	0.28	0.4±0.21	3.14±0.48	0.07±0.07	Mihailov *et al.*, 1999
♀	15	26.20±0.74	73.0±0.9	22.5±0.6	0.31	0.6±0.19	3.73±0.52	0.07±0.07	
♂	10	3.0±1.0	80±0.19	15±1.0	0.19	4.5±0.01	4±0.01	-	Mushi *et al.*, 1999
♀	90	5.0±1.5	70±0.04	19±1.0	0.27	4.1±0.05	4±0.01	-	
♂	31	22.34±6.30	58.23±11.40	27.06±7.44	0.46	11.13±7.19	3.19±4.21	0.87±1.43	Emoke, 2005
♀	157	20.17±6.63	63.4±8.88	26.36±5.63	0.42	5.76±5.67	2.96±3.06	1.48±1.64	
♂	15	19.9±0.28	62.53±1.18	25.8±1.96	0.41	5.72±0.38	3.1±0.13	2.9±0.31	Hako Touko *et al.*,
♀	15	21.0±1.28	61.6±0.2	25.9±0.46	0.42	6.38±0.14	3.18±0.32	2.9±0.18	2009
♂	10	9.92±1.56	65.39±4.5	28.3±3.77	0.43	3.4±1.07	2.6±1.26	0.4±0.52	Abdi-Hachesoo *et al.*,
♀	10	8.89±1.85	51.9±4.46	38.6±2.95	0.74	3.9±1.37	3.5±1.43	2.1±0.99	2011
♂	10	10.22±1.65	61.6±6.6	30.2±5.39	0.49	3.7±1.16	3.4±1.17	1.1±1.1	Abdi-Hachesoo *et al.*,
♀	10	8.85±2.13	53.0±4.14	37.8±4.82	0.71	3.7±1.34	3.4±1.5	2.1±0.99	2011
♂	40	30.6±1.5	41.9±3.7	41.9±3.7		4.4±0.5	3.6±0.5	1.4±0.5	Albokhadaim, 2012
♀	40	26.8±1.2	46.2±4.6	46.2±4.6		4.2±0.8	4.4±1.3	2.0±0.7	
Kashmir favorella									
♂	15	16.8±0.47	48.87±0.81	32.55±0.61	0.67	10.9±0.35	5.67±0.29	2.0±0.18	Pampory & Iqbal,
♀	15	22.3±0.37	49.98±0.72	26.32±0.46	0.53	10.85±0.36	8.69±0.26	3.19±0.23	2000

H/L – heterophil/lymphocyte ratio, n – number of birds; [a, b] means in the same column with different letters are significantly different ($P<0.05$).

Table 2 (cont'd). White blood cells picture in different species of Galliformes order

