Iranian Journal of Animal Biosystematics (IJAB)
Vol.20, No.2, 51-59, 2024
DOI: 10.22067/ijab.2024. 88476.1074

IJAB
ISSN: 1735-434X (print); 2423-4222 (online)

RESEARCH ARTICLE Open access

Helminths infection of wild rodents in two regions of Iran

Sima Parande Shirvan[1], Saeed Yaghfoori[2], Ahmad Mahmoudi[3], Saied Reza Naddaf[4], Ali Mohammadi[5,6]. Amin Ahmadi[7,8]. Hamed Hanifi[5,6]. Ehsan Mostafavi [*5,6]

[1] *Hormozgan Provincial Office of Iran's Department of the Environment, Bandar abbas, Iran.*
[2] *Hormozgan veterinary head office. Bandar abbas, Iran. Environment, Bandar abbas, Iran.*
[3] *Department of Biology, Faculty of Science, Urmia University.*
[4] *Department of Parasitology, Pasteur Institute of Iran, Tehran, Iran.*
[5] *National Reference laboratory for Plague, Tularemia and Q fever, Research Centre for Emerging and Reemerging infectious diseases, Pasteur Institute of Iran, Akanlu, Kabudar Ahang, Hamadan, Iran.*
[6] *Department of Epidemiology and Biostatistics, Research Centre for Emerging and Reemerging infectious diseases, Pasteur Institute of Iran, Tehran, Iran.*
[7] *Department of Basic Sciences, Faculty of Veterinary Medicine, Ardakan University, P.O. Box 184, Ardakan, Iran.*
[8] *Biology and Animal Reproduction Science Research Institute, Ardakan University, Ardakan, Iran.*

Abstract
Rodents play an important role in the transmission of parasitic diseases to humans and pets. This study was conducted to evaluate the prevalence of helminth infections in rodents of three Provinces of Iran. A total of 92 rodents were live-trapped from the Provinces Hamadan (n=64), Golestan (n=9), and Mazandaran (n=19). The animals were humanely euthanized, and their intestinal tracts were removed and examined for helminth infections. The rodents belonged to six genera and 12 species *Apodemus hyrcanus, Apodemus uralensis, Meriones libycus, Meriones persicus, Meriones tristrami, Meriones vinogradovi, Microtus paradoxus, Microtus qazvinensis, Mus musculus, Nesokia indica, Rattus norvegicus and Rattus rattus.* The overall prevalence of helminth infection was 59.78%. Nine nematode species were identified: *Nippostrongylus brasiliensis*, Trichostrongylidae sp., *Heligmosomoides polygyrus*, *Heligmonoides taiwanensis*, Syphacia sp., *Aspiculuris tetraptera*, *Heterakis spumosa*, *Mastophorus* spp., and *Trichuris* spp. Additionally, two cestode species, *Hymenolepis nana* and *Hymenolepis diminuta*, Mesocestoides larvae were identified. *Heligmonoides taiwanensis* isolated from *Meriones vinogradovi* is reported here for the first time from Iran. We identified three zoonotic helminth namely *H. nana*, *H. diminuta*, and *Syphacia* sp**.** in the examined rodents, and *M. persicus* is an efficient reservoir and spreader of eggs of these species. The findings of this study can provide insights into future-comprehensive programs regarding control strategies of these parasites.

Keywords: Wildlif, rodents, Helminths, Iran, Parasite**.**

Received:
14 June 2024

Accepted:
20 July 2024

INTRODUCTION

Small mammals, mainly rodents, are commonly found in urban and suburban environments and have an essential role in the life cycle of many parasites in various ecosystems, especially those with predator/prey relationships. Small mammals are considered as the paratenic and intermediate hosts for many protozoan and helminth parasites affecting humans and carnivores (Duscher et al. 2015, Rabiee et al. 2018) e.g., the genera *Hymenolepis*, *Echinococcus* (Thompson 2015), *Angiostrongylus* (Jarvi et al. 2017), *Capillaria* (Aghdam et al. 2015), and *Trichinella* (Sadighian et al. 1973). Wild rodents occasionally hunted by stray

*Corresponding Author: ✉ mostafaviehsan@gmail.com

and domestic dogs and cats provides the chance of parasite transmission from the sylvatic into the domestic cycle or even synanthropic cycle, increasing the risk of human infection (Duscher et al. 2015).

