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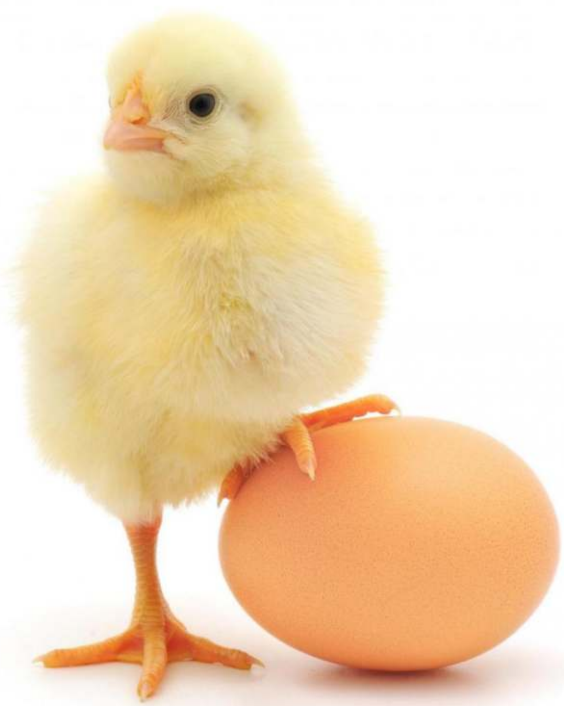

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# Comparative Studies on Haematological Values of Broiler Strains (Ross, Cobb, Arbor-acres and Arian)

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**Abstract:** Measurement of haematological parameters provides valuable information for evaluation of health status of man and animals, but due to lack of reference values for avian blood profiles, it is not widely used in poultry. This study has contributed to the current knowledge on avian blood profiles, or more specifically demonstrated leukograms and haemograms of four main broiler strains (Ross, Cobb, Arbor-Acres, and Arian) during 8 weeks husbandry period. Blood samples were collected from chickens at different age (1 to 56 days old) with 7-day sampling intervals. Total numbers of RBC and WBC, PCV, Hb, MCV, MCH, MCHC, ESR, together with absolute count of heterophils, lymphocytes, monocytes, eosinophils, and basophils as well as H / L ratio were determined. One-way ANOVA, Wilcoxon, Spearman correlation and Kruskal-Wallis H tests from SPSS11 were used for statistical analysis of the results. This study showed that age affects significantly ($P<0.05$) the haematological profiles of the broiler strains. With increasing of age, the erythrocytic parameters (except MCV, MCH, and MCHC) and leukocytic parameters (except heterophils and H / L ratio) were significantly increased ($P<0.01$), but MCV, MCH and absolute count of heterophils as well as H / L ratio were significantly decreased ($P<0.01$).

**Key words:** Haematology, leukogram, haemogram, ross, cobb, arian, arbor-Acres, broiler strains

## Introduction

Poultry industry continuously advancing by improvement of genetic potential of new broiler strains (Kemp and Kenny, 2003) to provide the high-quality with low-cost protein requirements of the human population world-wide. Genetic development for rapid growth together with intensive husbandry conditions have expedite the outbreaks of avian diseases. To combat clinical and subclinical forms of poultry diseases, accurate and differential diagnosis of the diseases at early stages of infections is necessary. Measurement of haematological parameters provides valuable information in this regards and routinely used in human's and animal's medicines, but unfortunately due to lack of information, blood profile have not been widely used in avian medicine (Mushi *et al*., 1999; Kral and Suchy, 2000). Avian blood differs in cells' characteristics from their mammalian counterpart (Smith *et al*., 2000). Several factors including physiological (Alodan and Mashaly, 1999) and environmental conditions (Vecerek *et al*., 2002, Graczyk *et al*., 2003), diet contents (Odunsi *et al*., 1999; Kurtoglu *et al*., 2005), water and feed restriction (Galip, 1999; Al-Rawashdeh, *et al*., 2000; Iheukwumere and Herbert, 2003), fasting (Lamosova *et al*., 2004), age (Furlan *et al*., 1999; Naziefy-Habibabadi, 1997; Seiser *et al*., 2000), administration of drugs (Khan, *et al*., 1994; Zaman *et al*., 1995), anti-aflatoxin premixes (Oguz *et al*., 2000) and continuous supplementations of vitamin E (Tras *et al*., 2000) affect the blood profiles of healthy birds. Although there is limited information concerning the normal blood profiles of different broiler strains at different ages. However, some haematological studies in birds have been carried out by a number of authors (Levi *et al*., 1989; Uko and Ataja, 1996b; Onifade and Odunsi, 1998; Hauptmanova *et al*., 2002) and a few haematological parameters of some broiler strains (Lohmann, Hubbard and Arbor-Acres) at very limited age of husbandry period have been studied (Qaisar *et al*., 1996).