Sex	n	White blood cells , G/L	Lymphocytes (%)	Heterophils (%)	H/L	Monocytes (%)	Eosinophils (%)	Basophils (%)	Source
Phasianus colchicus									
♂	30	28.53±3.38	41.78±6.13	41.11±26.71	0.98	7.18±2.1	4.1±1.16	8.66±2.03	Schmidt *et al.*, 2009
♀	55	27.82±3.10	28.32±4.28	48.06±21.64	1.69	4.56±0.40	4.64±0.65	18.91±3.88	
♂	101	8.58±3.54	63.8±10.0	29.1±10.4	0.46	1.6±1.9	1.0±1.5	4.6±5.0	Hauptmanova *et al.*,
♀	96	9.34±34.23	65.7±12.8	27.0±12.6	0.41	1.6±1.6	1.2±1.5	3.3±0.47	2006
♂	96	24.53±12.37	68.8±11.7	25.4±11.2	0.37	1.1±1.1	1.8±1.5	2.6±3.5	Hauptmanova *et al.*,
♀	94	27.41±12.02	68.8±12.8	25.3±12.6	0.37	1.3±1.7	2.4±2.1	2.3±2.7	2006
♂	88	12.58±4.71	66.1±12.4	26.1±12.3	0.39	3.0±2.6	1.6±1.4	3.2±2.5	Hauptmanova *et al.*,
♀	87	13.31±4.56	63.9±11.7	31.1±12.4	0.49	1.4±1.2	1.1±1.4	2.4±2.7	2006
♂	7	28.8±8.0[a]	69.4±11.0[a]	24.8±12.0	0.36	2.8±1.0	2.3±1.0	0.9±0.8	Kececi & Gol, 2010
♀	8	19.9±4.0[b]	77.7±11.0[b]	17.0±9.0	0.22	2.1±1.0	2.6±1.0	0.6±0.5	
Pavo cristatus									
♂	17	29.89±2.35	47.6±4.5	47.3±3.2	0.99	0.5±0.5	3.67±0.3	0.93±0.1[a]	Lashev *et al.*, 2013
♀	19	31.14±3.78	47.9±3.3	46.9±2.9	0.98	0.5±0.5	3.21±0.1	1.49±0.2[b]	
Coturnix coturnix japonica									
♂	25	19.7±0.7	73.6±2.1	20.8±1.9	0.28	2.7±0.3	2.5±0.4	0.4±0.1	Nirmalan & Robinson,
♀	30	21.2±0.9	74.5±1.5	19.9±1.3	0.28	2.5±0.2	2.7±0.4	0.4±0.1	1971
♂	15	26.57±0.72	75.5±1.23	21.87±0.71	0.29	0.17±0.09	2.33±0.65	2.33±0.65	Mihailov *et al.*, 1999
♀	15	24.51±0.81	75.73±0.91	21.33±0.67	0.28	0.4±0.19	2.33±0.41	0.13±0.09	
♂	12	12.61±0.56	47.34	38.46	0.81	7.78	6.74	0.23	Kaczanowska *et al.*,
♀	12	23.02±0.73	52.48	36.58	0.7	4.21	6.69	0.09	1988
♂	12	13.56±0.35	58.99	29.57	0.5	4.94	6.34	0.07	Kaczanowska *et al.*,
♀	12	15.34±0.83	54.69	36.31	0.66	3.58	5.02	0.39	1988
♂		10.12±1.39	68.33±1.47	23.04±1.55	0.34	–	–	–	Farahat *et al.*, 2010
♀		10.59±1.04	66.64±1.33	25.17±1.34	0.38	–	–	–	

H/L – heterophil/lymphocyte ratio, n – number of birds; [a, b] means in the same column with different letters are significantly different ($P<0.05$).

Table 2 (cont'd). White blood cells picture in different species of Galliformes order

Sex	n	White blood cells , G/L	Lymphocytes (%)	Heterophils (%)	H/L	Monocytes (%)	Eosinophils (%)	Basophils (%)	Source
Meleagris gallopavo									
♂	13	7.46±1.71	59.2±6.4	31.1±5.4	0.52	3.6±1.3	0.7±0.8	5.3±1.9	Schmidt *et al.*, 2009
♀	40	8.65±2.12	58.3±8	31.8±7.2	0.55	3.9±2	1.1±0.9	4.9±2.3	
♂	22	7.83±3.50	52.8±9.1	36.5±9.1	0.69	3.7±1.9	0.7±1	6.3±2.9	Schmidt *et al.*, 2009
♀	35	7.79±3.15	49.4±13.7	36.3±12.5	0.73	5.1±2.8	2.±2.9	7.1±3.3	
♂	15	28.66±8	68.3±10	24.8±11	0.36	2.8±1	2.2±1	0.9±0.7	Lazar *et al.*, 2012
♀	15	20.8±7	61.2±8	28.4±9	0.46	3.7±2	3.0±2	2.6±1.2	
Meleagris ocelata									
♂	2	9.35±8.26	60±10.1	36.5±10.8	0.61	1.5±0.6	2	–	Ortiz, 2004
♀	9	9.74±1.97	72.5±8.79	25.8±8.39	0.36	1.04±1.1	1.2±0.94	0.1±0.23	
Numida meleagris									
♂	41	24.31±3.48	53.8±4.9	33.7±3.4	0.63	7.4±1.7	3.4±0.3	1.4±0.2	Uko & Ataja, 1996
♀	37	25.2±2.72	57.0±6.4	32.3±4.2	0.57	6.5±1.9	2.9±0.6	1.3±0.2	
♂	49	22.4±10.26	79.7±4.04	16.5±2.26	0.21	1.0±0.16	2.2±0.21	1.1±0.09	Nalubamba *et al.,*
♀	41	21.42±10.71	80.1±5.16	15.6±2.28	0.19	0.7±0.17	2.3±0.26	0.9±0.08	2010

H/L – heterophil/lymphocyte ratio, n – number of birds; $^{a, b}$ means in the same column with different letters are significantly different (P<0.05).

