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Diversity and Parasitism Rates of Fleas on *Meriones shawi* from Hodna Region (M'Sila, Algeria)

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Abstract: Fleas (Siphonaptera) are a group of ectoparasites of medical and veterinary importance, known to infest a wide range of host species. Rodents are the principal reservoirs for these pathogens. The Hodna region has significant diversity of rodent fleas. This is the first study to record the diversity, abundance, and prevalence of flea species infesting *Meriones shawi* in arid region in an Algeria. An inventory of fleas in the Hodna region was carried out over a one-year period, from March 2022 to June 2023. 97 *Meriones shawi* were examined; of these rodents, 55 (56.70%) were infested with fleas. Overall, 206 fleas belonging to 3 families, 3 genera, and 3 species (*Xenopsylla ramesis*, *Synosternus cleopatrae*, and *Nosopsyllus oranus*) were identified. The *X. aramesis* dominated the flea community, with a high percentage of parasitism on *M. shawi*. It is important to note that this is the first time *Synosternus cleopatrae*has been found in *M. shawi*.

Key words: Fleas, ectoparasites, rodents, diversity, arid regions.

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Fleas are a diverse group of arthropods that infest humans and other domestic animals (De Souza Gonçalves *et al*., 2023). Siphonaptera constitute a very diverse taxonomic group, with most species being related to mammals and birds. They live in different latitudes (Medvedev, 1996). There are about 2500 species and subspecies of fleas that have been described so far. They are divided into 18 families and 220 genera (Lewis, 1998; Zhu *et al*., 2015).

The Siphonaptera (Siphonaptera) commonly known as fleas (formerly classified as Suctoria or as Aphaniptera) are holometabolous insects of very small size (a few millimeters on average), wingless, hematophagous ectoparasites of homeotherms, showing a pair(the third) of highly developed legs, generally, adapted for jumping (Beaucournu and Gomez-Lopez, 2015).Siphonaptera always raise concerns due to their association with zoonoses that can affect humans, notably the plague.

The majority of inventories on Siphonaptera in Algeria were conducted by Jordan and Rothschild (1912; 1915), Beaucournu and Kowalski (1985), Beaucournu and Gouat (1987), Beaucournu

and Launay (1990), and Sidhoum *et al*. (2023). Other fragmentary works on fleas from various other taxonomic groups (Ammam *et al*., 2022) have yielded summary results. Rodents, as the most common mammals around the world, pose significant public health concerns due to their close relationship with humans and as economic pests (West and Messmer, 1998).

Rodents play a significant role in flea inventories. Beaucournu and Launay (1990) note a specific host-parasite relationship in certain ctenodactylids. Ectoparasites can have a variety of direct and indirect effects on their hosts. Direct injury may be caused by blood loss (anaemia and debilitation) due to blood sucking, while indirect effects may include skin inflammation, pruritus and alopecia due to mange mites, as well as toxic and allergic responses due to ticks. Crucially, ectoparasites may act as mechanical or biological vectors (Wall and Shearer, 2008).

