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EFFECT OF THERMAL CONDITIONS ON WELFARE OF BROILER CHICKENS OF DIFFERENT ORIGIN*

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Abstract

The objective of the study was to determine the effect of the stress factor of elevated air temperature during the second rearing period on health, duration of tonic immobility, blood corticosterone levels and heterophil to lymphocyte ratio in commercial broilers representing three commercial lines. Day-old Hybro, Hubbard Flex and Ross 308 broiler chickens were assigned to 6 groups. In the experimental groups, birds were exposed to elevated air temperature (30°C) in the rearing area from 30 to 34 days of age (4 days), and to standard thermal conditions (20–18°C) from 34 to 42 days of the experiment. The control groups consisted of broilers maintained throughout rearing under standard thermal conditions, with the air temperature of 31–33°C during the first days being gradually decreased to 20–18°C at 6 weeks of age. Broiler mortality was monitored in all the groups throughout the experiment. The concentration of plasma corticosterone was determined at 30, 34 and 42 days of the experiment in 7 birds from each group. Blood smears were also performed to count lymphocytes (L) and heterophils (H), which made it possible to determine the H:L ratio. At 30, 34 and 42 days of the experiment, the duration of tonic immobility (TI) was examined in 7 birds from each group. The thermal factor applied in the second rearing period elicited a stress reaction in the chickens of all lines, as indicated by the increased level of blood corticosterone. However, Ross 308 broilers were less tolerant of reduced welfare levels associated with elevated air temperature compared to Hybro and Hubbard Flex broilers, as evidenced by higher mortality, the highest increase in blood corticosterone, longer duration of TI, as well as increased heterophil to lymphocyte ratio after the thermal factor was applied. The results of the present experiment show that Ross 308 chickens are probably the least suitable for rearing during the summer production cycles.

Key words: broiler chickens, air temperature, corticosterone, tonic immobility, H:L ratio

Modern poultry production should not only maximize production and profit but also provide appropriate rearing conditions to satisfy the basic needs of birds, to ensure their health and to allow them to express their natural behaviour. Despite the

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many regulations found in both EU and Polish legal acts that specify the conditions of animal housing and conservation, intensive farming continues to be associated with high discomfort of the reared birds and often induces stress reactions that upset the internal body homeostasis (Bessei, 2005).

Modern commercial lines of broiler chickens, selected for faster and more efficient growth, are characterized by low resistance to adverse environmental conditions, of which the indoor climate of poultry buildings plays a considerable role (Deeb and Cahaner, 2001). Indoor temperature is one of the microclimate components that has a significant effect on the well-being of broiler chickens. It is generally accepted that the optimum temperature in a broiler house is 31–33°C during the first days of growth and should be gradually decreased to 20–18°C at 6 weeks of age (Regulation of the Ministry of Agriculture and Rural Development of 2.09.2003, Journal of Laws 03. 167.1629 with later amendments). In practice, however, especially during the hot summer months it is difficult to maintain proper indoor temperature and the recommended standards are very often violated.

The high air temperature applied in broiler chicken rearing is associated, among others, with lower weight gains, poorer feed conversion and increased mortality due to the impaired immune function of the body (Altan et al., 2003; Akşit et al., 2006; Sosnówka-Czajka et al., 2007).

Many authors believe that a change in the plasma corticosterone level reflects the physiological response of the body to stress, thus indicating compromised welfare (Puvadolpirod and Thaxton, 2000; Star et al., 2008). Elevated air temperature and the associated heat stress can also influence the duration of tonic immobility (Altan et al., 2003; Yalçin et al., 2003; Akşit et al., 2006) and increase the heterophil to lymphocyte ratio (Akşit et al., 2006; Campo et al., 2006), which also serve as criteria for measuring the stress and welfare levels in birds (Gallup, 1979; Gross and Siegel, 1983; Campo et al., 2008).

