J. Product. & Dev.,30(2):267- 281(2025)

Immunity, Haematology and Biochemical analysis of Ross 308 and Avian 48 Broiler Strains under Different Egyptian Environmental Conditions and Housing Systems

Kamal Eid[1];Sherin Gabr[1] and Ahmed Gouda[2]
[1.] Animal Production Research Institute, Agriculture Research Center, Dokki, 12619. Giza, , Egypt
[2.]National Research Center, Ministry of Higher Education, Dokki, Giza, 12622, Egypt

ABSTRACT

Two genotypes of poultry (Ross 308 and Avian 48) in two housing systems (semi-closed and open system) in two different seasons (winter and summer) as Completely Randomized design for eight treatment groups were utilized to study immunity, haematology and biochemical traits.

These results showed that Ross and Avian genotypes raised in open system in summer showed highest values of immunity, haematology and biochemical traits. The results indicate that heat stress by summer season, especially for birds raised in open system, which is lacking the control in heat stress, resulting in improving immunity, haematology and biochemical values.

The present study findings are a good indicator of strain preferences under specific Egyptian conditions. Outcomes can be used by local farmers, as well as breeders who wish to further improve specific strains for different conditions.

***Conclusively,** the present results showed that Ross 308 and Avian 48 broilers raised under open system in summer performed better immunity and haematology than other groups under Egyptian subtropical conditions, while Ross 308 and Avian 48 broilers raised under open system and semi-closed system in summer and winter, respectively, performed better biochemical than other groups. Therefore, it is recommended that Ross 308 and Avian 48 broilers should be raised under open system with stocking density of 10 birds/m^{2}in summer. The study reveals significant differences in haematology and biochemical traits and immune responses between eight combinations, highlighting the importance of genetic and environmental factors in determining their immunological capabilities and suggesting future research to identify specific markers for enhanced immune function.*

Key words: Biochemical, Hematology, Immunity, Stocking density, Ross 308, Avian 48.

INTRODUCTION

Broilers breeding is very important for smallholder in Egypt. In tropical and subtropical countries, blood parameters and immunity traits is affecting body phonology and consider more important than growth performance traits and carcass characteristics for broilers breeding. According to Olanrewaju *et al.*,(2009), exposure broilers to tropical and suboptimal environmental factors affects blood physiological variables like blood acid-base balance, electrolytes, and metabolites. Blood hematological and biochemical profiles reflect the body's physiological state (Khan *et al.*,2014) and blood hematological and biochemical composition is used to evaluate metabolic diseases in poultry (Ibrahim *et al.* 2018). Moreover, hematological and biochemical analyses can help prevent future health issues by monitoring treatment effectiveness, determining drug toxicity, and providing prognosis (Alimi *et al.*, 2020). Furthermore, stress in poultry can alter metabolic metabolism which influence on serum biochemical composition by decrease or increase levels of cholesterol, glucose, and albumin.

Many factors including genotype, housing system, stocking density and environmental factors such as climate, feeding and managements have direct or/and indirect effects on broilers economic traits. Pompeu *et al.* (2018) reported that environmental stressors such as stocking density, temperature, and humidity are among the most important factors affecting the performance of the broiler industry. Genetic and environmental factors influence chicken biochemical and hematological parameters in serum (Nse Abasi *et al.*, 2014). Manzoor *et al.* (2003) has suggested that hematologic and biochemical parameters in broilers may be affected by genotype as well as by sex, feed, management and stress factors. Stocking density is well documented as a critical stressor in intensive poultry production because it is associated with an increase in stress hormones, which result in turbulences in hemato-biochemical parameters like Hb, heterophil-lymphocyte ratio (H/L), glucose, cholesterol, total protein, total albumin and triglyceride levels (Onbasilar*et al.*, 2008; Rambau *et al.*, 2016). Immune response in grower chickens affected by environmental temperatures where cellular immunity that represented in white blood cells and heterophils/lymphocyte ratio were affected by heat stress (Mashaly *et al.*, 2004). Cool temperature exhibited significant changes at five weeks of age in red blood cell counts, hemoglobin and hematocrit (Ipek and Sahan, 2006). On the other hand heat stress reduced antibody production in grower chickens (Zulkifi *et al.*, 2000). Ali Olfati *et al.* (2018) reported that cold and heat stress decreased antibody titer, lymphocyte count and increased heterophils and heterophils/lymphocyte ratio. In general cold stress caused retardation in immune function (Zhao *et al*., 2014).

Birds have an additional mechanism to promote heat exchange between their body and the environment, which are the air sacs. Air sacs are very useful during panting, as they promote air circulation on surfaces contributing to increase gas exchanges with the air, and consequently, the evaporative loss of heat (Fedde, 1998).Body temperature and metabolic activity are regulated by the thyroid hormones, Triiodothyronine (T3) and thyroxin (T4), and their balance.

Therefore, this study aimed to evaluate the effect of genotype, housing system and environmental condition on the immunity, hematology and biochemical parameters under Egyptian condition, as Ross 308 and Avian 48 breeds were studied under two different housing system (semi-closed and open system) in two different environments (winter and summer).

MATERIALS AND METHODS

1. *Ethics statement*

The ethical considerations for animal use and animal welfare that enforce good scientific quality and human treatment of animals were reviewed and approved by the Institutional Animal Care and Use Committee (ARC-IACUC) of Agricultural Research Center with approval number 2023/ARC-AHRI-63-23, Cairo, Egypt on September 27, 2023according to the Administration of Affairs Concerning Experimental Animals Regulations (Egypt, 1981). All efforts were made during blood collection and chicken slaughtering to minimize any discomfort.

