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Assessing the Efficiency of Different Coccidiostats against *Eimeria* spp. in Broiler Chickens Grown in the Floor Pen System

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ABSTRACT

Coccidiosis is a critical parasitic disease that affects poultry through severe impairment in growth and yield. The present study aimed to evaluate the efficacy of combined coccidiostats in broiler chickens reared in floor pen systems. A total of 1200 Cobb500 broiler chickens were divided into five treatment groups, each group consisting of eight replications, which were based on different coccidiostats, including Treatment 1 (Control), Treatment 2 (Maduramicin-Nicarbazin), Treatment 3 (Narasin-Nicarbazin), Treatment 4 (Semduramicin-Nicarbazin), and Treatment 5 (Monensin-Nicarbazin). Performance parameters were recorded on days 7, 14, 21, 28, and 33. Treatment 3 exhibited the lowest feed consumption per chicken (2.797 kg), followed by Treatment 5 (2.825 kg) and Treatment 2 (2.835 kg). The control group consumed the highest amount of feed (2.880 kg), followed by Treatment 4 (2.888 kg). During week five, Treatment 5 demonstrated the highest body weight gain (1915 g), whereas Treatment 2 showed the lowest (1808 g). The lowest feed conversion ratio (FCR) was observed in Treatment 5 (1.500), followed by Treatment 3 (1.504), Treatment 4 (1.547), Treatment 2 (1.571), and the control group (1.576). However, the maximum intestinal lesion scores were noted in the control group, compared to the experimental groups observed on the culling day. Treatment 5 indicated the lowest lesion scores, followed by treatments 3, 4, and 2. Among the observed species, *Eimeria (E.) tenella* exhibited the highest lesion scores compared to *E. maxima* and *E. acervulina* in all the groups. Therefore, the effective use of these coccidiostats is crucial for preventing and managing coccidiosis outbreaks in poultry.

Keywords: Broiler chicken, *Eimeria*, Feed conversion ratio, Floor pen system, Monensin, Narasin

INTRODUCTION

Poultry meat holds significant global importance as a major source of nutrition, with an annual production of approximately 120 billion tons, predicted to double by 2050 (Alexandratos and Bruinsma, 2012). Poultry meat accounts for 78% of the total meat demand in Bangladesh and is highly regarded for its nutritional benefits (Rony et al., 2021). Despite the expansion of commercial poultry farming in Bangladesh, the poultry industry faces significant challenges, notably from diseases such as coccidiosis and Newcastle disease (ND), which severely impact productivity (Datta et al., 2025). Moreover, ND remains endemic in the country and further hampers production (Hossain et al., 2023). However, coccidiosis remains a critical parasitic disease affecting poultry worldwide. Globally, coccidiosis leads to an estimated annual economic loss of three billion dollars (Dalloul and Lillehoj, 2006; Noack et al., 2019), primarily affecting weight gain and feed efficiency of chickens, which collectively account for approximately 70% of production costs in poultry farming. Coccidiosis is a major threat to commercial broiler farms in Bangladesh, causing considerable financial losses due to mortality, retarded growth, and the prevention and treatment costs (Quiroz-Castañeda, 2018).

Protozoan parasites of the genus *Eimeria (E.)* are responsible for the disease, which affects the intestinal tract and is commonly found across different poultry

