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Performance And Disease Outcomes In Arbor Acre Broilers And Two Nigerian Indigenous Chicken Genotypes Experimentally Challenged With Eimeria Tenella

Agishi, G., Oladele, S.B., Jatau, I.D. And Samson, J.E
Department Of Veterinary Pathology, Federal University Of Agriculture, Zuru
Department Of Veterinary Pathology, Ahmadu Bello University, Zaria
Department Of Veterinary Parasitology And Entomology, Ahmadu Bello University, Zaria

Abstract
Background: *Coccidiosis caused by Eimeria tenella is a major constraint to poultry production, with disease severity influenced by host genetic background. This study evaluated performance and disease outcomes in Arbor Acre broilers and two Nigerian indigenous chicken genotypes (Frizzle-feathered and Normal-feathered) experimentally challenged with E. tenella.*
Materials and Methods: Ninety (90) day-old chicks comprising Arbor Acre broilers (AA), Frizzle-feathered (FF), and Normal-feathered (NF) indigenous chickens (n=30 per genotype) were reared under controlled conditions and confirmed coccidia-free at 19 days of age. Birds were divided into six groups: three infected AA, FF, and NF (T1, T2, and T3 – n=15 each respectively) and three uninfected controls, AA, FF, and NF (C1, C2, and C3 – n=15 each respectively). On day 21, treatment groups received 40,000 sporulated E. tenella oocysts per bird orally, and clinical signs, mortality, body weight gain (BWG), feed conversion ratio (FCR), and faecal oocyst output were assessed post-infection.
Results: *Infected birds exhibited typical signs of caecal coccidiosis, including depression, reduced feed intake, bloody diarrhoea, and mortality, whereas control birds remained clinically normal. Mortality rate differed among genotypes, with Arbor Acre broilers recording the highest mortality (40%), followed by Normal-feathered (26.67%) and Frizzle-feathered chickens (20%). Faecal oocyst shedding was significantly highest ($p<0.05$) in Normal-feathered chickens, intermediate in Frizzle-feathered chickens, and lowest in Arbor Acre broilers. All infected groups showed reduced BWG and increased FCR compared with their respective controls; however, Arbor Acre broilers maintained significantly higher BWG at all post-infection time points, while indigenous chickens exhibited markedly poorer feed efficiency during peak infection.*
Conclusion: *These findings demonstrate pronounced genotype-dependent differences in susceptibility, parasite replication, and performance loss following E. tenella challenge. The relatively lower mortality observed in indigenous chickens particularly the Frizzle-feathered genotype, despite higher oocyst output, suggests greater tolerance to coccidiosis, highlighting the potential value of indigenous genetic resources for improving disease resilience in poultry production systems.*
Keywords: *Coccidiosis; Eimeria tenella; genotype differences; indigenous chickens; disease tolerance; performance indices*

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I. Introduction

Coccidiosis is one of the most significant enteric diseases of poultry worldwide, caused by intracellular protozoan parasites of the genus *Eimeria* (Atree *et al*., 2021). Among the recognized species in chickens, *Eimeria tenella* is highly pathogenic, producing severe lesions in the caeca, such as haemorrhagic typhlitis and ulceration of the caecal mucosa leading to impaired nutrient absorption, and substantial reductions in growth and feed efficiency (Jatau *et al*., 2014; Biallah *et al*., 2022). In commercial broiler production, *E. tenella* infection has been consistently associated with decreased body weight gain, increased feed conversion ratio (FCR), and elevated mortality (Lopez-Osorio *et al*., 2020), making it a major economic constraint, particularly in intensive systems (Blake and Tomley, 2014).

In Nigeria, coccidiosis is endemic, with *E. tenella* frequently detected in commercial and indigenous flocks under both intensive and free-range management (Mohammed and Sunday, 2015; Agishi *et al*., 2016). The combination of high environmental oocyst survival and variable management practices contributes to continual

exposure in smallholder and commercial poultry enterprises (Adang and Isah, 2016). Although anticoccidial drugs and vaccines are widely used, challenges such as drug resistance, suboptimal vaccination coverage, and genotype-specific differences in disease expression complicate control efforts (Chapman *et al*., 2016; Gao *et al*., 2024).

