# Assessment of the reproductive performance of wallowed and non-wallowed geese at high temperature humidity index during breeding season

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**Abstract**

Twenty-four geese (12 males and 12 females) were used to conduct a study on the reproductive performance of wallowed and non-wallowed geese at high temperature humidity index during breeding season. Each sex of the geese was randomly divided into 2 treatment groups (wallowed group and non-wallowed group) of 2 replicates with 3 geese per replicate. Semen was collected from each gander and analysed twice: 2 weeks post-wallowing and 4 weeks post-wallowing, for semen volume, mass activity, spermatozoa motility, live to dead ratio and spermatozoa concentration. Also, data on the egg production of the geese in each treatment group were recorded appropriately for a period of 5 weeks.

The wallowing effect showed no significant difference ($P > 0.05$) in all the semen quality parameters. Their values ranged from 0.52 ± 0.24–0.53 ± 0.25 mL, 56.50 ± 15.70–62.33 ± 7.70%, 50.58 ± 15.70–53.11 ± 9.05%, 84.86 ± 12.90–86.00 ± 12.90% and 115 ± 133 x $10^6$–223 ± 15.6 x $10^6$ sperm cells/mL respectively for the semen volume, mass activity, motility, live to dead ratio and concentration. However, the post-wallowing time effect indicated a significant difference ($P < 0.05$) in only the semen volume amidst all the parameters. Higher volume was recorded at 2 weeks post wallowing – PW1 (0.68 ± 0.21 mL) as compared to 4 weeks post wallowing – PW2 (0.36 ± 0.11). The interaction effect of wallowing and post wallowing time also showed a significantly ($P < 0.05$) higher volume (0.70 ± 0.21 mL) at 4 weeks than at 2 weeks (0.35 ± 0.06 mL) for the non-wallowed group.

There was a strong negative correlation between pulse rate and rectal temperature with a correlation coefficient of 0.32, while the correlation between mass activity and pulse rate was positive with a correlation coefficient of 0.47. Also, a negative correlation was observed between livability to dead ratio and volume with a coefficient of 0.49 while mass activity positively correlated with motility having a coefficient of determination of 0.89 indicating a strong positive relationship between these two variables.

Mean egg production was not significantly affected ($P > 0.05$) between the wallowed and the non-wallowed geese.

This suggests that wallowing and post wallowing time did not influence the egg production and the semen quality parameters of wallowed and non-wallowed geese except semen volume.

***Key words:*** egg production, geese semen quality, post wallowing, wallowing

## Introduction

The changing climate often affects the management of animals and higher temperature can result in decline in egg production and reproductive efficiency of the animals, consequently leading to impaired metabolic and immune response of the animals (Maurya, 2004). Temperature, humidity, ventilation and light are all related to the regulation of metabolic processes in animals, affecting the ability of the individual to adapt to its environment (Gongora and Hemandez, 2010; Halden and Schwab, 2011). As a result of these environmental factors, many reproductive parameters can be affected and altered (Shearer et al., 2006; Bara, 2008; Malmkvist et al., 2009). Extreme ambient conditions can negatively affect animal production. High environmental temperature may as well have a negative effect on the performance of laying birds (EI-Tarabany, 2016) and result in behavioural changes like reduced feed consumption and tendency to remain prostrated with wings opened, as an attempt to dissipate body heat to the environment (Santos et al., 2012).

Animals like wild or domestic pigs and geese are prone to overheating due to lack of sweat glands. Therefore, various methods such as allowing them to move around during the cooler hours of the day, occupying shaded areas and wallowing in water has been used to regulate their body temperature. Wallowing in geese is also very essential and it involves the process whereby their coat body is dipped inside water to maintain their body physiological response (Bracke, 2011). Heat stress can impair productivity, egg yield and quality, semen quality, reproductive performance, increase incidence of disease. It may therefore be necessary to cope with these adverse impacts of climate change through the development of proper management strategies and through the genetic selection of heat tolerant livestock species. (Nardone et al., 2010).

