NATIONAL INNOVATION AND RESEARCH ACADEMIA
International Journal of Sustainable Development
ISSN: 2713-4683. Volume 6, Issue 4. Pages 98-106. December, 2021
Double Blind Peer Reviewed International Research Journal
editornirajournals@gmail.com

Thermal Comfort Consideration in the Design of Poultry House of Semi Arid Region, a Case Study of Maiduguri

Fantami Ali [1], Baba Gana Halilu [2], Abdullahi Mohammed[3]

[1&2] Department of Architectural Technology,

[3]Department of Quantity Surveying

[1,2&3] Ramat Polytechnic Maiduguri, Borno State.

Corresponding author: Fantamiali24@gmail.com

Abstract: *Thermal comfort in the design of poultry house of semi arid region needs a micro climate that has a temperature of about 21 to 22 ºC which is known as comfort zone for laying chickens. The objectives were to determine; thermal comfort of birds in hot climate; space consideration at design stage of the poultry housing; and orientation of the poultry house. The data was collected through case study and oral interview of farm staffs in Goteri farm and Poultry Production Unit (PPU) here in Maiduguri. Data collected were analyzed using photographs and drawings. The findings shows that, both houses are open sided, oriented north-east, with dimension of 12x14 meters each. With slope gradient of the roofs having 30º and 26º respectively. With trees plantations and shrubs to create a micro climate. The room temperature during the hot season ranged from 38℃-40℃. It is recommended that, the width of the building should not exceed 12m and headroom minimum height of 3.5 meters with high pitch roof for ease of management and better production. East- West orientation can reduce direct solar radiation, electric humidifiers, foggers, sprinklers also use in managing the micro climate inside the poultry house. Insulating material on roof and side walls can help in reducing heat building up in the interior of the open sided cage during the hot period.*

Keywords: Poultry housing, Design, Orientation, Thermal comfort

Introduction

Poultry production has occupied a leading role in the agricultural industry worldwide in recent years. The compound annual growth rate of poultry protein between 2015 and 2025 is estimated to be +2.4% (Nan-Dirk, 2018). Asia, South America, and Africa characterized by rapid urbanization, poverty, and hot climate recorded the highest growth increment in poultry production (Nan-Dirk, 2018 and Daghir, 2008). Extreme weather conditions in the tropical regions of the world have proven generally detrimental to livestock production

and is particularly of interest in chicken because of the latter's high sensitivity to temperature change (Nienabar 2007 and Renaideau *et al*,. 2012). Just like mammals, the avian species have the ability to regulate their body temperatures by losing or generating heat in response to environmental temperature.

In terms of design the width of the open-sided poultry house should be about 30 ft (9.8 m) and no more than 40 ft (12.2 m) wide. Houses that are wider will not provide ample ventilation during hot weather. Wider houses also require additional interior supports that may interfere with equipment or manure removal. This width recommendation is basic for growing birds, broilers, and laying hens (Alchalabi, 2013). The sidewall consists of a dwarf wall built up to the roof eave with a permeable membrane such as a corrugated wire mesh and an adjustable curtain. A minimum height of 0.4 m is recommended to prevent the house from water seepage, direct and indirect solar radiation, pests, and predators (Daghir, 2008).

A roof slope of 45° was recommended because the angle reduces the heat gain of the roof from the direct solar radiation, it maximizes the distance of the bird from the heat accumulated under the roof, quick escape of the heat accumulated under the roof through ridge opening, maximization of air space to improve air exchange rate and open space above for installation of equipment (Clark, 2013, Daghir, 2008). Roof overhang can be used to shade the sidewalls of a building from direct and indirect solar radiation. However, the length of the roof overhang is dependent on the height of the sidewalls (Daghir 2008). Heat gain by the sidewall can be reduced by about 30% through roof overhang shading if properly applied at a roof slope of 45° (Clark, 2013).

In order to reduce the exposure of sidewall to direct sun radiation the poultry house should be orientated in the east-west direction (Daghir 2008 and Clark, 2013).This is very vital, because heat stress in birds can be hastened when they are exposed to direct solar radiation. Deep litter rearing may allow the birds avoid direct sunlight but this may lead to clustering or overcrowding of birds in an area of the house. Consequently, make cooling difficult and in severe cases this leads to stampede and even death (Daghir 2008).

Thermal comfort is the state of mind, which expresses satisfaction with the thermal environment. (Joost van Hoof and Hensen, 2010). For the characterization of the ideal thermal environment for the animal, the effects of wind, radiation, humidity, and temperature are considered as important parameters (Baeta & Souza, 2010).

In poultry the body which normally runs between 39.4 and 40°C, with rise in degrees temperature it affects the productivity of the birds. Heat stress in poultry production had resulted in under-nutrition, stunted growth, reduction in egg production and size, laying of premature eggs and even death (Bawa *et al*,. 2001, and Irshad *et al*,. 2012). According to Furlan and Macari (2008) reported that for one day old chicks the suitable thermo neutral zone is between 33 °C to 35 °C with 65% to 70% relative humidity.

