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ECOLOGICAL CONDITIONS OF CHAMOIS INFECTION BY LUNG NEMATODES IN THE SLOVAK NATIONAL PARKS

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Abstract

In the territory of Slovakia, the chamois is native only in the High Tatras and Belianske Tatras. The fact that the Tatras chamois are not only the glacial relict, but also the vital Tatras endemic subspecies considerably increases their cultural, historic and environmental importance. To prevent its extinction, the subspecies was introduced into the central part of the Low Tatras National Park (central Slovakia) in 1969-1974. On the other hand, Alpine chamois was introduced into the Slovak Paradise National Park and the Vel'ká Fatra National Park Alpine (eastern and central Slovakia) in 1964-1968. A substantially decreased number of Tatras chamois in the last decade has initiated a large-scale range of activities aimed at its protection. Parasite infections have also contribute to the decline of the chamois population. The attention is therefore being paid particularly to a health status of both chamois population, including monitoring of species composition and degree of infection with parasites and its intermediate hosts. In the present report we analyse data from the study of ecological conditions for infection of chamois with lung nematodes carried out during the last years in biotopes of Slovakia. In territories of the Tatra National Park and the Low Tatras National Park in Tatras chamois (*Rupicapra rupicapra tatrica* Blahout, 1971) and in the Slovak Paradise National Park and the Slovak National Park of Vel'ká Fatra in chamois of Alpine origin (*Rupicapra rupicapra rupicapra* Linnaeus, 1758), following species of lung nematodes were found: *Muellerius capillaris*, *Neostrongylus linearis*, the species specific for chamois *Muellerius tenuispiculatus* and the geohelminth *Dictyocaulus viviparus* was also sporadically determined. The degree of the infection depends on the geomorphologic conditions, which influence the composition of the substrates (granite, limestone-dolomite) having major impact on the structure and density of the snails-intermediate hosts of lungworms. The variety of snail species in all chamois biotopes of Slovakia constitutes the appropriate conditions for development and circulation of lung nematodes.

Key words: chamois, lung nematodes, prevalence, Slovak National Parks, snails.

Resumen

Condiciones ecológicas de la infección por nematodos pulmonares en el rebeco en los parques nacionales de Eslovaquia

En Eslovaquia, el rebeco sólo es autóctono en los Altos Tatras y los Tatras Belianske. El hecho de que el rebeco de los montes Tatras sea no sólo una especie relicta de las glaciaciones sino también la subespecie endémica de los Tatras aumenta considerablemente su importancia cultural, histórica y medioambiental. Para evitar su extinción, la subespecie ha sido introducida en la parte central del Parque Nacional de los Bajos Tatras (Eslovaquia Central) entre 1969-1974. Por otra parte, en los Parques Nacionales Slovak Paradise y Vel'ká Fatra se introdujo la subespecie alpina (Este y centro de Eslovaquia) entre 1964-1968. El importante declive del número de rebecos de los Tatras en la última década ha motivado toda una serie de actuaciones encaminadas a su protección. Las parasitosis también han influido al declive de la población de rebecos. Se está prestando particular atención al estatus sanitario de ambas poblaciones de rebeco, incluyendo el estudio de los diferentes parásitos que le afectan, así como en los hospedadores intermediarios. En el presente trabajo se analizan los resultados del estudio de las condiciones ecológicas para la infección del rebeco por nematodos pulmonares realizado en los últimos años en biotopos de Eslovaquia. En las poblaciones de rebeco (*Rupicapra rupicapra tatrica* Blahout, 1971) del Parque Nacional de los Montes Tatras y Parque Nacional de los Bajos Tatras y en las poblaciones de rebeco alpino (*Rupicapra rupicapra rupicapra* Linneo, 1758) del Parque Nacional Slovak Paradise y Parque Nacional Vel'ká Fatra, se han encontrado las siguientes especies de nematodos pulmonares: *Muellerius capillaris*, *Neostrongylus linearis* y la especie *Muellerius tenuispiculatus*, específica del rebeco; además, se determinó esporádicamente el geohelminto *Dictyocaulus viviparus*. El grado de infección depende de las condiciones geomorfológicas, que influyen sobre la composición de los sustratos (granito, caliza-dolomía), las cuales se reflejan en la estructura y densidad de los caracoles, hospedadores intermediarios de los nematodos pulmonares. La variedad existente de especies de caracol en todos los biotopos donde vive el rebeco es Eslovaquia constituyen condiciones idóneas para el desarrollo y circulación de los nematodos pulmonares.

Palabras clave: nematodos pulmonares, Parques Nacionales de Eslovaquia, prevalencia, Rebeco.

Introduction

Tatras chamois (*Rupicapra rupicapra tatrica* Blahout, 1971) was recently clasiffied as Critically Endangered, CR (see IUCN Red List of Threatened Species) (Caprinae Specialist Group 2000). It is also ranked as a threatened species by the European Mammal Assessment (EMA) commissioned by the European Commission (Aulagnier *et al.* 2008).

