Ashworthius sidemi Schulz, 1933 (Trichostrongylidae: Haemonchinae) in mountain ecosystems – a potential risk for the Tatra chamois Rupicapra rupicapra tatrica (Blahout, 1971/1972)

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A B S T R A C T
The Asian native Ashworthius sidemi is now in Europe, and several dozen years after its introduction, it is a widespread parasite of all wild cervids. For bovids, the nematode is a significant threat to the European bison (Bison bonus) population and has also been found in moulon (Ovis aries musimon). Our study aimed to assess the risk of infection for the endemic subspecies of northern (Alpine) chamois (Rupicapra rupicapra) – the Tatra chamois (R. r. tatrica), which has a critically endangered status. We conducted the investigation in the mountainous areas of Slovakia and Poland occupied by Tatra chamois (R. r. tatrica), Alpine chamois (R. r. rupicapra), red deer (Cervus elaphus) and roe deer (Capreolus capreolus). Animals (n = 93) shot during licensed hunting and killed in road accidents (roe deer, red deer), or which had died of natural causes (chamois) were post-mortem examined for the presence of Haemonchinae. The investigation confirmed the expansion of Ashworthius sidemi to high mountain regions via Cervidae. A. sidemi affected all of the examined roe deer and 90.0% of the red deer. As for the chamois, A. sidemi was found in one R. rupicapra originating from the Low Tatras, but not in any pure R. r. tatrica individuals living in the High and Western Tatras. Our work is the first confirmation of northern chamois infection with this alien and highly pathogenic blood-sucking nematode. Due to the important health hazard of A. sidemi infection for the Tatra chamois (R. r. tatrica), appropriate measures should be taken to reduce the possibility of parasite transmission between various cervid species living in the Tatra region, as well as the affected population of chamois and the pure Tatra chamois population inhabiting the higher parts of the mountains, constituting their natural habitat.

1. Introduction

Ashworthius sidemi Schulz (1933) is an alien and ecologically invasive parasite species of ruminants, which has been spreading in Europe since the second half of the twentieth century. Its occurrence has gradually increased over recent years, especially in cervids, but also among free roaming wild bovids. While it is a typical parasite of Cervidae and occurs in infections usually not exceeding several hundred specimens, its intensity of infection may reach tens of thousands of specimens and cause ashworthiosis-related changes include oedema, hyperaemia and effusion in the gastrointestinal mucosa, leading to chronic diarrhoea, deterioration and cachexia, or the animal’s death (Demiaszkiewicz et al., 2009).

The first description of this trichostrongylid worm was made by Schulz (1933) from sika deer (Cervus nippon Temmink, 1838) living in farm conditions in the Russian Far East. A. sidemi was also discovered in introduced sika deer in former Czechoslovakia (Kotrlá and Kotrlý, 1973) and registered in maral (Cervus elaphus sibiricus Severtzov, 1873) introduced from Asia to the European part of Russia (Nazarova and Starodubova, 1974). Therefore, its presence among wild ruminants in several European countries can be explained by the translocation of this parasite with sika deer from Asia (Hoberg, 2010). In France, A. sidemi was found in sika deer, fallow deer (Dama dama Linnaeus, 1758), roe...
deer (Capreolus capreolus Linnaeus, 1758) and red deer (Cervus elaphus Linnaeus, 1758) (Ferté et al., 2000). In Sweden, it was registered in fallow deer of Hungarian origin (Höglund et al., 2007). In the European part of Russia, apart from sika deer and maral, the worm species was registered in native moose (Alces alces Linnaeus, 1758) and roe deer (Nazarova and Starodynova, 1974; Kuznetsov et al., 2018). In Belarus, it was found in European bison (Bison bonasus Linnaeus, 1758) (Kochko, 2003) and detected in roe deer in Ukraine (Ruzmina et al., 2010). In Czechoslovakia, apart from sika deer, red deer and mouflon (Ovis aries musimon (Pallas, 1811)) have also harboured this parasite (Kotrly and Kotrly, 1980).

A. sidemi has been documented as an introduced species in Poland since 1997 (Dróżdz et al., 1998). The parasite was observed for the first time in the country in several European bison in the Bieszczady Mountains (Eastern Carpathians, south-eastern Poland). Following confirmation of ashworthiosis in red deer and roe deer living in this region, Dróżdz et al. (2000) concluded that the origin of A. sidemi was local red deer, which brought the parasite from neighbouring Ukraine and Slovakia along the Carpathian ecological corridor. Next, in 2001, the nematode was observed in lowland European bison in Bialowieża National Park (Dróżdz et al., 2002). Another documented concentration of ashworthiosis was the Dulowa Primeval Forest in southern Poland, where fallow deer introduced from Hungary were found to be infected (Kowal et al., 2012). Recently, the further and rapid expansion of this nematode has been observed among all Cervidae species living in the country, including moose (Demiaszkiewicz et al., 2013), and the parasite has also been identified for the first time in domestic cattle (Bos taurus Linnaeus, 1758) by means of the polymerase chain reaction method (Moskwa et al., 2015).

