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Haemo-thermoregulatory response of wallowed and non-wallowed geese during low temperature humidity index

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ABSTRACT

Haemo-thermoregulatory response of twenty-six adult geese comprising of 12 males and 14 females randomly allotted to four groups (Wallowed males, non-wallowed males, wallowed females and non-wallowed females) in a completely randomized design for seven weeks was evaluated. Wallowing was done every alternate day. Respiratory rate (RR), rectal temperature (RT) and pulse rate (PUR) were recorded. On days 1 and 49, blood samples (3mL/geese) were collected from geese in each group and analysed for haematological parameters using standard procedures. There was no sex effect on the RR and PUR but significantly ($p<0.05$) higher RT was observed in males (40.69˚C) compared to females (40.53°C). The RR, RT and PUR were not significantly affected by wallowing. Interactions effect between sex and wallowing on RR, RT and PUR was not significant. Only platelet counts were significantly higher in females (17.70) than males (14.68). Wallowed Geese had significantly lower packed cell volume (37.46±5.13%), haemoglobin (11.85±1.69g/dl) and monocytes (2.81±0.63%) than other treatments. Wallowed Female geese had significantly lower haemoglobin (10.93g/dL) and monocytes (2.86%) compared to those without wallow treatment. Therefore, wallowing has mild influence on the thermoregulatory and haematological indices of geese reared under low temperature-humidity index during non-breeding season.

Keywords: Geese blood, Stress index, thermoregulation, evaporative cooling

INTRODUCTION

Geese (*Anser spp.*) are members of the duck family (*Anatidae*). Geese and their eggs have been an important human food source for thousands of years, which may have been the reason why geese were among the first domesticated birds (FAO, 2002). They were fully domesticated approximately 3,000 years ago to provide meat, eggs and feathers (Todd, 1996; Buckland and Guy, 2002; FAO, 2002). Geese have practically been neglected in the previous years and yet geese is still the fastest growing bird to 10 weeks of age, often exceeding 11Ib (5 kg) by that time (Carmen and Mountney, 1988). The tropical ambient temperature has a significant effect on the performance of poultry generally. The thermal comfort of geese during exposure to extreme environmental temperature and relative humidity has necessitated the adoption of structural strategies with profound physiological influence. Wallowing could lower body temperature and reduce the adverse effects of high ambient temperature on animals. The respiration rate is higher in birds exposed to high temperature than those raised under normal ambient temperature (Kalamah, 2001).

The thermoregulatory characteristics of poultry differ to some extent from those of mammals due to their high rate of metabolism associated with more intensive heat production and low heat dissipation capacity caused by their feathers and lack of sweat glands. Respiratory rate is a major and efficient index of heat stress in animals and very sensitive cardinal physiological variable to stress caused by excessive heat (Yaqub et al., 2017). During thermal stress, changes and variations in respiratory rate are often preceded by variations in other cardinal physiological variable changes such as pulse or heart rate, rectal temperature and sweating (Jian et al., 2015), though increase in the temperature of the body is the most common factor controlling it (Entin et al., 2005; Robertshaw, 2006). Generally, birds exposed to high temperature are more prone to higher respiratory rate compared to those raised under normal environmental temperature (Kalamah, 2001).

Evaporative cooling is also achieved exclusively by panting (FASS, 2010). Ducks and geese also use water to regulate their body temperature during periods of heat stress, and access to open water is especially important for ducks farmed in tropical conditions (Edwards, 2019). Water fowls make use of thermoregulatory mechanisms such as wallowing that would protect them from solar radiation and provide cooling effect (Seijan et al., 2012, Nienaber et al., 1999).

Avian haematology has been used in ornithological, biological, pathological, ecological, physiological and behavioural studies (Puerta and Abelenda, 1989b). Measurement of haematological and biochemical parameters are used for the birds' health status assessment, good stress indicator most especially the heterophil:lymphocyte ratio, facilitate diagnosis

of disease, inflammations, intoxications subclinical processes (Katavolos et al., 2007; Clark et al., 2009; O'Connell et al., 2009).

However, information on the effect of sex and wallowing on the thermoregulatory parameters and haematology of geese are scanty and thus, investigated to know whether the geese response is sex dependent and to document the influence of cooling on both their thermoregulation and physiological processes when the ambient temperature is low in attempt to boost their productivity since non-breeding season in geese usually coincide with period of low temperature-humidity index. This study was therefore aimed at establishing the haemo-thermoregulatory response of wallowed and non-wallowed geese at low temperature-humidity index during non-breeding season.

