Effects of wallowing, sex and post wallowing time on the blood profile and thermoregulatory parameters of geese during the period of high temperature humidity index

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ABSTRACT

The means by which animals regulate their body temperature is called thermoregulation and during high ambient temperature, wallowing may help to improve homeostasis in animals. Some blood parameters have also been used as indicators of stress in poultry. Therefore, the effects of wallowing, sex and post-wallowing time on the blood profile and thermoregulatory parameters of geese at high-temperature humidity index were assessed. Twenty-four geese (12 ganders and 12 goose) were used for the assessment and the ganders and goose were randomly divided each into two groups: wallowed group and non-wallowed group. Wallowing and thermoregulatory assessment were done every alternate day and the experiment lasted for five weeks. Using standard procedures, temperature, humidity, pulse rate, respiratory rate and rectal temperature were measured. The blood samples of the animals were also collected and analysed for haematological profile at 2 and 4 weeks post-wallowing. The interactions showed that non-wallowed goose at 4 weeks post-wallowing had significantly ($P < 0.05$) lower packed cell volume than wallowed and non-wallowed ganders at 2 and 4 weeks. The lymphocyte count with lower heterophils in wallowed geese indicates healthy geese and better immunity than the non-wallowed geese with higher heterophils and stressed as adjudged by H/L ratio. The wallowing and sex interaction effect showed a significantly ($P < 0.05$) lower respiratory rate in the wallowed goose than in the non-wallowed goose. Rectal temperature in all the interactions was not significant ($P > 0.05$) while the pulse rate of wallowed ganders and goose were significantly ($P < 0.05$) lower than what was obtained in the non-wallowed ones. The values for their respiratory rate, rectal temperature and pulse rate ranged from 19.40 ± 4.10 to 22.70 ± 2.50 breaths/minute, 40.30 ± 0.50 to 40.50 ± 0.40 and 141.90 ± 15.90 to 166.90 ± 10.30 beats/minute, respectively. This study indicated that wallowing influenced the respiratory rate and pulse rate of the geese. The haematological profile of the geese was improved during high-temperature humidity index that could have induced heat stress in the animals with apparently stable reduced and stable H/L ratio.

Keywords: Thermoregulatory parameters, haematological response, wallowing, geese

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INTRODUCTION

Exposure of animals to adverse environmental conditions normally hinders them from expressing their full genetic potential. Environmental stressors are often blamed for this gap in production (Dobson *et al*., 2001). The increase in body temperature due to the exposure to ambient temperatures above the thermal comfort zone also has a negative effect on poultry performance (Deyhim and Teeter, 1991). The physiological changes of animals in response to high ambient temperature include increased pulse rate and dissipation of heat by evaporation through an increase in respiratory rate. There may also be dissipation of heat through an increase in blood flow to peripheral vessels as a result of an increased pulse rate. The relative humidity of the environment also remains a cogent determinant that may influence the ability of animals to acclimatize to the hot environment. This is because there are some physiological responses that the animal body automatically brings up when they are in such environment and it could be serious to the point of death in some instances (Crescio *et al.,* 2010). Hence, there are a couple of physiological maladjustments that excessive heat gain may cause such as damage to enzymes, increased dehydration and increased oxidative stress (McKechnie and Wolf, 2019).

Wallowing has been suggested and proven to be helpful in the improvement of homeostasis in the animal body and it performs functions like maintenance of respiratory rate and rectal temperature at physiologically normal level, provision of sunscreen, prevention of dehydration, skin maintenance, removal of ectoparasites and many other associated functions (Geist, 1998; Keck, 2011). Moreover, haematological parameters are good indicators of the physiological and pathological status of an animal (Ewuola and Egbunike, 2008). Changes in blood parameters are important in assessing the response of animals to various physiological situations (Muhammad *et al*., 2002; Owoyele *et al*., 2003; Muhammad *et al*., 2004). Also, concentrations of corticosteroids in the blood have been used as an indicator for monitoring environmental stress in birds and the relationship between adrenocorticotropic hormone (ACTH) and leukocyte response has been examined widely (Altan *et al*., 2000). Leukocyte parameters such as heterophils (Altan *et al*., 2000; Borges *et al*., 2003; Post *et al*., 2003; Lien *et al*., 2007), lymphocytes (Altan *et al*., 2000; Yalcin *et al*., 2004; Lien *et al*., 2007), monocytes, basophils and eosinophils (Altan *et al*., 2000) are also used as indicators of stress in poultry.

Previous studies on the blood profile of Canada geese done in the temperate region showed that age, sex and weight influenced the white blood cell counts, packed cell volume, heterophil and lymphocyte of geese (Charles-Smith *et al*., 2014). Also, due to the larger body size of waterfowl, some studies have shown that behavioural modifications such as huddling, and changes in posture to reduce exposure to the sunshine of non-feathered areas may be sufficient to maintain normal body temperature during inactivity, but the case is not so during migration in bar-headed geese (Brodsky and Weatherhead, 1984; Hawkes *et al*., 2013).