Reference blood profiles of broiler strains in natural condition on different age of husbandry period are essential for interpretation of haematological tests (Mushi *et al*., 1999; Seiser *et al*., 2000). Therefore, this study was carried out:

a) To determine haematological values including total red blood cells (RBC) and white blood cells (WBC) count, pocked cell volume (PCV), haemoglobin concentration (Hb), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), erythrocyte sedimentation rate (ESR) and differential leukocyte count of the broiler strains during 8 weeks husbandry period.
b) To compare blood profiles of these genetically improved broiler strains with each other.

This study differs from previous studies in some aspects; a) covers whole breeding period as well as after hatch, b) includes nearly all parameters of haemogram and leukogram, c) focuses on the main broiler strains.

## Materials and Methods

**Birds:** Eighty one-day old broiler chicks (20 chicks from each of four broiler strains including Ross–308, Cobb-500, Arian, and Arbor-Acres) were purchased. On the first day, the chicks of each strain were divided in two groups randomly (10 chicks per group). After leg labeling, the chicks were housed in cages and according to their strains, fed *ad libitum* and kept in separate rooms. Ambient temperature, lighting, ventilation and other environmental conditions fully met the requirements laid down in the technical instructions of each strain for broiler breeding.

**Sampling procedures:** On day 1, blood samples were collected in EDTA anticoagulant treated (Uko and Ataja, 1996a; Odunsi *et al.*, 1999; Iheukwumere and Herbert, 2003) syringes from chicks of group-A of each strain as described (Olorede and Longe, 1999) and were used as blood samples for day-1 of the group-B chicks of the same strain. On day 7, blood samples were collected from jugular veins using 1 ml EDTA treated syringes with 25 gauge needles, on day 14 and at weekly intervals until 56 days old, blood samples were collected from brachial vein as described (Alcorn, 2002; Bermudez and Stewart-Brown, 2003). Blood samples were labeled according to number and strain of chickens and date of sampling.

**Haematological tests:** Haematological parameters such as RBC, WBC, PCV, Hb, MCV, MCH, MCHC, ESR, together with absolute count of heterophils, lymphocytes, monocytes, eosinophils, and basophils as well as H / L ratio were determined by routine methods as previously described (Campbell, 1988).

**Statistical analysis:** One-way ANOVA and Wilcoxon (nonparametric tests, 2 Related Samples) tests were used for analyzing data of each haematological parameter within group and between groups, respectively. Kruskal-Wallis H test was used for comparative analysis of the results within four broiler strains studied. Relationship between age and haematological parameters contents were ascertained by means of Spearman correlation coefficient test.

## Results

The results of haematological examinations were given in mean ± standard error mean for each value. Regardless to the broiler strains, as shown in Table 1 and 2, the results may be categorized as:

**Erythrocytic values:** The erythrocytic parameters (except of MCHC) differed significantly ($P<0.05$) between groups of age. With increasing of age, the haematological values such as RBC, PCV, Hb and ESR contents were significantly increased ($P<0.05$), while erythrocytic indices such as MCV and MCH contents were significantly decreased ($P<0.05$) during breeding period as shown in Table 1. MCHC of all the broiler strains fluctuated in this study. There was a significant correlation between age and erythrocytic values of both the broiler strains ($P<0.05$).

In regard to Ross broiler strain, correlation was positive for RBC (r = 0.75), PCV (r = 0.64), HB (r = 0.80) and ESR (r = 0.45), but it was negative for MCV (r = -0.57) and MCH (-0.53).

In regards to Cobb broiler strain, correlation was positive for RBC (r = 0.74), PCV (r = 0.72), Hb (r = 0.83) and ESR (r = 0.37), but it was negative for MCV (r = -0.52) and MCH (-0.39).

In regard to Arian broiler strain, correlation was positive for RBC (r = 0.79), PCV (r = 0.73), Hb (r = 0.92), MCV (r = 0.73) and MCH (r = 0.64).

In regards to Arbor-Acres broiler strain, correlation was positive for RBC (r = 0.72), PCV (r = 0.71) and Hb (r = 0.75), but it was negative for MCV (r = -0.5) and MCH (-0.43). Comparison of individual erythrocytic parameter values of the broiler strains with each other showed slight but not significant ($P>0.05$) differences.