In the territory of Slovakia, the chamois is native only in the High and Belianske Tatras. Tatras chamois present not only the glacial relict, but also the perpetuated Tatras endemic subspecies (*Rupicapra rupicapra tatrica* Blahout, 1971) that markedly increases their cultural, historic and environmental importance. To prevent its extinction, the subspecies was introduced into the central part of the Low Tatras National Park (NAPANT) in 1969-1974. A different form, Alpine chamois (*Rupicapra rupicapra* Linnaeus, 1758) was introduced into the Slovak Paradise National Park (NAPSR) and the Vel'ká Fatra National Park (NAPAVF) in 1964-1968. The introduction of alpine chamois was preferably due to hunting motivation of attractive species. A considerably decreased number of Tatras chamois in the last decade has evoked a range of diverse activities to protection the subspecies (Blahout 1977, Chovancová 1990, Hell & Chovancová 1995). Parasitic diseases, particularly due to lung nematodes, contribute considerably to the morbidity of chamois in the Slovak National Parks (Mituch *et al.* 1989, Sattlerová-Štefančíková 1987, 2005, Štefančíková 1994, 1999a, 1999b, Krokavec & Krokavec 1991, Ciberej *et al.* 1997), and other localities (Hörning 1975, Clark & Clarke 1981, Genchi *et al.* 1984, Cancrini *et al.* 1985, Diez *et al.* 1990, Nocture *et al.* 1998, Panaytova-Pencheva 2006).

The paper was designed to analyze results of studies of ecological conditions for infection of chamois with lung nematodes undertaken during last several years in biotopes of Slovakia.

Material and methods

Characteristics of chamois habitats

The Tatra mountains constitute the northernmost and highest part of the 1,200 km long arch of the Carpathians. As far as the distribution of chamois is concerned, the High, West Tatras and Belianske Tatras (TANAP) differing in their geographical, orographical, geological, trophic and climatic conditions present the most important sites for animal perpetuation. The geomorphological and orographical conditions are favourable with respect to chamois conservation.

The habitats under study are situated at the subalpine to alpine vegetation level with an altitude of 1,749-2,655 m above sea level (Figure 1). The Tatras climate is continental, with typical features of an alpine climate characterized by extreme fluctuations in temperature. At the height of average summits with the characteristics of grassy uplands, the winter extends from mid October to early May.

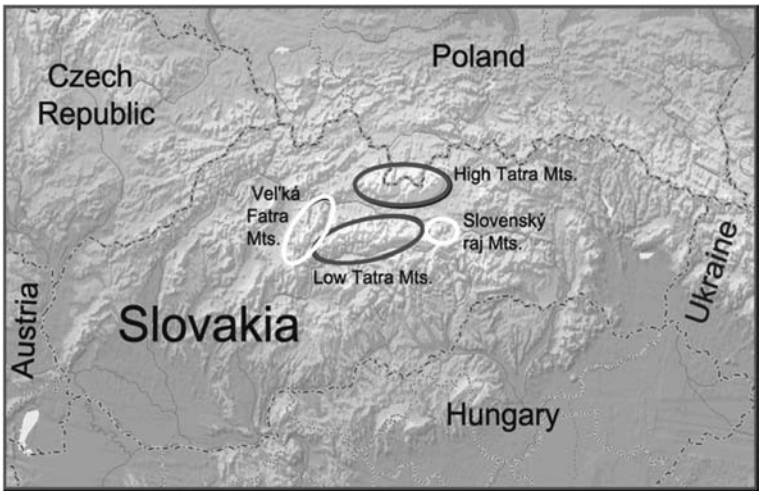

Figure 1. Mountain ranges of Slovakia inhabited by chamois (white – Alpine chamois, black – Tatra chamois (modified by Zemanova *et al.*, 2007).

The Low Tatra National Park (NAPANT) is a national park in Central Slovakia, situated between the Vah River and the Hron River valleys. Distinction from the High Tatras was caused by the lower activity of the glaciers and typical summits (jokuls) occur less frequently than those in the High Tatras. In geological composition prevail granites and crystalline schists, but limestones and dolomites are infrequent (Radúch & Karč 1981, Štefančíková 1994, 2005). The habitats are situated at the subalpine to alpine vegetation level with an altitude of 1,886-2,003 m above sea level (Figure 1). The climate is rather similar to that of the High Tatras (Houdek & Bohuš 1976).

