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Arthropod Ectoparasites of *Rattus norvegicus* in Four Governorates in Egypt and the Effect of Host Location, Sex and Age on Their Prevalence

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ABSTRACT

A total of 83 Norway rat hosts were captured from four governorates using live traps and examined for their arthropod ectoparasites. 77.2% of *Rattus norvegicus* were infested with at least one ectoparasite. Results revealed that 938ectoparasites, comprising: 140 (14.93%) fleas, 234 (24.95%) lice and 564 (60.1%) mites, belong to 4 orders, 7 families, 9 generaand 9 species. The 9 ectoparasites species included three fleas (*Xenopsylla cheopis, Echidnophaga gallinacean and Ctenocephalides felis*), two sucking lice (*Hoplopleura oenomydis* and *Polyplax spinulosa*) and four mites (*Ornithonussus bacoti, Lealaps nuttalli, Liponyssoides sanguineus* and *Radfordia ensifera*). Location is a key factor affects the Infection prevalence and general indices of ectoparasite since location alteration involves many criteria like geographical situation, ecological condition, rodent predators, seasonal activities, human practices andsources of infection that influence the ectoparasite prevalence and indices. No host sex-associated differences in the prevalence of infection were found for ectoparasites but host age may affect the foraging choices for them.

Key words: Ectoparasite, Zoonotic, Infection prevalence, *Rattusnorvegicus*, Location, Sex, Age.

INTRODUCTION

Norway rat, *Rattus norvegicus*, is a cosmopolitan rodent species with a wide distribution in urban and suburban-rural habitats. Itplays a significant role as definitive or intermediatehosts for vector-born animal and human diseases (Easterbrook *et al.*, 2007). Although *Rattus norvegicus* is often associated with crop attacking, infrastructural damages and eating or spoiling of stored food and products, it's veterinary and zoonotic risks are frequently underestimated. *Rattus norvegicus* can be reservoir and vector of a number of agents that cause serious diseases for human and domestic animals. There are more than 20 transmissible diseases that are known to be directly transmitted by rodents to humans, by the assistance of blood-sucking parasites like fleas, lice and mites (Khatoon *et al.*, 2004).

Fleas could transmit many zoonotic diseases from rat to man. Plague is essentially a disease of rodents from which it is contracted by humans through the bites of fleas, particularly *Xenopsylla cheopis* (Ryckman, 1971). Also, lice are permanent ectoparasites on rodents. The sucking louse, *Polyplux spinulosa* is a vector responsible for spread of *Haemobartonella muris* (rickettsia, blood parasite) and *Rickettsia typhi* between rats which may be passed to humans via rat fleas (Hendrix, 1998 and McArthur, 1999).

Mites are temporally blood-sucking ectoparasites of mammals (including rodents and human). Rat mites frequently attack man living in rodent infested buildings and their bites may produce irritation, and sometimes painful allergic dermatitis or mite respiratory allergy particularly in children (Bakr *et al.*, 1995). Rat mites are associated with groceries and warehouses (Cook, 1997). The tropical rate mite, *Ornithonyssus bacoti*, could transmit *Yersinia pestis* (the cause of plague). *Rickettsia typhi* (the cause of murine typhus) and *Coxiella buinetii* (the cause of Q fever). Also, *Allodermanyssus sanguineus* may transmit *Rickettsia akari* the cause of rickettsial pox of man (Hendrix, 1998).

This study aims at collecting and identifying the arthropod ectoparasites that parasitizing *Rattus norvegicus* in four governorates of Egypt and constituting a risk to human health to provide some information about species diversity, prevalence and frequency of these small arthropods. Moreover, it highlights the risks associated with contacts of rodents with people and pets. Also, this work helps in implementation of any prevention and control measures for zoonotic diseases in the local areas of study.

MATERIALS AND METHODS

Host collection and manipulation

Norway rats (*Rattus norvegicus*) were collected from four governorates; Bani-Sowaif, Giza, Qalyobia and Behaira. The study was carried out during the period from July 2012 to December 2013. Live rats were captured using wire-box traps of the usual spring-door type. Traps were distributed in the evening at houses, poultry farms and drainages, then collected next morning. Positive traps provided with water using wet cotton, were put in cloth bags then transferred to the laboratory. The collected rats were identified using the keys given by Osborn and Helmy (1980). Sex was determined, females' reproductive activity was obtained and weight was registered then a serial number was given to each individual.

Collecting of ectoparasites

Captured animals were examined and their ectoparasites were picked up in different ways as follows: Rats' skin with terminal parts of the four limps, tail and head were put in Berlese funnel, provided with a strong source of light and heat. The ectoparasites received in a petri dish containing 70% ethanol and then they were picked up with a moistened camel's hair brush with the aid of a strong source of light and dropped in separate vials containing 70% alcohol with a label comprising both the date and the corresponding code number of each animal. In some cases, ectoparasites were collected usingbrushing against the fur of rodents and were stored in 70% ethanol fortheir preservation and identification.

