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Comparative Efficacy of Coccidiostats on Growth and Feed Conversion Efficiency in Broiler Birds Experimentally Infected with *E. tenella*

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ABSTRACT

The current study was undertaken at University Poultry Farm, Anand to know the comparative efficacy of commonly used coccidiostats on oocyst index, growth and feed parameters in Cobb-400 strain of broilers. Fifty chicks T1, T2, T3 and T4 groups were given Diclazuril (0.1%), Salinomycin (12%), Diclazuril (0.1%) + Salinomycin (12%) in shuttle programme and Maduramicin (1 %) at a dose rate of 100 g, 50 g, 100 + 50 g and 50 g per 100 Kg broiler feed as coccidiostat, respectively. One group of 50 chicks will be kept as infected control (T5) and another group of 50 chicks will be kept as uninfected control (T6) without coccidiostat in feed. Oocyst Index value indicates better efficacy of T4 and T2 as compared to T1 and T3 group and T4 group showed highest body weight gain followed by T2, T1 and T3 group after experimental infection of *E. tenella* on 22nd of age. At the end of six weeks, significantly highest feed consumption was observed in T2 group followed by T4, T3 and T1 group. Over all FCR value were found lowest in T4 group followed by T1, T2, and T3. Significantly highest FCR (2.42 ± 0.01) was observed in T5 group and lowest (1.97 ± 0.51) in T6 group among all groups signifying better efficacy of Maduramicin followed by Diclazuril. This is the first time study undertaken in middle Gujarat to access the efficacy of commonly used coccidiostats in *E. tenella* infection in broiler chickens.

Keywords: Coccidiostats, diclazuril, FCR, growth, Gujarat, maduramicin, salinomycin

Eimeria tenella, is the most pathogenic and ubiquitous parasite responsible for caecal coccidiosis with high rate of mortality in poultry. The lesions caused by the parasite disturbs nutrient absorption, triggering several changes in carbohydrates, lipid, protein and mineral metabolism (Patra *et al.* 2010) resulting in reduced growth rate and poor feed conversion efficiency. This disease is one of the significant problems in poultry throughout the tropical countries (Chakrabarti, 1989). The global loss due to coccidiosis was estimated about $ 800 million (Williams, 1998) whereas Bera *et al.* (2010) appraised the total loss of ₹ 1.14 billion in Indian poultry industries during the year 2003-04. In spite of developments in immunological, biotechnological and genetical methods, still the control of coccidiosis chiefly relishes upon prophylactic chemotherapy with anticoccidial drugs. However, the emergence of drug resistance in coccidia is an emerging problem (Abbas *et al.* 2012). Middle Gujarat being the major belt of avian production and considering the problems of drug resistant, study on comparative efficacy of coccidiostats on oocyst index, growth performance and feed efficiency in broilers was being carried out by giving experimental infection of *E. tenella*.

MATERIALS AND METHODS

Feed- water management and experimental design

The present study was undertaken at University Poultry Farm to know the comparative efficacy of commonly used coccidiostats on growth and feed parameters in Cobb-400 strain of broilers reared on battery cage system with

routine standard protocols under coccidia-free conditions (Barley *et al.* 2015). Ground maize was given for first day in plastic feed dishes to broiler chicks. From second day, the experimental feed was offered. After first week of age, the feed was offered in the linear cage feeders adjusted outside of the cages up to 6 weeks of experimental period. Weighed quantity of feed was offered thrice a day i.e. at 9:00 a.m., 2:30 p.m. and 10:00 p.m. during entire experimental period. . Stirring and mixing of feeds in the feeder was done 4-5 times per day. Clean, fresh, wholesome drinking water was made available to all experimental birds throughout the experimental period. Experimental infection of 50,000 oocysts of *E. tenella* was given on 22nd day of age. Experimental work was approved by the Institutional Animal Ethics Committee (IAEC), Veterinary College, Anand having CPCSEA Registration number 486/01/A/ CPCSEA during the second meeting of the year 2011 with approval letter No. AAU/GVC/CPCSEA-IAEC/72/2011 dated 08/12/2011.