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species, particularly in chickens (Aarthi et al., 2010). Seven *Eimeria* spp., identified as *E. tenella, E. acervulina, E. maxima, E. necatrix, E. brunetti, E. mitis*, and *E. praecox*, infect poultry (Shirley et al., 1986). Among the *Eimeria* spp., *E. tenella, E. acervulina*, and *E. necatrix* are particularly problematic in Bangladesh (Iqbal et al., 2017; Alam et al., 2020). Avian coccidiosis is a highly infectious disease that can spread easily through insects, litter, apparatus, contaminated feed, and water. The disease is characterized by bloody diarrhea, enteritis, drooping wings, emaciation, and retarded growth (Abebe and Gugsa, 2018). Coccidiosis exhibited an average occurrence of 22.8% in the poultry industry, resulting in substantial economic losses in commercial poultry industries in Bangladesh (Rahman et al., 2019). The inadequate biosecurity and management practices have led to a very high prevalence of coccidiosis in many farms in Bangladesh (Datta et al., 2025). Being a tropical country, Bangladesh experiences a significant seasonal fluctuation in humidity and temperature, which accelerates the sporulation of *Eimeria* spp. Proper therapeutic measures are essential in controlling the disease as well as maintaining sustainable poultry production in the country. Biosecurity, sanitation protocols, and proper drug usage are crucial for sustainable poultry production in tropical environments (Chapman, 2018). The use of different coccidiostats, either separately or in combination, proves to be a successful substitute in the battle against coccidiosis (Quiroz-Castañeda and Dantán-González, 2015). Coccidiostats are divided into two main categories: chemical compounds and ionophores. Ionophores are commonly used as coccidiostats in poultry feed because they lead to slower development of resistance and can help enhance the host's immunity (Noack et al., 2019). However, prolonged use of coccidiostats triggers the emergence of drug-resistant strains, underscoring the need for effective control strategies (Hayajneh et al., 2024).

Gazipur is indeed a significant hub for poultry production in Bangladesh, especially for broiler chickens (Kamruzzaman et al., 2000), which not only supports local livelihoods but also meets the growing demand for poultry meat in urban areas. This industry contributes to the national economy and plays a vital role in food security for the country. Gazipur exhibits a wide tropical humid climate, seasonal variations in rainfall, high temperature, and high humidity, which are favorable for the survival and development of *Eimeria* spp. (Rony et al., 2021). As a result, thousands of birds die from severe coccidiosis every year, largely due to the indiscriminate use of coccidiostats by farmers (Martins et al., 2022). This indiscriminate use of coccidiostats contributes to the growing issue of drug resistance, making it immensely difficult to control outbreaks of coccidiosis. Therefore, the present study aimed to investigate the efficacy of four different combined coccidiostats against *Eimeria* spp. in broiler chickens.

MATERIALS AND METHODS

Ethical approval

All animal studies followed the ethical standards set by the Faculty of Animal Science and Veterinary Medicine, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh.

Study area

The current study was conducted at the Nourish Poultry and Hatchery Limited trial farm situated in Shreepur Upazila of Gazipur District, Bangladesh (24° 11' 60.00" N and 90° 28' 0.12" E) from April 2020 to May 2020.

Experimental design

A total of 1,200 day-old Cobb500 broiler chickens, being of mixed sex and having an average body weight of 38 g, were sourced from Nourish Hatchery, Bangladesh. The broiler chickens were reared in a floor pen system and maintained under standard nutrition and management practices of Cobb500 management guidelines until they reached 33 days of age (Hassan et al., 2016). The feeding program included pre-starter feed for the first 10 days, followed by starter feed from days 11 to 21, and concluded with grower rations (Toledo et al., 2011). The water and feed were supplied *ad libitum*. The feed ingredients included corn, soybean meal, rice bran, soybean oil, mono calcium phosphate (MCP), limestone powder, sodium bicarbonate, choline chloride, salt, vitamin and trace mineral premix, amino acids, and various feed additives (Table 1). The room temperature varied from 30°C to 34°C during the first week, gradually decreasing by the fourteenth day (Akter et al., 2023). Continuous lighting for twenty-four hours was provided for the entire period of the experiment. Vaccination was performed for ND (Nobilis® ND Clone 30, Germany) on days 5 and 25 through the intraocular route, and for Infectious bursal disease (IBD; Nobilis® Gumboro 228E, USA) on days 11 and 18 of age via drinking water. Since ND is endemic in Bangladesh (Hossain et al., 2023), and hatchery vaccination is not practiced, live ND vaccination is commonly used as a preventive measure on day five. Chlorinated water was provided, but no medications such as supplements or antibiotics were administered during the rearing period. No chickens were intentionally challenged with *Eimeria* spp., and no preventive measures were taken for coccidiosis, except for using coccidiostats in feed.