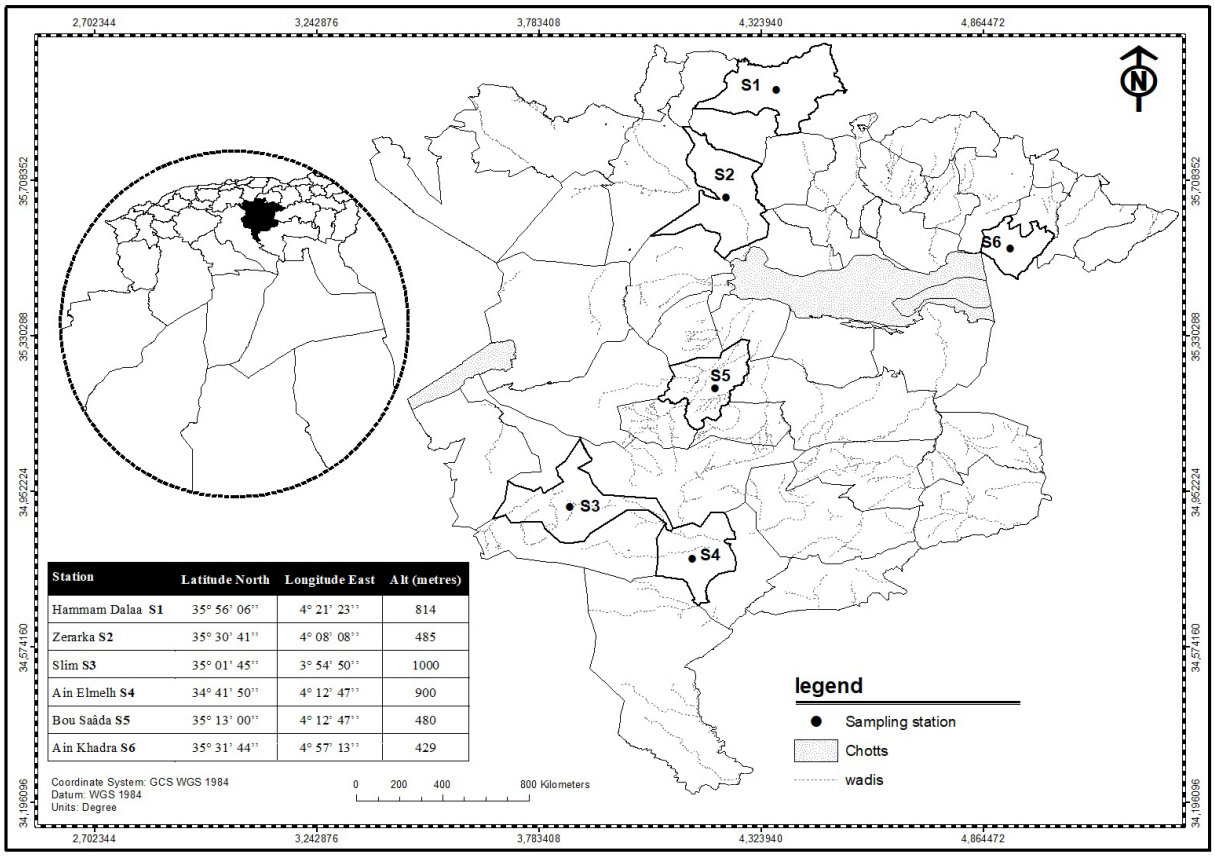
This study aims to identify flea (Siphonaptera) species that infest *Meriones shawi* in an arid region with a more or less closed continental climate.

Materials and Methods

The sampling of gerbils was carried out at 6 sites located in the M'Sila province (Fig. 1) from March 2022 to June 2023, during which 97 specimens were captured and examined. The study sites are located within the endorheic basin of Hodna. The region benefits from significant geomorphological and bioclimatic diversity. The sites are steppe agrosystems.

The rodent sampling took place over a year at 6 stations. The capture of rodents was carried out using Sherman traps at burrows identified as active, based on the freshness of the paw prints and feces. The traps were set at dusk near the openings of the burrows. The retrieval of the traps was done early in the morning. The *Meriones shawi* specimens were identified using rodent keys (Bernard, 1970; Aulanier and Thevenot, 1986).

The search for ectoparasites was done through brushing the rodent's fur with a fine



Station	Latitude North	Longitude East	Alt (metres)
Hammam Dalaa **S1**	35° 56' 06''	4° 21' 23''	814
Zerarka **S2**	35° 30' 41''	4° 08' 08''	485
Slim **S3**	35° 01' 45''	3° 54' 50''	1000
Ain Elmelh **S4**	34° 41' 50''	4° 12' 47''	900
Bou Saâda **S5**	35° 13' 00''	4° 12' 47''	480
Ain Khadra **S6**	35° 31' 44''	4° 57' 13''	429