Former few studies done on geese thermoregulation and blood profile were conducted in the temperate regions of the world. However, in the tropical region of the world known to be hotter than the temperate region, there is limited information on wallowing, blood profile and thermoregulation in geese at either high- or low-temperature humidity index periods. Hence, this experiment was designed to investigate the effects of wallowing, sex and post-wallowing on the blood profile and thermoregulatory parameters of geese during high-temperature humidity index.

MATERIALS AND METHODS

Experimental Animal Management and Experimental Design

This study was carried out at the Poultry Unit, Teaching and Research Farm, University of Ibadan, Nigeria, with latitude 7°26' N and longitude 3°54' E. A total number of twenty-four (24) one-year-old crossbred geese were randomly selected

and used; twelve (12) ganders and twelve (12) goose, with an average weight of 5.1 ± 0.4 kg for males and 4.3 ± 0.30 kg for females. The geese were procured from a reputable farm and were acclimatized for 2 weeks before the start of the experiment. The geese were housed differently based on sex and were given feed and water *ad libitum* throughout the experiment. Prior to their arrival and commencement of the experiment, the pen was thoroughly cleansed with all other necessary equipment. The animals were kept under a conducive and hygienic condition throughout the experimental period. The 12 ganders were randomly divided into 2 groups (wallowed group and the non-wallowed group) and vice versa for the 12 goose too.

The geese were fed with purchased commercial layer mash (brand name: Top Feed) during this experiment. The diet contained crude protein of 16.5%, digestible energy of 2,500 kcal/kg, crude fibre of 6%, crude fat of 5%, calcium of 3.5% and phosphorus of 0.41% as nutrient composition. Feed and clean water were provided *ad libitum* and served daily throughout the experimental period.

A wallowing space was provided outside the pen for the geese. Wallowing and thermoregulatory assessment were done every alternate day in the afternoon, over a period of 5 weeks between 12 p.m. and 2 p.m. daily. The blood collection was done at 2 and 4 weeks post-wallowing while restraining the birds, by holding their two wings with one hand and the two legs with the other hand. Blood samples (3 mL) each were collected aseptically from the jugular vein of the birds early in the morning into vacuumed sterile tubes with anticoagulant. This study was conducted under the Animal Ethics Committee guidelines of the University of Ibadan, Ibadan, Oyo State, Nigeria.

Data Collection

Thermoregulatory parameters

Data collected for the thermoregulatory responses of each animal were pulse rate, rectal temperature, and respiratory rate. The pen's relative humidity and temperature were also recorded thrice daily with the aid of a thermo-hygrometer. Pulse rate was determined using a stethoscope to measure the heart rate of the geese and recorded per minute. Rectal temperature was determined by inserting the thermometer in the vent of the geese and the reading from the thermometer after a minute was then documented. Respiratory rate was also determined by visual counting of the flank movement from each animal per minute. Temperature-humidity index (THI) was calculated from the values of pen ambient temperature and relative humidity as modified by Marai *et al.* (2001).

$$THI = t - [(0.31 - 0.31 \times RH/100)(t - 14.4)]$$

where THI = temperature-humidity index, RH = relative humidity and t = temperature. The implications of the THI values are: < 27.8 = absence of heat stress, 27.8–28.9 = moderate heat stress, 29.0–30.0 = severe heat stress, and > 30.0 = very severe heat stress

Blood parameters

Blood samples collected into tubes with anticoagulants were used for haematological analysis of packed cell volume (PCV), haemoglobin (Hb) concentration, red blood cells (RBC), platelets, white blood cells (WBC), lymphocytes, neutrophils, monocytes and eosinophils determination as described by Feldman *et al.* (2000). The ratio of heterophils to lymphocytes (H/L ratio) was estimated from the value of heterophils and lymphocytes.

Data Analysis

The experiment was designed in a 2 × 2 × 2 factorial arrangement in a completely randomized design for the haematological assessment (factor 1: wallowing, factor 2: sex, and factor 3: post-wallowing time) and in a 2 × 2 factorial arrangement in a completely randomized design for the thermoregulatory assessment (factor 1:

wallowing and factor 2: sex). Data were analyzed using descriptive statistics and ANOVA at **α** = 0.05 using the general linear model of SAS (2011) and means were separated using Tukey-Kramer mean separation procedure at a level of significance of P < 0.05 for the main effects and the interactions.

RESULTS AND DISCUSSIONS

Figures 1A–1C show the daily temperature, relative humidity and THI of the experimental pen during high THI. The THI in the morning, afternoon and evening ranged from absence of heat stress to very severe heat stress according to the definition and classification of the study done by Marai *et al. (*2001), who reported that some thermoregulatory parameters like rectal temperature are often altered and increased during severe heat stress. In the morning, heat stress was absent while in the afternoon when the thermoregulatory parameters were recorded; there was a rise in the temperature values recorded. Birds have to maintain balance with their environment to diminish heat loss, especially during high THI. The THI is often expressed as an indicator of the thermal comfort level of animals in an enclosure (Marai *et al*., 2001). Temperature is a major ambient factor and for the animals that are homeotherms, their thermo-neutral zone is the point in which the ambient temperature range causes energetic expenses that are minimal in the animals and their body reserves are not also compromised, thereby leading to the maintenance of body temperature that is constant which is referred to as the basal metabolic rate (Góngora and Hernández*,* 2010). If the body of the animal is unable to maintain a normal temperature and it increases significantly above normal, hyperthermia occurs.