Table 1. Feed ingredients used in the pre-starter, starter, and grower rations for broiler chickens from day 1 to 33

Feed ingredients	Pre-starter (kg)	Starter (kg)	Grower (kg)
Maize	510	523	524.5
Soyabean meal 46%	350	318	296
Full Fat soya 34%	55	65	75
Rice polish	30	40	50
Soyabean oil	12	18	22
Limestone powder 37%	13	10	10
Salt	1.8	2.1	2.2
Sodium bi carbonate	3.5	3.2	3.3
MCP	10	8	6
DL Methionine	3.7	3.2	2.5
L Lysine	2.8	1.8	1.3
L Threonine	1.4	1	0.6
Vitamin premix	1	1	1
Mineral premix	0.5	0.5	0.5
Choline chloride 60%	0.8	0.7	0.6
Toxin binder	1	1	1
Coccidiostat	0.5	0.5	0.5
Probiotic	0.4	0.4	0.4
Prebiotic	0.5	0.5	0.5
Xylanase enzyme	0.1	0.1	0.1
Protease enzyme	0.2	0.2	0.2
Phytase enzyme	0.1	0.1	0.1
Emulsifier	0.5	0.5	0.5
Antioxidant	0.2	0.2	0.2
Betaine anhydrous	1	1	1
Total	1000	1000	1000
ME (Kcal/kg)	2952.60	3029.67	3075.25

MCP: Mono calcium phosphate, DL methionine: DL-2-amino-4-(methylthio) butanoic acid, ME: Metabolized energy

Coccidiostats

Since Nicarbazin was used in combination with other coccidiostats, four commercially available combined coccidiostats were used, including the Maduramicin-treated group (Treatment 2, Maduramicin 0.75 ppm + Nicarbazin 8 ppm; Nimax®, Huvepharma, Bulgaria), the Narasin-treated group (Treatment 3, Narasin 8 ppm + Nicarbazin 8 ppm; Maxiban®, Elancho, USA), the Semduramicin-treated group (Treatment 4, Semduramicin 3 ppm + Nicarbazin 8 ppm; Aviax® Plus, Phibrio, Brazil), the Monensin-treated group (Treatment 5, Monensin 8 ppm + Nicarbazin 8 ppm; Monimax®, Huvepharma, Bulgaria), and the Control group (Treatment 1, no coccidiostat was used). These coccidiostats were provided to the broiler chickens from day 1 to day 33 through the feed.

Trial design

The entire shed was divided into 40 pens, each fenced by iron netting. Thirty chickens were placed in each pen (36 sq ft). The five treatments were randomly assigned to eight pens throughout the shed. Chicken groups were assigned by treatment doses (Table 2).

Data collection

Data regarding mortality rates (%), body weight (g), feed consumption (kg), feed conversion ratio (FCR), and intestinal lesion scores were collected at different intervals on days 7, 14, 21, and 28 from all five groups. To assess body weight gain, eight chickens were measured weekly using a standard weight scale. Ten percent of chickens (Three) from each pen were weighed weekly, with all chickens being weighed on day 33.

Moreover, weekly FCR per pen was calculated and averaged for each group. The FCR was calculated by dividing the total feed intake by the live weight of the chickens (Mwale et. al., 2008). Ten chickens per group were sacrificed randomly for post-mortem examination on day 28. Then, the intestinal lesion scores were evaluated using the methods provided by Johnson and Reid (1970) and Kang et al. (2019).

Table 2. Experimental group of broiler chickens with treatment dosage for coccidiosis control

Groups	Coccidiostats	Doses	Duration
Treatment 1	Control/Without coccidiostat		1-33 days
Treatment 2	Maduramicin 0.75 ppm + Nicarbazin 8 ppm	500 g/MT	1-33 days
Treatment 3	Narasin 8 ppm + Nicarbazin 8 ppm	500 g/MT	1-33 days
Treatment 4	Semduramicin 3 ppm + Nicarbazin 8 ppm	500 g/MT	1-33 days
Treatment 5	Monensin 8 ppm + Nicarbazin 8 ppm	500 g/MT	1-33 days

Statistical analysis

One-way ANOVA was used to statistically analyze the data using the statistical program for social sciences (SPSS) version 16. With a significance level of $p < 0.05$, Duncan's multiple comparison test was employed to assess differences in means.

