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Article

Relationship between the sex and age of *Mus musculus* (Rodentia: Muridae) with ectoparasites prevalence in northeast of Iran

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Abstract

Rodents' significant role in transmission of serious zoonotic diseases is considered as an interesting subject in public attention. With respect to the importance of arthropod-infested rodents in zoonotic diseases transmission and extent distribution of *Mus musculus*, the present study aimed to analyze the interrelationship between hosts' sex and age of *M. musculus* with the ectoparasites prevalence in Mashhad and vicinity, northeast of Iran. Mites, ticks and lice were cleared in Nesbit and fleas were made transparent by 10% KOH and then individually mounted in Hoyer's medium. They were identified with the aid of valid identification keys. A total of 267 ectoparsites belonging to eight species were collected from 93 hosts (48.38% male vs. 51.62% female). Among parasite groups, mites, ticks, lice and fleas occurred in prevalence of 46.06%, 22.84%, 16.85% and 14.23%, respectively. Our results demonstrated significant higher ectoparasite burden on male hosts for *Haemolaelaps* sp., *Nosopsyllus fasciatus, Ctenophthalmus* sp. and *Laelaps algericus.* However, two tick species of *Haemaphysalis punctata* and *Haemaphysalis* sp. showed a tendency of higher prevalence in females and no significant difference in the prevalence of lice species of *Hoplopleura captiosa* were observed between the host sexes. Similarly, no significant differences in ectoparasite infestations were observed between the age categories.

Key words: Ectoparasite; infestation; gender; maturity; prevalence; rodents.

Introduction

Rodents are recognized as significant hosts in transmission of serious zoonotic pathogens including *Borrelia* ssp., *Babesia* ssp., *Trypanosoma* ssp., *Leishmania* ssp. (Baker and Wharton 1952; Karbowiak *et al.* 2005; Klimpel *et al.* 2007). The house mouse (*Mus musculus*) has been considered as a cosmopolitan species that lives in close association with humans, and transported frequently to all areas by human's civilization (Hutchins *et al.* 2003). Due to their importance in infection of humans and other animals, they are considered as an interesting subject in public attention (Klimpel *et al.* 2007; Dziemian *et al.* 2014). Some studies have reported infestation parameters and indices of some ectoparasite species on this host (Lareschi and Iori 1998; Lareschi *et al.*

2003; Nava *et al.* 2003). Some investigations have showed the relationship between ectoparasties and different sexes of wild rodents (Lareschi and Cicchino 2002; Solanki 2013; Kowalski *et al.* 2014). Furthermore, several studies have been done based on the occurrence of ectoparasites of rodents and their role in the transmission of zoonotic diseases in Iran (Hanafi-Bojd *et al.* 2007; Allymehr *et al.* 2012; Pakdad *et al.* 2012; Shirazi *et al.* 2013; Hamidi *et al.* 2015; Moravvej *et al.* 2015).

Numerous researches on the association of host sex and ectoparasites infestation demonstrated that male or female bias of parasitism was in direct relation to the biology and ecology of rodent hosts (Marshall 1981). Various responses to parasitism depend on differences between males and females hosts in their anatomy, physiology, behavior, and evolutionary roles which are related to their roles in population and community dynamics of parasites (Combes 2001). It is obvious that sex-biased in parasite infestation may occur in several host-parasite relationships, at numerous locations, and in some periods of time but not in all cases (Krasnov *et al.* 2012). Most reports of sex-biased infestations in rodents show that there is more male-biased (Matthee *et al.* 2010; Scantlebury *et al.* 2010; Harrison *et al.* 2010) than female-biased host-parasite relationships (Hillegass *et al.* 2008; Rossin *et al.* 2010). With respect to the importance of arthropod-infested rodents in zoonotic diseases and extent distribution of *M. musculus*, the aim of the present study was to analyze the interrelationship between the sex and the age of *M. musculus* with the ectoparasites prevalence in Mashhad and vicinity, Khorasan Razavi Province, Iran.

