

The impact of grazing management on seasonal activity of gastrointestinal parasites in goats

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Summary

The aim of this study was to examine the impact of grazing management and other risk factors (age, treatment practices) on seasonal activity of gastrointestinal (GI) parasites in goats. Goat flocks naturally infected with GI parasites reared on four Lithuanian farms representing different management regimes were examined during the grazing season in 2011/2012. On three farms the adult goats were grazed in different ways on open pastures (with or without supplementary feeding) or tethered. On one farm all animals were kept indoor (zero-grazing). On each farm, samples were collected at monthly intervals from 13 – 15 adult and 10 kids. The results showed that grazing of adult goats with feed supplementation or kept indoor, shed the lowest number of strongyle eggs when compared to those kept on pasture ($P < 0.05$). Delayed turnout and zero-grazing significantly reduced excretion of strongyle eggs but increased the output of oocysts when compared to those grazed on set-stocked pasture together with adult goats. The most prevalent genus on all farms and in both age groups of goats were *Teladorsagia* spp. This study demonstrates that goats are infected with mixed species of parasites, but proportions of these parasites differed in different grazing management systems. The grazing management, age and season were all major factors that had an impact on GI parasite infection.

Keywords: goats; grazing management; risk factors; nematodes; *Eimeria* spp.

Introduction

Gastrointestinal (GI) parasites are important pathogens in ruminants including goats. Infection with GI nematodes is still one of the main constraints in dairy goat production (Rinaldi *et al.*, 2007), due to the negative effect of parasites on milk production (Alberti *et al.*, 2012). Production losses in young goats are related to clinical signs such as diarrhea,

mortality and subclinical effects, causing long-term weight loss and reduced growth (Chartier & Paraud, 2012). The risk of infection with parasites (nematodes and coccidia) in goats depends on several factors. One of the main risk factor, which has an influence on the prevalence of parasites, is the prevailing climatic condition. Lithuania is situated in the northern part of the mid-latitude climatic zone, where seasonal fluctuations in the number of trichostrongylid infective larvae is influenced by variations in temperature and moisture on the soil surface (Morgan & Van Dijk, 2012). Eggs of trichostrongylids develop to the infective third larval stage (L_3) above a threshold of around $+4\text{ }^\circ\text{C}$ (O'Connor *et al.*, 2006). The temperature from April to October is therefore favourable for development of the free-living stages on pastures also under Lithuanian climatic conditions. Several other factors may also be associated with GI parasite infection namely grazing management (Manfredi *et al.*, 2010), such as farm size, the stocking rate (Thamsborg *et al.*, 1996) and the age of animals (Cabaret & Gasnier, 1994; Gasnier *et al.*, 1997; Saratsis *et al.*, 2011). Moreover, physiological condition and genetic line may have the influence on individual immunity to GI parasite infections (Manfredi *et al.*, 2010). Designing and planning of control strategies requires the knowledge on the epidemiological factors that influence the risk for GI parasite infections. However published information from Eastern Europe on GI parasites in small ruminants from goats is limited. The aim of this study was to determinate the most important epidemiological risk factors that influence the level of GI infections indicated by parasite egg or oocyst output in goat faeces in Lithuania.

Materials and methods

Study design

The study was performed in four dairy breed goat farms, located in different regions of Lithuania during the grazing

Table 1. The study design

Farm		A	B	C	D
Breed		Czech white	Mixed	Saanen	Czech white
Flock size	Adult	160	20	13	110
	Kids	170	30	15	150
Grazing management	Adult	Open	Tethered	Set-stocked	Indoor
	Kids	Set-stocked	Open with adults	Delayed grazing	Indoor
Grazing period	Adult			15 May – 7 Oct	-
	Kids	25 April – 10 Nov	2 May – 25 Oct	20 Aug – 10 Oct	-
Stocking rate (kg/ha)	Adult	320		1260	-
	Kids	250 – 500	190 – 235	200 – 250	-
Separated pastures/pens for weaned kids		Yes	No	Yes/No	Yes/Pens
Feed supplementation		None	None	Clover, lucerne grass, grains	Fresh grass/hay, grains, vegetables
Number of treatments against GIN/month	Adult	1/Nov	1/Nov	2/May, Oct	1/Nov
	Kids	1/Oct	-	1/Nov	-
Treatment of kids against coccidiosis/month		1/May/June	-	-	-