Fifty chicks of T1, T2, T3 and T4 group were given Diclazuril (0.1%), Salinomycin (12%), Diclazuril (0.1%) + Salinomycin (12%) in shuttle programme (Diclazuril was given for initial three week followed by Salinomycin in last three week) and Maduramicin (1 %) at a dose rate of 100 gm, 50 gm, 100 + 50 gm and 50 gm. per 100 Kg. broiler feed as coccidiostat, respectively. One group of 50 chicks will be kept as infected control (T5) and another group of 50 chicks will be kept as uninfected control (T6) without coccidiostat in feed. All birds were given starter feed up to 4 weeks of age and finisher feed for 5 to 6 weeks of age. Wing banding was done to keep the accurate record of each chick/ bird.

Oocyst index

Oocyst index was determined by microscopic examination of mucosal scrapings from the caeca on day 7 post infection as per the method of Hilbrich (1978) with some modification. Briefly, the caecal mucosa was scrapped onto the cover slip and the cover slip was then pressed on a microscopic slide in such a way that the mucosal material got spread underneath the whole surface area of the cover slip. Five fields of cover slip were viewed for each scraping i.e. four corners and central field and the oocysts were counted in each field. The oocyst index was graded as 0, 1, 2, 3, 4, 5 for oocysts per field as <1 oocysts, 1-10 oocysts, 11-20 oocysts, 21-50 oocysts, 51-100 oocysts and >100 oocysts, respectively.

Growth and feed parameters

Body Weight (g) at day old (BW_0) and thereafter at weekly interval i.e. at 1st (BW_1), 2nd (BW_2), 3rd (BW_3), 4th (BW_4), 5th (BW_5) and 6th (BW_6) weeks of age were recorded in the cool morning hours before feeding. Body weight gain (g) was calculated at weekly interval. Broiler birds were weighed individually at weekly interval up to six weeks of age and weekly body weight gain was calculated by subtracting the average body weight (g) of previous week from that of average weekly body weight (g) of current week and were designated as $BWG_{(0-1)}$, $BWG_{(1-2)}$, $BWG_{(2-3)}$, $BWG_{(3-4)}$, $BWG_{(4-5)}$ and $BWG_{(5-6)}$. $BWG_{(0-4)}$, $BWG_{(4-6)}$ and $BWG_{(0-6)}$ were also calculated. Weight gains of each group were compared in between different treatment group and with non-medicated non- infected control group.

The weighed quantity of feed was offered daily to birds of each replication in each group. At the end of every week, the left over feed was weighed and recorded in each replicate. Feed consumption was calculated by subtracting the left over feed from total feed offered in each week. Feed consumption during 1st, 2nd , 3rd , 4th , 5th and 6th weeks were calculated and designated as FC_1, FC_2, FC_3, FC_4, FC_5, and FC_6, respectively. Feed consumption up to 4th week, 5 to 6 week and up to 6th week of age were calculated and designated as $FC_{(0-4)}$, $FC_{(5-6)}$, and $FC_{(0-6)}$, respectively. FCR was calculated during each week (FCR_1, FCR_2, FCR_3, FCR_4, FCR_5, and FCR_6), 0-4 weeks (FCR_{0-4}), 5-6 weeks (FCR_{5-6}) and 0-6 weeks (FCR_{0-6}) and it is derived by the following formula.

FCR = Average Feed Consumption (g)/ Average Body weight Gain (g).

Statistical analysis

Data so generated during the present study were statistically analyzed as per the method of Snedecor and Cochran (1980) by using completely randomized design. Statistical Analysis System (SAS, 2000) was also used for the description statistics of the data.

RESULTS AND DISCUSSION

Comparative efficacy of coccidiostats on oocyst index

The Oocyst index was studied on seventh day post infection and the values were given in table-1. Maduramicin and Salinomycin groups have lower oocyst index as compare to Diclazuril and Diclazuril + Salinomycin Shuttle group. Result indicates better efficacy of Maduramicin and Salinomycin which is completely incorporated with the findings of Muzurkiewez *et al*. (1987), Abbas *et al*. (2008) and Georgieva *et al*. (2010). These results might attributed to effects of maduramicin on lipid peroxidation reducing oxidative stress as reported by Georgieva *et al*. (2010). Raju *et al*. (2012) found higher oocyst index in Maduramicin and Salinomycin treatment group which might be due to location and oocysts dose difference.