Some authors believe that origin may determine the sensitivity of birds to high air temperature and their susceptibility to heat stress (Deeb and Cahaner, 2001, 2002).

Recent practice shows that hypethermia in broiler chickens, especially during the second rearing period, often causes losses to Polish poultry producers in the summer period (Sokołowicz and Herbut, 2004). For this reason, it is important to know the sensitivity of different commercial lines of broiler chickens available on the market to elevated air temperature during the growth period.

Therefore, the objective of the present study was to determine the effect of the stress factor of elevated air temperature during the second rearing period on health, duration of tonic immobility, blood corticosterone levels, and heterophil to lymphocyte ratio in commercial broilers representing three commercial lines.

Material and methods

The experiment was conducted with 720 broiler chickens from three commercial lines Hybro, Hubbard Flex and Ross 308, which were purchased from the Poultry

Hatchery in Łężkowice, Poland. After weighing and tagging on the first day of life, chicks were allocated to 6 groups with a stocking density of 15 birds/m^2.

Groups I, II and III contained Hybro, Hubbard Flex and Ross 308 broiler chickens, respectively, which were exposed to elevated air temperature (30°C) in the rearing area from 30 to 34 days of age (4 days), and to standard thermal conditions (20–18°C) from 34 to 42 days of the experiment. Groups IV, V and VI consisted of broilers maintained throughout rearing under standard thermal conditions, with the air temperature of 31–33°C during the first days being gradually decreased to 20–18°C at 6 weeks of age (Regulation of the Ministry of Agriculture and Rural Development of 2.09.2003, Journal of Laws 03. 167.1629 with later amendments).

Chickens were reared to 21 days of age in 6-tier batteries of heated cages with controlled temperature and to 42 days of age in 4-tier batteries of unheated cages. Groups I, II and III were kept in a separate, controlled environment room with a computer controlled heater. All the groups had the same environmental (air humidity, lighting programme) and feeding conditions.

Birds were fed *ad libitum* with concentrate-based starter (ME 3000 kcal, CP 21.0%), grower (ME 3100 kcal, CP 19.8%) and finisher diets (ME 3100 kcal, CP 18.5%) at 1–3, 4–5 and 6 weeks of age, respectively. Chickens had free access to water drinkers throughout the experiment.

Broiler mortality was monitored throughout the experiment. Blood was sampled from 7 birds from each group at 30 days (before the thermal factor was applied), 34 days (4 days after the stress factor was applied) and 42 days of the experiment to determine the level of corticosterone. Blood smears were also performed to count lymphocytes (L) and heterophils (H), which made it possible to determine the H:L ratio. The concentration of plasma corticosterone was determined immunoenzymatically using a DSL commercial kit (Diagnostic System Laboratories, USA). The measurement was made with a SIRIO S immunoenzyme analyser.

At 30, 34 and 42 days of the experiment, tonic immobility (TI) was measured according to the method of Akşit et al. (2006) in 7 birds from each group.

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

Results

The mortality of broiler chickens is shown in Table 1. Ross 308 broilers reared under standard thermal conditions during the entire experiment had an approximately 2% lower mortality compared to Hybro and Hubbard Flex broilers. In the groups reared under elevated air temperature from 30 to 34 days, the lowest mortality was found in group I compared to the other two groups. Ross 308 broilers from group III were characterized by higher mortality during the period of elevated air temperature compared to Hybro and Hubbard Flex chickens, and by 3.3% higher mortality compared to birds of the same commercial line reared under standard thermal conditions throughout the experiment.

