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Occurrence of ectoparasitic arthropods (Siphonaptera, Acarina, and Anoplura) on rodents of Khorasan Razavi Province, northeast of Iran

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ABSTRACT

Objective: To determine distribution of rodents' arthropods and estimate infestation parameters of fleas, mites, ticks, and lice associated with wild rodents in Mashhad and its vicinity, Iran.
Methods: The rodents were captured using live trap from April 2013 to December 2014 in Mashhad and vicinity, Khorasan Razavi, Iran. The ectoparasites were collected from body surface of rodents using brushing, combing or forceps and preserved in 70% ethanol. The samples were examined by stereomicroscope and classified into four groups including fleas, mites, ticks, and lice. Dark specimens were made more transparent by soaking in potassium hydroxide or Nesbitt's fluid (where appropriate). The specimens were mounted on glass slides using Hoyer's medium. Ectoparasitic identification was done based on the available keys and confirmed by qualified taxonomists.
Results: A total of 197 rodents were trapped representing 11 species which belong to the family Muridae (7 species), Cricetidae (3 species) and Sciuridae (1 species). The most common captured rodent species was *Mus musculus* (13.19%) and the least was *Apodemus witherbeyi* (6.59%). In total 783 ectoparasites related to 3 orders, 8 families, 10 genera and 15 species were collected. The infestation rates by fleas, mites, ticks, and lice on the rodents were 18.78%, 22.84%, 18.78% and 10.15 %, respectively.
Conclusions: Overall infestation rate was 42.13 % (83 out of 197 rodents). The most and least frequency of ectoparasites belonged to mites (50.44%) and lice (14.04%), respectively. The results suggested that the prevalence of ectoparasites could be influenced by rodent host species. Monitoring the rodent population and their ectoparasites is recommended to facilitate arthropod-borne disease control programs.

1. Introduction

Rodents as the most frequent mammals around the world have the ability to bring about public health problems because of their close association with humans and being economic pests[1]. Rodents with different families have close association by ectoparasites which act as zoonotic reservoirs. Due to ecological role of ectoparasites in the regulation of their host populations, estimating the richness of ectoparasitic species will supply valuable insights for scientists[2,3], but rodents' ectoparasites are less investigated mostly because of their small size.

More than 40 zoonotic diseases are transmitted by rodents' host including plague, leptospirosis, salmonellosis, rat-bite fever, leishmaniasis, Chagas' disease, Omsk hemorrhagic fever, bubonic plague, tularemia or Lyme disease, Lassa fever and murine typhus[4,5]. As many suitable conditions in rural and urban places cause the wild rodents to be infested by arthropods, research on distribution of rodents' ectoparasite is necessary for prevention of zoonotic diseases threatening humans.

Several studies have been managed on ectoparasites of rodents and other small mammals in some parts of Iran[6-13], most of which have been directed only to economically important species or disease vectors. The objective of the present work was to determine distribution of rodents' arthropods and estimate infestation parameters of fleas, mites, ticks, and lice associated with wild rodents from Mashhad and its vicinity located in Khorasan Razavi Province, northeast of Iran.

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2. Materials and methods

The study area was 15 different localities including farms and public places in Mashhad and vicinity (from 35˚60' N–59˚15' E to 36˚35' N–60˚25' E), Khorasan Razavi Province, northeast of Iran (Figure 1). The rodents were trapped from April 2013 to December 2014 with live trap baited with cheese, cucumber and sunflower seeds. The rodents were identified using taxonomic keys based on morphological traits[14]. Captured rodents were transported to the laboratory and euthanized with chloroform. A range of examination methods were done for detection of ectoparasites. Removal of ticks and lice required searching the fur while looking through a magnifier. Fur mites could only be detected using a binocular microscope. The rodents were then placed over a white tray and their ectoparasites were collected using brushing, combing or fine-tipped forceps and stored in 70% ethanol for their preservation and identification. Further inspection was performed using a magnifier around different parts of rodent's body such as anus, head, behind ears, face, thorax, abdomen, armpits and fur, especially near dermatological lesions[15]. Euthanized rodents were individually maintained in a small nylon bag at room temperature for a while, after which some ectoparasites leaving their host were also picked up. Animal experiments were approved by the Ethics Committee for Animal Experiments of Ferdowsi University of Mashhad, Iran. After the removal of ectoparasites, the animals were also used for further biosystematics projects of which the results did not reported in the present study. The ectoparasite specimens were classified into four groups including fleas, mites, ticks, and lice. Dark specimens were made more transparent by soaking in potassium hydroxide (for fleas) or Nesbitt's fluid (for ticks and lice). Then, the specimens were mounted on glass slides using Hoyer's medium. Ectoparasitic identification was done based on the valid keys which are available for Siphonaptera[16], Ixodida[17], and Anoplura[18].