Materials and Methods

Field study and parasitological collection

The study was conducted in 11 locations from Mashhad and vicinity, Khorasan Razavi Province, northeast of Iran (From 35° 60' N, 59° 15' E to 36° 35' N, 60° 25' E) during the period between April 2013 and April 2015. These sites were selected based on the previous author's pilot field studies which had demonstrated the presence of house mice, so it leads to increase the potential rate of capturing. Old buildings, storerooms, factories, parks, caravansaries, railway stations and so on were considered as our sampling targets. The rodents were captured with live traps baited with cheese, cucumber and sunflower seeds. They were transported to the laboratory and euthanized with chloroform and then placed over a white cloth. Ectoparasites were collected by brushing, combing or using a fine-tipped forceps and stored in 70% ethanol for their preservation until their identification. More detection was done using a magnifier instrument around different parts of rodent's body such as anus, head, behind ears, face, thorax, abdomen, armpits and underneath the fur, especially near dermatological lesions (Xie and Zeng 2000). The use of the rodents for the study was approved by the Ethics Committee for Animal Experiments of Ferdowsi University of Mashhad, Iran. The collected ectoparasite specimens were categorized into four groups including Siphonaptera (fleas), Acarina (mites and ticks) and Anoplura (lice). For taxonomic identification, mites, ticks and lice were cleared in Nesbitt's fluid and fleas were made transparent by 10% KOH and then individually mounted in Hoyer's medium. The ectoparasite specimens were identified using the valid taxonomic keys provided for Siphonaptera (Lewis 1967; Acosta and Morrone 2003), Acarina (Tenorio and Goff 1980; Baker 1999) and Anoplura (Kim *et al.* 1986; Korytkowski 2002). Photos were taken for both hosts and ectoparasites.

Data analysis

For age determination, we used many signs for grouping captured samples into two main age groups (mature and immature) as follows: 1. *Weight*: Mean weight of immatures and matures were 14 ± 2.5 and 18 ± 1.3 grams, respectively; 2. *Genital system*: In immatures it was hard to distinguish between male and female in first glance and it need more assessment. In matures, it was very easy to determine the sex based on the appearance of the testis in adult males and nipple glands in adult females; 3. *Tooth cusp pattern*: There are very significant differences in the tooth cusp pattern and also the amount of erosion of the molar teeth. In the other word, by increasing the age, the more erosion will be observed in molars.

The following parameters were calculated for each host sex and age category using SPSS. Mean Abundance (MA) = total number of individuals of a particular parasite species in a particular host sex or age category/total number of hosts of that sex or age category. Prevalence (P) = (number of hosts parasitized by a particular parasite species/ total number of hosts examined for that parasite species) × 100 (Bush *et al.* 1997). The significance of prevalence differences between host sexes and age categories for each ectoparasite species were analyzed using Student's t-test ($p < 0.05$) (Morales and Pino 1987).

Results

A total of 93 individuals of *M. musculus* were trapped from the study sites. About 48.38% of captured rodents were male and the rest were female (45 male individuals vs. 48 female individuals). Among captured rodents, 28 individuals were immature and 65 individuals were mature (30.10% vs. 69.89%) (Table 1). Total number of collected ectoparasites was 267 in which mites (prevalence = 46.06%), ticks (22.84%), lice (16.85%) and fleas (14.23%) showed the highest to lowest prevalence rate, respectively. Among all the captured specimens, about 36.55% (34 individuals out of 93) showed no ectoparasites infestations.

Table1. Total number of collected ectoparasites species for each host sex, age category, Student's t-test and p-value is detailed from *M. musculus* in Mashhad and vicinity, Iran during April 2013 to April 2015.

Ectoparasite species	Male (n = 45)	Female (n = 48)	t	p-value	Mature (n = 65)	Immature (n = 28)	t	p-value
Nosopsyllus fasciatus	23	9	1.679	0.002*	19	13	0.809	0.107
Ctenophthalmus sp.	15	2	1.217	0.013*	13	2	−0.578	0.226
Haemaphysalis punctata	24	17	0.746	0.37	18	23	2.180	0.00
Haemaphysalis sp.	8	12	−0.492	0.494	7	13	2.289	0.00
Haemolaelaps sp.	71	27	2.281	0.007*	56	42	1.292	0.135
Laelaps algericus	3	0	1.399	0.005*	3	0	−0.883	0.73
Microtrombicula sp.	11	11	0.092	0.805	3	19	3.738	0.00
Hoplopleura captiosa	25	20	0.491	0.396	31	14	0.075	0.563
Total	179	88			150	126		

* p < 0.0.5

The identified species of the ectoparasites were as follows: Siphonaptera: *Ctenophthalmus* sp. (Pullicidae), *Nosopsyllus fasciatus* (Ceratophyllidae); Acari (ticks): *Haemaphysalis punctata* and *Haemaphysalis* sp. (Ixodidae); Acari (mites): *Laelaps algericus* and *Haemolaelaps* sp. (Laelapidae), *Microtrombicula* sp. (Trombiculidae); Anoplura: *Hoplopleura captiosa* (Hoplopleuridae).