Table 1. Mortality of broiler chickens (%)

Days of growth	Group					
	I	II	III	IV	V	VI
	Hybro	Hubbard Flex	Ross 308	Hybro	Hubbard Flex	Ross 308
	elevated air temperature from 30 to 34 days of age			standard thermal conditions		
1–21	0	1.11	0	0	1.11	0
22–42	3.31	3.3	4.41	3.3	2.22	1.11
1–42	3.31	4.41	4.41	3.3	3.31	1.11

Table 2. Effect of elevated air temperature from 30 to 34 days of age on blood corticosterone levels (ng/ml) in broiler chickens

Days of growth	Group						SEM	Commercial line (A)	Temperature (B)	A×B
	I	II	III	IV	V	VI				
	Hybro	Hubbard Flex	Ross 308	Hybro	Hubbard Flex	Ross 308				
	elevated air temperature from 30 to 34 days of age			standard thermal conditions						
30	27.2 a	19.5 A	35.9 A	39.9	34.0	23.3	7.07	NS	NS	NS
34	55.3 b	58.3 B	81.7 B*	44.9	49.9	41.3*	10.69	NS	<0.05	NS
42	58.1	60.1	38.9	37.9	27.5	40.0	11.45	NS	NS	NS

Values in columns with different letters a, b differ significantly at P≤0.05; A, B highly significantly at P≤0.01.
Values in rows marked with * differ significantly at P≤0.05.

Table 3. Effect of elevated air temperature from 30 to 34 days of age on duration of tonic immobility (TI) in broiler chickens (s)

Days of growth	Group						SEM	Commercial line (A)	Temperature (B)	A×B
	I	II	III	IV	V	VI				
	Hybro	Hubbard Flex	Ross 308	Hybro	Hubbard Flex	Ross 308				
	elevated air temperature from 30 to 34 days of age			standard thermal conditions						
30	244.0	132.5	145.5 a	256.4	222.3	249.5	61.03	NS	NS	NS
34	205.1	173.4	331.6 b *	252.6	262.3	164.9 *	61.03	NS	<0.05	NS
42	163.2	88.7 *	84.0	203.0	232.7 *	191.4	46.14	NS	<0.05	NS

Values in columns with different letters a, b differ significantly at P≤0.05.
Values in rows marked with * differ significantly at P≤0.05.

Table 4. Effect of elevated air temperature from 30 to 34 days of age on heterophil to lymphocyte ratio

Days of growth	Group						SEM	Commercial line (A)	Temperature (B)	A×B
	I	II	III	IV	V	VI				
	Hybro	Hubbard Flex	Ross 308	Hybro	Hubbard Flex	Ross 308				
	elevated air temperature from 30 to 34 days of age			standard thermal conditions						
30	0.501	0.449	0.399 A	0.294 a x	0.531 y	0.521 y	0.07	<0.05	NS	NS
34	0.699	0.556	0.681 B *	0.509 b	0.550	0.424 *	0.07	NS	<0.05	NS
42	0.35 X	0.64 Y	0.56	0.41 x	0.47 x	0.69 y	0.07	<0.01	NS	NS

Values in columns with different letters a,b differ significantly at P≤0.05; A, B highly significantly at P≤0.01.
Values in rows with different letters x, y differ significantly at P≤0.05; X, Y highly significantly at P≤0.01.
Values in rows marked with * differ significantly at P≤0.05.

Blood corticosterone levels in the broiler chickens are presented in Table 2. At 34 days of the experiment, compared to 30 days of rearing, blood corticosterone levels in birds exposed to the thermal factor were higher by 51% in group I ($P \leq 0.05$), by 66.5% in group II and by 56% in group III ($P \leq 0.01$).

After the thermal factor was applied, a statistically significant difference was noted in the level of corticosterone between Ross 308 chickens raised under standard thermal conditions throughout the experiment and chickens of the same line exposed to elevated air temperature from 30 to 34 days of the experiment.