period (May – November) in 2011 and 2012. The representative farms in terms of flock size and grazing management (Table 1) were selected for the study. On Farms A and B the grazing period lasted from end of April until the beginning of November. The weaned kids on Farm A grazed in a separate paddock while those on Farm B kids grazed freely together with adult-tethered goats. The tethered goats grazed by a rotation principle, and returned to same pastures with 6 – 8 week intervals. On Farm C the grazing started in the middle of May for adults, whereas the kids remained indoors with outdoor access to pens for 5 hours/day from the middle of June until the end of August. During this period the kids were fed a diet comprised a mixture of hay or fresh cut clover, concentrates, some milk and water *ad libitum*. They also had some access to the grass in the pens. Thereafter the kids were turned out on pasture and grazed together with the adult dairy goats. All goats on Farm C were supplementary fed with clover or lucerne grass/hay and milled grains 2 times/day. The goats on Farm D were permanently stabled all the year around, with 10 – 15 animals in isolated pens. They were fed a mixture of fresh grass/hay, milled grains, bagasse and vegetables (carrots, beetroots, apples). Anthelmintics were only used routinely on farms A and C in previous years (received treatments on farms during study period seen in Table 1). Furthermore, toltrazuril (Baycox[®] Bovis) were used against *Eimeria* infection on Farm A due to the onset of severe clinical signs (diarrhea and few lethal cases) among the kids.

Parasitological analyses

On each farm faecal samples were collected from rectum

of 13 – 15 does and 10 kids. The samples were always collected from the same animals at each sampling occasion. The number of nematode eggs (EPG) and oocysts per gram of faeces (OPG) were determined by a modified McMaster technique (Roepstorff & Nansen, 1998) using zinc chloride (density 1.4) with a sensitivity of 20 eggs per gram of faeces.

Triplicate faecal cultures were prepared for each age group per farm by pooling of 1 g of faeces from the animals within the group and mixed with water and vermiculite (Henriksen & Korsholm, 1983). After 10 – 14 days L₃ were obtained for microscopical identification of nematodes to the genus or species level (Van Wyk *et al.*, 2004). Three replicate herbage samples of approximately 400 g of weight were collected from the pastures grazed by goats for the determination of the numbers of nematode larvae. Each herbage sample was collected while walking across the pasture in a W-shaped pattern and retrieving 3 subsamples at every 20 steps. Grass within 20 cm of faecal pellets was avoided. Larvae were isolated as described by Fernandez *et al.* (2001), counted and results were expressed as the number of L₃ per kg of dried grass. Hay and fresh grass samples were not obtained from Farm D as well as grass from outdoor pens on Farm C.

Other analyses

Data on monthly precipitation and average temperature were obtained from meteorological stations situated 7 – 11 km from the examined farms. For comparison the data during 30-year period (1961 – 1990) were obtained from Lithuanian Hydro Meteorological Service.

Parasitological data on EPG/OPG and prevalence of larvae

were analysed using BMI SPSS Statistics (Version 21). Statistical comparison of quantitative faecal egg/oocyst counts between farms or months was performed using Repeated Measures Analysis of Variance (ANOVA). The effect of categorical variables as age (kids – under 6 months, young – 6 – 12 months and adults – over 12 months) and grazing management (open-grazing, tethered, set-stocked of young, young grazing with adults, feed supplementation and zero-grazing) assessed for potential association with strongyle egg and *Eimeria* oocysts in faeces using Linear Mixed Models procedure. The first-order autoregressive (AR1) correlation structure was used by lower Akaike's Information Criterion (AIC). The effect of various factors on *Strongyloides* and *Trichuris* infections were also assessed. The data contained repeated binary measures of infection in goats with *Strongyloides* and *Trichuris* as dependant variables along with a fixed recording of age (young or adult), grazing management (open-grazing, tethered, set-stocked of young, young grazing with adults, feed supplementation and zero-grazing), season (spring, summer and autumn) and treated with anthelmintics or not before/during the study. The Generalized Estimating Equations (GEE) were used to fit a repeated measures logistic regression with this data, using

the effect model with the first-order autoregressive (AR1) correlation structure, given the lower Independence Model Criterion (QIC). A value of $P < 0.05$ was considered statistically significant.

