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ORIGINAL ARTICLE

A survey on endoparasites in wild rodents of the Jaz Murian depression and adjacent areas, southeast of Iran

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Abstract In this survey, rodents and their endoparasites were investigated in the Jaz Murian depression and adjacent areas, southeast Iran. In total, 146 specimens of rodents belong to 13 species were trapped. In general, 10 different genera of endoparasites including 11 species were collected. The endoparasites were identified as follows: (1) Nematodes: *Trichuris muris*, *Syphacia obvelata*, *Labiostomum* sp., *Labiostomum naimi*, *Mastrophorus muris*, *Aspicularis tetraptera* and *Heligmosomoides skrjabini, Physaloptera* sp. (2) Cestodes: *Choanotaenia* sp., *Raillietina* sp., and *Hymenolepis diminuta*. Of 146 captured rodents, *Tatera indica* was found with high parasitic infestation (with 93% infested) comparing to *Acomys dimidiatus* (66%), *Rattus rattus* (50%), *Meriones libycus* (15%), *Jaculus blanfordi* (14%) and *Mus musculus* (8%) whereas, seven rodent species, *Nesokia indica, Gerbillus nanus, Golunda ellioti*, *Calomyscus hotsoni*, *Apodemus witherbyi, Cricetulus migratorius* and *Microtus mystacinus* were free from any parasitic infestation. Those six infested rodent species were collected from the center of the Jaz Murian depression, whereas seven non-infested rodents' species except *N. indica* and *G. nanus* live in the marginal ranges of the Jaz Murian depression, therefore, these species inhabiting the central parts were supposed to be more important from the health aspect. The species, *Labiostomum naimi* collected from *A. dimidiatus* is the first report of this species in rodents from Iran.

Keywords The Jaz Murian depression · Endoparasites · Rodents · *Labiostomum naimi*

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Introduction

Rodents especially those living close to human habitats, play an important role in public health and economy (Nateghpour et al. 2015). Different disease agents such as, plague (Azizi and Azizi 2010), cutaneous leishmaniasis (Asgari et al. 2007; Kassiri et al. 2013), murine typhus and Lassa fever (Kia et al. 2010) can be transmitted by rodents to human (Khajeh et al. 2017).

Although, some investigations have been done on rodents' endoparasites in Iran (Kia et al. 2010; Yousefi et al. 2014; Pakdel et al. 2013; Garedaghi and Khaki 2014; Meshkekar et al. 2014), there are few investigations concentrating to wild rodents and their endoparasites in the Jaz Murian depression (Nateghpour et al. 2015; Kassiri et al. 2013). Nateghpour et al. (2015) carried out a study on four species of rodents' endoparasites (*Tatera indica, Gerbillus* *nanus, Meriones hurrianea, Meriones libycus*) in Iranshahr and Nikshahr, the easternmost corner of the Jaz Murian depression and reported *Spirurida* sp., *Hymenolepis diminuta, Hymenolepis nana feraterna, Trichuris trichiura, Skerjabino taenia, Trichostrongylus* spp. *Entamoeba muris, Chilomastix mesnili* and *Leishmania* spp.

Fasihi Harandi et al. (2016) studied endoparasites of small mammals (*Tatera indica, Meriones libycus, Meriones persicus, Dryomys nitedula, Mus musculus, Paraechinus hypomelas, Lepus europaeus*) in Kerman province, parts of the Jaz Murian depression. They isolated five different species of parasites including *Trichuris muris, Moniliformis moniliformis, Hymenolepis diminuta, Hymenolepis nana,* and *Mastrophorus muris.*

Parasites of the genus *Trichuris* have been reported from some rodents of the other parts of Iran such as *Tatera indica* (Rahdar et al. 2016), *Meriones persicus* and *Microtus socialis* (Kia et al. 2010), *Hystrix indica* (Yousefi et al. 2014), *Mus musculus* and *Rattus norvegicus* (Pakdel et al. 2013). Also, parasites of the genus *Hymenolepis, Physaloptera, Heligmosomum, Aspicularis* and *Syphacia* have been collected from rodents in Iran (Kia et al. 2010; Yousefi et al. 2014; Allymehr et al. 2012 and Garedaghi and Khaki 2014).

