COMPARISON OF LUNGWORM INFECTION IN A HERD OF YOUNG AND DAIRY GOATS AT AN ORGANIC FARM*

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The prevalence and intensity of infection of the lungworm *Muellerius capillaris* in dairy and young goats were evaluated at one organic farm in the Czech Republic. A total of 605 faecal samples were collected from rectum of thirty selected dairy and thirty young goats; each individual was examined monthly throughout a year. Data were statistically evaluated to verify the existence of differences in values of larvae count per gram (LPG) in dairy and young goats. Further, dairy goats were divided into three groups depending on the number of lactations and the differences in LPG values between groups were statistically evaluated. The species *M. capillaris* was the only lung parasite identified during our study with an overall prevalence 87.2 % and 93.1 % for young goats and dairy goats, respectively. The difference in the larvae count between young and dairy goats was not statistically significant. The comparison of larvae counts in goat groups depending on the number of lactation showed significant differences between dairy goats on the first and second lactation and between goats on the second and third lactation ($P < 0.05$) contrary to larvae count between goats on the first and third lactation.

small ruminants, lungs, Nematoda, *Muellerius capillaris*

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INTRODUCTION

The lungworm *Muellerius capillaris* (Mueller, 1889) is a common protostrongylid nematode of grazing sheep and goats worldwide (Smith, Sherman, 2009; Suarez et al., 2014). The prevalence of *M. capillaris* depends on many factors – local climatic conditions, favourable ecological conditions for intermediate host, humidity, temperature, farm management, and immunity of the animals itself (Adem, 2016).

The adults of *M. capillaris* are found in lungs as well as in bronchioles, pulmonary alveoli, and subpleural tissue (Suarez et al., 2014). Clinical signs of *M. capillaris* infection in goats are often not apparent and remain overlooked (Vadlejch et al., 2016) because they are usually less obvious in goats then in sheep or other ruminants (Adem, 2016).

Muelleriosis is considered to be cumulative with age, the older goats exhibit clinical signs more often than young animals due to heavier infection (Gorski et al., 2004). Clinical muelleriosis is associated with coughing, dyspnoea (Geurden, Vercruysse, 2007), impaired pulmonary gas exchange, reduced weight, and chronic inflammation. Secondary infection results in pulmonary tissue changes which lead to chronic inflammation and granulomatous reaction around adults in the lungs (Berrag et al., 1997; Panuska, 2006). *M. capillaris* is also considered as a predisposing agent for bacterial infections and heavy infections may cause economic loses (Suarez et al., 2014) due to failure to thrive and lower milk production in dairy goats (Geurden, Vercruysse, 2007).

The life cycle of this nematode is indirect, and it involves small ruminants as definitive hosts and terres-

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trial snails and slugs as intermediate hosts (Panuska, 2006). Intermediate host becomes infected by penetration of infective larvae in the first development stage (L_1) into its body and molluscs remain infective for at least one year (Smith, Sherman, 2009; Matthews, 2011). L_1 larvae, resistant to desiccation and freezing temperatures, undergo two molts to the L_3 stage within the snail. Goats become infected after eating contaminated snails or slugs while grazing (Paraud et al., 2005). Larvae released during digestion process penetrate the host intestinal wall and through the mesenteric nymph nodes enter the heart, pulmonary arteries, and finally lungs (Panuska, 2006).

Anthelmintic treatment of muelleriosis may be complicated, available anthelmintic drugs such as benzimidazole or ivermectin partly reduce the larval count and are not fully effective in elimination of adult lungworms from the host organism (Paraud et al., 2005; Geurden, Vercruysse, 2007; Vadlejch et al., 2016). On the other hand, study of Geurden, Vercruysse (2007) and Vadlejch et al. (2016) confirmed the high efficacy of eprinomectin and moxidectin on larvae count, respectively. Both anthelmintics are used as drugs in cattle and sheep, but they have not been registered for use in goat breedings (Geurden, Vercruysse, 2007; Vadlejch et al., 2016).

The aim of this study was to evaluate the difference of *M. capillaris* infection in herd of young and dairy goats at one organic goat farm. The study was based on preliminary hypothesis that the prevalence and intensity of infection of *M. capillaris* larvae may have an increasing trend depending on their cumulation during the growing age of the animals.

MATERIAL AND METHODS

Farm and goats

The present study was carried out at an organic goat farm located in Central Bohemia (49.33N, 14.18E) at an altitude of 450 m a.s.l. The long-term annual average temperature is 7°C with an average annual rainfall of 750 mm. Local climatological parameters obtained from the Czech Meteorological Institute are presented in the Fig. 1.