The main effects of wallowing, sex and post-wallowing time on geese haematology at high THI are shown in Table 1. There was no significant difference in the main effect of wallowing on all the haematological parameters except the lymphocyte counts which was significantly (P < 0.05) higher in the wallowed group than the non-wallowed group. However, the sex effect significantly (P < 0.05) influenced the packed cell volume, haemoglobin, red blood cells, platelets, lymphocytes and heterophils with the ganders having significantly (P < 0.05) higher values than the goose except in the heterophils. Although the H/L ratio was not significantly different among the treatments but was apparently lower in wallowed geese at the post-wallowing stage than in non-wallowed geese. The mean value of PCV has been reported to be 44% in graylag geese according to the findings of Jahantigh and Zamani-Ahmadmahmudi (2016) and this is similar to the value obtained in this study. Increased values in the ganders compared to the goose, in most of the blood parameters could be due to the heavier average weight of the ganders above the goose which may be associated with males having a higher level of the special sex hormone called androgen that works to influence rapid growth and body weight in males thus contributing to the anabolic status of somatic tissues than in females and in the development of male secondary sexual characters (Tatli-Cankaya *et al*., 2014; Handelsman, 2020). The sexual differences in the blood profile of the geese could also be due to the physiological condition of the females at the period of the experiment owing to the egg-laying experience since the experiment was done during their breeding season at high THI.

Mohamed *et al.* (2012) observed that the values of blood constituents are affected by many factors such as sex, physiological condition, genotype, and season. Also, in some avian species, numbers of red blood cells are more in males than females as indicated by Albokhadaim (2012) for chickens of different ages and sexes. Birds with high levels of packed cell volume are likely to be accompanied by high haemoglobin levels (Kostelecka-Myrcha, 1997). The heterophils value in this study that was higher in the goose than in the ganders could be due to the fact that the goose would have been more stressed than the ganders at the period this experiment was carried out.