The Slovak Paradise National Park (NAPASR) is situated in the northwestern part of the Spiš Ore Mountains, presenting a part of the Slovak Ore Mountains, which belong to the central zone of the Western Carpathians. Though not classified at the rank of high-mountainous parks (lying at 400-1,200 m above sea level), it is regarded as an area having an alpine character thanks to its well-known canyons with waterfalls and ravines. It is characterized as a biotope with a mesozoic bedrock, consisting largely of Triassic limestones and dolomites. Chamois frequently occur in the localities situated at the altitude of 660-1,057 m above sea level (Figure 1). The current population contains approx. 100 chamois specimens. The climate is continental (Houdek & Bohuš 1976).

The National Park Vel'ká Fatra (NAPAVF) and its protective zone, comprise most of the Greater Fatra Range which belongs to the Outer Western Carpathians. The National Park was declared on April 1st 2002, as an upgrade of the Protected Landscape Area of the same name and was established in 1972 in order to protect a mountain range with a high percentage of well-preserved Carpathian forests. The core of the range is built of granite that reaches the surface only in certain places, more common are various slates creating gently modelled ridges and summits and limestone and dolomite rocks constituting a rough and picturesque terrain. The habitats of introduced alpine chamois are situated at the level with an altitude of 800-1,350 m above sea level (Figure 1). The current population numbers approx. 53 chamois. The climate is continental (Houdek & Bohuš 1976).

Necropsy and faecal samples material

The lungs obtained by selective shooting or after natural death were examined by a complete organ dissection (Štefančíková 1994). First stage larvae (L1) were isolated from a weighed sample (3-5 g) by the Baermann's larvoscopical method and counted by micropipette of the micromanipulator or using McMaster chambers. The degree of infection was assessed by the number of larvae per gram of faeces: up to 10 larvae defined a poor infection, up to 100 larvae moderate infection, and over 100 larvae heavy infection. Differences in the prevalence of lung nematodes in the biotopes were statistically evaluated by the X^2 test. The

mean larval count per gram faeces was assessed using the analysis of variance or Mann-Whitney test (Reisenauer 1970).

Results

The results obtained by post-mortem dissection and of the larval examination of faecal samples collected at various chamois habitats showed in Tatra chamois living in the TANAP and NAPANT the presence of following nematodes species: *Muellerius capillaris*, *Neostrongylus linearis* and the specific chamois species *Muellerius tenuispiculatus* (Figures 2, 3, 4). In the NAPASR and NAPAVF, the same species of the lung nematodes in introduced chamois of an Alpine origin was found, whereas in the chamois of Tatras subspecies and Alpine origin we also sporadically determined the geohelmith *Dictyocaulus viviparus.* The 100% prevalence of lung nematodes was determined by autopsies and larvoscopic examination of chamois faeces in TANAP in 1977-1980. The number of L1 larvae per gram of faecal samples was constantly high in all seasons of the year (values over 100 larvae/g). Prevailing species in the central granite complex of the High Tatras were *M. capillaris* and *M. tenuispiculatus*, wheres in the limestone part in Belianske Tatras *N. linearis* was dominant. The re-examination of the helminth status in 1997 shown the presence of same species of lung nematodes,

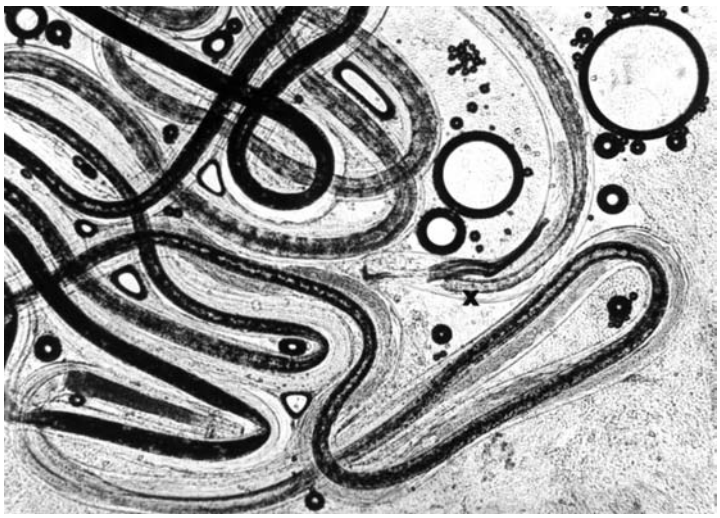

Figure 2 *Muellerius tenuispilucatus* – male with thin and evenly long spiculae.

Figure 3. *Muellerius capillaris* – male with rough, short and evenly long spiculae.