The farm has 90 ha of pastures and rear goats of the Czech national breed White Shorthaired goat. During our study, which was conducted from January 2014 to December 2014, 308 goats were on the farm (213 dairy goats, 90 young goats, and 5 adult males).

Dairy goats were on the pasture from April to December; from May to October (during the lactation period) they had access to the stable twice a day for milking. During the winter season (December–March), dairy goats had no access to the pasture; they were kept in the stable for kidding. Young goats were gradually on two pastures during our study; from January to October they were on winter pasture; in April, they were moved to new, summer pasture. The summer pasture was rich in vegetation and moist due to the flowing stream around the pasture. From December, young goats were kept in the stable without access to the pasture. Dairy and young goats stayed in the stable until the end of our study.

On the pasture, there was a shelter; water was provided by a mobile tank. Hay and mineral licks were also available to goats (without addition of plants with anthelmintic effect).

Fig. 1. Local climatological parameters

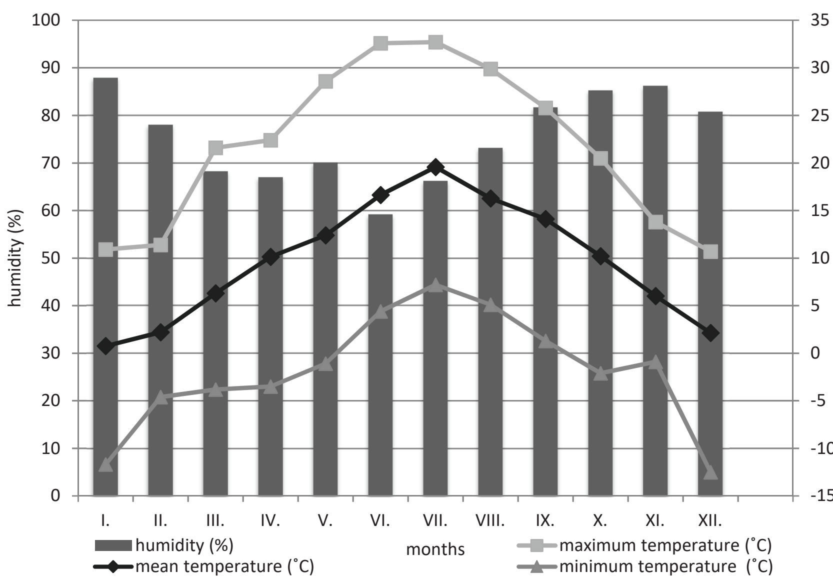

Table 1. Prevalence of the lungworm *Muellerius capilaris* in young and dairy goats, confidence intervals (CI) and minimum – maximum counts of its larvae per gram of faeces (LPG) during one-year survey

Month	Prevalence (CI) (%)		Young goats		Dairy goats	
	young goats	dairy goats	min. LPG	max. LPG	min. LPG	max. LPG
1	64 (47–79)	80 (61–91)	0	40.2	0	272.9
2	57 (39–73)	54 (31–74)	0	20.6	0	56.4
3	74 (55–84)	100 (85–100)	0	15.5	0.5	605.2
4	100 (80–100)	100 (84–100)	0.3	137.7	0.1	261.7
5	100 (85–100)	100 (84–100)	0.2	23.0	0.2	79.2
6	95 (85–100)	90 (74–97)	0	44.4	0	35.1
7	90 (70–97)	100 (90–100)	0	25.3	0.1	430.4
8	94 (74–99)	94 (81–98)	0	15.1	0	291.1
9	94 (75–99)	97 (84–99)	0	43.8	0	41.5
10	100 (87–100)	94 (80–98)	4.1	58.7	0	867.3
11	95 (79–99)	100 (89–100)	0	65.6	0.3	236.8
12	100 (88–100)	92 (77–98)	2.1	89.5	0	143.5

Prior to our survey, goats were treated once a year with ivermectin drugs (Ivomec), which was administered to the entire flock. The drug dosage was determined according to individual body weight. The last dose of antiparasitic drugs was given to the animals one year before our survey (January 2013). Throughout our study, animals were not medicated.

Sampling procedure and parasitological methods

For the purpose of our study, thirty dairy goats and thirty young goats were selected. Further, dairy goats were divided depending on the number of lactation into three groups of ten animals being in first, second, and third lactation. Faecal samples were collected directly from the rectum, repeatedly every month from each preselected animal through the whole survey. Samples were stored in labelled plastic bags at 4°C until further processing.

