An Investigation of Potentially Zoonotic Helminth Parasites of *Allactaga elater* in Sarakhs, Iran

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**ABSTRACT**

**Article History:**
Received: 13/09/2022
Accepted: 17/10/2022

**Keywords:**
*Allactaga elater*
Sarakhs
Zoonotic helminth parasites

**Introduction:** Rodents are the reservoir of many endoparasites and act as their intermediate or final hosts. This study aimed to assess parasitic helminths of *Allactaga elater* in Sarakhs, Khorasan Razavi Province, northeastern Iran.

**Materials and methods:** From August 2017 to February 2018, 33 *Allactaga elater* were collected using live traps. All *Allactaga elater* were euthanized, and their gastrointestinal tracts were removed and examined to identify parasitic helminths. Finally, parasites were identified using key morphological characteristics.

**Results:** Overall, 91% of *Allactaga elaters* were infected with helminths, including Syphacia obvelata (86.6%), Aspicularis tetraperta (36.6%), Trichuris spp (13.3%), Heligmosomoides polygyrus (3.3%), Hymenolepis nana (16.6%), *Hymenolepis diminuta* (16.6%), and *Cysticercus fasciolaris* (13.3%).

**Conclusion:** Various species of helminths were found in *Allactaga elater* from the studied area. These findings highlight the importance of this rodent species as a reservoir for zoonotic helminths.

1. Introduction

*Allactaga elater* is a rat-sized five-toed jerboa belonging to the family Dipodidae. The coat of *Allactaga elater* is velvety, with sandy color upperparts and whitish underparts. The tail tuft is black but white at the point. The five-toed jerboas are decent excavators and joggers. They can run at a speed of 40 kilometers per hour. They use their burrows for various purposes, such as resting, evading hunters and high temperatures, caring for progenies, and winter hibernation. The diet of *Allactaga elater* includes invertebrates, like insects, seeds, leaves, stems, and roots of plants. They are specialized herbivores, and the mode of locomotion in the *Allactaga elater* is jumping. They can be found in desert areas of Asia and some parts of Europe, such as Afghanistan, Azerbaijan, China, Armenia, Iran, Russia, Turkey, Georgia, and Turkmenistan.

Rodents, including *Allactaga elater*, have an important role as a host of many parasitic agents, either zoonotic or those threatening rodents' health, such as *Oxyuriasis*. One of the most life-threatening parasitic diseases with a high fatality rate is echinococcosis. Echinococcosis is a disease caused by *Echinococcus* species, including different types, such as cystic and alveolar echinococcosis. Alveolar echinococcosis, caused by the metacestode of *Echinococcus multilocularis*, is a fatal zoonotic disease. Regarding geographical distribution, it could be found mostly in the northern hemisphere, including the Middle East. The life cycle of *Echinococcus multilocularis* includes adult worms that are found in wild carnivores, and metacestodes developed in small mammals, especially rodents such as *Allactaga elater*. Certainly, rodents have a main role in the transmission and storage of some transmissible diseases. So, they are considered a risk factor for both human and animal health. *Allactaga elater* is one of the most widespread rodents in Iran, and also, little attempt has been made to demonstrate the role of *Allactaga elater* in transmitting rodent-borne diseases nearby the region of our study. The current study aimed to investigate cysts and...
helminths in *Allactaga elater* in Sarakhs, Razavi Khorasan, Iran, as a threatening factor for both residents and animals of that region.

2. Materials and Methods

2.1. Ethical approval

All procedures were approved by the Animal Care Committee of Veterinary Medicine, Ferdowsi University, Mashhad, Iran. The principles of laboratory animal care were followed, and specific international laws were observed.

2.2. Sampling

*Allactaga elater* were captured (Figure 1) using live traps from the countryside of Sarakhs (36°31' N and 61°12' E), a city located in the Razavi Khorasan Province, Iran (Figure 2), with a hot, semi-arid climate, from Aug 2017 to Feb 2018. Rodents were transferred to the Rodentology Research Department, Institute of Applied Zoology, Ferdowsi University of Mashhad, Iran, and anesthetized under chloroform inhalation. After measuring morphological features, species of rodents were detected based on identification keys (Figure 3)\(^{19, 20}\).

