EIMERIOSIS SEASONAL DYNAMICS PATTERNS AT AN ORGANIC SHEEP FARM IN THE CZECH REPUBLIC*

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This epidemiological study monitored the occurrence of the coccidia genus *Eimeria* and their species composition over a one-year period at an organic sheep farm in the Czech Republic. Individual faecal samples were collected from thirty lambs and thirty ewes once a month throughout the whole survey. As a result, 348 and 333 samples from ewes and lambs respectively were evaluated using the faecal flotation technique. The overall prevalence of eimeriosis was 75.7% and 54.0% for lambs and ewes respectively. Four *Eimeria* species (*E. ovinoidalis*, *E. crandallis/weybridgensis*, *E. parva*, and *E. intricata*) were identified in both, lambs and ewes, during this survey. The most prevalent species was *E. ovinoidalis*, with an overall prevalence of 84% in ewes and 85% in lambs, followed by *E. parva* and *E. crandallis/weybridgensis*. The oocysts faecal output was seasonal. The highest oocysts per gram levels were detected in February (139 000) and May (250 000) in ewes and in February (1 949 900), March (326 000), and May (187 700) in lambs. The intensity of *Eimeria* infection differed significantly ($P < 0.0001$) between ewes and lambs during the monitored period.

ovine coccidia, faecal flotation, prevalence, epidemiology, organic farming

DE GRUYTER OPEN

doi: 10.1515/sab-2017-0013

Received for publication on May 30, 2016

Accepted for publication on January 19, 2017

INTRODUCTION

Coccidiosis, caused by protozoan parasites of the genus *Eimeria*, is a highly prevalent infection affecting both housed and pastured sheep (Mundt et al., 2009), mostly lambs aged between four and eight weeks (Gauly et al., 2004; Saratsis et al., 2011). Coccidiosis is a serious parasitic infection of veterinary importance in ruminants throughout the world. The great economic importance of coccidiosis is due to diarrhoea and reduced growth, which causes lowered productivity (Gauly et al., 2001; Chartier, Paraud, 2012). Depending on the degree of infection in host and conditions that support intensive transmission, some of *Eimeria* species could be serious pathogens (Cox, 1998). Fifteen *Eimeria* species were described as etiological agents for sheep coccidiosis and ten of them have been found in Central Europe (Reeg et al., 2005). *Eimeria ovinoidalis*, *E. bakuensis*, *E. crandallis/weybridgensis*, *E. parva,* and *E. faurei* were described as a predominant causal agent of sheep eimeriosis in Central Europe (Platzer et al., 2005). In temperate climate conditions in Europe, as the most prevalent and the most pathogenic *Eimeria* species in sheep, especially in lambs, was suggested *E. ovinoidalis* followed by *E. crandallis/weybridgensis* (Reeg et al., 2005; Chartier, Paraud, 2012). Mixed infections with more or mild pathogenic *Eimeria* species are common (Jolley, Bardsley, 2006).

The life cycle of each *Eimeria* species is host-specific, direct, and involves sexual and asexual stages (Andrews, 2013). Sheep become infected with coccidia by the ingestion of sporulated oocysts with contaminated food or water (Jolley, Bardsley, 2006). The intensity and effect of eimeriosis on the animal health depends on the local environment condi-

* Partially supported by the Czech University of Life Sciences Prague, Internal Grant Agency (Project No. 20162012).

tions and on the immunity of each animal (G a u l y et al., 2004). The development of clinical or subclinical coccidiosis is affected by several factors like breeding management, animal density, hygiene, prolonged transport of animals, dietary changes, and other stress factors (S a r a t s i s et al., 2011). The adult animal acquires significant protective immunity to the pathogenic effect of eimeriosis (V a s i l k o v á et al., 2004; S a r a t s i s et al., 2013); this phenomenon is accompanied by shedding of small oocyst counts in faeces. However, these animals with mild eimeriosis contaminate the environment and are the main source of infection for lambs, particularly in the lambing period (A i t k e n , 2007). The first contact of lambs with infective oocysts comes within their first days of life (G a u l y et al., 2004) due to contamined udders of ewes. Later, straw on the floor or water containing infective oocysts from ewes or older lambs is the source of infection (P o u t , 1973; G r e g o r y et al., 1983).

Diagnosis of eimeriosis is often based only on clinical symptoms or presence of oocysts in faeces (A n d r e w s , 2004). Diarrhoea, the clinical sign of coccidiosis, usually coincides with the beginning of the oocysts excretion (A i t k e n , 2007). Unfortunately, serious infections caused by pathogenic coccidia species may induce diarrhoea before the oocysts excretion is initiated.