The presence of lungworm larvae was examined using modification of flask recovery procedure (McKenna, 1999) and determined to the species according to van Wyk, Mayhew (2013).

Statistical analysis

Data were statistically evaluated using non-parametric Mann-Whitney U-test (STATISTICA 12, 2012) to verify the existence of difference in values of larvae count per gram in young and dairy goats. The statistical significance level was established as $\alpha = 0.05$. Prevalence was evaluated according to Bush et al. (1997), and calculated for each month separately for young and dairy goats during whole survey.

RESULTS

In our study, we collected 605 faecal samples in total (334 from dairy goats and 271 from young goats). Lungworms larvae were identified as *Muellerius capillaris* with an overall prevalence 87.2 % and 93.1 % for young goats and dairy goats, respectively.

Table 1 shows the monthly prevalence, confidential intervals and minimum – maximum values of LPG count in both, young and dairy goats during our survey. In herd of young goats, the prevalence reached 100 % in April and did not fall below 90 % till the end of our study. In young goats, apparent decline of LPG was found during January–March while significant maximum occurred in April (137.7). During the rest of the year until December, the declined LPG count was maintained without any significant fluctuations. The second significant year maximum appeared in December (89.5).

In herd of dairy goats, the prevalence reached 100 % in March and like in young goats, it did not fall below 90 % till the end of our study. Dairy goats reached the highest larval count in March, July, and October, while the lowest LPG occurred always in the previous month – February, June, and September (Table 1). Statistical analysis did not show statistically significant effect in larvae count between young and dairy goats ($P > 0.05$) (Fig. 2).

When comparing dairy goats by number of lactations (Table 2), the highest LPG count during whole survey was observed in goats on the first lactation, with high LPG in March and July and maximum in October (867.3). The goats on the second lactation had the highest larval counts in January, April, and

Table 2. Minimum – maximum counts of *Muellerius capilaris* larvae per gram of faeces (LPG) of dairy goats on first, second, and third lactation

Month	First lactation goats		Second lactation goats		Third lactation goats	
	min. LPG	max. LPG	min. LPG	max. LPG	min. LPG	max. LPG
1	5.5	17.6	0	272.9	0	264.0
2	0	0	0	51.1	0	56.4
3	8.3	605.2	0.5	89.5	4.2	22.3
4	3.2	261.7	0.4	137.3	0.1	21.6
5	0.3	79.2	0.3	51.0	0.2	61.6
6	0	35.1	0	16.3	0.4	8.7
7	0.1	430.4	3.5	26.5	2.4	25.2
8	0	291.2	1.6	20.4	4.7	23.8
9	5.1	33.0	0	41.5	6.0	28.4
10	0	867.3	0	102.5	12.4	94.6
11	1.3	30.4	0.3	35.6	10.5	236.8
12	2.5	56.5	0	143.5	10.8	106.0

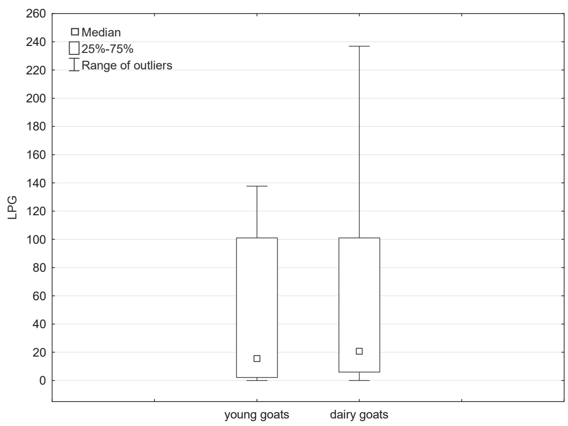

Fig. 2. Comparison of LPG count between young and dairy goats

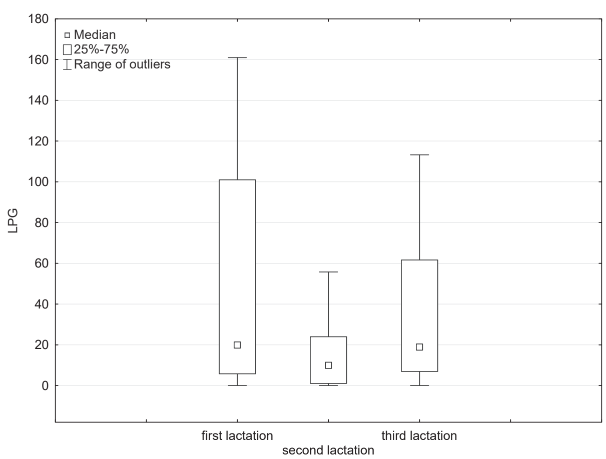

Fig. 3. Comparison of LPG count in dairy goats on first, second and third lactation

December, goats on the third lactation in January and November. Statistical analysis showed significant differences in larvae counts between goats on the second lactation ($P < 0.05$), contrary to larvae counts between goats on the first and third lactation ($P > 0.05$) (Fig. 3).