To invest enough time and energy in reducing internal heat, heat-stressed animals may reduce feed intake, causing body weight loss and ultimately diminishing the body energy available for reproduction which eventually leads to low productivity (Habeeb et al., 2018). Therefore, to mitigate heat stress effect in geese during extreme temperature, especially for those under intensive system of production, there should be balance in their physiological response and the environment.

In the tropical region, little has been done to hypothesize reproductive potential of geese subjected to wallowing during the dry season when there is hot weather. Hence, this study was designed to assess the reproductive performance of wallowed and non-wallowed geese at high temperature humidity index during breeding season.

## Materials and methods

This study was conducted according to the research ethics approved by the committee on research of the University of Ibadan, Ibadan, Nigeria.

*Experimental Site*

The experiment was carried out at the poultry unit of the Teaching and Research Farm, University of Ibadan, Oyo State, Nigeria, Latitude 7° 26′ N and Longitude 3° 54′ E.

*Experimental Animals and Management*

Twenty four geese (12 males and 12 females) with an average weight of 5.1 ± 0.4 kg for males and 4.3 ± 0.30 kg for females were used for this study. The animals were allotted randomly into 2 treatments (wallowed group and non-wallowed group) within each sex. Males and females were housed separately and were fed ad-libitum with commercial layer's mash (brand name: Top Feed) during this experiment. The diet contained crude protein of 16.5%, digestible energy of 2500 Kcal/kg, crude fibre of 6%, crude fat of 5%, calcium of 3.5% and phosphorus of 0.41% as nutrient composition.

*Experimental Design*

The experimental lasted for five (5) weeks. 2 x 2 factorial arrangements in a completely randomized design

*Wallowing Procedure and Temperature Humidity Index Estimation*

Wallowing was done in the afternoon every alternate day between 1 pm–3 pm on the day of measurement for a period of 5 weeks. Both temperature and relative humidity were measured at regular day times: morning (7–9 am), afternoon (12–2 pm) and evening (5–7 pm) every day throughout the period of the experiment to determine the temperature humidity index. The pen relative humidity and temperature were recorded with the aid of a thermo-hygrometer.

Temperature-Humidity Index (THI) was then calculated according to the procedure of Marai et al. (2001).

THI = Temperature - humidity index = t – [(0.31- 0.31 x RH/100) (t – 14.4)] (Marai et al., 2001).

Where: THI = temperature-humidity index;
t = temperature;
RH = Relative Humidity;
<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.

*Semen collection and Evaluation*

Semen was obtained from individual ganders by massaging the dorso-abdominal region of the ganders (Johnson, 1954; Lukaszewicz, 2010). This was achieved by abdominal massage with the palm and tip of the finger. The abdomen was massaged towards the tail with both hands and semen was collected with the aid of a tube and was labeled accordingly for microscopic assessment at each collection period. Immediately after the semen collection each ejaculate was evaluated for colour, volume, mass activity, motility, concentration and live to dead ratio as described by Ewuola and Egbunike (2010) and Adebisi and Ewuola (2019).

*Hen Day Egg Production*

This was determined by dividing the total number of eggs laid during the experimental period by the total number of birds in the pen at that period as expressed in percentage

Hen day egg production = Total number of eggs produced by the geese during the period x 100 (%) / Total number of geese in the pen at that period

*Statistical Analysis*

Data were analyzed using General Linear Model of SAS (2003) and means were separated using Tukey-Kramer Mean Separation Procedure. A correlation analysis was also done between the semen quality parameters and the thermoregulatory response of the geese.

## Results

The trend of average daily temperature, humidity and temperature-humidity index of the experimental pen for a period of 35 days are shown in Figures 1, 2 and 3. The chart shows the temperature values in °C and the humidity values in % during the period of high temperature humidity index.