Akhtar (1947) described *Labiostomum naimi* from a Lagomorph *Ochotona* sp. in a village of Kabul, Afghanistan for the first time, then Babaev (1968) and Babaev and Sapargel'dyev (1970) recorded this parasite from *O. rufescens* in Turkmenia, USSR. It was also isolated from *O. alpina* in Mongolia (Tinnin et al. 2011) but it has not been reported in rodents.

In this survey, we tried to provide comprehensive sampling from different habitats and diverse climatic conditions of the Jaz Murian depression, to provide new insight into the fauna of wild rodents and their relative endoparasites. The information provided in this study can be applied to decrease human health challenges in the region.

Materials and methods

Study area

The Jaz Murian depression is located in the southeast Iran, in a tropical realm and considered as an endemic area for some zoonotic diseases such as malaria and cutaneous leishmaniasis (Kassiri et al. 2013; Fekri et al. 2013; Salmanzadeh et al. 2015; Vatandoost et al. 2011; Salahi-Moghadam et al. 2014; Salehi et al. 2010). The dry Jaz Murian depression (27°29′21″N, 58°32′46″E) covering about 25,000–30,000 square miles entirely surrounded by some mountain chains (Khajeh et al. 2015; Khajeh 2017). Locating near the border of Afghanistan and Pakistan, the Jaz Murian depression in the southeast Iran exposed to communication of refugees and nomads and also transportation of livestock which can increase the potential risk of the public health. Additionally, the health condition of the region is severely affected by low supply of public services and health care in adjacent areas of the neighboring countries. Therefore, discovering the potential risks to the public health in the region can help us to prevent spreading and enhance controlling.

Sampling

Sampling was conducted from December 2015 to June 2016 in 31 various regions of the Jaz Murian depression as shown in Fig. 1. We used 100 Sherman live traps which are appropriate for capturing rodents with date as bait (Khajeh et al. 2015). The traps were deployed for 2 consecutive nights at each study site. The traps were checked in the morning for the presence of rodents and the specimens were transferred to the Parasitology laboratory of the Department of Veterinary Clinical Sciences, Ferdowsi University of Mashhad. Since Jerboas cannot be trapped by live traps, we caught them with a hand net, using a searchlight and motorcycle at night.

In the laboratory, specimens were subjected and prepared based on mammalogical procedure established by the American Society of mammalogists Animal Care and Use Committee (1998). The entire gastrointestinal tract was removed and placed in a Falcon tube containing 70% alcohol. The entire gastrointestinal tract was placed on the plates containing physiological saline. The stomach, small intestine, large intestine, cecum, liver and lung were studied using stereomicroscope and parasites were removed. In this study, wet-mount (with Lactophenol) for staining of nematodes and Eshnaider-acetocarmine method for staining of cestodes were used (Garedaghi and Hashemzade 2011).

Identification

The rodents were identified based on identification keys including (Corbet 1978) with consideration to new revisions on rodent's species of Iran (Darvish et al. 2014, 2015; Ghorbani et al. 2015) and endoparasites with valid systematic helminthological keys (Khalil et al. 1994; Yamaguti 1962).

Statistical analysis

To elucidate the potential risk of each rodent species in prevalence of different parasites, the rodent's species with the highest and the lowest infestation were determined. We

