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Journal:	<i>Revista Brasileira de Zootecnia</i>
Manuscript ID	Draft
Manuscript Type:	Full Length Research Article
Keyword:	chicken, economy, intake, oocyst, production cost, protozoa

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The economic impact of infection with *Eimeria* spp. in broiler farms from Romania

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ABSTRACT - A surveys was conducted in chicken broiler farms from Romania on August-November 2010 to evaluate economic losses due to coccidiosis. We collected data from 6 broiler farms of different capacity regarding chemoprophylaxis program, weight gain, food conversion and mortality, for two previous flocks in two houses of each farm, and finally we evaluated the economic losses. Also, we collected faeces samples and oocysts classified according to their size, and virulence of each *Eimeria* spp. field isolate determined by lesion scoring. The correlation between economic performance, and oocysts category, and virulence of *Eimeria* were assessed by multiple linear regression. The total economic losses per 24 flocks of 18,000 chicks each were about €37,948.2, with an average of €3,162.4 per flock, and they were caused by mortality (34.8%) and increased feed consumption (65.2%). We estimated that the total economic losses due to coccidiosis for 2010 in Romania may have been at least €28,971,818.18. Poor body weight gain (BWG) was associated with AM oocysts category, high lesion score in the duodenum and coccidiostatic used for chemoprophylaxis. Feed conversion ratio was linked to the same parameters as BWG, less chemoprophylaxis programme, plus total lesion score. The percentage of mortality was influenced by the lesion score in the caecum and total lesion score. Statistical analysis showed that epidemiological survey of broiler flocks during growing period can help the farmer to avoid important economic losses due to coccidiosis. As in other countries the economic losses caused by coccidiosis in Romania are important, and a good prophylaxis program can reduce the economic impact of coccidiosis.

Key Words: body weight gain, chickens, feed conversion ratio, losses

Introduction

Coccidiosis is the most common and costly disease of poultry industry, caused by apicomplexan parasites belonging to *Eimeria* genus that develops in the epithelial cells of the gut. Seven species of *Eimeria* are widely recognized to infect chickens: *E. acervulina*, *E. mitis*, *E. necatrix*, *E. tenella*, *E. praecox*, *E. maxima* and *E. brunetti* (Shirley, 1986). Based on epidemiological studies from the latest years, in broiler chickens frequently are found *E. acervulina*, *E. tenella*, *E. maxima* and *E. praecox*, and more rarely *E. mitis* and *E. necatrix* (Haug et al., 2008a; Sun et al., 2009; Hamidinejat et al., 2010; Ogedengbe et al., 2011).

The poultry industry cannot be viable without specific prophylaxis based mainly on use of in-feed anticoccidial drugs named coccidiostats (Peek and Landman, 2011) and rarely on vaccination (live vaccines), because of economic reasons and adverse effects on early chick growth (Williams, 2002). According to the European Commission (report COM 2008/233 of Regulation 1831/2003), in 2006 in Europe, approximately 84% of broilers were prevented with coccidiostats and 12% by vaccination. In Romania, prevention of coccidiosis in broiler farms is based on coccidiostats, vaccination (mainly Paracox-8) being used partially only in layers and breeders (personal observation). Nowadays in Europe are accepted 12 commercial products containing chemicals and ionophores. Their extensive use led to development of drug-resistance (Chapman, 1997), and it was described globally to all anticoccidial drugs and to all *Eimeria* species (Kawazoe & Fabio, 1994; Peeters et al., 1994; Stephen et al., 1997; Peek and Landman 2003; Williams, 2006; Abbas et al., 2008; Zhang et al., 2013). Even, coccidiosis did not occur in farms with drug-resistant strains of *Eimeria* (Hemsley, 1964), they do cause subclinical

coccidiosis expressed by poor weight gain and high food consumption (Harfoush et al., 2010; Jenkins et al., 2010), leading to considerable economic losses. Annual costs of coccidiosis in the world have been estimated at 2 billion euro (Peek and Landman, 2011).