Preparation of arthropod parasites for identification:

Arthropods preserved in 70% alcohol were brought down to water in descending grades of alcohol 50-30% 15 minutes each. Fleas and lice were then moved to 10% potassium hydroxide or lactophenol after puncturing the specimens on the ventral side, and then left overnight until soft parts were dissolve. The material was washed thoroughly in distilled water slightly acidified with 10 drops of acetic acid to remove the alkali and then treated with ascending grades of alcohol 50%, 70%, 90% and 95%, 20 minutes each. The individuals were then cleared in clove oil for 10 minutes. Mounting was performed in Canada balsam then left to dry in oven at 38°C. Mites were mounted from 70% alcohol after cleaning in water into Hoyer's medium.

RESULTS AND DISCUSSION

The hostinvestigations:

Rattus norvegicus was collected from four governorates: Giza, Behaira, Bani-Swaif and Qalyiobia. The structure of its population was studied. The whole number of *Rattus norvegicus* live trapped was 83 of which 34 from Giza, 24 from Behaira, 10 from Bani-Swaif and 15 from Qalyiobia.

Based on sex, the Norway rat population consisted of 48 male individuals and 35 female individuals. The male to female ratio (sex ratio) was 1.37:1. Furthermore, the maturity status was obtained; therefore, the population was divided into mature individuals (53) and immature individuals (30), Table (1).

The result showed that males' number is bigger than females', and the reason behind may be that females stay in borrows to lactate and to take care of offspring or to avoid the harsh weather conditions during pregnancy and after giving birth. While, on the other hand, males don't have all these constrains; they usually explore and roam more than females. This result is in accordance with that obtained by El-Bahrawyand Al-Dakhil (1993) but it is in discrepancy with that of Soliman *et al.* (2001).

Ectoparasites recorded during the study:

Rodents in particularly, *Rattus norvegicus* are usually infested with certain groups of arthropods; fleas, lice and mites. In this study 77.2% of *Rattus norvegicus* were infested with at least one ectoparasite. This high rate of infestation could be supported by the relatively small home range of the Norway rat in addition to its neighborhood to domestic animals which might pose an important source of infestation. Results of our study revealed that 938ectoparasites, comprising: 140 (14.93%) fleas, 234 (24.95%) lice and 564 (60.1%) mites, (Fig. 1), belong to 4 orders, 7 families, 9 generaand 9 species. Ectoparasite species collected from 83 individuals of live-trapped *Rattus norvegicus* included:

Fleas (Insecta: Siphonaptera)
Pulicidae: *Xenopsylla cheopis, Echidnophaga gallinacean and Ctenocephalides felis*
Lice (Insecta: Anoplura)
Hoplopleuridae:*Hoplopleura oenomydis*
Polyplacidae:*Polyplax spinulosa*
Mites (Acari: Mesostigmata)
Macronyssidae: *Ornithonyssus bacoti*
Laelapidae: *Laelaps nuttalli*
Dermanyssidae:*Liponyssoides sanguineus*
(Acari: Prostigmata)
Myobiidae:*Radfordia ensifera*

Infection prevalence and general indices of ectoparasite according to location:

Location of infestation could be a key factor of infection prevalence. In this study, the numbers of infected individuals varied among locations and the different ectoparasites general indices as well.

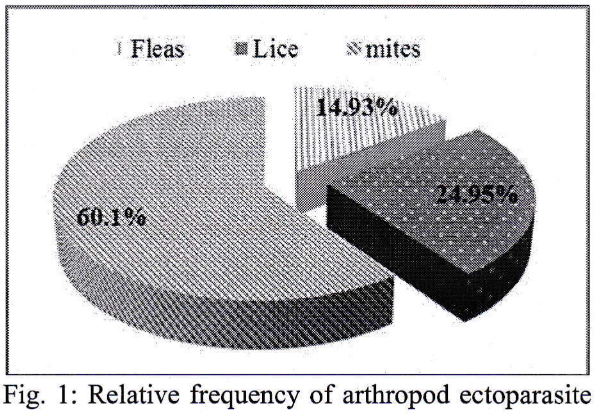

Fig. 1: Relative frequency of arthropod ectoparasite groups.