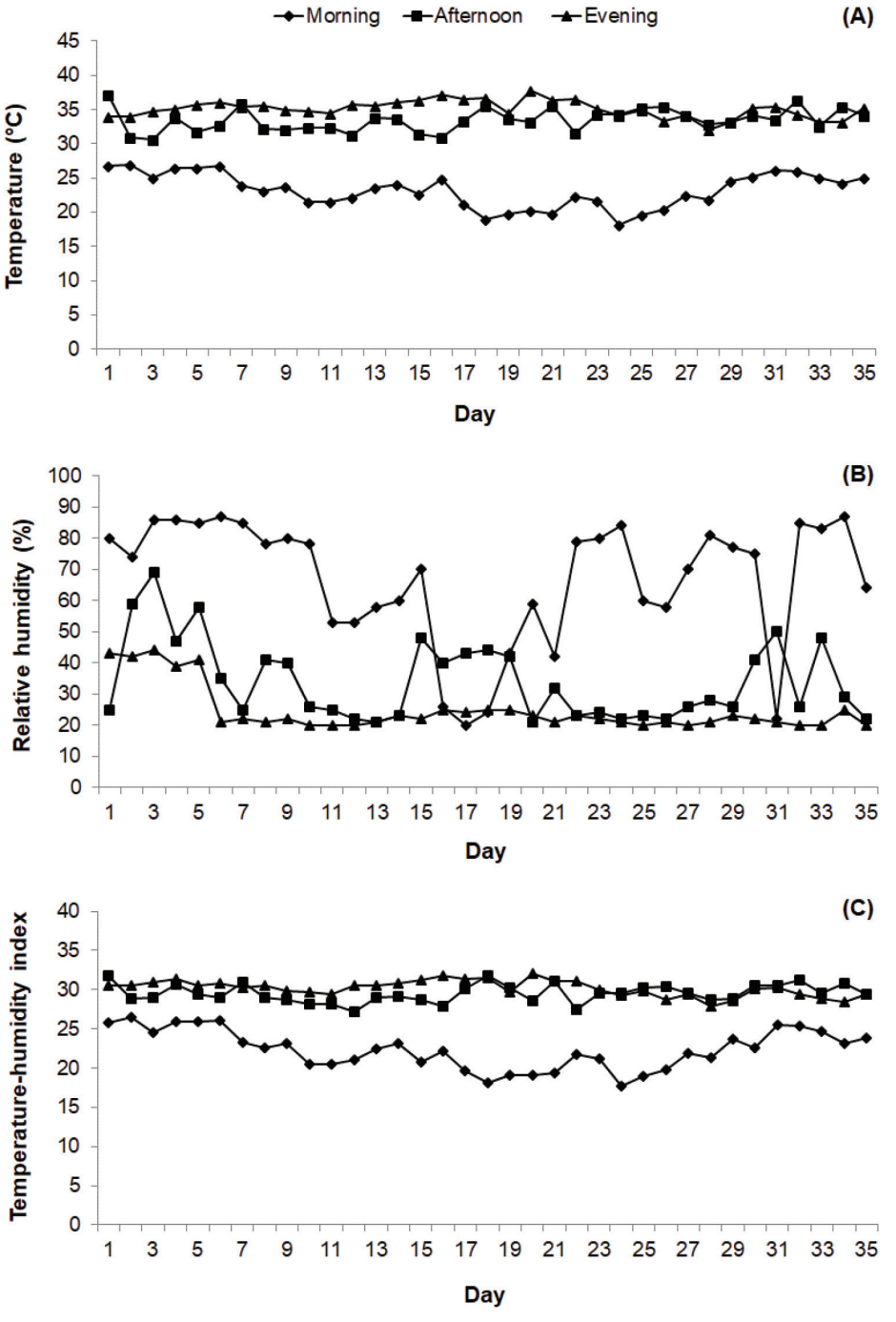

Figure 1 Daily temperature (A), relative humidity (B) and temperature-humidity index (C) of the experimental pen

This may be as a result of the physiological process of egg formation and egg laying going on in the goose at the period of the experiment. An increase in heterophils value could be due to inflammation or stress (Fudge, 2000), physiologic reaction, tissue destruction and necrosis (Fudge and Joseph, 2000). The relatively low value of H/L ratio is an indication of improved immune response and reduced stress in the wallowed group possibly induced by evaporative cooling due to wallowing in water. Since the higher the lymphocytes than the heterophils, the lower H/L ratio will be and the more stable the animals in terms of immunity and stress. However, immunity in males is apparently more pronounced than in female geese (Fudge, 2000).

Significantly ($P < 0.05$) higher white blood cell, platelet and lymphocyte values were observed at 4 weeks post-wallowing than at 2 weeks post-wallowing. This may be as a result of the concurrent increase in the age of the geese. Blood biochemical parameters have been shown to be subject to changes with increasing age in many animal species including birds (Ihrig *et al.,* 2001; Mohri *et al.,* 2007; Franson *et al.,* 2009). Significantly ($P < 0.05$) lower heterophils value observed at 4 weeks post-wallowing than at 2 weeks could be a result of haemodilution, due to increased water consumption rate at 4 weeks since this experiment was carried out in the high THI period. Higher temperature can lead to haemodilution (Borges *et al*., 2003; Tolba *et al*., 2005).

However, all the values were also within the normal physiological range for geese. Wallowed ganders at 4 weeks post-wallowing, also had significantly ($P < 0.05$) higher white blood cells than other ganders and goose at 2 weeks post-wallowing. For lymphocyte count, non-wallowed goose at 2 weeks had significantly ($P < 0.05$) lower value than wallowed males at 4 weeks. Since basophils, eosinophils and monocytes were similar in all the groups and their interactions, these parameters were not significantly different nor influenced by wallowing, sex and post-wallowing time.

Table 2 shows the interactions of wallowing, sex, and post-wallowing time on the haematological parameters of geese. Non-wallowed female geese at 4 weeks that had significantly ($P < 0.05$) lower packed cell volume than wallowed and non-wallowed ganders at 2 weeks and 4 weeks could be due to sex differentiations since it has been reported by Pavlak *et al*. (2005) that packed cell volume are often higher in males than in females. This could be due to the higher androgen level in them hastening increased body weight in males compared to their female counterparts (Tatli-Cankaya *et al*., 2014). Wallowed ganders, especially at 4 weeks post-wallowing had increased packed cell volume, red blood cell, white blood cell and lymphocytes than the non-wallowed goose at 2 weeks post-wallowing. This could be due to the fact that wallowing could help improve the blood profile of birds as it helps in thermoregulation and in preventing dehydration (Keck, 2011).

Table 1 Main effects of wallowing, sex and post-wallowing time on the haematology of male and female geese

Haematological parameters	Wallowing		Sex		Post-wallowing time	
	Non-wallowed geese	Wallowed geese	Female	Male	2 weeks	4 weeks
PCV (%)	40.90 ± 5.09	42.83 ± 3.56	39.38 ± 3.82^{b}	44.86 ± 2.99^{a}	42.13 ± 3.52	41.73 ± 5.24
Haemoglobin (g/dL)	13.50 ± 1.66	14.21 ± 1.28	13.00 ± 1.29^{b}	14.89 ± 1.00^{a}	13.82 ± 1.16	13.95 ± 1.81
RBC (×10^{6}/µL)	3.28 ± 0.35	3.41 ± 0.27	3.21 ± 0.35^{b}	3.51 ± 0.18^{a}	3.30 ± 0.35	3.40 ± 0.27
WBC (×10^{3}/µL)	15.19 ± 1.72	16.04 ± 2.10	15.31 ± 1.93	16.02 ± 1.96	14.51 ± 0.79^{b}	16.83 ± 2.11^{a}
Platelets (×10^{4})	16.69 ± 5.63	17.98 ± 6.58	16.60 ± 4.92^{b}	18.28 ± 7.28^{a}	12.21 ± 10.75^{b}	22.79 ± 4.16^{a}
Lymphocytes (%)	67.33 ± 5.10^{b}	69.92 ± 3.92^{a}	66.13 ± 4.15^{b}	71.67 ± 3.23^{a}	67.35 ± 4.32^{b}	70.14 ± 4.63^{a}
Heterophils (%)	25.19 ± 5.27	23.13 ± 4.05	26.75 ± 4.17^{a}	21.05 ± 3.28^{b}	25.52 ± 4.39^{a}	22.59 ± 4.68^{b}
H/L ratio	0.37 ± 1.03	0.33 ± 1.03	0.40 ± 1.00	0.29 ± 1.02	0.38 ± 1.02	0.32 ± 1.01
Monocytes (%)	3.29 ± 1.01	3.04 ± 0.91	2.96 ± 0.91	3.38 ± 0.97	3.04 ± 0.93	3.27 ± 0.98
Eosinophils (%)	3.95 ± 1.24	3.79 ± 1.56	4.00 ± 1.59	3.71 ± 1.19	3.91 ± 1.16	3.82 ± 1.65
Basophils (%)	0.24 ± 0.44	0.13 ± 0.34	0.17 ± 0.38	0.19 ± 0.40	0.17 ± 0.39	0.18 ± 0.39