MATERIALS AND METHODS

Experimental Site

The research was carried out at the poultry unit of the Teaching and Research Farm, University of Ibadan with Latitude 7°26' N and Longitude 3°54' E.

Experimental animals, design and management

This experiment lasted for seven (7) weeks and was carried out between July and August, when least temperature-humidity index (THI) was observed at the experimental site. Twenty-six one-year old geese (Fourteen females and twelve males), with average weight of 5.5±0.5kg for males and 4.2±0.35 kg for females were used for this experiment. The geese were fed 5% of their body weight, with diets containing crude protein 16.5%, digestible energy 2500 Kcal/kg, crude fibre 6%, fat 5%, calcium 3.5% and phosphorus 0.41%. The geese were randomly allotted to four groups (Wallowed male, Non-wallowed male, Wallowed female and Non-wallowed female), in a 2x2 factorial arrangement in a completely randomized design (CRD) for the thermoregulatory assessment and in a 2 x 2 x2 factorial arrangement in a CRD for the haematological assessment. Blood collection was done at the beginning and at the end of the experiment.

Meteorological Data of the Pen

Daily temperature and relative humidity of the poultry microclimate was recorded at 07.00h every morning, 12.00h afternoon and 16.00h evening during the study period using a thermo-hygrometer. The temperature-humidity index (THI), as an indicator of thermal comfort level, for animals in an enclosure was calculated as modified by Marai et al. (2001).

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

Where RH = relative humidity /100. t = ambient temperature.

The values of THI obtained for the temperate and tropical region are classified as:

<27.8°C = absence of heat stress
27.8 - 28.9°C = moderate heat stress
28.9 –30°C = severe heat stress and
Above 30°C = very severe heat stress

(Marai et al., 2001)

Thermoregulatory Assessment

Thermoregulatory indices of geese measured included respiratory rate (RR), pulse rate (PR) and rectal temperature (RT). Measurements were taken between 12.00 to 14.00h of the day. Rectal temperature was measured with a digital thermometer and expressed in °C. The respiratory rate was measured by visually counting the flank movement for 1 minute using stop watch and presented in breaths per minute. The pulse rate was measured using a stethoscope for 1 minute and recorded as beats per minute.

Wallowing

The male and female geese were divided equally at random into two groups; wallowed and non-wallowed groups. The wallowed group and non-wallowed group consist of six males and seven females. The wallowed group were allowed to wallow between 14.00 and 15.00h every other day. The dimension of the wallow facility was 12×6×4m and impound with water to about ¾ filled.

Blood sample collection and analysis

At week 7 of the experiment, the birds were restrained by holding the two wings with one hand and the two legs in the other hand. Blood samples (3ml) were collected aseptically from jugular vein of the birds early in the morning into vacuumed sterile tubes with anticoagulant. The blood samples were used for haematological analysis for 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 erythrocyte indices (mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC)) was calculated by the standard formulae.

Data analysis

Data obtained were subjected to descriptive statistics and ANOVA of SAS (2012) to detect significant effects at p=0.05. Significant mean differences were separated with Duncan multiple range test.

RESULTS

The temperature-humidity index (THI) of the geese house during the least temperature-humidity index of Ibadan is presented in Figure 1.