Table 1: Oocyst index number in different treatment group at 7 day post infection

Sl. No.	Treatment group	Index Value	0	1	2	3	4	5	Average mean
1	T1	2,0,3,4,4	1	-	1	1	2	-	2.6
2	T2	0,3,3,2,1	1	1	1	2	-	-	1.8
3	T3	2,2,3,3,4	-	-	2	2	1	-	2.8
4	T4	0,1,2,2,3	1	1	2	1	-	-	1.6
5	T5	3,4,4,4,5	-	-	-	1	3	1	4.0

Comparative efficacy of cocidiostats on body weight and body weight gain

Before experimental infection of *E. tenella* in broiler birds, body weight was significantly highest in T5 group followed by T4, T2, T6, T1 and T3, respectively indicating better efficacy of Maduramicin followed by Salinomycin, Diclazuril and Diclazuril + Salinomycin coccidiostat among coccidiostat given treatment group at three weeks of age (Table 2). After experimental infection of *E. tenella* on 22nd day of age, highest body weight was observed in T4 Maduramicin group followed by T2 Salinomycin group, T1 Diclazuril group and T3 Diclazulin + Salinomycin group at 4th week of age. T6 Negative control group birds having highest body weight among all six groups, while T5 Positive controls birds showing lowest body weight at this age. Similar trend of body weight was observed up to six week of age among four treatment groups. Highest body weight was observed in T6 negative control bird, while lowest body weight was observed in T5 positive control group at 4, 5 and 6 week of age, respectively among all six groups (Table 2).

Highest body weight was observed in Maduramicin given group followed by Salinomycin, Diclazuril and Diclazuril + Salinomycin group at 6 week of age in coccidiostat treatment groups. Among all groups, negative control group birds shown highest body weight and positive

Table 2: Weekly and overall body weight in gram (Mean ± S.E.) in different treatment group at starter stage and finisher stage

Week	T_1	T_2	T_3	T_4	T_5	T_6
BW_0	46.46 ± 0.52	47.06 ± 0.16	46.80 ± 0.14	47.08 ± 0.42	47.32 ± 0.11	46.84 ± 0.26
BW_1	120.20^{a} ± 1.43	117.96^{a} ± 1.48	116.86^{a} ± 1.47	105.08^{b} ± 0.29	122.46^{a} ± 0.84	116.66^{ab} ± 0.82
BW_2	289.10^{b} ± 4.70	251.00^{d} ± 3.00	265.32^{c} ± 4.51	266.66^{c} ± 3.29	307.34^{a} ± 0.33	310.00^{a} ± 3.30
BW_3	541.9^{d} ± 5.24	581.94^{c} ± 4.12	525.10^{e} ± 5.21	600.10^{b} ± 5.05	617.80^{a} ± 7.49	575.68^{c} ± 2.01
BW_4	989.04^{c} ± 5.57	1013.98^{b} ± 5.15	979.30^{cd} ± 11.04	1023.86^{ab} ± 6.92	974.84^{d} ± 2.85	1031.60^{a} ± 11.14
Treatment Mean	397.35^{c}	402.39^{c}	386.68^{d}	408.56^{b}	413.95^{ab}	416.16^{a}
	S Em(T)	C.D(T)	S Em(P)	C.D(P)	S Em(T*P)	C.D(T*P)
	2.00	5.59	1.82	5.11	4.47	12.51
BW_5	1413.14^{b} ± 7.96	1416.04^{b} ± 3.85	1339.04^{ab} ± 10.01	1416.54^{b} ± 12.69	1284.18^{d} ±13.84	1533.44^{a} ±8.20
BW_6	1767.14^{c} ± 8.26	1780.56^{c} ± 10.58	1743.44^{d} ± 1.42	1871.72^{b} ± 7.70	1520.12^{e} ± 2.72	1965.10^{a} ±12.93
Treatment Mean	1590.14^{c}	1598.30^{c}	1541.24^{d}	1644.13^{b}	1402.15^{e}	1749.27^{a}
	S Em(T)	C.D(T)	S Em(P)	C.D(P)	S Em(T*P)	C.D(T*P)
	4.66	12.92	3.30	9.14	8.08	22.39

The means bearing different superscript within same row differ significantly from each other (P<0.05).

Table 3: Weekly and overall body weight gain in gram (Mean ± S.E.) at starter and finisher stage in different treatment group.