Note: ^{a,b} Means in the same row with similar superscript are not significantly different (P > 0.05). PCV = packed cell volume, RBC = red blood cells/erythrocyte, WBC = white blood cells, H/L ratio = ratio of heterophils to lymphocytes

Table 2 Interactive effect of wallowing, sex, and post wallowing time on the haematological parameters of geese

Haematological parameters	NWF at 4 weeks	NWM at 2 weeks	NWM at 4 weeks	WF at 2 weeks	WF at 4 weeks	WM at 2 weeks	WM at 4 weeks
PCV (%)	37.17 ± 4.71^{b}	45.00 ± 3.00^{a}	44.50 ± 6.03^{a}	40.50 ± 2.88^{ab}	41.00 ± 4.73^{ab}	44.67 ± 1.86^{a}	45.17 ± 1.72^{a}
Haemoglobin (g/dL)	12.42 ± 1.56^{b}	14.68 ± 1.04^{ab}	14.85 ± 1.97^{ab}	13.27 ± 0.8^{ab}	13.60 ± 1.75^{ab}	14.77 ± 0.90^{ab}	15.22 ± 0.60^{a}
RBC (×10^{6})	3.22 ± 0.28^{ab}	3.52 ± 0.16^{ab}	3.47 ± 0.34^{ab}	3.24 ± 0.41^{ab}	3.38 ± 0.25^{ab}	3.47 ± 0.14^{ab}	3.56 ± 0.10^{a}
WBC (×10^{3})	15.48 ± 1.84^{ab}	14.64 ± 6.87^{b}	16.85 ± 2.50^{ab}	14.66 ± 1.11^{b}	16.84 ± 2.66^{ab}	14.49 ± 5.33^{b}	18.15 ± 4.87^{a}
Platelets (×10^{4})	18.93 ± 2.89^{b}	11.78 ± 1.09^{c}	25.55 ± 2.55^{a}	12.50 ± 1.02^{c}	22.32 ± 4.09^{ab}	11.85 ± 1.22^{c}	25.27 ± 3.58^{a}
Lymphocyte (%)	65.50 ± 4.14^{bc}	70.80 ± 2.39^{ab}	71.75 ± 6.08^{ab}	65.33 ± 3.78^{bc}	70.33 ± 2.58^{ab}	70.50 ± 2.43^{ab}	73.50 ± 1.64^{a}
Heterophil (%)	27.17 ± 4.45^{abc}	21.60 ± 2.70^{bcd}	20.75 ± 5.91^{cd}	28.00 ± 3.63^{ab}	22.67± 2.42^{bcd}	22.67 ± 2.25^{bcd}	19.17 ± 1.83^{d}
H/L ratio	0.41 ± 1.07	0.31 ± 1.13	0.29 ± 0.92	0.43 ± 0.96	0.32 ± 0.94	0.32 ± 0.93	0.26 ± 1.12
Monocyte (%)	2.83 ± 0.98	3.80 ± 1.10	3.75 ± 0.96	2.67 ± 0.82	3.33 ± 1.03	2.83 ± 0.75	3.33 ± 1.03
Eosinophil (%)	4.50 ± 1.38	3.60 ± 0.89	3.25 ± 0.96	3.83 ± 1.33	3.50 ± 2.26	4.00 ± 1.10	3.83 ± 1.72
Basophil (%)	0.00 ± 0.00	0.20 ± 0.45	0.50 ± 0.58	0.17 ± 0.41	0.17 ± 0.41	0.00 ± 0.00	0.17 ± 0.41

Note: ^{a,b,c,d} Means in the same row with similar superscript are not significantly different (P > 0.05). NWF = non-wallowed female, WF = wallowed female, NWM = non-wallowed male, WM = wallowed male, PCV = packed cell volume, RBC = red blood cells/ erythrocytes, WBC = white blood cells/leucocyte, H/L ratio = ratio of heterophils to lymphocytes

The main effect of wallowing and sex on the thermoregulatory response of geese during high THI is shown in Table 3. Sex did not have any significant effect on all parameters. Male and female geese had 20.24 ± 2.48 and 21.15 ± 3.69 breaths/minute for respiratory rate, 40.43 ± 0.45 and 40.42 ± 0.35°C for rectal temperature, and 152.74 ± 22.32 and 156.33 ± 17.43 beats/minute for pulse rate, respectively. The wallowing effect showed that significantly ($P < 0.05$) higher values were observed in the respiratory rate and pulse rate of non-wallowed geese than in the wallowed geese. However, there was no significant difference in their rectal temperature.

