



# Pilot research on gastrointestinal parasites of the Tatra chamois (*Rupicapra rupicapra tatrica*)

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## Abstract

**Introduction.** The Tatra chamois (*Rupicapra rupicapra tatrica*) is a significant representative of the High Tatra Mountains endemic fauna species. In terms of health hazards for these animals, an important role is played by parasitic infections that can lead to a significant depletion of the entire population.

**Objective.** The aim of the study was to describe the occurrence of gastrointestinal parasites of Tatra chamois in the current environmental and climatic conditions of the High Tatra Mountains.

**Materials and method.** During the pilot project in 2014 – 2017, a total of 494 chamois faecal samples were collected from the Slovak High Tatra and 114 samples in the Polish part of the mountain and examined using standard coprological methods.

**Results.** The results revealed that the overall positivity for gastrointestinal parasites in chamois of the Slovak High Tatra reached 74.7%. Most frequent were protozoa – *Eimeria* spp. (42.7%), helminths were represented by *Moniezia* spp. tapeworms (23.5%), eggs of GIS-strongylids (7.1%), and sporadically *Capillaria* spp. (1.4%). The chamois from the Polish Tatra Mts. were infected with *Eimeria* spp. (43.9%), GIT-strongylids (9.6%), and *Moniezia* spp. (6.1%). Parasitic infection was determined in 59.6 % of faecal samples from the Polish part of the mountains. Statistical analyses revealed a significant difference in *Moniezia* spp. occurrence in different Slovak Tatra Mts. Regions, as well as between Slovak and Polish Tatra Mts.

**Conclusions.** Initial research on the gastrointestinal parasites of the Tatra chamois revealed one indisputable finding – a relatively high prevalence of the genus *Moniezia*, which is closely linked to the climate and microclimate conditions of the mountains. Further intensive research on parasite composition and distribution in Tatra chamois is needed in broader temporal, ecological, and zoological contexts.

## Key words

Tatra chamois, High Tatra Mountains, helminths, *Eimeria* spp., *Moniezia* spp.

## INTRODUCTION

The Tatra chamois (*Rupicapra rupicapra tatrica* Blahout, 1972) is a significant representative of the original glacial fauna. In 1972, based mainly on morphological features, it was recognized as a separate subspecies and an evolutionarily significant unit that requires conservation management. The species was classified by the IUCN World Conservation Union as an endangered species (EN) in the Carpathian Mountains and on the Draft Carpathian Red List of threatened mammals, and are therefore also considered to be endangered. Tatra chamois has been classified as a threatened species also by the EMA (European Mammal 52 Assessment) [1, 2].

In Slovakia, the only native autochthonous population of the chamois inhabits the alpine zone of the High, Western, and Eastern Tatra Mountains (on the Slovak and Polish sides). In the mid-19th century, chamois in the Tatra Mountains were not protected and as a result of poaching, hunting, and farming management of alpine habitats, especially pastures of sheep and cattle, only 300 individuals were recorded in

1860. After the Second World War and the establishment of national parks – TANAP (Slovakian Tatra National Park) and TPN (Polish Tatra Park Narodowy), the number of chamois began to increase, and in the period 1959–1965, the Tatra population consisted of 1,000 individuals. Since the mid-1960s, the number of chamois began to decline again and by the end of the 20th century, less than 200 individuals lived in the territory of the Tatra Mountains [1]. To prevent its extinction, the subspecies was also introduced into the Low Tatra National Park during 1969–1974. During this period, rescue efforts intensified, the declining trend stopped and the population numbers started to increase (345 individuals in 2003; more than 1,000 individuals after 2012). During the last autumn count of chamois in 2021, 1095 individuals (TANAP archive, personal communication) were counted, of which 781 were in the Slovak and 314 in the Polish part of the Tatra Mountain.

