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Research Note

Parasitic helminths in snakes from the global legal trade

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Summary

In recent years, the demand for snakes imported from different countries around the world has increased in Slovakia. However, such snakes can be infected with a wide variety of parasites. We have been focused on monitoring the prevalence of parasitic helminths of snakes imported to Slovakia. From 2015 to 2020, 205 samples were collected. We examined faecal samples of 185 live snakes, and a parasitological autopsy was performed on 20 carcasses. Out of a total of 205 snakes, parasitic helminths were found in 44 individuals (21.46 %). Coprological examination of live snakes confirmed positivity for the presence of helminths in 38 snakes (20.54 %). Through parasitological autopsy of all the dead snakes, we found helminths or their eggs in 6 carcasses (30.00 %). The genera of helminths found in the positive snakes were: *Ophiotaenia* spp., *Kapsulotaenia* spp., *Strongyloides* spp., *Rhabdias* spp., *Ophidascaris* spp., *Ascaridia* spp., f. Heterakidae, *Kalicephalus* spp., *Capillaria* spp., order Oxyurida and stages of the plerocercoid of an unidentified species of tapeworm in the subcutaneous tissue.
Keywords: snakes; parasites; helminths; Slovakia

Introduction

The increasing interest in the breeding of various species of snakes is associated with growth in their imports from abroad. A large proportion of imported individuals are of unclear origin; these are usually snakes taken from the wild. The risk of parasites in such animals is very high. The import of these snakes without adequate veterinary control poses an increased risk of introducing parasitic helminths into the herd as well as a risk to the health of breeders, given the zoonotic potential of some species (Köhler, 2002). Parasitic helminths from the group of protozoans, nematodes, cestodes, trematodes, acanthocephalans, and pentastomids can be found in snakes (Grego *et al*., 2004; Yildirimhan *et al*., 2007; Paré, 2008; Richter *et al*., 2008; Duszynski & Upton, 2010; Mihalca *et al*., 2010; Vergles Rataj *et al*., 2011; Wolf *et al*., 2014). Various species of non-venomous and venomous snakes are bred in private collections as well as by professional breeders. The origin of kept snakes varies. A large number of imported snakes are captured in the wild in their countries of origin. Wild-caught animals are more likely to have parasitic disease than captive-bred animals, and parasites with direct life cycles are much more likely to persist in captive populations than those with indirect life cycles (Divers & Stahl, 2019). The different pathogens in these species vary greatly, and even a healthy reptile carries many pathogens (Vergles Rataj *et al*., 2011). In captivity, a reptile is highly stressed and this can induce many pathologies, mainly those related to parasites and especially in animals kept at improper environmental temperatures or those suffering from starvation or prolonged de-

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hydration after long transport (Siqueira *et al*, 2009). Parasites can reach high infection loads in hosts in captivity and may lead also to the death of a snake (Klingenberg, 2000).

Although the life cycle of a trematode may be unknown, an intermediate host is most likely involved, because an intermediate host is needed for all digenetic flukes; thus, infection in captivity should be self-limiting. (Jacobson, 2007). Reptiles are affected by tapeworms of the orders Cyclophyllida, Proteocephalida, and Pseudophyllida. The complex indirect life cycle naturally restricts tapeworm infection in a terrarium to some extent. However, tapeworms do pose a larger risk for wild-caught and farm-bred animals, as they can live inside their host for several years and may eventually cause the death of the captive reptile (Schneller & Pantchev, 2008). Nematodes are the most common parasitic helminths of reptiles, affecting different organs. Roundworms (*Ascarididae*) and hookworms (*Strongylidae*) are significant parasites of the gastrointestinal tract of snakes and lizards. (Doneley *et al*., 2018). Frey (1991) detected pinworm eggs in pythons. *Capillaria* spp. are common in reptiles from humid environments and are easily identified in faecal samples by their typical barrel-shaped eggs with polar plugs (Doneley *et al*., 2018). These tiny worms live mainly in the small intestine of the host (Mader, 2006). Nematodes of the genus Kalicephalus (Diaphanocephalidae) are typical gastrointestinal blood-sucking parasites of snakes with low host specificity. Cycle autoinfection and superinfection is very often among captive-bred snakes (Anderson, 2000).