Siphonaptera (Fleas)

A total of 38 fleas (Ceratophyllidae and Pullicidae) constituting of 14.23% of all captured ectoparasites were collected on the back of the rodent's body. From all the findings, 19 rodents had fleas of which 15 had *N. fasciatus* (16.12%) and 4 rodents had *Ctenophthalmus* sp. (4.30%). These results are shown in Table 1 and Fig. 1. Calculated values for mean abundance and prevalence rates of *N. fasciatus* (P_m = 22.22%, MA_m = 0.511 and P_f = 10.41%, MA_f = 0.187) and *Ctenophthalmus* sp. (P_m = 4.44%, MA_m = 0.333 and P_f = 4.16%, MA_f = 0.041) on *M. musculus*, showed differences between host sexes, and only *N. fasciatus* prevalence was significantly higher on male hosts. There was no difference between prevalence rate of immature hosts in comparison with mature hosts with *N. fasciatus* (P_I = 17% and P_M = 15%) and *Ctenophthalmus* sp. (P_I = 7% and P_M = 3%) as shown in Fig. 2 and Table 1.

Acari (Ticks)

A total of 61 ticks (Ixodidae) were recovered from 26 rodents (27.95%) which were located mostly on ears, and some on the nose, tail and toes. Two species of *H. punctata* (22.58%) and *Haemaphysalis* sp. (11.82%) were found parasitizing *M. musculus* (Table 1, Fig. 1). Calculated values for mean abundance and prevalence rate of *H. punctata* (P_m = 17.77%, MA_m = 0.644 and P_f = 27.08%, MA_f = 0.25) and *Haemaphysalis* sp. (P_m = 6.66%, MA_m = 0.177 and P_f = 16.66%, MA_f = 0.25) on *M. musculus* in the investigated areas were higher in female hosts than male hosts. There was no significant difference in prevalence rates between immature and mature hosts in *H. punctata* (P_I = 25% and P_M = 21%) and *Haemaphysalis* sp. infestations although immature rates were higher (P_I = 25% and P_M = 6%) as seen in Fig. 2 and Table 1.

Acari (Mites)

A total of 123 mites (Laelapidae and Trombiculidae) constituting 46.06% of all the collected ectoparasites were collected either on the rear part of the back, abdomen and on hind legs of the hosts. Of all examined *M. Musculus*, 37 individuals were infested by *Haemolaelaps* sp. (30.10%), *L. algericus* (3.22%) and *Microtrombicula* sp. (9.67%) shown in Table 1 and Fig. 1. Calculated values for mean abundance and prevalence rate for *Haemolaelaps* sp. infestation in *M. musculus* in the investigated areas were significantly higher in males than in females (P_m = 44.44%, MA_m = 1.577 and P_f = 16.66%, MA_f = 0.562) but no significant differences host sex infestations for *L. algericus* (P_m = 4.44%, MA_m = 0.044 and P_f = 2.08%, MA_f = 0.020) and *Microtrombicula* sp. (P_m = 8.88%, MA_m = 0.244 and P_f = 10.41%, MA_f = 0.229).

The prevalence rates amongst the immature hosts in comparison with mature hosts for *Haemolaelaps* sp. (P_I = 42%, P_M = 26%), *Microtrombicula* sp. (P_I = 25%, P_M = 3%) and *L. algericus* (P_I = 0%, P_M = 3%) showed higher prevalence rates in immature hosts than mature hosts but there was no significant differences in infestations between host age categories for any mite species (Fig. 2, Table 1).