DISCUSSION

Muellerius capillaris was the only lungworm found in our study of goats of different ages from a farm in the Czech Republic. Even though this nematode is known as the most common lungworm in young goats, there is a lack of detailed studies, particularly those focussing on larval counts in various age categories of the animal.

D o m k e et al. (2013) reported the occurrence of *M. capillaris* in goats in all monitored regions in Norway and its prevalence was 31.2%; V o i g t et al. (2016) found the first stage larvae in 35.1% samples collected from pastures of seven farms in Germany. P a n u s k a (2006) described the prevalence of 64% and 68% in Maryland and Georgia (USA), respectively. Compared to above-mentioned studies, our study recorded higher overall prevalence of the nematode in goats, namely 87.2% for young goats and 93.1% for dairy goats. The highest prevalence up to 100 % was recorded in goats from Stara Zagora (Bulgaria) by G e o r g i e v et al. (2003). It should be remembered that the examination method could affect the results. Many above quoted studies have used pooled coprological samples while we applied individual sampling for the same animals every month during one-year period, which gives us more accurate information about the prevalence and intensity of infection at the monitored farm.

Health problems caused by *M. capillaris* infections tend to accumulate with age and older goats exhibit clinical symptoms rather than young goats (Gorski et al., 2004). The high prevalence in young goats recorded in our study may be also caused by the age distribution of goats in monitored herd. Several ill adults, already lactating goats, were added to the herd of young goats to recover, and thus the heavily infected individuals might affect the presence of larvae on the common pasture and the higher infestation of snails.

During our study we observed significant differences between nematode LPG counts in goats of various age categories (first, second, and third lactation) as well as between individual host animals. These differences may be explained mainly by the immunity status of each goat which depends individually on its age and e.g. timing and level of infection load. As we applied a more sensitive method in recovering lungworm larvae (flask method) then the traditional funnel method, it was possible to identify also differences between individuals of the same age.

According to Panuska (2006), long-term survival of adult nematodes in goats allows contamination of pasture by first stage larvae for long time. Frequency of new infections of definitive hosts depends on the survival of larvae on the pasture, their ability to infect intermediate molluscan hosts, and on the presence of an intermediate host. Parasite's ability to survive throughout mollusc's life increases its availability for grazing animals.

The degree of infection of intermediate mollusc hosts is primarily related to temperature and frequency of rainfall, and secondarily to excretion of larvae in faeces (Lahmar et al., 1990). Moisture is essential for survival and development of young lungworm larvae on the pasture. Rainfall stimulates the activity of both, molluscs and parasite larvae, which is related to intensity of infection on the pasture (Tewodros, 2015). In our study, we recorded a sharp LPG count increase in herd of young goats in April which coincides with the transition of young goats from the winter pasture to new, summer pasture, which was, compared to winter pasture, rich in vegetation and moist (bordered by the stream). In the herd of dairy goats, the increase of LPG counts occurred repeatedly, always with increasing humidity (for detailed climatological parameters see Fig. 1). In general, the best environmental conditions for *M. capillaris* larvae are represented by cool, damp surrounding with long herbage, where they are most active at moderate temperature of 10–21°C (Tewodros, 2015).

CONCLUSION

The prevalence of *M. capillaris* lungworms may be affected by many factors, such as the presence of intermediate molluscan host on the pasture (or stable, shelter), number of larvae ingested by final mammalian host, immunity and age of each animal, lack of feeding, overstocking, and local micro-environmental climate. Some of these factors (immunity of animals, feeding, and pasture management) may be affected by farm management to reduce the impact of lungworm infections on animals. The transfer of adult animals (or ill animals) to herd of young goats may lead to increasing prevalence or intensity of infection in young goats that do not have fully developed immunity (several young goats died during the year on the farm, and the subsequent autopsy showed severe lung parenchyma damages caused by lungworms). This may be resulting in economic consequences due to reduced weight, impaired fertility, and reduced milk production of farmed ruminants.

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