Several research have recognized genotype as an important determinant of disease outcomes in poultry (Ngongeh *et al*., 2017; Adenaike *et al*., 2016; Oguntade *et al*., 2024). Commercial broilers, such as the Arbor Acre strain, have been intensively selected for rapid growth and high feed efficiency, and selection for these traits may have a negative impact on immune responsiveness or tolerance to enteric pathogens (Sakkasa *et al*., 2018; Zerjal *et al*., 2021). In contrast, indigenous chicken genotypes including frizzle-feathered and normal-feathered Nigerian chickens are often considered more resilient to locally prevalent diseases due to long-term adaptation to low-input environments, although empirical evidence supporting enhanced tolerance to coccidial infection remains limited and sometimes contradictory (Musa *et al*., 2008; Chniter *et al*., 2016).

Comparative studies that evaluate performance indices (feed intake, FCR, body weight gain), mortality, and faecal oocyst output across genetically distinct chicken types can provide valuable insights into resistance or tolerance mechanisms and productivity costs associated with coccidiosis. Such data are especially relevant for regions where integrating indigenous genetic resources into commercial or semi-intensive production systems may enhance resilience to endemic diseases.

The present study aimed to compare performance and disease outcomes in Arbor Acre broilers and two Nigerian indigenous chicken genotypes experimentally challenged with *E. tenella*. By quantifying genotype-specific differences in performance traits, mortality, and oocyst shedding, this research provides evidence that may inform breeding strategies and coccidiosis control programs in diverse poultry production systems.

II. Materials And Methods

Ethical approval

Ethical approval was granted for this study by the Ahmadu Bello University Committee on Animal Use and Care (ABUCAUC), with approval number ABUCAUC/2024/025.

Location of the study

The study was conducted at the Poultry Research Pen of the Veterinary Teaching Hospital, Ahmadu Bello University, Zaria.

Source of *Eimeria tenella* used for the experimental study

Eimeria tenella, previously isolated and characterized by Jatau *et al*. (2016) was obtained from the Department of Veterinary Parasitology and Entomology Laboratory, ABU Zaria, Nigeria.

Experimental chickens

Unsexed day-old chicks (DOCs) of two (2) genotypes of Nigerian indigenous chickens (Frizzle feathered [FF] and Normal feathered [NF]) and one (1) exotic breed of broiler (Arbor Acre [AA]) were obtained from the breeder stock of NF and FF indigenous chickens in the Poultry Breeding Unit of the Directorate Farm, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria and a reputable hatchery in Nigeria (CHI Hatchery, Ibadan) respectively.

The pens were cleaned, washed with detergent and water, and disinfected 7 days before the arrival of the birds. Coccidiostat-free and drug-free starter feed (ME = 2,926.38 kcal/kg, CP = 21.16%) was composed, milled, and fed to the birds *ad libitum*. Clean borehole water (coccidiostat-free and drug-free) was also administered *ad libitum*. The chicks were brooded for 19 days, screened, and confirmed negative for *E. tenella* oocysts and transferred to well-disinfected deep litter pens measuring 2m x 2m each.

Experimental design

A total of 90 chicks (Arbor Acre [AA], Frizzle-feathered [FF], and Normal-feathered [NF] – n=30 each) were obtained for the experiment. Six (6) groups; 3 control groups – C1, C2, and C3 (n=15 each) consisting of AA, FF, and NF, respectively, and 3 treatment groups – T1, T2, and T3 (n=15 each) consisting of AA, FF, and NF, respectively, were designed for the experiment. Each bird in all groups was wing-tagged for proper identification and data collection. At the third week of age (day 21, day 0 post-infection [pi]), each bird in the treatment groups was inoculated orally with 1ml of solution containing 40,000 sporulated *E. tenella* oocysts using gavage. Birds of the control group were not infected. The experiment was terminated at day 10 pi (Day 31 of the experiment).

Clinical signs and determination of mortality rate

Clinical signs were observed and recorded daily. Mortality rate was determined in the various groups by dividing the number of dead chickens by the number of initial chickens at the time of challenge, multiplied by one hundred (Wang *et al*., 2020).

Determination of faecal oocyst counts

Fresh faecal samples were collected on day 0 pi, days 5, 7, and 10 pi from the litter of each group. The faecal samples were collected, placed in polythene bags, labelled, and taken to the Veterinary Parasitology laboratory, Ahmadu Bello University, Zaria, for immediate processing. The faecal samples were examined for the presence of *E. tenella* oocysts using the McMaster technique as described by Zajac and Conboy (2012) to obtain the number of oocysts per gram (OPG) in faeces.