Along the significant role of the domestic and predomestic rodents in transmission of pathogens to humans (Meerburg et al. 2009, Rabiee et al. 2018), Since deforestation process and urban extension result in close contact between wild rodents and humans (Bordes et al. 2015), the role of domestic and predomestic rodents in transmission of pathogens to humans is significant (Meerburg et al. 2009, Rabiee et al. 2018). Therefore, information on helminth fauna of wild rodents in control of zoonotic parasites is important.

This study was conducted to evaluate the helminth fauna of several species of wild rodents in three Provinces of Iran possessing different types of climate. Given the fact that the susceptibility to parasites varies among different species of rodents, and life cycle of helminth is influenced by environmental factors, the results of this study can provide new insights into development of control strategies for those helminth transmitted by rodents.

MATERIAL AND METHODS

Study sites

In contrast to the Province of Hamadan (34°80′N and 48°51′E), which is located in the west of Iran on the slopes of Mount Alvand and has a cold semi-arid climate, the Provinces of Mazandaran and Golestan are along the southern coast of the Caspian Sea in the north of Iran with a mild and humid climate (Fig1).

Rodents trapping and laboratory examination

From July 2016 to February 2017, 64 rodents were captured by live traps from 18 localities in Hamadan Province. Also, during April 2017, 28 rodents were captured from four and nine localities in Golestan (n=9) and Mazandaran (n=19) Provinces, respectively. Rodents were transported to the laboratory, euthanized with chloroform, and morphological and morphometric characteristics were recorded for each specimen. Identification of animal species was performed based on valid references (Wilson and Reeder 2005, Hillson 2016, Darvish et al. 2015). The intestinal tracts together with their offshoots were transferred in a Petri dish containing normal saline and carefully examined under a stereomicroscope for helminth. The recovered nematodes were preserved in 70% ethanol. The nematodes were cleared in lactophenol, and the cestodes were stained with acid carmine dye. All the specimens were examined by microscopy and identified based on their morphological features (Anderson et al. 2009, Yamaguti 1959).

Due to the large sample size for *M. persicus*, the seasonal effect on infection rate was evaluated for this rodent species in Hamadan Province to aim this purpose. Captured samples were classified into two main seasons (rainy and dry) based on relative humidity range. February and November with 11 and 7 ml and June with 2 ml average of rainfall per day were considered as rainy and dry seasons, respectively. The statistical analysis was performed by Pearson Chi-Square test using Prism version 7 software (Graghpad, La Jolla, CA, USA).

RESULTS

Identified species of rodents

A total of 92 rodents were trapped from Hamadan (n=64), Golestan (n=9) and Mazandaran (n=19) Provinces of Iran. The specimens comprised six genera and 12 species. The genus *Meriones* was the largest group, including 66.30% of all specimens and four species, namely *M. persicus* (53.26%), *M. vinogradovi* (6.52%), *M. libycus* (4.35%) and *M. tristrami* (2.17%), followed by the genera *Rattus* (16.31%) and *Microtus* (5.43%) (Table 1).