As there are not many published studies about estimates for economic losses due to coccidiosis, we conducted a survey in chicken broiler farms from Romania on August-November 2010. The aim was to register the performance, and to evaluate their impact on the economic losses. In addition the correlation between performance and virulence of *Eimeria* isolates were assessed.

Materials and methods

Union of poultry breeders from Romania (UCPR) has 276 members, of which 18 large poultry companies (produce over 10 thousands tones of meat/year), 22 medium (produce between 5-10 thousands tones of meat/year) and 236 small (produce less than 5 thousands tones of meat/year) poultry companies. The production of poultry meat in 2010 was about 317 thousands tones. Average performances in the same year were: daily body weight gain 54.19g; feed conversion ratio of 1.859; mortality of 4.24%; and European Production Index 299.15 (data from official web page of UCPR). The most common broiler breeds are Cobb500 and Ross308, and they are reared in houses made of concrete on wood shavings. Prophylaxis of coccidiosis is based on use of in-feed anticoccidial drugs. The average age at slaughter is about 42 days, and average live weight of 2.2 kg. The time between successive grow-outs is about 2-3 weeks. Used litter is removed and the broiler houses are cleaned and chemically disinfected.

During August-November 2010, there were sampled 12 farms picked by simple random sample, for anticoccidial sensitivity test. Among these farms, 6 farms answered to a questionnaire

and were included in the present paper. Farms were subsequently divided according to their capacity in three groups: small ($n=3$), medium ($n=2$) and large-size ($n=1$) farms. The capacity of these farms is about 9×10^5 -2.3 mil chickens/year and they do not have their own feed mills.

A questionnaire was formulated in order to record data about coccidiostats used in those farms, chemoprophylaxis program, weight gain, food conversion and mortality for two previous flocks in two houses of each farm.

We estimated economic losses due to poor body weight gain, feed conversion ratio and mortality for flocks investigated following the model developed by Williams (1999). For this purpose we assumed some parameters presented in Table 1. These losses were calculated for values that exceed the national average regarding mortality, body weight gain and feed conversion ratio in broilers (Table 1). The costs were expressed in euro.

Estimates for cost of anticoccidial therapy were not possible because the farmers reported no outbreaks of coccidiosis or any treatment for coccidiosis. The cost of anticoccidial prophylaxis was comprised in the cost of feed.

Losses due to increased bird mortality. The total loss due to mortality is the sum of Eqs. (1) and (2).

LM (Loss due to mortality) = N (No. of chickens died) $\times$ [VC (Value of day-old chick) + CCF (Cost of cumulative feed consumed by a single bird in 21 days = 43.8% din total) + OC (Overhead cost)] (1)

PP (Potential Profit) = $[N \times ML$ (Mean liveweight of chickens) $\times$ SP (Selling price per kg of live chickens at processing plant)] $- [N \times (TRC$ (Total rearing cost of a chicken) $- VC)]$ (2)

Losses due to decreased body weight gain.

TSP (total selling price) = $(N \times ML \times SP)$ (3)

Losses due to increased feed conversion ratio

TCF (total cost of feed) = L (tonnes liveweight) × FCR × CF (Cost of feed per tonne) (4)

Also, we collected 12 faeces samples from 2 flocks per farm, when chickens were 20-35-days old (median 28 days). Approximately 250g of fresh faecal droppings/sample were collected along the feed and water lines. The samples were processed once they arrived in the lab by flotation and McMaster (number of oocysts per gram of faeces = OPG) methods with saturated sodium chloride (specific gravity 1.18-1.2) and stored at 4°C till the next day. Afterwards, oocysts were isolated, purified and concentrated from faeces with saturated salt solution (Shirley, 1995) and sporulated in 2.5% potassium dichromate solution. The oocysts were washed free from the salt and potassium dichromate by repeated centrifugation and resuspended in tap water. After sporulation, oocysts were classified according to their size (Haug et al., 2008b), and virulence of each *Eimeria* spp. field isolate was assessed by lesion scoring (Johnson and Reid, 1970) following experimental infection.

