INFLUENCE OF TEMPERATURE-HUMIDITY INTERACTION ON HEAT AND MOISTURE PRODUCTION IN RABBIT

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ABSTRACT

The heat and moisture production rates of mature rabbits were studied under different building environmental conditions in a tropical area of Ile-Ife, Southwestern Nigeria. The conditions considered were those of buildings having inlet openings of 30 and 50% of the sides and orientations of 45 and 90 degrees to the prevailing wind. Sixteen rabbits fed *ad libitum* a commercial pelleted feed were used for the experiment which was conducted for thirteen weeks. The indoor temperature and relative humidity of the pens were recorded twice daily throughout the period of experiment. The heat and moisture production of the rabbits in the pens were then calculated. The results obtained showed that the heat and moisture production of the rabbits are affected by temperature and relative humidity. The heat and moisture production of the rabbits increased with increase of the temperature-humidity index (THI). Rabbits in buildings with higher thermal comfort level (lower THI of 32.49°C obtained for 50% opening/90° orientation pen) produced less amount of heat (21.16 W/hr/animal) and moisture (16.5 gm/hr/animal) than those in the more thermally stressful enclosures THI of 33.82°C (50%/45°) with 25.37 W/hr/animal, 20.40 gm/hr/animal; THI of 34.21°C (30%/90°) with 26.18 W/hr/animal, 29.68 gm/hr/animal; THI of 35.40°C (30%/45°) with 30.26 W/hr/animal, 35.62 gm/hr/animal, respectively. The relationship existing between total heat production, moisture production and THI was determined and found to be expressed by regression models with high R^2 ranging from 0.98 to 0.99 and 0.77 to 0.92, respectively.

Key words: Environmental temperature, Heat stress, Micro-climate, Temperature-humidity index, Ventilation.

INTRODUCTION

The domestic rabbits have been recommended as a good alternative source of dietary protein for the increasing human population in developing countries due to their short-cycled production characteristics (Lukfahr and Cheeke, 1991; Ogunjimi, 2007). In hot climate regions rabbit production is faced with such problems as heat stress, poor quality food, diseases and parasites and among these, heat stress is the most important (El-Raffa, 2005). The relationship of environmental temperature, relative humidity, energy intake and heat production in growing animal is fundamental to good engineering design and efficient livestock production.

The distribution of animal heat on sensible and latent basis is important in respect to simulating both the indoor climate and the energy consumption, Pedersen *et al*. (2005). At low temperatures, metabolizable energy (ME) is converted directly into sensible heat while at high temperatures, energy is lost as work through such physiological responses as panting. These non-productive energy-consuming reactions reduce the overall efficiency of feed energy utilization and increase heat output. A combination of high temperature and high relative humidity to most animals is very stressful and detrimental to productivity.

Air circulation pattern (ventilation) is having a dominating influence on the air mixture, temperature and humidity gradients (Lokhorst *et al*., 1995) while both building orientation and amount of ventilating opening considerably affect the thermal comfort level of livestock micro-environment, (Ogunjimi *et al*., 2007). During heat stress an animal in order to keep within its body temperature range must reduce its internal heat production, enhance its heat dissipation mechanism or combine both. In rabbit several investigators found that respiration rate increased under heat stress conditions (Habeeb *et al*., 1993; Marai *et al*., 1994; 1996; Ogunjimi, 2007).

Agricultural engineers and animal scientists in the tropics need information on the effects of natural conditions and man-made micro-environments on animal productivity. Therefore the aims of this study were to determine the total heat and moisture production of rabbits under different building environments, and to investigate the effect of environmental temperature – humidity interaction on both the total heat and moisture production in rabbits

MATERIALS AND METHODS

This work was carried out at the Rabbitry of the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Nigeria. The study was conducted with sixteen New Zealand White weaned rabbits with 6 weeks of age during the months of November 2005 until March 2006 which equates to the hot period of the Southwest region of Nigeria. The animals were randomly allocated in pairs to a 1200 x 1200 x 1200 mm pen partitioned into a 600 x 1200 x 1200 mm pens for each animal to prevent physical contact while providing the same environment for the animals under a climatic treatment. All the animals were kept under similar management and hygienic conditions throughout the experimental period. The buildings were naturally ventilated while considering both building orientation and amount of ventilating opening. The pens were provided with individual feeders and watering containers and the animals fed a commercial pelleted ration and water *ad libitum*. Both internal temperature and relative humidity of each pen were measured twice daily at about 7.00 hours and 13.30 hours throughout the experimental period to determine the average temperature-humidity index (THI) values of each microenvironment of the animals.

