Journal of Microbiology, Biotechnology and Food Sciences

Muchacka et al. 2012 : 2 (1) 378-388

REGULAR ARTICLE

EFFECT OF ELEVATED AIR TEMPERATURE ON PHYSIOLOGICAL INDICATORS OF BROILER CHICKENS OF DIFFERENT ORIGIN

Renata Muchacka[*1], Iwona Skomorucha[2], Ewa Sosnówka-Czajka[2], Grzegorz Formicki[1], Agnieszka Greń[1], Zofia Goc[1]*

Address: [1]Pedagogical University, Department of Animal Physiology and Toxicology, Podbrzezie 3, 31 054, Krakow, Poland

[2]National Research Institute of Animal Production, Department of Technology, Ecology and Economics of Animal Production, Sarego 2, 31 047 Krakow, Poland

*Corresponding author: formicki@ap.krakow.pl

ABSTRACT

The objective of this study was to determine the effect of elevated air temperature in the first grow period on some physiological indicators of broiler chickens of different origin. Day-old Ross 308 and Hubbard Flex broiler chickens were assigned to 4 groups. Groups I (Ross 308) and II (Hubbard Flex) were kept under standard thermal conditions throughout rearing, and groups III (Ross 308) and IV (Hubbard Flex) were exposed to 10°C higher than recommended air temperature from 1 to 21 days of rearing. At 1, 21 and 42 days of the experiment, blood was collected from 10 birds in each group to determine T_3 and T_4, total protein, immunoglobulin complex, glucose, hemoglobin and hematocrit levels. The exposure to the thermal challenge decreased T_3 and T_4 levels at 21 days of rearing in both Ross 308 and Hubbard flex broilers compared to birds raised under standard thermal conditions. At 21 days of the experiment was observed a statistically significantly lower concentration of total protein in group I compared with group III and between group II and IV. There was no effect of elevated air temperature on the immunoglobulin complex concentration in the blood of birds of both genetic groups. In both genetic groups, the exposure to the thermal challenge caused a tendency to decrease the concentration of glucose. Statistically significant differences at 21 days of rearing of the hemoglobin content were observed between Ross 308

birds from groups I and III. The thermal challenge caused a statistically significant decrease in hematocrit levels in birds from both genetic groups at 21 days of the experiment. The thermal challenge upset the body's homeostasis in both genetic groups of chickens, which possibly suggests that elevated air temperature during the first period of rearing has a negative effect on the welfare of broilers, regardless of their origin.

Keywords: broiler chickens, genetic group, physiological indicators, heat stress

INTRODUCTION

The requirement for the proper performance of rearing chickens is to ensure the optimum environmental conditions necessary for their proper development, growth, maintenance and running of production. These conditions must be suitable to the needs of the birds and they depend not only on age and number of maintained animals, but also on the season and weather conditions.

During the hot summer months, it is difficult to maintain the right temperature inside the house. It leads to exceed the recommended standards of microclimatic conditions, which usually becomes the cause of stress, causing disturbances in the homeostasis of the body's internal environment of birds **(Akşit *et al.*, 2006).**

Chickens in the first 2 weeks of life are very susceptible to stress caused by environmental conditions. The chick body temperature after hatching is 39.7°C, and just at 3 weeks of age reaches 42°C, which is equal to body temperature in adult birds. Therefore, it is widely accepted that the optimal air temperature for broiler chickens should be 31-33°C at the first days of rearing, and then be lowered to 20-18°C at 6 weeks of age.

Symptoms of heat stress in adult birds begin to observe, when the air temperature exceeds 27-28°C. Birds not being able to heat dissipation from the body to the environment lose their ability to control body temperature. When the air temperature exceeds 38°C there is observed an increase in mortality of birds.