**Leukocytic values:** The leukocytic components differed significantly within groups of age ($P<0.01$). As shown in Table 2, with increasing of age, total numbers of WBC and lymphocytes together with absolute counts monocytes, eosinophils and basophils were significantly increased ($P<0.01$), but absolute counts of heterophils and H / L ratio were significantly decreased ($P<0.01$). There was a significant correlation between age and leukocytic parameters of both the broiler strains ($P<0.01$).

In regard to Ross broiler strain, correlation was positive for WBC (r = 0.89), lymphocytes (r = 0.94), monocytes (r = 0.95), eosinophils (r = 0.87) and basophils (r = 0.77) but correlation between age and absolute count of heterophils as well as H / L ratio were negative (r = -0.94).

In regards to Cobb broiler strain, correlation was positive for WBC (r = 86), lymphocytes (r = 0.93), monocytes (r = 0.90), eosinophils (r = 0.85) and basophils (r = 0.81) but correlation between age and absolute count of heterophils (r = -0.95) as well as H / L ratio (r = -0.93) were negative.

In regards to Arian broiler strain, correlation was positive for WBC (r = 0.93), lymphocytes (r = 0.94), monocytes (r = 0.97), eosinophils (r = 0.99) and basophils (r = 0.98), but correlation between age and absolute count of heterophils as well as H / L ratio were negative (r=-0.94).

In regards to Arbor-Acres strain, correlation was positive

Table 1: Haemogram of Arian (A), Arbore-Acres (AA), Ross (R) and Cobb (C) broiler strains (Mean ± SEM)