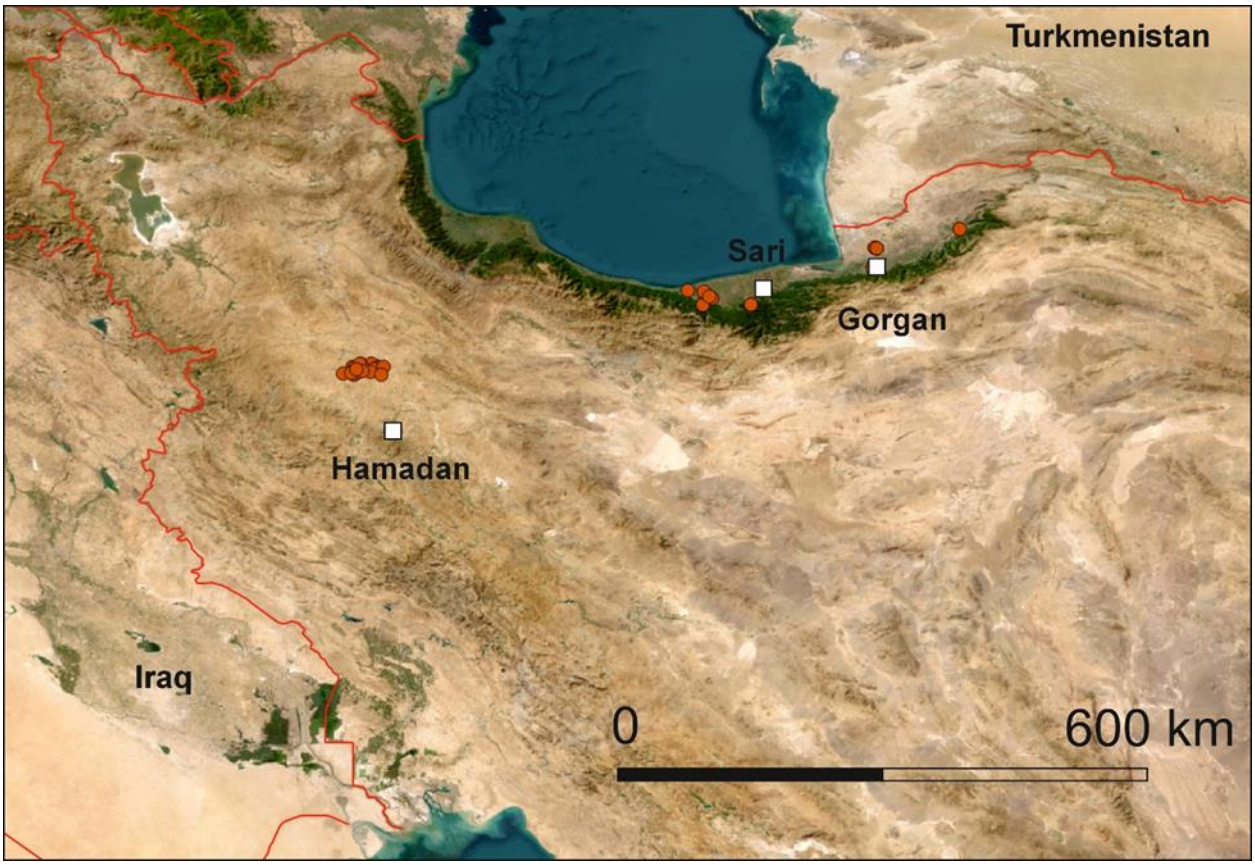

FIGURE 1. Geographical area of study.

Helminth Infection

Out of 92 rodents, 55 (59.78%) had an infection with at least one helminth species. Cestode-Nematode co-infection and nematodes infection with different species in the individual specimens were recorded in 10 (10.52%) and 7 (7.36%) rodents, respectively. The species *M. persicus* showed the highest prevalence of helminth infections (31 of 49, 63.26%). Table 2 shows the frequency of helminth infection based on the rodent species.

We identified nine nematode species: *Nipostrongylus brasiliense*, Trichostrongylidae sp., *Heligmosomoides polygyrus*, *Heligmonoides taiwanensis*, *Syphacia* sp., *Aspiculuris tetraptera*, *Hetrakis spumosa*, *Mastophorus* sp., *Trichuris* sp., two species of adult cestodes, *Hymenolepis nana*, *Hymenolepis diminuta*, and larvae of *Mesocestoides*. The *Trichuris* spp. With 31.94% (23 of 72) was the most frequent helminth infection, and 22 of them were found in Hamadan Province. The second and third common helminth species found in this study were *H. diminuta* (18.05%) and *Syphacia* sp. (12.50%), respectively. The species *H. taiwanensis,* isolated from *M. vinogradovi,* is reported here for the first time from Iran.

In this study, the samples of the province of Golestan exhibited the highest rate of helminth infection (66.66%), followed by Hamadan (59.37%) and Mazandaran (57.89%) (Table3).

We entrapped 24 specimens of *M. persicus* in the rainy season and 25 in the dry season. The overall prevalence of helminth infection in dry and rainy seasons was recorded as56% and 70.83%, respectively. A significant difference was observed between the dry and rainy seasons in overall helminth infection ($P \leq 0.05$) (Fig 2). *Trichuris* spp. were significantly higher ($P \leq 0.05$) in the rainy season (54.16%) compared with the dry season (24%), while *H. diminuta* was the most common helminth infection in the dry season (36%), and its prevalence significantly decreased in rainy seasons (8.33%) ($P \leq 0.05$).