2. *Animals management and diets*

The study was performed at a private poultry farm located in Ismailia governorate, North Eastern, Egypt. A total of 280 day-old Ross 308 and Avian 48 chicks without naturalization were randomly selected and distributed to four groups (n=70). The birds were housed separately per strain and reared on deep litter in two types of farming system; semi-closed system with stoking density of 14 birds/m^2 and open system with stoking density of 10 birds/m^2.The experiment was repeated twice in two different season, summer (July and August) and winter (January and February).Chicks were vaccinated against Newcastle, Gumboro and Infectious Bronchitis diseases, and no health problems were observed during the experiment. Minimum and maximum temperatures and humidity were recorded in day and night for each facility during both seasons. The temperature and humidity were ranged from 17-32 °C with an average of 24.5 °C and 33-60% with an average of 46.5%at day, respectively, and were ranged from 15-30 °C with an average of 22.5 °C and 43-65% with an average of 53.7% at night, respectively, in winter. They were ranged from 24-36 °C with an average of 30 °C and 23-50% with an average of 36.5%at day, respectively, and were ranged from 17-32 °C with an average of 24.5 °C and 38-60% with an average of 48.7%at night, respectively, in summer.

The birds were fed a commercial broiler starter diet contains 23% curd protein and 2950 k.cl for 15 days of age, grower diet contains 21% curd protein and 3150 k.cl for 28 days of age and finisher diet contains 19% curd protein and 3250 k.cl for 35 days of age and the diets were formulated according to the nutrient recommendations (NRC, 2007).The birds were allowed *ad libitum* access to the feed and water. Lighting was provided 24 hours a day by 40 W fluorescent tubes throughout the study period.

3. *Immunity, hematology and biochemical traits*

Ten birds from each group were selected for blood parameters. At age 14, 21, 28 and 35 days, one blood samples were getting from wing vein to measure immunity parameters such as AbNDV, AbH5V and AbH9V at same ages using ELISA method.

At age 35 days, one blood samples were getting from wing vein the blood samples underwent centrifugation at 3500 rpm for 10 min at 4 ◦C, and the resulting plasma was preserved in a deep freezer at approximately -20 ◦C until it was ready for chemical analysis. Commercial kits based on a method developed by Gornall *et al.* (1949) were utilized to measure plasma protein fractions including total protein (TP), albumin (AL), globulin (GL), and albumin /globulin (A/G) ratio. Additionally, the total lipid profile including total cholesterol (Ch), triglycerides (TRI), low-density lipoproteins (LDL), and high-density lipoproteins (HDL) were measured. Liver enzymes such as aspartate aminotransferase (AST) and alanine aminotransferase (ALT), as well as kidney function tests including creatinine (Cr) and uric acid (UA), were also measured using a colorimetric approach (Sirois, 2014). Assessment of triiodothyronine (T3) and thyroxine (T4) hormones. The quantities of T3 and T4 in serum samples were determined by using radioimmunoassay (RIA) kits adhering to the manufacturer’s instructions, as outlined in the methods described by Renden *et al.* (1994).

Haematology parameters such as WBC, Heterophony, Lymphocyte, H/Lratio, Monocyte, Eosinophils, Basophils, Hb, RBC, PCV, MCV, MCH, MCHC and ESR values according to previously described methods (Campbell, 1988). .

4. *Statistical analysis*

The study were analyzed using General linear model (GLM) procedure of Statistical Analysis Software Model (SAS, 2009).The following statistical analysis model as Completely Randomized design for eight treatment group according to Snedecor and Cochran (1982)were used for the analysis:

$$Y_{ij} = \mu + A_i + e_{ij},$$

Where Y_{ij} is the broiler's performance of the l^{th} chick in the i^{th} combination of strain, housing system and breeding season; μ is the overall mean; A_i is the effect of the i^{th} combination of strain, housing system and breeding season (i=1 to 8), and e_{ij} is the effect of the random error associated with the l^{th} individual assumed to be normally distributed $(0, I\sigma^2)$.

Differences between mean values of strains and dietary treatments were obtained by Duncan's Multiple Range Test (Duncan, 1955). Differences were considered statistically significant at $P<0.05$. The results were presented as least square means along with their standard errors (LSM±SE).

RESULTS AND DISCUSSION

1. Immunity Traits

The effect of genotype, housing system (stocking density) and breeding season on the immunity parameters on 14, 21, 28 and 35 days of age were analysis using one way ANOVA. Our results showed that Ross and Avian raised under open system in summer reported heights values for immunity parameters. Ross raised under open system in summer showed highest values for AbNDV, AbH5V and AbH9V at 14 and 28 days, while Avian raised under open system in summer showed highest values for AbNDV, AbH5V and AbH9V at 21, 28 and 35days. We can concluded that Ross raised under open system have more immunity system than Avian till 14 days of age and Avian have more immunity system than Ross till the end of experiment. It should be noted that Ross and Avian raised under open system in winter should also high values of AbNDV, AbH5V and AbH9V at 28 days (Table 1).

The present results showed that Ross 308 and Avian 48 raised under open system with stocking density of 10 birds/m^2 have major effects on most immunology, hematology and biochemical parameters. It means housing system and environmental conditions have influence more than genotype. For immunity parameters, Ross 308 and Avian 48 raised under open system with stocking density of 10 birds/m^2 have major effects on AbNDV, AbH5V and AbH9V at 14, 21, 28 and 35 days of age. While our study returned the cause of like results to housing system and environmental condition, many studies found the effect of genotypes on immunity parameters such as: Talebi, (2006) who reported that strains have the highest effect on antibody titers except for Bursa disease virus and bronchitis

Table 1: Mean ± standard deviation for the immunity parameters of Ross and Evian 48 strains under different stoking capacity and breeding seasons of Egyptian conditions at age 14, 21, 28 and 35 days.