3. Results

During the study period, a total of 197 rodents were trapped representing 11 species which belong to the family Muridae: *Meriones libycus* (*M. libycus*), *Meriones persicus* (*M. persicus*), *Apodemus witherbeyi* (*A. witherbeyi*), *Mus musculus* (*M. musculus*), *Nesokia indica* (*N. indica*), *Rattus norvegicus*, *Tatera indica* (*T. indica*); Cricetidae: *Cricetulus migratorius* (*C. migratorius*), *Ellobius fuscocapillus* (*E. fuscocapillus*), *Microtus transcaspicus* (*M. transcaspicus*); Sciuridae: *Spermophilus fulvus* (*S. fulvus*). The most and least collected species were *M. musculus* and *A. witherbeyi*, respectively (Table 1).

A total of 783 ectoparasites related to 3 orders, 8 families, 10 genera and 15 species were collected as follows (Figure 2): Siphonaptera: from Pulicidae, *Ctenophthalmus* sp. on *Rattus norvegicus* (*R. norvegicus*); *Xenopsylla cheopis* (*X. cheopis*) on *N. indica* and *M. persicus*; and *Xenopsylla* sp. on *N. indica*; from Ceratophyllidae, *Nosopsyllus fasciatus* (*N. fasciatus*) on *S. fulvus*, *M. persicus* and *N. indica*, also *Nosopsyllus* sp. on *N. indica* and *M. persicus*; from Ixodidae (Acari), *Haemaphysalis punctate* (*H. punctate*) on *M. persicus* and *N. indica*, and *Haemaphysalis* sp. on *A. witherbeyi*; *Ixodes trianguliceps* (*I. trianguliceps*) on *M. persicus*, and *Ixodes* sp. on *A. witherbeyi*; from Laelapidae (Acari), *Laelaps* sp. on *M. musculus*, *Haemolaelaps* sp. on *M. musculus*, and *M. persicus*; from Hirstionyssidae, *Hirstionyssus* sp. on *M. libycus*; from Polyplacidae (Anoplura), *Polyplax asiatica* (*P. asiatica*) on *M. persicus*, *S. fulvus* and *N. indica*, and *Polyplax paradoxa* on *M. persicus*; from Hoplopleuridae (Anoplura), *Hoplopleura captiosa* (*H. captiosa*) on *N. indica* and *M. musculus*.

The infestation rates by fleas, mites, ticks, and lice on the rodents were 18.78%, 22.84%, 18.78% and 10.15%, respectively. Overall infestation rate was 42.13% (83 infested out of 197 rodents) (Table 1). The most and least frequency of ectoparasites belonged to mites