In poultry, temperature control in buildings is considered to be the greatest difficulty in handling broiler chickens (Belusso & Hespanhol, 2010). As they grow and reach between ten and fifteen days of life temperature belonging to the zone of thermal comfort is reduced

between 24 ºC to 33 ºC, while for the fourth week of age and after the sixth week, the authors indicate that the recommended temperature becomes between 21 ºC to 22 ºC. Studies pointed that birds exposed to high temperatures, from 32 ºC to 38 ºC, suffer and may have panic, watery stools, bristling legs, open wings, depression and increased water consumption (Tan *et al*., 2010). In another experiment, it was observed that birds exposed for three hours at an ambient temperature of

35°C showed a state of heat stress, where it was possible to verify the increase in body temperature, respiratory alteration, and a dispersed distribution in the cage (Han *et al.,* 2010).

Methodology

Study Area

The study was conducted in Maiduguri the capital city of Borno state. It is located at the central part of the state and fall within the latitude 11°50'48.91''N longitude 13°9'25.63''E. It covers an area of approximately 50778km^2 and has a population of about 1,907,600 as of 2007. Maiduguri shares boundaries with Mafa to the east, Benisheik to the west, Konduga to the south and Nganzai local government to the north. It is located within the Sudan savannah region of Northern Nigeria with tree distinct seasons; namely dry cold, dry hot and wet season

Research Design

The research design chosen for this study is case study research. The interview involved semi-structured interview with head of the poultry farms and their workers. The interview was based on guides that include questions about their perception of the building and the immediate surroundings, which facilitated for the respondent to discuss about what they thought, were important within the themes.

In considering the thermal comfort in poultry farm the following aspects of the housing will be considered. Namely site selection, orientation, building materials and design of the building.

Case Study one: Goteri farm Maiduguri

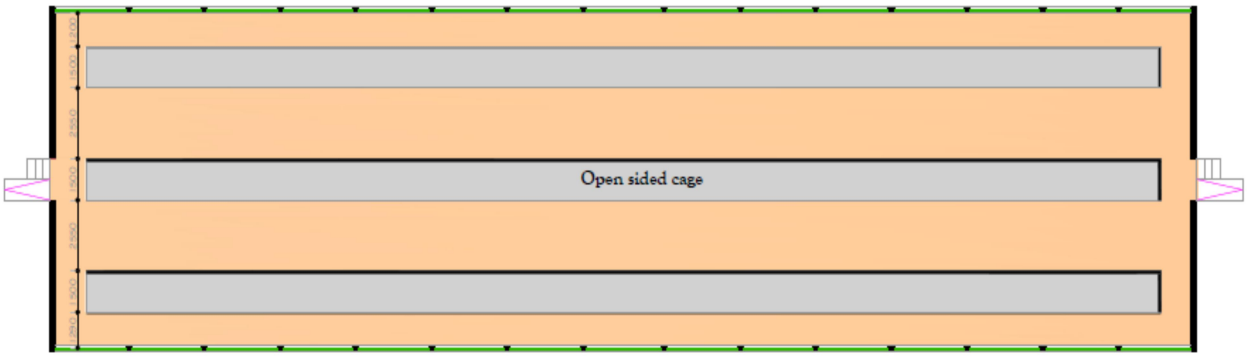
The poultry farm own by individual and established in 2014. Consisting of three different sections, the brooder the growing and rearing (battery cage system). The layers are kept in 3 tiers battery cage, the battery cage has dimension of 2.2m (width) x 2.2m (length) which has 24 cells with a capacity of 3-4 birds per cell forming a unit. Due to high temperature of the tropical region they are housing 3 birds per cell; each unit is accommodating 72 laying chickens as at when obtaining the data and had an oral interview with the farm manager. The large open sided cage has a size of 12m x 45m having 3 rows with 66 units with total number of about 4752 layers.

The room temperature during the hot season is average of 38°C which is above the thermal comfort of the laying chicken. The measures applied in reducing the excess thermal heat

were the use of fan, fogger, and drencher on top of roof as well as tree plantation at the environment.