The high sensitivity of birds to heat stress is caused by a small difference between the physiological body temperature and the temperature at which protein denaturation occurs, and disruption of vital functions. Heat stress, for example, causes slower growth and lower body weight of chickens, poor feed utilization, increases susceptibility to disease and increases

mortality caused by weakness of the body's immune function **(Altan *et al.*, 2003; Sosnówka-Czajka *et al.*, 2005; Akşit *et al.*, 2006; Sosnówka-Czajka *et al.*, 2007).**

Many authors have shown that the stress associated with a change in air temperature has a significant impact on a physiological processes such as increase rectal temperature **(Deeb and Cahaner, 2001a; Altan *et al.*, 2003; Lin *et al.*, 2005; Sosnówka-Czajka *et al.*, 2005; Sosnówka-Czajka *et al.*, 2006)** and radiation temperature **(Sosnówka-Czajka *et al.*, 2003)**, changes in thyroid hormones concentration **(Sosnówka-Czajka *et al.*, 2007; Star *et al.*, 2008)** and changes in blood corticosterone levels **(Post, 2003; Star *et al.*, 2008).** According to some authors, the origin of birds may be essential for sensitivity to high air temperatures and susceptibility to heat stress (**Berrong and Washburn, 1998; Deeb and Cahaner, 2001a, b).**

The aim of this study was to determine the effect of elevated air temperature at the first growth period on some physiological blood parameters of broiler chickens from two genetic groups.

MATERIAL AND METHODS

The experiment involved 720 broiler chickens from two commercial lines Ross 308 (360 birds) and Hubbard Flex (360 birds). After weighing and tagging on the first day of life, chicks were assigned to 4 groups, each of which had 12 subgroups with a stocking density of 15 birds/m^2: group I – Ross 308 broilers kept throughout rearing under standard thermal conditions (Regulation of the Ministry of Agriculture and Rural Development of 2 Sept. 2003, Journal of Laws 03.167.1629 with later amendments), group II – Hubbard Flex broilers kept throughout rearing under standard thermal conditions (Regulation of the Ministry of Agriculture and Rural Development of 2 Sept. 2003, Journal of Laws 03.167.1629 with later amendments), group III – Ross 308 broilers exposed in the rearing area from 1 to 21 days of age to 10°C higher than recommended temperature (41°C at one day of age was gradually decreased to 35°C on day 21 of rearing), group IV – Hubbard Flex broilers exposed in the rearing area from 1 to 21 days of age to 10°C higher than recommended temperature (41°C at one day of age was gradually decreased to 35°C on day 21 of rearing).

Chickens were reared to 21 days of age in 6-tier batteries of heated cages with electronic temperature control and until 42 days of age in 4-tier batteries of unheated cages. Groups III and IV were located in a separated, air-conditioned room with an electronically controlled heater. All the groups had the same environmental (air humidity, lighting regime) and feeding conditions. Chickens were fed *ad libitum* diets: starter diet until 3 weeks

(3083 kcal ME; 21.77% CP), grower diet from 4 to 5 weeks (3005 kcal ME; 19.97% CP), and finisher diet at 6 weeks of age (3004 kcal ME; 18.65% CP), all based on concentrates. Birds had free access to water drinkers at all times. At 1, 21 and 42 days of the experiment, blood was collected from 10 birds in each group to determine triiodothyronine (T_3) and thyroxine (T_4), total protein, immunoglobulin complex, glucose, hemoglobin and hematocrit levels.

The results were analysed statistically by two-way analysis of variance and significant differences were estimated with Duncan's test using Statgraphics Centurion XV.

RESULTS

Elevated air temperature had an influence on the concentration of T_3 and T_4 in the blood of chickens of both genetic groups (Table 1, 2). The exposure to the thermal challenge decreased these hormones levels at 21 days of rearing in both Ross 308 and Hubbard flex broilers compared to birds raised under standard thermal conditions, however, statistically significant differences were observed only between groups of chickens Ross 308 ($P \leq 0.05$). At 21 days of the experiment was observed a statistically significantly lower concentration of total protein (Table 3) in group I compared with group III ($P \leq 0.01$) and between group II and IV ($P \leq 0.05$). There was no effect of elevated air temperature on the immunoglobulin complex concentration in the blood of birds of both genetic groups (Table 4).

In both genetic groups, the exposure to the thermal challenge caused a tendency to decrease the concentration of glucose at 21 days of the experiment (Table 5). However, statistically significant differences in plasma glucose level were observed only at 42 days of experiment between the Hubbard Flex chickens from groups II and IV ($P \leq 0.05$). Statistically significant differences at 21 days of rearing of the hemoglobin content were observed between Ross 308 birds from groups I and III (Table 6).