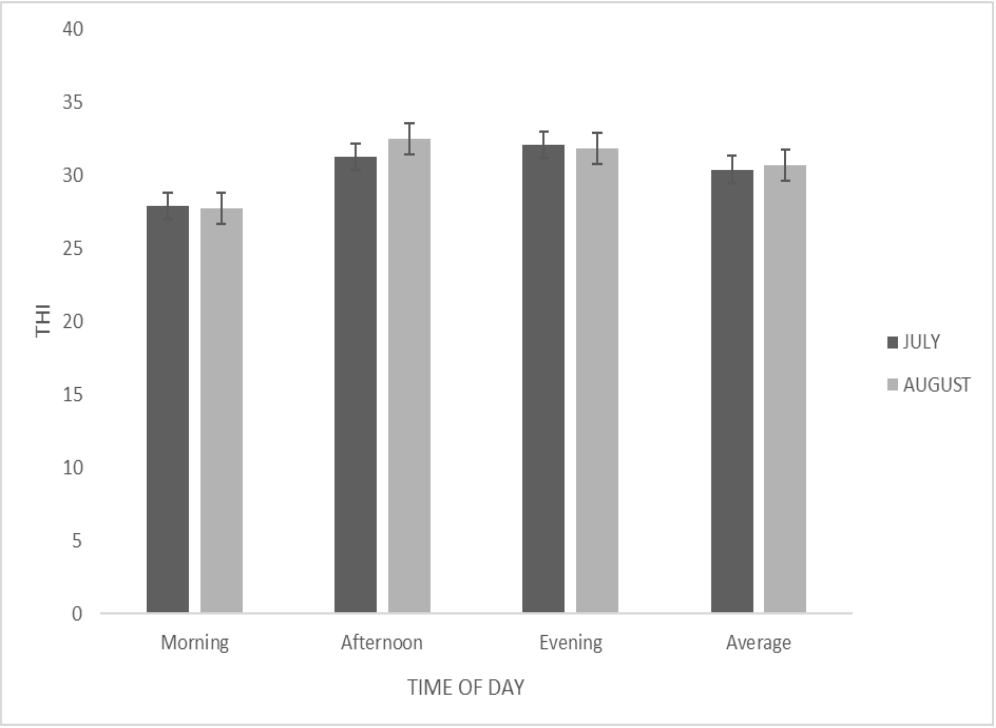

Figure 1. Average Temperature Humidity Index of geese house during Low Temperature Humidity Index (THI) in Ibadan

The month of August had higher THI than July except in the evening. In the morning, the THI of July and August were 27.90°C and 27.76°C respectively, and in the afternoon, THI were 31.28 and 32.53 °C respectively. The monthly THI for July and August were 30.43°C and 30.73°C, respectively.

The main effect of sex and wallow treatment on respiratory rate (RR), rectal temperature (RT), and pulse rate (PUR) of geese are shown in Table 1.

Table 1. Main effects of sex and wallow treatment on respiratory rate (RR), rectal temperature (RT), and pulse rate (PUR) of geese

Parameters	Sex		Wallow treatment		SEM
	Male	Female	With	Without	
Respiratory rate (breaths/min)	20.82	20.02	20.35	20.43	0.21
Rectal temperature (°C)	40.69[a]	40.53[b]	40.59	40.62	0.04
Pulse rate (heart beats/mins)	152.74	159.73	157.33	155.68	2.17

[ab]Means of treatments along a row with different superscripts differed significantly (P<0.05).

The RR and PUR values observed in geese were not significantly (p<0.05) influenced by sex and values ranged from 20.02 breath/minutes (females) to 20.82 breath/minute (males), and 152.74 heart beat/minute (males) to 159.73 heart beat/minute (females), respectively. However, significantly higher (p<0.05) RT was observed in males (40.69°C) compared to females (40.53°C). The RR, RT and PUR of geese were not significantly (p>0.05) affected by wallow treatment. The interaction effects of sex and wallow treatments on the RR, RT and PUR of the geese are shown in Table 2.

Table 2. Interaction effect of sex and wallow treatment on respiratory rate (RR), rectal temperature (RT), and pulse rate (PUR) of geese

Sex	Wallow Treatment	Respiratory Rate (bpm)	Rectal Temperature (°C)	Pulse Rate (hbpm)
Male	With	20.85	40.83[a]	158.06[a]
Male	Without	21.43	40.80[a]	154.45[ab]
Female	With	20.54	40.71[a]	155.74[ab]
Female	Without	20.04	40.69[ab]	164.52[a]
SEM		0.04	0.04	2.17

[ab]Means of treatments along a column with different superscripts differed significantly (P<0.05). bpm - breaths per minute, hbpm-heart beats per minute

There was no interaction between sex and wallowing effect on the RR, RT and PUR. The RR values ranged 20.04 to 21.43 breaths/minute. The RT observed ranged from 40.69 to 40.83°C

The main effects of wallow period, sex and wallowing on haematological parameters of geese are shown in Table 3.