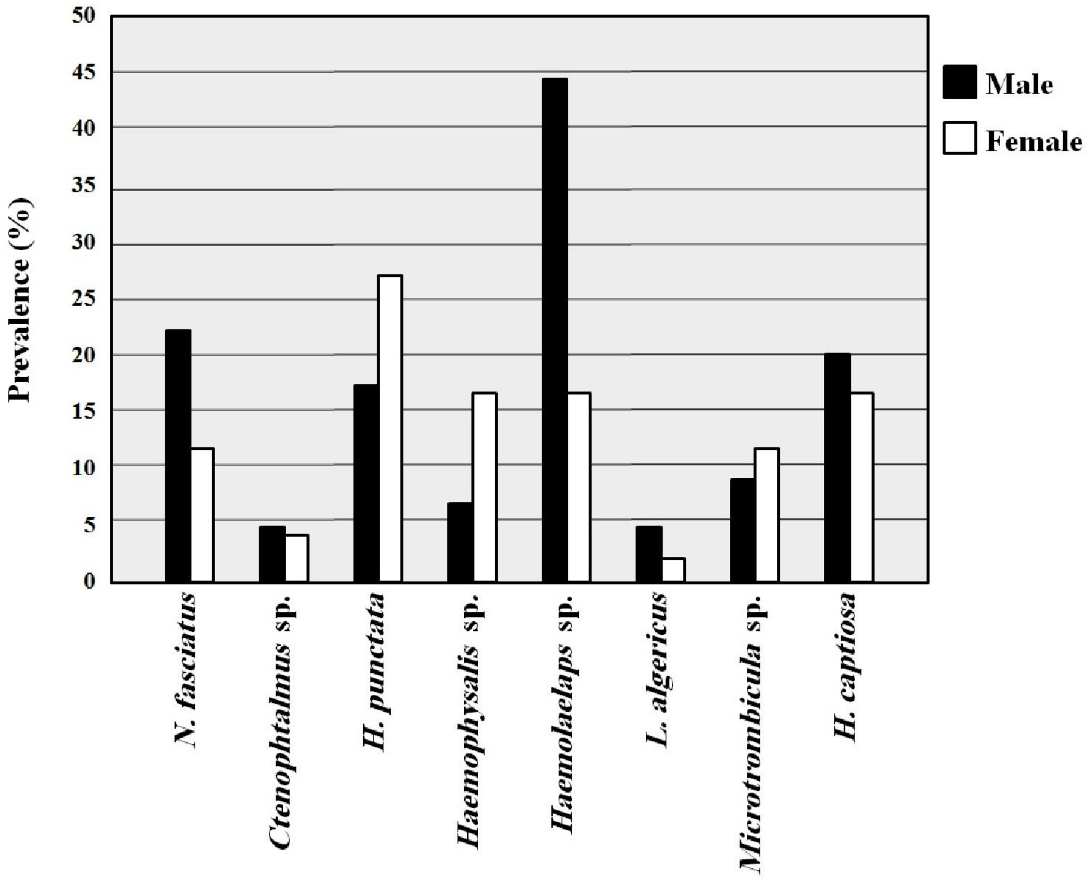

Figure 1. The prevalence rate of every ectoparasitic species for each host's sex from *M. musculus* in Mashhad and vicinity during April 2013 to April 2015.

Anoplura (Lice)

Among all examined rodent specimens, 17 individual (18.28%) were infested by *H. captiosa* which was the only founded lice species in our study (Table 1, Fig. 1). In case of Anoplura, the prevalence rate appears to be independent of host sex, although males showed a higher insignificant rate (P_m = 20%, MA_m = 0.555 and P_f = 16.67%, MA_f = 0.416). Similarly, the prevalence rate in immature hosts showed lower degree in comparison to matures, but this was not significant (P_I = 10% and P_M = 21%) (Fig. 2, Table 1).

Discussion

The Overall prevalence of ectoparasites in rodent hosts was 63.44%, in which mites (46.06%) and fleas (14.23%) constituted the highest and lowest prevalence in comparison to other ectoprasite groups. Similar to inferences by Soliman *et al.* (2001), our result could be attributed to the burrowing habit the host that made its mites to be influenced less by climatic changes and insecticides used for agricultural protection. Due to the fact that mites mainly live in the base parts of the hair- near the skin- they may be less affected by factors such as air disturbance, rain or using insecticides, in comparison with fleas which have flying ability and are distributed mainly on the body surface of their hosts. Furthermore, *M. musculus* live in colonies and so, transmission of ectoparasite from one host to the other host in the colony is very common. Some ecological and behavioral features including relative size and differences in the skin and anti-parasitic defenses, in addition to physiological aspects such as hormonal levels, might also affect ectoparasite infestation parameters and indices (Marshall 1981).

