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

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ABSTRACT - A survey was conducted on chicken broiler farms from Romania in August-November 2010 to evaluate economic losses due to coccidiosis. Data were collected from six broiler farms of different capacity regarding chemoprophylaxis program, weight gain, feed conversion, and mortality, for two previous flocks in two houses of each farm, and finally we evaluated the economic losses. Also, faeces samples were collected and oocysts were classified according to their size, and virulence of each *Eimeria* spp. field isolate was determined by lesion scoring. Correlations between economic performance, oocysts category, and virulence of *Eimeria* were assessed by multiple linear regression. 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 poor feed conversion (65.2%). Poor body weight gain was associated with AM oocyst category (presumptively *E. acervulina* and/or *E. mitis*), high lesion score in the duodenum, and coccidiostat used for chemoprophylaxis. Feed conversion ratio was linked to the same parameters as body weight gain, minus 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 the grower 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 programme 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 the poultry industry, caused by apicomplexan parasites belonging to the genus *Eimeria* that develop in the epithelial cells of the gut. Seven species of *Eimeria* are widely recognized to infect chickens: *E. acervulin*a, *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, *E. acervulina*, *E. tenella*, *E. maxima*, and *E. praecox* are frequently found, 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 the 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 on broiler farms is based on coccidiostats and vaccination (mainly Paracox-8), used partially only in layers and breeders (personal observation). Nowadays, in Europe, 12 commercial products containing chemicals and ionophores are accepted. Their extensive use led to development of drug resistance (Chapman, 1997), which was described globally for all anticoccidial drugs and for all *Eimeria* species (Kawazoe and Fabio, 1994; Peeters et al., 1994; Stephen et al., 1997; Peek and Landman, 2003; Williams, 2006; Abbas et al., 2008; Zhang et al., 2013). However, coccidiosis did not occur on farms with drug-resistant strains of *Eimeria* (Hemsley, 1964), which cause subclinical coccidiosis expressed by poor weight gain and high feed 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 two billion euro (Peek and Landman, 2011).

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

Material and Methods

The Union of Poultry Breeders from Romania (UCPR) has 276 members, comprising 18 large (produce over 10 thousand tonnes of meat/year), 22 medium (produce between 5-10 thousand tonnes of meat/year), and 236 small (produce less than 5 thousand tonnes of meat/year) poultry companies. The production of poultry meat in 2010 was about 317 thousand tonnes. Average performances in the same year were: daily body weight gain, 54.19 g; feed conversion ratio, 1.859; mortality, 4.24%; and European Production Index, 299.15 (data from the 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.

Chemoprophylaxis of coccidiosis, on the farms included in the study, was performed 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 six used the same coccidiostat for both flocks in a house. Otherwise, small-size farms used ionophores (lasalocid) for chemoprophylaxis; medium-size farms used ionophores (lasalocid, monensin), chemicals (diclazuril), and a combination of them (narasin + nicarbazin); while large-size farms used only chemicals (diclazuril) (Tables 2 and 3).

The average age at slaughter is about 42 days, and average live weight is 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, 12 farms were sampled by simple random sample picking (confidence interval of 5.45) for anticoccidial sensitivity test (Figure 1). Among these farms, six answered a questionnaire and were included in the present paper. Because only half of farmers filled the questionnaire, the confidence interval increased from 5.45 to 7.85 (confidence level of 95.0%). Farms were subsequently divided according to their capacity into three groups: small (n = 3), medium (n = 2), and large (n = 1). The capacities of these farms are ranged between 9×10^5-2.3 thousand chickens/year and they do not have their own feed mills.

A questionnaire was formulated to record data about coccidiostats used on those farms, chemoprophylaxis program, weight gain, feed conversion, and mortality for two previous flocks (cycles) in two separate houses of each farm.

Economic losses were estimated 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). 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.

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[1])	UCPR[2]
Value of dressed broiler meat/kg	7.36 RON (1.75 E)	UCPR
Value of 42-day-old chicken/kg	5.18 RON (1.23 E)	UCPR
Cost of feed/kg (including the cost of coccidiostats)	1.6 RON (0.38 E)	UCPR
Mortality (%)	4.24	UCPR
Number of chicks/flock	18,000	Farmers
Body weight gain (g/day)	54.19	UCPR
Body weight at slaughter (kg)	2.2	Farmers
Feed conversion ratio	1.859	UCPR
Overhead costs	15%	Williams (1999)

[1] 1 E = 4,2099 RON (average for 2010).
[2] Union of Poultry Breeders from Romania.