The aim of this study was to monitor the seasonal occurrence of the eimeriosis over a one-year period, the prevalence of this infection and coccidia species composition in ewes and lambs at an organic sheep farm under conditions of temperate climate.

MATERIAL AND METHODS

The study was carried out at an organic sheep farm located in the district of Sokolov (West Bohemia), near the Czech-German border (50.30°N, 12.53°E). The farm is located in the highland area at an altitude of 566 m a.s.l. Pastures (131 ha) are located approximately at the same altitude. The basic climatological parameters obtained from the Czech Meteorological Institute are presented in Fig. 1. The flock of sheep comprised 255 ewes, 50 lambs, and 6 breeding rams of the Czech national breed 'Šumavka'. The breeding rams were added to the flock of ewes from early August to early October. Lambing took place in a stable from December to March. Ewes were separated after lambing for 2–3 days. For the purpose of our study, which was conducted from February 2014 to January 2015, thirty ewes and thirty lambs were selected.

The grazing season on the monitored farm began in May 2014 and ran until November 2014. The animals had no access to the stable during the grazing period. Pastures were not used by other ruminants. Access to water on the pasture was provided by a mobile tank. From the first snow until mid-May, the herd was stabled without access to the pasture. Breeding rams were placed in their own barn. The deep litter removal in the stable ran once in the winter time.

Before this survey, lambs intended to be sold were only therapeutically treated with sulfadimidine (Sulfacox T) after the coprological examination performed upon appearance of diarrhoea. Throughout our study the animals were not given any antiparasitic drugs.

Faecal samples were collected from preselected, permanently marked lambs and ewes in the stable or on the pasture. Samples were collected directly from the rectum, monthly throughout the year survey, and stored in the labelled plastic bags at 4°C until examination.

The modification of the McMaster method (C o l e s , 2003), with a sensitivity of 50 oocysts per gram (OPG), was used for quantifying the faecal parasite output. *Eimeria* oocysts identification was based on their morphology according to T a y l o r et al. (1995). Oocysts of *E. crandallis* and *E. weybridgensis* were united to one group *E. crandallis*/*weybridgensis* because of their morphological similarity.

Statistical analysis

Data were statistically evaluated using one-way ANOVA in the STATISTICA software package (Statistica 12, StatSoft ČR, 2012). This method was used to verify the existence of a statistically significant difference in the influence of months (season) on the progress of OPG excretion during the monitored period. The level of 99% was considered as statistically significant. Due to the unequal number of samples in individual months, the HSD post-hoc test was applied for adjusting the level of the unequal number of samples.

RESULTS

In our study, we collected 348 faecal samples from ewes and 333 from lambs. The overall prevalence of coccidia oocysts was 75.7% for lambs and 54.0% for

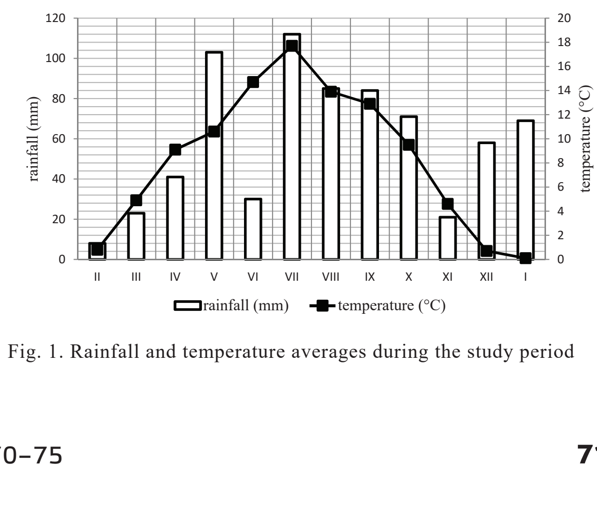

Fig. 1. Rainfall and temperature averages during the study period

Table 1. Prevalence (%) of the most abundant *Eimeria* species, extreme OPG values recorded in individual months of our survey, and standard deviation for each month and animal category