The PCV value observed before wallow treatment (40.31%) was significantly (p<0.05) higher compared to what was observed after wallow treatment (37.15%). The Hb observed in the geese before wallow treatment (13.15g/dl) was significantly (p<0.05) higher compared to what was observed after wallow treatment (11.39g/dl). However, RBC, WBC, platelet, lymphocyte, heterophil, monocyte, eosinophil and basophil values were not significantly (p>0.05) different before and after wallow treatment and values ranged from 3.24×10^6/µl to 3.32×10^6/µl; 13.40×10^3/µl to 14.07×10^3/µl; 15.15×10^3/µl to 17.47×10^3/µl; 67.96% to 69.62%; 23.50% to 23.69; 3.00% to 3.35%, 3.65%

and 0.23% to 0.46%, respectively. Heterophil:Lymphocyte ratio was also similar among the treatments.

In the sex effect, there was no significant ($p>0.05$) difference observed in PCV, Hb, RBC, WBC, lymphocyte, heterophil, monocyte, eosinophil and basophil values in both male and female geese and values ranged from 38.54% to 38.96%; 12.16g/dl to 12.41g/dl; 3.17×10^6/µl to 3.40×10^6/µl; 13.68×10^3/µl to 13.78×10^3/µl; 68.25% to 69.42%; 23.29% to 23.86%; 3.14% to 3.21%; 3.50% to 3.83% and 0.33% to 0.36%, respectively. Also, there was significant difference in platelet counts with higher values in females compared to males.

The PCV observed in geese subjected to wallow treatment (37.46%) was significantly ($p < 0.05$) lower compared to those without wallow treatment (40.00%). The Hb value in geese on wallow (11.85g/dl) was significantly ($p<0.05$) lower than those without wallow treatment (12.70g/dl). Higher ($p<0.05$) monocyte counts was observed in geese without wallow treatment (3.54%) compared to those on wallow treatment (2.81%). Eosinophil counts observed in geese on wallow treatment (4.23%) was significantly ($p<0.05$) higher compared to those without wallow treatment (3.08%). However, the RBC, WBC, platelet, lymphocyte, heterophil and basophil values were not significantly ($p>0.05$) affected by wallow treatment and values ranged from 3.19×10^6/µl to 3.37×10^6/µl; 13.12×10^3/µl to 14.35×10^3/µl; 16.11×10^3/µl to 16.50×10^3/µl; 67.77% to 69.81%; 22.81% to 24.39% and 0.35%, respectively.

The interaction effect of wallow period and sex on haematological parameters of geese is shown in Table 4.

Males before wallowing (40.58%) and females before wallowing (40.07%) had similar PCV values and were significantly ($p<0.05$) higher compared to males (37.33%) and females (37.00%) after wallow treatment. The Hb values observed in males (13.25g/dl) and females (13.06g/dl) before wallow treatment were significantly ($p<0.05$) higher compared to males (11.57g/dl) and females (11.25g/dl) after wallow treatment. Higher ($p<0.05$) platelet count was observed in females after wallow treatment (18.96×10^3/µl) compared to other treatment groups. However, there were no significant ($p>0.05$) differences observed in RBC, WBC, lymphocyte, heterophil, monocyte, eosinophil and basophil counts before and after wallow treatment, and values ranged from 3.12×10^6/µl to 3.43×10^6/µl; 13.39×10^3/µl to 14.18×10^3/µl; 67.14% to 69.92%; 23.17% to 24.14%; 3.00% to 3.42%; 3.43% to 3.92% and 0.17% to 0.50%, respectively. Heterophil:lymphocyte ratio was similar among the treatment groups

Table 3. Main effects of wallow period, sex and wallow treatment on the haematological parameters of geese

Parameters	Wallow Period		Sex		Wallow Treatment		P values			SEM
	Before	After	Male	Female	With	Without	Period	Sex	Wallow	
PCV (%)	40.31[a]	37.15[b]	38.96	38.54	37.46[b]	40.00[a]	0.01	0.71	0.03	0.61
Hb (g/dl)	13.15[a]	11.39[b]	12.41	12.16	11.85[b]	12.70[a]	<0.0001	0.46	0.01	0.21
RBC (×106/µl)	3.24	3.32	3.40	3.17	3.19	3.37	0.56	0.12	0.18	0.07
WBC (×103/µl)	14.07	13.40	13.68	13.78	13.12	14.35	0.39	0.89	0.14	0.38
Platelet (×103/µl)	15.15	17.47	14.68[b]	17.70[a]	16.50	16.11	0.13	0.05	0.83	0.75
Lymphocytes (%)	69.62	67.96	69.42	68.25	67.77	69.81	0.14	0.28	0.05	0.54
Heterophils (%)	23.69	23.50	23.29	23.86	24.39	22.81	0.88	0.62	0.15	0.54
Monocytes (%)	3.00	3.35	3.21	3.14	2.81[b]	3.54[a]	0.11	0.76	0.002	0.12
Eosinophils (%)	3.65	3.65	3.83	3.50	4.23[a]	3.08[b]	0.97	0.31	0.001	0.17
Basophils (%)	0.23	0.46	0.33	0.36	0.35	0.35	0.09	0.86	1.00	0.07
H:L	0.34	0.35	0.34	0.35	0.36	0.33				0.61