Whereas the increased abundance of these mountain-dwelling ruminants is a welcome event in general, more frequent contact with sympatric livestock might imply a risk of the transmission of pathogens [3]. In recent years, increasing emphasis has been given to research focused on protected animal species, particularly studying various risk factors, including climate conditions, anthropogenic

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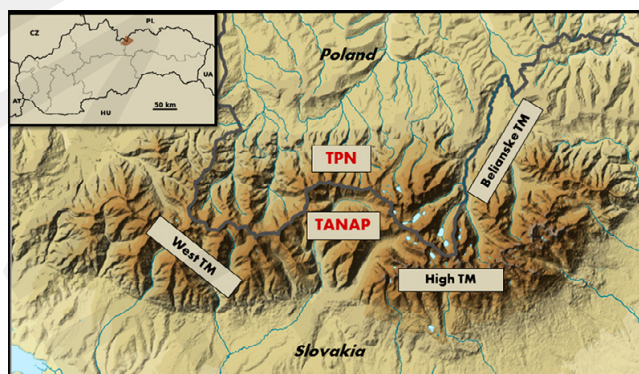
effects of inbreeding, as well as various infectious diseases, in particular parasitic infections. While the Alpine chamois populations have been subjected to several parasitological studies [4], parasites of the High Tatra endemics have generally been poorly studied. Partial research on chamois was carried out in the 1960s and 1980s [5], with the focus mainly on lungworms [6], but more recent data on parasite fauna of Tatra chamois is lacking.

## OBJECTIVE

The aim of this pilot study was to describe the gastrointestinal parasite fauna in the Tatra chamois in specific conditions of its habitat in the High Tatra Mountains in Slovakia and Poland.

## MATERIALS AND METHOD

**Study area.** The Tatra Mountains constitute the northernmost and highest part of the 1,200 km long arch of the Carpathian Mountains bordering Poland (Fig. 1). The total area of the Tatra Mountains covers 786 km<sup>2</sup> of which about 22% lies in Poland a 78% in Slovakia. It is the only mountain range in Slovakia and Poland with an alpine character. The geomorphological complex is divided into two sub-areas: the East Tatra Mountains (High Tatra and Belianske Tatra) and the West Tatra Mountains. The climate is continental with a typical alpine climate, with extreme temperature fluctuations, an average annual temperature of 2.5 – 3.9°C and annual precipitation of 599 to 1,498 mm [7, 8].



**Figure 1.** Chamois faeces sampling area.

TPN – Tatra National Park in Poland; TANAP – Tatra National Park in Slovakia; TM – Tatra Mountains.

The natural range of Tatra chamois covers an area of about 300 km<sup>2</sup>; the horizontal west-east distribution limit is 19°39'30''E, in south-north 49°08'18''N – 49°15'35''N. The species avoids forested parts of the mountains and inhabits the biotopes of the subalpine to the alpine vegetation level at an altitude of 1,749–2,655 m above sea level. Occasionally, it also descends to lower elevations (400–500 m), but only to areas that are characterized by rocky bedrock, steep slopes, and ecological heterogeneity [1].

**Faecal samples and flotation analyses.** Scat sampling was performed during 2014–2017 in different localities of chamois distribution in the High, West, and Belianske

Tatra Mountains. A total of 410 samples were collected from the High Tatra, 64 from the West Tatra, and 20 from the Belianske Tatra Mountains. In addition, 114 faecal samples were obtained from the territory of the Polish Tatra Mountains. All collections were carried out by the staff of the Tatra National Park Research Station and Museum, under the permit issued by the Ministry of Environment of the Slovak Republic (No. 4189/2014–2.3).

Faecal material collected in the field was stored at 4°C and delivered within 48 hours to the Institute of Parasitology (SAS) for parasitological examinations. Due to the varying condition and quality of the faeces, the samples were analyzed using a conventional qualitative centrifugal-flotation technique for the detection of coccidia oocysts and helminth eggs, in which neither EGP nor OPG values were calculated. Parasite propagative stages were identified based on morphology. Strongylid eggs were designed as GIT (gastrointestinal tract) strongylids.

