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

Gholamhossein Moravvej1*, Kordiyeh Hamidi2, Leila Nourani2, Hamed Bannazade1

1Department of Plant Protection, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran
2Department of Biology, Faculty of Science, Ferdowsi University of Mashhad, Mashhad, Iran

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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.
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 their ectoparasites. Removal of 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], Ixodidae[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. witherbey), 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. witherbey, 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. witherbey; Ixodes trianguliceps (I. trianguliceps) on M. persicus, and Ixodes sp. on A. witherbey; from Laelapidae (Acarina), 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 paradoxus 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
witherbeyi either for the region or country [19]. The maximum and minimum frequency in Khorram Abad district, Iran[6]. reported that mites (64.67%) and lice (3.21%) showed the same Anoplura (14.04%), respectively. Similarly, Shayan and Rafinejad frequencies belonged to mites, Acarina (50.44%) and sucking lice, (50.44%) and lice (14.04%), respectively (Figure 2).

An ectoparasite species infesting wild small mammals in Mashhad vicinities, Khorasan Razavi Province located present study reported 15 ectoparasitic species infesting wild small mammals in Mashhad, Iran during 2013-2014.

| Host species                | Host family  | Total No. of hosts | Ticks | Mites | Fleas | Lice |
|-----------------------------|--------------|--------------------|-------|-------|-------|------|
| M. transcaucasicus          | Cricetidae   | 20                 | 8     | 6 (75.00%) | 4 (50.00%) | 1 (12.50%) |
| C. migratorius              | Cricetidae   | 17                 | 3     | 0     | 3 (100.00%) | 1 (33.33%) |
| E. fuscoguttatus            | Cricetidae   | 16                 | 4     | 0     | 4 (100.00%) | 0     |
| M. libycus                 | Muridae      | 14                 | 4     | 0     | 2 (50.00%) | 4 (100.00%) |
| 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    | (63.33%) | 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).

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, 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 iranianus 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[12]. 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 nasutus 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 echininus on R. rattus[8], and Laelaps paulistanensis, Laelaps echininus and Laelaps manguinii on Scapteromys...
the first records on crowded social place. Some other studies reported of lice was on species of ticks and mites. The rodents in the district Khaje Morad, as a populated place infestation (77.14%) was regarded as the most common host for mites. The rodents in the district K haje M orad, as a populated place with numerous passengers, showed the highest rate of infestation to ticks and mites. From Anoplura, three ectoparasite species P. asiatica, Polyplex 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 Ghdair 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 ectoparasites[35]. In a study on the ectoparasites of rodents in Bandar Abbas, Iran, the ectoparasites of Rhipicephalus spp., Polyplex 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 animal[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 squinrels 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. Disease as a bacterial infection transmitted indirectly from rodent reservoirs to humans through tick bites. Lyme disease as a bacterial infection transmitted indirectly from rodent reservoirs to humans through tick bites.

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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