Results

Nematodes

In the beginning of study the number of strongyle eggs in adult goat faeces was decreasing in both years (Figure 1a). Furthermore it started to increase reaching the peak values in July/August (Farm B), September (Farm A) and October (Farm C). The highest egg excretion was recorded on Farm B ($P < 0.001$) during the first year and Farm A ($P < 0.001$) during the second year of study. The lowest egg excretion was recorded on Farm D ($P < 0.05$) where 43.8 and 60.0 % of goats were not infected with strongyles in 2011 and 2012, respectively.

In beginning of study the egg excretion in young goats was low on Farms A and B (Figure 1b). Furthermore it started to increase reaching the peak values in September (Farm B) and September/October (Farm A). The highest excretion of eggs was observed in young goats on Farm B ($P < 0.05$) in 2011, and Farm A ($P < 0.001$) in 2012. Egg

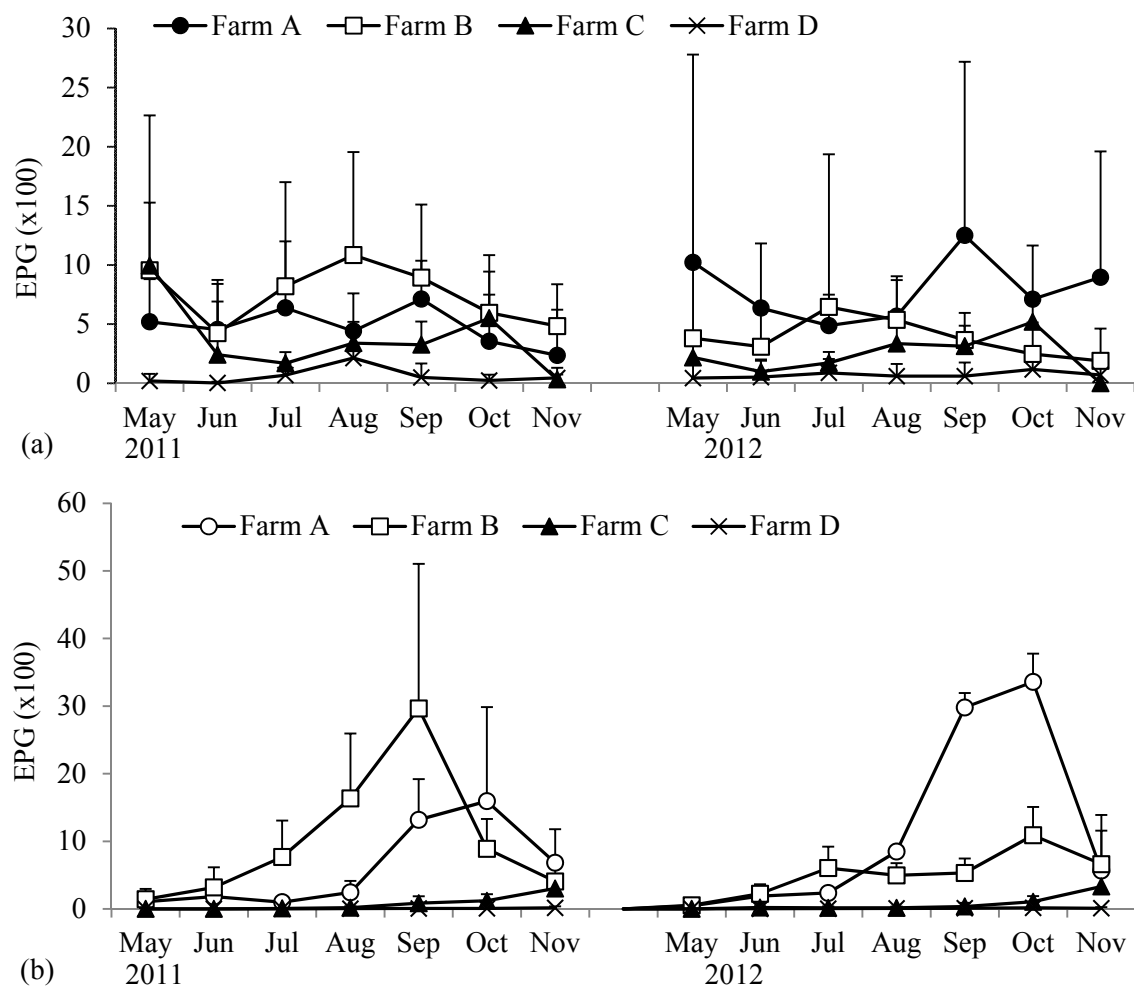


Fig. 1. The mean number of strongyle nematode eggs per gram (EPG) of dairy goat (a) and kid/young goat (b) faeces during grazing periods in 2011 – 2012

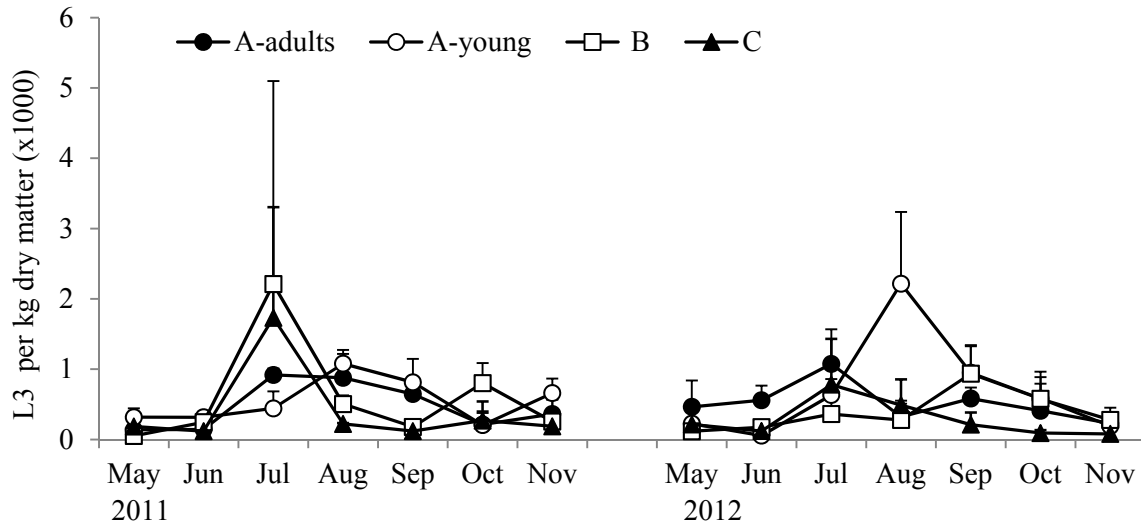


Fig. 2. The mean number of L₃ stage larvae per kg dry matter of grass on farms during grazing periods in 2011 – 2012

excretion in young goats started in June and remained low throughout the study on Farms C and D. On these farms the young goats were least infected with strongyles (41.4 and 82.9 %, respectively).