| Age (days) | Strain | RBC ($x10^6$/µL) | PCV (%) | Hb (g/dl) | MCV (fl) | MCH (Pg) | MCHC (%) | ESR (mm/h) |
|---|---|---|---|---|---|---|---|---|
| 1 | A | 2.19 ± 0.05 | 28.6 ± 1.8 | 7.5 ± 0.67 | 120.4 ± 0.6 | 34.9 ± 3.6 | 23.4 ± 1.51 | 3.0 ± 0.0 |
| | AA | 2.14 ± 0.06 | 28.28 ± 0.7 | 12.19 ± 0.2 | 132.3±3.3 | 57.11±1.56 | 43.22±1.09 | 3.05±0.3 |
| | C | 2.04 ± 0.1 | 27.43 ± 0.97 | 11.84 ± 0.23 | 132.28 ± 4.0 | 58.14 ± 2.79 | 43.4 ± 0.94 | 3.0 ± 0.1 |
| | R | 1.97 ± 0.08 | 28.28 ± 0.7 | 11.98 ± 0.27 | 144.26 ± 3.88 | 61.58 ± 1.46 | 42.37 ± 0.68 | 3.0 ± 0.01 |
| 7 | A | 2.21 ± 0.09 | 29.5 ± 0.57 | 8.2 ± 0.8 | 118.0 ± 2.64 | 35.9 ± 1.3 | 25.7 ± 3.72 | 3.0 ± 0.0 |
| | AA | 2.29 ± 0.1 | 28.57 ± 0.8 | 12.78 ± 0.17 | 125.6±4.35 | 56.32±2.06 | 44.85±1.03 | 3.11±0.6 |
| | C | 2.08 ± 0.1 | 27.58 ± 0.96 | 11.86 ± 0.31 | 132.02 ± 4.76 | 56.57 ± 1.58 | 42.61 ± 1.12 | 3.05 ± 0.03 |
| | R | 2.12 ± 0.15 | 29 ± 0.84 | 12.25 ± 0.23 | 140.37 ± 8.71 | 60 ± 4.25 | 42.3 ± 0.52 | 3.02 ± 0.02 |
| 14 | A | 2.73 ± 0.43 | 31.3 ± 0.7 | 9.5 ± 0.89 | 125.5 ± 0.5 | 36.6 ± 0.57 | 27.1 ± 2.47 | 3.0 ± 0.0 |
| | AA | 2.35 ± 0.12 | 29.4 ± 0.15 | 13.06 ± 0.32 | 125.7±3.06 | 55.85±1.54 | 44.6±1.34 | 3.03±0.04 |
| | C | 2.14 ± 0.14 | 28.14 ± 1.07 | 12 ± 0.33 | 130.62 ± 3.41 | 56.14 ± 1.05 | 42.65 ± 0.66 | 3.08 ± 0.05 |
| | R | 2.26 ± 0.12 | 29 ± 0.84 | 12.95 ± 0.18 | 129.81 ± 3.21 | 58.42 ± 2.02 | 44.77 ± 0.73 | 3.02 ± 0.03 |
| 21 | A | 2.74 ± 0.41 | 32.3 ± 1.5 | 10.2 ± 0.51 | 113.4 ± 2.31 | 36.6 ± 2.1 | 28.5 ± 1.20 | 3.0 ± 0.0 |
| | AA | 2.39 ± 0.09 | 30.7 ± 0.86 | 13.19 ± 0.25 | 129.0±5.48 | 55.37±2.04 | 43.01±0.98 | 3.27±0.09 |
| | C | 2.34 ± 0.49 | 29.0 ± 0.92 | 12.23 ± 0.3 | 126.58 ± 6.1 | 54.51 ± 3.32 | 41.57 ± 0.78 | 3.1 ± 0.07 |
| | R | 2.33 ± 0.09 | 29.57 ± 0.1 | 13.09 ± 0.12 | 129.41 ± 4.38 | 57 ± 1.75 | 44.67 ± 0.8 | 3.08 ± 0.05 |
| 28 | A | 2.79 ± 0.48 | 32.8 ± 2.9 | 12.6 ± 0.79 | 113.8 ± 0.52 | 46.8 ± 2.9 | 34.6 ± 2.63 | 3.0 ± 0.0 |
| | AA | 2.5 ± 0.15 | 31.0 ± 0.37 | 13.42 ± 0.64 | 123.8±6.98 | 52.88±3.54 | 43.21±1.93 | 3.11±0.06 |
| | C | 2.38 ± 0.12 | 29.85 ± 0.5 | 12.77 ± 0.3 | 124.81 ± 5.75 | 53.41 ± 0.31 | 42.87 ± 1.37 | 3.1 ± 0.05 |