Classification of oocysts in each sample was made according to the protocol described by Haug et al. (2008b). Briefly, 50 oocysts from each sample were measured with software CELL-F using digital photographs (camera Olympus ODP72) made to Olympus BX61 microscope at 400x magnification (Long and Reid, 1982). Oocysts were categorized into three groups: AM group - small oocysts being to 18.8 µm long (presumptively *E. acervulina* and/or *E. mitis*); NTP group - medium-sized oocysts of 18.9 to 23.8 µm long (presumptively *E. necatrix*, *E. tenella* and/or *E. praecox*) and BM group - large oocysts, longer than 23.9 µm long (presumptively *E. brunetti* and/or *E. maxima*).

In order to evaluate the virulence of *Eimeria* spp. field isolates, one hundred thirty 1-day-old broiler chicks (breed Ross 308) were obtained from a hatchery (Bihor county) and reared as a

single group from one-day old to 14-days-old, when chicks were randomly divided into 13 groups of 10 birds each, in cages, as negative control and 12 experimental groups, challenged with *Eimeria* isolates from the farms (2 isolates per farm). Experimental infection was done at 14-days-old with 5000 oocysts/isolate. Virulence of *Eimeria* field isolates were evaluated by lesion score at 6 days post-challenge using a score of 0–4 according with Johnson and Reid (1970). Diet formulas contained no anticoccidial feed additives. Chicks were offered feed and water ad libitum, and were exposed to continuous light.

The differences in mortality rate, body weight gain and feed conversion ratio between farms according to their capacity was done by t-test in Excel and a p value of <0.05 was statistically significant. In addition the correlation between economic performance, and oocysts category, and virulence of *Eimeria* isolates were assessed by multiple linear regression in EpiInfo version 3.5.2.

Results

Detailed data for each farm, house and flock are presented in table 2, while in table 3 mean and range by farm size. The averages of body weight gain (BWG), feed conversion ratio (FCR) and mortality in the farms included in the present study were 54.8 (42.3-62.4), 2.0 (1.6-2.4) and 5.5 (2.5-11.9) respectively. These data are less or more in accordance with the averages at national level in 2010 (BWG=54.19; FCR=1.859; mortality=4.24%). The lowest BWG was registered in farm “A”, a small-size farm (42.3 g/day/chicken in house 2, flock 2) and the highest in farm “C”, a medium-size farm (62.4 g/day/chicken in house 1, flock 1). The best FCR was noticed in farm “G”, a medium-size farm (1.6 in house 1, flock 1) and the lowest in farm “A” (2.4 in house 1, flock 2). In farm “C” (2.5-3.2%)

was observed the lowest percentage of mortality, while in farms “A” (6.4-11.9%) and “J” (6.6-10.6%) was the highest.

Chemoprophylaxis of coccidiosis, in the farms included in the study, was made with lasalocid (4/6 farms), narasin/nicarbazin (1/6 farms), monensin (1/6 farms), and diclazuril (2/6 farms) (Table 2). In all cases, the farmers used the full program. Four farms (“A”, “F”, “J”, and “K”) out of 6 used the same coccidiostatic for both flocks in a house. Otherwise small-size farms used ionophores (lasalocid) for chemoprophylaxis, medium-size farms ionophores (lasalocid, monensin), chemicals (diclazuril) and a combination of them (narasin+nicarbazin), while large-size farms used only chemicals (diclazuril) (Table 2 and 3).

There were found all three categories of oocysts (AM, NTP and BM) in 10 out of 11 flocks (Table 3), the most prevalent being AM (43.1%) and NTP (44.4%) groups. Prevalently in small-size farms was NTP group (50.6%), while in medium-size farms was AM group (52%). In large-size farms those two groups were almost at the same level (AM=41.4%; NTP=44.6%).