[ab] Means of treatments along a row with different superscripts differed significantly (P<0.05). PCV-packed cell volume, Hb-haemoglobin, RBC-Red blood cells, WBC-White blood cells. SEM-standard error of means, H:L= Heterophil:Lymphocyte

Table 4. Interaction effect of Wallow period and Sex on the haematological parameters of geese

Wallow Period	Sex	PCV (%)	Hb (g/dl)	RBC (×10⁶/µl)	WBC (×10³/µl)	Platelets (×10³/µl)	Lymphocytes (%)	Heterophils (%)	H:L	Monocytes (%)	Eosinophils (%)	Basophils (%)
Before	Male	40.58[a]	13.25[a]	3.37	13.94	13.64[b]	69.92	23.17	0.33	3.00	3.75	0.17
Before	Female	40.07[a]	13.06[a]	3.12	14.18	16.44[ab]	69.36	24.14	0.35	3.00	3.57	0.29
After	Male	37.33[b]	11.57[b]	3.43	13.41	15.73[b]	68.92	23.42	0.34	3.42	3.92	0.50
After	Female	37.00[b]	11.25[b]	3.22	13.39	18.96[a]	67.14	23.57	0.35	3.29	3.43	0.43
SEM		0.61	0.21	0.07	0.38	0.75	0.54	0.54	0.06	0.12	0.17	0.07

[ab]Means of treatments along a column with different superscripts differed significantly (P<0.05) PCV-Packed Cell Volume, Hb- Haemoglobin, RBC-Red blood cells, WBC-White blood cells. SEM-standard error of means, H:L= Heterophil:Lymphocyte

The interaction effect of wallow period and wallow treatment on haematological parameters of geese is shown in Table 5. Higher ($p<0.05$) PCV values were observed in T1 (39.04%) and T2 (41.62%) compared to T3 (35.82%) and T4 (38.51%). The Hb concentration in T2 (13.62g/dl) was significantly ($p<0.05$) higher compared to T3 (10.99g/dl) and T4 (11.82g/dl). Lymphocyte counts observed in T2 (70.82%) was significantly ($p<0.05$) higher compared to T3 (67.09%). Geese in T4 (3.77%) had significantly ($p < 0.05$) higher monocytes count compared to T1 (2.69%) and T3 (2.93%), but was not significantly ($p>0.05$) different from T2 (3.31%). Eosinophils count observed in T1 (4.31%) and T3 (4.17%) were significantly ($p < 0.05$) higher compared to T2 (3.01%) and T4 (3.18%). However, RBC, WBC, platelets, heterophils and basophils counts were not significantly ($p>0.05$) affected by wallow period and wallow treatment interaction, and values ranged from 3.12×10^6/µl to 3.39×10^6/µl; 12.85×10^3/µl to 14.67×10^3/µl; 14.78×10^3/µl to 17.41×10^3/µl; 22.63% to 24.68% and 0.23% to 0.46%, respectively

The interaction effect of sex and wallow treatment on haematological parameters of geese is shown in Table 6. It was observed that males without wallow treatment (40.92%) had significantly ($p < 0.05$) higher PCV compared to males with wallow treatment (37.00%) and females with wallow treatment (37.86%). Higher ($p<0.05$) Hb value was observed in males without wallow treatment (12.98g/dl) compared to males with wallow treatment (11.83g/dl) and females with wallow treatment (11.86g/dl), but did not differ significantly ($p>0.05$) from females without wallow treatment (12.46g/dl). The RBC value observed in males without wallow treatment (3.54×10^6/µl) was significantly ($p < 0.05$) higher compared to females with wallow treatment (3.12×10^6/µl). Similar RBC values were observed in males with wallow treatment (3.26×10^3/µl) and females without wallow treatment (3.23×10^3/µl).