Strain	Ross 308				Evian 48			
Traits	WCS	WOS	SCS	SOS	WCS	WOS	SCS	SOS
AbNDV14	$2.7^{c}\pm$ 0.105	$2.8^{b}\pm$ 0.11	$2.7^{b}\pm$ 0.11	$2.9^{a}\pm$ 0.11	$2.4^{e}\pm$ 0.11	$2.7^{b}\pm$ 0.11	$2.5^{d}\pm$ 0.11	$2.8^{b}\pm$ 0.11
AbNDV21	$2.9^{d}\pm$ 0.107	$3.0^{b}\pm$ 0.11	$2.9^{c}\pm$ 0.11	$3.1^{b}\pm$ 0.11	$2.6^{e}\pm$ 0.11	$3.1^{b}\pm$ 0.12	$2.7^{d}\pm$ 0.12	$3.2^{a}\pm$ 0.10
AbNDV28	$3.2^{c}\pm$ 0.105	$3.3^{a}\pm$ 0.11	$3.2^{b}\pm$ 0.11	$3.4^{a}\pm0$ .11	$2.9^{e}\pm$ 0.11	$3.3^{a}\pm$ 0.11	$3.0^{d}\pm$ 0.11	$3.4^{a}\pm$ 0.11
AbNDV35	5.1± 0.105	$4.9^{f}\pm$ 0.11	$4.7^{g}\pm$ 0.11	$5.0^{e}\pm$ 0.11	$5.1^{d}\pm$ 0.11	$5.4^{b}\pm$ 0.11	$5.2^{c}\pm$ 0.11	$5.5^{a}\pm$ 0.11
AbH5V14	$2.2^{c}\pm$ 0.105	$2.3^{b}\pm$ 0.11	$2.2^{b}\pm$ 0.11	$2.4^{a}\pm$ 0.11	$1.9^{e}\pm$ 0.11	$2.2^{b}\pm$ 0.11	$2.0^{d}\pm$ 0.11	$2.3^{b}\pm$ 0.11
AbH5V21	$2.6^{d}\pm$ 0.107	$2.7^{b}\pm$ 0.11	$2.6^{c}\pm$ 0.11	$2.8^{b}\pm$ 0.11	$2.3^{e}\pm$ 0.11	$2.8^{b}\pm$ 0.12	$2.4^{d}\pm$ 0.12	$2.9^{a}\pm$ 0.10
AbH5V28	3.0± 0.105	$3.1^{a}\pm$ 0.11	$3.0^{b}\pm$ 0.11	$3.2^{a}\pm$ 0.11	$2.7^{e}\pm$ 0.11	$3.1^{a}\pm$ 0.11	$2.8^{d}\pm$ 0.11	$3.2^{a}\pm$ 0.11
AbH5V35	$4.1^{h}\pm$ 0.106	$4.4^{f}\pm$ 0.11	$4.2^{g}\pm$ 0.11	$4.5^{e}\pm$ 0.11	$4.6^{d}\pm$ 0.11	$4.9^{b}\pm$ 0.11	$4.7^{c}\pm$ 0.11	$5.0^{a}\pm$ 0.11
AbH9V14	$2.3^{c}\pm$ 0.105	$2.5^{b}\pm$ 0.11	$2.4^{b}\pm$ 0.11	$2.6^{a}\pm$ 0.11	$2.1^{e}\pm$ 0.11	$2.4^{b}\pm$ 0.11	$2.2^{d}\pm$ 0.11	$2.5^{b}\pm$ 0.11
AbH9V21	$2.7^{d}\pm$ 0.107	$2.9^{b}\pm$ 0.11	$2.8^{c}\pm$ 0.11	$3.0^{b}\pm$ 0.11	$2.5^{e}\pm$ 0.11	$3.0^{b}\pm$ 0.12	$2.6^{d}\pm$ 0.12	$3.1^{a}\pm$ 0.10
AbH9V28	$3.2^{c}\pm$ 0.105	$3.4^{a}\pm$ 0.11	$3.3^{b}\pm$ 0.11	$3.5^{a}\pm$ 0.11	$3.0^{e}\pm$ 0.11	$3.4^{a}\pm$ 0.11	$3.1^{d}\pm$ 0.11	$3.5^{a}\pm$ 0.11
AbH9V35	$4.3^{h}\pm$ 0.105	$4.6^{f}\pm$ 0.11	$4.4^{g}\pm$ 0.11	$4.7^{e}\pm$ 0.11	$4.8^{d}\pm$ 0.11	$5.1^{b}\pm$ 0.11	$4.9^{c}\pm$ 0.11	$5.2^{a}\pm$ 0.11

^{a,b} Means within a row with different superscripts differ significantly ($P \leq 0.05$).

WCS= Winter close system, WOS= Winter open system, SCS = Summer close system, SOS = Summer close open system, Ab NDV = Antibodies of Newcastle diseases virus, Ab H5N1= Antibodies of avian influenza H5N1, Ab H5N1 =Antibodies of avian influenza H9N2.

virus? Poultry farms are attacked by many major contagious endemic viral diseases, including Newcastle disease (ND), avian influenza (AI), and infectious bronchitis (IB), which cause significant destructive economic effects and deaths in the poultry industry worldwide (Talebi *et al.*, 2015). The theory suggests that higher body weight, often linked to higher body fat percentage, may weaken immune function, as the tendency towards greater antibody response is not offset by the increase in body weight according by (Eid, 2010).

2. Biochemical blood traits

The present result showed that Ross and Avian raised on open and semi-closed system in summer and winter, respectively, showed highest values of most biochemical parameters. Ross raised under open system in summer showed highest values of total protein, Albumin, Globulin, A/G ratio,AST (UL), ALT (UL), T3, T4 and Urea (mg/dl), while Avian raised under semi-closed system in winter showed highest values ofA/G ratio, Triglyceride, HDL, LDL, Creatinine, and Uric acid. In the same times, Globulin showed same values in Ross WOS, Uric acid showed same values in Ross WCS. Also Globulin showed same values in Avian SOS, A/G ratio showed same values in Avian WCS, WOS and SCS, and total cholesterol showed same values in Avian SCS (Table 2).