Figure 1.0

Floor plan of Case study one



Source: Author field work

Figure 2.0

Photograph of Case study one

Figure 3.0

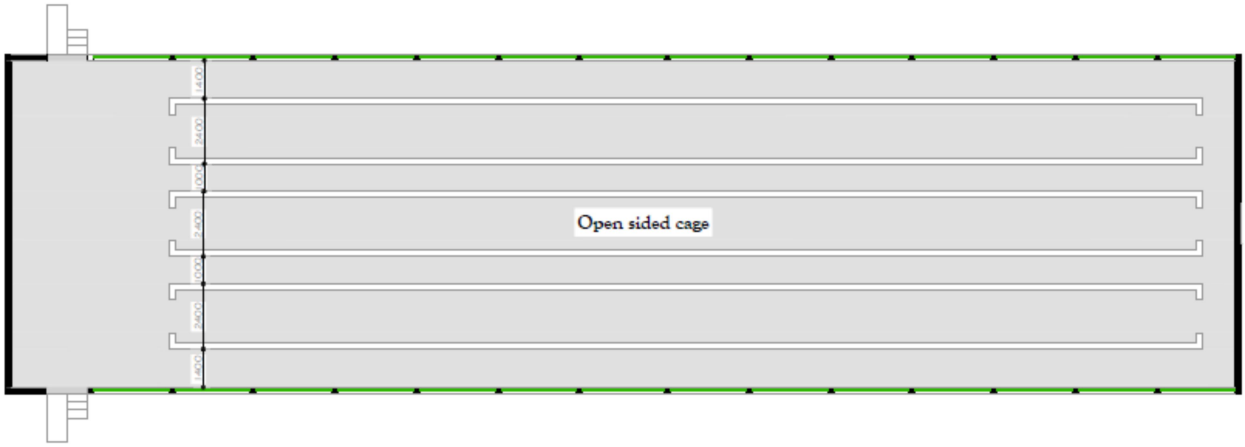
Photograph of Case study one

Case Study two: Poultry Production Unit (PPU) Ministry of Animal Resources and Fishery Development Gamboru Ngala Road Maiduguri

The Poultry Production Unit (PPU) own by Borno state government. It was established and formally commission on 27th April, 1974. Consisting of four different sections: the feed mill, brooder, growing and rearing. The layers are kept in 3 tiers battery cage and dip liters. The battery cage has dimension of 2.4m (width) x 2.4m (length) which has 24 cells forming a unit. each cell accommodating 3-4 birds but due to high temperature of the tropical region they are housing 3 birds in a cell, each unit accommodating 72 laying chickens as at when obtaining the data and had an oral interview with the deputy farm manager. The large open sided cage has a size of 12m x 45m having 3 rows with 54 units with total number of about 3888 layers.

The room temperature during the hot season is average of 39℃ which is above the thermal comfort of the laying chicken. The measures applied in reducing the excess thermal heat were the use of fan, fogger, and as well as tree plantation at the environment.

Figure 4.0
Floor plan of the Case study two



Source: Author field work

Figure 5.0 Photograph of Case study two

Figure 6.0 Photograph of Case study two

Findings and discussion

Result shows that the two different case studies; Goteri farm and Poultry Production Unit (PPU) have the same dimensions, the widths of the buildings are 12meters, and the lengths are 45 meters respectively. The width of the open-sided poultry house should be about 30 ft (9.8 m) and no more than 40 ft (12.2 m) wide. Houses that are wider will not provide ample ventilation during hot weather. Wide houses also require additional interior supports that may interfere with equipment or manure removal. This width recommendation is basic for growing birds, broilers, and laying hens (Alchalabi, 2013). The roof slope of 30.26° and 32.56° for Goteri farm and PPU respectively was quite below the reports of Daghir(2008) and Clark(2013) where they reported recommended slope of 45° which reduces the heat gain of the roof from the direct solar radiation; maximizes the distance of the bird from the heat accumulated under the roof.

The orientation of Goteri farm shows that, the shortest side facing East-West direction while the longest side facing Norh-south and the orientation of PPU shows that, the shortest side facing SouthEast – NorthWest direction while the longest side facing NorthEast- SouthWest Direction. Both farm structure coresponds with Daghir(2008) and Clark(2013) where he says if reduces the exposure of sidewall to direct sun radiation the poultry house should be orientated in the east-west direction.

It is also recorded and observed that the comfort zone of birds in both the two poultry houses: at brooders stage required a temperature of about 33 to 35 °C, as they are growing to reach fifteen days of life temperature belonging to the zone of thermal comfort is reduced between 24 ºC to 33 ºC while for the fourth week of age and after the sixth week, the recommended temperature becomes between 21 to 22 ºC.

Recommendation

Base on the study it is recommended that comfort of birds can be guaranteed in the poultry house of semi arid region are as follows.

1. The orientation of the building, the shortest side that has no openings should face east-west or north/west-south-east and also planting of trees at the surrounding help in creating micro climate.

2. The use of insulating material on roof and side walls can help in reducing heat that build up in the interior of the open sided cage during the hot period

3. The width of the building should not exceed 12m and the headroom has a minimum height of 3.5 meters with high pitch roof.

4. Roof drenchers also recommended using at the roof apex; this can serve as a cooling agent during the hot period.

5. Use of electric humidifiers and foggers also, good in changing the micro climate inside the poultry house.

Conclusion

Thermal comfort in poultry house can only be effective if the environmental temperature is below or within the bird's thermo neutral zone. Micro climate in open sided poultry housing system can help in the tropics to improve the environment for optimum productivity of birds. Proper consideration of architectural elements such as building orientation, roof slope, roof overhang, landscape, building height, building width, building length, etc. have been reported to enhance thermal comfort for optimum production in chicken. In addition, the incorporation of cooling systems such as fogging system, sprinkling system and circulation fan in naturally ventilated design house systems have proven positive in optimizing birds' performances in general. Consequently, in cases where the environmental temperature is severely high and unbearable for birds the mechanical ventilated open housing system have been introduced.

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