Higher ($p<0.05$) WBC was observed in females without wallow treatment (14.86×10^3/µl) compared to females with wallow treatment (12.71×10^3/µl). Lymphocyte count observed in males without wallow treatment (71.00%) was significantly ($p<0.05$) higher compared to other treatments. Monocytes observed in males without wallow treatment (3.58%) and females without wallow treatment (3.50%) were significantly ($p<0.05$) higher compared to other treatment groups. Eosinophil counts was significantly ($p<0.05$) higher in males with wallow treatment (4.33%) and females with wallow treatment (4.14%) compared to females without wallow treatment (2.86%). However, platelet count, heterophils and basophils were not significantly ($p>0.05$) affected by sex and wallow treatment interaction, and values ranged from 14.30×10^3/µl to 18.40×10^3/µl; 22.08% to 24.50%; and 0.33% to 0.36%, respectively.

Table 5. Interaction effect of wallow period and wallow treatments on the haematological parameters of geese

Gr	Wallow Period	Wallow treatment	PCV (%)	Hb	Gr	Wallow Period	Wallow treatment	PCV (%)	Hb	Gr	Wallow Period	Wallow treatment	PCV (%)
T1	Before	With	39.04^{a}	12.69^{ab}	3.12	13.45	15.29	68.45^{ab}	24.68	0.36^{a}	2.69^{c}	4.31^{a}	0.23
T2	Before	Without	41.62^{a}	13.62^{a}	3.37	14.67	14.78	70.82^{a}	22.63	0.32^{b}	3.31^{ab}	3.01^{b}	0.23
T3	After	With	35.82^{b}	10.99^{c}	3.26	12.85	17.41	67.09^{b}	24.11	0.36^{a}	2.93^{b}	4.17^{a}	0.46
T4	After	Without	38.51^{b}	11.82^{b}	3.39	13.96	17.28	68.96^{ab}	22.88	0.33^{b}	3.77^{a}	3.18^{b}	0.46
	SEM		0.61	0.21	0.07	0.38	0.75	0.54	0.54	0.02	0.12	0.17	0.07

^{abc}Means of treatments along a column with different superscripts differed significantly (P<0.05). Gr = Group, PCV-packed cell volume, Hb-haemoglobin, RBC-Red blood cells, WBC-White blood cells, SEM-standard error of means, H:L= Heterophil:Lymphocyte

Table 6. Interaction effect of Sex and Wallow treatment on haematological parameters of geese

Sex	Wallow Treatment	PCV (%)	Hb (g/dl)	RBC (×10^{6}/µl)	WBC (×10^{3}/µl)	Platelet (×10^{3}/µl)	Lymphocytes (%)	Heterophils (%)	H:L	Monocytes (%)	Eosinophils (%)	Basophils (%)
Male	With	37.00^{b}	11.83^{b}	3.26^{ab}	13.59^{ab}	14.30	67.83^{b}	24.50	0.36^{a}	2.83^{b}	4.33^{a}	0.33
Male	Without	40.92^{a}	12.98^{a}	3.54^{a}	13.77^{ab}	15.06	71.00^{a}	22.08	0.31^{c}	3.58^{a}	3.33^{ab}	0.33
Female	With	37.86^{b}	11.86^{b}	3.12^{b}	12.71^{b}	18.40	67.71^{b}	24.28	0.36^{a}	2.79^{b}	4.14^{a}	0.36
Female	Without	39.21^{ab}	12.46^{ab}	3.23^{ab}	14.86^{a}	17.00	68.79^{ab}	23.43	0.34^{b}	3.50^{a}	2.86^{b}	0.36
SEM		0.61	0.21	0.07	0.38	0.75	0.54	0.54	0.03	0.12	0.17	0.07

^{ab}Means of treatments along a column with different superscripts differed significantly (P<0.05) PCV-packed cell volume, Hb-haemoglobin, RBC-Red blood cells, WBC-White blood cells, SEM-standard error of means, H:L= Heterophil:Lymphocyte

Table 7 shows the interaction effect of wallow period, sex and wallow treatment on haematological parameters of geese. Higher ($p<0.05$) PCV values were observed in Ta (38.50%), Tb (42.67%), Tc (39.57%) and Td (40.57%) compared to Te (35.50%). The Hb concentration observed in Tb (13.90g/dl) was significantly ($p<0.05$) higher compared to other treatments, except Td (13.34g/dl). Higher ($p<0.05$) platelet counts was observed in Tg (19.43×10^3/µl) compared to Ta (13.22×10^3/µl), but was similar to other treatment groups. Lymphocyte counts observed in birds in Tb (71.50%) was significantly ($p<0.05$) higher compared to Tg (66.86%). The Tf (3.83%) and Th (3.71%) had similar values of monocytes, and were significantly ($p<0.05$) higher compared to Ta (2.67%), Tc (2.71%) and Tg (2.86%).