The total lesion score (TLS) was significantly higher ($p<0.05$) in small (TLS = 2.9) and large-size (TLS = 2.5) farms than in medium size-farms (TLS = 0.9) (Table 3). Overall, the lesion score was the highest in duodenum (1.8(0.4-4.0)) in small-size farms and in caecum (1.5(0.0-3.0)) in large-size farms. The most virulent *Eimeria* spp. field isolates were found in farm “A”, a small-size farm (TLS = 5.4-6.1), followed by isolates from farms “F” (small-size farm; TLS = 1.4-3.5) and “J”, a large-size farm (TLS = 1.5-3.5) (Table 2).

The results of multiple linear regression analysis are presented in table 4. Body weight gain was associated with AM oocysts category, lesion score in the duodenum and coccidiostatic used for chemoprophylaxis. Feed conversion ratio was linked to the same parameters as BWG, less

chemoprophylaxis programme, plus total lesion score. The percentage of mortality was influenced by the lesion score in the caecum and total lesion score.

The total economic losses (Table 5) per 24 flocks of 18,000 chicks each were about €37,948.2, with an average of €3,162.4 per flock, and they were caused by mortality (34.8%) and increased feed consumption (65.2%). Nevertheless two farms among six recorded profits. The highest economic losses were registered in farm “A”, a small-size farm (€57,441.0/4 flocks), where 18.6%, 44.2% and 37.2% of losses were caused by mortality, poor body weight gain and increased feed consumption respectively. If in large-size farms the economic losses were due to mortality and FCR, in small and medium-size farms BWG was also incriminated. We estimated that the total economic losses due to coccidiosis for 2010 in Romania may have been at least €28,971,818.18.

Discussion

The most problematic disease in the poultry industry worldwide is coccidiosis, mainly due to subclinical forms of diseases that interfere with body weight and feed conversion. It is estimated that 95.6-98.1 percentages of the economic losses in commercial broiler industry are caused by coccidiosis (Williams, 1999; Bera et al., 2010).

Economic losses estimated by us for farms and flocks included in this study are underestimated because we didn't estimate the cost with prophylaxis, with treatment, and the loss due to intercurrent diseases, which generally occur along with coccidiosis. We assumed the cost with prophylaxis as part of costs for feed, as for treatment, the farmers told us that they didn't apply any treatment for coccidiosis in investigated flocks.

Interesting, apart from other studies, important economic losses were due to mortality (24.4% in small-size farms and 43.9% in the large-size farm). These flocks presented high percentage of mortality, between 6.6 and 11.9. The causes of mortalities in a farm can be multiple, but in our cases we suspect they were caused by infection with *E. tenella*. In farms with high mortalities the lesion score in the caecum after infection with 5000 oocysts of *Eimeria* spp. was between 2 and 3, and the NTP oocysts category were predominant. Moreover after statistic analysis mortality was associated with lesion score in the caecum and total lesion score ($p=0.02$). *E. tenella* is one of the most pathogenetic species and cause bloody lesions, high morbidity, and mortality in naïve chickens (Morris et al., 2007; Iacob and Duma 2009). Possible in these farms, there were some outbreaks of coccidiosis. Outbreaks of coccidiosis may result from drug-resistance of parasites to the prophylactic drug used, accidental underdosing, overdilution of medicated feed with whole wheat, excessive drug withdrawal period, or reduced feed intake (Williams, 1999). Many other factors can cause outbreaks of coccidiosis as environmental and management factors; lack of use of overalls by visitors, bad hygienic status, personnel who might also be working on other farms, feeding and drinking systems which are more difficult to clean, the presence of other diseases on the farm, and *Eimeria* species found in the previous flock increase the risk of coccidiosis (Graat et al., 1998).

Otherwise, the increased FCR amounted to 50.8-65.2% of the total losses due to coccidiosis, and it was statistic associated with AM oocysts category, score lesion in the duodenum and total lesion score. In India the losses due to increased FCR are estimated at 23.74% from total cost (Bera et al., 2010).

