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Performance and behavioural characteristics of Pigs as affected by types and duration of evaporative cooling

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Target Audience: Pig farmers, academic researchers, extension agents:

Abstract

Heat stress is one of the main constraints to pig production. Pigs rely on evaporative cooling by wallowing which is unsanitary while most advanced cooling methods are capital intensive. Cheaper evaporative cooling facilities could be installed to mitigate the negative consequences of heat stress on pigs. However, effects of hourly exposure to evaporative cooling on gilts have not been adequately documented. Hence, behavioral attributes and performance of pigs given access to evaporative cooling were studied. In a completely randomized design, cross bred gilts (n=40) (Landrace x Large White) weighing 25.00±2.5kg were allotted to five treatments each replicated four times consisting eight gilts per replicate. Treatment 1 (Negative control, T1) no shower/no wallow, Treatment 2 (Positive control, T2) had only wallow, Treatment 3 (T3) had shower activated 5 minutes hourly for six hours, Treatment 4 (T4) had shower activated 5minutes every 2 hours and Treatment 5 (T5) had shower activated 5 minutes every 3hours. Gilts were evaluated at growing phase (10weeks). At average weight of 40.50±2.50kg, gilts were mated. Data on feed intake (AFI, Kg), weight gain (WG, Kg), Final weight (FW, Kg) and feed conversion ratio (FCR) were determined using standard methods. Behavioural attributes (%) observed include Lateral Lying (LL), Huddling (HD), Frequency of Defecating in Resting Area (FDRA), Frequency of Visiting Water Trough (FVWT) and Frequency of Using Wallow or Shower (FUWS). Also, Respiratory Rate (RR, breath per minute bpm), Rectal Temperature (RT, °C) and Skin Temperature (ST, °C) were monitored, while pens Temperature Humidity Index (THI) were monitored. Indices of reproductive performance (%) include oestrus, anaestrus and conception rate (CR) was determined. Data were analysed using descriptive statistics and ANOVA at α0.05. In the study, THI ranged between 81.12 and 86.39. Pigs that were subjected to 5 minutes shower activation every 3 hours (T5) had significantly highest FW (52.50±0.04) and relatively low AFI of 10.71±0.04 with a FCR of 3.32±0.02 which is not significantly different from pigs that were subjected to 5 minutes shower activation every hour (T3) (4.09±0.02) and pigs that were subjected to 5 minutes shower activation every 2 hours (T4) (4.05±0.01). Pigs exposed to continuous wallowing (T2) had significantly the highest AFI (14.13±0.04) and there was no significant difference in the WG for all treatments. The ST, RT and RR were highest in pigs under no shower/wallow (T1) (37.4, 39.4 and 53.0, respectively). Lateral lying

(LL) was highest in T5 (65%) while T2 had the highest HD (40%). FVWT and FDRA were highest in T1 (50 and 55%, respectively) while CR was 75% for T1, T3 and T5 and T2 had 25%.

Keywords: Pig, Performance, evaporative cooling, Reproduction

Description of problem

Pigs are relatively sensitive to high environmental temperatures when compared to other species of farm animals (1). This is because pigs lack functional sweat glands, do not pant well and have large deposit of subcutaneous fat under their skin when compared to other animals (2). Air temperature as a cardinal factor is influenced by relative humidity and air flow velocity (1). The recommended optimum of air temperature for growing pig is 16-27°C (3). As pigs get older and larger, its optimum temperature decreases. Thus, the effects of heat stress are more of a concern with older finishing swine (>50 kg) and with sows and boars than with younger pigs. Sows, boars, and finishing pigs begin to feel the negative effects of heat stress at about 20°C.

Pigs are exposed to heat stress when temperature exceeds the upper critical temperature of the thermoneutral zone of the pigs (4). Thermoneutral zone is the range of environmental temperatures within which the metabolic rate is minimum and independent of temperature. The temperatures that bound this zone are known as upper and lower critical temperatures (5). Above the upper critical temperature of this zone the animal will reduce both production and reproduction to control body temperature. Above the upper limit of the thermal neutral, feed consumption is reduced to limit the metabolic heat production (6). In the sow, temperatures higher than 27°C will delay or prevent the occurrence of estrus, reduce conception rate, increase early embryonic death and increase stillbirth (3). Heat stress in pigs impairs the animals' welfare and environment (7, 8) and economics of pig industry (9).