Week	T_1	T_2	T_3	T_4	T_5	T_6
$BWG_{(0-1)}$	73.74 ^{a} ± 1.50	70.90 ^{a} ± 1.47	70.06 ^{a} ± 8.52	58.00 ^{b}± 0.46	75.14 ^{a} ± 0.90	69.82^{ab} ± 0.66
$BWG_{(1-2)}$	168.60b ± 5.30	133.04d ± 4.04	148.46cd ± 3.77	161.58 bc ± 3.12	184.88ab ± 1.01	193.34a ± 3.77
$BWG_{(2-3)}$	252.84^{c} ± 6.62	330.94^{a} ± 4.95	259.78^{c} ± 2.47	333.44 ^{a} ± 5.12	310.46 ^{b} ± 7.19	265.68 ^{c} ± 1.45
$BWG_{(3-4)}$	447.10^{a} ± 6.27	432.04^{b} ± 6.19	454.20^{a} ± 15.73	423.76^{b} ± 7.16	357.04^{c} ± 10.06	455.92^{a} ± 12.43
$BWG_{(0-4)}$	512.58^{b} ± 5.50	966.92^{a} ± 5.06	932.50^{b} ± 10.96	976.78^{a} ± 17.10	927.52^{b} ± 12.94	984.76^{a} ± 11.07
Treatment Mean	235.64^{bc}	241.73^{ab}	233.12^{c}	244.19 ^{a}	231.88^{c}	246.19 ^{a}
	S Em(T)	C.D(T)	S Em(P)	C.D(P)	S Em(T*P)	C.D(T*P)
	3.02	8.50	2.47	6.93	6.05	16.98
$BWG_{(4-5)}$	424.10^{b} ± 8.97	402.06^{bc} ± 4.14	359.74^{d} ± 8.40	392.68^{c} ± 10.35	309.34^{e} ± 14.13	501.84^{a} ± 10.65
$BWG_{(5-6)}$	354.00^{d} ± 8.37	364.52^{d} ± 11.34	404.40^{c} ± 9.67	455.18^{a} ± 10.96	235.94^{e} ± 15.21	431.66^{b} ± 10.51
Treatment Mean	389.05^{c}	383.29^{c}	382.07^{c}	423.93^{b}	272.064^{d}	466.75^{a}
$BWG_{(4-6)}$	778.10^{c} ± 8.96	766.58^{c} ± 11.47	764.14^{c} ± 7.01	847.86^{b} ± 6.03	545.28^{d} ± 4.01	933.50^{a} ± 13.24
$BWG_{(0-6)}$	1720.68^{c} ± 7.49	1733.50^{c} ± 7.45	1696.04^{d} ± 1.32	1824.64^{b} ±1126	1472.80^{e} ± 4.96	1918.26^{a} ± 9.86
	S Em(T)	C.D(T)	S Em(P)	C.D(P)	S Em(T*P)	C.D(T*P)
	4.66	12.92	3.30	9.14	8.08	22.39

The means bearing different superscript within same row differ significantly from each other (P<0.05).

control group birds shown lowest body weight at 6 week of age (Table 2). Results indicate increased body weight with non-infected non medicated group as compare to four coccidiostat treatment groups. Similar results were observed by Majumdar *et al.* (1993) and Thyagarajan *et al.* (1989) for non infected non medicated group and also by Anosa *et al*. (2011) for infected but non medicated group. Maduramicin shown highest body weight followed by Salinomycin, Diclazuril and Diclazuril + Salinomycin Shuttle group among coccidiostat treatment groups. Similar results were observed by Azizi *et al.* (2010). Felfeldi (1991) stated that sensitivity of *E tenella* did not change after 24 successive trials to maduramicin with higher BW as compare to other coccidiostat. Miyazaki *et al.* (1975) found that the salinomysin drug was effectively in reducing the mortality and increasing the average weight of chickens experimentally infected with *E. tenella.*

Body weight gain was highest in Maduramicin given group (333.44 ± 5.12) followed by Salinomycin given group (330.94 ± 4.95), Diclazuril + Salinomycin group (259.78 ± 2.47) and Diclazuril group (252.84 ± 6.62) at 3 week of age before experimental infection of *E. tenella*. Positive control birds showing decreasing trend of body weight gain after experimental infection to six week of age, while negative control bird showing increasing trend of body weight gain up to 5 week of age.

Over all highest body weight gain was observed in T4 group followed by T2 group, T1 group and T3 group at the end of six week period in coccidiostats given group. All four values are differing significantly among coccidiostat group as well as from control group. Negative control T6 birds shown significant highest BWG (1918.26 ± 9.86) and positive control T5 birds showing significant lowest BWG (1472.80 ± 4.96) at the end of six week period (Table 3).