For biochemical parameters, Ross raised in SOS and Avian Raised in WCS showed highest values for biochemical parameters. Our results may be due to the interaction between genotype, housing system and environmental conditions. Total protein is affected by albumin and total globulin. In total protein in the study was ranged between 5.2 to 6.8 mg/dl. Previous studies have reported broiler blood protein levels of approximately 40 mg/dl (Filipović *et al.,* 2007; Turkyilmaz *et al.*, 2011). Carsia *et al.*(2000) reported that chickens consume blood serum proteins and triglycerides as part of the process of gluconeogenesis, which increases their blood-glucose levels, and that blood total protein and triglyceride levels decrease as a result. Albumin values increase due to thyroid and adrenal gland hypo function, indicating a healthy digestive system. Globulins carry hormones, lipids, metals, and antibodies. High levels may indicate chronic infections and a fatty liver. The A/G ratio is a key indicator of disease states. Cholesterol levels in our study ranged between 174 to 193 mg/dl. Cholesterol levels in chickens have been reported to range between 125–200 mg/dl (Karagul *et al.,*2000). Total cholesterol is essential for cell membranes, nerve fibers, and sex hormones. Increased cholesterol levels can be attributed to a high carbohydrate or fat diet, which is lowered by methionine. Elevated A/G ratio, protein, and cholesterol may indicate excessive protein consumption. Decreased protein, cholesterol, and SGPT may indicate fatty liver congestion, while increased protein may be affected by dehydration**.**

Triglycerides are fats used for energy and fuel in the body. High levels indicate excessive carbohydrate intake and hype-lipidism. Methionine can lower LDL levels. High-density lipoprotein (HDL) is cholesterol carried by alpha lipoproteins and indicates a healthy metabolic system. However, high HDL levels may be influenced by nutrition, with diets high in refined carbohydrates, lack of

Table 2: Mean ± standard deviation for the biochemical parameters of Ross 308 and Evian 48 strains under different stoking capacity and breeding seasons of Egyptian conditions at age 35 days.

Strain	Ross 308				Evian 48			
Traits	WCS	WOS	SCS	SOS	WCS	WOS	SCS	SOS
T pro	$5.3^{d}\pm$ 0.26	$6.3^{b}\pm$ 0.26	$5.8^{c}\pm$ 0.26	$6.8^{a}\pm$ 0.26	$5.2^{d}\pm$ 0.21	$5.8^{c}\pm$ 0.26	$5.3^{d}\pm$ 0.26	$6.3^{b}\pm$ 0.26
Albumin	$3.0^{e}\pm$ 0.11	$3.9^{b}\pm$ 0.21	$3.5^{d}\pm$ 0.16	$4.4^{a}\pm$ 0.26	$3.5^{d}\pm$ 0.16	$3.8^{bc}\pm$ 0.11	$3.5^{d}\pm$ 0.11	$3.7^{c}\pm$ 0.11
globulin	$2.3^{ab}\pm$ 0.37	$2.4^{a}\pm$ 0.47	$2.3^{ab}\pm$ 0.42	$2.4^{a}\pm$ 0.53	$1.8^{c}\pm$ 0.37	$2.0^{bc}\pm$ 0.37	$1.8^{c}\pm$ 0.37	$2.6^{a}\pm$ 0.37
A/ G ratio	$1.4^{c}\pm$ 0.27	$1.7^{abc}\pm$ 0.44	$1.6^{bc}\pm$ 0.35	$1.9^{ab}\pm$ 0.53	$2.1^{a}\pm$ 0.53	$2.0^{a}\pm$ 0.44	$2.1^{a}\pm$ 0.50	$1.5^{c}\pm$ 0.26
T.cholesterol	$184.0^{d}\pm$ 1.05	$179.0^{f}\pm$ 1.05	$186.0^{c}\pm$ 1.05	$174.0^{g}\pm$ 1.05	$191.0^{b}\pm$ 1.05	$186.0^{c}\pm$ 1.05	$193.0^{a}\pm$ 1.05	181.0^{e} $\pm$ 1.05
Triglyceride	$133.0^{c}\pm$ 1.05	$123.0^{f}\pm$ 1.05	$131.0^{d}\pm$ 1.05	$111.0^{h}\pm$ 1.05	$138.0^{a}\pm$ 1.05	$128.0^{e}\pm$ 1.05	$136.0^{b}\pm$ 1.05	116.0^{g} $\pm$ 1.05
HDL	$35.0^{c}\pm$ 1.05	$31.0^{f}\pm$ 1.05	$33.0^{e}\pm$ 1.05	$27.0^{h}\pm$ 1.05	$38.0^{a}\pm$ 1.05	$34.0^{d}\pm$ 1.05	$36.0^{b}\pm$ 1.05	$30.0^{g}\pm$ 1.05
LDL	$29.0^{b}\pm$ 1.05	$25.0^{d}\pm$ 1.05	$27.0^{c}\pm$ 1.05	$23.0^{e}\pm$ 1.05	$31.0^{a}\pm$ 1.05	$27.0^{c}\pm$ 1.05	$29.0^{b}\pm$ 1.05	$25.0^{d}\pm$ 1.05
AST (UL)	$24.7^{e}\pm$ 0.67	$28.5^{b}\pm$ 0.53	$26.7^{d}\pm$ 0.67	$29.5^{a}\pm$ 0.53	$22.7^{f}\pm$ 0.67	$26.5^{d}\pm$ 0.53	$24.7^{e}\pm$0. 67	$27.5^{c}\pm$ 0.53
ALT (UL)	$20.7^{e}\pm$ 0.67	$24.5^{b}\pm$ 0.53	$22.7^{d}\pm$ 0.67	$25.5^{a}\pm$ 0.53	$18.7^{f}\pm$ 0.67	$22.5^{d}\pm$ 0.53	$20.7^{e}\pm$ 0.67	$23.5^{c}\pm$ 0.53
T3	$1.5^{d}\pm$ 0.05	$1.64^{b}\pm$ 0.05	$1.5^{e}\pm$ 0.05	$1.8^{a}\pm$ 0.03	$1.3^{g}\pm$ 0.05	$1.4^{e}\pm$ 0.05	$1.3^{f}\pm$ 0.05	$1.6^{c}\pm$ 0.03
T4	$2.45^{e}\pm$ 0.05	$2.7^{c}\pm$ 0.11	$2.6^{d}\pm$ 0.05	$3.2^{a}\pm$ 0.11	$2.4^{f}\pm$ 0.05	$2.7^{c}\pm$ 0.05	$2.5^{de}\pm$ 0.00	$2.9^{b}\pm$ 0.05
Creatinine	$1.05^{c}\pm$ 0.05	$0.8^{g}\pm$ 0.00	$0.95^{e}\pm$ 0.05	$0.7^{h}\pm$ 0.00	$1.2^{a}\pm$ 0.00	$1.0^{d}\pm$ 0.00	$1.15^{b}\pm$ 0.05	$0.9^{f}\pm$ 0.00
Uric acid	$3.5^{a}\pm$ 0.53	$1.8^{ef}\pm$ 0.26	$2.5^{bc}\pm$ 0.53	$1.5^{f}\pm$ 0.00	$3.3^{a}\pm$ 0.26	$2.3^{cd}\pm$ 0.26	$2.8^{b}\pm$ 0.26	$2.0^{de}\pm$ 0.00
Urea (mg/dl)	$13.7^{f}\pm$ 0.67	$16.5^{c}\pm$ 0.53	$15.6^{d}\pm$ 0.52	$18.5^{a}\pm$ 0.53	$12.7^{g}\pm$ 0.67	$15.5^{d}\pm$ 0.53	$14.6^{e}\pm$ 0.52	$17.5^{b}\pm$ 0.53