FIGURE 2. The impact of seasonality on prevalence and diversity of helminth infection in *M. persicus* from Hamadan Province, Iran.

FIGURE 3. *Heligmonoides taiwanensis* isolated from *M. vinogradovi* in Hamadan Province, Iran. a) posterior end of an adult male. b) anterior end of an adult male.

TABLE 1. The frequency of rodent species identified in two climate zones of Iran.

	Province	*Meriones vinogradov*	*Meriones persicus*	*Meriones tristrami*	*Meriones libycus*	*Microtus qazvinensis*	*Microtus paradoxus*	*Rattus norvegicus*	*Rattus rattus*	*Mus musculus*	*Apodemus hyrcanicus*	*Apodemus uralensis*	*Nesokia indica*
Semi-arid climate	Hamadan	6	49	2	4	3	-	-	-	-	-	-	-
Mild and humid climate	Mazandaran	-	-	-	-	-	-	14	1	2	2	-	-
	Golestan	-	-	-	-	-	2	-	-	1	-	1	5
	Total	6	49	2	4	3	2	14	1	3	2	1	5

TABLE 2. The frequency of helminth infection in rodent species of Iran examined in this study.

Rodent species	Number rodents examined	*Nipostrongylus brasiliense*	*Trichostrongylidae*	*Heligmosomoides polygyrus*	*Heligmonoides taiwanensis*	*Syphacia* sp	*Aspiculuris tetraptera*	*Hetrakis spumosa*	*Mastophorus* spp	*Trichuris* spp	*Hymenolepis nana*	*Hymenolepis diminuta*	*Mesocestoides* sp
Meriones vinogradovi	6				1				1	1			1
Meriones persicus	49		1					1	2	19	1	10	3
Meriones tristrami	2									1			
Meriones libycus	4					3							
Microtus qazvinensis	3									1			
Microtus paradoxus	2					1	1						
Apodemus hyrcanicus	2			1		1							
Apodemus uralensis	1			1		1							
Nesokia indica	5	1	1			1							
Rattus norvegicus	14			2		1		5		1		3	
Rattus rattus	1							1			1		
Mus musculus	3			1		1					1		

DISCUSSION

The knowledge on helminth infections of wild rodents can provide valuable information regarding their potential transmission to human, pets and domestic animals. In this study, the Persian jird, *Meriones persicus*, as the most captured species, showed the highest rate of helminth infection. *Meriones persicus* is known as a widely distributed species with a high prevalence of helminth infection in Iran (Arzamani et al. 2018, Ranjbar et al. 2017, Harandi et al. 2016). In this study, this species harbored four species of nematodes, Trichostrongylidae, *Hetrakis spumosa*, *Mastophorus* sp., *Trichuris* spp., two species of cestodes (*Hymenolepis nana*, *H. diminuta*) and *Mesocestoides* sp. larvae with the highest prevalence belonging to *Trichuris* spp. Previously, reports from Kerman Province indicated *Trichuris muris* as the most frequent helminth infection in *M. persicus* (Harandi et al. 2016). Due to the presence of *H. nana* and *H. diminuta* in *M. persicus*, this species has a high potential role for transmission of these zoonotic helminth to humans in Iran.

TABLE 3. The diversity of helminth infection in two climate zones of Iran.

Climate type	Province	*Nipostrongylus brasiliense*	*Trichostrongylidae*	*Heligmosomoides polygyrus*	*Heligmonoides taiwanensis*	*Syphacia* sp	*Aspiculuris tetraptera*	*Hetrakis spumosa*	*Mastophorus* spp	*Trichuris* spp	*Hymenolepis nana*	*Hymenolepis diminuta*	*Mesocstoides*
Semi-arid climate	Hamadan	-	1	-	1	3	-	1	3	22	1	10	4
Mild and humid climate	Mazandaran	-	1	3	-	2	-	6	-	1	2	3	-
	Golestan	1		2	-	4	1	-	-	-	-	-	-
	Total	1	2	5	1	9	1	7	3	23	3	13	4