Overall result of body weight and body weight gain indicating better efficacy of Maduramycin among treatment group. Salisch and Shakshouk (1990) reported that broiler chickens infected with *Eimeria tenella* (2.5 × 104 oocysts per bird) given Maduramicin at 5 ppm showed increased weight gain and feed conversion, when compared with narasin and monensin. The efficacy of Maduramicin against *E. tenella, E. maxima, E. necatrix, E. brunetti* and *E. acervulina* in Hubbard - cross were studied by Folz *et al*. (1988) who reported that birds treated with Maduramicin had significantly higher weight gain. These results are in agreement with our findings. Raju *et al.* (2012) observed that *Eimeria tenella* infected and Salinomycin treated group had better weight gain when compared to Maduramicin and Lasalocid groups. These observations are also in accordance with Chappel and Babcock (1979) who found higher relative weight gain and lower lesion score in the Salinomycin than the lasalocid treated group.

Table 4: Weekly and overall feed consumption in gram (Mean ±S.E.) in different treatment group at starter stage and finisher stage

Week	T_1	T_2	T_3	T_4	T_5	T_6
FC_1	$140.20^{c} \pm 0.65$	$142.40^{bc} \pm 0.60$	$141.05^{c} \pm 1.60$	$144.40^{ab} \pm 0.26$	$145.22^{a} \pm 0.58$	$145.25^{a} \pm 0.29$
FC_2	$268.00^{b} \pm 0.65$	$270.22^{ab} \pm 0.61$	$269.44^{b} \pm 1.17$	$271.16^{a} \pm 0.80$	$271.12^{a} \pm 0.33$	$272.24^{a} \pm 0.46$
FC_3	$480.32^{bc} \pm 0.62$	$482.22^{b} \pm 0.61$	$481.16^{b} \pm 1.08$	$480.56^{b} \pm 0.69$	$478.52^{bc} \pm 0.64$	$485.18^{a} \pm 0.90$
FC_4	$790.16^{e} \pm 0.76$	$820.20^{b} \pm 0.80$	$802.80^{d} \pm 0.53$	$808.50^{c} \pm 0.50$	$770.42^{f} \pm 0.61$	$840.66^{a} \pm 1.54$
TFC_{0-4}	$1678.68^{e} \pm 2.10$	$1715.04^{b} \pm 1.07$	$1694.45^{d} \pm 1.61$	$1704.62^{c} \pm 1.48$	$1665.28^{f} \pm 0.84$	$1743.33^{a} \pm 2.28$
Treatment Mean	419.67^{e}	428.76^{b}	423.61^{d}	426.15^{c}	416.32^{f}	435.83^{a}
	S Em(T)	C.D(T)	S Em(P)	C.D(P)	S Em(T*P)	C.D(T*P)
	0.40	1.12	2.70	0.32	0.80	2.23
FC_5	900.50 ± 23.33	920.78 ± 0.46	910.10 ± 0.37	915.20 ± 0.36	898.62 ± 0.59	960.86 ± 0.62
FC_6	1000.88 ± 1.23	1030.28 ± 0.50	1010.00 ± 0.39	1020.40 ± 0.59	996.64 ± 0.52	1070.58 ± 0.49
Treatment Mean	950.69^{d}	975.53^{b}	960.05^{cd}	967.80^{bc}	947.63^{d}	1015.72^{a}
$TFC_{(5-6)}$	$1901.38^{d} \pm 23.60$	$1951.06^{b} \pm 0.59$	$1920.10^{cd} \pm 0.67$	$1935.60^{bc} \pm 0.74$	$1898.26^{d} \pm 0.62$	$2031.44^{a} \pm 0.77$
$TFC_{(0-6)}$	3579.98^{e}	3666.10^{b}	3614.55^{d}	3640.22^{c}	3560.54^{f}	3774.77^{a}
	S Em(T)	C.D(T)	S Em(P)	C.D(P)	S Em(T*P)	C.D(T*P)
	4.78	13.40	2.76	7.73	6.76	NS

The means bearing different superscript within same row differ significantly from each other (P<0.05).

These results indicates better efficacy of Salinomycin as compare to Maduramicin which might be due to some resistant against Maduramicin compare to Salinomycin in that area.

Comparative efficacy of coccidiostats on feed consumption and feed conversion ratio

Before experimental infection of *E. tenella*, there was no consistent trend regarding feed consumption in all six groups up to 3 week of age. After experimental infection, feed consumption was highest in T2 group followed by T4 group, T3 group and T1 group at 4, 5 and 6 week of age, respectively. There was significant decrease feed consumption observed in positive control T5 group, while significant increase feed consumption was observed in negative control T6 group as compare at coccidiostat treatment group at starter stage (Table 4).