The interaction of wallowing and sex on the thermoregulatory parameters of geese is shown in Table 4. The wallowing and sex interactive effect depicted a significantly ($P < 0.05$) lower respiratory rate and pulse rate in the wallowed goose than in the non-wallowed goose. This could be a result of the influence of wallowing on thermoregulation, although both were within the normal physiological range for geese which has been reported to be 12–30 breaths/minute and 180–340 beats/minute (Singh and Bhattacharya, 1991). Wallowing can help birds in thermoregulation, promote evaporative cooling and in preventing dehydration (Keck, 2011), thereby reducing the need for panting in wallowed birds. However, the geese did not suffer severe heat stress since the high temperature experienced during this study did not exceed the critical level for birds which can lead to severe heat stress.

No significant difference in rectal temperature in all the groups showed that wallowing and sex interactions did not influence the geese rectal temperature. The values obtained in all treatments (39.99–40.72°C) were within the normal physiological range for geese (McDowell *et al.,* 1976) and similar to the findings of Akinbola and Ewuola (2020), Akinbola *et al*. (2021) and Ewuola *et al.* (2021) who reported a close range of geese rectal temperature in both sexes at high and low THI. Isidahomen (2012) also reported a range of 40.09–41.27°C rectal temperature in three genotypes of Nigerian indigenous chickens. Normally, the chicken's body temperature is 41.5°C but will fluctuate depending upon the temperature of its environment. Birds regulate the balance between heat production and heat loss to maintain their deep body temperature at approximately 40°C (Mutibvu *et al.,* 2017). In this study, the animals were not affected by heat stress, and they were able to properly adapt and balance to their environment, as indicated in their response shown in the rectal temperature. The internal thermoregulation process is one aspect of homeostasis, a state of dynamic stability in an organism's internal conditions maintained far from thermal equilibrium with its environment.

Table 3 Main effect of wallowing and sex on the thermoregulatory response of geese during high temperature humidity index

Parameters	Wallowing		Sex	
	Non-wallowed geese	Wallowed geese	Female	Male
Respiratory rate (Brt/min)	22.04 ± 2.69[a]	19.68 ± 3.57[b]	21.15 ± 3.69	20.24 ± 2.48
Rectal temperature (°C)	40.44 ± 0.32	40.40 ± 0.44	40.42 ± 0.35	40.43 ± 0.45
Pulse rate (Bts/min)	166.81 ± 14.20[a]	143.55 ± 15.86[b]	156.33 ± 17.43	152.74 ± 22.32

Note: [a,b] Means in the same row with the same superscript are not significantly different ($P > 0.05$). Brt/min = breaths/minute, Bts/min = beats/minute, °C = degree Celsius

Table 4 Interactive effect of wallowing and sex on the thermoregulatory parameters of geese

Parameters	Wallowing and sex			
	NWF	NWM	WF	WM
Respiratory rate (Brt/min)	22.70 ± 2.50[a]	20.30 ± 2.41[ab]	19.40 ± 4.10[b]	20.20 ± 2.70[ab]
Rectal temperature (°C)	40.40 ± 0.30	40.50 ± 0.40	40.40 ± 0.40	40.30 ± 0.50
Pulse rate (Bts/min)	166.90 ± 10.30[a]	166.60 ± 22.60[a]	144.70 ± 16.30[b]	141.90 ± 15.90[b]

Note: [a,b] Means in the same row with the same superscript are not significantly different (P > 0.05). NWF = non-wallowed female, NWM = non-wallowed male, WF = wallowed female, WM = wallowed male, Brt/min = breaths/minute, Bts/min = beats/minute, °C= degree Celsius

CONCLUSION

This study showed that during high THI, wallowing influenced the blood profile and thermoregulatory responses of the geese of both sexes, increased erythrogenesis, oxygen-carrying capacity and boosted immune capability through evaporative cooling, conferred by wallowing and complete mitigation of heat stress effect in geese when temperature humidity index is high. Also, non-wallowed females showed increased respiratory rate and pulse rate than wallowed ones, which are indicative of the influence of wallowing. In the tropical region, geese reared can still maintain a normal body temperature despite the increased environmental temperature.

REFERENCES

Akinbola, E.T. and E.O. Ewuola. 2020. Variations in the thermoregulatory response of geese during high temperature humidity index, pp. 187–190. *In*: Proceedings of the 9th ASAN-NIAS Joint Annual Meeting, 15–18 November 2020, Gwarimpa, Abuja.