[a,b] Means within a row with different superscripts differ significantly ($P \leq 0.05$).
WCS= Winter close system, WOS= Winter open system, SCS = Summer close system, SOS = Summer close open system, T pro = Total protein. Cholesterol = Total cholesterol. T3 =Triiodothyronine, T4 = thyroxin.

exercise, and genetic predisposition lowering it. Both TG and HDL levels are crucial for maintaining a healthy metabolic system. Uric acid levels can be increased or decreased due to conditions like gout, infections, high protein diets, and kidney disease. Urease levels can increase due to excessive protein intake, kidney damage, and decreased pancreatic enzyme production. Creatinine levels can be increased or decreased due to low protein intake, liver disease, and kidney damage. T3 is the main physiological thyroid hormone regulating oxygen consumption and daily active activities, particularly in young chickens (Bobek *et al.,* 1977), and is metabolically more active than T4 (Klandorf *et al.,* 1981). T3 hormone is closely associated with feeding and is also a key factor influencing conversion of T4 to T3 (McNabb, 2000), and that a higher T3 level is associated with increased protein deposition. Rotava *et al.* (2008)reported that aminotransferase (AST) is a major indicator of liver and muscle damage, with increased AST resulting in cell damage. Nobakht *et al.* (2016) found higher AST levels in 24L treatment due to physiological stress-induced cell damage, as previously studied (Campo *et al.,* 2002; Onbasılar *et al.*, 2007). Hoffmann and Solter (2008), an increase in AST on its own may be a sign of hepatocellular injury. Transaminases (ALT) and (AST) levels can be increased or decreased due to liver disease, hepatitis, or may indicate a B-6 deficiency.

3. Haematology traits

The results in Table 3 also, showed high values for Ross and Avian SOS in all haematology parameters. Ross 308 raised under open system in summer showed highly significant values of WBC, Heterophony, Lymphocyte, H/L ratio, Monocyte, and Eosinophils parameters, while Avian 48 raised under open system in summer showed highly significant values of H/L ratio and Basophils parameters.

Data in Table 3 showed that Ross 308 and Avian 48 raised in SOS have highly significant values than other groups, the results indicated that housing system and environmental conditions effect hematological parameters than genotype. Low levels of Red Blood Cells may indicate a decrease in B-12, B-6, and toxicity. While increase of may indicate a Respiratory distress, cystic fibrosis and adrenal hyper functions. Increase of WBC indicated to active infections. While decreased of WBC may be causes by chronic viral or bacterial infections. Lymphocytes, elevated in acute and chronic infections. Decreased in viral infection and immune deficiency. While increase of lymphocytes may indicate active infections, chronic viral or bacterial infection. Our results in line with Sabri *et a*l. (2022), who reported that Cobb and Hubbard strains did not significantly impact broiler blood picture. While, Gbayi*et al.* (2023) found that native white turkeys had higher concentrations of white blood cells and red blood cells compared to native

Table 3: Mean ± standard deviation for the heamatology parameters of Ross and Evian 48 strains under different stoking capacity and breeding seasons of Egyptian conditions at age 35 days.