Table (1): *Rattus norvegicus* population structure

Gov.	No.	Males' No.			Females' No.		
		Mature	Immature	Total	Mature	Immature	Total
Giza	34	12	7	19	10	5	15
Behaira	24	9	5	14	6	4	10
Bani-Swaif	10	4	1	5	3	2	5
Qalyobia	15	6	4	10	3	2	5
Total	83	31	17	48	22	13	35

Table (2): Infection prevalence and general indices of ectoparasites according to location

Gov.	Flea		Lice		Mites	
	Total infected no, (%)	General flea index	Total infected no, (%)	General Lice index	Total infected no, (%)	General Mite index
Giza	17, (50)	2.56	9, (26.47)	3.76	17, (50)	5.26
Behaira	6, (25)	1.16	6, (25)	2.46	16, (66.67)	11.3
Bani-Swaif	2, (20)	0.5	5, (50)	2.1	7, (70)	5
Qalyobya	4, (26.67)	1.4	4, (26.67)	1.73	6, (40)	4.27

Table (3): Infection prevalence of ectoparasites based on host sex.

	Males			Females		
	Infected No.	Infected males %	Infection prevalence %	Infected No.	Infected females' %	infection prevalence %
Fleas	19	22.89	39.58	10	12.05	28.57
Lice	12	14.46	25.00	12	14.46	34.29
Mites	28	33.73	58.33	18	21.69	51.43

Table (4): General indices of ectoparasites based on host sex.

Gov.	Flea index		Lice index		Mite index	
	Male	Female	Male	Female	Male	Female
Giza	2.26	2.93	4.42	2.93	6	4.33
Behaira	1.2	1	0.86	4.7	11.7	11.6
Bani-Swaif	1	0	0.6	3.6	4.4	5.6
Qalyobya	1.6	1	2	1.2	6	0.8
Total	1.69	1.69	2.85	2.77	7.31	6.09

Table (5): Infection prevalence of ectoparasites based on host age.

	Mature			Immature		
	Infected Mature No.	Infected Mature %	Infection prevalence %	Infected Immature No.	infected Immature %	Infection prevalence %
Fleas	20	24.10	37.74	9	10.84	30.00
Lice	18	21.69	33.96	6	7.23	20.00
Mites	33	39.76	62.26	13	15.66	43.33

Table (6): General indices of ectoparasites based on host age

Gov.	Flea index		Lice index		Mite index	
	Mature	Immature	Mature	Immature	Mature	Immature
Giza	3.14	1.5	5.82	0	7.32	1.5
Behaira	1.27	0.89	3.27	1.1	14.53	5.89
Bani-Swaif	0.43	0	1.7	3	2.85	9
Qalyobya	2.1	0.33	2	1.33	4.33	4.17
Total	1.96	1.20	3.75	1.17	7.15	6.17

Regarding to fleas infection, Giza governorate had the highest infection percentage (50%) and the highest flea index as well (2.56). On the other side, Bani-Swaif had the lowest flea infection percentage (20%) and the lowest flea index (0.5), Table (2).

Lice and lice index had a certain pattern which is different from that in fleas. Although Bani-Swaif governorate had the highest lice infection percentage (50%), Giza governorate had the highest lice index (3.76). This means that the lice burden is higher in Giza than that in the other three locations. In the same context, Behaira governorate had the lowest lice infection percentage (25%), but its lice index (2.46)is bigger than that of Bani-Swaif (2.1) and Qalyobia (1.73), Table (2).

With regard to mite infection, Bani-Swaif governorate came first (70%) followed by Behaira governorate (66.67%) while Qalyiobia had the lowest percentage of infection (40%). Mite indices were relatively high; since it ranged from 4.27 in Qalyiobia governorate to 11.3 in Behaira governorate, Table (2).

From the aforementioned data, it is obvious that the rate and the indices of infestation of different ectoparasites vary from one location to another. These findings are in accordance with El Deeb *et al.* (1999) and Soliman *et al.* (2001) that the distribution of ectoparasites varies according to rodent host and location. Also, Kia *et al.* (2009) stated: "the infestation rate to different ectoparasite depends on season, size of rodents, host preference, sex of host, host age, location of capture and co-evolution between rodent and ectoparasites". Similarly, Telmadarraiy *et al.* (2007) mentioned the infection prevalence and general indices of ectoparasite mainly depend on season, rodent species, ectoparasite species, location, method of catch, and host population dynamics. For instance, the indices of infestation by the mite *Laelaps nuttalli*, the louse *Polyplax spinulosa* and the flea *Xenonpsylla cheopis*, on *Rattus norvegicus* in Brazil were related to seasonal period, sex of the host and area of capture (Linardi *et al.,* 1985).

At last, location is a key factor affects the infection prevalence and general indices of ectoparasite because location-change involves many criteria like geographical situation, ecological condition, rodent predators, seasonal activities, human practices andsources of infection that influence the ectoparasite prevalence and indices.

Infection prevalence of ectoparasites based on host sex

Rattus norvegicus population was divided into males and females to find out if there is a variation of the infection prevalence of different ectoparasites between both rat sexes. The male infection prevalence percentage calculated as the percent of infectedmales' number to the whole males' population.

In Table 3, nineteen infected male individuals (22.89%) represent 39.58% of the whole males' population. Infected females were 10 individuals with a percentage of 12.05%. The prevalence of infection among females was 28.57%.