The thermal challenge caused a statistically significant decrease in hematocrit levels in birds from both genetic groups at 21 days of the experiment, Hubbard Flex chickens at $P \leq 0.01$, Ross 308 at $P \leq 0.05$ (Table 7).

Table 1 T3 (ng/ml)

Day of rearing	Group				SEM	Genetic group (A)	Temperature (B)	A x B
	standard thermal conditions		elevated air temperature					
	I	II	III	IV				
	Ross 308	Hubbard fleks	Ross 308	Hubbard fleks				
1	0.86	0.95	0.86	0.95	0.05	NS	-	-
21	1.46^{b}	1.43	1.18^{a}	1.31	0.08	NS	0.05	NS
42	1.70	1.68	1.74	1.72	0.04	NS	NS	NS

Legend: A,B,a,b - statistical differences between broilers chickens of the same genetic group reared in different thermal conditions. NS - not significant.

a, b – values in rows with different letters differ significantly ($P \leq 0.05$)

A, B – values in rows with different letters differ highly significantly ($P \leq 0.01$)

Table 2 T4 (µg/dl)

Day of rearing	Group				SEM	Genetic group (A)	Temperature (B)	A x B
	standard thermal conditions		elevated air temperature					
	I	II	III	IV				
	Ross 308	Hubbard fleks	Ross 308	Hubbard fleks				
1	1.09	1.15	1.09	1.15	0.03	NS	-	-
21	1.41^{b}	1.35	1.28^{a}	1.25	0.04	NS	0.05	NS
42	1.49	1.47	1.40	1.48	0.05	NS	NS	NS

Legend: For significant differences, see Table 1.

Table 3 Total protein (g/dl)

Day of rearing	Group				SEM	Genetic group (A)	Temperature (B)	A x B
	standard thermal conditions		elevated air temperature					
	I	II	III	IV				
	Ross 308	Hubbard fleks	Ross 308	Hubbard fleks				
1	3.13	3.23	3.13	3.23	0.19	NS	-	-
21	4.22^{B}	4.10^{b}	3.63^{A}	3.70^{a}	0.13	NS	0.01	NS
42	3.85	3.99	3.84	4.01	0.09	NS	NS	NS

Legend: For significant differences, see Table 1.

Table 4 Immunoglobulin complex (g/dl)

Day of rearing	Group				SEM	Genetic group (A)	Temperature (B)	A x B
	standard thermal conditions		elevated air temperature					
	I	II	III	IV				
	Ross 308	Hubbard fleks	Ross 308	Hubbard fleks				
1	1.02	1.06	1.02	1.06	0.05	NS	-	-
21	1.26	1.30	1.34	1.27	0.03	NS	NS	NS
42	1.31	1.39	1.36	1.30	0.04	NS	NS	NS

Legend: For significant differences, see Table 1.

Table 5 Glucose (mg/dl)

Day of rearing	Group				SEM	Genetic group (A)	Temperature (B)	A x B
	standard thermal conditions		elevated air temperature					
	I	II	III	IV				
	Ross 308	Hubbard fleks	Ross 308	Hubbard fleks				
1	187.49	190.57	187.49	190.57	6.73	NS	-	-
21	244.19	238.69	227.35	232.19	6.79	NS	NS	NS
42	254.69	255.35^{b}	249.85	230.41^{a}	7.14	NS	NS	NS

Legend: For significant differences, see Table 1.

Table 6 Hemoglobin (g/dl)

Day of rearing	Group				SEM	Genetic group (A)	Temperature (B)	A x B
	standard thermal conditions		elevated air temperature					
	I	II	III	IV				
	Ross 308	Hubbard fleks	Ross 308	Hubbard fleks				
1	11.24	11.30	11.24	11.30	0.19	NS	-	-
21	12.23^{b}	12.39	10.54^{a}	11.54	0.43	NS	0.05	NS
42	12.54	12.79	12.63	12.93	0.21	NS	NS	NS

Legend: For significant differences, see Table 1.

