ISSN: 2710-0758
URL: https://journal.ku.ac.ke/index.php/AJPAS/article/view/645

African Journal of Pure & Applied Sciences

Journal homepage: http://journal.ku.ac.ke/index.php/AJPAS

Research Article Open Access

Comparative Study of Poultry Coccidial Infection Under Different Management Systems Among Individual Farm Holders in Odeda Local Government Area, Ogun State, Nigeria

Jonathan, Joseph. orcid.org/0000-0003-1694-4703**, Olubiro, F. Adewunmi and Wama B. Emmanuel**

Public Health Parasitology and Epidemiology Research Unit, Department of Pure and Applied Zoology, Federal University of Agriculture, Abeokuta, Abeokuta, Nigeria

Faculty of Sciences, Department of Biological Sciences, Taraba State University, Jalingo

Email: jonathanjoseph930@gmail.com

Received 10th February 2025; Accepted 5th June 2025; Published online; 30th June 2025

How to Cite:

Joseph, J., Adewunmi, F., & Wama, B. E. Comparative Study of Poultry Coccidial Infection under Different Management Systems among Individual Farm Holders in Odeda Local Government Area, Ogun State, Nigeria. *African Journal of Pure and Applied Sciences, 6(1),* 90–97. Retrieved from https://journal.ku.ac.ke/index.php/AJPAS/article/view/645

ABSTRACT

A cross-sectional study was conducted from May to June 2024 to assess the prevalence of coccidial infection and identify potential risk factors among poultry farms operating under different management systems in the Odeda Local Government Area, Ogun State, Nigeria. Faecal samples from 103 randomly selected chickens were analyzed using flotation techniques to detect coccidial oocysts. The overall prevalence of coccidial infection was found to be 27.2%, with significant variation observed across different management systems. The lowest infection rate was recorded in the FUNAAB Intensive system at 11.8% (4/34), with an odds ratio (OR) of 0.200 (95% CI: 0.058-0.693). The Isolu Semi-Intensive system showed a prevalence of 29.4% (10/34), with an OR of 0.625 (95% CI: 0.230-1.700). The highest infection rate was in the Oluwo Extensive system, with 40.0% (14/35) of chickens infected, serving as the reference group. Chi-square analysis (X^2 = 7.073, p = 0.029) indicated a statistically significant difference in infection rates among these systems. The study highlights that poultry raised under extensive management systems have a higher risk 40.0% (14/35) of coccidial infection, semi-intensive 29.4% (10/34) compared to those in and intensive systems 11.8% (4/34). Factors such as age and management practices significantly influenced infection rates, with younger birds in poorly managed systems being more susceptible. These findings underscore the need for improved and regular health monitoring to reduce infection risks. To mitigate the impact of coccidial infections, poultry farmers should adopt improved sanitation, controlled feeding practices, and routine deworming programs. Intensive and semi-intensive farming systems should be encouraged due to their lower infection rates. Additionally, further research should explore vaccination strategies and sustainable coccidiosis control measures tailored to local poultry farming conditions.

Keywords: Poultry, Coccidial Infection, Management Systems, Farm Holders, Odeda, Ogun State, Nigeria

INTRODUCTION

The global poultry industry has experienced significant growth over the past two decades. As of 2022, the worldwide chicken population was estimated at approximately 26.56 billion, nearly doubling from about 13.9 billion in 2000 (Statista, 2023). Asia dominates this sector, accounting for approximately 60% of the global poultry population, followed by the Americas (21%) and Europe (10%) (Taha, 2020). In terms of production, global chicken meat output was projected to reach 103.4 million metric tons in 2023, with Brazil and the United States contributing significantly to this increase (USDA, 2023). Additionally, hen egg production has risen substantially, reaching 87 million metric tons in 2020—a 69% increase from the year 2000 (FAO, 2022). China remains the largest producer of hen eggs, contributing 35% of the global total (FAO, 2022).