Material and Method

From 2015 to 2020, we examined 205 individuals of 26 species of snakes from several import companies. We examined faecal samples of 185 live snakes and a parasitological autopsy was performed on 20 carcasses. Due to the small amount of samples, it was only possible to perform a single flotation examination. This allowed us to identify parasites at the genus or family level only. Examined samples were from snakes of the species *Morelia viridis*, *Python regius*, *Orthriophis taeniurus friesei*, *Thamnophis butleri*, *Pantherophis guttatus*, *Boiga dendrophila*, *Montivipera raddei*, *Ophiophagus hannah*, *Naja haje legionis*, *Naja haje haje*, *Cerastes cerastes*, *Echis pyramidum*, *Aspidelaps lubricus*, *Naja peroescobari*, *Crotalus durissus vegrandis*, *Agkistrodon contortrix*, *Elaphe obsoleta*, *Corallus caninus*, *Vipera ammodytes*, *Dispholidus typus*, *Philothamnus punctatus*, *Chrysopelea paradise*, *Ahaetulla prasina*, *Simalia amethistina*, *Leiopython albertisii* and *Apodora papuana*.

Snake droppings were collected from snakes held in quarantine facilities, before antiparasitic administration. In the laboratory, faeces were examined using a standard flotation method (Foreyt, 2001). Autopsies were performed with a focus on the digestive tract and respiratory system (Letková & Čisláková, 2010). Snakes examined by autopsy died during transport or in the first few days in quarantine. They were stored in a freezer and then transported to our laboratory. None of the examined individuals were euthanized. The intestinal content of dissected snakes was examined by the flotation method. An inspection of the coelom cavity, subcutaneous tissue, and other organs was also done. In dead individuals of ball pythons (*Python regius*), a portion of the colon contents was collected during necropsy and flotation-examined for the presence of helminth eggs. Subsequently, the digestive system was examined for the presence of adult worms. This means that all identified helminths were detected as eggs by the flotation method and only some were confirmed by the finding of adult worms (Table 1).

The finding of a plerocercoid stage in the subcutaneous tissue of snakes (*Ahaetulla prasina, Philothamnus punctatus*) occurred during surgery aimed at their removal, following the standard anesthesiology and surgical procedures used in reptiles.

Results

Out of the total number of 205 snakes, parasitic helminths were found in 44 individuals (21.46 %). We found 38 snakes (20.54 %) infected by helminths by coprological examination. By parasitological autopsy, we found helminths or their eggs in 6 carcasses (30.00 %).

Table 1 lists the positive snakes and the identified parasitic helminths. The genera of helminths found in the positive snakes were *Ophiotaenia* spp., *Kapsulotaenia* spp., *Strongyloides* spp., *Rhabdias* spp., *Ophidascaris* spp., f. Heterakidae, *Kalicephalus* spp., *Capillaria* spp., order Oxyurida and stages of a plerocercoid (spargana) of an unidentified species of tapeworm in the subcutaneous tissue.

Reptiles that are traded are sourced directly from the wild, local farms or are bred in captivity. Animals may die during any part of the trade chain, from the collection in the wild, in transit or at home. The use of prophylactic methods is very common and may have affected our results. This may be the reason why we did not find as rich a parasitic fauna in our examined snakes as we expected.

Discussion

Understanding the parasites of a particular species is crucial. It is very important to provide data on the parasitic fauna of imported snakes to establish prophylactic and therapeutic methods to properly reduce the mortality of captive reptiles. European parasitological investigations have found high prevalences of endoparasite infections in snakes in captivity with prevalences of 36.7 % (Pasmans *et al*. 2008). Vergles Rataj *et al*. (2011) examined a total of 949 specimens imported into Slovenia for parasitic fauna. Twelve different groups (Nematoda, Trematoda, Acanthocephala, Pentastomida, and Protozoa) of endoparasites were determined in 26 (47.3 %) of the 55 snakes examined. A helminthological survey in Poland reported on 642 specimens of reptiles, namely *Natrix natrix*, *Vipera berus*, *Lacerta agilis*, *Zootoca vivipara*, *Anguis fragilis* sensu lato, and *Zamenis longissimus*. The highest species richness of internal parasites was observed in *N. natrix* and *V. berus* (Kuśmierek et.al., 2020). The study of Nasiri *et al*. (2014) evaluated parasitic infection rates of snakes in Iran. A total of 87 snakes belonging to eight different species were examined for the presence of gastrointestinal parasites, and 12 different genera of endoparasites in 73.56 % of the examined snakes were determined. In total, 47.12 % of the snakes had gastrointestinal parasites. Authors Okulewicz, Kaźmierczak and Zdrzalika (2014) examined a total of 28 snakes housed in the City Zoological Garden in Wrocław and 23 snakes from zoological wholesale for the presence of endoparasites. Helminths were detected in a total of 13.7 % of snakes. Two groups of protozoa were detected (*Choleoeimeria sp., Ciliata*) as well as nematodes (*Kalicephalus sp., Dioctowittidae*) and Oxyurida.

Numerous trematodes have been reported from all groups of reptiles; however, relatively few have been associated with any disease process. In snakes, they can be found in the digestive, respiratory, and urinary tracts. Snakes can be the intermediate host of the genera *Alaria* and *Fibricola*, the mesocercariae and metacercariae stages of which have been found in subcutaneous lesions and coelomic fat (Jacobson, 2007). However, in the samples we examined, we found no trematode eggs in live snakes or developmental stages in dissected individuals.