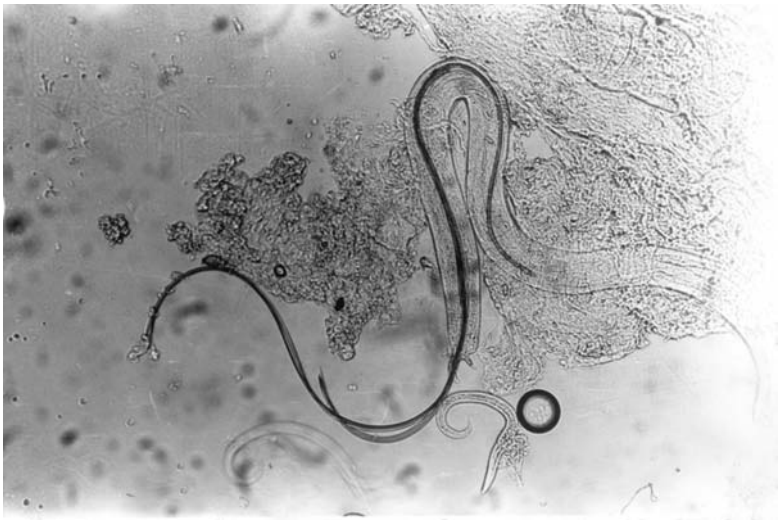

Figure 4. *Neostrongylus linearis* – male with thin and unevenly long.

but the prevalence was substantially lower (48.4%), with prevailing *Muellerius* spp. (45.6%) in both complex of Tatras (High, Belianske Tatras). *N. linearis* occurred only in 11.9% of examined chamois. Mean larvae per gram of faeces was low 7.6 ± 13.2 (Table 1). In 2007-2009 the prevalence repeatedly increased to 85.7% in TANAP, in individual complexes the prevalence ranged from 72.9 to 97.0%. Mean larvae number showed a high degree of infection in TANAP (117.6 ± 101.8 L1/g), in individual complexes medium levels were recorded in granite central and western part, with values from 44.5 ± 87.8 to 65.8 ± 55.4 L1/g, while in dolomite Belianske Tatras the larvae number was high (240,5 ± 55,9 L1/g).

Table 1
Seasonal prevalences and mean number of larvae/g of faeces of lung nematodes in chamois herds from biotopes of TANAP in 1997.

Locality/Month	Lung nematodes		*Muellerius* spp.		*N. linearis*	
	Prevalence (%)	L1/g ± S.D.	Prevalence (%)	L1/g ± S.D.	Prevalence (%)	L1/g ± S.D.
High Tatras	44,9	8.7± 15.5	41,7	9.4 ± 16.8	11,2	5.8 ± 7.9
July	73,1	25.9 ± 22.8	73,1	15.9 ± 20.4	7,7	8.8 ± 5.6
August	85,0	4.3 ± 4.8	85,0	3.6 ± 3.8	30,0	6.6 ± 6.3
September	60,9	2.4 ± 1.6	56,5	2.6 ± 1.7	10,9	1.8 ± 1.1
October	17,9	7.2 ± 16.4	16,8	7.4 ± 18.9	8,4	6.9 ± 11
Belianske Tatras	58,5	5.4 ± 5.6	56,9	5.4 ± 5.5	13,8	3.8 ± 5.5
July	83,3	8.8 ± 7.2	83,3	8.8 ± 7.2	0	0
August	63,6	3.1± 2.2	63,6	2.9 ± 1.5	18,1	3.8 ± 4.7
September	50,0	3.8 ± 1.4	50,0	3.8 ± 1.5	9,1	3.7
October	37,5	3.1 ± 4.4	37,5	2.6 ± 2.4	25,0	3.8 ± 6.6
Total (TANAP)	48,4	7.6 ± 13.2	45,6	8.2 ± 14.4	11,9	5.2 ± 7.2

During 1981-1988 in NAPANT larval stages L1 *Muellerius* spp. (*M. capillaris, M. tenuispuculatus*) prevailed in faecal samples, *D. viviparus* occurred only sporadically. The results of autopsy revealed the prevalence of 71.4%, larvoscopic examination of faecal samples - 89,6%. Mean number of larvae L1 per gram faeces in individual years varied from 28.2 ± 11.9 to 61.6 ± 35.9. The degree of infection was significantly higher in spring and autumn, except the spring of 1981, compared with the summer seasons ($P < 0.05$) (Figure 5). Larvoscopic re-examination of faeces in 1998 showed the similar prevalence as in the previous period - 88.5%. The degree of the infection was also comparable, remaining at the medium level; it ranged from 25.4 ± 10.9 to 57.8 ± 32.6 larvae per gram of faeces. Besides *Muellerius* spp., we have recorded the presence of species *N. linearis*, which was not found in the previous period. The examination of faecal samples in 2007-2009 confirmed steady prevalence of 87.7%, correspondingly mean larvae L1 per gram faeces remained almost at the same level (68.7 ± 42.6 L1/g).