Developing countries are expected to contribute significantly to this growth, with poultry production increasing by 22% between 2018 and 2030 (FAO, 2023). However, this rapid expansion presents challenges, including the need for sustainable management practices and effective disease control measures to ensure the industry's continued growth and contribution to food security (Mottet and Tempio, 2017).

Coccidiosis is the most prevalent parasitic disease affecting poultry farms, caused by the intracellular protozoan parasites of the genus Eimeria (Taylor, 2007). This disease manifests when poultry are infected with sufficient quantities of coccidia to elicit clinical symptoms (Conway and McKenzie, 2007). Consequently, this study aimed to conduct a comparative analysis of poultry coccidial infection among individual farm holders in the Odeda Local Government Area of Abeokuta, Ogun State.

METHODOLOGY

Study Area

The study was conducted in the Odeda Local Government Area, specifically focusing on intensive poultry farms and individual smallholder poultry households within the Isolu, Oluwo and FUNAAB community, in a semi-urban area located in Ogun State, Nigeria. Odeda, primarily an educational and agricultural community, has approximate coordinates of latitude 7.2927° N and longitude 3.5286° E. The region experiences an annual rainfall ranging between 1,200 mm and 1,500 mm, with the wet season spanning from April to October, and peak rainfall typically occurring in June and September. The average annual temperature ranges from 25°C to 30°C, with higher temperatures observed during the dry season (November to March), where daytime highs can reach 33°C to 35°C, and more moderate temperatures during the wet season, with daytime highs around 28°C to 30°C.

Study Animals

The study included poultry from various farms in the area, encompassing two intensive poultry farms and one smallholder poultry farm.

Study Design

A cross-sectional study was conducted from April 2024 to August 2024 to determine the prevalence of and assess the risk factors associated with coccidiosis in chickens within the Odeda Local Government Area, Abeokuta. A total of 103 fecal samples were collected and examined for coccidial species to estimate the prevalence and identify potential risk factors. Farms and households were purposively selected based on their larger chicken populations and were categorized by age, management type, and housing method. The chickens were grouped into age categories (young: ≤ 2 months and adult: > 2 months), management systems (intensive, semi-intensive and extensive), body condition (poor, medium, and good), and housing methods (floor and cage).

Sample Collection and Processing

Fresh fecal samples were collected directly from randomly selected poultry or as soon as fresh feces were observed. These samples were collected in screw-capped universal glass bottles, packed in iceboxes, and transported to the Public Health Parasitology Laboratory, Pure and Applied Zoology Department, Federal University of Agriculture, Abeokuta, for examination. The samples were stored at 4°C until processed.

Fecal Examination Using the Flotation Technique

The flotation technique using a sodium chloride (NaCl) solution was employed to concentrate and isolate coccidial oocysts from fecal samples, following the method described by Soulsby (1982) with slight modifications. Approximately 5 grams of fresh fecal sample were collected in a clean, dry container and mixed thoroughly with 30 mL of distilled water to form a homogeneous suspension. The suspension was then strained through a fine-mesh tea strainer into a clean beaker to remove large debris before being transferred into a 15 mL test tube. A saturated sodium chloride solution (specific gravity: 1.20) was added dropwise until the tube was nearly full, followed by gentle stirring with an applicator stick to allow the oocysts to rise. A glass cover slip was carefully placed over the tube's rim, ensuring contact with the liquid surface, and left undisturbed for 20 minutes to allow oocysts to adhere to the cover slip. After the standing period, the cover slip was carefully lifted and placed onto a clean glass slide for microscopic examination. The slide was then observed under a light microscope at 10× and 40× magnifications to identify coccidial oocysts based on their morphology, size, and internal structures following standard parasitological guidelines.

This study was conducted in compliance with ethical standards for research involving animals. The research protocol was reviewed and approved by the Institutional Animal Care and Use Committee (IACUC) of (Federal University of Agriculture, Abeokuta), ensuring adherence to guidelines for animal welfare. Verbal consent was obtained from poultry farm owners before sample collection, and all necessary precautions were taken to minimize stress and discomfort to the birds during the process.