Heat and moisture production characteristics of the animals were estimated using the Sallvik and Pedersen (1999) equation. For rabbit's total heat production (THP), it is given as:

$$THP = 1000[1 + 4\times10^{-5}(t-10)^4] \quad \text{..........} 1.0$$

Where t°C is the indoor temperature of the pen. For the moisture production (MP), it is given as:

$$MP = \frac{THI\{1-[0.8-\alpha(t-K)^4]\}}{r} \quad \text{..........} 2.0$$

Where α is non-dimensional factor (1.28×10^{-7}); K is coefficient of proportionality between sensible and latent heat dissipation (-10) and r is constant (0.68 Wh/g water at 20°C) according to Sallvik (1999).

The temperature-humidity index (THI), an indicator of thermal comfort level for animals in an enclosure was calculated according to LPHSI (1990) which was modified for rabbit by Marai *et al*. (2001) and given as:

$$THI = t - [(0.31 - 0.31\times RH)(t-14.4)] \quad \text{..........} 3.0$$

Where RH = relative humidity percentage/100. The values of THI obtained for the temperate and subtropical 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*., 2002).

The data collected were statistically analyzed using SAS (2000). Differences between treatment means were determined by Duncan's Multiple Range tests.

RESULTS AND DISCUSSION

THP and Mp as a function of THI for the experimental rabbits during the period of experiment are plotted in Figures 1 and 2, respectively. The regression equations developed that relate the THP and MP to THI are of the following forms.

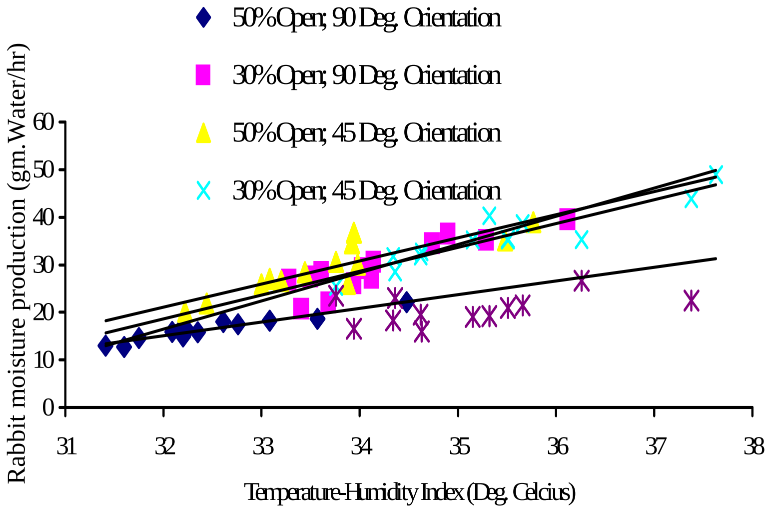

Figure 1: Rabbit heat production as affected by building thermal comfort (THI) level