**Statistical analyses.** The positivity of the analyzed samples for the surveyed parasites is presented as the relative frequency with a 95% confidence interval (95% CI). A Chi-squared test was used to test the differences in the occurrence of detected parasitic taxa for all monitored Tatra Mountains regions (High, West, Belianske, and Polish Tatra Mountains) with a value of  $p < 0.05$  considered significant. Statistical analyses were performed by the Quantitative Parasitology on the Web [9].

## RESULTS

Coprolological examination of 494 chamois faeces from the Slovak side of the High Tatra Mountains revealed the presence of gastrointestinal parasites in 369 samples, representing a positivity of 74.7%. However, the diversity of parasite fauna was relatively limited. The most prevalent were *Eimeria* spp. oocysts (42.7%). Gastrointestinal helminth eggs were detected in 158 samples (32.0%). *Moniezia* spp. eggs were the most common helminth eggs found in 23.5% of the samples tested. Unspecified strongyle-type eggs were detected in 7.1% and *Capillaria* spp. eggs were present in 1.4% of samples (Tab. 1). No Trematoda eggs were detected. During the period under study, no fluctuation in parasite occurrence was observed concerning season and year.

Regarding the geographic differences, despite the inequable sample size from different localities, *Eimeria* spp. predominated in samples from all three regions of the Slovak Tatra Mts. The second most numerous taxon was *Moniezia* genus with more than 25% of infected samples from the High Tatra and 17% from the West Tatra samples. On the contrary, in the Belianske Tatra region, *Moniezia* spp. was found in only a single sample (5%). The observed differences in *Moniezia* spp. occurrence in the three Slovak Tatra Mountains areas were statistically significant ( $p = 0.00003$ ). The occurrence of GIT strongylid eggs was relatively balanced (7.8% in the West Tatra, 6.8% in the High Tatra, and 10% in the Belianske Tatra).

The composition of the parasite fauna in chamois from the Polish part of the High Tatra Mountains was very similar, but variations in the abundance of individual parasite taxa were recorded. As with Slovak chamois, *Eimeria* spp. oocysts were the most frequent finding with a total

**Table 1.** Parasites found in faecal samples of Tatra chamois (*Rupicapra rupicapra tatrica*) from the High Tatra Mountains, Slovakia and Poland

|                        | Slovak Tatra Mountains |                                |                    |                                 |                        |                               |               |                                 | Polish Tatra Mountains (n=114) |                               |
|------------------------|------------------------|--------------------------------|--------------------|---------------------------------|------------------------|-------------------------------|---------------|---------------------------------|--------------------------------|-------------------------------|
|                        | West Tatra (n=64)      |                                | High Tatra (n=410) |                                 | Belianske Tatra (n=20) |                               | Total (n=494) |                                 | positive                       | % (95 % CI)                   |
|                        | positive               | % (95 % CI)                    | positive           | % (95 % CI)                     | positive               | % (95 % CI)                   | positive      | % (95 % CI)                     |                                |                               |
| <i>Eimeria</i> spp.    | 34                     | 53.1 (40.2 – 65.7)             | 170                | 41.5 (36.72 – 46.4)             | 7                      | 35.0 (15.4 – 59.2)            | 211           | 42.7 (38.3 – 47.1)              | 50                             | 43.9 (15.4 – 59.2)            |
| <i>Moniezia</i> spp.   | 11                     | 17.2 <sup>a</sup> (8.9 – 28.7) | 104                | 25.4 <sup>a</sup> (21.2 – 29.9) | 1                      | 5.0 <sup>a</sup> (0.1 – 24.9) | 116           | 23.5 <sup>b</sup> (19.8 – 27.5) | 7                              | 6.1 <sup>b</sup> (2.5 – 12.2) |
| GIT strongylids        | 5                      | 7.8 (2.59 – 17.3)              | 28                 | 6.8 (4.6 – 9.7)                 | 2                      | 10.0 (1.2 – 31.7)             | 35            | 7.1 (5.0 – 9.7)                 | 11                             | 9.6 (4.9 – 16.6)              |
| <i>Capillaria</i> spp. | 1                      | 1.6 (0.04 – 8.4)               | 6                  | 1.5 (0.5 – 3.2)                 | 0 (nc)                 | 0 (nc)                        | 7             | 1.4 (0.6 – 2.9)                 | 0 (nc)                         | 0 (nc)                        |

a – statistically significant (p=0.00003); b – statistically significant (p=0.0049); nc – not calculated.