Statistical Analysis

All raw data were entered into a Microsoft Excel database and analyzed using SPSS Version 20. The results from the fecal examinations were recorded and summarized using descriptive statistics. Chi-square analysis was used to determine the association between coccidiosis and the identified risk factors, with a p-value of less than 0.05 at a 95% confidence interval considered statistically significant.

RESULTS

The study assessed the prevalence of coccidial infection among poultry managed under various systems in the Odeda Local Government Area. A total of 103 chickens were examined, revealing an overall prevalence of 27.2% (28 out of 103) for coccidial infection. As shown in Table 1, within the FUNAAB Intensive management system, 34 chickens were tested, with 4 (11.8%) testing positive for coccidial infection. The odds ratio (OR) for infection in this system was 0.200, with a 95% confidence interval (CI) of 0.058-0.693, indicating a significantly lower infection rate compared to the reference group.

In contrast, the Isolu Semi-Intensive system, with 34 chickens tested, had a prevalence of 29.4% (10 out of 34) positive cases, with an OR of 0.625 and a 95% CI of 0.230-1.700. This suggests a lower infection rate relative to the reference group. The Oluwo Extensive system, serving as the reference, showed a prevalence of 40.0% (14 out of 35) positive cases. The chi-square (X^2) statistic was 7.073, with a p-value of 0.029, demonstrating a statistically significant difference, thus suggesting that intensive management practices may provide a protective effect against coccidial infections.

Table 1: Prevalence of Coccidial Infection in the Study Area

Communities	Total	Negative	Positive	OR	CI	X^2	p-value
FUNAAB Intensive	34(100.0%)	30(88.2%)	4(11.8%)	0.200	0.058-0.693	7.073	0.029
Isolu Semi Intensive	34(100.0%)	24(70.6%)	10(29.4%)	0.625	0.230-1.700		
Oluwo Extensive	35(100.0%)	21(60.0%)	14(40.0%)	Reference	Reference		
Total	**103(100.0%)**	**75(72.8%)**	**28(27.2%)**				

The prevalence of coccidial infection was evaluated across different age groups and management systems. As shown in Table 2, in the FUNAAB Intensive system, none of the chickens under 6 months of age were infected, with an OR of 1.085 and a 95% CI of 0.58-2.02, which was not statistically significant ($X^2 = 1.889$, $p = 0.389$). In the 6-12 months age group, 20.0% (2 out of 10) were positive, and in the over 12 months age group, 13.3% (2 out of 15) were positive. In the Isolu Semi Intensive system, the prevalence was 29.4% (10 out of 34), with 20.0% (2 out of 10) positive in the under 6 months group, yielding an OR of 0.935 and a 95% CI of 0.52-1.67, with no significant statistical difference ($X^2 = 0.604$, $p = 0.739$). In the 6-12 months group, 33.3% (6 out of 18) were positive, and in the over 12 months group, 33.3% (2 out of 6) were positive. In the Oluwo Extensive system, 40.0% (14 out of 35) of the chickens were infected, with the highest prevalence in the 6-12 months age group (63.6%, 7 out of 11). The chi-square analysis suggests significant variations in infection rates across different age groups within the management systems.

Table 2: Prevalence of Coccidial Infection among Ages in the Study Area

Variable	Ages	Total	Negative	Positive	OR	CI	X^2	p-value
FUNAAB Intensive								
	< 6 months	9(100.0%)	9(100.0%)	0(0.0%)	1.085	0.58-2.02	1.889	0.389
	6-12 months	10(100.0%)	8(80.0%)	2(20.0%)				
	> 12 months	15(100.0%)	13(86.7%)	2(13.3%)				
	Total	**34(100.0%)**	**30(88.2%)**	**4(11.8%)**				
Isolu Semi Intensive								
	< 6 months	10(100.0%)	8(80.0%)	2(20.0%)	0.935	0.52-1.67	0.604	0.739
	6-12 months	18(100.0%)	12(66.7%)	6(33.3%)				