Strain	Ross 308				Evian 48			
Traits	WCS	WOS	SCS	SOS	WCS	WOS	SCS	SOS
WBC	$20.2^{d}\pm 0.69$	$21.8^{b}\pm 0.11$	$21.1^{c}\pm 0.37$	$22.6^{a}\pm 0.26$	$20.2^{d}\pm 0.37$	$21.6^{b}\pm 0.37$	$20.8^{c}\pm 0.37$	$21.6^{b}\pm 0.37$
Heterophony	$4.1^{g}\pm 0.11$	$5.4^{c}\pm 0.21$	$4.6^{e}\pm 0.11$	$5.9^{a}\pm 0.21$	$4.4^{f}\pm 0.11$	$5.1^{d}\pm 0.16$	$4.7^{e}\pm 0.05$	$5.6^{b}\pm 0.11$
Lymphocyte	$11.3^{f}\pm 0.11$	$12.7^{b}\pm 0.16$	$12.0^{c}\pm 0.11$	$13.2^{a}\pm 0.11$	$10.9^{g}\pm 0.11$	$11.9^{d}\pm 0.05$	$11.5^{e}\pm 0.16$	$12.6^{b}\pm 0.16$
H/Lratio	$0.37^{e}\pm 0.01$	$0.43^{b}\pm 0.01$	$0.39^{d}\pm 0.01$	$0.45^{a}\pm 0.01$	$0.41^{c}\pm 0.01$	$0.43^{b}\pm 0.01$	$0.41^{c}\pm 0.00$	$0.44^{a}\pm 0.01$
Monocyte	$0.71^{g}\pm 0.01$	$0.98^{c}\pm 0.01$	$0.81^{e}\pm 0.02$	$1.1^{a}\pm 0.01$	$0.62^{h}\pm 0.02$	$0.91^{d}\pm 0.02$	$0.77^{f}\pm 0.07$	$1.04^{b}\pm 0.01$
Eosinophils	$0.77^{g}\pm 0.02$	$1.15^{b}\pm 0.05$	$0.95^{d}\pm 0.05$	$1.25^{a}\pm 0.05$	$0.67^{h}\pm 0.02$	$0.9^{e}\pm 0.00$	$0.85^{f}\pm 0.05$	$1.05^{c}\pm 0.05$
Basophils	$1.6^{e}\pm 0.03$	$2.0^{c}\pm 0.05$	$1.7^{d}\pm 0.02$	$2.1^{b}\pm 0.02$	$1.8^{d}\pm 0.02$	$2.1^{b}\pm 0.02$	$2.0^{c}\pm 0.03$	$2.3^{a}\pm 0.03$

^{a,b} Means within a row with different superscripts differ significantly ($P \leq 0.05$).
WCS= Winter close system, WOS= Winter open system, SCS = Summer close system, SOS = Summer close open system, WBC= White blood cell, H/L Heterophony to Lymphocyte ration.

black turkeys. Karl and Suchy (2000) suggest that blood parameters like WBC and RBC can provide insights into the immune system, cell respiration, and bird feed consumption. Dramani *et al.* (2022) confirmed that the strain significantly affected the H/L index, heterophils, and lymphocyte counts of guinea fowl. Nitish *et al.* (1999) discovered that low immunoglobulin M (LIM) lines showed greater differences between high immunoglobulin G (HIG) and low immunoglobulin G (LIG) lines due to differential selection for serum immunoglobulin M and G levels, suggesting studying hemato-biochemical characteristics could help understand bird responses.The thymus's role in immunity is to create a particular milieu that is necessary for T-cell differentiation, which is necessary for cell-mediated immunity and immune response modulation (Owen, 1977).

Ross 308 raised under open system in summer showed highly significant values of Hb, RBC,MCV, and MCH parameters, while Avian 48 raised under open system in summer showed highly significant values of PCV, MCHC and ESR parameters (Table 4).

Table 4:Mean± standard deviation for the heamatology parameters of Ross and Evian 48 strains under different stoking capacity and breeding seasons of Egyptian conditions.

Strain	Ross 308				Evian 48			
Traits	WCS	WOS	SCS	SOS	WCS	WOS	SCS	SOS
Hb	$12.6^{d}\pm$ 0.16	$13.3^{b}\pm$ 0.11	$12.9^{c}\pm$ 0.11	$13.6^{a}\pm$ 0.21	$12.3^{e}\pm$ 0.16	$12.7^{d}\pm$ 0.21	$12.6^{d}\pm$ 0.16	$13.0^{c}\pm$ 0.26
RBC	$2.4^{e}\pm$ 0.05	$2.7^{b}\pm$ 0.05	$2.6^{cd}\pm$ 0.05	$2.8^{a}\pm$ 0.11	$2.4^{e}\pm$ 0.05	$2.5^{d}\pm$ 0.11	$2.4^{e}\pm$ 0.11	$2.6^{bc}\pm$ 0.11
PCV	$29.6^{h}\pm$ 0.11	$30.5^{f}\pm$ 0.11	$30.2^{g}\pm$ 0.05	$30.8^{e}\pm$ 0.11	$31.3^{d}\pm$ 0.11	$32.0^{b}\pm$ 0.05	$31.8^{c}\pm$ 0.16	$32.4^{a}\pm$ 0.16
MCV	$120.6^{d}\pm$ 0.11	$122.8^{b}\pm$ 0.16	$122.0^{c}\pm$ 0.58	$123.6^{a}\pm$ 0.11	$115.6^{h}\pm$ 0.11	$117.6^{f}\pm$ 0.42	$116.8^{g}\pm$ 0.16	$119.9^{e}\pm$ 0.11
MCH	$50.8^{e}\pm$ 0.16	$52.6^{b}\pm$ 0.16	$52.1^{c}\pm$ 0.69	$53.3^{a}\pm$ 0.21	$49.9^{f}\pm$ 0.11	$51.2^{d}\pm$ 0..35	$50.6^{e}\pm$ 0.16	$52.0^{c}\pm$ 0.11
MCHC	$40.7^{f}\pm$ 0.16	$41.8^{c}\pm$ 0.11	$41.3^{e}\pm$ 0.21	$42.4^{b}\pm$ 0.11	$41.5^{d}\pm$ 0.11	$42.3^{b}\pm$ 0.11	$41.9^{c}\pm$ 0.11	$42.8^{a}\pm$ 0.16
ESR	$4.12^{e}\pm$ 0.01	$4.18^{bc}\pm$ 0.01	$4.14^{d}\pm$ 0.01	$4.185^{b}\pm$ 0.03	$4.15^{cd}\pm$ 0.01	$4.2^{b}\pm$ 0.01	$4.17^{bcd}\pm$ 0.02	$4.33^{a}\pm$ 0.08

^{a,b} Means within a row with different superscripts differ significantly ($P \leq 0.05$).
WCS= Winter close system, WOS= Winter open system, SCS = Summer close system, SOS =Summer close open system,, Hb = hemoglobin, RBC = Red blood cell, PCV= Packed cell volume, MCV =Mean corpuscular volume, MCH = Mean corpuscular hemoglobin,MCHC = Mean corpuscular hemoglobin concentration, ESR = Erythrocyte sedimentation rate.