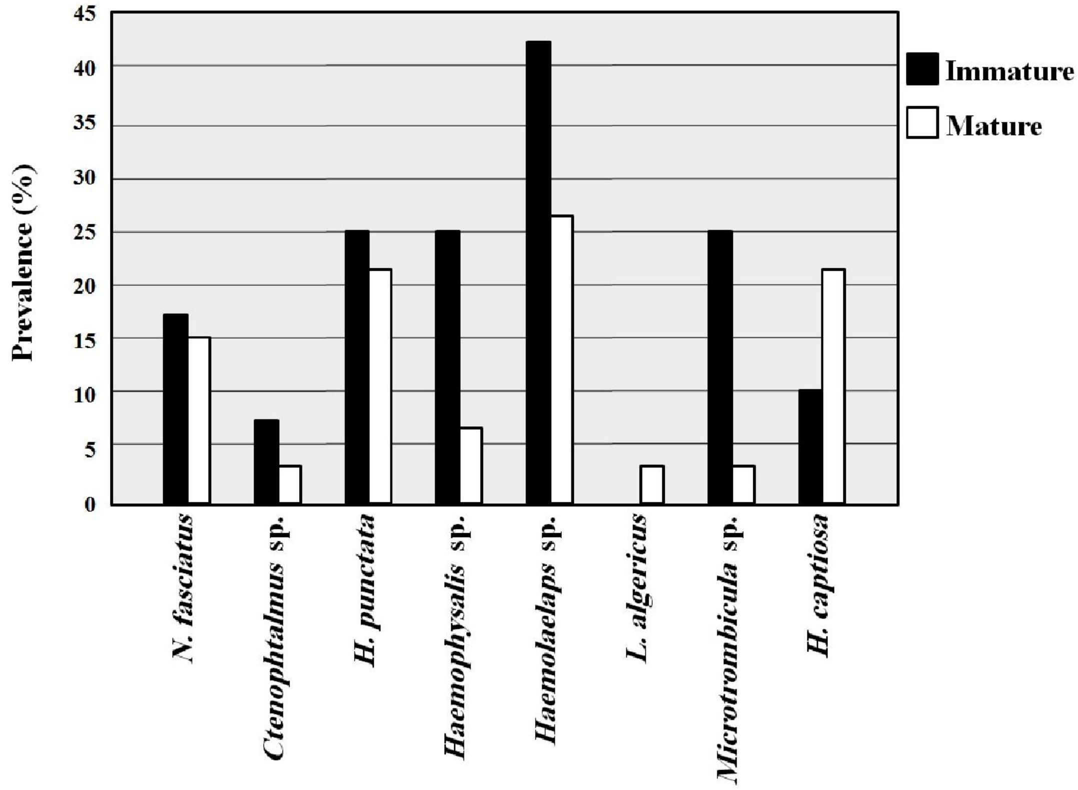

Figure 2. The prevalence rate of every ectoparasitic species for age categories from *M. musculus* in Mashhad and vicinity during April 2013 to April 2015.

Relation of host's sex and ectoparasites species

Our results demonstrated a significant higher ectoparasite burden on male host for *Haemolaelaps* sp., *N. fasciatus, Ctenophthalmus* sp. and *L. algericus* which were similar to some finding of previous studies (Hillegass *et al.* 2008; Matthee *et al.* 2010; Kowals-ki *et al.* 2014). Greater size of male hosts might be the reason for higher load of ectoparasites because of its extensive ability of movements, home range size, and a superior chance of contact with individuals of the same and other species in comparison to the females (Sánchez López 1998). These behavioral features of males may provide better potentials of them being colonized by ectoparasites. Some earlier studies also indicated that male hosts are more seriously infested by fleas (Marshall 1981), while others specified that females have higher infestation (Soliman *et al.* 2001). In *R. pumilio*, the increase in male-biased parasitism of ectoparasites was affected by host density that might be related to increased male dispersal in a growing population of small mammals (Matthee *et al.* 2010). The other famous hypotheses to describe sex-biased parasitism in males is associated to their higher degree of androgens which can affect their immune system (Zuk 1996; Zuk and McKean 1996). This hormone is related to reproductive system and aggressive actions during mate competition (Razzoli *et al.* 2003).

In the present study, two tick species of *H. punctata* and *Haemaphysalis* sp. showed a tendency of higher prevalence in females than males but this were not significant. Similarly, in some studies on ixodid ticks of rodents, no significant difference between infestations in host sexes was detected (Matthee *et al.* 2010; Kiffner *et al.* 2011) but in other research, male mice showed greater tick loads than females and analyses suggested that this sex-bias was related to body mass as opposed to sex category (Harrison *et al.* 2010).

Our results demonstrated that there was no significant difference in the prevalence of lice species of *H. captiosa* in different host sex which could be related to the fact that lice spend their whole life on the individual host (Kim *et al.* 1986). Similar rate of the prevalence and mean abundance of ectoparasites in male and female rodents was recorded for *Oxymycterus rufus* with the exclusion of those unintentionally connected (Lareschi 2006). Another investigation recorded that *Hoplopleura* species presented similarities of infestations on female and male hosts, whereas others reported male-bias due to larger body size (Marshall 1981). Moreover, no significant differences between both host sexes have been documented for *H. scapteromydis* and the spatial distribution of its eggs on the host body has been found to be similar (Liljesthröm and Lareschi 1998). Furthermore, there are documented studies of no sex-biased parasitism for rodents such as *Apodemus flavicollis*, *Peromyscus leucopus* and *Myodes glareolus* (Ferrari *et al.* 2004; Luong *et al.* 2009; Ribas *et al.* 2009). In our result, there was no difference between hosts sex for the mite, *Microtrombicula* sp. Previous results on Laelapidae from other host species and areas displayed substantial higher prevalence rate on males (Soliman *et al.* 2001).

Relation of host's age and ectoparasites species

A total of 267 ectoprasites were collected in which 56.17% infested mature hosts and the rest of infested immature hosts. However, there was no significant difference between prevalence rates of immature hosts in comparison to mature hosts in eight ectoparasite species collected from *M. Musculus*. In another study on 339 *Apodemus flavicolis*, immature hosts demonstrated a higher prevalence of ectoparasites than matures, but the differences related to the ectoparasite prevalence, were not significant between the host sex and also the age categories (Benedek *et al.* 2006). A study examining relationship of endoparasites infection and ectoparasite infestation with sex, age and sampling site on *Rattus* demonstrated that several parasites infection and infestation increased with age and depended on habitat but none of them was related to sex (Stojcevic *et al.* 2004).