RESULTS

Weekly feed intake

During week 5 (Day 28 to Day 33), the average weekly feed intake per chicken was 2.880 kg for the control group, 2.835 kg for Treatment 2, 2.797 kg for Treatment 3, 2.888 kg for Treatment 4, and 2.825 kg for Treatment 5. Treatment 3 recorded the lowest feed consumption (2.797 kg) per chicken, followed by Treatment 5, Treatment 2, the Control group, and Treatment 4, respectively (Table 3), all of which were found statistically significant ($p < 0.05$).

Body weight gain

At week 5 (Day 28 to 33), the average body weight of broiler chickens treated with Treatment 5 documented the highest body weight gain (1915 g), followed by Treatment 3 (1883 g), Treatment 4 (1832 g), and Treatment 2 (1808 g) (Table 4). The differences in body weight gain across the treatment groups were statistically significant ($p < 0.05$).

Food conversion ratio

Treatment 5 demonstrated the lowest FCR (1.500), followed by Treatment 3 (1.504), Treatment 4 (1.547), Treatment 2 (1.571), and the control group (1.576) at the culling week for broiler chickens, which were statistically significant ($p < 0.05$). In this study, flocks raised on feed without coccidiostats showed a greater FCR compared to those raised on feed containing anticoccidials (Table 5).

Lesion score

On day 28, ten chickens from each dietary group were subjected to post-mortem examination to assess lesion scores (Figure 1; Johnson and Reid, 1970; Kang et al., 2019). In Treatment 5, *E. acervulina*, *E. tenella*, and *E. maxima* had lesion scores of 1, 3, and 4, respectively. For *E. acervulina*, *E. tenella*, and *E. maxima*, Treatment 3 had lesion scores of 1, 7, and 5, respectively. For the same species, Treatment 4 demonstrated lesion scores of 2, 6, and 9, whereas Treatment 2 had lesion scores of 2, 11, and 13, respectively. For these species, non-treated broiler chickens exhibited lesion scores of 4, 15, and 13, respectively. However, the highest lesion scores (4, 15, and 13) were recorded in the non-treated group, while the lowest scores (1, 3, and 4) were seen in broilers subjected to Treatment 5, followed by Treatments 2, 3, and 4. The lesion scores of *E. tenella* were higher than those of *E. maxima* and *E. acervulina* (Table 6).

Table 3. Feeding performance according to weekly feed intake per broiler chicken from day 1 to 33

Feed	Total flock	Week 1 (Kg)	Week 2 (Kg)	Week 3 (Kg)	Week 4 (Kg)	Week 5 (Kg)	p-value
Treatment 1 (Control group)	Cobb500 (30 × 8)	0.149	0.565	1.193	2.110	2.880*	
Treatment 2 (Md + Nb)	Cobb500 (30 × 8)	0.154	0.574	1.156	2.075	2.835*	
Treatment 3 (Nr + Nb)	Cobb500 (30 × 8)	0.151	0.562	1.132	2.079	2.797*	0.05
Treatment 4 (Sd + Nb)	Cobb500 (30 × 8)	0.150	0.572	1.220	2.131	2.888*	
Treatment 5 (Mn + Nb)	Cobb500 (30 × 8)	0.149	0.572	1.144	2.066	2.825*	

Md+Nb: Maduramicin + Nicarbazin, Nr+Nb: Narasin + Nicarbazin, Sd+Nb: Semduramicin + Nicarbazin, Mn+Nb: Monensin + Nicarbazin. *The values were significantly different at $p < 0.05$

Table 4. Weekly body weight gains in broiler chickens from day 1 to 33

Feed	Total flock	Week 1 (g)	Week 2 (g)	Week 3 (g)	Week 4 (g)	Week 5 (g)	p-value
Treatment 1 (Control group)	Cobb500 (30 × 8)	195	525	823	1412	1805*	
Treatment 2 (Md + Nb)	Cobb500 (30 × 8)	197	534	850	1435	1808*	
Treatment 3 (Nr + Nb)	Cobb500 (30 × 8)	201	540	864	1468	1883*	0.05
Treatment 4 (Sd + Nb)	Cobb500 (30 × 8)	199	535	862	1467	1832*	
Treatment 5 (Mn + Nb)	Cobb500 (30 × 8)	201	541	913	1517	1915*	