The Tatra chamois (Rupicapra rupicapra tatrica (Blahout, 1971/1972)) is a representative of the Bovidae family and the northernmost subspecies of the northern (Alpine) chamois (Rupicapra rupicapra (Linnaeus, 1758)), which is native to the mountainous parts of central and southern Europe and Asia Minor. In the Alps, where the bulk of the northern chamois population is found, the species is relatively secure and consequently assessed as least concern (LC) in the International Union for Conservation of Nature’s Red List of Threatened Species (Aulagnier et al., 2008). However, several chamois subspecies qualify as globally threatened and require urgent conservation action, including the Tatra chamois, which is listed as critically endangered (CR).

The Tatra chamois occur in the Tatra Mountains of Poland and Slovakia, living in areas protected by national parks of both countries, i.e. in the High, Belianske and Western Tatras. The population has been declining steadily since the 1960s and had dropped to below 200 individuals by 2002 (Aulagnier et al., 2008). Since then, by strictly regulating tourism and suppressing poaching, the population has started to recover, reaching the highest ever recorded population of 1431 individuals in 2018 (https://tpn.pl/nowosci/kozice-policzone-5, accessed Dec 14, 2020).

In Slovakia, Tatra chamois have also been artificially introduced (30 individuals) to the Low Tatras to create a reserve population (Shackleton et al., 1997) (Fig. 1). However, the Alpine chamois were introduced there for hunting purposes before the Tatra chamois were officially classified as a separate subspecies, and the Low Tatra population of R. r. tatrica crossbred with Alpine chamois migrating from the Fatra Mountains and the Slovak Paradise National Park. Therefore, it cannot act as a reserve population for the Tatra chamois because it is no longer pure population. On the contrary, according to Shackleton et al. (1997), the R. r. rupicapra introduced to Slovakia should be removed, as they pose a threat to the wild population of R. r. tatrica living in the High Tatras, from which they are separated by only a single valley – a distance of about 30 km.

The present study aimed to determine the threat to both populations of chamois living in the Tatras from the alien Ashworthius sidemi

Fig. 1. Map of Tatras showing the geographical origin of the animals included in the study.
2. Materials and methods

2.1. Study area and material collection

The study was conducted in the mountainous territory of Tatra National Park (High and Western Tatras; altitude from 800 to 2655 m a.s.l.), Piwniczna Forest District (Beskid Sądecki Mountains, West Carpathians; up to 1114 m a.s.l.), as well as other hunting areas managed by Slovak State Forests, i.e. Liptovský Hradok and Presov (Low Tatras; up to 2043 m a.s.l.). The areas are occupied by Tatra chamois (R. r. tatrica; High and Western Tatras), Alpine chamois (R. r. rupicapra; Low Tatras), and stable populations of red deer (C. elaphus) and roe deer (C. capreolus). Animals shot during licensed hunting, killed in road accidents (roe deer, red deer), or that had died a natural death (chamois) constituted the research material.

2.2. Laboratory analysis and identification of worms

Parasitological examinations of the abomasum collected from a total of 93 wild ruminants (Fig. 1, Table 1) were conducted according to a modified Hansen and Perry method (Hansen and Perry, 1994). The whole contents and washings of the mucosa were rinsed over a 250 μm mesh sieve, and then transferred in small portions into Petri dishes to be examined under a stereomicroscope. All isolated nematodes were preserved in 75% ethanol. The Haemonchinae were identified to species on the basis of the morphometric features of the bursa copulatrix, spiculae and the career of the examined chamois host.

| Host species          | Ashworthia sidemi (n = 93) | Haemonchus contortus (n = 93) |
|-----------------------|-----------------------------|-------------------------------|
|                       | P (%)                       | I (%)                        | R (%)                        | MA (%)                     |
| Rupicapra rupicapra   |                             |                              |                              |                           |
| (n = 31)              | 3.2*                        | 25                            | 25                            | 0.8                        |
|                       |                             | 0.0                           | –                             | –                          |
|                       |                             | 0.0                           | –                             | –                          |
| Capreolus capreolus   |                             |                              |                              |                           |
| (n = 42)              | 100                         | 196                           | 1-2276                        | 294                        |
|                       |                             | 7.1                          | 4-9                           | 0.5                        |
|                       |                             | –                            | –                             | –                          |
| Cervus elaphus        |                             |                              |                              |                           |
| (n = 20)              | 90.0                        | 210                           | 2-1756                        | 202                        |
|                       |                             | 0.0                          | –                             | –                          |
|                       |                             | –                            | –                             | –                          |

Abbreviations: P – prevalence given as percentage of infected/examined animals; I – mean intensity; R – range; MA – mean abundance.

* A. sidemi derived from one Alpine/crossbred chamois Rupicapra rupicapra; the pure Tatra chamois R. r. tatrica were not infected.

with a prevalence of 7.1%, and it co-occurred with A. sidemi in two of the three infected animals. The intensity of H. contortus infection did not exceed several specimens.