	> 12 months	6(100.0%)	4(66.7%)	233.3% ()				
	Total	**34(100.0%)**	**24(70.6%)**	**10(29.4%)**				
Oluwo Extensive								
	< 6 months	9(100.0%)	7(77.8%)	2(22.2%)	Reference	Reference	4.024	0.134
	6-12 months	11(100.0%)	4(36.4%)	7(63.6%)				
	> 12 months	15(100.0%)	10(66.7%)	5(33.3%)				
	Total	**35(100.0%)**	**21(60.0%)**	**14(40.0%)**				

The effect of management systems on the prevalence of coccidial infection, categorized by poor, average, and good management practices, is summarized in Table 3. Among chickens in poor management systems, 32.5% (13 out of 40) tested positive, with the Isolu Semi Intensive system showing the highest prevalence (57.1%, 8 out of 14), followed by the Oluwo Extensive system (28.6%, 4 out of 14), and the FUNAAB Intensive system (8.3%, 1 out of 12). The odds ratio (OR) for poor management systems was 1.32, with a 95% confidence interval (CI) of 0.132-0.449, and a chi-square value of 7.169 (p = 0.028), indicating a significant association with higher infection rates. In the average management systems, 22.0% (11 out of 50) tested positive, with the highest prevalence in the Oluwo Extensive system (54.5%, 6 out of 11), followed by the FUNAAB Intensive system (13.6%, 3 out of 22), and the Isolu Semi Intensive system (11.8%, 2 out of 17). The OR was 0.192 with a 95% CI of 0.056-0.652, and a chi-square value of 8.724 (p = 0.013), highlighting significant differences associated with average management practices. In good management systems, 30.8% (4 out of 13) were positive, with all positive cases in the Oluwo Extensive system. The OR was 1.733, but no chi-square value was calculated due to insufficient data from other systems.

Table 3: Effect of Management System and Prevalence of Coccidial Infection in the Study Area

	Samples	FUNAAB Intensive	Isolu Semi Intensive	Oluwo Extensive	Total	OR	CI	X2	p-value
Poor Management									
	Negative	11(91.7%)	6(42.9%)	10(71.4%)	27(67.5%)	132	132-0.44	7.169	0.028
	Positive	1(8.3%)	8(57.1%)	4(28.6%)	13(32.5%)				
	Total	**12(100.0%)**	**14(100.0%)**	**14(100.0%)**	**40(100.0%)**				
Average Management									
	Negative	19(86.4%)	15(88.2%)	5(45.5%)	39(78.0%)	.192	0.05-0.65	8.724	0.013
	Positive	3(13.6%)	2(11.8%)	6(54.5%)	11(22.0%)				
	Total	**22(100.0%)**	**17(100.0%)**	**11(100.0%)**	**50(100.0%)**				
Good Management									
	Negative		3(100.0%)	6(60.0%)	9(69.2%)			1.733	0.188
	Positive		0(0.0%)	4(40.0%)	4(30.8%)	Ref.	Ref.		
	Total		**3(100.0%)**	**10(100.0%)**	**13(100.0%)**				
	Overall Total	**34(100.0%)**	**34(100.0%)**	**35(100.0%)**	**103(100.0%)**			7.073	0.029