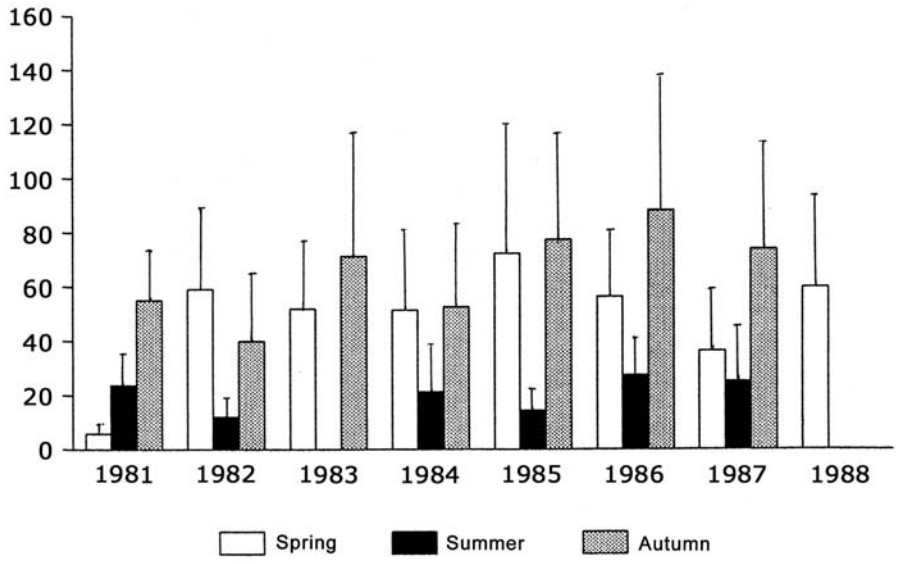

Figure 5. Mean larvae L1 per gram of chamois faeces in the Low Tatra National Park by seasons.

Examination of faecal samples collected over 1984-1993 from Alpine chamois in the Slovak Paradise National Park revealed the parasite prevalence of 57.7% in chamois herds. Among them, *Muellerius* spp. were predominant (56.5%), *N. linearis* occurred in 29.2% and *D. viviparus* was prevalent in 2.5% (Table 2). Mean larval count per gram faeces in individual years ranged between 73.7 ± 60.1 and 148.5 ± 58 and was predominantly lower in summer seasons (Figure 6). A necropsy confirmed the presence of adult stages of all three nematodes in the lung parenchyma, whereas in bronchi and trachea no adults of *D. viviparus* were observed. At present, a total prevalence of lung nematodes was 97.8% and mean larvae L1 per gram ranged from 129,3 ± 42,1 to 185,2 ± 38,5 in respective localities.

Table 2
Prevalence of lung nematodes in feaces from chamois herds in the Slovak Paradise National Park by localities.

Localities	Nº examined	Lung nematodes	*Muellerius* spp.	*N. linearis*	*D. viviparus*
		Prevalence (%)	Prevalence (%)	Prevalence (%)	Prevalence (%)
Dedinky-Stratená	51	64,7	62,7	29,4	1,9
Vernárska Tiesňava	119	57,1	55,4	21	4,2
Vel'ký Sokol	109	54,1	52,3	19,2	2,7
Malý Sokol	81	60,4	60,4	27,1	0
Sokolie skaly	111	58,5	56,7	36,9	0
Rárohové skaly	33	63,6	63,6	48,4	0
Suchá Belá	95	53,6	53,6	36,8	6,3
Total	599	57,7	56,5	29,2	2,5

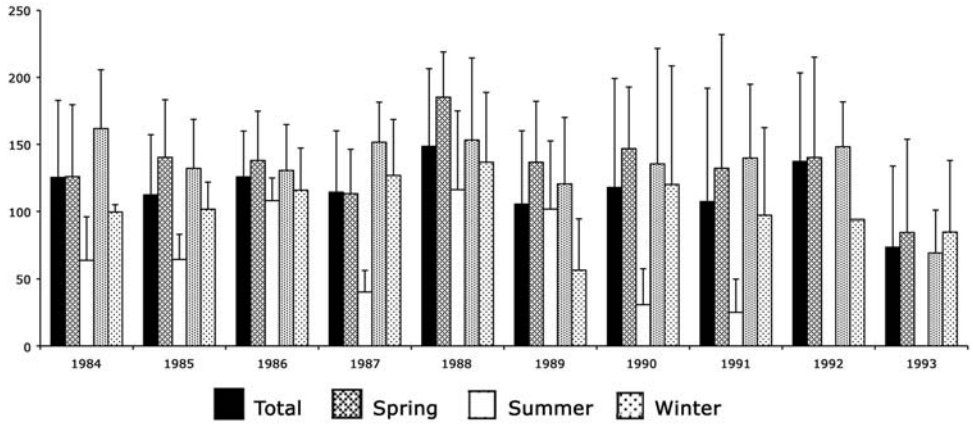

Figure 6. Mean larvae L1 per gram of chamois faeces in the Slovak Paradise National Park by years and seasons.