Eosinophils of geese on Ta (4.33%), Tc (4.29%) Te (4.33%) and Tg (4.00%) were significantly ($p<0.05$) higher compared to Td (2.86%) and Th (2.86%). However, RBC, WBC, and heterophil counts were not significantly ($p>0.05$) affected by period, sex and wallow interaction, and values ranged from 3.04×10^6/µl to 3.56×10^6/µl; 12.55×10^3/µl to 15.48×10^3/µl; and 21.83% to 24.86%, respectively.

DISCUSSION

The absence of sweat glands and the enclosure of the body in a layer of contour feathers have been taken as indications that birds lose only negligible amounts of water through the skin (Schmidt-Nielsen et al. 1969). The result of this study was in agreement with the report of Jimoh and Ewuola (2016) which showed that THI in the morning and evening are lower than the THI in the afternoon. The range of THI values obtained for July and August in the University of Ibadan between 2009 and 2014 was 23.61–25.30 °C and 23.42–25.43 °C, respectively as reported by Jimoh and Ewuola (2016). The monthly THI for July and August in the geese microclimate were higher than the THI values obtained in the University of Ibadan from 2009 to 2014 except 2013 (Jimoh and Ewuola, 2016). The difference could be due to the contributions of geese in-habitation in the pen to increase the ambient temperature and humidity and its efficient dissipation in the enclosure (geese pen), compared to the meteorological station. The difference could also be due to climate and environmental changes at the varied years of data collection. Thuy (2005) opined that the evaporative cooling system might favour the thermal comfort of animals during exposure to extreme environmental heat and reduce the harmful effects of heat stress.

Table 7. Interaction effect of wallow period, sex and wallow treatment on the haematological parameters of geese

Group	Wallow Period	Sex	Wallow Treatment	PCV (%)	Hb (g/dl)	RBC ($\times10^6$/µl)	WBC ($\times10^3$/µl)	Platelet ($\times10^3$/µl)	Lym (%)	Het (%)	H:L	Mon (%)	Eos (%)
Ta	Before	Male	With	38.50^{a}	12.60^{b}	3.20	14.04	13.22^{b}	68.33^{ab}	24.50	0.36^{a}	2.67^{b}	4.33^{a}
Tb	Before	Male	Without	42.67^{a}	13.90^{a}	3.53	13.85	14.07^{ab}	71.50^{a}	21.83	0.31^{b}	3.33^{ab}	3.17^{ab}
Tc	Before	Female	With	39.57^{a}	12.79^{b}	3.04	12.86	17.37^{ab}	68.57^{ab}	24.86	0.36^{a}	2.71^{b}	4.29^{a}
Td	Before	Female	Without	40.57^{a}	13.34^{ab}	3.21	15.48	15.50^{ab}	70.14^{ab}	23.43	0.33^{b}	3.29^{ab}	2.86^{b}
Te	After	Male	With	35.50^{b}	11.07^{cd}	3.31	13.14	15.38^{ab}	67.33^{ab}	24.50	0.36^{a}	3.00^{ab}	4.33^{a}
Tf	After	Male	Without	39.17^{ab}	12.07^{bc}	3.56	13.68	16.07^{ab}	70.50^{ab}	22.33	0.32^{b}	3.83^{a}	3.50^{ab}
Tg	After	Female	With	36.14^{ab}	10.93^{d}	3.21	12.55	19.43^{a}	66.86^{b}	23.71	0.35^{a}	2.86^{b}	4.00^{a}
Th	After	Female	Without	37.86^{ab}	11.57^{c}	3.24	14.23	18.50^{ab}	67.43^{ab}	23.42	0.34^{ab}	3.71^{a}	2.86^{b}
	SEM			0.61	0.21	0.07	0.38	0.75	0.54	0.54	0.02	0.12	0.17