Conclusively, the presentresults showed that Ross 308 and Avian 48 broilers raised under open system in summer performed better immunity and haematology than other groups under Egyptian subtropical conditions, while Ross 308 and Avian 48 broilers raised under open system and semi-closed system in summer and winter, respectively, performed better biochemical than other groups. Therefore, it is recommended that Ross 308 and Avian 48 broilers should be raised under open system with stocking density of 10 birds/m^{2}in summer. The study reveals significant differences in haematology and biochemical traits and immune responses between eight combinations, highlighting the importance of genetic and environmental factors in determining their immunological capabilities and suggesting future research to identify specific markers for enhanced immune function.

Declaration of Funding: This research did not receive any specific funding.

Conflicts of Interest: The authors declare no conflicts of interest.

Data Availability: The data that support this study will be shared upon reasonable request to the corresponding author.

Acknowledgments: The authors are grateful to the poultry commercial farm (Al Skary Farm) located in Al Ismiala Government, Manaif Center.

REFERENCES

Alimi, O.A.; Abdulwahab, W.F.; Amid, S.A.; Abdulkadir, S.Z.; Lawal, F.M.; Aliyu, A.; Adediran, S.O.; Ajadi, A.A.; Bolaji, M.; Uthman, H.O.; and Deyanju, J.B. 2020. Hematological prediction study of peritonitis following laparotomy in goats. *J. Vet. Med. Sci.* , 2020, 82(5), 531–535. DOI: 10.1292/JVMS.19-0552.

Bobek, S., M. Jastrzebski, and M. Pietras. 1977. Age-related changes in oxygen consumption and plasma thyroid hormone concentration in the young chicken. Gen. Comp. *Endocrinal*ogy, 31:169–174.

Campbell, T. W. (1988). *Avian Hematology and Cytology*. Iowa State University Press, Ames, IA. pp. 3–17.

Campo, J.L.; Davila, S.G. (2002). .Effect of photoperiod on heterophil to lymphocyte ratio and tonic immobility duration of chickens. *Poultry Sci*. 2002, 81, 1637–1639.

Carsia, R. V., & Weber, H. (2000). Dietary protein restriction stress in the domestic chicken (*Gallus gallusdomesticus*) induces remodeling of adrenal steroidogenic tissue that supports hyper function. *General and Comparative Endocrinology*, *120* (1), 99-107.

Cheema, M. A., Qureshi, M. A., &Havenstein, G. B. (2003). A comparison of the immune profile of commercial broiler strains when raised on marginal and high protein diets. *International Journal of Poultry Science*, *2*(5), 300-312.

Duncan, D.B. (1955).The multiple range and multiple F tests. *Biometrics*, 11(1):1-42.

Dramani1, W.; Naandam, J.; Annor, S.Y.; Husein1, S.M.A.; and Birteeb1, P.T. (2022).Effects of sex and strain on docility and some performance traits of local guinea fowl Local Guinea Fowl (*Numidameleagris*) in Ghana. *Ghana. J. Anim. Sci*., Vol. 13 No. 1, 2022.

Eid, K. M. A. (2010). Study of the correlated response to the selection of some economic traits for antibody production in broiler chickens. Ph.D. Thesis, Faculty of Agriculture, Benha University, Egypt.

Fedde, M.R. (1998). Relationship of structure and function of the avian respiratory system to disease susceptibility. *Poultry Sci.*, 77, 1130–1138.

Filipovic, N., Stojevic, Z., Milinkovic-Tur, S., Ljubic, B. B., &Zdelar-Tuk, M. (2007). Changes in concentration and fractions of blood serum proteins of chickens during fattening. *Veterinar skiarhiv*, *77*(4), 319.

Gornall, A.G., Bardawill, C.J., David, M.M., (1949). Determination of serum proteins by means of the biuret reaction. *J. Biol. Chem*. 1772, 751–766.

Gbayi; Godwin, U.; Ahomen, I.; Ebanehitah, C.; Oluwafemi, G.D.; and Imounu, I. (2023). Haematological and Biochemical Profiles of Exotic and Nigerian Locally Adapted Turkeys Reared in a Tropical Environment. *Int. J. Res. Agric*. for, Volume 2, Number 2, Page 1, April 2023.

Hoffmann, W.E., Solter, P.F. (2008). Chapter 12 - diagnostic enzymology of domestic animals. Clin.Biochem.Domest.Anim.

Ibrahim, R.R.; Khalil, F.; Mostafa, A.S.; and Emeash, H.H. (2018). Efficacy of probiotics in improving welfare and mitigating overcrowding stress in broilers. Adv. Vet. Res., 8: 73–78.

Ipek, A. Y. D. I. N., &Sahan, U. (2006). Effects of cold stress on broiler performance and ascites susceptibility. *Asian-Australasian Journal of Animal Sciences*, *19*(5), 734-738.

Karagul , H.; A. Altintaş; U.R. F Idanci and T. SEL (2000). KlinikBiyokimya. BirinciBaskı, MedisanYayınları, pp:188, Ankara, Turkey.

Khan, R.U.; Rahman, Z.U.; Javed, I. and Muhammad, F. 2014. Serum antioxidants and trace minerals as influenced by vitamins, protein and probiotics in male broiler breeders. *J. Appl. Anim. Res*., 42:249–255. doi.org/10.1080/ 09712119.2013.82281 5.