Examination of faecal samples collected over 1981-1987 and a biopsy of lungs from Alpine chamois in the National Park of Vel'ká Fatra shown the total prevalence of 78.4% in chamois herds. *Muellerius* spp. were predominant (54.7%) in comparison to *N. linearis* (26.7%) (Table 3). Mean larval count per gram faeces in individual years conformed to low and moderate degrees of infection, ranging between 7.2 ± 6.5 and 95.1 ± 62.8, and was significantly lower in summer seasons (Figure 7). The re-examination survey of the helminth spectrum in 2005 substantiated the occurrence of the same species of lung nematodes. The mean prevalence in chamois herds was lower than that in previous period (62.1%). *Muellerius* spp. more commonly occurred (42.2%) in comparison to *N. linearis* (21.3%). The degree of the infection was also similar, remaining at the low and/or medium level (7.1 ± 6.2 to 46.3 ± 11.6). The current situation pointed out for the increasing trend of parasite infestation with the mean prevalence of 83.6%, but the number larvae/g remained at an approximately same level, ranging from 9,3 ± 7,4 to 69,3 ± 71,1).

TABLE 3
Prevalence of lung nematodes from feaces of chamois herds in NAPAVF by localities.

Localities	Examined	Lung nematodes	*Muellerius* spp.	*N. linearis*
		Prevalence (%)	Prevalence (%)	Prevalencia (%)
Ďurd'ášová	45	91,0	64,4	26,6
Štrochy	25	76,0	48,0	28,0
Suchý Jasienok	60	75,0	51,6	23,3
Pekárová skala	28	60,7	39,2	21,4
Horné piesky	75	78,6	64,0	28,0
Biela skala	32	78,1	43,7	34,3
Total	265	78,4	54,7	26,7

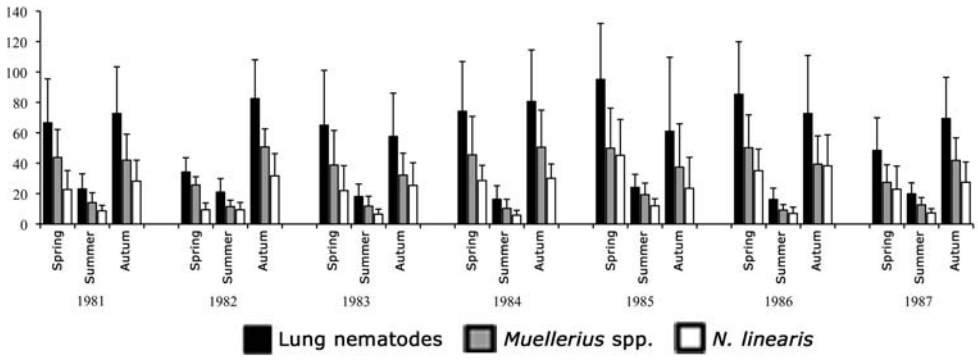

Figure 7. Mean larvae L1per gram of chamois faeces in National Park Vel'ká Fatra by years and seasons.

Discussion

The most frequent lungworms harbouring by chamois in various territories of Europe and New Zealand are generally species belonging to the genera *Muellerius, Neostrongylus* and *Protostrongylus. Dictyocaulus* spp. was found to be less common and *Cystocaulus* spp. were very rarely present (Diez *et al.* 1990).

Based on our data, it can be concluded that both Alpine and Tatra chamois from all studied national parks harbour the following lung nematode species: *Muellerius capillaris*, *Muellerius tenuispiculatus*, *Neostrongylus linearis* and sporadically *Dictyocaulus viviparus*. Given that the lung nematodes in chamois include the species parasitizing in small domestic ruminants (sheep, goat) and other game (moufflon, fallow deer, roe deer), our findings are useful for wider practical implications. The concerned species are *Muellerius capillaris* and *Neostrongylus linearis* that can be transmitted between domestic and wild animals. While during 1977-1980 in the TANAP in the central part of the High Tatras *Muellerius* spp. was the predominant species, in the Belianske Tatras it was *Neostrongylus linearis.* Upon revision of the presence of lung nematodes of chamois in 1997 and 2007-2009 the species *Muelerius* spp. prevailed in both parts of the High Tatras, *Neostrongylus linearis* was less frequent. In the NAPANT during 1981-1988, only two *Muellerius* spp. were recorded in the lung and faecal samples. *Neostrongylus linearis* was found in this biotope in 1998, at less frequency than the *Muellerius* spp. This could be due to the fact that the chamois introduced from the High Tatras into the Low Tatras during 1981-1988 did not harbour this nematode. It can be transmitted from the Alpine chamois living in the national parks of Slovak Paradise and Vel'ká Fatra, which migrated into the adjacent zone of occurrence of Tatra chamois in the NAPANT. Sporadic occurrence of *Dictyocaulus viviparus* in both NAPANT and NAPSR may be connected with the transmission from roe and red deer, as their biotopes overlap and with the synanthropization the chamois descend to meadows and pastures, thus providing a potential contact with livestock. Chroust (1991) reported the predominancy of both *Muellerius* spp. in Jeseníky mountains in the Cezech Republic, whereas Kotrlá *et al.* (1984) for Lusatian