Analyses of nematode larvae from faecal cultures showed that strongyle nematode population in adult and young goats consisted of *Teladorsagia* (44.9 %), *Trichostrongylus* (25.6 %), *Oesophagostomum* (18.9 %), *Chabertia* (5.5 %) and *Haemonchus contortus* (5.1 %). The highest prevalence of *Teladorsagia* was recorded in adult goats on Farm D (36 – 82 %). *H. contortus* was frequently recorded on Farms A and B and with the highest prevalences ($P < 0.05$) in May, July and October (13 – 45 %). On all farms the prevalence of *Teladorsagia* and *Trichostrongylus* were comparable in both years. The prevalence of *Oesophagostomum* was higher in 2011, while *Chabertia* and *H. contortus* in 2012 ($P < 0.05$).

Teladorsagia was the dominant genus on all farms. *H. contortus* were recorded only on Farms A and B, while it was not recorded at all on Farms C and D. The excretion of *H. contortus* eggs started in June and the highest prevalence ($P < 0.05$) was recorded in July – September. The prevalence of *Oesophagostomum* was significantly lower ($P < 0.05$) on Farm D when compared to those on other farms. There were no significant differences between farms for other nematodes. The significant higher proportion of *H. contortus* was observed on Farm A in 2012 and *Oesophagostomum* on Farm C in 2011.