Akinbola, E.T., E.O. Ewuola and A.T. Olujimi. 2021.Variations in the thermoregulatory response of geese during low temperature humidity index, pp. 744–747. *In*: Proceeding of the 46th Annual Conference of the Nigerian Society for Animal Production (NSAP), 14–18 March 2021, Katsina, Nigeria.

Albokhadaim, I. 2012. Haematological and some biochemical values of indigenous chickens in Al-Ahsa Saudi Arabia during summer season. Asian J. Poult. Sci. 6(4): 138–145.

Altan, O., A. Altan, M. Cabuk and H. Bayraktar. 2000. Effects of heat stress on some blood parameters in broilers. Turk. J. Vet. Anim. Sci. 24: 145–148.

Borges, S.A., A.V. Fischer da Silva, J. Ariki, D.M. Hooge and K.R. Cummings. 2003. Dietary electrolyte balance for broiler chickens exposed to thermoneutral or heat-stress environments. Poult. Sci. 82(3): 428–435.

Brodsky, L.M. and P.J. Weatherhead. 1984. Behavioural thermoregulation in wintering black ducks: roosting and resting. Can. J. Zool. 62: 1223–1226.

Charles-Smith, L.E., M.E. Rutledge, C.J. Meek, K. Braine, E. Massey, L.N. Ellsaesser, C.S. DePerno, C.E. Moorman and L.A. Degernes. 2014. Hematologic parameters and hemoparasites of nonmigratory Canada geese (*Branta canadensis*) from Greensboro, North Carolina, USA. J. Avian Med. Surg. 28(1): 16–23.

Crescio, M.I., F. Forastiere, C. Maurella, F. Ingravalle and G. Ru. 2010. Heat-related mortality in dairy cattle: a case crossover study. Prev. Vet. Med. 97(3–4):191–197.

Deyhim, F. and R.G. Teeter. 1991. Research note: sodium and potassium chloride drinking water supplementation effects on acid-base balance and plasma corticosterone in broilers reared in thermoneutral and heat-distressed environments. Poult. Sci. 70(12): 2551–2553.

Dobson, H., J.E. Tebble, R.F. Smith and W.R. Ward. 2001. Is stress really all that important? Theriogenology 55(1): 65–73.

Ewuola, E.O. and G.N. Egbunike. 2008. Haematological and serum biochemical response of growing rabbits bucks fed different levels of dietary fumonisin B_1. Afr. J. Biotechnol. 7(23): 4304–4309.

Ewuola, E.O., E.T. Akinbola, A.A. Ogundele and J.O. Oyewale. 2021. Effects of wallowing, sex and daytime on the thermoregulatory response of geese at high temperature humidity index, pp. 697–701. *In*: Proceedings of the 10th ASAN-NIAS Joint Annual Meeting, 5–9 September 2021, Akwa Ibom State, Nigeria.

Feldman, B.F., J.G. Zinkl and N.C. Jain. 2000. Schalm's Veterinary Haematology. 5th Edition. Lippincott Williams & Wilkins, Philadelphia, USA.

Franson, J.C., D.J. Hoffman and J.A. Schmutz. 2009. Plasma biochemistry values in emperor geese (*Chen canagica*) in Alaska: comparisons among age, sex, incubation, and molt. J. Zoo Wildl. Med. 40(2): 321–327.

Fudge, A.M. 2000. Avian blood sampling and artifact considerations, pp. 1–8. *In*: A.M. Fudge, (Ed), Laboratory Medicine: Avian and Exotic Pets. W.B. Saunders Company, Philadelphia, USA.

Fudge, A.M. and V. Joseph. 2000. Disorders of avian leukocytes, pp. 19–27. *In*: A.M. Fudge, (Ed), Laboratory Medicine: Avian and Exotic Pets. W.B. Saunders Company, Philadelphia, USA.

Geist, V. 1998. Deer of the World: Their Evolution, Behaviour, and Ecology. Swan Hill, Victoria, Australia.

Góngora, A. and A. Hernández. 2010. High environmental temperatures affect reproduction in the cow. Rev. U.D.C.A Act. & Div. Cient. 13(2): 141–151.

Handelsman, D.J. 2020. Androgen Physiology, Pharmacology, Use and Misuse. *In*: K.R. Feingold, B. Anawalt, A. Boyce *et al*., (Eds), MDText.com, Inc., South Dartmouth, Massachusetts, USA.

Hawkes, L.A., S. Balachandran, N. Batbayar, P.J. Butler, B. Chua, D.C. Douglas, P.B. Frappell, Y. Hou, W.K. Milsom, S.H. Newman, D.J. Prosser, P. Sathiyaselvam, G.R. Scott, J.Y. Takekawa, T. Natsagdorj, M. Wikelski, M.J. Witt, B. Yan and C.M. Bishop. 2013. The paradox of extreme high-altitude migration in bar-headed geese *Anser indicus*. Proc. R. Soc. B. 280: 20122114.

Ihrig, M., L.G. Tassinary, B. Bernacky and M.E. Keeling. 2001. Hematologic and serum biochemical reference intervals for the chimpanzee (*Pan troglodytes*) categorized by age and sex. Comp. Med. 51(1): 30–37.