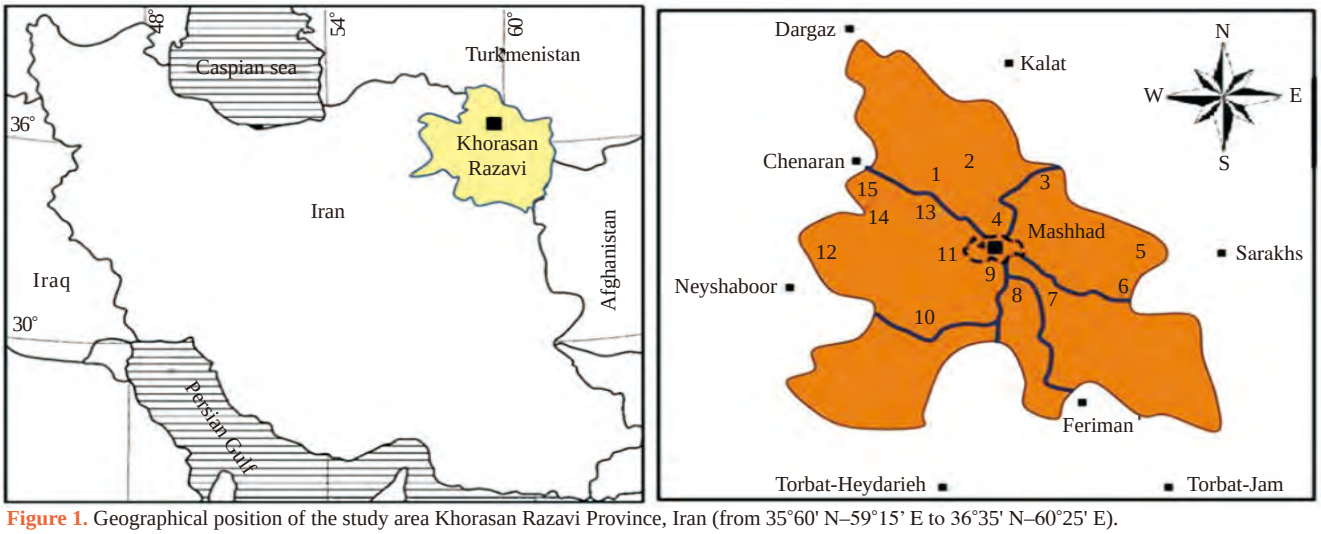

Figure 1. Geographical position of the study area Khorasan Razavi Province, Iran (from 35˚60' N–59˚15' E to 36˚35' N–60˚25' E).
1: Govareshk; 2: Sade Kardeh; 3: Goojgi; 4: Farokhad; 5: Mayamey; 6: Shoorak Maleki; 7: Abravan; 8: Tape Salam; 9: Torogh; 10: Moghan; 11: Hesar Golestan; 12: Zoshk; 13: Veyrani; 14: Kahoo; 15: Golmakan.

Table 1

Number of infested rodents and infestation rate (in parenthesis)* by four ectoparasite groups in Mashhad, Iran during 2013-2014.

Host species	Host family	Total No. of hosts		Ectoparasite group			
		Examined	Infested	Ticks	Mites	Fleas	Lice
M. transcaspicus	Cricetidae	20	8	6 (75.00%)	4 (50.00%)	1 (12.50%)	1 (12.50%)
C. migratorius	Cricetidae	17	3	0	3 (100.00%)	1 (33.33%)	0
E. fuscocapillus	Cricetidae	16	4	0	4 (100.00%)	0	0
M. libycus	Muridae	14	4	0	2 (50.00%)	4 (100.00%)	0
M. persicus	Muridae	19	10	8 (80.00%)	6 (60.00%)	7 (70.00%)	4 (40.00%)
A. witherbeyi	Muridae	13	7	3 (42.85%)	5 (71.42%)	5 (71.42%)	0
M. musculus	Muridae	26	12	10 (83.33%)	7 (58.33%)	0	5 (41.66%)
N. indica	Muridae	16	12	4 (33.33%)	0	8 (66.66%)	6 (50.00%)
R. norvegicus	Muridae	19	9	3 (33.33%)	5 (55.55%)	4 (44.44%)	4 (44.44%)
T. indica	Muridae	14	4	0	3 (75.00%)	0	0
S. fulvus	Sciuridae	23	10	3 (30.00%)	6 (60.00%)	7 (70.00%)	0
Total		197	83	37 (44.57%)	45 (54.21%)	37 (44.57%)	20 (24.09%)

*: Calculated as the number of rodents infested by each ectoparasite group divided by number of rodents infested by all groups multiply 100.

(50.44%) and lice (14.04%), respectively (Figure 2).