Conclusion

The results attained in the present research support the observation that the sex of the *M. musculus* may affect its ectoparasite load and specific richness which is related to the prevalence and abundance of some parasite species. Regarding the worldwide distribution of house mice and their habitat overlapping with mankind, this information will provide more knowledge of the interrelationship between ectoparasites and *M. musculus* sex and age as a cosmopolitan and high mobility species in Mashhad and vicinity. Understanding the role of ectoparasite vectors and rodents reservoirs in the preservation of diseases in the study area, and the possibilities of distribution of pathogens will help in strategies to control zoonotic diseases which threaten human and other animals.

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References

Acosta, R. & Morrone, J.J. (2003) Clave ilustrada para la identificación de los taxones supra específicos de Siphonaptera de México. *Acta Zoologica*, 89: 39–53.

Allymehr, A., Tavassoli, M., Manoochehri, M.H. & Ardavan, D. (2012) Ectoparasites and gastrointestinal helminths of house mice (*Mus musculus*) from poultry houses in northwest Iran. *Comparative Parasitology*, 79 (2): 283–287.

Baker, A.S. (1999) *Mites and ticks of domestic animals*. The Stationery Office, London, 240 pp.

Baker, E.W. & Wharton, G.W. (1952) *An introduction to Acarology*. Macmillan. New York, 465 pp.

Bendek, A.M., Sirbu, I., Lazar, A.M. & Cheoca, D. (2013) Ecological aspects of ectoparasites' infestation in the yellow-necked mouse (*Apodemus flavicollis*: Rodentia, Muridae) from Transylvania (Romania). *In*: Marascu-Klein, V., Panaitescu, F.V. & Panaitescu, M. (Eds.), *Proceedings of the 11th International Conference on Environment: Advances in Environment, Ecosystems and Sustainable Tourism*, 1–3 June 2013, Brasov, Romania, pp. 197–202.

Bush, A.O., Lafferty, K.D., Lotz, J.M. & Shostak, A.W. (1997) Parasitology meets ecology on its own terms: Margolis *et al*. revisited. *Journal of Parasitology*, 83: 575–583.

Combes, C. (2001) *Parasitism: The ecology and evolution of intimate interactions.* University of Chicago Press, Chicago, IL, 552 pp.

Dziemian, S., Michalik, J., Piłacińska, B., Bialik, S., Sikora, B. & Zwolak, R. (2014) Infestation of urban populations of the Northern white-breasted hedgehog, *Erinaceus roumanicus*, by *Ixodes* spp. ticks in Poland. *Medical Veterinary Entomology*, 28: 465–469.

Ferrari, N., Cattadori, I., Nespereira, J., Rizzolli, A.P. & Hudson, P.J. (2004) The role of host sex in parasite dynamics: field experiments on the yellow-necked mouse *Apodemus flavicollis*. *Ecology Letter*, 7: 88–94.

Hamidi, K., Nourani, L. & Moravvej, G. (2015) The relationship of ectoparasite prevalence to the capturing season, locality and species of the murine rodent hosts in Iran. *Persian Journal of Acarology*, 4(4): 409–423.

Hanafi-Bojd, A.A., Shahi, M., Baghaii, M., Shayeghi, M., Razmand, N. & Pakari, A. (2007) A study on rodent ectoparasites in Bandar Abbas: the main economic southern seaport of Iran. *Iranian Journal of Environmental Health Science and Engineering*, 4 (3): 173–176.

Harrison, A., Scantlebury, M. & Montgomery, W.I. (2010) Body mass and sex-biased parasitism in wood mice *Apodemus sylvaticus*. *Oikos*, 119: 1099–1104.

Heske, E.J., Shenbrot, G.I. & Rogovin, K.A. (1995) Spatial organization of *Stylodipus* *telum* (Dipodidae, Rodentia) in Dagestan, Russia. *Journal of Mammalogy,* 76: 800–808.

Hillegass, M.A., Waterman, J.M. & Roth, J.D. (2008) The influence of sex and sociality on parasite loads in an African ground squirrel. *Behavioral Ecology*, 19: 1006–1011.

Hutchins, M., Kleiman, D.G., Geist, V. & McDade, M.C. (2003) *Grzimek's animal life encyclopedia*. 2nd edition. Volumes 12–16, Mammals I–V, Farmington Hills, MI: Gale Group, 586 pp.

Karbowiak, G., Rychlik, L., Nowakowski, W. & Wita, I. (2005) Natural infections of small mammals with blood parasites on the borderland of boreal and temperate forest zones. *Acta Theriolgica*, 50: 31–42.

Kiffner, C., Vor, T., Hagedorn, P., Niedrig, M. & Ruhe, F. (2011) Factors affecting patterns of tick parasitism on forest rodents in tick-borne encephalitis risk areas, Germany. *Parasitology Research*, 108: 323–335.