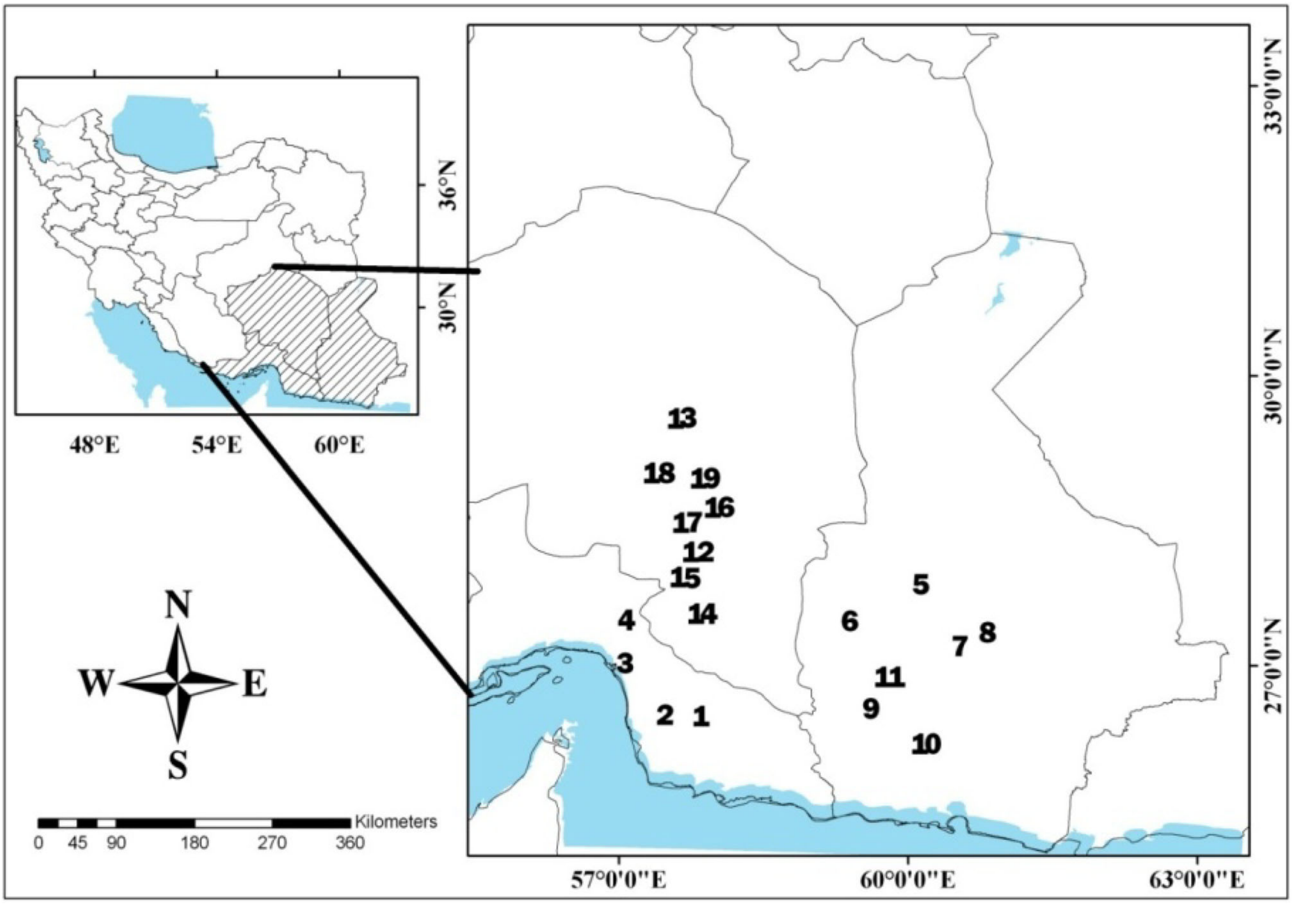

Fig. 1 Map showing the collecting sites of rodents used for this study

also determined the parasites with the highest and the lowest prevalence in the rodents from Jaz Murian depression. Prevalence of the infected rodents, abundance of the endoparasites and mean intensity of parasites related to each hosts were calculated following (Margolis et al. 1982) as below:

$$\text{Prevalence}\,(\%) = (\text{Number of infected host}) \div (\text{Total number of host examined}) \times 100$$

$$\text{Abundance}\,(\%) = (\text{Number of parasites}) \div (\text{Total number of host examined}) \times 100$$

$$\text{Mean intensity}\,(\%) = (\text{Number of parasites}) \div (\text{Total number of infected host}) \times 100$$

Statistical analysis was estimated using SPSS 16 (SPSS Inc., Chicago, IL, USA).