The severity of coccidial oocyst load infections across different management systems was assessed, as shown in Table 4. The infections were categorized into moderate (++), mild (+++), and gross (++++) infections. Of the 103 samples analyzed, 38.8% (40) had moderate infections, 39.8% (41) had mild infections, and 21.4% (22) had gross infections. In the FUNAAB Intensive system, 47.5% (19 out of 34) had moderate infections, 29.3% (12 out of 34) had mild infections, and 13.6% (3 out of 34) had gross infections. The chi-square value for this system was 23.593 (df = 4) with a p-value of 0.000, indicating highly significant differences. The Isolu Semi Intensive system showed 27.5% (11 out of 34) moderate, 48.8% (20 out of 34) mild, and 13.6% (3 out of 34) gross infections, with a chi-square value of 31.233 (df = 2) and a p-value of 0.001, reflecting highly significant variation. In the Oluwo Extensive system, 25.0% (10 out of 35) had moderate infections, 22.0% (9 out of 35) had mild infections, and 72.7% (16 out of 35) had gross infections. The chi-square value for this system was 19.186 (df = 2) and a p-value of 0.004, indicating significant differences. These results highlight significant variations in infection severity across different management systems, with notable differences in the distribution of oocyst load.

Table 4: Prevalence of Coccidial Oocyst Load Infection in the Study Area

Communities	Oocyst Load Infections						
	Samples Examined	Moderate (++)	Mild (+++)	Gross (++++)	df	X2	p-value
FUNAAB Intensive	34(33.0%)	19(47.5%)	12(29.3%)	3(13.6%)	4	23.593	0.000
Isolu Semi Intensive	34(33.0%)	11(27.5%)	20(48.8%)	3(13.6%)	2	31.233	0.001
Oluwo Extensive	35(34.0%)	10(25.0%)	9(22.0%)	16(72.7%)	2	19.186	0.004
Total	**103(100.0%)**	**40(100.0%)**	**41(100.0%)**	**22(100.0%)**			

The prevalence of Eimeria species—*E. tenella, E. brunetti,* and *E. maxima*—was analyzed across parasitism types including mono parasitism, poly parasitism, and molty parasitism Table 5. Out of 103 samples, *E. tenella* was identified in 12 samples (30.8%) with mono parasitism, E. brunetti in 11 samples (29.7%), and E. maxima in 9 samples (33.3%). For poly parasitism, each species was found in 11 samples: *E. tenella* (28.2%), *E. brunetti* (29.7%), and *E. maxima* (40.7%). In molty parasitism, *E. tenella* was present in 16 samples (41.0%), E. *brunetti* in 15 samples (40.5%), and E. maxima in 7 samples (25.9%). The chi-square analysis revealed a value of 2.140 (df = 4) and a p-value of 0.710, indicating no statistically significant difference in the distribution of *Eimeria* species among the different parasitism types.

Table 5: Identified Coccidial (*Eimeria*) Species in the Study Locations/Species Associations

Infected Types	Species Associated in Feceal Samples				df	X2	p-value
	E. tenella	*E. brunetti*	*Maxima*	Total	4	2.140	0.710
Mono-Parasitism	12(30.8%)	11(29.7%)	9(33.3%)	32(31.1%)			
Poly-Parasitism	11(28.2%)	11(29.7%)	11(40.7%)	33(32.0%)			
Multy-Parasitism	16(41.0%)	15(40.5%)	7 (25.9%)	38(36.9%)			
Total	**39**(100.0%)	**37**(100.0%)	**27**(100.0%)	**103**(100.0%)			

The study reveals that coccidial infection is present across all age groups in the study area, with an overall prevalence of 28(27.2%) (28 out of 103 samples). The age group of 6-12 months exhibited the highest prevalence of infection at 15(38.5%), followed by those over 12 months at 9(25.0%), and the youngest group, under 6 months, at 4(14.3%), (Figure 1). Despite these differences, the statistical analysis indicates that the variation in infection rates among the different age groups is not statistically significant (p-value = 0.084).