Nowadays, with the changes in global climate, deforestations and other anthropogenic activities, like housing in remote areas, wild rodents are coming closer to human communities, particularly in densely urbanized regions with poor hygiene, e.g., most developing countries (Thompson 2015, Duscher et al. 2015). *H. nana* is the most common of human cestode worldwide (Crompton 1999, Rokni 2008). This helminth has a monoxenous life cycle with eggs immediately infective when passed in the feces. The direct life cycle of this worm makes its transmission to humans easier. In our study, only 3.26% of the examined rodents were infected with *H. nana*, while, *H. diminuta*, another zoonotic helminth with an indirect life cycle, showed a 14.13% prevalence rate. These results are in accordance with previous reports indicating a higher prevalence of *H. diminuta* compared to *H. nana* (Moradpour et al. 2018, Harandi et al. 2016). The high prevalence rate of this tapeworm in *M. persicus* was probably due to the omnivore food regime of this animal and the presence of beetles as intermediate hosts in their living habitats. Nonetheless, only a few reports of H. diminuta infection in humans are available (Motakef 1968, Mowlavi et al. 2008) because the infection of this parasite occurs via ingestion of infected arthropods, e.g. the beetle genus Tribolium (Makki et al. 2017) .

Syphacia sp. was the third most frequent species with a prevalence of 9.78% in three Provinces. Available data indicate a high variation in the prevalence rate of this nematode in Iran and other countries (Nateghpour et al. 2015, Pakdel et al. 2013, Moradpour et al. 2018, Arzamani et al. 2018, Galán-Puchades et al. 2018). In Iran, the prevalence of this nematode species among rodents in Kermanshah (Pakdel et al. 2013), Kerman (Harandi et al. 2016) and Boyer-Ahmad district (Ranjbar et al. 2017), were 16.65%, 0%, and 5.7%, respectively. Such a variation in prevalence rate might be related to different factors, e.g., the rodent species examined. Further studies are needed to evaluate the infection rate of Syphacia among different rodent species.

Here, we report *Heligmonoides taiwanensis* for the first time from Iran (Fig.3). Other nematode parasites recovered in this study have previously been identified in other rodent species of Iran.

This difference in distribution and diversity of helminth among captured rodents may be related to the trapping period. The effect of seasonal variation on the parasitic fauna of rodents is available in other studies (Kataranovski et al. 2011, Zain et al. 2012). In our study, seasonal variation had a significant effect on helminth composition. The low prevalence of *Trichuris* spp. in the dry season might be due to rapid desiccation of their ova (Burden and Hammet 1979). In contrast, *H. diminuta*, in agreement with previous studies (Ahmad et al. 2014, Kataranovski et al. 2011), showed a higher prevalence in the dry season. The high prevalence of this parasite in the dry season is probably due to the abundance of beetles, which serve as the intermediate host for this species. The difference, as mentioned earlier, in the distribution and diversity of helminth may also be related to the study area. Many reports indicated that diversity and frequency of helminth, especially those with an intermediated host in their life cycle, are affected by the weather conditions (Mas-Coma et al. 2009).

Climate plays a crucial role in ecosystems affecting animals and plants as well as their associated pathogens, and changes in this factor influence survival rate, reproduction, and maturation of helminth (Mccarthy 1999, Cattadori et al. 2005). Our study showed almost a similar rate of helminth infection in rodents from two geographical areas with different climates types. However, the composition of their helminth fauna was different, supporting the climate impact on helminth diversity. Rodent species can also affect the distribution and diversity of helminth. The host species have shown to play a primary role in the distribution of the parasite infection (Zain et al. 2012). Due to the small sample size of the rodent species examined in this study, a strong conclusion on the relation between host and helminth diversity was not possible.

Our study provided information on the status of rodent helminth infection in two different climate zones of Iran. The results presented here are a part of the ongoing research assessing the risk of rodent-borne diseases in Iran. In this study, the assessment of the intrinsic and extrinsic factors such as sex, age, season and host species that may affect parasitic abundance was not possible due to random trapping. Further studies should be conducted to evaluate various parasite component and parasite burden, primarily their corresponding interactions with helminth infection for each rodent species. Our findings provide useful data on each species as a potential source of helminth infection to human.

Our results add credence to previous studies indicating rodents as a public health threat. Here, we identified three zoonotic helminth in rodents of two different geographical zones. Our results revealed that several species of rodents could possibility transmit *Syphacia* sp. to human and the eggs of this nematode can survive in the environment and potentially affect humans in the future. *Meriones persicus* was the most common rodent species entrapped in this study and showed the highest prevalence of helminth infection. Hence a comprehensive investigation regarding potentials of this species in the transmission of zoonotic diseases would be crucial.