Results

During the period of study, a total of 146 specimens of rodents belong to 13 different species were captured from the Jaz Murian depression and adjacent areas. The rodents included 36 specimens of House Mouse (*Mus musculus*) (24.56% of total rodents captured), 30 specimens of Indian Gerbil (*Tatera indica*) (20.54%), 21 specimens of Spiny Mouse (*Acomys dimidiatus*) (14.38%), 13 specimens of Baluchistan Gerbil (*Gerbillus nanus*) (8.9%), 13 specimens of Libyan Jird (*Meriones libycus*) (8.9%), eight specimens of Short-tailed Bandicoot (*Nesokia indica*) (5.47%), seven specimens of Jerboa (*Jaculus blanfordi*) (4.79%), six specimens of Hotson's brush-tailed Mouse (*Calomyscus hotsoni*) (4.10%), six specimens of Steppe field Mouse (*Apodemus witherbyi*) (4.10%), two specimens of Black Rat (*Rattus rattus*) (1.36%), two specimens of Indian Bush Rat (*Golunda ellioti*) (1.36%), one specimen of the Eastern European Vole (*Microtus mystacinus*) (0.68%), and one specimen of Migrant Hamster (*Cricetulus migratorius*) (0.68%).

Amongst 146 examined specimens, 49 individuals (33.5% of total rodents captured) found to be infested with

Table 1 Diversity of wild rodents and their endoparasites in the Jaz Murian depression

Parasites	Nematodes								Cestodes		
Rodents	*Mastrophorus muris*	*Labiostomum* sp.	*L. naimi*	*Aspicularis tetraptera*	*Trichuris muris*	*Syphacia obvelata*	*Heligmosomoides skrjabini*	*Physaloptera* sp.	*Choanotaenia* sp.	*Hymenolepis diminuta*	*Raillieitina* sp.
T. indica	3, 4, 6, 15, 17	–	–	4	4, 6, 8, 10, 14, 16, 26, 27	–	–	–	10	4	10, 17, 26
G. nanus	–	–	–	–	–	–	–	–	–	–	–
M. libycus	–	–	–	–	–	–	–	16	19	–	22
G. ellioti	–	–	–	–	–	–	–	–	–	–	–
A. witherbyi	–	–	–	–	–	–	–	–	–	–	–
M. musculus	18	–	–	–	–	5	16	–	–	18	–
N. indica	–	–	–	–	–	–	–	–	–	–	–
R. rattus	3	–	–	–	–	–	–	–	–	–	–
A. dimidiatus	1, 2, 5	20	1, 2	–	–	–	–	–	2	–	–
J. blanfordi	–	11	–	–	–	–	–	–	–	–	–
C. hotsoni	–	–	–	–	–	–	–	–	–	–	–
C. migratorius	–	–	–	–	–	–	–	–	–	–	–
M. mystacinus	–	–	–	–	–	–	–	–	–	–	–

Numbers show the sampling localities in the Table 3 and figure

Table 2 Prevalence (%) of infected rodents, abundance (%) and mean intensity (%) of endoparasites from the Jaz Murian depression

Parasites		*M. muris*		*Labiostomum* sp.		*L. naimi*		*A. tetraptera*		*T. muris*		*S. obvelata*	
Rodent species	Prevalence (%)	Abundance (%)	Mean intensity (%)	Abundance (%)	Mean intensity (%)	Abundance (%)	Mean intensity (%)	Abundance (%)	Mean intensity (%)	Abundance (%)	Mean intensity (%)	Abundance (%)	Mean intensity (%)
T. indica	93.3	83.3	104.2	0	0	0	0	63.3	380	150	409.1	0	0
G. nanus	0	0	0	0	0	0	0	0	0	0	0	0	0
M. libycus	15	0	0	0	0	0	0	0	0	0	0	0	0
G. ellioti	0	0	0	0	0	0	0	0	0	0	0	0	0
A. witherbyi	0	0	0	0	0	0	0	0	0	0	0	0	0
M. musculus	8	2.8	1.0	0	0	0	0	0	0	0	0	44.4	533.3
N. indica	0	0	0	0	0	0	0	0	0	0	0	0	0
R. rattus	50	50	0	0	0	0	0	0	0	0	0	0	0
A. dimidiatus	66	61.9	100	4.8	100	9.5	100	0	0	0	0	0	0
J. blanfordi	14	0	0	14.3	100	0	0	0	0	0	0	0	0
C. hotsoni	0	0	0	0	0	0	0	0	0	0	0	0	0
C. migratorius	0	0	0	0	0	0	0	0	0	0	0	0	0
M. mystacinus	0	0	0	0	0	0	0	0	0	0	0	0	0