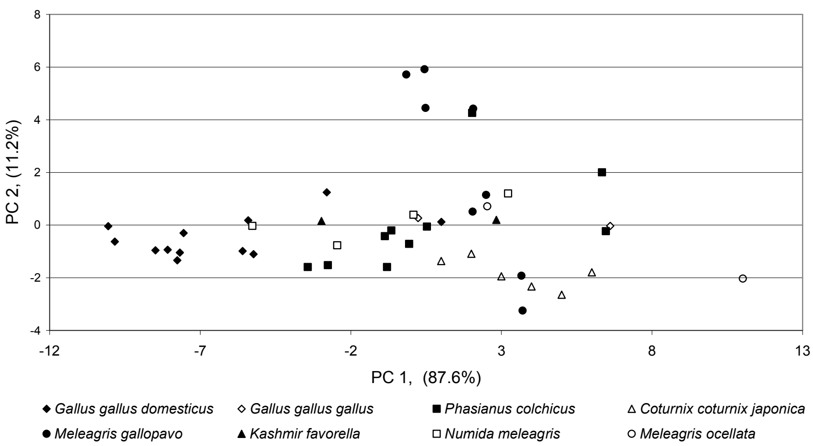

Fig. 1. Score plot of principal component (PC) 1 (red blood cells) and PC 2 (haemoglobin), calculated from red blood cell data.

Table 3. Results from principal component analysis, applied for white blood cell (WBC) data

Factors	Percent of total variance	Highest correlation with
Principal component 1 (WBC count)	71.31	Lymphocytes
Principal component 2 (lymphocytes)	19.67	White blood cells
Principal component 3 (heterophils)	5.23	Heterophils
Principal component 4 (monocytes)	2.84	Basophils
Principal component 5 (eosinophils)	0.72	Eosinophils, monocytes
Principal component 6 (basophils)	0.23	Eosinophils

mate conditions. These differences could have a significant impact upon studied parameters and be responsible for the large amount of inter- and intra-species variations registered. Therefore, sex-related differences could be accepted as more precisely evaluated whereas breed-related (including those connected with domestication) or species-related could be outlined only as a trend. It was difficult to recognise the individual influence of any specific factor as well.

The data for a particular species were not uniform with regard to their quantity and possibilities for analysis. They are the most abundant for chickens and thus, provide substantial evidence in support of conclusions made, particularly with respect to gender-related differences in red blood picture parameters. It should be emphasised that such differences were reported by investigators for various latitudes, altitudes and breeds. It could be assumed that they could be valid for the other gallinaceous bird species with less data available, because in these studies the general trend was also confirmed.

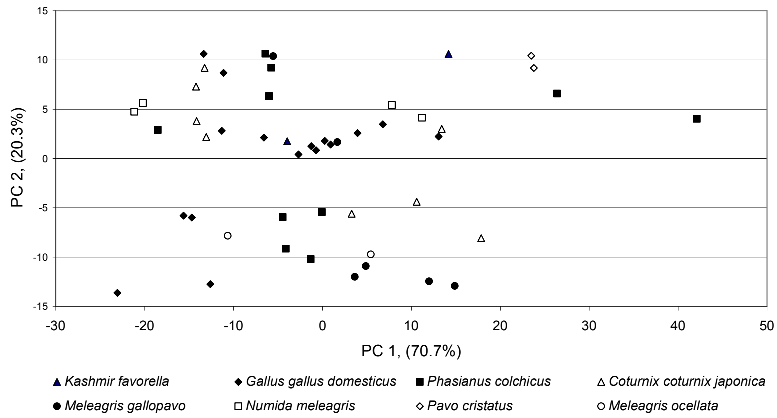

Fig. 2. Score plot of principal component (PC) 1 (white blood cells) and PC2 (lymphocytes), calculated from WBC data.