positivity of 43.9%. Strongylid eggs were present in 9.6% of samples and *Moniezia* spp. eggs were found in seven samples (6.1%), which was a significantly lower rate compared to the Slovak Tatra Mountains. (p = 0.0049) (Tab. 1). Overall, the presence of gastrointestinal parasites was detected in 68 samples of chamois scat from Poland, representing a positivity of 59.6%, which is almost 15% less compared to the chamois samples obtained from the Slovak regions of the Tatra Mountains.

## DISCUSSION

Passive surveillance of wildlife health helps to detect the occurrence, spread, and distribution of infections, and improves the likelihood of early detection of emerging diseases [10]. It has been proved that parasites have a direct impact on the health status of natural ruminant populations [4]. The presented pilot survey on parasite fauna of the Tatra chamois therefore partially fills the gap that has arisen over the last 30 years, as the latest data on parasites of the species originated from the 1970s and 1980s. This applies in particular to GIT parasites, because chamois had been regularly tested for lungworms. Štefančíková et al. [6] investigated 258 samples of chamois faeces from the territory of the High Tatra Mountains which revealed the overall prevalence of pulmonary nematodes being 70.9%, with *Muellerius* spp. (68.2%) and *Neostromylus linearis* (38.0%) found in the samples. Compared to other TANAP areas (West Tatra, Belianske Tatra) and the Low Tatra National Park, the occurrence of lungworm was significantly the lowest in the High Tatra Mts.

The presented results indicate that even though propagative stages of GIT parasites were detected in nearly 75% of Slovak chamois samples, the parasite diversity in environmental conditions of the High Tatra Mountains is relatively low. A similar situation was observed in Polish individuals. Genus *Eimeria* was the most frequently detected parasite taxon.

Surprisingly, in the current study, nematode eggs were found only sporadically in chamois samples, which is in contrast to findings in the Balkan chamois from the Rhodope Mountains, where the GIT nematodes represent a dominant taxonomic group with the genera *Trichostrongylus* and *Nematodirus* being the most frequent findings (89.5% and 42.1%, respectively) [11].

Passive surveillance of Alpine chamois in Slovenia also revealed that nematodes were the predominant group of helminths, with *Haemonchus contortus*, Protostongylid nematodes, and *Chabertia ovina* diagnosed as the cause of death or emergency removal in 1.4 – 9.5% of animals and multiple parasitic infections in 15.1% [4]. Coprology and intestine examination of Alpine chamois in Croatia showed the presence of nine parasite taxa, of which eight were nematodes. *Oesophagostomum venulosum* and *Trichuris ovis* were the most prevalent species (45% and 35%, respectively) [12]. Similarly, the most common gastrointestinal parasites of chamois from Catalan Pyrenees, Spain, were *Trichostrongylus* spp., *Nematodirus* spp., *Ostertagia* spp., and *Haemonchus* spp. [13]. The average prevalence of gastrointestinal helminth infection was also high (69.5%) in Pyrenean chamois herds from the Catalan Pyrenees in Spain [14].