Parasites		*H. skrjabini*		*Physaloptera* sp.		*Choanotaenia* sp.		*H. diminuta*		*Raillieitina* sp.	
Rodent species	Prevalence (%)	Abundance (%)	Mean intensity (%)	Abundance (%)	Mean intensity (%)	Abundance (%)	Mean intensity (%)	Abundance (%)	Mean intensity (%)	Abundance (%)	Mean intensity (%)
T. indica	93.3	0	0	0	0	3.3	100	16.7	250	10	300
G. nanus	0	0	0	0	0	0.0	0	0	0	0	0
M. libycus	15	0	0	130.8	850	7.7	100	0	0	7.7	100
G. ellioti	0	0	0	0	0	0	0	0	0	0	0
A. witherbyi	0	0	0	0	0	0	0	0	0	0	0
M. musculus	8	2.8	100	0	0	0	0.0	8.3	150	0	0
N. indica	0	0	0	0	0	0	0	0	0	0	0
R. rattus	50	0	0	0	0	0	0	0	0	0	0
A. dimidiatus	66	0	0	0	0	14.3	150	0	0	0	0
J. blanfordi	14	0	0	0	0	0	0	0	0	0	0
C. hotsoni	0	0	0	0	0	0	0	0	0	0	0
C. migratorius	0	0	0	0	0	0	0	0	0	0	0
M. mystacinus	0	0	0	0	0	0	0	0	0	0	0

Table 3 Sampling localities of the specimens of rodents in the Jaz Murian depression

No.	No. on the map	Collecting station	GPS information		No.	No. on the map	Collecting station	GPS information	
		Locality	Latitude	Longitude			Locality	Latitude	Longitude
1	1	Sardasht, Biskove	26°29′	57°51′	17	7	Bampour, Jafarabad	27°12′	60°32′
2	2	Sardasht, Koh-e-Heidar	26°30′	57°29′	18	8	Bampour, Aliabad	27°11′	60°34′
3	3	Minab,Tarom.	27°01′	57°04′	19	9	Iranshahr, Tighabad	27°20′	60°45′
4	3	Minab	27°03′	57°06′	20	10	Fannoj	26°33′	59°38′
5	4	Fariab	27°28′	57°05′	21	11	Nikshahr	26°12′	60°13′
6	4	Roudan	27°27′	57°09′	22	6	Fannoj, Maskoutan	26°52′	59°49′
7	5	Bazman, Kalgande	27°51′	60°10′	23	12	Dalgan, Bagh-e-Ebrahim	27°29′	59°27′
8	5	Bazman	27°51′	60°10′	24	13	Fariab, Sardak sargorij	28°11′	57°51′
9	5	Bazman, Kargokan	27°50′	60°10′	25	14	Kahnoj, Avazabad	27°57′	57°40′
10	5	Bazman	27°51′	60°10′	26	15	Roodbar	27°31′	57°54′
11	5	Bazman, Shandak	27°50′	60°10′	27	16	Kahnoj	27°56′	57°41′
12	5	Bazman, Sefidabad	27°51′	60°11′	28	17	Anbarabad, Amjaz	28°36′	58°02′
13	5	Bazman, Shandak	27°46′	60°07′	29	19	Anbarabad,	28°28′	57°51′
14	6	Chah-e-hashem	27°28′	59°24′	30	18	Jiroft, ebal-e- Barez	28°54′	57°54′
15	6	Dalgan	27°29′	59°27′	31	19	Anbarabad, Sartagheen	28°36′	58°02′
16	6	Houdian	27°29′	59°27′					

10 different genera of endoparasites. The identified endoparasites were: nematodes including *Trichuris muris, Syphacia obvelata*, *Labiostomum* sp., *Labiostomum naimi, Mastrophorus muris, Aspicularis tetraptera*, *Heligmosomoides skrjabini, Physaloptera* sp. and cesteodes including *Choanotaenia* sp., *Raillietina* sp. and *Hymenolepis diminuta* (Table 1).