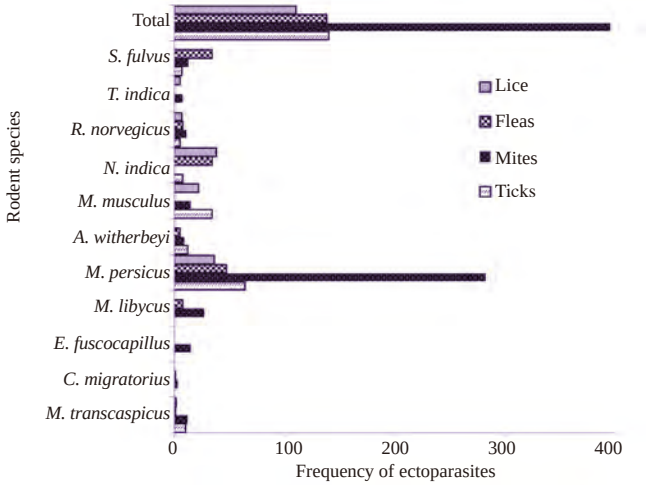

Figure 2. Frequency of ectoparasites collected on various host species in Mashhad, Iran during 2013-2014.

4. Discussion

The synanthropic rodents as the most important reservoirs of zoonotic diseases transmit various parasitic infections. The present study reported 15 ectoparasitic species infesting wild small mammals in Mashhad vicinities, Khorasan Razavi Province located in the northeast of Iran. In our samplings, the most common captured rodent species was *M. musculus* (13.19%) and the least was *A. witherbeyi* (6.59%). Some ectoparasite species were reported newly either for the region or country[19]. The maximum and minimum frequencies belonged to mites, Acarina (50.44%) and sucking lice, Anoplura (14.04%), respectively. Similarly, Shayan and Rafinejad reported that mites (64.67%) and lice (3.21%) showed the same order in frequency in Khorram Abad district, Iran[6].

From Siphonaptera, we found five species in the families of Pulicidae and Ceratophyllidae. The scurid, *S. fulvus* (62.96%) showed the highest percentage of infestation to fleas. Furthermore, the fleas were found in the highest frequency in Behesht Reza area – as a cemetery – compared to other sampling locations. Two flea species including *N. fasciatus* and *Nosopsyllus iranus* on *M. musculus* have been reported from Lorestan Province located in the west of Iran[6]. The flea *N. fasciatus* was detected on *R. norvegicus* with the frequency of 3.8% while no fleas' infestation on *M. musculus*, as reported in a survey on rodent's ectoparasites in north district of Tehran, Iran[11]. In our study, we found that *M. persicus* and *S. fulvus* were infested by *N. fasciatus*. Other studies reported *X. cheopis* and *Xenopsylla ramesis* from Egypt[20], and *Xenopsylla* sp. on *Mastomys awashensis*, *Arvicanthis dembeensis* and *Acomys* sp. from Tigray, Northern Ethiopia[21]. *X. cheopis* was also reported as the predominant flea species on rodents in many studies[22,23]. A survey on the rodents *R. norvegicus*, *Rattus rattus* (*R. rattus*) and *M. musculus*, in Iran demonstrated that 40.3% of the rodents were infested with *X. cheopis* and *Xenopsylla astia*[23]. In our study, *X. cheopis* was found on the common rodents, *M. persicus* and *N. indica*. The flea species of *X. cheopis* has been regarded as an important vector of *Yersinia pestis* – the causative agent of plague and murine typhus and as a possible intermediate host of the tapeworm, *Hymenolepis diminuta*[24-26].

From Ixodida, the species *Haemaphysalis* sp., *H. punctate* and *Ixodes* sp. and *I. trianguliceps* were detected. Moreover, *Haemaphysalis* sp. and *Ixodes* sp. were collected in both nymphal and adult stages. In other surveys, the larval stages of these tick species were also reported[27,28] mainly as pests of livestock[29]. The tick species of *H. punctate* has been recently collected on *Calomyscus bailwardi*, *Meriones persicus*, *Microtus socialis* and *R. rattus* in Iran[6], and *M. musculus* and *R. norvegicus* in Nigeria[30]. In the present study, *N. indica* was found to be an alternative host for this tick species. The tick species of *I. trianguliceps* has been reported on *Apodemus flavicollis*, *R. norvegicus* and *R. rattus*[26,31]. We found that *I. trianguliceps* could be harbored by *M. persicus*. The highest percentage of tick's infestation was on *M. musculus* (47.88%).