The main effect of wallowing on the semen quality parameters of male geese is shown in Table 1. There was no significant difference (P > 0.05) in all the semen quality parameters. Their values ranged from 0.52 ± 0.24–0.53 ± 0.25 mL, 56.50 ± 15.70–62.33 ± 7.70%, 50.58 ± 15.70–53.11 ± 9.05%, 84.86 ± 12.90–86.00 ± 12.90% and 115 ± 133 x $10^6$–223 ± 15.6 x $10^6$ sperm cells

**Table 1.** Main effect of wallowing on the semen quality parameters of male geese

| Semen Quality Parameters | Wallowed Group | Non-wallowed Group |
|---|---|---|
| Volume (mL) | 0.52 ± 0.24 | 0.53 ± 0.25 |
| Mass Activity (%) | 62.33 ± 7.70 | 56.50 ± 15.70 |
| Sperm Motility (%) | 53.11 ± 9.05 | 50.58 ± 15.70 |
| Live to Dead Ratio (%) | 84.86 ± 12.90 | 86.00 ± 12.90 |
| Sperm Concentration (x$10^5$ cells/mL) | 115.27 ± 133.64 | 223.73 ± 156.04 |

*a, b means within the same rows with different superscripts are significantly different (P < 0.05)*

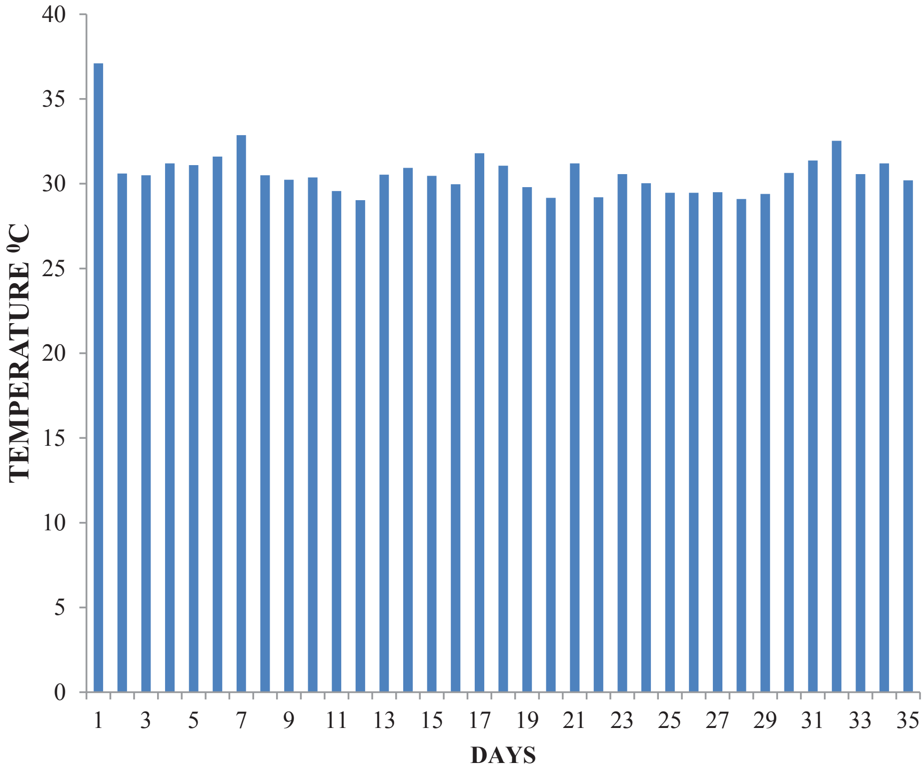


**Fig. 1.** Average Daily Temperature of the Experimental Pen

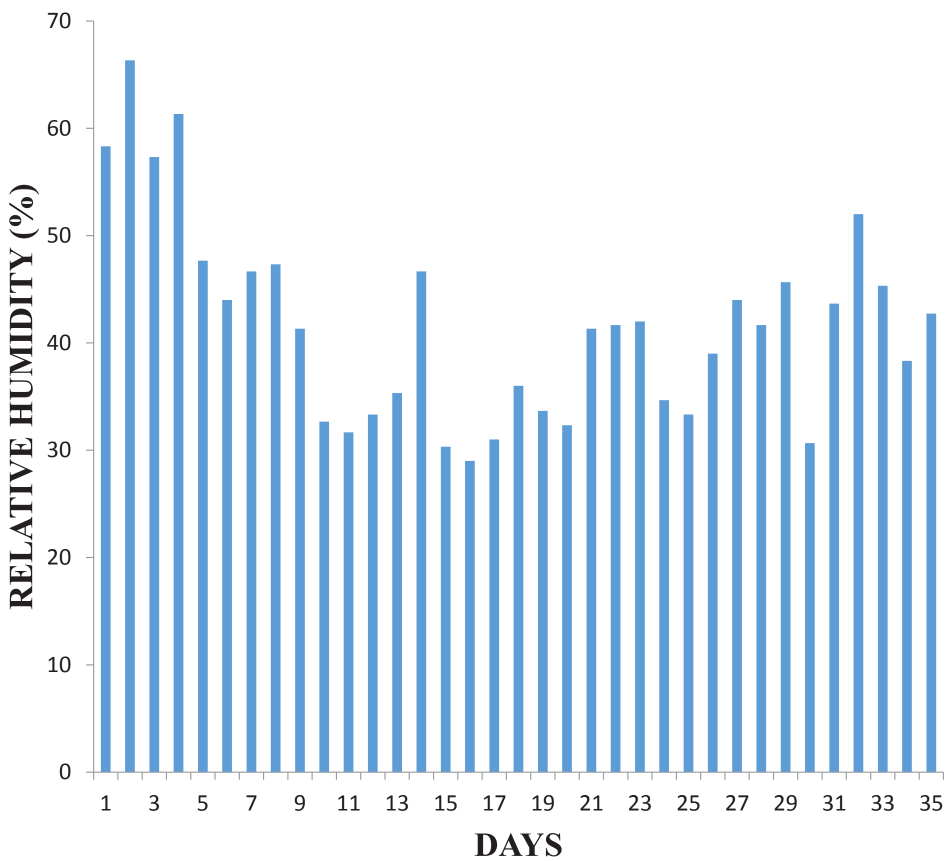


**Fig. 2.** Average Daily Relative Humidity of the Experimental Pen

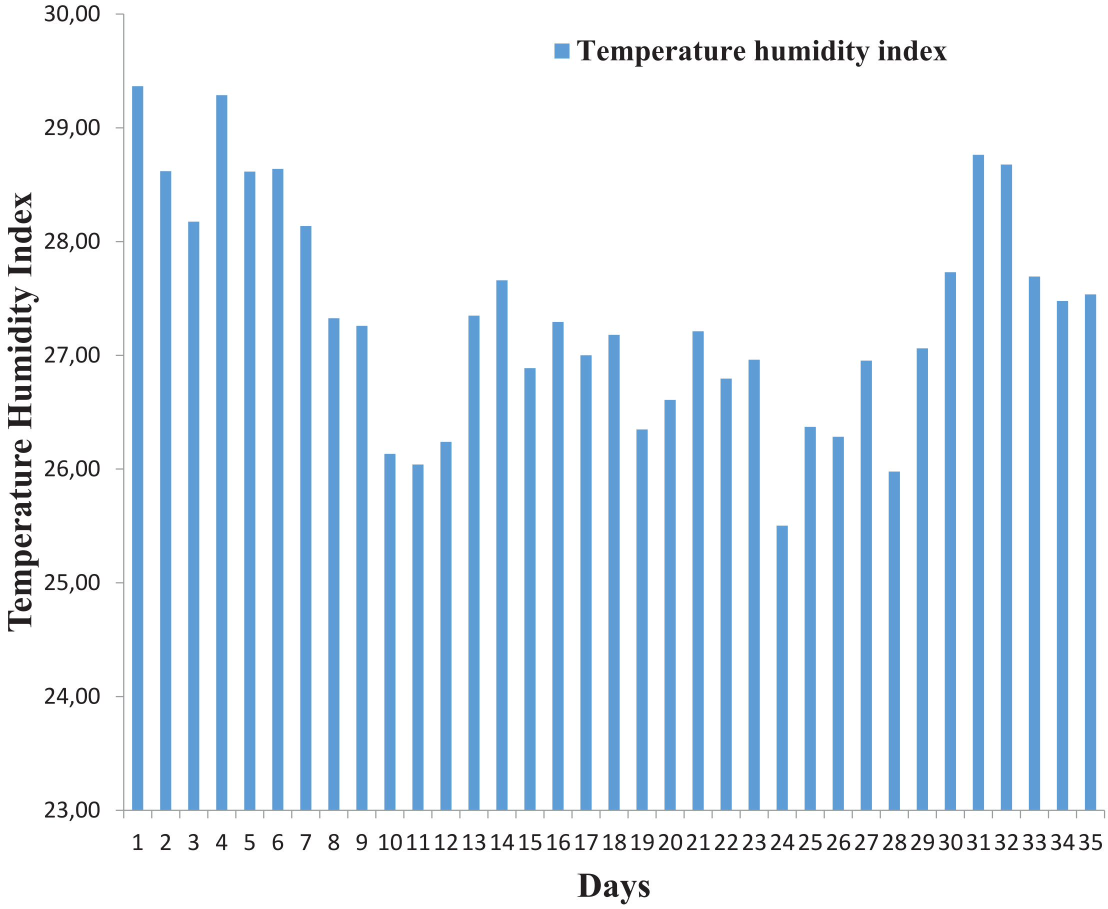