Table 7 Hematocrit (%)

Day of rearing	Group				SEM	Genetic group (A)	Temperature (B)	A x B
	standard thermal conditions		elevated air temperature					
	I	II	III	IV				
	Ross 308	Hubbard fleks	Ross 308	Hubbard fleks				
1	34.71	33.43	34.71	33.43	0.70	NS	-	-
21	40.14^{b}	39.00^{B}	36.00^{a}	34.71^{A}	1.03	NS	0.01	NS
42	35.71	38.14	37.71	38.86	0.97	NS	NS	NS

Legend: For significant differences, see Table 1.

DISCUSSION

The effectiveness of rearing depends on many factors including good chicks quality and good chicks genotype, the right environmental conditions, nutrition and veterinary prevention. With the large developments in the field of genetic progress increases the sensitivity of birds to environmental conditions (microclimate in henhouse) **(Sosnówka-Czajka *et al.*, 2006).**

One of the components of microclimate significantly affecting the productivity and health of broiler chickens is the temperature in henhouse. A major danger for broiler production is heat. To chronic overheating occurs when the outside temperature exceeds 27-30°C. Resistance to environmental factors and susceptibility to stress is genetically determined **(Campo *et al.*, 2006)**.

Thyroid hormones (triiodothyronine and thyroxine) play a key role in metabolic processes, influencing the rate of proteins and fats. Therefore, collecting information about the changes and the level of these hormones can be treated as a relative indicator of metabolic changes occurring in the body during the planned experiments. Raising the temperature to 35ºC with humidity of 70-75% reduces the levels of triiodothyronine in the blood plasma **(Yahav *et al.*, 1995).** Generally, increased rearing temperature causes a decrease in the concentration of T_3 and T_4 in the blood plasma and a decrease in metabolic rate of broiler chickens **(Williams and Njoya, 1998; Sokołowicz and Herbut, 1999).**

In our study, elevated air temperature also had an influence on the concentration of T_3 and T_4 in the blood of chickens of both genetic groups. Both chickens Ross 308 and Hubbard flex reared at elevated air temperatures were observed at 21 days of raising the lower levels of these hormones in the blood compared with the chickens reared at standard thermal conditions. **Berrong and Washburn (1998)** noted a tendency to increase the total protein in

the blood of broiler chickens exposed from 3th weeks of rearing at elevated air temperature (32°C), whereas at higher temperature (38°C), the authors noted a decrease in total protein in the blood of birds. In our study, at 21 days of the experiment concentration of total protein in group I was a statistically significantly lower compared with group III and between group II and IV.

Broiler chickens lines which currently bred differ genetically in terms of cellular and humoral immune response **(Cheema *et al.*, 2003**). According to **Cheema *et al.* (2003)** stresses generally reduce the efficiency of the immune response of broiler chickens, but the body's resistance is genetically determined. Therefore, decisive importance in immune system's response to stress is the origin and genotype of the birds, then the type and intensity of the stressor. Environmental stresses generally associated with the weakening of immune function in poultry, and thus the deterioration of welfare. The efficiency of the immune system is often determined by the level of immunoglobulin **(Sivaraman *et al.*, 2005).** In our study there was no effect of elevated air temperature on the concentration of the immunoglobulin complex in the blood of birds of both genetic groups.

The level of biochemical and haematological blood indicators in poultry is affected by many factors (e.g age, sex, species, breed, nutrition, physiological status and breeding technology) **(Brodacki *et al.*, 2006; Fudge, 2000)**. **Brodacki *et al.* (2006)** showed changes in glucose and uric acid concentrations in birds kept in different environmental conditions.

Puvadolpirod and Thaxton (2000a, b, c) indicate that the increase in blood glucose levels is due to stress. In our study, under the influence of elevated air temperatures was observed a trend towards decrease in glucose concentration at 21 days of experiment in both genetic groups. Morphological differences in the blood may result from varying susceptibility of birds on the stress factors **(Campo *et al.*, 2005; Akşit *et al.*, 2006; Campo *et al.*, 2006; Nowaczeski, 2008).** Under the influence of heat stress observed a decrease in hematocrit and an increase in heterophils to lymphocytes ratio **(Altan *et al.*, 2003, Yahav and Hurwitz, 1996).** According **Kołacz *et al.* (1995)** in broiler chickens held at 30°C, 35°C and 38°C regularly decreased hematocrit, platelets and hemoglobin. It also showed decrease in total protein, albumin and globulins. In our study, elevated air temperature evoked at 21 days of the experiment a statistically significant decrease in hematocrit in birds of both genetic groups. A statistically significant difference at 21 days of raising the hemoglobin content was observed between birds Ross 308. Metabolic slowdown, and thus less need for oxygen affects the decrease of hemoglobin, the number of erythrocytes and hematocrit **(Kołacz *et al.*, 1995; Yahav and Hurwitz 1996)**, which were also found in our study.