Klimpel, S., Förster, M. & Schmahl, G. (2007) Parasites of two abundant sympatric rodent species in relation to host phylogeny and ecology. *Parasitology Research*, 100: 867–875.

Kim, K.C., Prati, H.D. & Stojanovich, C.J. (1986) *The sucking lice of North America, an illustrated manual for identification*. University Park, Pennsylvania, 241 pp. + illustrations.

Korytkowski, C.A. (2002) *Guía de Estudio Sistemática de Insectos*. Vicerrectoría de Investigación y Postgrado, Universidad de Panamá, Panamá, 174 pp.

Kowalski, K., Eichert, U., Bogdziewicz, M. & Rychlik, L. (2014) Differentiation of flea communities infesting small mammals across selected habitats of the Baltic coast, central lowlands, and southern mountains of Poland. *Parasitology Research*, 113: 1725–1734.

Krasnov, B.R., Bordes, F., Khokhlova, I.S. & Morand, S. (2012) Gender-biased parasitism in small mammals: patterns, mechanisms, consequences. *Mammalia*, 76: 1–13.

Krasnov, B.R., Shenbrot, G.I., Khokhlova, I.S. & Degen, A.A. (2004) Flea species richness and parameters of host body, host geography and host milieu. *Journal of Animal Ecology*, 73 (1): 121–128.

Lareschi, M. (2006) The relationship of sex and ectoparasite infestation in the water rat *Scapteromys aquaticus* (Rodentia: Cricetidae) in La Plata, Argentina. *Revista de Biologia Tropical*, 54(2): 673–679.

Lareschi, M. & Cicchino, A. (2002). Abundancia, prevalenciay preferencia de *Amblyopinodes gahani gahani* (Fauvel, 1901) (Coleoptera: Staphylinidae) en roedores sigmodontinos de la Reserva Selva Marginal de Punta Lara, Provincia de Buenos Aires, Argentina. *Acta Zoológica Mexicana* (Nueva Serie), 85: 1–9.

Lareschi, M. & Iori, A. (1998) Nuevas citas de Siphonaptera (Rhopalopsyllidae; Hystrichopsyllidae) parásitos de roedores de la provincia de Buenos Aires, Argentina. *Revista Brasileira de Zoologia,* 41: 165–167.

Lareschi, M., Notarnicola, J., Navone, G. & Linardi, P.M. (2003) Arthropod and filarioid parasites associated with wild rodents from the northeast marshes of Buenos Aires, Argentina. *Memorias do Instituto Oswaldo Cruz*, 98: 673-–677.

Lewis, R.E. (1967) The fleas (Siphonaptera) of Egypt; an illustrated and annotated key. *Journal of Parasitology*, 53: 863–885.

Luong, L.T., Grear, D.A. & Hudson, P.J. (2009) Male hosts are responsible for the transmission of a tropically transmitted parasite, *Pterygodermatites peromysci*, to the intermediate host in the absence of sex-biased infection. *International Journal of Parasitology*, 39: 1263–1268.

Marshall, A.G. (1981) The ecology of ectoparasitic insects. New York, USA, 459 pp.

Matthee, S., McGeoch, M.A. & Krasnov, B.R. (2010) Gender-biased ectoparasite infections: species-specific variation and the extent of male-biased parasitism. *Parasitology*, 137: 651–660.

Morales, G., & Pino, L.A. (1987) *Parasitología cuantitativa.* Fundación Fondo Editorial. Acta científica venezolana. Caracas, Venezuela. 132 pp.

Moravvej, G., Hamidi, K., Nourani, L., & Bannazade, H. (2015) Occurrence of ectoparasitic arthropods (Siphonaptera, Acarina, and Anoplura) on rodents of Khorasan Razavi Province, northeast of Iran. *Asian Pacific Journal of Tropical Disease*, 5(9): 930–934.

Nava, S., Lareschi, M. & Voglino, D. (2003) Interrelationship between ectoparasites and wild rodents in Buenos Aires Province, Argentina. *Memórias do Instituto Oswaldo Cruz*, 98: 45–49.

Pakdad, K., Ahmadi, N.A., Aminalroaya, R., Piazak, N. & Shahmehri, M. (2012) A study on rodent ectoparasites in the North district of Tehran, Iran during 2007–2009. *Journal of Paramedical Sciences*, 3: 27–31.

Razzoli, M., Cushing, B.S., Carter, C.S. & Valsecchi, P. (2003) Hormonal regulation of agonistic and afflictive behavior in female Mongolian gerbils (*Meriones unguiculatus*). *Hormones and Behavior*, 43: 549–553.