Contact between livestock and free-living ruminants represents a risk for the cross-transmission of parasites that chamois share with domestic ruminants. In most of the European mountain ranges, wild and domestic ungulates (sheep, goats) share the alpine and sub-alpine meadows during pasture season, which allows the transmission of parasites with the direct life cycle causing typical pasture helminthiasis [11, 15]. The low incidence of gastrointestinal nematodes in Tatra chamois might be due to some differences in their habitats compared to Alpine populations. The chamois in the High Tatra Mountains inhabit the alpine vegetation zone above the spruce forests where no other ruminant species occur. The population is completely isolated from other mountain areas, so that neither emigration nor immigration is possible [16, 17]. Farming and sheep grazing in the national park has been banned for more than 60 years. On the contrary, in other European habitats chamois are also found in the forest vegetation zone, and in the upper limit of the forest, where they share the habitat with other wildlife and domestic animals.

A completely different situation was observed in the occurrence of the family Anoplocephalidae in sampled animals from the Slovak part of the High Tatra Mountains. In the current study, compared to other authors, a significantly higher rate of infection with tapeworms of the Anoplocephalidae family was recorded; in 116 out of 494 samples tested (23.5%) *Moniezia* spp. eggs were found. The tapeworm was found in only 1% of chamois from the Austrian Alps [18], rarely in chamois from the Catalan Pyrenees [13],



in 10% of chamois from Gorski Kotar and Velebit region in Croatia [12], while no Anoplocephalid infection was found in Balkan chamois in Bulgaria [11]. Babják et al. [19] found 2.65% of dairy goats in Slovakia infected with *Moniezia* spp. Interestingly, in the current study, tapeworm eggs were detected in only seven samples (6.1%) from the Polish part of the High Tatra Mountains.

Considering the indirect life cycle of anoplocephalid tapeworms with oribatid mites as an intermediate host, the presence or absence of *Moniezia* infection may be determined by several biotic factors. It can be assumed that the high occurrence of anoplocephalid tapeworms in Tatra chamois may be because of the increased abundance of moss mites (Oribatida), and as a direct result of the gale in 2004 when a large part of the area was severely damaged. The following year, the area also suffered an extensive fire. All these events have been truncated in the changes of the High Tatra Mountain biota, and also in the shift in the soil fauna and a significant increase in the arthropod species diversity in all the calamity areas, with oribatid mites being the most frequently occurring group [20]. Oribatid mites are suitable intermediate hosts for trophically-transmitted parasites since they provide a stable and rich supply of susceptible hosts in most soils. However, the ecology of transmission of anoplocephalid tapeworms by oribatid mites is relatively unknown [21]. In natural conditions, the prevalence rate of mites infected with cysticercoids is usually low (less than 3%), which is attributed to the high density of oribatid mites in soil, resulting in dilution of infection in mites, species composition of oribatid mites, and temperature-dependent variation in infection rate [22]. The epidemiological role and potential of various oribatid species to host larval stages of cestodes is determined by their susceptibility to tapeworm eggs, their distribution, and abundance in different soils and vegetation zones. Also, the body size, anatomy of the mouth parts, habitat preference, and behaviour of the mites are important factors influencing infection transmission [23]. Critical environmental factors affecting oribatid mites distribution are temperature, soil moisture, solar radiation, food availability, and soil depth [24].

Based on the results of the current research, it can be assumed that the above-mentioned changes, together with global climate warming, have created favorable conditions for both, parasite eggs and intermediate host survival in chamois habitats in the High Tatra Mountains. Although the *Moniezia* spp. infections are usually non-pathogenic, especially in juvenile individuals, heavy infections may result in diarrhea, enterotoxaemia, and weak animals. Taking into account the possibility of co-infection with other pathogens (e.g., bacterium and virus), the negative consequences on host fitness may affect the very survival of the infected individuals.

## CONCLUSIONS

The results obtained indicate a high positivity of chamois faecal samples for oocysts and eggs of gastrointestinal parasites; however, the parasite diversity in environmental conditions of the High Tatra Mountains is relatively low. Surprisingly, a high rate of infection was recorded with tapeworms of the Anoplocephalidae family with *Moniezia*

spp. eggs found in 23.5% of examined samples. Further detailed research is needed to target the soil mites in habitats typical for chamois in the alpine vegetation zone, and the prevalence in them of cysticercoid larval stages of anoplocephalid tapeworms.

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