^{abcd}Means of treatments along a column with different superscripts differed significantly (P<0.05) PCV-packed cell volume, Hb-haemoglobin, RBC-Red blood cells, WBC-White blood cells. Lym- Lymphocyte, Het- Heterophil, Mon- Monocyte, Eos- Eosinophil, Bas- Basophil, SEM-standard error of means, H:L= Heterophil:Lymphocyte

Sex that significantly influenced the rectal temperature of the geese, with relatively higher rectal temperature in males, could be due to higher and heavier weight of the males above the females. The result of this study followed the same trend as compared to the study of Akinbola and Ewuola (2020). However, according to the findings of Akinbola et al. (2021) and Ewuola et al. (2021), sex did not influence the rectal temperature of the geese. Omeran et al. (2011) noted that rectal temperature is a good indicator of core body temperature and is often used as a practical and representative method for measuring internal body temperature. Respiratory rate was not affected by sex and wallow treatment in this study. FASS (2010) noted that thermoregulation characteristics of poultry differ to some extent from those of mammals due to their high rate of metabolism associated with more intensive heat production and low heat dissipation capacity caused by their feathers and lack of sweat glands as evaporative cooling is achieved exclusively by panting.

The results of haematologic tests in this study that indicated no significant differences between males and females except in platelets shows that blood haematological parameters are similar in male and female geese. Also, significant lower PCV, Hb, and Monocytes in geese exposed to wallowing and wallow period increasing PCV and HB in the non-wallowed group could be due to haemodilution effect. Haemodilution leads to the reduction of the concentration of plasma constituents and red blood cells (Kaya and Li, 2001).

Differences also occurred in the sex and wallowing interaction with more emphasis on the wallow factor. Franson et al. (2009) reported that the measurement of haematological parameters is an efficient tool in examining health and condition of free-living birds. However, these advantages are limited by some factors such as lack of reference values and sensitivity of the haematological and biochemical variables, to uncontrolled environmental conditions and the state of birds (Newman et al., 1997; Nyholm, 1998). Packed Cell Volume (%), Haemoglobin concentration, and WBC counts in the samples were similar to the results published in swans (Milani et al., 2012), and adult snow (*Clieti caerulescens*), blue (*Clieti caerulescens*) and Canada geese (*Branta canadensis interior*) (Williams and Trainer, 1971). Female geese having higher WBC counts and platelets compared to male geese in this study could mean that the females had more protective property against infectious diseases. White blood cells are the defence cells of the body; their levels have a great participation in the immune responses and the ability of animals to fight infection (Schalm et al., 1975). Birds with higher WBC counts are able to resist infection more than those with lower WBCs level.

PCV (%), Hb concentration, and WBC count obtained in this research were similar to the results published in swans (Milani et al. 2012), adult snow, blue and Canada geese (Williams and Trainer 1971). The PCV (haematocrit) value has often been used as an indicator of health status in both wild and captive or

domestic birds (Fair et al., 2007). Approximately, 15% of the adult avian species showed a PCV value of 35-40%. The value of PCV is 44% in graylag geese (Jahantigh and Zamani-Ahmadmahmudi, 2016). It is likely that birds with high levels of PCV are accompanied by their high haemoglobin levels (Kostelecka-Myracha et al., 1997). However, the lower PCV and Hb that were obtained for wallowed males than non-wallowed males, at the end of the experiment could be due to the haemodilution effect. Also, it might have been as a result of age progression (weeks).

Previous investigations revealed that in some avian species, number of red blood cells is more in males than females (Domm et al., 1943). However, in agreement with findings in adult snow, blue and Canada geese (Williams and Trainer 1971), there was no significant difference in red blood cells count between males and females in this study, indicating that wallowing did not affect this parameter. This study also showed that lymphocyte constituted the predominant WBC population (69.6%) whereas heterophils was in the second rank (23%). This is supported by Thrall et al. (2012), who stated that Anseriformes such as duck and geese have high numbers of circulating lymphocytes. However, the heterophil:lymphocyte ratio did not reveal any adverse effect that could be attributed to stress.

CONCLUSION

The results obtained from this study revealed that sex did not influence haematological indices examined beside thrombocytes. Differences observed in the wallow periods are indicative of changes in geese blood constituents with time. Sex, wallowing and wallow period interactions positively influenced blood volume and oxygen carrying capacity of the blood in the non-wallowed geese at low temperature humidity index. Sex and wallowing had no influence or threat on the thermoregulatory processes in geese when the ambient temperature is low.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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