Regarding lice infection, a total of 12 male-individuals (out of 83, the whole population) were infected (14.46%). The infection prevalence among them was 25% (12 out of 48 males). Infected females' number was equal to that of males' (12, 14.46%), but the infection prevalence among females (34.28%) was greater than that among males.

Mite infection and prevalence was the greatest comparing to other ectoparasites as 28 males (33.73%) and 18 females (21.69%) were infected. Also, the prevalence of infection among males (52.33%) and females (51.43%) was the highest when compared with fleas and lice. There were no differences of infection prevalence based on host sex.

General indices of ectoparasites based on host sex:

Ectoparasites indices were calculated for both sexes for determining if there is a relationship between the host sex and the parasite burden or not.

The flea index in males was bigger than that in females in all governorates except for Giza but the total flea indices in both males and females were equal (1.69). There was a big difference between the male and female lice indices in Bohaira and Bani-Swaif as they were 0.86 / 4.7 and 0.6 / 3.6 respectively, but the total lice index in males (2.85) was slightly higher than that in females (2.77). With regard to mite, the total mite index was approximately bigger in males than it in females. But still there were some differences according to locations, Table (4).

Overall outcome reflects that no host sex-associated differences in the prevalence of infection were found for ectoparasites. This result is in agreement with Nur Syazana *et al.* (2013) who did not find any strong independent effects of host sex on the prevalence of ectoparasites although more females were observed infested compared to males. But, at the same time, this result contradicts the findings of Linardi *et al.* (1985) and Kia *et al.* (2009) that the intensity changes of mites, fleas and lice on the separate sexes of rodents were presented and the ectoparasites preferentially infested male rodents, both in wild and urban environments.

Infection prevalence of ectoparasites based on host age:

We divided the host population into two groups, mature and immature, to study the effect of the age on the infection prevalence of ectoparasites

Table 5 shows that a total of 20 (24.1%) mature individuals versus 9 (10.84%) immature individuals were infected with fleas. The flea infection prevalence inside the mature population (37.74%) was relatively higher than that inside the immature population (30%). It means that the mature individuals are likely to be infected than immature's.

Lice infection varied between mature and immature rats, as a total of 18 mature individuals (21.69%) and 6 immature individuals (7.23%) were infected. The infection prevalence of lice inside the mature population (33.96%) was higher than that inside immature population (20%). It is clear that there was a high tendency of infection prevalence to be higher in mature individuals.

Unlike fleas and lice, mites' infestation was higher and more prevalent; as 33 mature individuals (39.76%) and 13 immature individuals (15.66%) were infested. When comparing the infection prevalence between mature and immature individuals, it found that the infection prevalence in mature individuals (62.26%) was greater than it in immature individuals (43.33%).

General indices of ectoparasites based on host age:

General indices of the three main groups of ectoparasites, fleas, lice and mites, were conducted for each age stage as follows:

Generally, mature individuals tended to have bigger ectoparasite index than immature individuals. Flea index was 1.96 in mature individuals versus 1.2 in immature's, also lice index in mature individuals (3.75) was three times bigger than it in immature's (1.17). Likewise, the mite index was bigger in mature individuals (7.15) than it in immature's (6.17). So it is predictable for us to record high infection and high prevalence percentages of ectoparasite in mature individuals, while they tended to be low in immature individuals, Table (6).

Host age is a pivotal element that may affect the foraging choices of ectoparasites. The increased prevalence and general infestation index of ectoparasites are positively correlated to the increased densities of their hosts (Anderson and Gordon, 1982). Randolph (1975); Thompson *et al.* (1998) and Kia *et al.* (2009) stated that the catch rate and infestation rate of different ectoparasite depended on host age. Many important parameters in host–parasite dynamics, such as infestation level of hosts and the consequent parasite distribution among host individuals are often age-dependent (Hudson and Dobson, 1997).

Juvenile rodents have larger surface to volume ratio and thus, higher energy requirements for maintenance per unit body mass (Kleiber, 1975). Also, they require additional energy for somatic growth, maturation, and for mounting an immune response. Thus, adult rodents under field conditions usually represent a better nutritional resource than juveniles (Buxton, 1984). In addition, adult hosts show higher infestation levels than juveniles because they have more time to accumulate parasites (Hawlena *et al.*, 2006).

In conclusion, the presence of zoonotic ectoparasites that have medical and veterinary importance confirms *Rattus norvegicus* as a reservoir for different types of pathologies, which, therefore, constitutes a risk to the public health. The information presented in this study enables us to understand the major parasitic infections that *Rattus norvegicus* harbors and transmits to people and domestic animals in Egypt. Periodical surveillance and monitoring in local problem areas combined with raising awareness help local authorities in the emergency situations prevent rodent-borne diseases.

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