Heat stressed pigs alter their behaviour and physiology to increase heat loss and reduce heat production (10). They would rid themselves of excess body heat by panting or surface wetting in water or their own excreta under the high ambient temperature and humidity (10, 11). Hot and humid weather conditions have a great impact on the performance, genetic components and hygienic conditions in pigs (12, 13, 14). Response to heat stress begins with increased respiration rate, continues with decreased feed intake, and leads to increased rectal temperature (7). Decreased feed intake and increased rectal temperature are good indicators of decreased performance of heat-stressed pigs (7). These responses are at the expense of production and reproductive performances.

Cooling strategies include increased water supply, wet skin cooling, nutritional manipulations, adequate ventilation, increased floor space, adequate insulation and provision of shades. Evaporative cooling from body surface through artificial surface wetting reduces heat stress. Alternative cooling system for pigs is a shower or a wallow. Wallow is an effective means of cooling pigs but unsanitary due to microbial build up in the wallow over time. Sprinkling pigs periodically and allowing them to dry out between wettings is more effective (7). This study was carried out to investigate the effect of shower cooling duration and wallow on the behavioural, physiological and performance responses of growing pigs.

Materials and methods

The study was carried out in the Swine Unit, Teaching and Research Farm, University of Ibadan between October, 2015 and December, 2015. Forty-eight individually tagged healthy, growing cross bred pigs (Landrace x Large White) of 20-25kg gilts were used. Each treatment was replicated four times with four pigs per replicate in a completely randomized design. Experimental diet was formulated to meet the nutrient requirements of the growing pigs (15) (2600Kcal ME, 18% Protein, 0.6% Calcium, 0.45% Phosphorus, 0.80% Lysine). The treatments were Treatment (T1): Pen without wallow/shower (Negative Control), Treatment (T2): Pen with wallow (Positive Control), Treatment (T3): Pen with Shower activated at 5minutes hourly for six hours, Treatment (T4): Pen with shower activated at 5minutes every 2 hours for six hours, Treatment (T5): Pen with shower activated at 5minutes every 3 hours for six hours. The pigs were preconditioned for one week to acclimatize to the new environment and were tagged for identification purposes. Vaccination and medications were administered accordingly. *Standard* diet and water supply were provided *ad libitum*. The wallow was filled with clean water throughout and shower was activated from 11.00am-5.00pm on daily basis.

Data collection

Temperature and Relative Humidity Data

Temperature and relative humidity of the pen was measured with the aid of a thermo-hygrometer which was suspended in the pen. The temperature –humidity index (THI) was calculated from the result of the ambient temperature and relative humidity as an indication of heat stress index using the stated formula:

$$THI\,(^{o}C) = 0.8T + (RH/100) \times (T-14.3) + 46.4$$

$THI \geq 74$ is safe, $74 < THI < 79$ is critical, $79 \leq THI < 84$ is dangerous and $THI \geq 84$ is emergency (16)

Physiological Data

Skin temperature (ST): The skin temperature (°C) was measured using radiant thermometer on the body of pigs. Respiratory rate (RR): The number of uninterrupted flank movement (bpm) per minute (60seconds) using a stopwatch. Rectal temperature (RT): The rectal temperature (°C) was measured using digital thermometer inserted 50mm into the rectum until the reading was constant.

Performance Data

The average feed intake (kg) per week, Weight gain (kg) per week and the Feed conversion ratio (FCR) was calculated as ratio of feed intake to weight gain.

Behavioural Data

Close circuit television (C.C.TV) cameras were installed to capture and record pig behaviour from 11.00am to 5.00pm throughout the duration of the study. Parameters observed (%) include lateral lying, huddling, frequency of defecating in resting area, frequency of defecating in wallow, frequency of visiting water trough, frequency of using wallow/shower.

Results and Discussion

The temperature, humidity and temperature-humidity index are presented in table 1.0. The minimum temperature over the ten weeks trial was recorded in the first week (30.34°C) with a corresponding average relative humidity of 65.43% which translate into a THI value of 81.12 while the maximum temperature was recorded in the third week (34.13°C) and corresponding relative humidity of 59.42% and THI value of 85.49. The peak of relative humidity was recorded in the ninth week (70.42%) with an average temperature of 31.19°C while the least relative humidity was in the second week (54.57%) with average temperature of 34.01°C. However, the minimum THI was 81.12 in the first week and a peak of 86.39 in the second week which eventually decreases until the ninth week of the study with an index of 83.25.