Pasture contamination

The number of larvae was low (51 – 464 L₃/kg) after turnout on all farms in both years (Figure 2). In June – July it increased steeply reaching the values of 2210 ($P < 0.05$) and 1730 ($P < 0.05$) L₃/kg of dry grass on Farms B and C respectively in 2011. The larval contamination on Farm A increased in July on the pasture grazed by the adults and month later on the pasture for the young stock. However, it was lower when compared to those on Farms B and C ($P > 0.05$).

In the second year of study contamination of grass with infective L₃ stage larvae experienced a different pattern. The numbers of larvae were low throughout the season on Farms B and C while it increased in August ($P > 0.05$) on the pasture grazed by the young animals on Farm A.

Oocysts

In total 812 of dairy goat and 560 of young goat samples were examined. Of those 794 (97.8 %) and 550 (98.2 %) contained *Eimeria* spp. oocysts respectively. The output of oocysts in adult goats on Farms A and B was higher in October/November in both years (Figure 3a), while on Farm C it peaked in August. The continuously elevated output of oocysts in the faeces was recorded on Farm D ($P < 0.05$) when compared to those on Farms A and B.

The oocyst counts in young goat faeces were low ($P < 0.01$) of Farm B when compared to those on Farms A, C and D (Figure 3b). In 2011 the increase in oocyst production was recorded in July on all farms with the highest oocyst excretion on Farm C (above 15,000 OPG). In 2012 the higher oocysts excretion was recorded in beginning of study (May to June on Farms A and D).

Risk factors

The results from Linear Mixed Model analysis showed higher ($P < 0.001$) strongyle egg counts in young (6 – 12 months) goats as well as oocyst counts in kids and young goats when compared to those of adult animals (Table 2). The output of strongyle eggs was significantly reduced with zero-grazing management, when compared to those in other systems. However, zero-grazing was associated with increased oocyst excretion when compared to most of other grazing regimes. Only free grazing of young animals together with adults had significant association with decrease in oocyst excretion.

The cestode *Monezia expansa* infection was recorded only in young goats grazed on pastures (data not shown). The impact of significant risk factors for the presence of *Strongyloides* and *Trichuris* was performed (Table 3). The GEE