Acknowledgments
We are grateful to the Pasteur Institute of Iran and Center for Communicable Diseases, Ministry of Health for supporting this investigation (Grants 617 & 810).

Statements & Declarations
Ethical approval: The study was approved by the Ethics Committee at Pasteur Institute of Iran.
Funding: This research received no external funding.
Availability of data and materials: All authors ensure that all data and materials support the findings.
Consent for publication: All authors read and approved the manuscript.
Competing interests: The authors declare no competing interests.

LITERATURE CITED

Aghdam, M. K., Karimi, A., Amanati, A., Ghoroubi, J., Khoddami, M., Shamsian, B. S. and Far, S. Z. 2015. *Capillaria hepatica*, A Case Report and Review of the Literatures, *Archives of Pediatric Infectious Diseases*, 3(2).

Ahmad, M., Maqbool, A., Anjum, A., Ahmad, N., Khan, M., Sultana, R. and Ali, M. 2014. Occurance of *Hymenolepis diminuta* in rats and mice captured from urban localities of Lahore, Pakistan, *Journal of Animal and Plant Sciences*, 24, 392-396.

Anderson, R. C., Chabaud, A. G. and Willmott, S. 2009. *Keys to the nematode parasites of vertebrates: archival volume*, Cabi.

Arzamani, K., Mohammadi, Z., Shirzadi, M. R., Alavinia, S. M., Jafari, B. and Darvish, J. 2018. Faunistic study of the rodents of north Khorasan Province, north east of Iran, 2011–2013, *Journal of arthropod-borne diseases*.

Bordes, F., Blasdell, K. and Morand, S. 2015. Transmission ecology of rodent-borne diseases: New frontiers, *Integrative zoology,* 10(5), 424-435.

Burden, D. and Hammet, N. 1979. The development and survival of Trichuris suis ova on pasture plots in the south of England, *Research in veterinary science,* 26(1), 66-70.

Cattadori, I. M., Haydon, D. T. and Hudson, P. J. 2005. Parasites and climate synchronize red grouse populations, *Nature,* 433(7027), 737.

Crompton, D. 1999. How much human helminthiasis is there in the world?, *The Journal of parasitology,* 397-403.

Darvish, J., Mohammadi, Z., Mahmoudi, A. and Siahsarvie, R. 2015. Faunistic and taxonomic study of Rodents from northwestern Iran, *Iranian Journal of Animal Biosystematics,* 10(2), 119-136.

Duscher, G. G., Leschnik, M., Fuehrer, H.-P. and Joachim, A. 2015. Wildlife reservoirs for vector-borne canine, feline and zoonotic infections in Austria, *International Journal for Parasitology: Parasites and Wildlife,* 4(1), 88-96.

Galán-Puchades, M. T., Sanxis-Furió, J., Pascual, J., Bueno-Marí, R., Franco, S., Peracho, V., Montalvo, T. and Fuentes, M. V. 2018. First survey on zoonotic helminthosis in urban brown rats (Rattus norvegicus) in Spain and associated public health considerations, *Veterinary parasitology,* 259, 49-52.

Harandi, M. F., Madjdzadeh, S. M. and Ahmadinejad, M. 2016. Helminth parasites of small mammals in Kerman Province, southeastern Iran, *Journal of Parasitic Diseases,* 40(1), 106-109.

Hillson, S. 2016. *Mammal bones and teeth: an introductory guide to methods of identification,* Routledge.

Jarvi, S. I., Quarta, S., Jacquier, S., Howe, K., Bicakci, D., Dasalla, C., Lovesy, N., Snook, K., McHugh, R. and Niebuhr, C. N. 2017. High prevalence of Angiostrongylus cantonensis (rat lungworm) on eastern Hawai ‘i Island: A closer look at life cycle traits and patterns of infection in wild rats (Rattus spp.), *PloS one,* 12(12), e0189458.

Kataranovski, M., Mirkov, I., Belij, S., Popov, A., Petrović, Z., Gačić, Z. and Kataranovski, D. 2011. Intestinal helminth infection of rats (Ratus norvegicus) in the Belgrade area (Serbia): the effect of sex, age and habitat, *Parasite: journal de la Société Française de Parasitologie,* 18(2), 189.