Determination of body weight gain and feed conversion ratio

The birds were weighed individually in each group, using a weighing balance on days 0, 5, 7, and 10 pi (days 21, 26, 28, and 31 respectively). These values were used to determine the mean (±SEM) body weight gain (BWG) of each group by subtracting the body weight of the birds at day 0 pi from the body weight of the birds on days 5, 7, and 10 pi.

The Feed conversion ratio was calculated by dividing the total weight of feed consumed (g) by the BWG (g). Feed consumption was assessed based on daily feed intake (DFI) of birds per group from days 0-5, 0-7, and 0-10 pi by subtracting the quantity of feed left from the quantity of feed offered per day (Ayssiwede *et al*., 2011).

Thus:

- FCR at day 5 pi = Total feed consumed from day 0-5 pi / BWG at day 5 pi
- FCR at day 7 pi = Total feed consumed from day 0-7 pi / BWG at day 7 pi
- FCR at day 10 pi = Total feed consumed from day 0-10 pi / BWG at day 10 pi

III. Result

Clinical signs and mortality rate

The clinical signs of coccidiosis observed in birds of all the groups inoculated with *E. tenella* oocysts (groups T1, T2, and T3) included depression, dullness, somnolence, reduced feed intake, bloody-watery diarrhoea, emaciation, and death. No clinical signs were observed in birds of the control groups (C1, C2, and C3).

No mortalities due to coccidiosis were observed in the control groups. Among the infected groups, 40%, 26.67%, and 20% mortality rates were observed in groups T1, T3, and T2, respectively (Table 1).

Table 1: Mortality rates for Arbor acre, Frizzle feathered, and Normal feathered chickens infected with *E. tenella* and their controls

Group	Number of mortalities					Total mortality	Population	Mortality rate (%)
	0-4 dpi	5 dpi	6 dpi	7 dpi	8-10 dpi			
C1	0	0	0	0	0	0	15	0
C2	0	0	0	0	0	0	15	0
C3	0	0	0	0	0	0	15	0
T1	0	5	1	0	0	6	15	40
T2	0	3	0	0	0	3	15	20
T3	0	3	0	1	0	4	15	26.67

dpi – days post-infection

C1 – Arbor acre control; C2 – Frizzle feathered control; C3 – Normal feathered control; T1 –Arbor acre infected; T2 – Frizzle feathered infected; T3 – Normal feathered infected

Faecal oocyst counts

The mean (± SEM) of the total oocysts shed in faeces from day 5 to day 10 pi was highest ($p<0.05$) in group T3 (824,270±790), followed by group T2 (337,330±4790), which was significantly higher ($p<0.05$) than that of group T1 (120,290±2030) (Table 2).

Table 2: Mean (± SEM) faecal oocyst counts for Arbor acre, Frizzle feathered, and Normal feathered chickens infected with *E. tenella*

Group	Faecal oocyst count (per gram)

	5 dpi	7 dpi	10 dpi	Total
T1	0[c]	119,770±2030[b]	520±72[c]	120,290±2030[c]
T2	1,850±90[b]	42,480±2880[c]	292,810±1810[a]	337,140±1160[b]
T3	111,620±80[a]	707,990±350[a]	2,740±80[b]	822,350±190[a]

Values with different superscript alphabet along the same column are statistically significant ($p<0.05$)
T1 – Arbor acre infected; T2 – Frizzle feathered infected; T3 – Normal feathered infected

Body Weight Gain

At days 5, 7, and 10 pi, the mean (± SEM) body weight gains (BWG) of birds in the infected groups (T1, T2, and T3) were lower than the mean BWG of birds in their respective control groups (C1, C2, and C3) (Table 3).

At day 5 pi, group T1 (167.42±17.77g) had the highest ($p<0.05$) mean (± SEM) BWG, followed by T2 (55.95±3.97g), which was not significantly ($p>0.05$) higher than T3 (40.25±6.32g) (Table 3). At day 7 pi, group T1 (179.00±52.01g) had the highest ($p<0.05$) mean (± SEM) BWG, followed by group T3 (15.50±10.23g), which was not significantly ($p>0.05$) higher than group T2 (1.93±4.81g) (Table 3). At day 10 pi, group T1 (493±0.00g) had the highest ($p<0.05$) mean (± SEM) BWG, followed by group T2 (24.22±15.53g), which was not significantly ($p>0.05$) higher than group T3 (23.57±27.13g) (Table 3).

Feed Conversion Ratio

At days 5, 7, and 10 pi, the mean (± SEM) feed conversion ratios (FCR) of birds in the infected groups (T1, T2, and T3) were higher than the mean (± SEM) FCR of birds in their respective control groups (C1, C2, and C3) (Table 3).