In the world, the economic losses due to subclinical coccidiosis are significant, being estimated at more than 3 billion US\$ annually (Dalloul and Lillehoj 2006). We estimated that the

total economic losses due to coccidiosis for 2010 in Romania may have been at least €28,971,818.18. In comparison in India the cost for 2003-2004 was estimated at Rs1089170162 (~€15,210,694.20) (Bera et al., 2010), and in UK for 1995 at about GB£38 588 795 (~€44,643,989.69) (Williams, 1999). In Ethiopia average total losses were estimated at 898.8, and 5,301.8 Ethiopian Birr per farm in small scale and large-scale farms, respectively (Kinung'hi et al., 2004). Generally it is assumed that 70 percent of the estimated costs are due to subclinical coccidiosis, by impact on weight gain and feed conversion rate (Gussem, 2007), and the economic importance of subclinical coccidiosis vary with composition of coccidial populations (Haug et al., 2008b).

Intensive chicken farming depends on specific prophylaxis of coccidiosis with in-feed anticoccidial drugs and live vaccines. Over time, the coccidiostats have become less effective due to development of drug-resistance. Drug-resistant *Eimeria* strains are responsible for subclinical coccidiosis and, subsequently, for impaired economical performance as body weight gain and feed conversion ratio (Shirzad et al., 2011). Drug-resistance was described recently in Romanian broiler farms to monensin, salinomycin, narasin, nicarbazin, robenidine, lasalocid, and diclazuril (Györke et al., 2011a; Györke et al., 2012). In this study low body weight gain was associated also with coccidiostatic (ionophores) used for chemoprophylaxis. It is well known that ionophores do not prevent replication of *Eimeria* completely (Chapman and Johnson 1992) as chemicals do. In order to prevent drug resistance, rotation of coccidiostats and shuttle programmes are recommended. Small and medium farms in Romania don't have their own feed mill and in the most cases they can't control the prophylaxis program (personal observation).

In investigated farms occurred mixed infections with all three categories of oocysts. During an epidemiological study by PCR in Romanian broiler farms were identified *E.*

acervulina, *E. tenella*, *E. maxima* and *E. praecox* (Györke et al., 2011b). Most likely, the mixed infections are more prevalent in small and medium farms due to poor management and bio-security practises as high stocking densities, reduced time between successive grow-outs (Lobago et al., 2005), microclimate and workers (Kiani et al., 2007), but it wasn't our case; we found mixed infections in all three types of farms.

Conclusions

Statistical analysis regarding correlation between economic performance, and oocysts category, and virulence of *Eimeria* isolates showed that epidemiological survey of broiler flocks during growing period by classical methods can help the farmer to avoid important economic losses due to coccidiosis. As in other countries, the economic losses caused by coccidiosis in Romania are important, and they are caused mainly by mortality and high feed conversion ratio. Moreover, a good prophylaxis program can reduce the economic impact of coccidiosis.

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Figures

Figure 1. Location of the farms from where the data were collected

Tables

Table 1. Assumed parameters for estimation of economic losses

Parameter	Mean	Source
Length of life	42 days	Farmers
Value of day-old chickens	2.1 RON (0.50 E*)	UCPR**
Value of dressed meat/kg	7.36 RON (1.75 E)	UCPR
Value of 42 old chicken/kg	5.18 RON (1.23 E)	UCPR
Cost of feed/kg	1.6 RON (0.38 E)	UCPR
(including the cost of coccidiostats)		
Mortality (%)	4.24	UCPR
Number of chicks/flock	18,000	Farmers
Body weight gain (g/day)	54.19	UCPR
Body weight at slaughtering (kg)	2.2	Farmers
Feed conversion ratio	1.859	UCPR
Overhead costs	15%	Williams, 2009

*1 E = 4,2099 RON (average for 2010)

** Union of poultry breeders from Romania

Table 2. Performance, prophylaxis of coccidiosis, oocysts categories and virulence of *Eimeria* isolates in investigated broiler farms during August-November 2010 in Romania