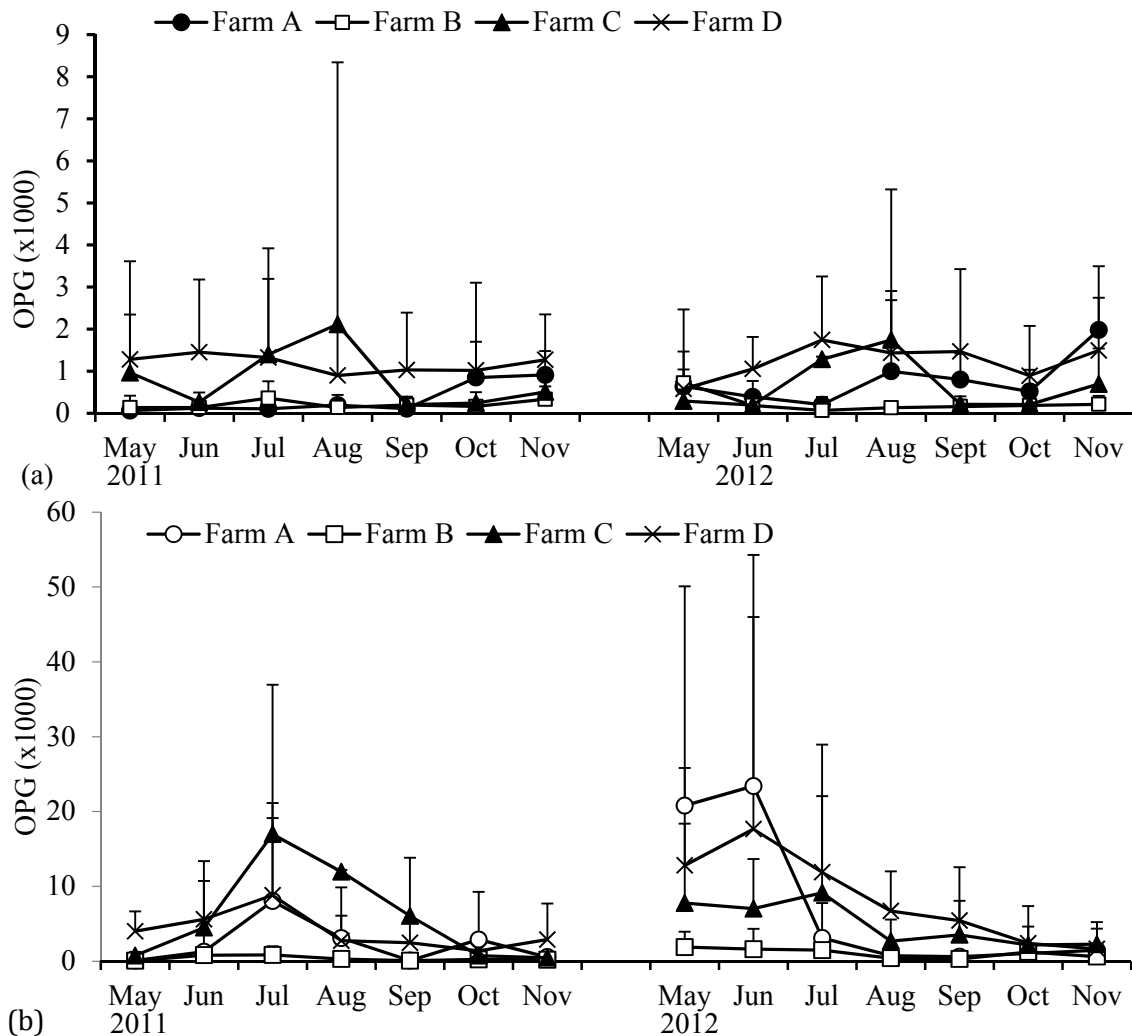


Fig. 3. The mean number of *Eimeria* oocysts per gram (OPG) of dairy goat (a) and kid/young goat (b) faeces during grazing periods in 2011 – 2012

model suggested that young goats were significantly lower infected with *Strongyloides* and *Trichuris* in summer period. The open-grazing and tethered grazing management has decreased the incidence of *Strongyloides* infection when compared to those of zero-grazing. The presence of regular anthelmintic treatments on farms was a significant regressor with *Strongyloides* infection.

Meteorological data

The monthly temperature was comparable on all farms. The highest average temperature was in July +18.9 – 19.6 °C. In comparison to multi-annual average values the temperature was higher by 1 – 3 °C during the grazing season particularly in June, 2011. The rainfall was lower in 2011 when compared to those of 2012, but still higher than multi-annual average value. The highest precipitation (58.0 – 170.6 mm) was recorded in July and August 2011 and 2012 on all farms.

Discussion

Teladorsagia was the most prevalent genus observed in this study irrespective of goat age and farm management. This genus was similarly predominant on goat farms in Norway (Domke *et al.*, 2013), France (Chartier & Reche, 1992), Greece (Papadopoulos *et al.*, 2003) and Spain (Valcarcel *et al.*, 1999). Under colder laboratory conditions *Teladorsagia circumcincta* reach the infective stage to a larger extent than those of *Trichostrongylus colubriformis* (O'Connor *et al.*, 2006). The larvae of *Teladorsagia* are therefore likely to be able to result in an early pasture contamination with infective stage larvae. That may explain why it was the only genus isolated from grass samples in May in present study.