Among four coccidiostat group, Salinomycin given group have highest feed consumption followed by Maduramicin group in starter and finisher phase, respectively among coccidiostats groups. Significant increase feed consumption in negative control, while significant decrease feed consumption in positive control among all treatment groups was observed during starter and finisher phase respectively. At the end of six week significantly highest feed consumption was observed in T2 group (3666.10g) followed by T4 group (3640.22g), T3 group (3614.55g) and T1 group (3579.98g) among four coccidiostat group. All values are differing significantly among coccidiostat treatment group. In positive control group significant lowest feed consumption (3560.54g), while in negative control group significant highest feed consumption 3774.77g was observed at above age among all groups (Table 4).

Before experimental infection of *E. tenella* lowest feed conversion ratio was observed in T4 group followed by T2 group, T3 group and T1 group at 3 week of age. Above result indicate better efficacy of Maduramicin followed by Salinomycin for lowering feed conversion ratio at 3 week of age (Table 5).

At the age of six week after experimental infection of *E. tenella*, Maduramicin given group have lowest FCR followed by shuttle program of Diclazuril + Salinomycin, while Salinomycin given and Diclazuril given groups have 2.85 ± 0.09 and 2.84 ± 0.07 FCR value, respectively. Over all FCR value were found lowest in T4 group followed by T1, T2, and T3 among treatment group. Significant highest FCR (2.42 ± 0.01) was observed in T5 group and lowest FCR (1.97 ± 0.51) was observed in T6 group among all groups (Table 5).

Table 5: Weekly and overall feed conversion ratio (Mean ± S.E.) in different treatment group at starter stage and finisher stage

Week	T_1	T_2	T_3	T_4	T_5	T_6
FCR_1	1.90^{c} ±0.04	2.01^{bc} ±0.04	2.01^{bc} ±0.06	2.49^{a} ±0.02	1.93^{c} ±0.02	2.08^{b} ±0.02
FCR_2	1.59^{c} ±0.05	2.03^{a} ±0.06	1.81^{b} ±0.04	1.68^{c} ±0.03	1.47^{d} ±0.01	1.41^{d} ±0.03
FCR_3	1.90^{a} ±1.05	1.46^{b} ±0.02	1.85^{a} ±0.02	1.44^{b} ±0.02	1.54^{b} ±0.04	1.83^{a} ±0.01
FCR_4	1.77^{c} ±0.03	1.90^{b} ±0.03	1.77^{c} ±0.06	1.91^{b} ±0.03	2.16^{a} ±0.06	1.84^{b} ±0.05
$FCR_{(0-4)}$	1.78^{abe} ± 0.01	1.77^{abe} ± 0.01	1.82^{a} ± 0.02	1.75^{c} ± 0.01	1.80^{ab} ± 0.01	1.77^{bc} ± 0.2
Treatment Mean	1.79^{b}	1.85^{ab}	1.87^{a}	1.88^{a}	1.78^{b}	1.79^{b}
	S Em(T)	C.D(T)	S Em(P)	C.D(P)	S Em(T*P)	C.D(T*P)
	0.02	0.06	0.02	0.05	0.04	0.11
FCR_5	2.13^{bc} ± 0.06	2.29^{b} ± 0.02	2.54^{b} ± 0.06	2.35^{b} ± 0.06	2.96^{a} ± 0.04	1.92^{c} ± 0.04
FCR_6	2.84^{b} ± 0.07	2.85^{b} ± 0.09	2.51^{c} ± 0.06	2.25^{c} ± 0.05	4.40^{a} ± 0.31	2.49^{c} ± 0.6
Treatment Mean	2.49^{bc}	2.57^{b}	2.53^{b}	2.30^{cd}	3.68^{a}	2.21^{d}
$FCR_{(5-6)}$	2.45^{c} ± 0.03	2.55^{a} ± 0.04	2.51^{bc} ± 0.02	2.28^{d} ± 0.02	3.48^{a} ± 0.03	2.18^{e} ± 0.03
$FCR_{(0-6)}$	2.08^{b} ± 0.01	2.12^{c} ± 0.01	2.13^{c} ± 0.02	2.00^{a} ± 0.01	2.42^{d} ± 0.01	1.47^{a} ± 0.01
	S Em(T)	C.D(T)	S Em(P)	C.D(P)	S Em(T*P)	C.D(T*P)
	0.08	0.23	0.05	0.13	0.11	0.32

The means bearing different superscript within same row differ significantly from each other (P<0.05).

