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Impact of Environmental Temperatures on Feed and Water Consumption in Broilers and Layers in Commercial and Backyard Poultry Farms, Maiduguri, Borno State

Lawal JR[1]*, Ibrahim UI[1], Igbokwe NA[2], John B[3], Sarki MJ[1] and Hussaini I[1]

[1]Department of Veterinary Medicine, University of Maiduguri, Nigeria
[2]Department of Veterinary Physiology and Biochemistry, University of Maiduguri, Nigeria
[3]Faculty of Veterinary Medicine, University of Maiduguri, Nigeria

***Corresponding author:** Jallailudeen Rabana Lawal, Department of Veterinary Medicine, Faculty of Veterinary Medicine, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria, Tel: +234 803 2886 428; Email: rabanajallailudeen@yahoo.com

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Abstract

This study investigates the influence of environmental temperatures on feed intake and water consumption in broilers and layers across commercial and backyard poultry farms in Maiduguri, Borno State. Data were collected over six months from multiple farms, accounting for seasonal variations and management practices. The findings revealed significant differences in feed and water intake between commercial and backyard farms influenced by temperature fluctuations. Specifically, broilers showed higher sensitivity to temperature changes compared to layers. At temperatures below 25°C, broilers in commercial farms consumed significantly more feed (120 ± 0.5g) and less water (250 ± 0.3ml) compared to higher temperatures above 40°C where feed consumption decreased (100 ± 0.3g) and water intake increased (380 ± 0.6ml) ($p < 0.05$). Layers followed a similar trend with higher feed intake (110 ± 0.5g) at temperatures below 25°C and increased water consumption (350 ± 0.5ml) at temperatures above 40°C ($p < 0.05$). Comparative analysis indicated that commercial broilers had a significantly higher average feed intake during the rainy season (180 ± 0.5 g/day) compared to backyard broilers (120 ± 0.3 g/day, $p < 0.05$), with similar patterns observed during the hot dry season. In contrast, backyard broilers consumed more water (350 ± 0.6 ml/day) than commercial broilers (300 ± 0.4 ml/day) during the hot dry season ($p < 0.05$). These findings suggest that temperature management is crucial for optimizing poultry performance, with implications for different farming systems.

Keywords: Broilers; Layers; Environmental Temperature; Feed Intake; Water Consumption; Commercial Farms; Backyard Farms; Maiduguri

Abbreviations

ANOVA: Analysis of Variance.

Introduction

Poultry farming is a significant component of the agricultural sector in most African developing countries, including Nigeria, contributing to food security and economic development [1]. Poultry production is a growing enterprise that attracts both lower and higher-income earners, who invest in backyard and commercial poultry farms in northern Nigeria, including Maiduguri [2]. In Maiduguri, Borno State, the poultry industry includes both commercial and backyard poultry farms, each with distinct management practices and environmental challenges [3]. However, the environmental temperatures in this region can be extreme, affecting the productivity and health of the poultry.

Extreme temperatures have been reported to negatively impact the behavior of chickens, altering their attitude towards feed and water intake frequency [4-6]. For instance, broilers and layers exhibit different physiological responses to temperature changes, with broilers being more susceptible to heat stress due to their higher metabolic rate [7]. Layers, on the other hand, may adjust their feed intake based on energy needs for egg production, which can be compromised under extreme temperatures [8].

Several studies have documented the impact of environmental temperatures on poultry feed and water consumption. Orakpoghenor, et al. [9] reported that fluctuations in environmental temperatures influence water intake in broilers, while Freeman [10] highlighted the interdependence of water and feed consumption, noting that reduced water intake can lead to decreased feed intake. Teyssier, et al. [11] and Apalowo, et al. [6] documented that poultry reduce feed intake at high temperatures to minimize metabolic heat production, thereby reducing heat stress. Similarly, increased water consumption at higher temperatures is a physiological response to aid in thermoregulation and maintain hydration [12].

The management practices and environmental control in commercial farms often differ significantly from those in backyard farms. Commercial farms typically have superior temperature control and management practices, leading to higher feed intake and lower water consumption compared to backyard farms [13]. Rocha, et al. [14] noted seasonal variations in feed and water intake in broiler chickens, emphasizing the importance of optimized feeding schedules and effective cooling systems in commercial settings.