Makki, M. S., Mowlavi, G., Shahbazi, F., Abai, M. R., Najafi, F., Hosseini-Farash, B. R., Teimoori, S., Hasanpour, H. and Naddaf, S. R. 2017. Identification of Hymenolepis diminuta cysticercoid larvae in *Tribolium castaneum* (Coleoptera: Tenebrionidae) beetles from Iran, *Journal of arthropod-borne diseases,* 11(2), 338.

Mas-Coma, S., Valero, M. A. and Bargues, M. D. 2009. Climate change effects on trematodiases, with emphasis on zoonotic fascioliasis and schistosomiasis, *Veterinary parasitology,* 163(4), 264-280.

McCarthyA. M. 1999. The influence of temperature on the survival and infectivity of the cercariae of *Echinoparyphium recurvatum* (Digenea: Echinostomatidae), *Parasitology*, 118(4), 383-388.

Meerburg, B. G., Singleton, G. R. and Kijlstra, A. 2009. Rodent-borne diseases and their risks for public health, *Critical reviews in microbiology*, 35(3), 221-270.

Moradpour, N., Borji, H., Darvish, J., Moshaverinia, A. and Mahmoudi, A. 2018. Rodents Helminth Parasites in Different Region of Iran, *Iranian journal of parasitology*, 13(2), 275.

Motakef, M. 1968. Report of a case infected with *Hymenolepis diminutain* Mashad, *Medical Journal of Mashhad University of Medical Sciences*, 10:472–4.

Mowlavi, G., Mobedi, I., Mamishi, S., Rezaeian, M., Ashtiani, M. H. and Kashi, M. 2008. *Hymenolepis diminuta* (Rodolphi, 1819) infection in a child from Iran, *Iranian Journal of Public Health*, 37(2), 120-122.

Nateghpour, M., Motevalli-Haghi, A., Akbarzadeh, K., Akhavan, A. A., Mohebali, M., Mobedi, I. and Farivar, L. 2015. Endoparasites of wild rodents in southeastern Iran, *Journal of arthropod-borne diseases*, 9(1), 1.

Pakdel, N., Naem, S., Rezaei, F. and Chalehchaleh, A.-A. 2013. *A survey on helminthic infection in mice (Mus musculus) and rats (Rattus norvegicus and Rattus rattus) in Kermanshah, Iran*, translated by Faculty of Veterinary Medicine, Urmia University, Urmia, Iran, 105.

Rabiee, M. H., Mahmoudi, A., Siahsarvie, R., Kryštufek, B. and Mostafavi, E. 2018. Rodent-borne diseases and their public health importance in Iran, *PLoS neglected tropical diseases*, 12(4), e0006256.

Ranjbar, M. J., Sarkari, B., Mowlavi, G. R., Seifollahi, Z., Moshfe, A., Khabisi, S. A. and Mobedi, I. 2017. Helminth Infections of Rodents and Their Zoonotic Importance in Boyer-Ahmad District, Southwestern Iran, *Iranian journal of parasitology*, 12(4), 572.

Rokni, M. 2008. The present status of human helminthic diseases in Iran, *Annals of Tropical Medicine & Parasitology*, 102(4), 283-295.

Sadighian, A., Arfaa, F. and Movafagh, K. 1973. *Trichinella spiralis* in carnivores and rodents in Isfahan, Iran, *Journal of Parasitology*, 59(6).

Thompson, R. A. 2015. Neglected zoonotic helminth: *Hymenolepis nana*, *Echinococcus canadensis* and *Ancylostoma ceylanicum*, *Clinical Microbiology and Infection*, 21(5), 426-432.

Wilson, D. E. and Reeder, D. M. 2005. *Mammal species of the world: a taxonomic and geographic reference*, JHU Press.

Yamaguti, S. 1959. Systema Helminthum. vol. II. The cestodes of vertebrates, *Systema helminthum. Vol. II. The cestodes of vertebrates.*

Zain, S. N. M., Behnke, J. M. and Lewis, J. W. 2012. Helminth communities from two urban rat populations in Kuala Lumpur, Malaysia, *Parasites & vectors*, 5(1), 47.