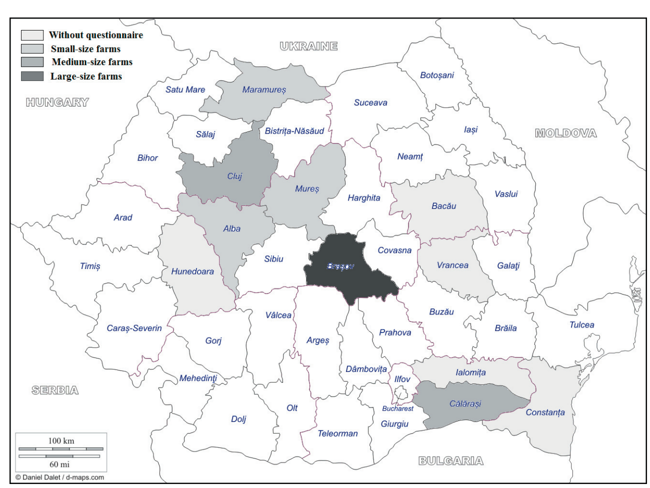

Figure 1 - Location of the farms where the data were collected.

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

Farm	House	Body weight gain (g)		Feed conversion ratio		Mortality (%)		Coccidiosis prophylaxis		Length category (%)			Lesion score			
		F1	F2	F1	F2	F1	F2	F1	F2	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[1]		54.19		1.859		4.24										

F - flock; AM - *E. acervulina* and/or *E. mitis*; NTP - *E. necatrix*, *E. tenella*, and/or *E. praecox*; BM - *E. brunetti* and/or *E. maxima*; D - duodenum; J - jejunum; C - caecum. Las - lasalocid; Nar - narasin; Nic - nicarbazin; Dicl - diclazuril; Mon - monensin; nd - not done.
[1] Data from the Union of Poultry Breeders from Romania.

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

Sample characteristic (mean)	Small-size farms[a] (6 flocks)	Medium-size farms[b] (4 flocks)	Large-size farms[c] (2 flocks)	P-value	Total (12 flocks)	Average in 2010[1]
Body weight gain (g) (range)	53 (42.3-57.5)	56.7 (49.2-62.4)	56.1 (52.4-58.5)	0.19	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)	0.06	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)	0.002	5.5 (2.5-11.9)	4.24
Length category (%) (range)						
AM	39.2 (34.6-52.8)	52 (28.6-87.5)	41.4	0.94	43.1 (28.6-87.5)	
NTP	50.6 (43.5-61.1)	31.8 (12.5-42.9)[a]	44.6	0.02	44.4 (12.5-61.1)	
BM	10.2 (1.4-21.7)	16.2 (0-28.6)	11.6	0.09	12 (0-28.6)	
Number of categories involved (n) (range)						
One length category	0	0	0	0.67	0	
Two length categories	2	1	0		3	
Three length categories	4	3	2		9	
Number of oocysts in inoculum (5,000 oocysts/chicken)						
AM	1960 (1730-2640)	2602 (1430-4375)	2070 (1700-2440)	0.94	2155 (1430-4375)	
NTP	2532 (2175-3055)	1590 (625-2145)[a]	2230 (2195-2265)	0.02	2220 (625-3055)	
BM	509 (70-1085)	810 (0-1430)	578 (115-1040)	0.94	604 (0-1430)	
Lesion score (range)						
Duodenum	1.8 (0.4-4.0)[b]	0.7 (0-1.4)	0.6 (0.5-0.7)	0.03	1.2 (0-4)	
Jejunum	0.1 (0-0.1)	0.1 (0-0.3)	0.4 (0-0.8)	0.61	0.1 (0-0.8)	
Caecum	1.0 (0-2.1)	0.1 (0-0.1)	1.5 (0-3.0)	0.43	0.8 (0-3)	
Total	2.9 (0.4-6.1)	0.9 (0-1.7)	2.5 (1.5-3.5)	0.35	2.2 (0-6.1)	
Coccidiostats	Ionophores (lasalocid sodium)	Ionophores (3) + chemicals (2)	Chemicals (diclazuril)			

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≤0.05.
[1] Union of Poultry Breeders from Romania.