Given these observations, this study aims to compare how different temperatures influence feed and water consumption in broilers and layers across different farming systems in Maiduguri. Specifically, it seeks to address the following research questions:

- How do environmental temperatures affect feed intake and water consumption in broilers and layers?
- What are the differences in feed and water consumption between commercial and backyard poultry farms under varying temperature conditions?
- How do management practices in commercial and backyard farms influence the observed patterns of feed and water consumption?

Materials and Methods

Study Area

The present study was conducted in Maiduguri, capital of Borno State, located in the northeastern region of Nigeria. Maiduguri, also known as Yerwa, was founded in 1902 and is the largest metropolis in this region. The city is situated in the Arid Zone with an area of approximately 69,436 km^2. Geographically, Maiduguri lies between latitude 10° and 13° North and longitude 12° and 15° East, with more specific coordinates placing it at 11°48'N to 11°52'N and 13°02'E to 13°12'E.

Maiduguri is part of the Sahel Savannah Zone, characterized by low rainfall and a tropical continental climate. The city experiences a hot and dry climate for most of the year, with a rainy season extending from late June to early October in the north, and from May to October in the south. The mean annual rainfall is around 600-650 mm, with extreme northern areas receiving less than 500 mm. The average annual temperature is about 32°C.

The relative humidity in Maiduguri is generally low throughout the year, ranging from 13% during the driest months of February and March, to 70-80% during the peak of the rainy season in July and August. The dry season lasts between 4 to 8 months, typically from October to May, followed by a short but intense rainy period.

Maiduguri occupies a significant portion of the Chad Basin and shares international borders with the Republics of Niger to the north, Chad to the northeast, and Cameroon to the east. Within Nigeria, it borders Yobe State to the west.

This climatic and geographic profile of Maiduguri provides a unique environment for various agricultural and livestock activities, which are essential to the local economy and livelihoods. Maiduguri is characterized by a semi-arid climate with significant temperature variations throughout the year, making it an ideal location to study the influence of environmental temperatures on poultry.

Study Design

A cross-sectional and comparative study design was adopted to compare feed intake and water consumption relative to environmental temperatures in broilers and layers across commercial and backyard poultry farms.

Farm Selection

The study involved ten commercial poultry farms and ten backyard poultry farms. The selection was based on farm size, location, willingness to participate, and their representation of typical farming practices in the area. To minimize selection bias, a total of 20 poultry farms were chosen using stratified random sampling. The selection criteria included farm size, management practices, and geographic location to ensure a representative sample of the region's poultry farming practices. Farm owners were approached through local poultry associations and veterinary networks to identify potential participants who met the inclusion criteria.

Inclusion and Exclusion Criteria

Only farms with a minimum of 50 birds, located within Maiduguri, and operational for at least one year were included. Farms with less than 50 birds, newly established farms, and those outside Maiduguri were excluded. Farms with mixed breeds or incomplete records were also excluded to maintain data consistency.

Sample Size

While the initial study involved ten commercial and ten backyard farms, we acknowledge that a larger sample size could enhance the reliability of the results. Future studies will aim to include a more extensive number of farms to improve the generalizability of the findings. Despite the limited sample size, the selected farms were representative of the farming practices in the study area.

Period of Data Collection

Data were collected over a period of nine months, from February, 2023 to October, 2023, covering the peak of the cold dry season, hot dry season, and the onset of the rainy season. This period was chosen to capture the significant temperature variations typical of the region.

Data Collection Methods

The study involved both direct observations and structured interviews with farm managers to gather comprehensive data. Temperature data were recorded using calibrated digital thermometers placed at various points within the poultry houses to ensure accurate and consistent temperature readings. Data on feed intake (grams per bird per day) and water consumption (milliliters per bird per day) were collected daily for broilers and layers separately. Farm managers were trained on standardized data recording procedures to ensure data consistency and reliability. The collected data were cross-verified through periodic visits by the research team.