Month	Prevalence								Intensity of infection					
	E. ovinoidalis		*E. crandallis/ weibridgensis*		*E. parva*		*E. intricata*		min. OPG		max. OPG		SD	
	E	L	E	L	E	L	E	L	E	L	E	L	E	L
II	93	100	53	46	30	100	0	0	0	4900	139 000	1 949 900	69 500	972 500
III	36	100	53	60	23	96	0	13	0	6600	550	326 000	275	159 700
IV	76	89	40	82	10	53	0	28	0	550	4000	61 100	2000	30 275
V	79	86	10	27	0	17	0	0	0	0	250 000	187 700	125 000	93 850
VI	17	96	3	58	0	41	3	24	0	100	500	18 000	250	8950
VII	27	86	10	51	0	34	0	20	0	0	1000	9900	500	4950
VIII	51	28	17	3	0	0	0	3	0	0	620	2400	310	1200
IX	35	54	25	16	0	4	0	0	0	0	3400	10 300	1700	5150
X	27	39	20	14	0	0	0	0	0	0	1200	1500	600	750
XI	27	75	0	25	3	0	0	0	0	0	400	2900	200	1450
XII	28	51	7	7	0	0	3	0	0	0	400	3000	200	1500
I	21	39	7	17	0	0	3	0	0	0	600	300	300	150

OPG = oocysts per gram of faeces, SD = standard deviation, E = ewes, L = lambs

ewes. The following *Eimeria* species were identified: *E. ovinoidalis*, *E. crandallis/weybridgensis*, *E. parva,* and *E. intricata*. *E. ovinoidalis* was found as the most prevalent, with an overall prevalence of 84% in ewes and 85% in lambs (Table 1). We found statistically significant differences in numbers of oocysts shedding throughout the whole survey between ewes and lambs. There was a level of 139 000 OPG in ewes in February (Table 1); however, at the beginning of the grazing season in May 2014 (Fig. 3), up to 250 000 OPG were observed. After their birth in February 2014, lambs shed up to 1 949 900 OPG (see Fig. 2), and after the start of the grazing season in May 2014, they shed 187 700 OPG. The number of OPG was ten times higher than in ewes.

DISCUSSION

Eimeria species composition recovered in our study coincides with that commonly occurring in Central Europe (G a u l y et al., 2001; R e e g et al., 2005; D i t t m a r et al., 2010). The most prevalent *Eimeria* species in our study, *E. ovinoidalis, E. crandallis/*

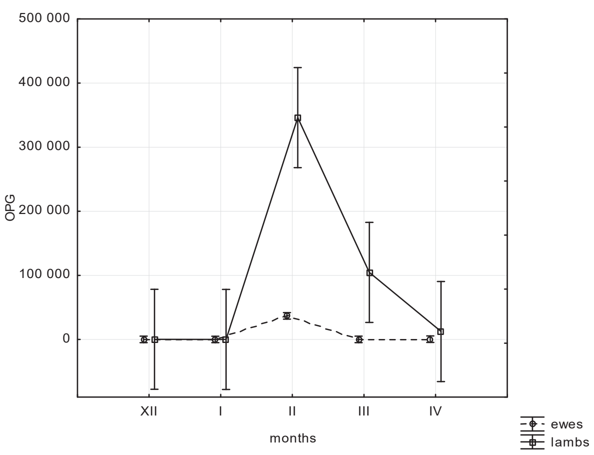

Fig. 2. Seasonal dynamics of oocysts shedding in ewes and lambs during the period when the animals were in the stable
OPG = oocysts per gram of faeces

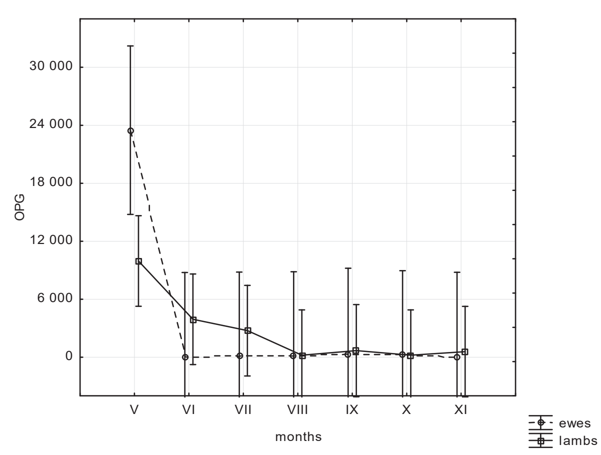

Fig. 3. Seasonal dynamics of oocysts shedding in ewes and lambs during the period when the animals were on the pasture
OPG = oocysts per gram of faeces

weybridgensis, E. intricata, and *E. parva*, were identified in both ewes and lambs (Table 1). Lopes et al. (2013) found no differences regarding the occurrence of *Eimeria* species between animals in various age. The most prevalent *Eimeria* species in our study was *E. ovinoidalis* with prevalence 84% and 85% for ewes and lambs, respectively. Vasilková et al. (2004) described in their study conducted in Slovakia *E. parva* followed by *E. ovinoidalis* as the most abundant in both animal categories. A high prevalence (85–95%) of *E. ovinoidalis* at sheep farms in Germany described Reeg et al. (2005). According to Catchpole et al. (1976), the predominance of this *Eimeria* species could be explained by the high fertility of *E. ovinoidalis* compared to other species in sheep.