**Fig. 3.** Average Daily Temperature Humidity Index of the Experimental Pen

/ mL, for the volume, mass activity, motility, live to dead ratio and concentration, respectively.

The main effect of post wallowing time on the semen quality of ganders is presented in Table 2.

**Table 2.** Main effect of post wallowing time on the semen quality parameters of male geese

| Semen Quality Parameters | 2 weeks post wallowing | 4 weeks post wallowing |
|---|---|---|
| Semen Volume (mL) | 0.68 ± 0.21[a] | 0.36 ± 0.11[b] |
| Mass Activity (%) | 56.91 ± 15.31 | 61.30 ± 10.12 |
| Sperm Motility (%) | 51.45 ± 13.02 | 51.90 ± 13.76 |
| Live-Dead Ratio (%) | 84.08 ± 15.05 | 87.08 ± 9.75 |
| Sperm Concentration ($x10^6$ cells/mL) | 19.82 ± 16.10 | 15.40 ± 15.00 |

*a, b Means in the same rows with different superscripts are significantly different ($p < 0.05$)*

There were no significant differences ($P > 0.05$) in all the semen quality parameters except the volume. Semen volume at 2 weeks post wallowing (0.68 ± 0.21 mL) was significantly ($P < 0.05$) higher than that of 4 weeks post wallowing (0.36 ± 0.11 mL).