Table 1: Average temperature, average relative humidity and temperature humidity index (THI) of experimental pen for the growing phase

Weeks	Average temperature (°C)	Average relative humidity (%)	Temperature humidity index (THI)
1	30.34	65.43	81.12
2	34.01	54.57	86.39
3	34.13	59.42	85.49
4	33.38	60.28	84.61
5	33.39	60.14	84.60
6	32.29	70.00	84.83
7	30.66	67.42	81.96
8	32.82	64.42	84.59
9	31.19	70.42	83.25

Table 2.0: Performance responses of Growing pigs under different evaporative cooling

Parameters	T1	T2	T3	T4	T5	SEM
Initial weight (kg)	27.25	26.75	26.50	27.00	26.50	4.55
Final weight (kg)	46.00^{a}	46.75^{ab}	47.75^{ab}	48.25^{ab}	52.50^{a}	5.68
Total weight gain (kg)	18.75	20.00	21.25	21.25	26.00	7.98
Weight change (kg/wk)	2.34	2.50	2.66	2.57	3.25	0.15
Average feed intake (kg/wk)	10.81^{b}	14.13^{a}	10.78^{b}	10.61^{b}	10.71^{b}	0.09
Feed conversion ratio	4.65^{ab}	5.65^{a}	4.09^{b}	4.05^{b}	3.32^{b}	0.26

a, b, c means within rows with unlike superscripts are significantly different from each other ($p<0.05$), SEM: standard error of mean, T1: Pen without water bath/shower, T2: Pen with water bath, T3: Pen with Shower 5mins/1hr, T4: Pen with Shower 5mins/2hrs, T5: Pen with Shower 5mins/3hrs

From table 2, all treatment groups had no significant difference in the initial weight in kg, weight gain in kg and weight change/week in kg. The initial weight ranged from 26.50kg in T3 and T5 to 27.25kg in T1 while the weight gain varied from 18.75kg in T1 to 26.00kg in T5. Weight change ranged from 2.50kg in T2 to 3.25kg in T5. Also from the table, T5 had significant final weight of 52.50kg and a relatively low average feed intake of 10.71kg which is not significantly different from T1,T3 and T4 (10.81kg, 10.78kg and 10.61kg respectively). The final weight of T2, T3 and T4 are not significantly different from one another. T2 had significantly the highest average feed intake and feed conversion ratio of 14.13kg and 5.65 respectively. T5 had the least FCR of 3.32 which is not significantly different from T3 and T4 (4.09 and 4.05 respectively) while T2 had significantly the highest FCR of 5.65.

Figure 1 showed the responses of the rectal temperature of the growing pigs under different evaporative cooling systems during the period under study. Over the ten weeks growing phase trial, T1 had relatively the highest rectal temperature of 39.4°C in week 3 while T2 had relatively the least rectal temperature of 36.7°C in week 1. The rectal temperature of T2 increases from week 1 to week 3 and fairly constant with T1, T3, T4 and T5 in week 4 until it rises in week 4 to week 7. Treatments 3, 4 and 5 had fairly constant rectal temperature. Week 3 recorded the highest rectal values over the period of study while other weeks maintained a fairly constant rectal temperature.

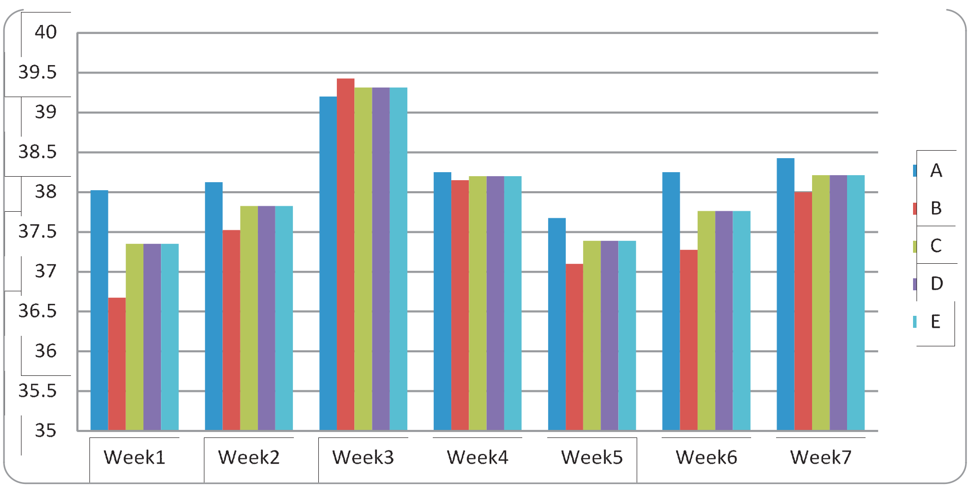

Figure 1: Rectal temperatures of growing pigs under different evaporative cooling