| | R | 2.42 ± 0.12 | 30.14 ± 0.46 | 13.38 ± 0.3 | 128.26 ± 6.98 | 56.14 ± 2.15 | 43.93 ± 0.44 | 3.08 ± 0.06 |
| 35 | A | 2.86 ± 0.34 | 33.1 ± 2.9 | 13.3 ± 0.84 | 115.8 ± 0.14 | 47.6 ± 5.2 | 42.4 ± 2.18 | 3.0 ± 0.0 |
| | AA | 2.8 ± 0.19 | 32.14 ± 0.1 | 13.52 ± 0.1 | 116.6±4.31 | 48.94±2.87 | 42.25±1.13 | 3.17±0.06 |
| | C | 2.17 ± 0.15 | 31.28 ± 1.01 | 13.48 ± 0.21 | 120.22 ± 4.69 | 53.0 ± 2.09 | 43.17 ± 0.84 | 3.15 ± 0.04 |
| | R | 2.83 ± 0.09 | 31.0 ± 0.82 | 13.46 ± 0.26 | 125.44 ± 4.28 | 53.34 ± 0.6 | 42.61 ± 0.54 | 3.13 ± 0.05 |
| 42 | A | 2.88 ± 0.23 | 34.0 ± 1.0 | 13.7 ± 0.7 | 118.4 ± 0.57 | 48.5 ± 1.2 | 45.4 1.27 | 3.0 ± 0.0 |
| | AA | 2.85 ± 0.12 | 32.71 ± 0.94 | 13.95 ± 0.22 | 114.9±1.5 | 49.84±1.09 | 42.75±0.68 | 3.21±0.04 |
| | C | 2.82 ± 0.14 | 32.0 ± 0.81 | 14.11 ± 0.2 | 119.01 ± 1.0 | 50.62 ± 1.46 | 43.45 ± 0.78 | 3.18 ± 0.05 |
| | R | 2.84 ± 0.18 | 31.71 ± 1.32 | 13.94 ± 0.25 | 120.11 ± 0.4 | 51.04 ± 1.59 | 43.07 ± 1.13 | 3.17 ± 0.05 |
| 49 | A | 2.9 ± 0.24 | 35.2 ± 0.4 | 15.4 ± 0.84 | 121.7 ± 0.74 | 52.7 ± 4.2 | 46.2 ± 0.68 | 3.0 ± 0.0 |
| | AA | 2.91 ± 0.1 | 33.0 ± 0.53 | 14.5 ± 0.23 | 114.1±2.53 | 50.8 ± 0.76 | 43.97 ± 0.34 | 3.34±0.03 |
| | C | 2.9 ± 0.14 | 32.28 ± 1.04 | 14.25 ± 0.4 | 113.95 ± 2.79 | 50.45 ± 1.89 | 44.27 ± 0.72 | 3.18 ± 0.04 |
| | R | 2.97 ± 0.07 | 32.43 ± 1.06 | 14.1 ± 0.38 | 115.65 ± 2.3 | 50.74 ± 2.4 | 43.48 ± 0.4 | 3.18 ± 0.07 |
| 56 | A | 2.94 ± 0.41 | 37.7 ± 1.33 | 16.1 ± 0.6 | 127.2 ±1.09 | 54.0 ± 6.6 | 47.2 ± 2.6 | 3.0 ± 0.0 |
| | AA | 3.1 ± 0.05 | 35.71± 0.77 | 15.97 ± 0.24 | 113.84±1.33 | 51.5 ± 0.43 | 44.77±0.35 | 3.21±0.08 |
| | C | 3.0 ± 0.04 | 35.71 ± 0.68 | 16.03 ± 0.23 | 111.88 ± 1.99 | 49.37 ± 1.73 | 45.08 ± 0.43 | 3.27 ± 0.06 |
| | R | 3.06 ± 0.15 | 35.43 ± 0.84 | 15.85 ± 0.25 | 113.74 ± 3.38 | 48.34 ± 1.26 | 45.05 ± 0.64 | 3.27 ± 0.05 |
| Average | A | 2.69 ± 0.09 | 32.72 ± 0.93 | 11.83 ± 1.0 3 | 117.91±1.57 | 43.73 ± 2.56 | 35.61±3.24 | 3.0 ± 0.0 |
| | AA | 2.59 ± 0.05 | 31.28 ± 0.16 | 13.62 ± 0.16 | 121.75±1.49 | 53.18 ± 0.72 | 43.62±0.36 | 3.18±0.02 |
| | C | 2.49 ± 0.05 | 30.39 ± 0.42 | 13.17 ± 0.19 | 123.49 ± 1.58 | 53.58 ± 0.71 | 43.23 ± 0.3 | 3.12 ± 0.1 |
| | R | 2.53 ± 0.06 | 30.73 ± 0.39 | 13.44 ± 0.16 | 127.45 ± 1.92 | 55.18 ± 0.87 | 43.58 ± 0.25 | 3.1 ± 0.02 |