Table 3 shows the duration of tonic immobility in the birds. In Ross 308 broilers, tonic immobility was 186.1 s longer after the thermal factor was applied compared to 30 days of the experiment ($P \leq 0.05$). At 34 days of rearing, a statistically significant difference in the duration of TI was found between Ross 308 chickens from group III and chickens of the same commercial line from group VI. At 42 days of the experiment, the difference occurred in Hubbard Flex birds between groups II and V ($P \leq 0.05$)

Ross 308 (group VI) and Hubbard Flex broilers (group V) were characterized by a significantly higher H:L ratio at 30 days of the experiment compared to Hybro broilers from group IV (Table 4). At 42 days of age, groups IV (Hybro) and V (Hubbard Flex) showed a statistically significant difference in the H:L ratio in relation to group VI (Ross 308). In the groups exposed to the thermal factor, a highly significant difference in the H:L ratio was found at 42 days of the experiment between Hubbard Flex and Hybro chickens.

After the stress factor was applied, the H:L ratio increased in Ross 308 broilers by 41% ($P \leq 0.01$). At 34 days of rearing, a statistically significant difference was also observed in the H:L ratio between Ross 308 chickens from groups III and VI.

Discussion

The intensive selection for rapid body weight gains that has been applied over many years led to the creation of new lines of broilers that are sensitive to heat stress. Elevated air temperature and the related heat stress may be associated with increased mortality resulting from a deterioration of overall health due to hyperthermia (Yahav, 2000). In our study, the thermal factor caused mortality to increase in Hubbard Flex and Ross 308 broilers compared to the groups reared under standard thermal conditions. Likewise, Skomorucha et al. (2009 b) reported increased mortality in Hubbard Flex and Ross 308 broilers subjected to elevated air temperature during the first period of rearing. Also Sosnówka-Czajka et al. (2006) found a 2.17% increase in the mortality of broiler chickens exposed to a 3-day heat stress in the first and second rearing period compared to the control group. In our study, we found that the thermal stress applied had no negative effect on survival of Hybro broilers. Similarly, Berrong and Washburrn (1998) reported that the effect of heat stress on mortality of chickens varied according to their origin.

The application of stress induces many physiological changes in avian bodies, including increased plasma corticosterone levels (Puvadolpirod and Thaxton, 2000). Star et al. (2008) showed the level of corticosterone to rise in line WB of White Leghorn chickens reared at 32°C for 23 days. These authors did not find any changes in the blood level of this hormone under the influence of the thermal factor in lines WA and WF of White Leghorn and in Rhode Island Red chickens. In the present study, the heat stress caused an increase in corticosterone levels in broiler chickens of all three commercial lines. However, Ross 308 chickens showed the highest increase in the blood concentration of this hormone, possibly indicating different responses of the birds to the heat stress. Different results were also obtained by Lin et al. (2004), who found no effect of heat stress on the blood corticosterone level in broiler chickens.

Unlike in the present study, Star et al. (2008) and Skomorucha et al. (2009 a) reported that origin has an effect on the birds' blood corticosterone concentration.

According to Yalçin et al. (2003), broiler chickens exposed to heat stress have a longer duration of tonic immobility. Likewise, Altan et al. (2003) showed that heat stress has an effect on increasing the tonic immobility response. However, Akşit et al. (2006) found no effect of elevated air temperature on the duration of tonic immobility. Also Skomorucha et al. (2009 b) reported no effect of the thermal factor on the duration of tonic immobility in both Ross 308 and Hubbard Flex broiler chickens. In the present study, elevated air temperature increased the duration of tonic immobility response only in Ross 308 broilers, possibly indicating that this line of chickens is more sensitive to heat stress compared to Hybro and Hubbard Flex lines. In our study we found no effect of origin on the duration of tonic immobility, which is consistent with the findings of Altan et al. (2003).

The increased heterophil to lymphocyte ratio may indicate compromised welfare of the birds (Campo et al., 2008). Altan et al. (2003) reported that heat stress contributes to lower lymphocyte and higher heterophil production in the blood of birds, thus increasing the H:L ratio. In our study, the thermal factor increased the H:L ratio for Ross 308 broilers. At the same time, broiler chickens of this commercial line were characterized by a higher H:L ratio at 34 days of the experiment compared to the same commercial line exposed to no elevated air temperature. The increased H:L ratio in the blood of birds after increasing air temperature was also reported by Altan et al. (2003) and Yalçin et al. (2005).