Farm	House	BWG ^a (g)		FCR ^b		Mortality (%)		Coccidiosis prophylaxis		Length categories (%) ^c			Lesion score ^d			
		F 1	F 2	F 1	F 2	F 1	F 2	F 1	F 2	AM	NTP	BM	D	J	C	Total
Small-size farms																
A	1	49.3	48.3	2.1	2.4	6.4	11.9	Las	Las	34.8	43.5	21.7	4.0	0.0	2.1	6.1
	2	47.0	42.3	2.2	2.3	10.0	6.9	Las	Las	34.6	50.0	15.4	3.3	0.1	2.0	5.4
F	1	57.5	57.5	1.8	1.8	3.8	3.4	Las	Las	52.8	44.4	2.8	1.7	0.1	1.7	3.5
	2	57.5	57.5	1.8	1.8	3.9	3.6	Las	Las	35.5	58.1	6.5	1.1	0.0	0.3	1.4
K	1	57.5	55.0	1.9	1.9	4.5	5.2	Las	Las	40.0	46.7	13.3	0.5	0.1	0.1	0.7
	2	55.0	51.8	2.0	2.0	4.7	5.6	Las	Las	37.5	61.1	1.4	0.4	0.0	0.0	0.4
Medium-size farms																
C	1	62.4	62.1	1.7	1.7	2.5	2.9	Nar/Nic	Dicl	87.5	12.5	0	1.4	0.0	0.1	1.5
	2	59.2	59.3	1.8	1.8	2.8	3.2	Nar/Nic	Dicl	nd	nd	nd	1.3	0.3	0.1	1.7
G	1	56.1	49.2	1.6	2.1	2.9	5.1	Mon	Las	40.0	40.0	20.0	0.0	0.2	0.0	0.2
	2	56.2	49.2	1.7	2.3	3.2	5.3	Mon	Las	28.6	42.9	28.6	0.0	0.0	0.0	0.0
Large-size farms																
J	1	58.5	58.5	2.2	2.1	10.6	8.8	Dicl	Dicl	34.0	45.3	20.8	0.5	0.0	3.0	3.5
	2	52.4	55.0	2.0	2.1	6.6	8.6	Dicl	Dicl	48.8	43.9	2.3	0.7	0.8	0.0	1.5
Average in 2010 ^e		54.19		1.859		4.24										

^aBody weight gain.

^bFeed conversion ratio.

^cAM = *E. acervulina* and/or *E. mitis*; NTP = *E. necatrix*, *E. tenella* and/or *E. praecox*; BM = *E. brunetti* and/or *E. maxima*.

^dD = duodenum; J = jejunum; C = caecum.

^eData from Union of poultry breeders from Romania.

Table 3. Average and range of evaluated parameters by farm capacity

Sample characteristics (mean)	Small-size farms ^a (<i>n</i> = 6 flocks)	Medium-size farms ^b (<i>n</i> = 4 flocks)	Large-size farms ^c (<i>n</i> = 2 flocks)	Total (<i>n</i> = 12 flocks)	Average in 2010 [*]
Body weight gain (g) (range)	53(42.3-57.5)	56.7(49.2-62.4)	56.1(52.4-58.5)	54.8(42.3-62.4)	54.19
Feed conversion ratio (range)	2(1.8-2.4)	1.8(1.6-2.3)	2.1(2-2.2)	2(1.6-2.4)	1.859
Mortality (%) (range)	5.8(3.4-11.9)	3.5(2.5-5.3) ^{a,c}	8.7(6.6-10.6)	5.5(2.5-11.9)	4.24
**Length categories					
(%)(range)					
AM	39.2(34.6-52.8)	52(28.6-87.5)	41.4	43.1(28.6-87.5)	
NTP	50.6(43.5-61.1)	31.8(12.5-42.9) ^a	44.6	44.4(12.5-61.1)	
BM	10.2(1.4-21.7)	16.2(0-28.6)	11.6	12(0-28.6)	
Number of categories involved (<i>n</i>) (range)					
One length categorie	0	0	0	0	
Two length categories	0	1	0	1	
Three length categories	6	2	2	10	
Number of oocysts in inoculum (5000 oocysts/chicken)					
AM	1960(1730-2640)	2602(1430-4375)	2070(1700-2440)	2155(1430-4375)	
NTP	2532(2175-3055)	1590(625-2145) ^a	2230(2195-2265)	2220(625-3055)	
BM	509(70-1085)	810(0-1430)	578(115-1040)	604(0-1430)	
Lesion score (range)					
Duodenum	1.8(0.4-4.0) ^{b,c}	0.7(0-1.4)	0.6(0.5-0.7)	1.2(0-4)	
Jejunum	0.1(0-0.1)	0.1(0-0.3)	0.4(0-0.8)	0.1(0-0.8)	
Caecum	1.0(0-2.1) ^b	0.1(0-0.1)	1.5(0-3.0) ^b	0.8(0-3)	
Total	2.9(0.4-6.1) ^b	0.9(0-1.7)	2.5(1.5-3.5) ^b	2.2(0-6.1)	
Coccidiostats					
	Ionophores (Lasalocid sodium)	Ionophores (3) + chemicals (2)	Chemicals (Diclazuril)		