Several genera of tapeworms infect snakes. The major genus, *Ophiotaenia*, consists of approximately 50 species. The life cycle includes an intermediate invertebrate (copepod) host, and reptiles serve as the definitive host (Jacobson, 2007). In the group of snakes we examined, we confirmed the eggs of this genus in four venomous snakes originating from Asia and Africa. We found characteristic clusters of eggs of *Kapsulotaenia* spp. in faecal samples

Table 1. Positivity of examinated snakes and the identified parasitic helminths

Snake species	**Helminths identified**
Morelia viridis (52/2/20)*	*Kapsulotaenia* spp., *Capillaria* spp., *Kalicephalus* spp., *Heterakis* spp., *Ophidascaris* spp.
Python regius (11/15/6)	*Strongyloides* spp., ***Heterakis* spp., *Capillaria* spp., ***Kalicephalus* spp., ***Ophidascaris* spp.
Orthriophis taeniurus friesei (2/0/0)	none
Thamnophis butleri (4/2/2)	*Strongyloides* spp., *Heterakis* spp., *Kalicephalus* spp., o. Oxyurida
Pantherophis guttatus (3/0/1)	*Kalicephalus* spp., *Capillaria* spp.
Boiga dendrophila (4/1/2)	*Heterakis* spp., *Capillaria* spp., *Kalicephalus* spp., o. Oxyurida
Montivipera raddei (3/0/1)	*Ophiotaenia* spp., *Heterakis* spp., o. Oxyurida
Ophiophagus hannah (3/0/2)	*Ophiotaenia* spp., *Capillaria* spp., *Ophidascaris* spp., o. Oxyurida
Naja haje legionis (12/0/3)	*Ophiotaenia* spp., *Heterakis* spp., *Capillaria* spp., o. Oxyurida
Naja haje haje (15/0/0)	none
Cerastes cerastes (10/0/0)	none
Echis pyramidum (15/0/0)	none
Aspidelaps lubricus (6/0/2)	*Ophiotaenia* spp., *Heterakis* spp., *Capillaria* spp., o. Oxyurida
Naja peroescobari (2/0/0)	none
Crotalus durissus vegrandis (4/0/0)	none
Agkistrodon contortrix (3/0/0)	none
Elaphe obsoleta (4/0/0)	none
Corallus caninus (9/0/0)	none
Vipera ammodytes (4/0/2)	*Kalicephalus* spp., *Heterakis* spp., o. Oxyurida
Dispholidus typus (2/0/0)	none
Philothamnus punctatus (1/0/1)	*Rhabdias* spp., ***Acanthocephala
Chrysopelea paradise (3/0/0)	none
Ahaetulla prasina (4/0/1)	***Acanthocephala
Simalia amethistina (3/0/0)	none
Leiopython albertisii (4/0/1)	*Ophidascaris* spp.
Apodora papuana (2/0/0)	none

* Number of live/dead/infected snakes examined.
** Indicates eggs found on float and adult worms found at necropsy. For all others, eggs were found on float only.
***Larval stages found under the skin.

from the Green Tree Python (*Morelia viridis*), as described by Schneller and Pantchev (2008).

Nematodes were the most frequently determined group of parasitic helminths in the examined snakes. In virtually all infected snakes, a mixed infection was found, with at least two genera of helminths. Nematodes of the genus Capillaria had the highest proportion in positive individuals (18 snakes). Species of *Ophidascaris* (Ascarididae) and *Kalicephalus* (Strongylidae) are frequently found in reptiles (Doneley *et al*., 2018). Together, these genera represented the most numerous group in the snakes we tested. Heavy burdens may lead to gastrointestinal inflammation, haemorrhagic ulceration, and death (Kavitha *et al*., 2014). The genus Kalicephalus is reported to infect snakes all over the world and parasitizing the gastrointestinal tract of snakes from the esophagus to the small intestine (Purwaningsih, 2011; Kavitha *et al*., 2014;). In the parasitological survey, Hallinger *et al*. (2020) examined 586 stool samples from 71 different snake species either kept as pets in households or at zoological gardens in Germany. The examined samples contained 20 different parasites, and the ancylostomatid *Kalicephalus spp*. was the most prevalent nematode species. Frey (1991) described pinworm eggs in pythons. We found them not only in pythons but also in cobras and vipers as well. The identified nematode genera have a direct developmental cycle and can easily spread in snake collections. This highlights the need for adherence to quarantine, quality parasitological screening, and appropriate anthelmintic therapy of all newly imported snakes already in the facilities of commercial companies.

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