An overall result of feed efficiency and feed conversion ratio indicates better result by Maduramicin and Dicalzuril among treatment groups at the age of six week which is completely in line with Azizi *et al*. (2010), Georgiva *et al*. (2010) reported better results with Maduramicin in *E tenella* infected broilers by improving WG and FCR. Safety of Maduramicin (Cygro) was studied in 600 Tetra-82 broilers by Laczay *et al.* (1989). They fed Maduramicin at the dose rate of 2.5, 5.0, 7.5 and 10.0 ppm in feed during the starter and grower phases between the 1st and 42nd days and reported that Maduramicin at 5 ppm did not influence body weight gain, feed consumption, feed conversion, or death rate which not supports the present study. This difference might be due to higher dose of mixed inoculums of *Eimeria* spp. given at later age.

In the present study, Salinomycin at 60 ppm showed less feed efficiency, while Ashraf *et al*. (2002) used Sacox (12 per cent Salinomycin sodium) as anticoccidial in the feed and reported that it was significantly better (P>0.05) in terms of live weight gain and feed efficacy. Ebrahimnezad and Pourreza (2005) studied the effect of ionophorous anticoccidial drugs, Salinomycin and lasalocid on performance of broiler chicks and results showed that Salinomycin was better than lasalocid sodium. Badstue and Johansen (1986) evaluated the efficacy of Maduramicin ammonium at 5 ppm (Cygro) and Salinomycin 66 ppm (Sacox, coccistac) in broiler chickens. The Salinomycin group had a lower feed consumption/kg live weight than the Maduramicin group in their study. This difference might be due to variation in the dose of infection and age of birds.

Based on the finding of this study, it is concluded that coccidiostats are proved to have growth promoting action in broiler chickens during the experimental infection of 50,000 dose of *E. tenella*. Birds fed with Maduramicin medicated (5 ppm) performed well in terms of live weight gain and feed conversion ratio and it was followed by salinomycin (60 ppm) for weight gain and Diclazuril for feed efficiency in broiler birds. Based on the findings of the present study, it was concluded that Maduramicin at 5 ppm and Salinomycin at 60 ppm can also be used for prevention and control of coccidiosis with less alteration in body weight and feed efficiency in broiler birds.

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REFERENCES

Abbas, R.Z., Iqbal, Z., Khan, A., Sindhu, Z.U., Khan, J.A., Khan, M.N. and Raza, A. 2012. Options for integrated strategies for the control of avian coccidiosis. *Int. J. Agric. Biol.*, **14:** 1014-1020.

Abbas, R.Z., Iqbal, Z., Sindhu, Z.D., Khan, M.N. and Arshad, M. 2008. Identification of cross resistance and multiple resistances in *Eimeria tenella* field isolates to commonly used anticoccidials in Pakistan. *J. Appl. Poult. Res.*, **17:** 361–368.

Anosa, G.N., Obetta, V.C., Okorie-Kanu, C.O. and Eze, J.I. 2011. Comparative efficacy of Toltrazuril, Amprolium and Embazine Forte against mixed *Eimeria* spp. infection in broilers. *Nigerian Vet. J.*, **32**(3):214-217.

Ashraf, M.A., Pasha, T.N., Mian, N.A., Hashmi, A. and Zulfiqar, A. 2002. Comparative Efficacy of Different Feed Additive Anticoccidials in Broilers. *Int. J. Poul. Sci.*, **1 (6):** 185-187.

Azizi, H.R., Zamani, A.M., Fattahi, R., Rashidi, M. and Dehsahraei, J. 2010. Comparison of effect of anticoccidial drugs, salinomycin and maduramicin on frequency of excreted oocytes and performance in experimental coccidiosis in broiler chicken. *Pajouhess and sazandegi V. J.*, **22**(4):54-63.

Badstue, P.B. and Johansen, J. 1986. Floor-pen trials with maduramicin ammonium (Cygro) and salinomycin (Sacox, Coccidiosis). Research in avian coccidiosis Proceedings of the Georgia Coccidiosis Conference, Nov, 1985, Georgia, U.S. States, 279-284.

Barley, G.G., Baghel, R.P.S and Das, Babita. 2015. Performance and Nutrient Utilization of Broilers Supplemented Mineral Premix without Cobalt, Iron and Copper. *J. Anim. Res.*, **5(1)**: 61-65.