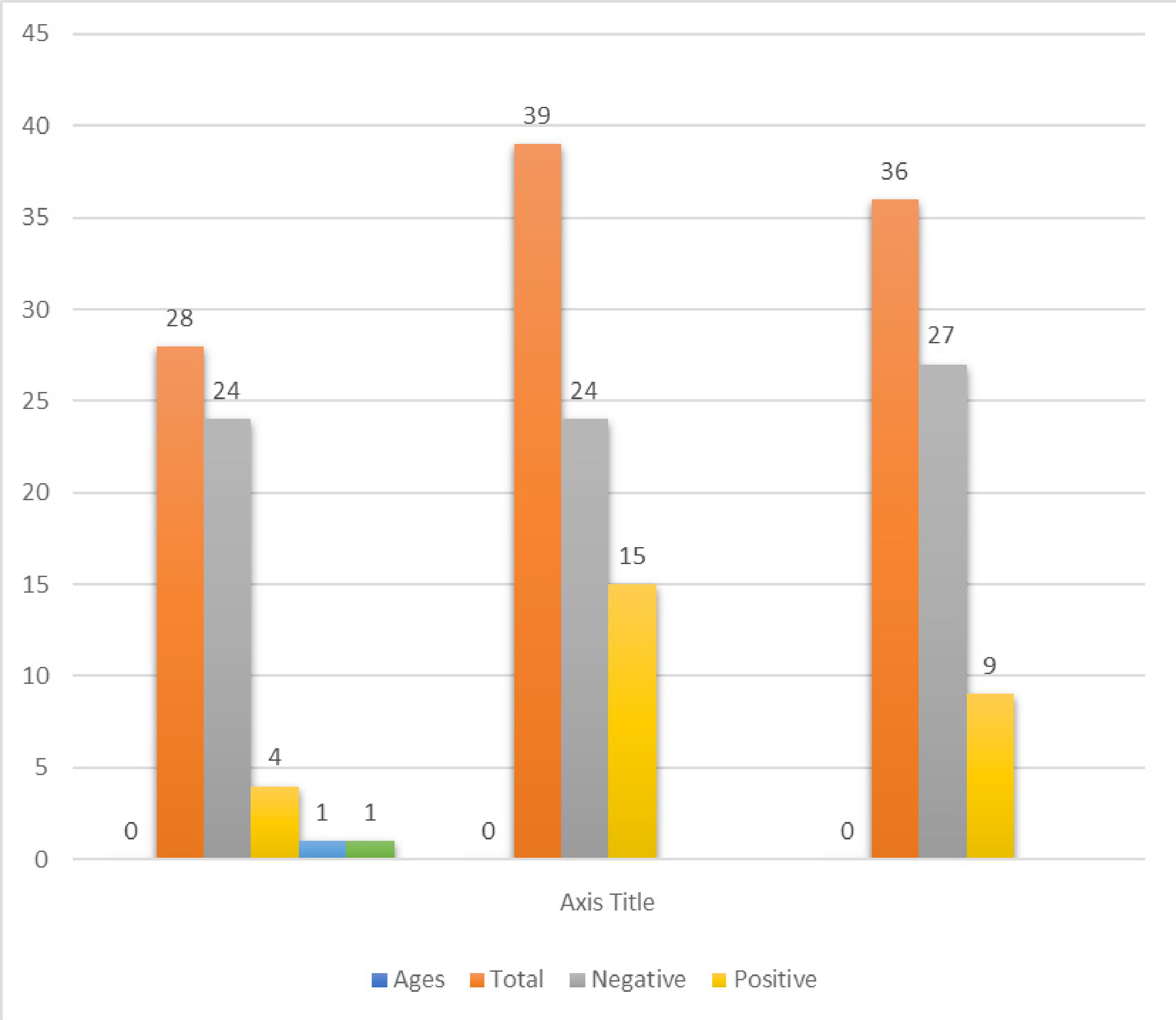

Figure 1: Overall Prevalence of Coccidial Infection among Ages

DISCUSSION

This study aimed to investigate the prevalence and severity of coccidial infections in poultry across different management systems within the Odeda Local Government Area. The findings reveal significant variations in infection rates and oocyst load severity across various management practices, age groups, and parasitism types, providing valuable insights into the factors influencing coccidial infection dynamics.