The first order interaction of wallowing and post wallowing time is presented in Table 3. There was no significant differences ($P > 0.05$) in the values obtained for all the semen quality parameters except in the semen volume which was significantly ($P < 0.05$) lower value at 2 weeks after the commencement of the experiment than at 4 weeks for the males that were not exposed to wallowing.

The result on the correlation between the thermoregulatory responses and the semen quality parameters of the male geese is shown in Table 4. It was observed that there was a negative cor-

**Table 3.** Interaction effect of wallowing and post wallowing time on semen quality parameters of male geese

| Treatment | Non wallowed group | | Wallowed group | |
|---|---|---|---|---|
| Time | 2 weeks | 4 weeks | 2 weeks | 4 weeks |
| Volume (mL) | 0.35 ± 0.06[b] | 0.70 ± 0.21[a] | 0.36 ± 0.15[b] | 0.66 ± 0.24[ab] |
| Mass Activity (%) | 65.75 ± 4.35 | 54.67 ± 19.71 | 58.33 ± 12.11 | 59.60 ± 9.13 |
| Sperm Motility (%) | 52.50 ± 11.59 | 49.67 ± 16.75 | 51.50 ± 16.11 | 53.60 ± 7.89 |
| Live-Dead Ratio (%) | 82.90 ± 13.28 | 82.14 ± 16.98 | 89.86 ± 6.48 | 86.42 ± 13.91 |
| Sperm Concentration ($x10^5$ cells/mL) | 80.00 ± 42.26 | 159.38 ± 201.45 | 296.63 ± 157.50 | 150.80 ± 127.50 |