Table 2: Leukogram of Arian (A), Arbore-Acres (AA), Ross (R) and Cobb (C) broiler strains (Mean ± SEM)

| Age (days) | Strain | WBC ($x10^3$/µL) | Heterophils ($X10^3$/µL) | Lymphocytes ($X10^3$/µL) | Ratio H/L | Monocytes ($X10^3$/µL | Eosinophils ($X10^3$/µL) | Basophils ($X10^3$/µL) |
|---|---|---|---|---|---|---|---|---|
| 1 | A | 20.45 ± 0.51 | 7.11 ± 0.49 | 5.52 ± 0.37 | 1.23 ± 0.10 | 0.36 ±0.26 | 0.85 ± 0.05 | 0.75 ± 0.10 |
| | AA | 20.09 ± 0.05 | 10.68 ± 0.19 | 8.57 ± 0.9 | 1.65 ± 0.08 | 0.58 ± 0.08 | 0.6 ± 0.04 | 1.67 ± 0.05 |
| | C | 20.65 ± 0.13 | 10.54 ± 0.22 | 6.9 ± 0.14 | 1.48 ± 0.07 | 0.6 ± 0.02 | 0.6 ± 0.07 | 1.71 ± 0.05 |
| | R | 20.45 ± 0.13 | 10.6 ± 0.22 | 6.67 ± 0.18 | 1.54 ± 0.07 | 0.63 ± 0.03 | 0.6 ± 0.07 | 1.17 ± 0.06 |
| 7 | A | 21.83 ± 0.81 | 6.86 ± 0.15 | 6.76 ± 0.39 | 1 ± 0.15 | 0.55 ± 0.19 | 0.62 ± 0.01 | 0.83 ± 0.31 |
| | AA | 20.39 ± 0.12 | 9.82 ± 0.15 | 8.6 ± 0.14 | 1.14 ± 0.04 | 0.6 ± 0.04 | 0.67 ± 0.05 | 1.77 ± 0.14 |
| | C | 20.99 ± 0.21 | 10.11 ± 0.15 | 7.4 ± 0.20 | 1.47 ± 0.09 | 0.62 ± 0.05 | 0.71 ± 0.07 | 1.97 ± 0.07 |
| | R | 20.62 ± 0.14 | 9.87 ± 0.12 | 7.17 ± 0.17 | 1.34 ± 0.04 | 0.64 ± 0.01 | 0.73 ± 0.08 | 1.9 ± 0.08 |
| 14 | A | 21.90 ± 0.41 | 6.82 ± 0.41 | 10.53 ± 0.64 | 0.65 ± 0.09 | 0.61 ± 0.31 | 0.80 ± 0.23 | 0.96 ± 0.63 |
| | AA | 21.01 ± 0.2 | 8.67 ± 0.18 | 8.85 ± 0.15 | 0.94 ± 0.03 | 0.65 ± 0.03 | 0.7 ± 0.07 | 2.22 ± 0.13 |
| | C | 21.32 ± 0.16 | 8.78 ± 0.16 | 8.98 ± 0.16 | 0.95 ± 0.04 | 0.65 ± 0.06 | 0.74 ± 0.36 | 2.14 ± 0.05 |
| | R | 21.06 ± 0.14 | 8.68 ± 0.17 | 8.88 ± 0.15 | 0.94 ± 0.04 | 0.65 ± 0.06 | 0.74 ± 0.04 | 2.14 ± 0.04 |
| 21 | A | 22.49 ± 0.31 | 6.75 ± 0.41 | 13.34 ± 1.26 | 0.50 ± 0.05 | 0.91 ± 0.19 | 0.91 ± 0.22 | 1.30 ± 0.29 |
| | AA | 21.77 ± 0.12 | 8.38 ± 0.8 | 9.37 ± 0.13 | 0.84 ± 0.02 | 0.71 ± 0.02 | 0.71 ± 0.07 | 2.23 ± 0.05 |
| | C | 21.54 ± 0.27 | 8.34 ± 0.13 | 9.27 ± 0.16 | 0.84 ± 0.02 | 0.72 ± 0.05 | 0.8 ± 0.06 | 2.22 ± 0.04 |
| | R | 21.81 ± 0.15 | 8.45 ± 0.06 | 9.41 ± 0.13 | 0.85 ± 0.02 | 0.8 ± 0.04 | 0.77 ± 0.05 | 2.26 ± 0.06 |
| 28 | A | 22.74 ± 0.55 | 6.44 ± 0.90 | 13.58 ± 1.15 | 0.48 ± 0.02 | 0.93 ± 0.24 | 0.97 ± 0.11 | 1.35 ± 0.12 |
| | AA | 22.62 ± 0.14 | 6.83 ± 0.04 | 10.92 ± 0.014 | 0.68 ± 0.05 | 1.23 ± 0.05 | 1.04 ± 0.04 | 2.31 ± 0.04 |
| | C | 21.87 ± 0.11 | 7.44 ± 0.11 | 9.92 ± 0.16 | 0.7 ± 0.02 | 0.88 ± 0.05 | 0.9 ± 0.04 | 2.43 ± 0.07 |