Data Analysis

Data were analyzed using SPSS software (version 26.0). Descriptive statistics including means and standard deviations, were used to summarize the data. Analysis of Variance (ANOVA) and t-tests, were employed to compare feed intake and water consumption between broilers and layers, and between commercial and backyard farms. Multiple regression analysis was performed to assess the impact of temperature on feed and water consumption, with p-value < 0.05 considered statistically significant. Post-hoc tests (Tukey's HSD) were conducted to identify specific differences between groups.

Results

Feed Intake and Water Consumption across Temperatures

Table 1 presents the average feed intake and water consumption of broilers and layers at different temperatures. Broilers consumed significantly more feed (120 ± 0.5g) and less water (250 ± 0.3ml) at temperatures below 25°C compared to consuming less feed (100 ± 0.3g) and more water (380 ± 0.6ml) at temperatures above 40°C ($p < 0.05$). Layers showed a similar trend, consuming more feed (110 ± 0.5g) at temperatures below 25°C and more water (350 ± 0.5ml) at temperatures above 40°C ($p < 0.05$). These results demonstrate that environmental temperatures significantly influence feed intake and water consumption in both broilers and layers.

Temperature (°C)	Broilers (Feed Intake, g)	Broilers (Water Consumption, ml)	Layers (Feed Intake, g)	Layers (Water Consumption, ml)
<25	120 ± 0.5	250 ± 0.3	110± 0.5	220 ± 0.6
25-35	115± 0.2	320± 0.5	105± 0.3	290± 0.3
>40	100± 0.3	380± 0.6	95 ± 0.4	350 ± 0.5

Table 1: Average Feed Intake and Water Consumption in Broilers and Layers across Different Temperatures in Maiduguri, Borno State, Nigeria.

Comparative Analysis of Commercial and Backyard Farms

Table 2 illustrates the average daily feed intake (g/day) and water consumption (ml/day) for broilers and layers in commercial and backyard farms across different seasons. During the rainy season, commercial broilers had a significantly higher average feed intake (180 ± 0.5 g/day) compared to backyard broilers (120 ± 0.3 g/day, $p < 0.05$). Similar trends were observed during the hot dry season, with commercial broilers consuming more feed (120 ± 0.5 g/day) than backyard broilers (90 ± 0.2 g/day, $p < 0.05$). Commercial layers consistently consumed more feed than backyard layers across all seasons. However, water consumption exhibited a different pattern, with backyard broilers consuming significantly more water (350 ± 0.6 ml/day) than commercial broilers (300 ± 0.4 ml/day) during the hot dry season ($p < 0.05$).

Parameter	Commercial Broilers	Backyard Broilers	Commercial Layers	Backyard Layers
Feed Intake (Hot dry Season)	120 ± 0.5	90 ± 0.2	100± 0.5	70 ± 0.6
Feed Intake (Cold dry Season)	170 ± 0.2	90 ± 0.4	130 ± 0.5	90 ± 0.3
Feed Intake (Rainy Season)	180 ± 0.5	120 ± 0.3	180 ± 0.6	100 ± 0.2
Water Consumption (Hot dry Season)	300 ± 0.4	350 ± 0.6	220 ± 0.4	270 ± 0.5
Water Consumption (Cold dry Season)	170 ± 0.2	220 ± 0.5	150 ± 0.2	190 ± 0.2
Water Consumption (Rainy Season)	140 ± 0.4	110 ± 0.2	120± 0.5	110± 0.3

Table 2: Average Feed Intake (g/day) and Water Consumption (ml/day) for Broilers and Layers in Commercial and Backyard Farms in Maiduguri, Borno State, Nigeria.

Control Variables

Other Environmental Factors: While temperature was the primary focus of this study, other environmental factors such as humidity, wind speed, and sunlight were also monitored but not reported in the initial manuscript. Future studies should integrate these factors into the analysis to provide a more comprehensive understanding of their effects on feed and water consumption.