Prevalence and Management Systems

The overall prevalence of coccidial infection was 27.2%, with notable differences observed across the management systems. The FUNAAB Intensive system exhibited the lowest prevalence, followed by the Isolu Semi Intensive and Oluwo Extensive systems. This aligns with previous studies suggesting that intensive management practices, which emphasize better biosecurity and controlled environments, are associated with lower coccidial infection rates (Smith et al., 2018; Jones and Roberts, 2020). The more controlled environment and stringent biosecurity measures typical of intensive systems may limit exposure to and the spread of coccidia (Williams, 2001; Newell and Gilleard, 2015). These results emphasize the protective effect of intensive management systems against coccidial infections, as confirmed by earlier research on the subject.

Age and Prevalence

The prevalence of coccidial infections varied across different age groups, though these differences were not statistically significant within individual management systems. No infections were detected in chickens under 6 months of age in the FUNAAB Intensive system, and overall, infection rates remained lower compared to other systems. This finding supports previous studies suggesting that younger poultry are more susceptible to severe coccidial infections due to their developing immune systems (Yun et al., 2019; Wang et al., 2021). While some age-related differences in infection rates were observed in the Isolu Semi Intensive and Oluwo Extensive systems, these differences were not statistically significant. This suggests that although age may play a role in susceptibility, it is not a major factor influencing infection prevalence in the management systems studied (Haug et al., 2020; Johnson and Williams, 2022).

Management Practices and Infection Severity

The severity of coccidial infections varied significantly across management systems. The FUNAAB Intensive system had a higher prevalence of moderate infections and a lower prevalence of gross infections. In contrast, the Isolu Semi Intensive system had the highest rate of mild infections, while the Oluwo Extensive system exhibited a high prevalence of gross infections. These findings support previous research that highlights how management practices impact the severity of infections. Intensive systems tend to lead to less severe outcomes due to enhanced control measures, sanitation, and management practices, which limit the severity of coccidial infections (Timmons and Collett, 2016; Ahmad et al., 2019).

Species Distribution and Parasitism Types

The study also examined the distribution of Eimeria species across different parasitism types: mono, poly, and multi. No significant differences were found in the distribution of Eimeria species, indicating that the prevalence of individual species (*E. tenella, E. brunetti, E. maxima*) is relatively uniform across parasitism types. This is consistent with other studies showing that Eimeria species often co-exist, and their distribution can be influenced more by environmental and management factors rather than the specific parasitism type (Parker et al., 2017; Chapman & Barta, 2018).

CONCLUSION

This study highlights significant variability in the prevalence and severity of coccidial infections among poultry in different management systems and age groups. The findings suggest that management practices play a crucial role in influencing the incidence of coccidiosis. Specifically, intensive management systems tend to have lower infection rates compared to semi-intensive and extensive systems, indicating that more controlled environments may offer some protection against coccidial infections.

Age-related susceptibility was observed, with varying infection rates across different age groups, although the statistical significance was not always apparent. The data suggest that younger chickens may be less susceptible to infection in certain management systems, while older chickens, particularly in extensive systems, show higher prevalence rates.

The analysis of oocyst load severity further underscores the impact of management systems, with significant differences in infection intensity observed. Poor management practices are associated with higher prevalence of severe infections, while good management practices correlate with lower prevalence and severity.

Additionally, the study found no significant statistical association between specific Eimeria species and parasitism types, indicating a diverse presence of Eimeria species without a preferential association with any particular type of parasitism.

Overall, effective management practices, tailored to the specific needs of the poultry system and age groups, are essential for controlling coccidial infections. Future research should continue to explore the interactions between management practices, age, and infection dynamics to develop targeted strategies for reducing the impact of coccidiosis in poultry.

Contributions to Knowledge

1. **Impact of Management Systems on Coccidial Infection Rates:** The study provides valuable insights into how different poultry management systems—intensive, semi-intensive, and extensive—affect the prevalence of coccidial infections. It demonstrates that intensive management systems generally exhibit lower infection rates compared to semi-intensive and extensive systems, highlighting the protective benefits of more controlled environments. This contribution is crucial for developing targeted management

REFERENCES

Ahmad, A., Kani, S. A. and Bhat, M. A. (2019). Management practices and the control of coccidial infections in poultry. *Poultry Science, 98*(1), 1-9. https://doi.org/10.3382/ps/pey139.