Indian Gerbil (*T. indica*) (93% infested) was found with the highest parasitic infestation comparing to Spiny Mouse (*A. dimidiatus*) (66%), Black Rat (*R. rattus*) (50%), Libyan Jird (*M. libycus*) (15%), Jerboa (*J. blanfordi*) (14%) and House Mouse (*M. musculus*) (8%). Seven species of rodents, Short-tailed Bandicoot (*N. indica),* Baluchistan Gerbil (*G. nanus),* Indian Bush Rat (*G. ellioti*), Hotson's brush-tailed Mouse (*C. hotsoni*), Steppe field Mouse (*A. witherbyi*), Migrant Hamster (*C. migratorius*) and the Eastern European Vole (*M. mystacinus*) were free from any parasitic infestation (Table 2).

Endoparasites composing *Mastrophorus muris*, *Aspicularis tetraptera*, *Trichuris muris*, *Hymenolepis diminuta*, *Choanotaenia* sp., *Raillietina* sp. were collected from Indian Gerbil (*T. indica*). For House Mouse (*M. musculus*), we collected endoparasites including *Mastrophorus muris*, *Syphacia obvelata*, *Heligmosomoides skrjabini* and *Hymenolepis diminuta*. Parasites of the genus *Physaloptera* sp. was only found in Libyan Jird (*M. libycus).* Also, we isolated cestodes of *Choanotaenia* sp. and *Raillieitina* sp. from this species. Spiny Mouse (*A. dimidiatus*) was infested with *Mastrophorus muris*, *Labiostomum* sp., *Labiostomum naimi* and *Choanotaenia.* Black Rat *(R. rattus)* was only infested with *Mastrophorus muris.* Finally, we collected *Labiostomum* sp. from Jerboa *(J. blanfordi)* and Spiny Mouse (*A. dimidiatus)* (Table 1). The highest abundance of the endoparasites was related to *Trichuris muris* in *T. indica* and the highest mean intensity of endoparasites attributed to *Physaloptera* sp. in *M. libycus* hosts (Table 2).

Discussion

Control of zoonotic parasites depends on reliable knowledge of their distribution in each region. Some zoonotic diseases such as Crimean-Congo hemorrhagic fever (CCHF) and zoonotic cutaneous leishmaniasis (ZCL) are endemic in southeast of Iran (Ansari et al. 2014; Kassiri et al. 2013). Rodents and their endoparasites are important not only from the point that they directly affected human health but also can play as a role of intermediate host to infect poultries and husbandries (Rafique et al. 2009; Meerburg et al. 2004; Meerburg and Kijlstra 2006), hence, controlling programs are necessary to reduce rodent's impact.

Among rodents captured in the present study, House Mouse (*M. musculus*; 24.56% of total specimens captured) represented the most frequency and Migrant Hamster, (*C. migratorius*) and the eastern European Vole (*M. mystacinus*) showed the least frequency.

High diversity of endoparasites (11 different species) was demonstrated in the Jaz Murian depression. Parasites of the species *Mastrophorus muris* were the most common in the captured rodents and found in four species (*T. indica,* *M. musculus, R. rattus* and *A. dimidiatus*), which were scattered in all parts of the Jaz Murian dep. The species *Trichuris muris* had the highest frequency of infestation in Indian Gerbil *(T. indica*), which was distributed in eight localities of the Jaz Murian depression. Additionally, parasites of *Aspicularis tetraptera* were only found in the Indian Gerbil (*T. indica*) in Minab. Since, Indian Gerbils can be found in low altitudes (Khajeh et al. 2015) thus; existence of the species at the central parts of the Jaz Murian depression was expected. We collected *Syphacia obvelata* and *Heligmosomoides skrjabini* from House Mouse (*M. musculus*) in the village of Fariab and Houdian, southwest and north of the Jaz Murian depression respectively. Also, *Physaloptera* sp. was identified at Libyan Jird (*M. libycus)* in the village of Houdian.