Klandorf, H., P. J. Sharp, and W. S. Newcomer. (1981). The influence of feeding patterns on daily variation in the concentrations of plasma thyroid hormones in the hen. *IRCS Med. Sci*., 9:82–87.

Kral, I. .and Suchy, P.(2000). Haematological studies on adolescent breeding cocks. *Acta Vet. Brno*, 69: 189–192.

Mashaly MM. Hendricks GL, Kalama MA, Gehad AE, Abbas AO, Patterson PH. (2004). Effect of heat stress on production parameters and immune responses of commercial laying hens. *Poultry Science*, 83: 889-94.

McNabb, F. M. A. (2000). Thyroids. Pages 461–471 in Sturkie's Avian Physiology. 5th ed. G. C. Whit tow, ed. Academic Press, San Jose, CA.

Nitish, S.; Tsudzuki, M.; Nishibori, M.; and Yamamotoi, Y. (1999).Direct and Correlated Response to Divergent Selection for Serum Immunoglobulin M and G Levels in Chickens. *Poultry Sci*. 78:1–7.

Nobakht, A.; Fard, B.H.(2016). The effects of using rice bran, enzyme and probiotic on performance, egg quality traits and blood metabolites in laying hens. Iran. *J. Appl. Anim. Sci.*, 46, e417–e427.[Cross Ref].

NRC(2007). *Nutrient Requirements of Poultry*.National Academy of Sciences.

NseAbasi, N.E.; Williams, M.E.; Akpabio, U.; and Offiong, E.E.A. (2014). Hematological Parameters and Factors Affecting Their Values Agricultural Science. Published by the Science and Education Centre of North Am Rev. , 2(1), 37–47.

Olanrewaju, H. A., J. L. Purswell, S. D. Collier, and S. L. Branton (2009). Age-related effects of varying ammonia concentrations on Hematophysiological variables in broiler chickens. *Int. J. Poultry. Sci*., 8:138–144.

Olfati, A.; Mojtahedin, A.; Sadeghi, T.; Akbari, M.; and Martínez-Pastor, F. (2018). Comparison of growth performance and immune responses of broiler chicks reared under heat stress, cold stress and thermoneutral conditions. *Span. J. Agric. Res.* 16: 15- 21.

Onba¸sılar, E.E.; Erol, H.; Cantekin, Z.; Kaya, Ü. (2007). Influence of intermittent lighting on broiler performance, incidence of tibialdyschondroplasia, tonic immobility, some blood parameters and antibody production. *Asian-Aust. J. Anim. Sci.* , 20: 550–555. [Cross Ref].

Onbaşılar E.E., Poyraz O. and Çetin S. (2008).Effects of breeder age and stocking density on performance, carcass characteristics and some stress parameters of broilers. *Asian-Australasian J. Anim. Sci*. 21: 262-269.

Owen, J.J.T. (1977). *Ontogenesis of Lymphocytes*. In: B and T, all in immune recognition. JWS. New York, pp. 21–34.

Pompeu MA, Cavalcanti LFL, Toral FLB. (2018). Effect of vita-min E supplementation on growth performance, meatquality, and immune response of male broiler chickens: ameta-analysis. *Livestock Sci*., 208:5–13.

Renden, J., Lien, R., Oates, S., Bilgili, S.(1994). Plasma concentrations of corticosterone and thyroid hormones in broilers provided various lighting schedules. *Poultry. Sci*., 731: 186–193.

Rambau M.D., Mudau M.L., Makhanya S.D. and Benyi K. (2016).Effects of stocking density and daily feed withdrawal periods on the performance of broiler chickens in a semi-arid environment. *Trop. Anim. Health Prod*., 48: 1547-1554.

Rotava, R.; Zanella, I.; Karkow, A.K.; Dullius, A.P.; da Silva, L.P.; Denardin, C.C. (2008). Blood biochemistry of poultry fed with grape by-products. *Rev. Agrar*., 1: 91–104.

Sabri, M.; Khulel,R.; and Abdullah- Majeed, A. (2022). Effect of Strain and Sex on Live Body Weight, Some Blood Traits, and Carcass Cuts of Broiler. *PEB*. 15/50 (2022), 126–134.

Sirois, M., (2014). *Laboratory Procedures for Veterinary Technicians*-E-Book. Elsevier Health Sciences.

SAS, (2009): Users Guide, statistics, 9.2th Ed., sas Inst. Inc., Cary Nc, USA.

Snedecor, G.W. and W.G. Cochran, (1982).*Statistical Methods*.6th ed. Iowa State University Press.Ames, Lowa, U.S.A.

Talebi A. 2006. Biochemical Parameters in Broiler Chickens Vaccinated Against ND, IB, and IBD. *International Journal of Poultry Science*, 5 (12): 1151–1155, 2006. ISSN 1682-8356 © Asian Network for Scientific Information.

Talebi A., Amani A., Pourmahmod M., Saghaei P., Rezaie R. (2015). Symbiotic enhances immune responses against infectious bronchitis, infectious bursa disease, Newcastle disease and avian influenza in broiler chickens. *Proc. Veterinary Research Forum.*

Türkyılmaz, M. K., A. Nazlıgül, EvrimDereli, and Pınar A. Ulutaş.(2011). "Akutgürültününetlikpiliçlerdekorkuvebazıstresgöstergeleriüzerineetkileri."*KafkasÜniversitesiVeterinerFakültesiDergisi* , 17(6) : 957-962.

Zhao, F. Q.; Zhang, Z. W.; Qu, J. P.; Yao, H. D.; Li, M.; Li, S.; and Xu S. W. (2014). Cold stress induces antioxidants and Hsps in chicken immune organs. *Cell Stress Chaperon*. 19: 635-648.

Zulkifli, Idrus, et al. (2000). "Growth performance and immune response of two commercial broiler strains fed diets containing Lactobacillus cultures and oxytetracycline under heat stress conditions." *British poultry science* 41.5: 593-597.