Fig. 1. Study map

Table 1. Number (N) and relative frequency (RF%) of fleas collected on M. shawi at the different sites

Site	*Xenopsylla ramesis*		*Nosopsyllus oranus*		*Synosternus cleopatrae*	
	N	RF%	N	RF%	N	RF%
Hammam Dalaa	21	13.91	0	0.00	0	0.00
Zerarka	49	32.45	0	0.00	14	53.85
Slim	38	25.17	0	0.00	0	0.00
Ain Elmelh	12	7.95	0	0.00	0	0.00
Bou Saâda	26	17.22	5	17.24	12	46.15
Ain Khadra	5	3.31	24	82.76	0	0.00
Total	151	100	29	100	26	100

comb. The recovered ectoparasites were placed in labeled pillboxes containing 75% ethanol. The identification of siphonaptera was done using the keys of Beaucournu and Launay (1990), and Lewis (1967a).

For mounting and microscopic observation, the fleas were cleared in a 10% concentrated KOH solution from 2 to 12 hours, after rinsing with distilled water, the specimens were dehydrated in ethanol baths at progressive concentrations (25, 50, 75, 99) for a duration of 2 minutes each. The samples were then soaked in toluene and left to dry, and then placed between a slide and coverslip in a drop of Canada balsam. To eliminate air bubbles that hinder microscopic observation, the slides were placed in an oven at a temperature of 40 °C for a duration of 36 to 48 hours, with the operation repeated until all the air bubbles are eliminated.

We calculated the following to find out how diverse the flea populations were at each site:

- The relative frequency (RF) of each flea species (RF = percentage of the number of individuals of a species on the total number N in each station);
- The species richness (S), which is the total number of species found;
- The N/S ratio; (iv) the Shannon diversity index (H): $H = -\Sigma((ni/N) \times \log2 (ni\ N))$, where ni is the number of individuals of a species and N is the total number of individuals of a given sample;
- The evenness (E) with E = H/H max, where H max= log2 S. (Magurran, 2013).

To establish a state of parasitism in *Meriones shawi*, various parasitic indices were employed, using the terminology of Margolis *et al.* (1982). Average Parasitic Intensity (API) = the number of individuals of a certain parasite species in a sample of hosts divided by the number of afflicted host individuals.

The prevalence, which is expressed as a percentage of infestation within a rodent population. This index, sometimes referred to as prevalence, measures the percentage of the total rodent population that has a disease or parasite infection, giving an indication of how the infection affects that particular group. Prevalence (Pr) = (Number of infested rodents / Number of examined rodents) x 100

Average parasitic abundance (APA) = Total number of individuals of a particular parasite species in a host sample/Total number of individuals of the host species (infested + non-infested)

Kruskal-Wallis was used to assess the impact of habitat as a grouping factor on biodiversity and species abundances. All of these analyzes were developed using PAST version 4.16 (Hammer *et al*., 2024).

Results and Discussions

Ninety seven specimens of *Meriones shawi* were captured at 6 sites during this study. 55 individuals were parasitized by 3 species of Siphonaptera belonging to 2 families (Ceratophyllidae and Pulicidae), and 3 genera.

Among the 206 fleas collected from this rodent (Table 1), 151 individuals belong to *Xenopsyll aramesis* (Rothschild, 1904) (Fig. 2-3), 26 to *Synosternus cleopatrae* (Rothschild, 1903) (Fig. 4), and 29 individuals belong to *Nosopsyllus oranus* (Fig. 5). The Kruskal-Wallis test revealed a significant variation in flea abundances between the six stations (χ^2= 6.629, p< 0.05).

Fig. 2. Xenopsyll aramesis female.

The diversity of Siphonapteran ectoparasites associated with *Meriones shawi* in this study is not significant in number, which can be explained by the geomorphological nature of the Hodna region, which is a closed endorheic basin bordered to the north by the Tell Atlas mountain range and to the south by the Saharan Atlas. It is characterized by ecological and bioclimatic diversity ranging from semi-arid to hyper-arid.