CONCLUSION

The thermal challenge upset the body's homeostasis in both genetic groups of chickens, which possibly suggests that elevated air temperature during the first period of rearing has a negative effect on the welfare of broilers, regardless of their origin.

REFERENCES

AKŞIT, M. – ALÇIN, S. – ÖZKAN, S. – METIN, K. – ÖZDEMIR, D. 2006. Effects of temperature during rearing and crating on stress parameters and meat quality of broilers. In *Poultry Sciences,* vol. 85, 2006, p. 1867-1874.

ALTAN, Ő. – PABUÇCUOĞLU, A. – ALTAN, A. – KONYALIOĞLU, S. – BAYRAKTAR, H. 2003. Effect of heat stress on oxidative stress, lipid peroxidation and some stress parameters in broilers. In *British Poultry Sciences,* vol. 44, 2003, no. 4, p. 545-550.

BERRONG, S. L. – WASHBURN, K. W. 1998. Effect of genetic variation on total plasma protein, body weight gains, and body temperature responses to heat stress. In *Poultry Sciences,* vol. 77, 1998, p. 379-385.

BRODACKI, A. – BATKOWSKA, J. – ZADURA, A. 2006. Wpływ systemu chowu na poziom wskaźników hematologicznych i biochemicznych krwi indyków rzeźnych. In *Annales Universitatis Mariae Curie-Skłodowska Lublin – Polonia*, vol. 24, 2006, p. 335-342.

CAMPO, J. L. – GIL, M. G. – DAVILA, S. G 2005. Social aggressiveness, pecking at hands, and its relationships with tonic immobility duration and heterophil to lymphocyte ratio in chickens of different breeds. In *Archive Geflügelk.,* vol. 69, 2005, p. 11-15.

CAMPO, J. L. – GIL, M. G. – DAVILA, S. G. – MUÑOZ, I. 2006. The genetics of three welfare indicators: tonic immobility duration, heterophil to lymphocyte ratio, and fluctuating asymmetry. In *World's Poultry Sciences Journal,* suppl., vol. 62, 2006, p. 606-607.

CHEEMA, M. A. – QURESHI, M. A. – HAVENSTEIN, G. B. 2003. In *International Journal of Poultry Sciences*, vol. 2, 2003, no. 5, p. 300-312.

DEEB, N. – CAHANER, A. 2001a. Genotype-by-environment interaction with broiler genotypes differing in growth rate: 2. The effect of high ambient temperature on dwarf versus normal broilers. In *Poultry Sciences,* vol. 80, 2001a, p. 541-548.

DEEB, N. – CAHANER, A. 2001b. Genotype-by-environment interaction with broiler genotypes differing in growth rate: 1. The effect of high ambient temperature and naked-neck

genotype on lines differing in genetic background. In *Poultry Sciences,* vol. 80, 2001b, p. 695-702.

FUDGE, A. M. 2000. Laboratory Medicine: Avian and Exotic Pets. Philadelphia: W. B. Saunders Company, 482.

KOŁACZ, R. – BODAK–KOSZAŁKA, E. – DOBRZAŃSKI, Z. – MATAR, S. 1995. Physiological response of broiler hens to heat stress. In *Rocz Nauk Zoot,* vol. 22, 1995, no. 2, p. 335-345.

LIN, H. – ZHANG, H. F. – DU, R. – GU, X. H. – ZHANG, Z. Y. – BUYSE, J. – DECUPERE, E. 2005. Thermoregulation responses of broiler chickens to humidity at different ambient temperatures. II. Four weeks of age. In *Poultry Sciences,* vol.84, p. 1173-1178.