| | R | 21.99 ± 0.18 | 7.45 ± 0.16 | 9.99 ± 0.17 | 0.7 ± 0.02 | 0.91 ± 0.07 | 0.91 ± 0.05 | 2.28 ± 0.06 |
| 35 | A | 23.38 ± 1.26 | 5.67 ± 1.5 | 15.48 ± 1.51 | 0.36 ± 0.04 | 0.93 ± 0.44 | 1.11 ± 0.25 | 1.38 ± 0.38 |
| | AA | 23.89 ± 0.62 | 6.5 ± 0.11 | 14.24 ± 0.85 | 0.46 ± 0.02 | 1.3 ± 0.02 | 1.25 ± 0.06 | 2.37 ± 0.1 |
| | C | 24.07 ± 0.78 | 6.52 ± 0.07 | 14.24 ± 0.71 | 0.53 ± 0.06 | 1.23 ± 0.02 | 1.27 ± 0.04 | 2.47 ± 0.07 |
| | R | 23.49 ± 1.04 | 6.45 ± 0.08 | 15.0 ± 1.11 | 0.51 ± 0.07 | 1.2 7 ± 0.03 | 1.35 ± 0.03 | 2.32 ± 0.07 |
| 42 | A | 25.74 ± 1.29 | 4.90 ± 0.75 | 15.90 ± 2.48 | 0.30 ± 0.04 | 1.09 ± 0.48 | 1.30 ± 0.14 | 1.73 ± 0.40 |
| | AA | 25.53 ± 0.4 | 6.32 ± 0.16 | 16.06 ± 0.79 | 0.4 ± 0.02 | 1.32 ± 0.02 | 1.30 ± 0.05 | 2.49 ± 0.08 |
| | C | 24.99 ± 1.05 | 6.45 ± 0.13 | 15.0 ± 0.99 | 0.44 ± 0.03 | 1.32 ± 0.02 | 1.33 ± 0.01 | 2.48 ± 0.08 |
| | R | 26.18 ± 0.77 | 6.51 ± 0.12 | 16.62 ± 0.75 | 0.39 ± 0.02 | 1.3 7 ± 0.06 | 1.42 ± 0.04 | 2.42 ± 0.06 |
| 49 | A | 29.16 ± 1.37 | 4.70 ± 0.75 | 19.14 ± 0.49 | 0.23 ± 0.0 | 1.25 ± 0.11 | 1.36 ± 0.34 | 1.83 ± 0.55 |
| | AA | 27.22 ± 0.73 | 6.2 ± 0.18 | 15.57 ± 0.72 | 0.35 ± 0.02 | 1.42 ± 0.02 | 1.33 ± 0.01 | 2.47 ± 0.09 |
| | C | 27.82 ± 0.65 | 6.34 ± 0.18 | 17.6 ± 0.83 | 0.36 ± 0.02 | 1.42 ± 0.05 | 1.35 ± 0.03 | 2.49 ± 0.05 |
| | R | 28.86 ± 0.38 | 6.47 ± 0.09 | 19.11 ± 0.47 | 0.33 ± 0.01 | 1.54 ± 0.04 | 1.58 ± 0.05 | 2.47 ± 0.09 |
| 56 | A | 29.70 ± 0.61 | 3.33 ± 0.70 | 19.19 ± 2.41 | 0.18 ± 0.01 | 1.36 ± 0.35 | 1.57 ± 0.12 | 2.60 ± 0.30 |
| | AA | 30.13 ± 0.27 | 5.79 ± 0.27 | 21.47 ± 0.85 | 0.27 ± 0.02 | 1.47 ± 0.02 | 1.39 ± 0.03 | 2.51 ± 0.09 |
| | C | 30.04 ± 0.39 | 5.55 ± 0.12 | 19.99 ± 0.53 | 0.28 ± 0.01 | 1.48 ± 0.03 | 1.62 ± 0.03 | 2.66 ± 0.07 |
| | R | 30.1 ± 0.5 | 5.53 ± 0.16 | 20.36 ± 0.27 | 0.27 ± 0.01 | 1.68 ± 0.08 | 1.71 ± 0.05 | 2.48 ± 0.08 |
| Average | A | 24.15 ± 1.10 | 5.84 ± 0.43 | 13.3 ± 1.64 | 0.54 ± 0.11 | 0.88 ± 0.10 | 1.02 ± 0.11 | 1.35 ± 0.15 |
| | AA | 23.63 ± 0.42 | 7.69 ± .22 | 12.68 ± 0.61 | 0.77 ± 0.06 | 1.03 ± 0.05 | 1.01 ± 0.04 | 2.23 ± 0.05 |
| | C | 23.7 ± 0.43 | 7.78 ± 0.2 | 12.14 ± 0.58 | 0.78 ± 0.05 | 0.99 ± 0.04 | 1.03 ± 0.04 | 2.29 ± 0.04 |
| | R | 23.84 ± 0.46 | 7.78 ± 0.21 | 12.58 ± 0.65 | 0.76 ± 0.05 | 1.05 ± 0.05 | 1.09 ± 0.05 | 2.22 ± 0.04 |