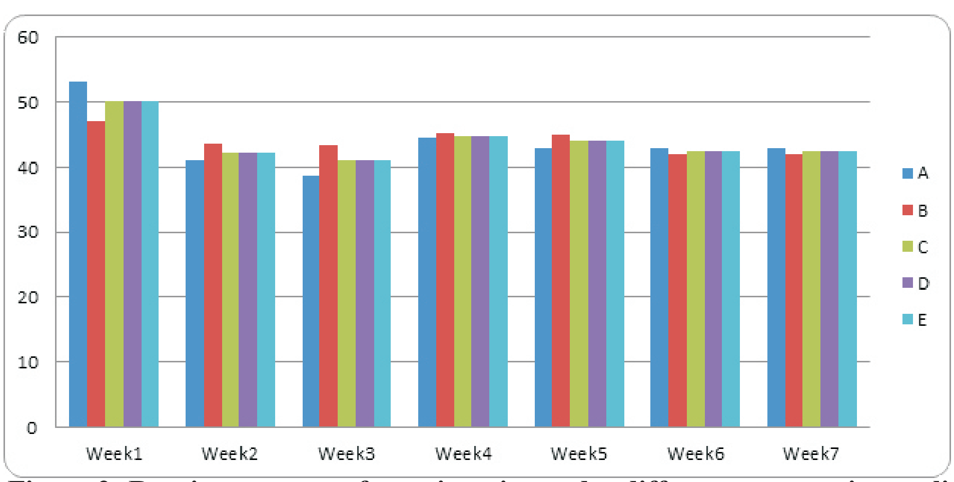

Figure 2: Respiratory rate of growing pigs under different evaporative cooling

From the figure 2 , T1 had relatively the highest respiratory rate of 53 breath per minute (bpm) in week 1 while treatments 3, 4, 5 had a fairly constant respiratory rate which ranged between 40-53 breath per minute. Treatment 2 had respiratory rate that rose slightly above treatment 3, 4 and 5 in weeks 2, 3, and 4. However, week 1 recorded the highest respiratory rate for all treatment groups while the respiratory rates of other weeks were fairly constant.

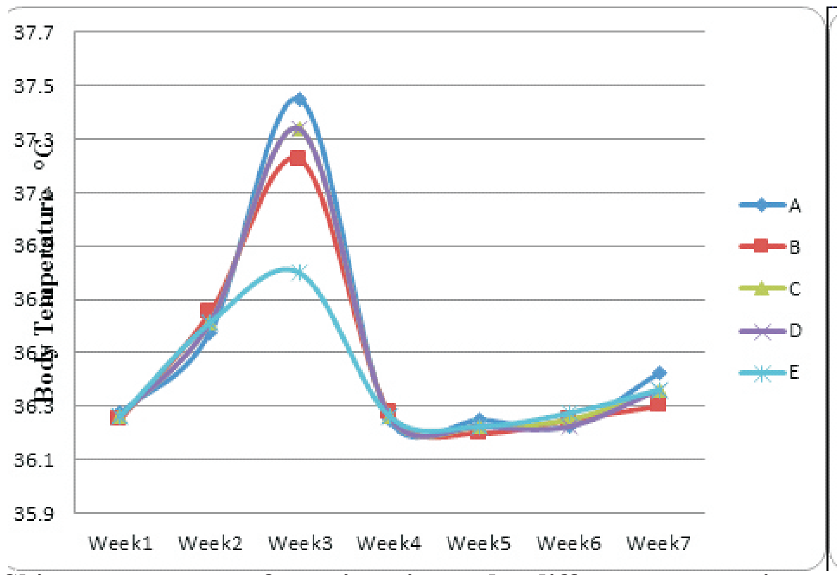

Figure 3: Skin temperatures of growing pigs under different evaporative cooling

Figure 3 showed the skin temperature pattern of the growing pigs under different evaporative cooling conditions. Over the eight weeks trial, treatment 1 had the highest skin temperature of 37.45°C while treatment 5 had the least skin temperature of 36.2°C. Treatments 2, 3 and 4 had skin temperature which lies between 36.8°C and 37.45°C. The peak of skin temperatures was recorded in the 3rd week while the least was in the 5th week of study.