Discussion

The results of this study demonstrate that environmental temperatures significantly affect feed intake and water consumption in both broilers and layers in Maiduguri, Borno State, Nigeria. These findings align with Orakpoghenor, et al. [9], who reported that fluctuations in environmental temperatures influence water intake in chickens, especially the broilers. It is well-established that water and feed consumption are interdependent; reduced water intake can lead to decreased feed intake [10]. Our study also found that commercial poultry farms, with superior temperature control and management practices, exhibited higher feed intake and lower water consumption compared to backyard farms, supporting the findings of Singh, et al. [13]. This indicates that enhancing temperature regulation in backyard farms could improve poultry productivity. The observed differences between broilers and layers highlight their distinct metabolic rates and physiological requirements, underscoring the necessity for species-specific management strategies.

In broilers, feed intake was higher (120g) and water consumption lower (250ml) at temperatures below 25°C. Conversely, at temperatures exceeding 40°C, feed intake decreased to 100g, while water consumption significantly increased to 380ml, corroborating the findings of Onagbesan, et al. [15]. Our results are consistent with the established understanding that poultry reduce feed intake at high temperatures to minimize metabolic heat production, thereby reducing heat stress, as documented by Teyssier, et al. [11] and Apalowo, et al. [6]. Increased water consumption at higher temperatures is a physiological response to aid in thermoregulation and maintain hydration [12]. A similar pattern was observed in layers, with higher feed intake (110g) at temperatures below 25°C, and reduced intake at temperatures above 40°C, while water consumption increased from 250ml to 350ml. This trend parallels that seen in broilers and can be attributed to similar thermoregulatory mechanisms. Additionally, layers might adjust their feed intake based on energy needs for egg production, which can be compromised under extreme temperatures, as reported by Kim et al. [8].

During the rainy season of the study period, commercial broilers exhibited a significantly higher average feed intake (180 g/day) compared to backyard broilers (120 g/day). This disparity can be attributed to better nutrition management, improved feed quality, and optimized feeding schedules in commercial farms. Similarly, during the hot dry season, commercial broilers had a higher feed intake (120 g/day) than backyard broilers (90 g/day). This difference is likely due to more effective cooling systems and controlled environments in commercial setups, which mitigate heat stress better than backyard settings. These findings are consistent with Rocha, et al. [14], who also reported seasonal variations in feed and water intake in broiler chickens.

Commercial layers consistently consumed more feed (100 g/day) compared to backyard layers (70 g/day). The consistently higher feed intake in commercial settings can be attributed to controlled feeding practices, superior housing conditions, and potentially less competition for feed, which is often a challenge in backyard systems where multiple birds might be feeding from the same source. These results align with the findings of Alig, et al. [16].

Interestingly, water consumption trends varied. During the hot, dry season of the study period, backyard broilers consumed more water (350 ml/day) compared to commercial broilers (300 ml/day). Similarly, backyard layers drank more water than their commercial counterparts. These findings could be attributed to the fact that backyard farms, typically lacking sophisticated cooling systems, may lead to higher water consumption as birds naturally drink more to cope with elevated ambient temperatures. This observation is consistent with El Sabry, et al. [17], who explained that increased temperatures result in higher water intake in chickens under intensive management systems.

In backyard settings, water might be more readily available in larger quantities throughout the day, whereas commercial farms may have scheduled watering times, leading to more regulated water intake. This aligns with El Sabry, et al. [18], who described that limiting access to drinking water can be managed in two ways: water restriction (WR, controlling the amount of ad libitum water intake) or water deprivation (WD, controlling the water supply for a certain period of time). Both methods of limited water supply negatively impact chicken productivity when exposed to extreme temperature variations.

During the hot, dry season, both broilers and layers exhibited decreased feed intake and increased water consumption across all farm types. This seasonal variation underscores the significant impact of high environmental temperatures on poultry behavior and physiology. These findings support those of Wasti, et al. [4], who documented the impact of heat stress on the feeding and overall performance of intensively reared chickens, especially broilers and layers. The reduction in feed intake during hotter periods can be attributed to the birds' efforts to reduce metabolic heat production, as documented by Onagbesan, et al. [15]. The concurrent increase in water consumption is a compensatory mechanism to enhance evaporative cooling and maintain homeostasis [9].