Md+Nb: Maduramicin + Nicarbazin, Nr+Nb: Narasin + Nicarbazin, Sd+Nb: Semduramicin + Nicarbazin, Mn+Nb: Monensin + Nicarbazin. *The values were significantly different at $p < 0.05$

Table 5. Weekly feed performance according to the feed conversion ratio in broiler chickens from day 1 to 33

Feed	Total flock	Week 1	Week 2	Week 3	Week 4	Week 5	p-value
Treatment 1 (Control group)	Cobb500 (30 × 8)	0.789	1.095	1.436	1.485	1.576*	
Treatment 2 (Md + Nb)	Cobb500 (30 × 8)	0.757	1.070	1.405	1.470	1.671*	
Treatment 3 (Nr + Nb)	Cobb500 (30 × 8)	0.751	1.052	1.311	1.408	1.504*	0.05
Treatment 4 (Sd + Nb)	Cobb500 (30 × 8)	0.756	1.060	1.327	1.417	1.547*	
Treatment 5 (Mn + Nb)	Cobb500 (30 × 8)	0.740	1.045	1.306	1.391	1.500*	

Md+Nb: Maduramicin + Nicarbazin, Nr+Nb: Narasin + Nicarbazin, Sd+Nb: Semduramicin + Nicarbazin, Mn+Nb: Monensin + Nicarbazin. *The values were significantly different at $p < 0.05$