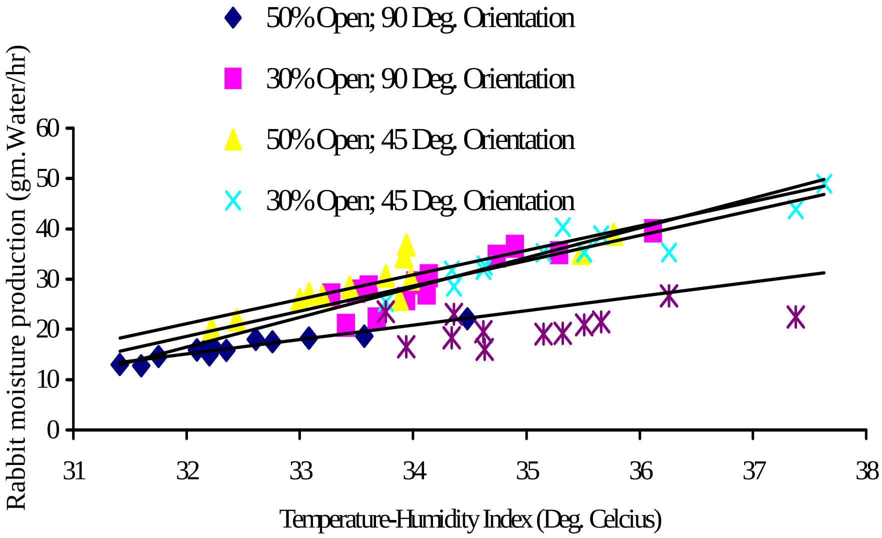

Figure 2: Rabbit moisture production as affected by building thermal comfort (THI) level

Heat production

As a function of the pen thermal comfort level (THI), total heat production in regression is:

$$THP_a = 3.5209(THI) - 94.271; \quad (R^2 = 97.58\%) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.1$$

$$THP_b = 3.0441(THI) - 77.73; \quad (R^2 = 97.64\%) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.2$$

$$THP_c = 4.0064(THI) - 111.55 \quad (R^2 = 98.76\%) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.3$$

$$THP_d = 3.4923(THI) - 93.134 \quad (R^2 = 98.13\%) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3.4$$

Where subscripts a, b, c, and d represent 30% opening/90 degree orientation, 50% opening/90 degree orientation, 30% opening/45 degree orientation and 50% opening/45 degree orientation pens, respectively.

As shown in Figure 1, the THP of rabbits increased with increasing THI values throughout the period of experiment for all the pens. It was observed that rabbits in buildings with better thermal comfort levels, lower THI values, produced less heat as against those in the more thermally stressful enclosures. This result is in conformity with the findings of Brown-Brandl *et al*. (1998) and Ogunjimi (2007) from which it was observed that with less feed consumption, less heat is produced by rabbits as there were reduced calories gained from the feed.

Moisture production

On the other hand, it was observed that the rate of moisture production of the rabbits is related to the amount of heat produced since high rate of respiration occur in relation to the level of heat stress. As shown in Figure 2, MP of the rabbits increased with increasing THI which indicates the level of thermal comfort of an enclosure. MP is a function of respiration rate (the release of moisture from the lungs) and urine production by an animal in order to reduce internal heat. As a function of the pen's thermal comfort level indicator, THI, Mp in regression is:

$$MP_a = 5.9275(THI) - 173.21; \quad (R^2 = 79.30\%) \quad \ldots\ldots\ldots\ldots\ldots\ldots \; 3.5$$

$$MP_b = 2.865(THI) - 76.586; \quad (R^2 = 91.86\%) \quad \ldots\ldots\ldots\ldots\ldots\ldots \; 3.6$$

$$MP_c = 5.0103(THI) - 141.72; \quad (R^2 = 84.93\%) \quad \ldots\ldots\ldots\ldots\ldots\ldots \; 3.7$$

$$MP_d = 4.8539(THI) - 134.21; \quad (R^2 = 76.71\%) \quad \ldots\ldots\ldots\ldots\ldots\ldots \; 3.8$$

The means of THI and MP for different building openings and orientations are shown in Table 1; this result conforms to the conclusion of Brown-Brandl *et al*. (1998) and Ogunjimi (2007) that respiration, that is, a method through which energy is lost is affected by temperature and diurnal effects.

CONCLUSIONS

Heat and moisture production characteristics of mature rabbits are significantly correlated to the temperature-humidity interaction level of the enclosure in which they are being raised. The regression equations relating THP and Mp production rate to thermal comfort level of their pens have been established.

Further research is needed to verify in some other locations with a view to establish a data base for the design of rabbit structure to provide an all year round thermally conducive environment for the animal's productivity.

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