The differences in water consumption between commercial and backyard farms, particularly during the hot, dry season, could also be influenced by variations in water management practices. In commercial farms, where water availability may be more controlled, birds might consume less water due to scheduled watering times, whereas backyard farms may provide ad libitum access to water, resulting in higher consumption [18]. This pattern aligns with the findings of El Sabry, et al. [17], who reported that water management practices significantly impact poultry hydration and overall performance.

Overall, this study highlights the critical role of environmental temperature management in optimizing feed and water consumption in poultry. Future research should focus on developing and implementing advanced cooling and hydration strategies, particularly in backyard farms, to mitigate the adverse effects of extreme temperatures and enhance poultry productivity.

Conclusion

The study reveals that extreme environmental temperatures significantly affect feed intake and water consumption in broilers and layers in the study area. Broilers exhibit a greater reduction in feed intake with increasing temperatures compared to layers, indicating a higher sensitivity to heat stress. Water consumption increased in both broilers and layers as temperatures rose, highlighting the importance of ensuring adequate water supply during hotter periods. Commercial farms, with better housing and management practices, showed less variation in feed and water intake compared to backyard farms, suggesting that improved infrastructure can mitigate the impact of temperature fluctuations.

Recommendations

Practical Application of Findings

Heat Stress Management for Broilers: Broilers are more affected by heat stress than layers, necessitating targeted interventions during hot weather.

- Cooling Systems: Implementing cooling systems such as fans, misters, or evaporative cooling pads can help reduce heat stress. While the initial cost of these systems can vary, misters and fans are relatively affordable and can be cost-effective for small-scale farmers. Evaporative cooling pads, though more expensive, are highly effective in larger commercial setups. A cost-benefit analysis should be conducted to determine the most feasible options for different farm sizes.
- Shade Provision: Providing shade using inexpensive materials like shade cloths or constructing simple thatched structures can significantly reduce the ambient temperature in poultry houses. This is a low-cost solution that can be easily adopted by backyard farmers.

Infrastructure and Temperature Management in Backyard Farms: There is a need for improved infrastructure and temperature management practices in backyard farms to mitigate the impact of temperature fluctuations.

Housing Improvements: Enhancing the design of poultry houses to improve ventilation and insulation can help maintain more stable temperatures. This may include constructing houses with higher roofs, using reflective roofing materials, and ensuring adequate cross-ventilation.

Cost Considerations: These improvements may require an initial investment, but government or non-governmental organizations can provide subsidies or financial assistance to help small-scale farmers adopt these practices.

Ensuring Continuous Water Supply: During hotter periods, it is crucial to ensure continuous access to clean water to prevent dehydration and maintain productivity.

- **Water Management Systems:** Installing automated water systems that ensure a constant supply of clean water can be beneficial. These systems can range from simple gravity-fed systems to more advanced automated drinkers, depending on the farm's size and resources.

Education and Outreach

Training Programs for Poultry Farmers: Specific training programs should be developed to educate farmers on the importance of temperature regulation and best practices for managing feed and water intake.

- **Workshops and Seminars:** Organize workshops and seminars in collaboration with agricultural extension services to demonstrate practical techniques for heat stress management, housing improvements, and water management. These sessions should include hands-on demonstrations and provide farmers with practical tools and resources.
- Educational Materials: Develop and distribute educational materials such as pamphlets, posters, and instructional videos in local languages to ensure wider reach and understanding. These materials should cover the importance of maintaining optimal temperatures, signs of heat stress, and simple, cost-effective solutions.

Outreach Activities: Implement outreach activities to ensure that the study's findings are effectively communicated to farmers and other stakeholders.

- **Field Days:** Organize field days where farmers can visit demonstration farms that have successfully implemented the recommended practices. This provides an opportunity for peer learning and encourages the adoption of new techniques.
- **Partnerships with Local Organizations:** Partner with local agricultural organizations, cooperatives, and non-governmental organizations to extend the reach of educational programs and provide ongoing support to farmers.

Future Research

Longitudinal Studies: Conduct longitudinal studies to explore the long-term impacts of temperature on poultry productivity and health. These studies should aim to identify specific thresholds for temperature-related stress and develop more refined management practices.

Cost-Benefit Analysis: Perform detailed cost-benefit analyses of the recommended interventions to provide farmers with clear guidance on the economic feasibility and potential return on investment.

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