Isidahomen, C.E., A.A. Njidda and E.A. Olatunji. 2012. Heat tolerant traits among local and exotic chickens in southern Nigerian. IOSR-JAVS 1(6): 31–36.

Jahantigh, M. and M. Zamani-Ahmadmahmudi. 2016. Hematology and serum biochemistry values in greylag geese (*Anser anser*) in southeast Iran. Comp. Clin. Pathol. 25: 671–675.

Keck, S. 2011. ELK (*Cervus canadensis*). Available Source: http://www.bowhumting.net/NAspecies/elk1.html#subspecies. June 17, 2017.

Kostelecka-Myrcha, A. 1997. The ratio of amount of haemoglobin to total surface area of erythrocytes in birds in relation to body mass, age of nestlings and season of the year. Physiol. Zool. 70(3): 278–282.

Lien, R.J., J.B. Hess, S.R. McKee, S.F. Bilgili and J.C. Townsend. 2007. Effect of light intensity and photoperiod on live performance, heterophil-to-lymphocyte ratio, and processing yields of broilers. Poult. Sci. 86(7): 1287–1293.

Marai, I.F.M., M.S. Ayyat and U.M. Abd El-Monem. 2001. Growth performance and reproductive traits at first parity of New Zealand White female rabbits as affected by heat stress and its alleviation under Egyptian conditions. Trop. Anim. Health Prod. 33: 451–462.

McDowell, R.E., N.W. Hooven and J.K. Camoens. 1976. Effects of climate on performance of Holsteins in first lactation. J. Dairy Sci. 59(5): 965–971.

McKechnie, A.E. and B.O. Wolf. 2019. The physiology of heat tolerance in small endotherms. Physiology 34: 302–313.

Mohamed, E.A.A., O.H.A. Ali, Huwaida, E.E. Malik and I.A. Yousif. 2012. Effect of season and dietary protein level on some haematological parameters and blood biochemical compositions of three broiler strains. Int. J. Poult. Sci. 11(12): 787–793.

Mohri, M., K. Sharifi and S. Eidi. 2007. Haematology and serum biochemistry of Holstein dairy calves: age related changes and comparison with blood composition in adults. Res. Vet. Sci. 83(1): 30–39.

Muhammad, N.O., A.O. Adeyinka and O.M. Peter. 2002. Nutritional evaluation of fungi treated cocoa bean shell. Nig. J. Pure & Appl. Sci. 5: 1059–1064.

Muhammad, N.O., O.B. Oloyede, B.V. Owoyele and J.E. Olajide. 2004. Deleterious effect of defatted *Terminalia catappa* seed meal-based diet on haematological and urinary parameters of albino rats. NISEB J. 4(2): 51–57.

Mutibvu, T., M. Chimonyo and T.E. Halimani. 2017. Physiological response of slow-growing chickens under diurnally cycling temperature in a hot environment. Rev. Bras. Cienc. Avic. 19(4): 567–576.

Owoyele, B.V., J.O. Adebayo, N.O. Muhammed and A.O. Ebunlomo. 2003. Effects of different processing techniques of tunbran meal on some haematological indices in rats. Nig. J. Pure & Appl. Sci. 18: 1340–1345.

Pavlak, M., K. Vlahovic, J. Jarcic, A. Dorc and Z. Zupancic. 2005. Age, sexual and seasonal differences of haematological values and antibody status to *Chlamydophila* sp. in feral and racing pigeons (*Columbia livia* forma *domestica*) from an urban environment (Zagreb, Croatia). Eur. J. Wildl. Res. 51(4): 271–276.

Post, J., J.M.J. Rebel and A.A.H.M. ter Huurne. 2003. Automated blood cell count: a sensitive and reliable method to study corticosterone related stress in broilers. Poult. Sci. 82(4): 591–595.

SAS. 2011. SAS/STAT® 9.3 User's Guide. SAS Institute Inc., Cary, North Carolina, USA.

Singh, K. and N.K. Bhattacharyya. 1991. Thermosensitivity of *Bos indicus* cattle and their F1 crosses with three breeds of *Bos taurus.* Anim. Sci. 52(1): 57–65.

Tatli-Cankaya, I., S.I. Alquasoumi, R.F. Abdel-Rahman, H. Yusufoglu, S.A. Anul, G. Akaydin and G.A. Soliman. 2014. Evaluating the antifertility potential of the ethanolic extracts of *Bupleurum sulphureum* and *Cichorium intybus* in male rats. Asian J. Pharm. Clin. Res. 7(1): 211–218.

Tolba, A.A., M.A. Abd El-Galyl and M.H. Abd El-Samad. 2005. The effect of using some herbal additives on physiological and productive performance of two Egyptian chicken strains during winter and summer seasons. Egypt. Poult. Sci. 25(1): 107–123.

Yalcin, O., M. Uyuklu, J.K. Armstrong, H.J. Meiselman and O.K. Baskurt. 2004. Graded alteration of RBC aggregation influence in in vivo blood flow resistance. Am. J. Physiol. Heart Circ. Physiol. 287: H2644–H2650.