The total loss due to mortality is the sum of equations (1) and (2).

LM (loss due to mortality) = N (no. of chickens dead) × [VC (value of day-old chick) + CCF (cost of cumulative feed consumed by a single bird in 21 days = 43.8% from total) + OC (overhead cost)] (1)

PP (potential profit) = [N × ML (mean live weight of chickens) × SP (selling price per kg of live chickens at processing plant)] – [N × (TRC (total rearing cost of a chicken) − VC)] (2)

Losses due to decreased body weight gain:

TSP (total selling price) = (N × ML × SP) (3)

Losses due to increased feed conversion ratio:

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

Also, faeces samples (12, in total) were collected from two flocks per farm, when chickens were 20-35 days old (median 28 days). Approximately 250 g of fresh faecal droppings/sample were collected along the feed and water lines. The samples were processed once they arrived in the laboratory 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 until 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.

Oocysts in each sample were classified according to the protocol described by Haug et al. (2008b). Briefly, 50 oocysts from each sample were measured with CELL-F software using digital photographs (camera Olympus ODP72) taken with an Olympus BX61 microscope at 400x magnification (Long and Reid, 1982). Oocysts were categorized into three groups: AM group - small oocysts 18.8 µm long (presumptively *E. acervulina* and/or *E. mitis*); NTP group - medium-sized oocysts 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 (presumptively *E. brunetti* and/or *E. maxima*).

To evaluate the virulence of *Eimeria* spp. field isolates, 130 one-day-old broiler chicks (Ross 308) were obtained from a hatchery (Bihor county) and reared as a single group from 1 to 14 days of age, 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 (two isolates per farm). Experimental infection was performed at 14 days old with 5,000 oocysts/isolate. Virulence of *Eimeria* filed isolates was evaluated by lesion score at six days post-challenge using a score of 0-4 according to 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.

Differences in mortality rate, body weight gain, feed conversion ratio, oocyst categories, and lesion score between farms according to their capacity were evaluated by one-way analysis of variance (ANOVA) (GraphPad software) and a P-value of <0.05 was statistically significant. In addition, correlations between economic performance, oocyst category, and virulence of *Eimeria* isolates were assessed by bivariate linear regression in GraphPad software.

Results

The averages of body weight gain (BWG), feed conversion ratio (FCR), and mortality on the farms included in the present study were 54.8 g/day (42.3-62.4), 2.0 (1.6-2.4), and 5.5 % (2.5-11.9), respectively. The lowest BWG was recorded on farm “A”, a small-size farm (42.3 g/day/chicken in house 2, flock 2), and the highest on farm “C”, a medium-size farm (62.4 g/day/chicken in house 1, flock 1). The best FCR was observed on farm “G”, a medium-size farm (1.6 in house 1, flock 1), and the lowest on farm “A” (2.4 in house 1, flock 2). The lowest percentage of mortality (2.5-3.2%) was observed on farm “C”, while farms “A” (6.4-11.9%) and “J” (6.6-10.6%) had the highest mortality.

Al three categories of oocysts (AM, NTP, and BM) were found in 10 out of 11 flocks (Table 3), the most prevalent being AM (43.1%) and NTP (44.4%) groups. Prevalently on small-size farms was NTP group (50.6%), while on medium-size farms was AM group (52%). On 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) on small (TLS = 2.9) and large-size (TLS = 2.5) farms than on medium size-farms (TLS = 0.9) (Table 3). Overall, the lesion score was the highest in the duodenum [1.8(0.4-4.0)] on small-size farms and in the caecum [1.5(0.0-3.0)] on large-size farms. The most virulent *Eimeria* spp. field isolates were found on 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).

Body weight gain was associated with oocyst category AM, lesion score in the duodenum, and coccidiostat used for chemoprophylaxis (Table 4). Feed conversion ratio was linked to the same parameters as BWG, minus 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 intake (65.2%). Nevertheless, two farms out of six recorded profits. The highest economic losses were recorded on 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 intake, respectively. If on large-size farms the economic losses were due to mortality and FCR, on small and medium-size farms, BWG was also incriminated.