NOWACZESKI, S. 2008. Wskaźniki hematologiczne ptaków jako źródło cennych informacji. In *Polskie Drobiarstwo*, vol. 11, 2008, p. 27-29.

POST, J. 2003. Physiological effects of elevated plasma corticosterone concentrations in broiler chickens. An alternative means by which to assess the physiological effects of stress. In *Poultry Sciences,* vol. 82,2003, p. 1313-1318.

PUVADOLPIROD, S. – THAXTON, J. P. 2000a. Model of physiological stress in chickens. 1. Resopnse parameters. In *Poultry Sciences,* vol. 79, 2000a, p. 363-369.

PUVADOLPIROD, S. – THAXTON J. P. 2000b. Model of physiological stress in chickens. 2. Dosimetry of adrenocorticotropin. In *Poultry Sciences,* vol. 79, 2000b, p. 370-376.

PUVADOLPIROD, S. – THAXTON, J. P. 2000c. Model of physiological stress in chickens. 3. Temporal patterns of response. In *Poultry Sciences,* vol. 79, 2000c, p. 377-382.

SIVARAMAN, G. K. – KUMAR, S. – SAXENA, V. K. – SINGH, N. S. – SHIVAKUMAR, B. M. 2005. Genetics of immunocompetent traits in a synthetic broiler dam line. In *British Poultry Sciences,* vol. 46, 2005, p. 169-174.

SOSNÓWKA-CZAJKA, E**.** – HERBUT, E. – SKOMORUCHA, I. 2003. Wpływ paszy wzbogaconej w olej lniany na zdrowotność i wyniki produkcyjne kurcząt brojlerów w warunkach stresu termicznego. In *Pr. Kom. Nauk Rol. I Biol. BTN,* seria B, vol. 51, 2003, p. 249-258.

SOSNÓWKA-CZAJKA, E. – SKOMORUCHA, I. – HERBUT, E. 2005. Effect of dietary vitamin supplements on productivity and physiological parameters of broiler chickens exposed to elevated ambient temperature. In Proceeding of XIIth International Conference - ISAH, Warsaw, 2005, p. 111-114.

SOSNÓWKA-CZAJKA, E. – SKOMORUCHA, I. – HERBUT, E. 2006. Effect of reduced dietary energy levels and vitamin C and E supplementation on the performance and some physiological parameters of broiler chickens exposed to elevated air temperatures. In *Polish Journal of Natural Science.,* Suppl., vol. 3, 2006, p. 517-522.

SOSNÓWKA-CZAJKA, E. – SKOMORUCHA, I. – HERBUT, E. 2007. Effect of thermal stress on physiological parameters of broiler chickens after injection of linseed oil into the yolk sac. In *Annals of Animal Sciences,* vol. 7, 2007, no. 1, p. 163-169.

STAR, L. – DECUYPERE, E. – PARMENTIER, H. K. – KEMP, B. 2008. Effect of single or combined climatic and hygienic stress in four layer lines: 2. Endocrine and oxidative stress responses. In *Poultry Sciences,* vol. 87, 2008, p. 1031-1038.

YAHAV, S. – HURWITZ, S. 1996. Induction of thermotolerance in male broiler chickens by temperature conditioning at an early age. In *Poultry Sciences,* vol. 75, 1996, p. 402-406.

YAHAV, S. – GOLDFELD, S. – PLAVNIK, I. – HURWITZ, S. 1995. Physiological responses of chickens and turkeys to relative humidity during exposure to high ambient temperature. In *Journal of Thermal Biology.,* vol. 20, 1995, p. 245–253.

WILLIAMS, J. – NJOYA, J. 1998. Plasma concentrations of thyroid hormones in growing pullets and laying hens reared under two tropical climates and fed on diets with different energy concentrations. In *British Poultry Sciences*, vol. 39, 1998, p. 579-582.

SOKOŁOWICZ, Z. – HERBUT, E. 1999. Effect of chronic high temperature stress on thyroid activity and metabolic rate of broiler pullets cockerels. In *Annals of Animal Sciences.,* vol. 26, 1999, no. 4, p. 377-383.