^{*}Union of poultry breeders from Romania

** AM = *E. acervulina* and/or *E. mitis*; NTP = *E. necatrix*, *E. tenella* and/or *E. praecox*; BM = *E. brunetti* and/or *E. maxima*.^{a,b,c} t-test $p \leq 0.05$.

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Table 4. Results of multiple linear regression [r(p)] regarding the correlation between economic performance and oocysts categories, lesion score in the gut and chemoprophylaxis of coccidiosis

	BWG ^a	FCR ^b	Mortality
AM (<i>E. acervulina</i> and/or <i>E. mitis</i>)	0.60 (0.05)	0.6 (0.05)	0.45 (0.16)
NTP (<i>E. necatrix</i> , <i>E. tenella</i> and/or <i>E. praecox</i>)	0.42 (0.19)	0.37 (0.26)	0.26 (0.42)
BM (<i>E. brunetti</i> and/or <i>E. maxima</i>)	0.44 (0.17)	0.50 (0.11)	0.37 (0.26)
Lesion score in duodenum	0.7 (0.01)	0.60 (0.04)	0.52 (0.08)
Lesion score in jejunum	0.25 (0.43)	0.31 (0.32)	0.52 (0.08)
Lesion score in caecum	0.01 (0.96)	0.47 (0.12)	0.65 (0.02)
Total lesion score	0.44 (0.15)	0.63 (0.03)	0.66 (0.02)
Chemoprophylaxis of coccidiosis	0.61 (0.03)	0.28 (0.38)	0.10 (0.76)

^aBody weight gain.

^bFeed conversion ratio.

Table 5. Economic losses caused by high mortality, poor body weight gain and increases feed conversion ratio

Farm	Mortality	BWG	FCR	Total
Small-size farms				
A (4 flocks)	-10,673.8	-25,400.9	-21,366.3	-57,441.0
F (4 flocks)	+1,322.5	+11,863.3	+3,421.3	+16,607.2
K (4 flocks)	-1,779.0	+2,274.1	-5,199.9	-4,704.7
Economic losses/flock (average)	-1,855.1	-1,877.3	-3,857.5	-7,589.8
%	24.4	24.7	50.8	
Medium-size farms				
C (4 flocks)	+3,253.6	+23,721.7	+6,379.4	+33,354.8
G (4 flocks)	+269.2	-5,265.7	-3,626.1	-8,622.6
Economic losses/flock (average)	880.7	4614.0	688.3	6183.1
Large-size farms				
J (4 flocks)	-10,322.7	+6,374.1	-13,193.3	-17,141.8
Economic losses/flock (average)	-5,161.4	3,187.1	-6,596.7	-8,570.9
%	43.90		56.10	
Total				
Total (24 flocks)	-17,930.1	13,566.7	-33,584.8	-37,948.2
Economic losses/flock (average)	-1,494.2	1,130.6	-2,798.7	-3,162.4
Economic losses/chicken (average)	-0.08		-0.16	-0.18
%	34.8		65.2	