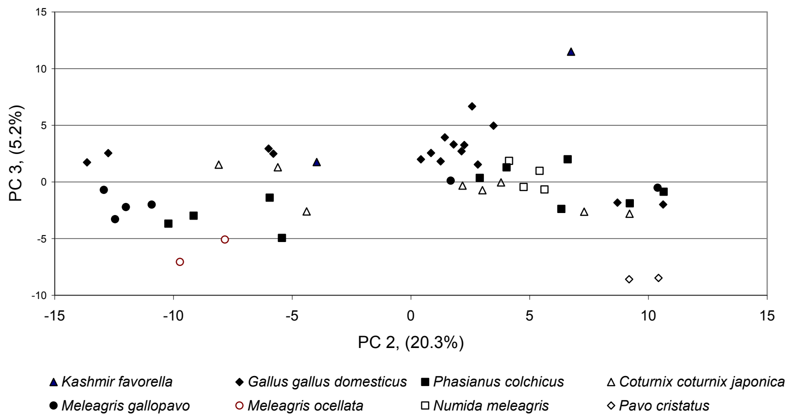

Fig. 3. Score plot of principal component (PC) 2 (lymphocytes) and PC3 (heterophils), calculated from WBC data.

According to the data, roosters often show higher values of RBC, PCV and haemoglobin. A possible reason for the difference is the higher level of oestrogens in blood of female birds, which depresses erythropoiesis, whereas androgens have the opposite action (Herbert *et al.*, 1989; Itoh, 1992). Another factor could be the considerably decreased haemoglobin level associated to the intensity of egg production (Uko & Ataja, 1996). Only female pheasants and bronze turkeys have higher values of previously mentioned indices than males of the same species (Hauptmanova *et al.*, 2006; Schmidt *et al.*, 2007). These findings could be due to other factors such as environment, age, reproductive status and season (Herbert *et al.*, 1989; Hauptmanova *et al.*, 2006).

With regard to intra-species variations, it could be concluded that indigenous breeds of domesticated chickens living freely in conditions similar to those of their wild relatives, exhibited lower RBC counts than urbanised intensively reared breeds. Data could reflect better conditions of rearing and the complete and balanced ration (Herbert *et al.*, 1989).

The high values of PCV in Japanese quails might be attributed to genetic factors. Moreover, slight increases in the peripheral red blood cells mass may occur in excited or stressed avian patients (Fudge, 2000). The high values of PCV in wild non-gallinaceous birds also support that statement (Okeudo *et al.*, 2003; Aengwanich & Tanomtong, 2004; Milani, 2009).

There is a considerable variability in the total WBC counts not only between species of the Galliformes order, but also between different breeds within the same species. Total and differential WBC counts can provide valuable information about the state of the immune system and whether birds have been exposed to infectious or immunotoxic agents (Campbell & Coles, 1986). A high WBC counts in birds with high extent of domestication should be noted (Mihailov *et al.*, 1999; Yarkov, 2001). The analysis often showed higher WBC counts in females although this tendency was not always present (Table 2). Also, substantial differences in H/L ratios among species and breeds were found. The H/L ratio reflects the various rearing conditions of birds, subject of analysed studies. In most cases males have higher H/L values (also non-gallinaceous birds), as reported by Fairbrother & O'Loughlin (1990); Plischke *et al.* (2009), although some authors found the opposite tendency (Mihailov *et al.*, 1999). The breed of the examined birds in the last study was White Plymouth Rock. It is widely known that under stress conditions the number of heterophils increases and the number of lymphocytes is reduced (Davis *et al.*, 2008). The higher H/L ratios in females in this study may result from stress due to the laying cycle (Latimer & Bienzle, 2000). This effect is also observed in tundra swans, ostriches and lesser adjutants (Levi *et al.*, 1989; Salakij *et al.*, 2004; Milani, 2009). Their high H/L values could be at least partly due to the stress, involving handling of the wild animals (Davis *et al.*, 2008).

In conclusion, it could be said that *Gallus gallus gallus* showed sex-related differences in the number of RBC, as well as in haemoglobin content and PCV. The influences of the climate, breed or technology are not sufficient for significant changes of the red and white blood picture indices. According to the principal component analysis, the biggest variations among species existed in the PCV values, followed by haemoglobin values and RBC counts. The results of principal component analysis, applied for WBC data of tested species in the space of PC2 and PC3 shows that only the *Meleagris gallopavo* and *Pavo cristatus* species formed separate groups. The other bird species were not separated because of the smaller variations in RBC. Our data allowed supporting partly the conclusions of Scanes & Christensen (2014) concerning the differences between blood parameters of wild and domesticated species belonging to Galliformes order.

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Paper received 04.09.2013; accepted for publication 25.04.2014

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