Nematode egg counts in the faeces from the adult goats were elevated in beginning of study and thus could be regarded as the result of spring/post-parturient rise. This was presumably associated with resumed development of inhibited larvae in spring due to depressed immunity

Table 2. The impact of age and grazing management on strongyle egg and *Eimeria* oocyst counts in goat faeces

Factor	Variable	EPG		OPG	
		Beta Estimate (P-value)	95 % CI	Beta Estimate (P-value)	95 % CI
Age	Kids (<6 months) ^a	-502.8 (0.000)	-646.9 – -358.8	6934.9 (0.000)	5601.2 – 8268.5
	Young (6 – 12 months) ^a	245.9 (0.002)	88.6 – 403.1	2624.2 (0.001)	1084.1 – 4165.7
Grazing management	Open-grazing (adults) ^b	509.5 (0.000)	333.4 – 685.6	-820.5 (0.281)	-2317.2 – 676.2
	Tethered (adults) ^b	464.7 (0.000)	288.6 – 640.8	-1021.2 (0.178)	-2509.4 – 467.1
	Set-stocked (young) ^b	413.9 (0.000)	192.7 – 635.1	-1285.6 (0.155)	-3060.6 – 489.4
	Open-grazing (young + adults) ^b	879.4 (0.000)	658.2 – 1100.5	-5950.6 (0.000)	-7723.5 – -4177.6
	Feed suppl. (2 treatments) ^b	131.7 (0.032)	11.6 – 251.9	-539.1 (0.391)	-1775.7 – 697.5

^a Compared with adult group^b Compared with zero-grazing management

against strongyle nematodes during lactation period (Chauhan *et al.*, 2003). It can be assumed that adult animals served as the source for pasture contamination with strongyle eggs in spring and early summer leading to increased numbers of infective L₃ stage larvae on pastures in July and August. In adult animals the excretion of strongyle eggs markedly increased in August and September, while in young goats - September or October as the result of increased contamination of pastures in July and September. Results of our study show that FEC in goats and particularly young goats were significantly higher on Farms A and B when compared to those on Farms C and D, where different management including feed supplementation and double anthelmintic treatment or zero-grazing, prevented the animals from the high level of infection. Feed supplementation with red clover and lucerne on Farm C reduced the intake of infected grass from pasture and enriched the diet with proteins. It has been shown that protein supplementation provides positive effects to improve the host response to nematodes (Hoste *et al.*, 2005). Additionally, the red clover (*Trifolium pratense*) and lucerne (*Medicago sativa*) are characterised as bioactive ingredients, containing some amount of condensed tannins. The legume forages were represented as potential sources for secondary compounds affecting different stages of parasites (Hoskin *et al.*, 2003; Hoste *et al.*, 2005).

The infective larvae of *Ostertagia/Teladorsagia* are able to survive during the winter and persist on pasture until early June (Šarkūnas *et al.*, 2007; Koopmann *et al.*, 2009). Even in low numbers these larvae may serve as the source of infection in separately grazing young animals. Thus delayed turn-out could serve as control measure for preven-

tion of early GIN infections in young stock. On Farm C the young goats were turned out and grazed together with the adults in August when pasture contamination has decreased. The kids have therefore avoided the most risky period for infection and excreted very low numbers of eggs until the end of the grazing season when compared to those on Farms A and B, despite of higher grazing intensity. Anthelmintic treatment during the first weeks on pasture significantly reduced the infection level in the adult goats on Farm C but it did not prevent from the increased pasture contamination observed in July. Due to low exposure of adult animals to infective stages by the end of grazing season in 2011 the egg excretion in 2012 was lower when compared to those on Farm A ($P > 0.05$) and Farm B ($P > 0.05$).

The clinical manifestation of trichostrongylid infection usually may be observed in kids, as fully expressed immune response against parasites appears in the age of 12 months (Hoste *et al.*, 2010). In the present study kids less than 6 months of age were less infected with strongyles, while young goats older than 6 months of age had higher egg excretion when compared to those of adults. While in some studies no significant impact of age on GIN infection in young and adult goats was recorded (Magona & Musisi, 2002), kids are considered as the most susceptible age group for GIN infection (Mandonnet *et al.*, 2003).