In the present study, the origin had an effect on the H:L ratio at 30 and 42 days of the experiment in broiler chickens reared under standard thermal conditions and at 42 days of the experiment in broilers exposed to the thermal factor. Also Campo et al. (2008) showed differences in the H:L ratio when comparing five commercial lines of chickens, whereas Altan et al. (2003) found no effect of chicken origin on percentage of heterophils and lymphocytes in the white blood cell smear.

In summary, the thermal factor applied in the second rearing period elicited a stress reaction in the chickens of all lines, as indicated by the increased level of blood corticosterone. However, Ross 308 broilers were less tolerant of reduced welfare levels associated with elevated air temperature compared to Hybro and Hubbard Flex broilers, as evidenced by higher mortality, the highest increase in blood corti-

costerone, longer duration of TI, as well as increased heterophil to lymphocyte ratio after the thermal factor was applied.

The results of the present experiment show that Ross 308 chickens are probably the least suitable for rearing during the summer production cycles.

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Wpływ warunków termicznych na dobrostan kurcząt brojlerów o różnym pochodzeniu

STRESZCZENIE

Celem przeprowadzonych badań było określenie wpływu podniesionej temperatury powietrza w drugim okresie odchowu, jako czynnika stresowego, na zdrowotność, czas trwania tonicznego bezruchu, poziom kortykosteronu oraz stosunek heterofilii do limfocytów we krwi kurcząt brojlerów trzech linii towarowych.

Jednodniowe pisklęta brojlery linii: Hybro, Hubbard Flex oraz Ross 308 zostały przydzielone do 6 grup. W grupach doświadczalnych w okresie od 30. do 34. dnia życia (4 dni) w strefie odchowu kurcząt podniesiono temperaturę powietrza do 30°C, a następnie od 34. do 42. dnia doświadczenia powrócono do standardowych warunków termicznych (20°–18°C). Grupy kontrolne natomiasta utrzymywano w standardowych warunkach termicznych przez cały kres odchowu, tj. w temperaturze 31°–33°C w pierwszych dniach i obniżając stopniowo temperaturę powietrza do 20°–18°C w 6. tygodniu życia ptaków. We wszystkich grupach kontrolowano upadki kurcząt brojlerów. W 30., 34. oraz w 42. dniu doświadczenia u 7 ptaków z każdej grupy zostało określone stężenie kortykosteronu w osoczu krwi. Wykonano również rozmazy krwi w celu policzenia limfocytów (L) i heterofilii (H), co pozwoliło na określenie stosunku H:L. W 30., 34. oraz w 42. dniu doświadczenia zbadano także czas trwania reakcji (TI) u 7 ptaków z każdej grupy.

Termiczny czynnik doświadczalny zastosowany w drugim okresie odchowu spowodował wystąpienie reakcji stresowej u wszystkich badanych linii kurcząt brojlerów, na co wskazuje wzrost poziomu kortykosteronu we krwi. Kurczęta brojlery Ross 308 charakteryzowały się jednak mniejszą tolerancją na obniżony dobrostan związany z podwyższoną temperaturą powietrza w porównaniu z kurczętami Hybro i Hubbard flex, o czym świadczy większa śmiertelność, najwyższy wzrost poziomu kortykosteronu we krwi, dłuższy czas trwania TI, a także wzrost stosunku heterofilii do limfocytów we krwi po zadziałaniu termicznego czynnika doświadczalnego.

Wyniki z przeprowadzonych badań wskazują więc, że prawdopodobnie najmniej odpowiednim materiałem do odchowu podczas letnich cykli produkcyjnych są kurczęta linii Ross 308.