Bera, A.K., Bhattacharya, D., Pan, D., Dhara, A., Kumar, S. and Das, S.K. 2010. Evaluation of Economic losses due to coccidiosis in Poultry Industry in India. *Agricul. Econo. Res. Rev*., **23**: 91-96.

Chakrabarti, A. 1989. In: Practice of Poultry Medicine. New Delhi, India: Kalyani Publisher Ltd. pp. 22-34.

Chappel, L.R. and Babcock, W.E. 1979. Field trials comparing salinomycin (Coxistac), Monensin and Lasalocid in the control in broiler. *Poult. Sci.*, **56**: 933-936.

Ebrahimnezhad, Y. and Pourreza, J. 2005. Effects of Ionophorous Anticoccidial Drugs, Salinomycin and Lasalocid, on the Performance of Broiler Chicks and the Relationship of These Drugs to Supplementary Methionine. *Int. J. Poult. Sci.*, **4 (11)**: 911-916.

Felfeldi, M. 1991. Efficacy of the coccidiostat Cygro (Maduramicin) in broiler chickens. *Vestnik Sel'skokhoztaiatvennei Nauki (Mosleva*), CAB Abstr., **2**: 134-136.

Folz, S.D., Lee, B.L., Nowakowski, L.H. and Conder, G.A. 1988. Anticoccidial evaluation of halofuginone, lasalocid, maduramicin, monensin and salinomycin. *Vet. Parasitol.*, **28**:1-9.

Georgieva, N.V., Koinarski, V. and Gabrashanska, M. 2010. Combined effect of Cygro and vitamin E on oxidative stress status of broiler chickens infected with *Eimeria tenella*. *J. Agri. Sci. Tech.*, **2(4)**: 191 – 196.

Hilbrich, P. 1978. Krankheiten des Geflugels unter besonderer Beruckichtigung der Haltung and Flutterung, 3rd edn. Verlag Hermann Kuhn KG. Schwenninger am Necar,Germany.

Laczay, P., Simon, F. and Lehel, J. 1989. Study of the maduramycin tolerance in broilers. *Magy. Allatorv. Lap*., **44(9)**: 529-532.

Majumdar, P., Guha, C. and Pramanik, A.K. 1993. Studies of the comparative efficacy of Duocoxin, Amadon and IHP-250 against *E. tenella* infection in broiler chicks. *Indian vet. J*., 70(6):501:504.

Miyazaki, Y. Shibuya, M. Sugarvara, M.H., Kawaguchi, O., Hirose, C., Nagatsu, J. and Esumi, S. 1975. Salinomycin, a new polyether antibiotic. *J. Antibiotics*, **27**: 814-821.

Mazurkiewicz, M., Harenza, T. and Madel, J.A. 1987. In: Proceedings of the XVIII World's Poultry Congress, Nagoya, Japan, pp.1210.

Patra, G., Rajkhow, T.K., Ali, M.A., Tiwari, J.G. and Sailo, L. 2010. Studies on clinical, gross, histopathological and biochemical parameters in Broiler Birds suffered from *Eimeria necatrix* infection in Aizwal District of Mizoram, India. *Int. J. Poul. Sci*., **9(12)**:1120-1124.

Raju, M., Placid E.D., Narasimhamurthy, H.N. and Umakanta, B. 2012. Efficacy of commonly used coccidiostats against experimental *E. tenella* infection on broiler chickens. *J. vet. Parasitol.*, **26(1)**: 53-56.

Salisch, H. and Shakshouk, A.G.R. 1990. Comparison of the anticoccidial activity of narasin, monensin and maduramicin with broiler chicks in cages. *Archiv. fur. Geflugelkunde*., **54 (3)**: 106-110.

SAS. 2000. Statistical Analysis System. SAS Institute Inc. Cary, North Carolina, USA. 1028 pp.

Snedecor, G.W. and Cochran, W.G. 1980. Statistical Methods. 8th Ed. Iowa State Univ. Press, Ames. Iowa, USA.

Thyagarajan. D., Narahari, D., Kothandaraman, P. and Ebenezer R.E. 1989. Relative performance of broiler chicks subjected to different anticoccidial treatments. *Indian J. Anim. Sci*., **59 (2)**: 216-220.

Williams, R.B. 1998. Epidemiological aspects of the use of live anticoccidial vaccine for chickens. *Int. J. Parasitol.*, **28**: 1089-1098.