Furthermore, from mite group, we found *Laelaps* sp., *Haemolaelaps* sp. and *Hirstionyssus* sp. In other surveys, various species of mites have been reported on different host including *Laelaps nuttalli* on *R. norvegicus* and *T. indica*[7,24,25,32], *Laelaps echidninus* on *R. rattus*[8], and *Laelaps paulistanensis*, *Laelaps echidninus* and *Laelaps manguinhosi* on *Scaptermomys*

aquaticus[33], and *Laelaps alaskensis* and *Laelaps kochi* on *Microtus ochrogaster*[34]. In the present study, the unspecified mites *Laelaps* sp. and *Haemolaelaps* sp. were found on *M. musculus*. The latter mite was also collected on *M. persicus*. In Bauchistan area, three species of *Laelaps accuninata*, *Andralaelaps hermophrodita* and *Paracheylaellaps pyriformis* have been recently considered as the first records[35]. In addition, a study on rodents' ectoparasites in Tehran district showed that among all arthropods, mites and ticks had the highest (97.4%) and the lowest frequency (0.1%), respectively[11]. In our study *M. libycus* with the highest rate of infestation (77.14%) was regarded as the most common host for mites. The rodents in the district Khaje Morad, as a populated place with numerous passengers, showed the highest rate of infestation to ticks and mites.

From Anoplura, three ectoparasite species *P. asiatica*, *Polyplax paradoxa* and *H. captiosa* were detected. The maximum frequency of lice was on *N. indica* (47.5%). We reported the highest abundance of lice on the rodents of Ghadir camp which is regarded as a crowded social place. Some other studies reported *H. captiosa* on *R. norvegicus*[7], *P. asiatica* on *R. norvegicus*[9,26] and *Sciurus anomalus*[12]. From Baluchistan area, southeast of Iran, lice (68.4%) were the most prevalent ectoparasties[35]. In a study on the ectoparasites of rodents in Bandar Abbas, Iran, the ectoparasites of *Rhipicephalus* spp., *Polyplax gerbil* and *H. captiosa* were collected on *R. norvegicus*, *R. rattus* and *T. indica* after application of a control program[7]. Our investigation declared that *M. persicus*, *S. fulvus* and *N. indica* could be harbored by *P. asiatica*. Furthermore, *H. captiosa* was regarded as a common louse on *N. indica* and *M. musculus*.

The overall frequency of the ectoparasites and their abundance could be affected by rodent hosts and their microhabitats diversity[36]. Fleas, ticks, mites and lice are considered as the most important vectors of pathogens in human, domestic and wild animals[37-40].

Many species of rodents threaten human health, especially in densely populated areas. Therefore, understanding the richness of their ectoparasite species would provide valuable insights into their roles in the control of host populations[41,42]. During the European epidemic, *R. rattus* of Muridae, and squirrels and chipmunks (Sciuridae) were recorded as the major rodent hosts of plague in California, generally endangering humans in rural areas. Lyme disease as a bacterial infection transmitted indirectly from rodent reservoirs to humans through tick bites. *Peromyscus leucopus* (Muridae) act as reservoirs by supporting the larval and nymphal stages of tick species known to transmit the disease[43]. Lice bites will cause pain, redness and itching of the bite site and anemia. Some infectious diseases including: flea tapeworms (*Dipylidium caninum*) and human typhus (*Rickettsia prowazekii*) can be transmitted from animal to animal or human to human by sucking lice[44,45].

Due to high prevalence of ectoparasites on rodents and their serious zoonotic importance, further epidemiological and zoonotic investigations are recommended to ascertain the role of rodents in the lifecycle of emerging new infestations in Iran.

Conflict of interest statement

We declare that we have no conflict of interest.

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