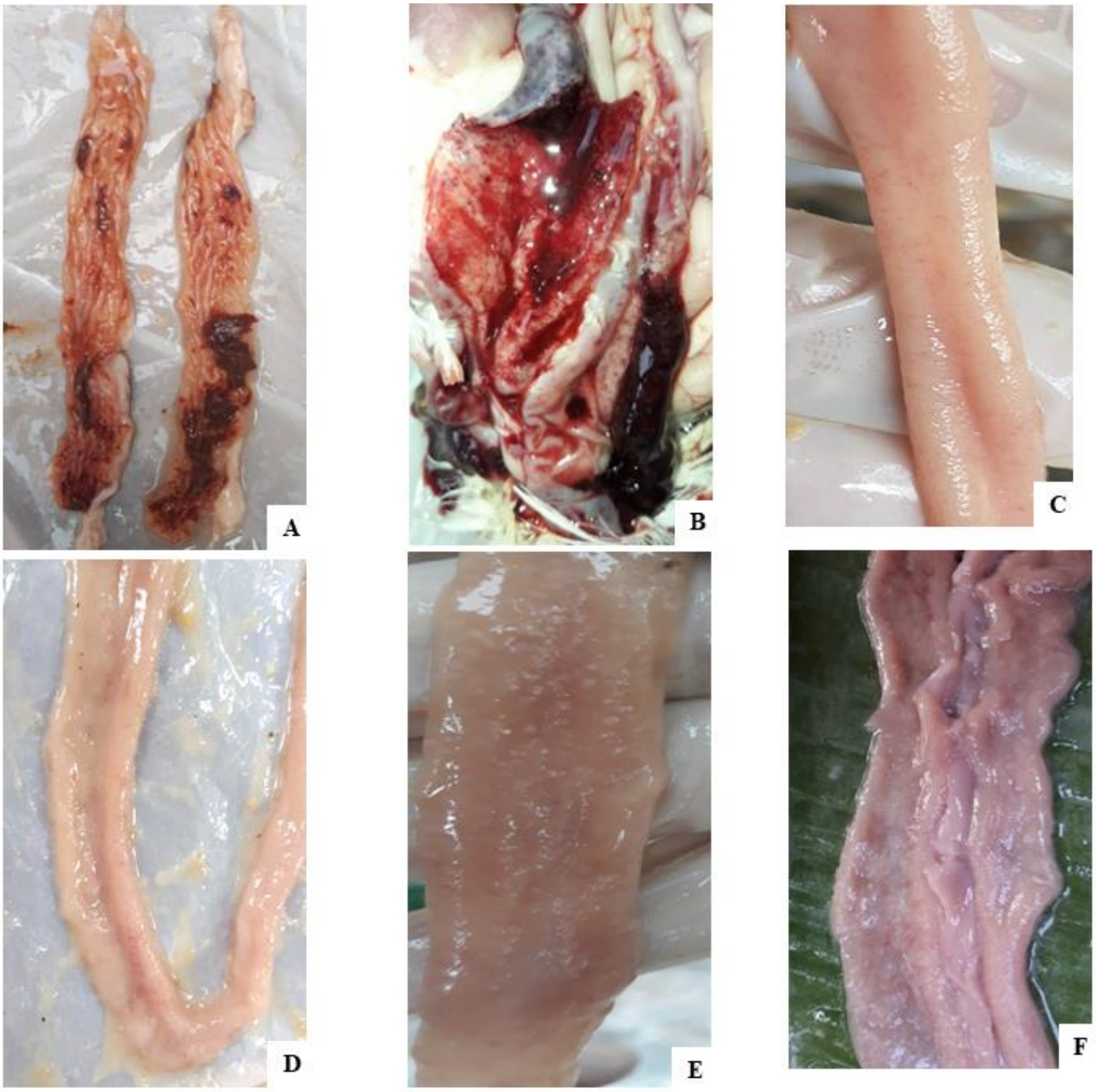

Figure 1. Post-mortem lesion score of *Eimeria* species in broiler chickens on day 28. **A** and **B**: Lesion score of *Eimeria tenella*, **C** and **D**: Lesion score of *Eimeria maxima*, **E** and **F**: Lesion score of *Eimeria acervulina*.

Table 6. Lesion score of different *Eimeria* species treated with different coccidiostats in broiler chickens on day 28

Treatment *Eimeria* spp.	Lesion score of treatment 1 (Control group)	Lesion score of Treatment 2 (Md + Nb)	Lesion score of Treatment 3 (Nr + Nb)	Lesion score of Treatment 4 (Sd + Nb)	Lesion score of Treatment 5 (Mn + Nb)
E. acervuline	4	2	1	2	1
E. maxima	13	13	5	9	4
E. tenella	15	11	7	6	3

Source of lesion score: Johnson and Reid (1970) and Kang et al. (2019). Md+Nb: Maduramicin + Nicarbazin, Nr+Nb: Narasin + Nicarbazin, Sd+Nb: Semduramicin + Nicarbazin, Mn+Nb: Monensin + Nicarbazin.

DISCUSSION

Eimeria species are responsible for causing substantial economic losses in the commercial poultry industry in Bangladesh. The reduced efficacy of anticoccidials has adverse effects on body weight gain and FCR in chickens (Abdelhady et al., 2021). The present study indicated the presence of variation in FCR, feed intake, lesion score, and body weight gain due to the use of coccidiostats in feed. Coccidiosis outbreaks can be avoided by using a proper combination of anticoccidial medicines in feed (Kabell et al., 2006). Ionophores are the most recommended treatment for coccidiosis due to their slower resistance development, enabling the host to gain immunity following initial exposure (Chapman et al., 2010). Although many coccidiostats have shown to develop resistance in the field, a field trial was conducted to test four specific combinations in broiler chicken feed: Monensin plus Nicarbazin, Narasin plus Nicarbazin, Maduramicin plus Nicarbazin, and Semduramicin plus Nicarbazin.

In the present study, the chickens treated with Narasin showed the lowest feed consumption per chicken, whereas the highest body weight gain (1915 g) was documented in the Monensin-treated group. These findings align with the observations of MacPherson (1978) and Vereecken et al. (2020), who recorded that Monensin contributes to enhancing body weight gain in broiler chickens. On the other hand, Jeffers et al. (1988) found that chickens treated with Monensin had lower body weight gain than those treated with Narasin. The difference in body weight gain might be due to the flock size of chickens, the composition of coccidiostats in feeds, geographical locations, and the feeding methods. The lowest FCR (1.500) was observed in the Monensin-treated group during the culling week, which was also supported by Vereecken et al. (2020) and MacPherson (1978), who recorded a reduced FCR in a floor pen system when Monensin was used in feed. The present study demonstrated that supplementing broiler feed with coccidiostats improved weight gain and reduced FCR compared to feed without them. The present findings aligned with those reported by Stallbaumer and Daisy (1988) in Europe (England, Netherlands, Spain, Germany, Italy) and El-Morsy et al. (2016) in Egypt.