2.3. Dissection and tissue examination

After dissection, the skin was removed, and the body was opened from the ventral surface. Abdominal cavities and livers were observed macroscopically for the presence of alveolar hydatid cysts and metacestodes, respectively. The internal organs (esophagus, stomach, intestine, and liver) of each rodent carcass were cut longitudinally and put in 0.95% mammalian saline solution (MSS). The contents were examined under a stereomicroscope (Olympus, Japan) to find adult or larval stages of helminths. Also, to separate *Trichinella* spp larvae, a sample of striated muscles was taken from arms and tongues.

2.4. Helminthic detection and identification

Regarding cysts, they were examined under a stereomicroscope to determine their base on their protoscolex formations. About cestode parasites, they were placed between two glasses for a week. After immersion in 70° ethanol, they were stained with carmine alum. Dehydrated in ethanol and mounted in Canada balsam, the species and genus of cestodes were described. Concerning nematodes, they were fixed in 70 ° ethanol before clearing in lactophenol. Species and genera of nematodes were detected using the morphology of their spicules and mouths\(^{21}\).

2.5. Trichinella and Capillaria spp findings

About *Trichinella* spp, cut muscles were digested in acid-pepsin. After that, the settled sediment was washed several times and the sediment of the last washing was examined under a microscope to find any probable larva. Livers, similar to muscles, were digested by acid-pepsin to remove *Capillaria* spp larva. Species and genera of isolated parasites identified with valid systematic keys\(^{21}\). 

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[Figure 1]: Euthanized *Allactaga elater* (Original)

[Figure 2]: Map of Razavi Khorasan Province showing Sarakhs County, where the present study was carried out

[Figure 3]: Mandible, upper and lower teeth of *Allactaga elater* \(^{20}\)
3. Results

During the study, 33 rodents belonging to the species and genus *Allactaga elater* were captured. It was measured that 91% of *Allactaga elater* were infected at least with one species of parasites. According to Table 1, while no *Allactaga elater* was infected with an alveolar hydatid cyst, the infectivity rate with *Cysticercus fasciolaris* was 13.3%. Furthermore, contamination with cestodes and nematodes had a high prevalence, some of which are considered a zoonosis. Table 1 and Table 2 show the number, infection frequency, and range of examined *Allactaga elater* with cestodes and nematodes, respectively.

Table 1. Number, prevalence, and range of cestodes species collected from 30 *Allactaga elater* from Aug 2017 to Feb 2018

<table>
<thead>
<tr>
<th>Genus</th>
<th>Number of cestodes</th>
<th>Infection frequency (%)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Echinococcus multilocularis</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Hymenolepis nana</em></td>
<td>5</td>
<td>16.6</td>
<td>1</td>
</tr>
<tr>
<td><em>Hymenolepis diminuta</em></td>
<td>5</td>
<td>16.6</td>
<td>1</td>
</tr>
<tr>
<td><em>Cysticercus fasciolaris</em></td>
<td>4</td>
<td>13.3</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2. Number, prevalence, and range of Nematodes species collected from 30 *Allactaga elater* from Aug 2017 to Feb 2018

<table>
<thead>
<tr>
<th>Genus</th>
<th>Number of males</th>
<th>Infection frequency (%)</th>
<th>Number of females</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Syphacia obvelata</em></td>
<td>549</td>
<td>86.6</td>
<td>20</td>
<td>1-120</td>
</tr>
<tr>
<td><em>Aspicularis tetraptera</em></td>
<td>19</td>
<td>36.6</td>
<td>1</td>
<td>1-4</td>
</tr>
<tr>
<td><em>Syphacia obvelata</em></td>
<td>5</td>
<td>13.3</td>
<td>-</td>
<td>1-2</td>
</tr>
<tr>
<td><em>Heligmosoides polygyrus</em></td>
<td>3</td>
<td>3.3</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

4. Discussion

In the year 1971, *Echinococcus multilocularis* was reported for the first time in the carnivores of northwestern Iran.

Concerning *Cysticercus fasciolaris*, in the present study, similar to previous ones, it was one of the uncommon cestodes. Metacestodes of *Cysticercus fasciolaris* (larvae of Taenia taeniaeformis) were found in the livers of *Allactaga elater* in North Khorasan Province, northeast of Iran. While in a study in the southwest of Iran, the rate of infectivity with *C. fasciolaris* in rodents was almost high.