Mountains (Czech Republic) and the High Tatras, Hörning (1975) for hills in Switzerland, Kutzer & Hinaidy (1969) and Stroh (1936) for Austria, Diez *et al.* (1987, 1990) for Spain reported *Neostrongylus linearis* as the prevailing species. In Austria (Gebauer 1932, Kutzer & Hinaidy 1969), Germany (Stroh 1936, Salzmann & Hörning 1974), France (Hugonnet & Euzébý 1980, Nocture 1986), Italy (Balbo 1973, Balbo *et al.* 1975, Genchi *et al.* 1984, Cancrini *et al.* 1985), Slovenia (Bidoveč *et al.* 1985), Spain (Diez *et al.* 1987, 1990), and Russia (Pupkov 1971), besides both *Muellerius* species and *Neostrongylus linearis*, the common parasites in chamois are the species belonging to the genera *Protostrongylus.* Neither we nor the aforementioned authors who studied the helminthofauna of Alpine chamois within the territory of the Czech and Slovak Republics reported these species encountering chamois. It seems that they have not been established for parasitizing the lungs of imported chamois or being extinct due to unfavourable conditions for their development.

Prevalence of lung nematodes in chamois herds in the TANAP throughout 1977-1980 reached 100%, while in 1997 it was 48.4%, and 85.7% in 2007-2009. Mituch (1969) reported the prevalence of 15-22%, in the TANAP, Rajský and Beladičová (1987) 28% occurrence. The prevalence in the NAPANT reached the values of 86.6% and 71.4%, respectively. The prevalence of lung nematodes in the NAPSR was higher (57.7% and 97.8%, respectively) than that stated by Krokavec & Krokavec (1991) (40.7%), and Ciberej *et al.* (1997) (40.9%) in the chamois from the Slovak Paradise, and by Chroust (1991) in Alpine chamois in Jeseníky mountains in the Czech Republic (41.2% in the lungs and 52.4% in the faeces). Nocture (1986) reported in the French Alps in the Bauges reserve the prevalence of 35.2%, Salzmann & Hörning (1974) in the German Alps prevalence of 33.6 / 8.3%), Cancrini *et al.* (1985) in the Italian Alps in the Abruzzo reserve prevalence of 47.6%. These prevalences were lower than that we found in the Alpine chamois in the NAPVF (61.6-91%) and that reported by Stroh (1936) in the German Alps (98%) and Genchi *et al.* (1984) in the Italian Alps in the Val Belviso reverve (95%).

In the TANAP during 1977-1980, the mean number of larvae L1 per gram of faeces was high and stable throughout all seasons of the year, while in 1997 the

value was low, and in 2007-2009 fluctuated from medium to high levels. In the NAPANT moderate levels of infection were observed, in the NAPAVF and the NAPASR moderate and/or high levels of infection were noticed. Our findings concerning the level of infection in chamois in the NAPSR are in concordance with those of Krokavec & Krokavec (1991), Chroust (1991) and Ciberej et al (1997) who reported ranges from moderate to high levels of infection in Alpine chamois.

The surveyed differences in the species composition, prevalence, level of infection in chamois are affected by a broad scale of ecological factors, such as climatic factors determining both larvae survival in the environment and rate of larval development in intermediate hosts and influence their activity. Geomorphological and orographic conditions affect migration of definitive hosts, geological foundation has a significant impact on the trophic base of the hosts, determines occurrence and biodiversity of snails-intermediate hosts of lung nematodes. Besides aforementioned factors, different amounts of material under study may have also contributed to the recorded variances.

The biotopes of the High Tatras differ from those of the Belianske Tatras in having a significant effect on the structure and density of the mollusc fauna. The granite bottom of the High Tatras with a continuous belt of spruce forests producing acid substrate do not provide a favourable living conditions for snails. On the contrary, in the limestone part of the Belianske Tatras the snails are abundant. Their abundance, and the species diversity is decreasing with the higher altitude and in the Alpine zone (approx. 1,800 m above sea level) as the snails are scarcely found on the granite. Within the limestone areas the species diversity is quite rich with steady snail populations. The results of the malacological excursions at the chamois sites proved that the snail populations in the Belianske Tatras are more diverse than those in the central complex of the High Tatras. Following species were recorded: *Clausilia grimmeri* (A. Schmidt, 1857), listed by Ložek (1956) as syn. *Clausilia dubia* var. *carpathica, Ena montana* (Draparnaud, 1801), *Cochlodina laminata* (Montagu, 1803), *Collumella edentula* (Draparnaud, 1801) and *Pyramidula rupestris* (Draparnaud, 1801). These species were mostly found at 1,500-1,800 m above sea level (subalpine zone) under