The intensity of infection in ewes and lambs during the monitored period showed statistically significant differences ($P < 0.0001$). After a peak in February (Table 1), when the OPG level reached 139 000 in ewes and 1 949 900 in lambs, output declined during March and April in both (Fig. 2). After the transition of ewes and lambs from the stable to the pasture in May (Fig. 3), the OPG shedding increased again. In May, the OPG in ewes reached a higher level (250 000 OPG) while in lambs a significantly lower level (187 700 OPG) than in February. The OPG declined from May till June (500 OPG) in ewes and from May till August (2400 OPG) in lambs. The curve of OPG did not change distinctly from March in ewes and from August in lambs till the end of our study. No studies monitoring the seasonal dynamics of *Eimeria* oocysts shedding in similar climatic conditions and breeding management were found to compare the results found in our study.

According to de Souza et al. (2015), the animal age category is a significant factor influencing oocysts shedding. Young animals are more affected by eimeriosis because of their lower immunological status. Oocysts shedding decreases to a lower OPG level with the age of the animals; this is related to the development of immunity as a response to naturally received infection (Gauly et al., 2004). This age-related phenomenon was also observed in our survey. The high level of oocyst counts in lambs was observed at the beginning of the monitoring period after birth (February); the OPG level detected in lambs was at that period ten times higher than in ewes. This high OPG in lambs in the first three months of our study corresponds with the well-known fact that eimeriosis mostly affects young lambs aged 4–8 weeks (Scala et al., 2014). According to Gregory et al. (1989) the susceptibility of lambs to *E. ovinoidalis* and *E. crandallis* increases up to 4 weeks of age. The possible sources of infective oocysts in this period may be the high number of oocysts shed by ewes around the lambing, when their immunity is low. Another source of infection may be oocysts surviving in faeces or oocysts shed by older lambs (Pout, 1973). The decrease in OPG in April in lambs can be explained by the development of immunity. Oocysts are mostly shed around the time of weaning, but then, after a short peak, decline due to the development of strong animal immunity (Platzer et al., 2005; Chartier, Paraud, 2012). The increased OPG in lambs in May and June can be explained by the transition from the stable to the pasture. Pasture may be the source of infective oocysts the same as the stable (Craig, 2009). According to Helle (1970), infective oocysts are able to survive winter on the pasture and stay infective especially for young animals in the next grazing season.

Aitken (2007) reported that the clinical sign of coccidiosis includes acute diarrhoea. In severe cases, especially in infections caused by *E. ovinoidalis,* bloody diarrhoea may be a symptom of intestinal epithelium damage. This author also noted that diarrhoea usually coincides with the beginning of the oocysts shedding. In our study, the highest oocyst counts were not associated with an increased incidence of diarrhoea. The non-bloody diarrhoea was observed in ewes in May, and this sign was associated with increased OPG levels. However, this diarrhoea had probably dietological origin and it was a consequence of the animal transition from the stable to the pasture.

Local climate conditions, especially the moisture after rain, may influence the *Eimeria* prevalence (de Souza et al., 2015). The climate conditions during the monitored period are shown in Fig. 1. Oocysts pass with faeces into the environment and sporulate according to the suitability of climate conditions; temperature, moisture, and oxygen are especially important (Chartier, Paraud, 2012; Taylor, 2012; de Souza et al., 2015). During our study increased oocyst counts were not reported in the warm and moist weather conditions. *Eimeria* oocysts are present on the land surface and because they are not motile, they need to be directly ingested to cause infection. For this reason, the height of vegetation on the pasture may affect the *Eimeria* infection patterns. This can explain the absence of correlation between the OPG level and the weather conditions during our survey.

CONCLUSION

Predicted climate changes have a potential negative impact on sheep breeding and on the epidemiological patterns of parasites, their distribution and prevalence. Especially on the free-living stages of parasites which are sensitive to moisture and temperature. Increased rainfall and temperature provide optimal conditions for oocysts development and survival on the pasture. However, there are grazing management practices that can prevent or reduce the risk of coccidiosis. Pasture management should be aimed at reducing the faecal–oral transmission, minimizing stress for the animals, and last but not least at hygiene, which is essential in breeding.

ACKNOWLEDGEMENT

The authors thank Jana Breburdová for help with collection and examination of samples.

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