At day 5 pi, there were no significant differences ($p>0.05$) in the mean (± SEM) FCR among the infected groups (T1, T2, and T3) (Table 3). However, at day 7 pi, group T2 (24.25±11.09) had the highest ($p<0.05$) mean (± SEM) FCR, followed by group T3 (10.87±4.54), which was not significantly ($p>0.05$) higher than group T1 (4.07±1.67) (Table 3). At day 10 pi, group T3 (11.66±6.98) had the highest ($p<0.05$) mean (± SEM) FCR, followed by group T2 (8.06±4.52), which was not significantly ($p>0.05$) higher than group T1 (1.87±0.00) (Table 3).

Table 3: Mean (±SEM) body weight gain, feed consumption ratio and feed conversion ratio (FCR) of Arbor acre, Frizzle feathered, and Normal feathered chickens experimentally infected with *E. tenella* and their controls at 5, 7, and 10 days post-infection.

Group	**Parameters**				
	Initial weight (g) W_0	Final weight (g) W_5	Weight gain (g)	Feed consumed (g)	FCR
5 dpi					
C1	648.31±32.06[a]	933.69±39.10[a]	285.39±9.66[a]	478.00±0.00	1.70±0.05
C2	249.8±26.50[b]	327.30±31.69[c]	77.50±6.75[c]	214.40±0.00	2.93±0.22
C3	243.5±8.38[b]	327.5±11.34[c]	84.00±6.33[c]	205.15±0.00	3.51±1.03
T1	623.5±44.18[a]	790.92±49.36[b]	167.42±17.77[b]	410.42±0.00	2.85±0.41
T2	210.4±6.55[b]	246.35±8.70[c]	55.95±3.97[cd]	137.95±0.00	5.01±0.63
T3	253.05±8.48[b]	293.30±10.86[c]	40.25±6.32[d]	164.85±0.00	4.91±0.70
	Initial weight (g) W_0	Final weight (g) W_7	Weight gain (g)	Feed consumed (g)	FCR
7 dpi					
C1	657.10±40.36[a]	1,061.90±53.45[a]	404.80±15.97[a]	719.10±0.00	1.80±0.07[b]
C2	238.88±27.04[b]	338.25±34.67[c]	99.38±8.71[c]	299.65±0.00	3.17±0.25[b]
C3	241.73±10.63[b]	346.33±15.12[c]	104.60±9.37[c]	294.02±0.00	3.37±0.53[b]
T1	605.33±51.95[a]	784.33±79.50[b]	179.00±52.01[b]	555.42±0.00	4.07±1.67[b]
T2	209.86±9.00[b]	211.79±9.45[d]	1.93±4.81[d]	146.95±0.00	24.25±11.09[a]
T3	252.75±12.82[b]	268.25±17.43[cd]	15.50±10.23[d]	189.85±0.00	10.87±4.54[b]
	Initial weight (g) W_0	Final weight (g) W_{10}	Weight gain (g)	Feed consumed (g)	FCR
10 dpi					
C1	653.86±54.81[a]	1,227.14±82.26[a]	573.29±39.23[a]	1039.81±0.00	1.86±0.01[c]
C2	250±42.30[b]	400.40±57.40[b]	150.4±16.20[b]	417.25±0.00	2.92±0.34[bc]
C3	231±12.00[b]	345.4±19.05[b]	114.40±16.30[bd]	362.72±0.00	4.59±1.37[bc]
T1	702±0.00[a]	1,195±0.00[a]	493.00±0.00[a]	920.42±0.00	1.87±0.00[bc]
T2	207.89±10.00[b]	232.11±16.66[b]	24.22±15.53[c]	210.17±0.00	8.06±4.52[ab]
T3	261±20.51[b]	284.57±40.53[b]	23.57±27.13[dc]	260.42±0.00	11.66±6.98[a]

Values with different superscript alphabets within the same column are statistically significant ($p<0.05$)
C1 – Arbor acre control; C2 – Frizzle feathered control; C3 – Normal feathered control; T1 – Arbor acre infected; T2 – Frizzle feathered infected; T3 – Normal feathered infected
dpi – days post-infection; W_0 – weight at 0 dpi; W_7 – weight at 7 dpi; W_{10} – weight at 10 dpi

IV. Discussion

The present study demonstrated clear genotype-dependent differences in mortality, parasite replication, and performance outcomes following *E. tenella* challenge in Arbor Acre broilers and two Nigerian indigenous chicken genotypes. As expected for caecal coccidiosis, infected birds developed classical signs including depression, bloody diarrhoea, reduced feed intake, and somnolence, consistent with descriptions in recent experimental studies (Hambesha *et al*., 2023; Oguntade *et al*., 2024). No clinical signs or mortality occurred in the uninfected controls, confirming that observed morbidity was attributable to the *E. tenella* challenge.