*a, b means within the same row with different superscripts are significantly different (P < 0.05)*

**Table 4.** Correlation of thermoregulatory response and semen quality parameters of male geese

| Parameters | Respiratory rate | Rectal temperature | Pulse rate | Semen Volume | Mass activity | Motility | Live-Dead Ratio | Spermatozoa Concentration |
|---|---|---|---|---|---|---|---|---|
| Respiratory rate (breaths/minute) | 1.00000 | -0.17241<br>0.1566 | 006119<br>0.6174 | -0.26619<br>0.2435 | -0.24981<br>0.2748 | -0.38328<br>0.0863 | 0.08020<br>0.7297 | -0.12054<br>0.6027 |
| Rectal temperature (°C) | - | 1.00000 | -0.31942<br>0.0075 | -0.10808<br>0.6410 | 0.01022<br>0.9649 | 0.01830<br>0.9372 | -0.06684<br>0.7733 | -0.01826<br>0.9374 |
| Pulse rate (beats/minute) | - | - | 1.00000 | -0.32171<br>0.1550 | 0.46783<br>0.0325 | 0.38048<br>0.0889 | 0.24913<br>0.2761 | -0.24468<br>0.2851 |
| Volume (mL) | - | - | - | 1.00000 | -0.05192<br>0.8231 | -0.01610<br>0.9448 | -0.49257<br>0.0233 | 0.20622<br>0.3698 |
| Mass activity (%) | - | - | - | - | 1.00000 | 0.88963<br>□.0001 | 0.37453<br>0.0944 | 0.13451<br>0.5610 |
| Spermatozoa Motility (%) | - | - | - | - | - | 1.00000 | 0.45057<br>0.0404 | 0.24643<br>0.2815 |
| Live to Dead Ratio (%) | - | - | - | - | - | - | 1.00000 | 0.02349<br>0.9195 |
| Concentration ($x10^5$ cells/mL) | - | - | - | - | - | - | - | 1.00000 |

relation between pulse rate and rectal temperature with a correlation coefficient of 0.32. This indicates a negative relationship between these two variables. It was also observed that correlation between mass activity and pulse rate was positive with a correlation coefficient of 0.47 indicating a relationship between these two variables.

Negative correlation was observed between live to dead ratio and volume with a coefficient of 0.49 showing a negative relationship between them. Mass activity positively correlated with motility. The coefficient of determination of 0.89 derived indicates a strong positive correlation and a strong relationship between these two variables. Motility also positively correlated with

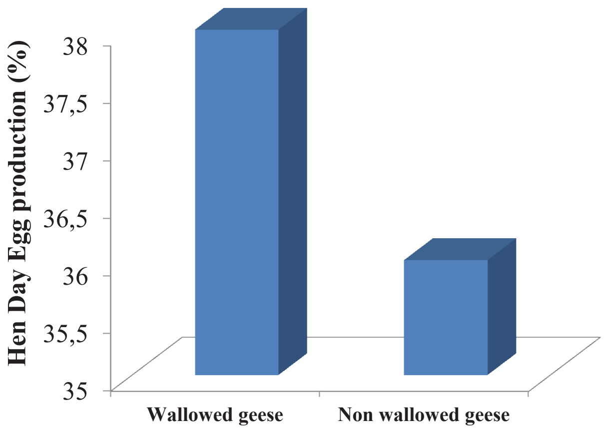


**Fig. 4.** Percentage Hen day egg production of wallowed and non-wallowed female geese during the experimental period

live to dead ratio with a coefficient of 0.45 showing a positive relationship between them.

The mean value of egg production obtained from wallowed and non-wallowed geese during the experimental period is shown in Figure 4. There was no significant different (P > 0.05) between the egg production of geese in both treatments.