for WBC (r = 0.92), lymphocytes (r = 0.90), monocytes (r = 0.91), eosinophils (r = 0.84) and basophils (r = 0.71), but correlation between age and absolute count of heterophils as well as H / L ratio were negative (r = -0.94).

In comparison of individual leukogram parameter values of these broiler strains with each other showed slight but not significant differences among them.

## Discussion

Available information indicate that haematological values of avian species are also significantly influenced by poultry diseases including fowl typhoid (Kokosharov and Todorova, 1987), mycoplasmosis (Branton *et al.*, 1997; Burnham *et al.*, 2003), avian coccidiosis (Koinarski *et al.*, 2001), infectious bursal disease (Panigraphy *et al.*, 1986; Juranova *et al.*, 2001), Newcastle disease (Galindo-Muniz *et al.*, 2001) and toxoplasmosis (Kaneto *et al.*, 1997). On the other hand, the intensive husbandry system of poultry industry excludes the most effective factors in alternation of blood parameters values by offering almost the same husbandry conditions and nearly same dietary programs using the nutrients which are available world-wide. Therefore, intensive poultry husbandry system have provided a suitable atmosphere for using reference blood profiles of broiler chickens world-wide for interpretation of haematological analyses in regards to immunological status of birds (Seiser *et al.*, 2000), predicting susceptibility for ascites in broiler strains (Luger *et al.*, 2001; Scheele *et al.*, 2003a; Scheele *et al.*, 2003b), predicting potential resistance to environmental conditions (Silversides *et al.*, 1997), estimation of body weights in future (Singh *et al.*, 1998), diagnosis of diseases (Latimer *et al.*, 1988; Goodwin *et al.*, 1991), evaluation of health disorders already at the pre-clinical stage (Harper and Lowe, 1998), developing new broiler strains that genetically resistant to poultry diseases (Shlosberg *et al.*, 1996) and hastail environmental conditions (Silversides *et al.*, 1997). Haematological parameters contents observed in these genetically improved broiler strains were lower than those reported for indigenous chickens (Sturki, 1986; Uko and Ataja, 1996b; Mushi *et al*, 1999; Iheukwumere and Herbert, 2003) indicating that blood profiles varied among different breeds and while haemogram of these strains remained almost unchanged but there is difference in leukogram of genetically developed strains with indigenous chickens as previously described (Islam *et al.*, 2004). Since the white blood cells in the avian species, in general, serve to phagocytic function similar to their mammalian counterparts (Campbell and Coles, 1986) and differential leukocyte count as well as H / L ratio were used as indicators of stress response and sensitive biomarkers crucial to immune function (Shaniko, 2003), therefore, low leukogram of genetically developed new strains may be a reason behind their high susceptibility to avian pathogenic agents when compared with indigenous chickens which are relatively resistant to poultry diseases.

Haemograms and leukograms observed in this study for Ross and Cobb broiler strains contrasted to some extent with those of the other genetically developed broiler strains such as Hubbard (Odunsi *et al.*, 1999), indicating the differences between these genetically developed broiler lines as previously described (Manzoor *et al.*, 2003). Comparison of individual haematological values of the four broiler strains, showed slight but no significant (P>0.05) differences, indicating the new developed broiler strains are nearly similar to each other in haematological parameters. Haematological parameters contents have been seen in this study for Arian strains were almost in agreement with those reported by Zinkl (1986) but absolute count of basiphils was slightly higher than that observed by Naziefy-Habibabadi and Saloky (1992). Erythrocytic parameters observed in this study for Arbor-Acres broiler strain differed from the results obtained by Naziefy-Habibabadi (1997) and the ESR value was almost half of that previously reported (Sturki, 1986; Naziefy-Habibabadi, 1997).

The age-related haematologic profile in broiler strains observed in this study has also been documented in different breeds of chickens (Islam *et al.*, 2004), adolescent cocks (Kral and Suchy, 2000) and pigeons (Seiser *et al.*, 2000). The high correlation between age and haematological parameters contents of Ross, Cobb, Arian and Arbor-Acres broiler strains indicates that in using the blood profiles of chickens as a reference for diagnostic purposes, the age of birds should be considered as an important criterion in this regard. Fluctuation of MCHC, which has been observed for the all broiler strains during this study, has also been reported (Kral and Suchy, 2000, Islam *et al.*, 2004).

Negative correlation between age and absolute count of heterophils (r = -0.95) as well as H / L ratio has been observed in this study is in agreement with those reported (Alodan and Mashaly, 1999). The H / L ratio quantifies the balance between the non-specific, fast-acting defenses of heterophils and the antigen specific, slower-acting defenses of lymphocytes (Shaniko, 2003). Therefore, H / L ratio is considered as a sensitive haematological indicator of stress response among chickens' populations (Graczyk *et al.*, 2003) and as a general biomarker relevant to immune function (Shaniko, 2003) in poultry.

In conclusion, the present study indicated that: 1) Age affects the haematological profiles of all broiler strains. 2) These effects were positive on haemogram (except MCV, MCH and MCHC) and leukogram (except heterophils and H / L ratio). 3) Haemogram and leukogram of these genetically improved broiler strains were slightly differed from each other, but the differences were not significant (P>0.05).

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