Table 3.0: Behavioural Response of Growing pigs under Different Evaporative Cooling

Parameters (%)	T1	T2	T3	T4	T5
Lateral lying	60	40	60	64	65
Huddling	25	30	21	15	11
Frequency of visiting water trough	50	10	40	45	49
Frequency of defecating in resting area	55	15	10	10	10
Frequency of defecating in wallow	0	45	0	0	0
Frequency of using wallow/ shower	0	50	45	50	55

T1: Pen without water bath/shower, T2: Pen with water bath, T3: Pen with Shower 5mins/1hr, T4: Pen with Shower 5mins/2hrs, T5: Pen with Shower 5mins/3hrs

Table 3.0 showed the behavioural responses of the growing pigs under different evaporative cooling conditions. From the table, T5 had the highest lateral lying of 65%, T1 and T3 had 60% lateral lying while T2 had the least with 40%. Huddling was highest in T2 (30%) while T3, T4 and T5 were 21%, 15% and 11%. The frequency of visiting water trough and defecating in resting area was highest in T1 (50% and 55% respectively) while T3, T4 and T5 had water trough visiting frequency of 40%, 45% and 49% respectively. T3, T4 and T5 had constant frequency of defecating in resting area (10% each) and did not have wallow to defecate in while T2 had 45% frequency of defecation in wallow. T5 (55%) used the shower more than T3 and T4 (45% and 50% respectively) while T2 had 50% frequency of using wallow.

Table 4.0: Microbial count of water samples from wallow, shower and water trough

Sample	Average bacterial count cfu/ml	Average fungal count cfu/ml
Wallow	26×10^4	2×10^4
Shower	12×10^4	1×10^4
Water trough	12×10^4	1×10^4

Source: Adebiyi and Muibi (23)

Table 4.0 showed the bacterial and fungal count of the water samples from the wallow, shower system and water trough. From the table, the water from the wallow had an average bacterial and fungal count of 26 x 10^4cfu/ml and 2 x 10^4cfu/ml respectively while the water from both the shower system and water trough had an average bacterial and fungal count of 12 x 10^4cfu/ml and1 x 10^4cfu/ml respectively

Table 5.0: Reproductive performance of gilts under differe nt evaporative cooling

Treatments	No. in Oestrus	No. in Anaestrus	No. returning	Conception rate %
T1	8	0	2	75
T2	8	0	6	25
T3	8	0	2	75
T4	8	0	4	50
T5	8	0	2	75

T1: Pen without water bath/shower, T2: Pen with water bath, T3: Pen with Shower 5mins/1hr, T4: Pen with Shower 5mins/2hrs, T5: Pen with Shower 5mins/3hrs

The reproductive performance (Table 5) of the gilts under different evaporative cooling above, all the sows came on oestrus after natural synchronization by boar exposure with none on anaestrus. However treatments 1, 3 and 5 had conception rate of 75% each while treatment 2 had the least (25%) and treatment 4 had conception rate of 50%. 75% conception rate translate into conception ratio of 6:2, 50% means 4:4 and 25% means 2:6.

In this study, the minimum and maximum temperatures recorded over the ten weeks growing phase trial was above the recommended optimum temperature range of 16-27°C. These high temperature values coupled with high relative humidity contributed immensely to the temperature humidity index that lied between dangerous and emergency as classified by National

Oceanic and Atmospheric Administration (16) (THI$\leq$ 74 is safe, 74<THI<79 is critical, 79$\leq$THI<84 is dangerous and THI $\geq$84 is emergency). Temperature humidity index is used as a basis for the livestock weather safety index to describe categories of heat stress associated with hot weather conditions for livestock exposed to extreme conditions (17). The finding corroborates the statement that high humidity in itself does not have a negative effect on swine performance. Combined with high temperatures, however, high humidity can enhance the negative effects of the high temperatures (3).

The performance responses showed that the initial weight, weight gain and weight change/week were not significantly different for all treatment groups (p>0.05). T1 had significantly the highest average feed intake compare to T1, T3, T4 and T5. The increase in average feed intake by pigs in T2 can be attributed to the availability of unrestricted wallow cooling which the pigs had access to at all times. The cooling relief led to increase in feed intake. However, T5 had significantly the highest final weight while T2, T3 and T4 had final weight that are not significantly different (p>0.05). T1 which are pigs on no cooling had the least final weight. The FCR of T3, T4 and T5 are not significantly different (p>0.05) while the improved average feed intake did not translate to a better feed conversion ratio as T2 had the highest FCR of 5.65. The reduced performance in T1 supports the fact that pigs can reduce their metabolic heat production by eating less feed. Thus, voluntary reduction in feed intake by the pig is an effort to lower the heat increment of feeding and thereby decreases the amount of heat that will need to be dissipated into the environment. Unfortunately, a reduction in feed intake results in reduced growth (3).