## Discussion

The non-significant difference in the semen quality parameters of both the wallowed and non-wallowed groups except in the semen volume could indicate that, wallow or non- wallow exposure does not really influence or alter the semen quality parameters of the ganders. Thus, ganders can survive and have good reproductive performance either in the presence or absence of water for swimming. Tokushi (1975) reported that although geese prefer to mate in water, it can also happen successfully in the open air without the provision of water to mate and successful egg fertility can still be recorded from geese that have been mated with ganders without access to water for swimming. This is an indication that the semen quality and reproductive performance of ganders cannot be adversely affected even in the absence of water for wallowing. Collection of semen at varied post-wallowing times did not influence the mass activity, spermatozoa motility, live to dead ratio and spermatozoa concentration of the gander semen, indicating that there was no long-term effect of wallowing on all the semen quality parameters of the ganders except in the volume that decreased at 4 weeks post-wallowing than at 2 weeks post-wallowing. This could be due to variations in environmental conditions (temperature, humidity and light intensity) at the various times of collection. This experiment was carried out during high temperature humidity index. Hence, the physiological state of the ganders could have been altered at the varied times of semen collection and evaluation.

Semen volume that increased with time effect for the non-wallowed group could be as a result of the possibility that semen production volume increased with increased times of collection at 4 weeks compared to 2 weeks. It has been reported that total sperm ejaculate volume may vary with differences in the times of collection from the findings of Frangez et al. (2005). According to the findings of Singleton (1970), sperm ejaculate volume may increase with increase in the collection times of semen from the male animal. Also, since semen was collected at different times during the experiment, there could also be variations in semen volume due to differences in environmental conditions at the times of collection. Moreover, the physiological state of the ganders could have been different at varied times of collection and evaluation.

A negative relationship between the rectal temperature and pulse rate as observed in this study carried out at high temperature – humidity index is an indication that high ambient temperature is responsible for the increase in rectal or body temperature of animals while low ambient temperature may induce increased pulse rate as the heart may have to work harder during the coolest period of the day, commonly in the morning to keep the body warm, thereby increasing pulse rate (Altan et al., 2003; Zahoor et al., 2016). Also, the functionality of the leydig cells could increase at the cooler periods than at hot times thereby bringing about a lower sperm cell activity during hotter periods (Ohashi et al., 1995). Motility and morphology are usually poor with an excessive volume of semen that may be seen in association with oligospermia (Miell et al., 2014). This could have led to increased semen volume in a negative proportion to the live spermatozoa in the semen as observed. It is also generally expected that higher mass activity of semen will influence the semen motility positively and a direct strong and positive relationship was observed between them in this study. Moreover, since all motile sperm cells must be alive before they can be counted as motile, a strong positive correlation is expected as seen between the number of live spermatozoa and the number of motile sperm cells in the semen sample. Hence, a percentage of the live spermatozoa will definitely account for the motile sperm cells observed.

Exposure or non-exposure to wallowing did not affect egg production in the geese as the egg production from the wallowed group did not differ from the non-wallowed group. This implies that geese can still perform well in terms of egg production even when they are outside their ecological environment in terms of exposure to wallowing. This is in line with the report of Tokushi (1975), who observed that most breeds of geese and ducks will mate satisfactorily and produce strongly fertile eggs without access to water for swimming although the larger breeds mate more readily in shallow water. A goose can still lay even in the absence of a pool of water according to Tokushi (1975). This buttresses the non-significant influence of wallowing on the mean egg production obtained from geese exposed to wallowing and from those that were not.

## Conclusion

This study indicated that male and female geese can have a good reproductive performance in terms of semen quality and egg production either in the presence or absence of water for wallowing since wallowing did not influence the sperm motility, spermatozoa concentration, live to dead ratio of spermatozoa or egg production of wallowed and non-wallowed geese.

The existence of positive and negative correlations between the semen quality parameters of males and their thermoregulatory responses also suggest their interrelationship and it can be inferred that a reasonable and acceptable level of thermobalance must be maintained between the animal and their environment for optimum reproductive performance.

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