Kids on Farm B were exposed to highest contamination of pastures in July, which subsequently led to highest strongyle infection in both adult and young animals in 2011. However such situation was markedly improved by anthelmintic treatment administered in November 2011. This resulted in markedly reduced pasture contamination

Table 3. The incidence of *Strongyloides* and *Trichuris* nematode eggs in faeces and significant risk factors for infection

Parasite	No pos./exam. (%)	Factor	Variable	Beta Estimate	OR (95 %CI)
<i>Strongyloides</i>	373/1372 (27.2 %)	Age	Young ^a	-1.09	0.34 (0.19 – 0.61)
			Grazing management	Open-grazing ^b	-0.64
		Tethered		-0.59	0.551 (0.33 – 0.91)
		Season		Summer ^c	-0.29
		Treatment	No	0.82	2.26 (1.52 – 3.37)
<i>Trichuris</i>	168/1372 (12.2 %)	Age	Young ^a	-1.50	0.22 (0.09 – 0.54)
			Season	Summer ^c	-0.69

^a Compared with adult group

^b Compared with zero-grazing

^c Compared with the autumn

($P > 0.05$) and a delayed peak contamination observed in September 2012 and lower infection levels in both adult ($P < 0.01$) and young animals ($P < 0.001$) in 2012.

Pasture contamination and infection of adult and young animals exhibited a different pattern on Farm A. As young animals were set-stocked on the same pasture in both years this resulted in higher accumulation of infective stages on the grass in August 2012 ($P > 0.05$) when compared to those of previous year on the same pasture. This was followed by proportional increase in egg excretion in young animals manifested in 2012 ($P < 0.001$).

Oesophagostomum, *Chabertia* and *H. contortus* infection was lower on farms with zero-grazing and feed supplementation management when compared to those of pasturing regimes. These nematodes are characterized by a low potential to survive unfavourable climatic conditions (Waller *et al.*, 2004; O'Connor *et al.*, 2006; Šarkūnas *et al.*, 2007).

The young goats were less infected than adults with *Strongyloides* and *Trichuris* during the summer period presumably due to the short period to higher infection incidence. The goats on open grazing management and tethered goats were less infected with *Strongyloides* than feed supplemented or kept indoor, which corresponds to the findings reported by Manfredi (2010). *Trichuris* eggs were more frequently excreted in spring and autumn in association with indoor period. *Monezia expansa* infection was recorded only in pastured young goats on Farms A and B, which indicate that access to grazing should be considered as a favourable condition for the transmission of this parasite.

In present study the high prevalence ($\approx 98\%$) of *Eimeria* infection was recorded in all examined goat farms which is in agreement with reports from other counties. In Poland *Eimeria* oocysts were found in 81 – 100 % (Balicka-Ra-

misz, 1999), and in 95 % in Estonia (Lassen *et al.*, 2013), 92 % in the Czech Republic (Koudela & Boková, 1998), 100 % in Slovakia, (Vasilková *et al.*, 2004), 97 % in Florida, USA (Kahan & Greiner, 2013). Goat kids are particularly susceptible to the pathological effects of *Eimeria* infections, especially newly weaned kids kept in large numbers under intensive management conditions (Ruiz *et al.*, 2006). In the present study the highest oocysts excretion was observed in kids (under 6 months; $P < 0.0001$) and young goats (6 – 12 months; $P < 0.001$) when compared to those in adult animals, supporting the findings of several authors (Borgsteede & Dercksen, 1996; Koudela & Boková, 1998; Gorski *et al.*, 2004). The highest average oocyst count exceeding 20,000 OPG was recorded in kids on Farm A in the beginning of grazing season of 2012. This increase in oocyst production was followed by clinical disease characterized by severe diarrhea and some mortality of kids. This outbreak presumably could be explained by highest stocking rate combined with poor sanitation on this farm.

In our study, the peak output of oocysts in adult goats was recorded in July-August following the most favourable period with warm and wet environmental conditions for sporulation observed in most of the farms. While oocyst production in adult animals remained comparable throughout the rest of the season, the OPG levels in faeces of young animals was slowly decreasing starting from August – July to the levels comparable to those in adult animals, which could be associated with obtained immunity against coccidiosis.

In conclusion, the grazing management and age of goats were important risk factors, which markedly influenced the level of infection with the gastrointestinal nematodes and *Eimeria* in goats. The number of strongyle eggs and *Eime-*

ria oocysts in goat faeces has fluctuated on each examined farm during the grazing season in relation to herbage contamination with infective L₃ stage larvae, anthelmintic treatments and immune response in animals.

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