The respiratory rate of T1 was significantly highest (54bpm) while the RR of T2, T3, T4 and T5 were fairly lower and constant. A normal respiratory rate of growing pigs should range between 29.1 to 32.7min^{-1}on the average as reported by (11). This is quite lower than what was obtained in the present research which ranged from 41 to 50 min^{-1}. A higher RR above the expected RR corroborates the deduction of the dangerous or emergency state of the animals as revealed by National Oceanic and Atmospheric Administration chart (16). The rectal temperature measurement showed that T1 without cooling had the highest rectal temperature when compared to other treatment groups with different forms of evaporative cooling. The peak of RT was recorded in the 3rd week (39.4°C) in T1 while T2 which are pigs with wallow cooling had the least RT in the first week (36.6°C). T3, T4 and T5 had fairly constant RT owing to the cooling effect of the shower. It was concluded that increased RT is an important indicator of heat stress in growing pigs. Also, the skin temperature (ST) ranged from approximately 36.2°C to 37.3°C which means that the deep body temperature revealed by the rectal temperature (RT) reflected on the skin temperature. The ST of pigs in T2 (wallow) was much reduced simply because of the cooling effect of the wallow. This value of ST is slightly higher than that of previous studies. Geer *et al.* reported that the comfort ST of homoeothermic animals ranges from 32 to 35°C (18).

The high ST of pigs in T1 showed that pigs raised under tropical conditions not only reacted by maintaining a high RR but also by maintaining a high ST. This is logical, because vasodilatation of epidermal blood vessels allows deep body heat load to be dissipated more easily to the cooler environment (19).

However, the behavioural responses revealed that lateral lying increased in T3, T4, and T5 as the duration of shower cooling reduces. This implies that the pigs benefited from the direct effect of shower cooling and floor cooling by lying on areas where there was presence of water from the shower while T2 had the least LL due to the presence of wallow. Huddling increased as cooling increased from T5 to T2. According to (11), increasing lying behavior indicates heat stress, because lying animals avoid expending energy on movement and therefore reduce their total heat load. Also, the frequency of visiting water trough was highest in T1 (55%) without cooling while it decreases as shower cooling duration increases. Pigs in T1 visited the water trough not only to drink water but to displace the water on the floor and wallow in it. By nature, pigs are clean animals that keep their excreting and lying locations separate (20) such that the excreting area is located far away from the lying area (21) but this contradicts the finding in this research with T1 defecating 55% in resting area. It has been reported that a 60 kg pig provided with 1 m^2 floor space (with 40% slatted floor) in hot conditions did not discriminate between its resting and defecation areas at all(7, 10, 11). This suggests that they were heat stressed. T2 defecated in the wallow by 45% confirming the statement that the pig's basic instinct is to excrete in a wet, cool place (22). These findings might explain the high frequency of excretion in the wallow. This is undesirable with respect to hygiene and health.

The microbial count of water samples from the wallow and shower showed that there was high incidence of microbes in the water meant for cooling these animals. Pigs in wallow treatment drink from the wallow water which expose them to various pathogens in water. This poses health threat to pigs and farmers since they equally use from the contaminated water. The high count of microbes could be as a result of excreted materials and other animal waste products which are the predominant sources of waterborne pathogens. The pathogens use these material as transport vehicles from the animal reservoir to the particular water environment, where their stability in that environment will influence the infectivity and thereby the risk to man and animal. However, water provided to livestock should be clean, cool, plentiful and easily available during hot climate.

The reproductive performance showed that T1, T3 and T5 had 75% conception rate while T2 and T4 had 25 and 50% conception rate. This is a pointer to the fact that cooling supported reproductive performance in T3 and T4 while the reduced conception rate in T2 could be as a result of unhygienic and health concern in the wallow. Pigs in T1 had

75% conception rate possibly because they were able to adapt behaviourally and physiologically while those in T2 came on heat the same time as those of other treatments and were mated but did not give conception rate as other treatments due to complications possibly from the unhygienic environment.

Conclusion

1. Pigs in wallows are more predisposed to diseases due to microbial load in the wallow water as reflected in their reproductive performance.
2. Lying, excretion in resting areas and regular visits to water trough increased with increase in environmental temperature.
3. Shower cooling activated at 5 minutes hourly for six hours improved behaviour, physiology and performance of growing pigs without fear of microbial infections.

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