small rocks or on the ground parts of the plants. Another species was dominant *Helicigona faustina* (Rossmäsler, 1835). They were found high in the Alpine zone over 2000 m above sea level, and on the tops of the mountain peaks - either hiding in the rocks screes or basking in the sun. According to our experience, the snail numbers in the Belianske Tatras during our study were not decreasing with the growing altitude. The areas covered with parched and decomposed plants provide thanks to their air-thermic isolation an ideal place for snail hibernation. The species *Helicigona faustina* occurred in these areas even when they were covered by snow. It was seen during collections in June when at the lower locations of chamois pastures new vegetation already emerged, while the higher locations were still under snow. The chamois become infected in the High Tatras during seasonal migrations, in particular in spring, when they translocate down to the lover altitudes in search of food and during irregular migrations during the tourist season. These observations are verified by the determined prevalence of lung nematodes in chamois herds that varied in the different localities of this part of the Tatras. On the other hand, in the Belianske Tatras the prevalence in different localities during 1977-1980, in 1997, and in 2007-2009 has not varied markedly, as the infections can occur throughout the whole year. Experimental infection of various intermediate host species with individual lung nematodes showed that the larvae reached the infective stage in all snails collected on the chamois sites (*Muellerius* spp. on day 35 and *N. linearis* on day 21). In addition to these impacts, transmission dynamics of lung nematodes in chamois of TANAP is determined also by another factors. Harsh climatic conditions occurring over several years at the time of the birth coupled with the presence of predators and increasing anthropic interference have decimated the chamois population. While in 1964-1967 chamois population reached the number of 600, in 2000 it was merely about 260 animals. The strong contamination of environment (toxic metal substances) has led to the decline of biodiversity of trophic base of chamois that contributed to decrease in reproduction of chamois population, vitality and resistance; and its impact on the quality of gene pool is still unravelled. (Hell & Chovancová 1995). The decreased resistance has resulted in the disturbance of parasite-host balance as a consequence of previous heavy infections, which

contributed to the decrease in chamois population and in turn has resulted in the lower dissemination of the lungworm propagative stages into the environment. These factors have limited the infectivity of the intermediate and definitive hosts and hence the infection rate in 1997 was lower than those recorded in 1977-1980. At present increasing trend of infection is apparent that is influenced by increased protection of the chamois activity implying the increased acumulation of animals. This results in the higher dissemination of propagative stages into environment and consequently the increased infectivity of intermediate and definitive hosts and the infectivity rate. Global climatic changes might also contribute to this phenomenon.

Despite the geomorphologic and climatic similarity of the chamois biotopes in both the High and Low Tatras, the current area of chamois distribution in Low Tatras does not contain calciphile plants since this is an area without the limestone-dolomite substrate. This affects both the chamois trophic base and the occurrence of snails-the intermediate hosts of lungworms. They are abundant mainly in lower zones, but towards the alpine zone the number of snails is rapidly decreasing and over 1,500 m above sea level they occur only sporadically. The moderate degree of infection in chamois in this reservation showed that animals are predominantly infected during their seasonal migrations, when they translocate to lower altitudes, below the upper forest line (mainly in spring, but also throughout the whole during their irregular migrations).

Rather rugged terrain of the Slovak Paradise, temperature and humidity differences between cold and humid canyons, and sun-exposed rocks with a warm and nutrient rich limestone base determine the abundance and species diversity of plant cover, which is also reflected in the number and species composition of malacofauna. This territory yielded 114 snail species (Šteffek 1975). The most abundant species, besides many others, in this territory are: *Helicigona faustina* (Rossmasler, 1835), *Clausilia dubia* (Draparnaud, 1805), *Cochlodina laminata* (Montagu, 1803), *Succinea putris* (Linné, 1758), *Ena monntana* (Draparnaud, 1801) (Šofránková 1982). These species also occur in numerous populations in the area of the High Tatras and they have been experimentally proved to play the role of intermediate hosts. Species of *H. faustina* contained lung nematode

larvae at different stage of development also under natural conditions. Similarly, in the National Park of Vel'ká Fatra dolomite and limestone substrates provide appropriate living conditions for the snails, thus creating possibility for chamois to become infected with lung nematodes.

The variety of snail species in the all of the Slovak National Parks and their great ability to serve as the intermediate hosts of lung nematodes in different biotopes establish the appropriate conditions for the development of lung nematodes. Long lifetime and great reproduction abilities of parasites in the lung along with great resistance of L1 larvae in the environment and the opportunity to hibernate in snails enables them for being preserved in all chamois biotopes in Slovakia (Sattlerová-Štefančíková 1982).

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