Ribas, A., Torre, I., Feliu, C., Arrizabalaga, A. & Casanova, J.C. (2009) Helminth communities of the bank vole *Myodes glareolus* (Rodentia, Arvicolinae) in two populations: Montseny Natural Park (north-eastern Spain) and Pi Natural Reserve (French Pyrenees). *Revista Ibero-Latinoamericana de Parasitologia*, 1: 73–81.

Rossin, M.A., Malizia, A.I., Timi, J.T. & Poulin, R. (2010) Parasitism underground: determinants of helminth infections in two species of subterranean rodents (Octodontidae). *Parasitology*, 137: 1569–1575.

Sánchez López, M.I. (1998) *Factores que limitan la abundancia de los roedores muridos en el Delta del Paraná*. Doctoral Thesis, Universidad Nacional de Buenos Aires, Buenos Aires, Argentina, 150 pp.

Scantlebury, M., McWilliams, M.M., Marks, N.J., Dick, J.T.A. Edgar, H. & Lutermann, H. (2010) Effects of life-history traits on parasite load in grey squirrels. *Journal of Zoology*, 282: 246–255.

Shirazi, Sh., Bahadori, F., Mostafaei, T. & Ronaghi, H. (2013) First Report of *Polyplax* sp. in a Persian squirrel (*Scuirus anomalus*) in Tabriz, northwest of Iran. *Turkish Journal of Pasrasitology*, 37: 299–301.

Solanki, S.K., Chauhan, R., Rahman, A. & Solanki, K. (2013) Prevalence of ectoparasites in commensal rats in Dehradun, India. *International Journal of Current Microbiology and Applied Sciences*, 2: 38–41.

Soliman, S., Main, A.J., Marzouk, A.S. & Montasser, A.A. (2001) Seasonal studies on commensal rats and their ectoparasites in a rural area of Egypt: the relationship of ectoparasites to the species, locality, and relative abundance of the host. *Journal of Parasitology*, 87: 545–553.

Stojcevic, D., Mihaljevic, Z. & Marinculic, A. (2004) Parasitological survey of rats in rural regions of Croatia. *Veterinarni Medicina*, 49: 70–74.

Tenorio, J.M. & Goff, M.L. (1980) *Ectoparasites of Hawaiian rodents (Siphonaptera,* *Anoplura and Acari)*. Bishop Museum Special Publication. Bishop Museum Press, Honolulu, Hawaii, 32 pp.

Xie, B.Q. & Zeng, J.F. (2000) *The Siphonaptera of Yunnan*. Yunnan Science and Technology Press, 456 pp. (In Chinese).

Zuk, M. (1996) Disease, endocrine-immune interactions, and sexual selection. *Ecology*, 77: 1037–1042.

Zuk, M., & McKean, K.A. (1996) Sex differences in parasite infections: patterns and processes. *International Journal of Parasitology*, 26: 1009–1024.

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ارتباط میزان آلودگی به انگل های خارجی با جنسیت و سن در *Mus musculus* (Rodentia: Muridae) شمال شرق ایران

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چکیده

اهمیت جوندگان در انتقال بیماری‌های زئونوتیک به عنوان یکی از موضوعات مورد توجه عموم است. با توجه به اهمیت جوندگان آلوده به بندپایان در بیماری‌های زئونوتیک و توزیع گسترده گونه موش خانگی (*Mus musculus*)، هدف این مطالعه بررسی رابطه بین جنسیت و سن میزبان‌های *M. musculus* با میزان شیوع انگل‌های خارجی در نواحی مشهد و حومه، شمال شرق ایران است. شفاف‌سازی نمونه‌های مایت، کنه و شپش در محلول نسبیت و نمونه‌های کک با استفاده از هیدروکسید پتاسیم ۱۰٪ انجام و هر نمونه به صورت جداگانه در محلول هویر نصب شد. در مجموع ۲۶۷ انگل خارجی متعلق به ۸ گونه از ۹۳ میزبان جمع‌آوری شد. در بین گروه‌های انگلی به ترتیب مایت‌ها (۴۶/۰۶٪)، کنه‌ها (۲۲/۸۴٪)، شپش‌ها (۱۶/۸۵٪) و کک‌ها (۱۴/۲۳٪) بیشترین و کمترین درصد فراوانی را نشان دادند. نتایج نشان داد که بیشترین بار انگلی معنی‌دار در جنس نر متعلق به *Ctenophthalmus* sp.، *Nosopsyllus fasciatus*، *Haemolaelaps* sp. و *Laelaps algericus* بودند. دو گونه کنه *Haemaphysalis punctata* و *Haemaphysalis* sp. بیشترین آلودگی را در جنس ماده نشان دادند و هیچ گونه بار انگلی معنی‌داری در شپش *Hoplopleura captiosa* دیده نشد.

واژگان کلیدی: انگل های خارجی؛ آلودگی؛ جنسیت؛ بلوغ؛ میزان شیوع، جوندگان.

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