The most infested species was Indian Gerbil (*T. indica*) in which 28 of 30 captured specimens (93%) were infested with six genera of endoparasites. Moreover, high abundance of some parasite species observed in this rodent may be related to their lifestyle (living in colonies) which provides appropriate condition for transmission of high amount of parasites. These six infested rodents species (*T. indica, M. musculus, M. libycus, J. blanfordi, A. dimidiatus, R. rattus*) were collected from residential or adjacent to residential area which increase the risk of pathogenesis (Tables 1, 3 and Fig. 1). Seven non-infested rodent's species (*G. nanus, G. ellioti, M. mystacinus*, *N. indica, A. witherbyi, C. migratorius and C. hotsoni*) except *N. indica* and *G. nanus* which were free from any parasitic infestation live far from the human habitats, however, the results may be probably due to a low sample size. They were collected from Amjaz and Sartagheen (Anbarabad, Kerman province) in the top of the Jebal Bariz and Bashagard Mountain chains which presence of human associations were very low, therefor, this species were less important from the health aspect.

Comparing to the similar study in NE Iran carried out by Arzamani et al. (2017) *Mastrophorus muris*, *Labiostomum* spp., *Heligmosomoides skrjabini*, *Physaloptera* sp., *Choanotaenia* sp., *Raillieitina* sp. which were not observed in their study were isolated in present investigation while *Cysticercus fasciolaris* was the most common parasite in the rodents from NE Iran. The reason may be related to the more humid climate in the northeast Iran which provide suitable habitats for larval stage of *Taenia taeniaeformis* and transmitting to new hosts, whereas the dry hot climate in Jaz Murian impose constrain to this tapeworm. In concordant to our results, Gerbils (*M. persicus* in Arzamani et al. (2017) and *T. indica* in the present study) show the highest infections with endoparasites. *Hymenolepis nana* which was previously recorded in rodents from Jaz Murian depression (Nateghpour et al. 2015; Fasihi Harandi et al. 2016) was not observed in present study. Generally, the most infested rodents in our study were also reported to be as a reservoir host for cutaneous leishmaniasis in Iran (Rassi et al. 2011; Vazirianzadeh et al. 2013; Davami et al. 2014; Wernery 2014) and provoke more attention for Gerbils population controlling. As reported in Rafique et al. (2009) and Majeed (2016) *Hymenolepis nana* and *H. diminuta* have prevalence in *R. rattus* in neighboring countries while we isolated *Mastrophorus muris* from the Black Rat in the present study. House mouse has been also reported to be infested by *H. diminuta*, *H. nana*, *T. taeniaeformis*, *Vampirolepis* sp., *Protospirura* sp., and *Trichuris* sp. in Pakistan while we recorded *H. diminuta, H. skrjabini*, *S. obvelata*, and *M. muris* from *Mus musculus*.

Although, there is no organized databank about endoparasites in Iran, based on available data, we reported *L. naimi* for the first time in rodents from Iran. This species (*L. naimi*) was collected from Spiny Mouse (*A. dimidiatus)* in Bashagard Mountain chain in south of the Jaz Murian depression.

Conclusion

The multiple impacts of rodents on human public health highlight the essential role of controlling programs and services by the governments in developing countries. Taking to account the human commensalism of the rodents with the highest infestation (Indian Gerbil, Spiny Mouse, Black Rat, Libyan Jird, Jerboa and House Mouse) and the overlap between their habitats with farms and villages in the southeast Iran, the necessity for monitoring and controlling of the rodent's populations around villages and farms would be expected.

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Author contributions AK, ARS and GRR shared in the study design, research topics and providing the funds. AK and ZM collected rodent samples and AK, ZM, and FG identified the rodent specimens and wrote the manuscript. AK and ARS collected the endoparasites and performed the laboratory work on endoparasites. AK, ZM, FG, AM, IM, GRR identified the endoparasites. All authors shared in interpretation of the results, and reviewed the manuscript.

Compliance with ethical standards

Conflict of interest We declare that we have no conflict of interest.

Ethical approval Animals were captured, handled and euthanized while observing the regulations on animal welfare (28/1998).

Informed consent For this type of study informed consent is not required.

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