Mortality varied widely among genotypes, with Arbor Acre broilers (T1) experiencing the highest mortality (40%), followed by normal-feathered indigenous birds (T3; 26.67%) and frizzle-feathered birds (T2; 20%). These findings support the notion that intensive selection for rapid growth in commercial broilers may compromise their ability to cope with enteric pathogens and inflammatory stressors (Rauw, 2012; Sakkasa *et al*., 2018). Indigenous chickens, which are traditionally raised in low-input environments, exhibited lower mortality, aligning with reports of enhanced resilience in African local breeds under infectious and environmental stress (Pinard van der Laan *et al*., 2009; Ngongeh *et al*., 2017). The particularly low mortality in the frizzle-feathered genotype suggests a potential advantage in disease tolerance, although the immunological, metabolic, or microbiota-associated mechanisms require further investigation.

Mean total faecal oocyst counts differed significantly among infected groups, with T3 (normal-feathered) shedding the highest number of oocysts, followed by T2 (frizzle-feathered), and with T1 (Arbor Acre) shedding the least. High oocyst output in T3 suggests greater parasite replication and lower resistance, consistent with the concept that resistance is defined by the host's ability to limit pathogen burden (Swaggerty *et al*., 2015; Boulton *et al*., 2018). In contrast, Arbor Acre broilers exhibited substantially lower oocyst shedding yet suffered the greatest mortality and performance losses. This pattern is characteristic of a low-tolerance phenotype, in which birds suppress parasite replication but fail to maintain physiological function during infection (Bishop and Wooliams 2014). On the other hand, the frizzle-feathered genotype displayed moderate oocyst output but relatively low mortality, consistent with higher tolerance, in line with recent discussions of trade-offs between resistance and tolerance traits in poultry (Zerjal *et al*., 2021).

Across all infected groups, *E. tenella* challenge significantly reduced body weight gain, as expected from the mucosal damage, haemorrhage, and nutrient malabsorption associated with caecal coccidiosis (Sun *et al*., 2024). However, strong genotype differences were evident. Arbor Acre broilers maintained the highest BWG at all time points, despite the high mortality and clinical severity. This reflects their strong baseline growth potential, consistent with observations that broilers continue to grow rapidly even under enteric stress, although at substantial metabolic cost (Zerjal *et al*., 2021). By contrast, both indigenous genotypes exhibited severely reduced BWG at days 5, 7, and 10 pi, indicating a more pronounced suppression of growth during infection.

Feed conversion ratio (FCR) followed a similar pattern. Although all infected birds showed worsened feed efficiency, the indigenous genotypes, especially T2 and T3, exhibited extremely high FCR values during peak infection. Poor feed efficiency has been linked to reduced intake, diarrhoea-associated nutrient loss, and impaired intestinal absorption during *E. tenella* infection (Gao *et al*., 2024). The frizzle-feathered (T2) and normal-feathered (T3) genotypes demonstrated markedly inefficient feed conversion at days 7 and 10 pi, consistent with their low weight gains. Arbor Acre broilers again performed better in terms of feed conversion, having substantially lower FCR values, however, this advantage must be interpreted cautiously given their high mortality and clinical vulnerability.

These findings support the concept that genetic selection for rapid growth may come at the expense of immune function and disease coping capacity (Zerjal *et al*., 2021). Meanwhile, indigenous breeds may not always exhibit strong resistance (as seen in T3) but may maintain better survival (as seen in T2), which is a hallmark of tolerance described in recent coccidiosis immunobiology literature (Boulton *et al*., 2018).

V. Conclusion

The results highlight substantial genotype-dependent differences in disease outcomes, parasite shedding, and performance under *E. tenella* challenge. The frizzle-feathered genotype appears the most resilient overall, combining relatively low mortality with moderate oocyst shedding, while Arbor Acre broilers show vulnerability despite their superior inherent growth potential. These findings have important implications for poultry breeding strategies in regions where coccidiosis is endemic and underscore the value of indigenous genetic resources in developing resilient poultry populations.

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