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% the economic losses in the 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 did not 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 did not apply any treatment for coccidiosis in the investigated flocks.

Important economic losses were due to mortality (24.4% on small-size farms and 43.9% on the large-size

Table 4 - Results of linear regression regarding the correlation between economic performance and oocyst categories and lesion score in the gut and chemoprophylaxis of coccidiosis

	Body weight gain coefficient (SD)	P-value	Feed conversion ratio coefficient (SD)	P-value	Mortality coefficient (SD)	P-value
AM (*E. acervulina* and/or *E. mitis*)	0.60 (0.40)	0.052	−0.6 (0.40)	0.053	−0.45 (0.44)	0.16
NTP (*E. necatrix*, *E. tenella*, and/or *E. praecox*)	−0.45 (0.35)	0.16	0.40 (0.36)	0.23	0.29 (0.37)	0.38
BM (*E. brunetti* and/or *E. maxima*)	−0.33 (0.78)	0.32	0.60 (0.66)	0.05	0.67 (0.62)	0.02
Lesion score in duodenum	−0.68 (1.06)	0.02	0.60 (1.12)	0.04	0.52 (1.19)	0.08
Lesion score in jejunum	0.29 (0.9)	0.38	0.31 (0.85)	0.32	0.52 (0.77)	0.08
Lesion score in caecum	−0.05 (1.28)	0.88	0.47 (1.07)	0.12	0.42 (0.93)	0.02
Total lesion score	−0.44 (2.12)	0.17	0.63 (1.75)	0.03	0.66 (1.69)	0.02
Chemoprophylaxis of coccidiosis	0.56 (0.49)	0.07	−0.28 (0.64)	0.38	−0.10 (0.66)	0.76

SD - standard deviation.

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

Farm	Mortality	Body weight gain	Feed conversion ratio	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	

farm). These flocks presented high percentages of mortality, between 6.6 and 11.9. The causes of mortalities on a farm can be multiple, but in our cases we suspect they were caused by infection with *E. tenella*. On farms with high mortalities, the lesion score in the caecum after infection with 5,000 oocysts of *Eimeria* spp. was between 2 and 3, and the NTP oocyst category were predominant. Moreover, after statistical 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 causes bloody lesions, high morbidity, and mortality in chickens (Morris et al., 2007; Iacob and Duma, 2009). On these farms, there were possibly 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, such as environmental and management factors; lack of use of overalls by visitors; poor hygienic status; personnel who might also be working on other farms; feeding and drinking systems, which are more difficult to clean; presence of other diseases on the farm; and *Eimeria* species found in the previous flock, which increases 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 statistically associated with oocyst category AM, score lesion in the duodenum, and total lesion score. In India, losses due to increased FCR are estimated at 23.74% from total cost (Bera et al., 2010).

In the world, economic losses due to subclinical coccidiosis are significant, estimated at more than US$3 billion 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 Rs1.089.170.162 (~€15,210,694.20) (Bera et al., 2010), and in the 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 on small- and large-scale farms, respectively (Kinung'hi et al., 2004). Generally, it is assumed that 70% 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 varies 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, 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 on Romanian broiler farms to monensin, salynomicin, 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 coccidiostats (ionophores) used for chemoprophylaxis. It is well known that ionophores do not prevent replication of *Eimeria* completely (Chapman and Johnson, 1992) as chemicals do. To prevent drug resistance, rotation of coccidiostats and shuttle programmes are recommended. Small and medium farms in Romania do not have their own feed mill and in the most cases they cannot control the prophylaxis program (personal observation).

Investigated farms had mixed infections with all three categories of oocysts. In an epidemiological PCR study on Romanian broiler farms, *E. acervulina*, *E. tenella*, *E. maxima*, and *E. praecox* were identified (Györke et al., 2011b). The mixed infections are most likely more prevalent on small and medium farms due to poor management and bio-security practises such as high stocking densities, reduced time between successive grow-outs (Lobago et al., 2005), microclimate, and workers (Kiani et al., 2007), but this was not our case; we found mixed infections in all three types of farms.

Conclusions

Statistical analysis regarding correlation between economic performance, oocyst category, and virulence of *Eimeria* isolates showed that epidemiological survey of broiler flocks during the grower 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 poor feed conversion. Moreover, a good prophylaxis programm can reduce the economic impact of coccidiosis.

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