Post-mortem examination findings in this study were based on naked-eye observations of the intestines. Chickens without coccidiostat treatment demonstrated the highest lesion scores, while the Monensin-treated group had the lowest lesion scores. The number of lesion scores in the control group was followed by the Maduramicin-treated group, the Semduramicin-treated group, and the Narasin-treated group. However, Ruff et al. (1980) found that Narasin was more effective than Monensin in reducing intestinal lesion scores in chickens. In this study, *E. tenella* showed higher lesion scores compared to *E. maxima* and *E. acervulina*, which was consistent with the findings of Amer et al. (2010). Alam et al. (2020) indicated that broiler chickens in Bangladesh commonly suffer from mixed infections of *E. tenella* and *E. acervulina*, reflecting the higher prevalence of coccidiosis due to inadequate farm management practices. The majority of anticoccidials in Bangladesh were found to be less effective in broiler production because of their overuse, abuse, or misuse, and occasionally, they are used as feed supplements for an extended period. Chickens are more susceptible to developing resistance to coccidiostats and medicines than other farm animals (Einstein et al., 1994). The combination of Monensin and Nicarbazin was used in the present study due to its slow resistance development against *Eimeria* spp., a fact supported by Vereecken et al. (2020).

In the present study, chickens were raised with different coccidiostats throughout the rearing period. However, some broiler chickens showed a lesion score of *Eimeria* spp., which was similar to that of Nematollahi et al. (2009). These lesion scores could result from resistance development or the abuse of coccidiostats (Hadipour et al., 2011). Subclinical coccidiosis, which is responsible for poor economic output, FCR, and body weight gain, is caused by drug resistance (Györke et al., 2013). Chemical coccidiostats exhibited a quick rise in resistance, whereas the opposite was true for ionophores (Noack et al., 2019).

The sole use of Nicarbazin exhibits delayed resistance development. Products containing both chemicals, coccidiostats and ionophores, develop resistance more slowly than those having merely one of the coccidiostats or ionophores due to their distinct mode of action (Chapman and Rathinam, 2022). Furthermore, Monensin and Nicarbazin have synergistic effects, and their cumulative strength is higher than the sum of the potencies of the individual components (Callender and Jeffers, 1980). Therefore, it is recommended to go through a rotational program to stop drug resistance, which is consistent with the findings of Györke et al. (2013).

CONCLUSION

Coccidiosis remains a major constraint for profitable broiler farming in Bangladesh. The widespread and prolonged use of coccidiostats has led to a global development of resistance. This is the first investigation on these coccidiostats in broilers in Bangladesh. In the present study, the Monensin-treated group (Treatment 5) recorded the highest body weight gain (1915 g), the lowest FCR (1.500), and the smallest lesion scores (1, 3, 4), whereas the Narasin-treated group (Treatment 3) documented the lowest feed intake. To minimize the incidence of resistance, the rotational approach of the coccidiostat in individual/shuttle programs could unlock a window for broiler farmers to control coccidiosis and promote sustainable poultry production. Further studies should explore the long-term impacts of rotational and integrated coccidiostat strategies, including natural alternatives, to enhance efficacy and minimize resistance development in broiler chickens.

DECLARATIONS

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Author's contributions

Mohammad Arifur Rahman and Al Wasef collected the data and samples, designed the methodology, wrote the manuscript, and edited the manuscript. Nitol Chandra Das, Md. Rubel Islam, Md. Nooralam Islam, Nurul Basar Sarker, Muhammad Abdul Mannan, and Md. Aftabuzzaman contributed to the methodology and data collection. Uday Kumar Mohanta conceptualized, supervised, and reviewed the manuscript. All authors checked and confirmed the last edition of the submitted article.

Competing interests

The authors state that they have no conflicts of interest for publication.

Availability of data and materials

The required data will be supplied by the authors upon reasonable request.

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Ethical considerations

All authors confirm that they have followed ethical guidelines, including those related to plagiarism, consent for publication, research misconduct, data falsification, duplicate submission, and redundancy.

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