4. Discussion

This is the first confirmation of A. sidemi infection in the chamois R. rupicapra. Although the methodological work of Lehrter et al. (2016) has a statement on the infection of northern chamois with A. sidemi – which was later quoted, e.g. by Kuznetsova et al. (2018) – the results of that work (Lehrter et al., 2016) indicate another Haemonchinae species, H. contortus, as the one isolated from the examined chamois host.

The generalist nematode H. contortus is transmitted in the Alps between populations of domestic and wild ruminants, and is commonly found in northern chamois (Citterio et al., 2006; Cerutti et al., 2010). However, the nematode was never found in chamois living in the Tatras, and the current study also failed to confirm the presence of H. contortus in Tatra chamois. Instead, the presence of A. sidemi was revealed.

In the autochthonous range of R. r. tatrica (Fig. 1) on the Slovak side of the Tatras – although the presence of H. contortus together with Teladorsagia circumcincta was confirmed in sheep (Mituch 1974) – the grazing of domestic animals is not allowed, whereas on the Polish side, cultural grazing of local sheep breeds is practiced on the mountain pastures of the Tatra National Park. The herds of sheep from this region of Poland are confirmed to be infected by H. contortus, T. circumcincta, and a dozen nematode species from the genera of Trichostrongylus, Cooperia, Nematodirus, Oonchotheca, Chabertia, Oesophagostomum, Trichuris and Skrjabinema (Nosal et al., 2015). Apart from Marshallagia species, T. circumcincta was also noted in the Tatra chamois (Kowal et al., 2017). Fortunately, H. contortus seems to be weakly resistant to high mountain conditions (Citterio and Lanfranchi, 2006), and northern chamois may also be able to avoid pastures contaminated with sheep dung (Fankhauser et al., 2008). In the present research, we found cervids to be highly infected with asworthiosis – both roe deer and red deer, while only roe deer were found to have H. contortus specimens. The red deer covers long distances, while the roe deer does not leave its home range and can be a local source of asworthiosis for other ruminant species, including domestic ones. Thus far, A. sidemi has been found in the high Tatras only in red deer (Mituch et al., 1992), while our current research has also confirmed its presence in roe deer. The nematode is considered typical for the Cervinae subfamily but ecologically invasive, and all Cervidae and Bovidae species can become hosts. This was the case of the European bison, the introduction of which to the Bieszczady Mountains has considerably changed this bovid’s nematode fauna, with the adoption of A. sidemi and loss of H. contortus (Droźdź et al., 2002). At the same time, even all the red and roe deer examined were free of H. contortus, and only A. sidemi was widespread. Double infections of Ashworthius and Haemonchus were not found in the roe deer studied by Ferte et al. (2000), and only A. sidemi occurred in the red deer – similarly to our findings. In a study conducted by Demiażkiewicz et al. (2016) on red deer from the Lower Silesian Wilderness in south-western Poland, only A. sidemi was found, albeit some European authors (Droźdź, 1966; Kortlí and Kotrál, 1980) declare the presence of H. contortus in this host species. On the other hand, H. contortus was observed as a co-parasite of A. sidemi in roe deer in Ukraine (Kuzmina et al., 2010) and in France (Lehrter et al., 2016) – although here, only a few individuals were found, which was also the case in our present investigation.

A. sidemi, as an alien and ecologically invasive parasite species of wild ruminants, is spreading extremely quickly across Poland (Demiażkiewicz et al., 2017). The present work confirms its spread also in high mountain regions. An important issue associated with the lower risk of R. r. tatrica acquiring A. sidemi infections may only be the fact that while Alpine chamois normally descend below the forest border of the mountains in winter, and the animals occur from 500 m to 3100 m a.s.l. in the Alps (Aulagnier et al., 2008), the Tatra chamois do so sporadically, ranging from 1200 m upwards – to 2630 m a.s.l. (Krístofík and Danko, 2017).
2012). However, roe deer in the Tatras reach a height of about 1660 m a.s.l. and red deer are found up to a height of 1800–2000 m a.s.l. (Kristofik and Danko, 2012). Further, on the Slovak side of the Tatras, feeding racks for animals are provided at an altitude of 900 m a.s.l. In severe winters, when chamois can descend to such racks, and during the red deer rut – when the cervids climb to high altitudes – the risk of infection is highest. Special attention should also be paid to minimising likely contact between the pure Tatra chamois and the other population from the Low Tatras, which have already been affected by this highly pathogenic parasite. The latest data show that A. sidemi also has a very negative effect on the activity of the digestive system of this host species, which may result in weight loss of the infected animals (Vadljev et al., 2019).

4.1. Conclusions

Hopefully, it seems that no pure R. r. tatraica, a critically endangered subspecies of R. rupicapra, has acquired ashworthiosis, and this has only occurred in the chamois crossed population from the Low Tatras. Nevertheless, the risk of A. sidemi appearing in the indigenous Tatra chamois is presently very high and requires constant monitoring. It is particularly important to take appropriate countermeasures to reduce the possibility of parasite transmission between the cervids and chamois living in the High, Belianske and Western Tatras.

Ethical statement

The study was performed in accordance with the law regulations in Poland and Slovakia.

Declaration of competing interest

The authors declare that they have no conflict of interests.

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