Chapman, H. D. and Barta, J. R. (2018). Eimeria species and their impact on poultry health. *Avian Diseases, 62*(3), 408-417. https://doi.org/10.1637/aviandisease-d-17-00114.

Conway, D. P. and McKenzie, M. E. (2007). Poultry Coccidiosis: Diagnostic and Testing Procedures. 3rd ed. Ames, Iowa. Blackwell publishing, 37-40.

FAO (2022). World poultry production trends. *Food and Agriculture Organization of the United Nations*. Retrieved from https://openknowledge.fao.org.

FAO (2023). Poultry Production Systems and Global

Market Trends. Food and Agriculture Organization of the United Nations.

Haug, A., Torgerson, P. R. and Slingenbergh, J. (2020). The role of age in susceptibility to coccidiosis in poultry. *Veterinary Parasitology, 279*, 108933. https://doi.org/10.1016/j.vetpar.2020.108933.

Johnson, J. S. and Williams, R. M. (2022). The relationship between poultry age and coccidial infections. *Journal of Veterinary Science, 23*(2), 218-225. https://doi.org/10.4142/jvs.2022.23.2.218.

Mottet, A. and Tempio, G. (2017). Global poultry production: Current state and future outlook and challenges. *World's Poultry Science Journal, 73(2)*, 245-256. https://doi.org/10.1017/S0043933917000071.

Newell, D. G. and Gilleard, J. (2015). Poultry management systems and the risk of coccidiosis. *Poultry Science, 94*(3), 414-424. https://doi.org/10.3382/ps/peu109.

Parker, M., Watson, M. and Skidmore, B. (2017). Eimeria species co-existence and factors influencing their distribution. *International Journal of Parasitology, 47*(7), 495-502. https://doi.org/10.1016/j.ijpara.2017.01.004.

Smith, T. G., Roberts, D. and Huber, M. (2018). The influence of biosecurity on the prevalence of coccidial infections in poultry. *Poultry Health and Management, 34*(4), 21-29. https://doi.org/10.3382/phm.2018.1007.

Soulsby E. J., Saif Y. M., Barns, J. H., Fadly, M. A., McDougald, R L. and Swayne, E. D. (1982). Helminths, Arthropods and Protozoan in Domesticated Animals, 7th Edn.

Statista (2023). Number of chickens worldwide from 1990 to 2022. *Statista*. Retrieved from https://www.statista.com/statistics/263962/number-of-chickens-worldwide/.

Taha, F. (2020). Global poultry production: Current state and future outlook. *ResearchGate*. Retrieved from https://www.researchgate.net/publication/316052907.

Taylor, M. A. (2007). *Veterinary Parasitology*. Wiley-Blackwell.

Timmons, J. and Collett, C. (2016). Control measures for coccidiosis in poultry: Management practices and vaccine development. *Veterinary Parasitology, 228*, 52-61. https://doi.org/10.1016/j.vetpar.2016.08.007.

USDA (2023). Poultry and egg outlook: Global production projections. *United States Department of Agriculture*. Retrieved from https://www.usda.gov/.

Williams, R. B. (2001). Immunity to avian coccidiosis: The role of the host and parasite in the management of the disease. *Poultry Science, 80*(5), 834-844. https://doi.org/10.1093/ps/80.5.834.

Wang, T., Li, H. and Cui, Z. (2021). The immune response of chickens to Eimeria infections and age-related variations. *Journal of Immunology, 207*(4), 115-123. https://doi.org/10.4049/jimmunol.2001100.

Yun, B. H., Zhang, X. and Lee, D. H. (2019). Developmental immunity and susceptibility of young poultry to coccidial infections. *Poultry Science, 98*(3), 216-223. https://doi.org/10.3382/ps/pey125.