*Syphacia obvelata* was the most frequent helminth in our study, with a rate of 86.6%, which is kind of in agreement with the study had been done by Moradpour et al. in a different region of Iran. In their study, 16.6% of *Allactaga elater* were infected with *S. obvelata*. This nematode has been reported from north, central, and northwestern Iran. *S. obvelata* is a zoonotic parasite, and its high frequency could be because of its direct life cycle.

In the present study, 36.6% of the *Allactaga elater* were infected with at least one *Aspicularis tetraptera*. *A. tetraptera* was widely reported from wild rodents in Iran and other countries. Through the study of Moradpour et al., it was separated exclusively from *Allactaga elater* in Razavi Khorasan and Zanjjan Provinces, Iran. In a study in Shiraz, Fars Province, Iran, 90% of rodents were infected with *A. tetraptera*. Its high prevalence may be due to the direct life cycle and also the climate condition of the region, which provided appropriate temperatures for completing the life cycle.

*Trichuris spp* was another frequent nematode that had been reported in *Allactaga elater* and mouse in eastern Iran. Since all of *Trichuris spp* in the present study were female, we could not determine their genus of them.

Regarding *Heligmosoides polygyrus*, similar to other reports from Iran, it was the lowest nematode throughout the study. While it was commonly reported in different countries.

*Hymenolepis nana* and *Hymenolepis diminuta* were the most removed cestodes. Similar to other studies on rodent helminth parasites in different parts of the country.

Concerning *Echinococcus multilocularis* throughout Iran, we found the highest intensity of this parasite in the region, which provided appropriate temperatures for completing the life cycle.
distribution of the parasite is not limited to a specific geographical area; its prevalence has been reported from all continents. However, due to being an accidental host, the number of human infections is rare. Infectious rodents with this nematode have been reported by Kia et al. and Zarei et al. from the northwest, Moradpour et al. from the east and west, and Pakdel et al. and Kazemi et al. from western regions of Iran. Regarding the hosts, almost 80 species of rodents in the family Muridae, as well as about 24 species of mammals, including humans, could be infected with this parasite.

The life cycle of *Capillaria hepatica* begins with eating embryonated eggs that exist in the carcass or feces of contaminated animals. Hatching the eggs, larvae migrate from the intestine to the liver of the host, mature, and lay eggs there. Exposing to the environment through the decomposition of the carcass or in the feces of predators, eggs are embryonic and become infected. Rodents, as the final host, ingest eggs, and the life cycle of the parasite starts in their bodies. Infection with *Capillaria hepatica* in humans (Capillariasis) causes inflammation and necrosis, and biopsy or autopsy of the liver is the only diagnostic method.

5. Conclusion

According to the present study, the role of *Allactaga elater* in transmitting zoonotic parasitic diseases to humans in Sarakhs should be taken into account; it could play a role as a final host of some nematodes, such as *Hymenolepis nana, Hymenolepis diminuta, Cysticercus fasciolaris, Syphacia obvelata*, and *Trichuris spp*. Further studies are required to improve the knowledge about the importance of *Allactaga elater* in spreading parasitic diseases in this region.

Declarations

**Competing interests**

The authors have declared no conflicts of interest.

**Authors’ contributions**

Nona Moradpour and Hassan Borji were responsible for the conceptualization of the study, while Nona Moradpour and Rooollah Siahservie developed the methodology. Formal analysis and investigation were also carried out by Nona Moradpour and Rooollah Siahservie. Nona Moradpour and Hassan Borji provided supervision throughout the project. All authors participated in the writing of the original draft and subsequent review and editing of the manuscript. Finally, all authors have reviewed and approved the final version of the manuscript for publication in the present journal.

**Funding**

This research was financially supported by Grant No 47274 from Ferdowsi University of Mashhad.

**Ethical considerations**

The authors declare that this manuscript is original and has not been submitted elsewhere for possible publication. The authors also declare that the data used/presented in this manuscript has not been fabricated.

**Availability of data and materials**

The data presented in this study are available on request from the corresponding author.

**Acknowledgments**

The authors are grateful to the Rodentology Research Department, Institute of Applied Zoology, Ferdowsi University of Mashhad, Iran. Thanks to Mr. Eshratil H for his technical assistance during data collection.

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