Nosopsyllus (*Gerbillophilus*) *oranus* was cited for the first time in western Algeria. The paratypes collected in 1930 by Heim De Balzac of *Meriones shawi* near Chellif and of *Gerbillus* compestris in Telaghma (Chellif department) were used for identification and all citations in the literature (Lewis, 1967b). The description of this species by Lewis (1967b) and Beaucournu (1990) is based on samples collected and preserved at the Natural History Museum in Paris and the Natural History Museum in London.

Fig. 3. Xenopsyll aramesis male.

Xenopsylla ramesis, first described in 1904 by Rothschild, is considered by Lewis (1967a) as a species of semi-desert environments. Its distribution extends from North Africa to the Middle East. It is subordinate in Africa to the Gerbillinae, particularly to the genera *Meriones* and *Psamommys*. Smit (1963) reported the distribution of *Synosternus cleopatrae* (Rothschild) in Algeria.

The specific diversity of ectoparasites in *M. shawi* sampled from the 6 study sites reveals the existence of 3 species of fleas. Boussada is the richest site in species with (*X.aramesis*, *N. oranus*, and *S. cleopatrae*), followed by Zerarka and Ain Khadra with two species each (*X.aramesis*, *S. cleopatrae*), then Slim, Ain Melh, and Hammam-Dalaa with only one species (*X .aramesis*) (Table 2).

The Shannon diversity index, Equitability, and Simpson index calculated for the ectoparasites collected at the study sites are illustrated in Table 2. The values of the Shannon and Simpson indices converge toward significant diversity at the Boussaada site, with Equitability ranging between 0 and 0.8. The highest values are recorded at the Boussaada (0.82), Zerarka (0.76), and Ain Khadra (0.66) sites (Table 2). For the other sites, the values of Shannon diversity index, equitability and Simpson index are equal to zero.

Fig. 4. Nosopsyllus oranus.

Table 2. Diversity indices of fleas in the study area (S: species richness)

Site	Hammam Dalaa	Zerarka	Slim	Ain Elmelh	Bou Saâda	Ain Khadra
S	1	2	1	1	3	2
Simpson	0	0.3513	0	0	0.5559	0.2956
Shannon	0	0.5376	0	0	0.9338	0.4769
Equitability	0	0.7757	0	0	0.85	0.6881

Table 3. Number of rodents examined (NRE), and number of rodents parasitized (NP) at the study sites. Parasitic prevalence (PP), average parasitic intensity (API), and average parasitic abundance (APA) for each flea

	Sites	Hammam Dalaa	Zerarka	Slim	Ain Elmelh	Bou Saâda	Ain Khadra
M. shawi (Rodent)	NRE	9	18	15	18	14	12
	NRP	5	15	5	12	8	5
X. aramesis	PP	55.6	72.2	60.0	38.9	35.7	8.3
	API	4.2	3.8	4.2	4.9	5.2	5.0
	APA	2.3	2.7	2.5	1.9	1.9	0.4
N. oranus	PP	-	-	-	16.7	14.3	41.7
	API	-	-	-	6.7	2.5	4.8
	APA	-	-	-	1.1	0.4	2.0
S. cleopatrae	PP	-	27.8	-	-	21.4	-
	API	-	2.8	-	-	4.0	-
	APA	-	0.8	-	-	0.9	-

The Shannon diversity index, equitability and Simpson index provide a comprehensive overview of diversity across all populations (Mimeche *et al*., 2024). Crucially, these indices provide more information than simply counting the number of species present (Drouai *et al*., 2018). The equitability, Shannon, and Simpson indices equal zero indicates extreme dominance by one species aligns with the interpretation of these diversity metrics, where low or zero values reflect low species evenness and high dominance (Faith and Du 2018; Silva *et al*., 2020)

Fig. 5. Synosternus cleopatrae female.

The data on parasitic indices recorded in Table 3 reveal that the parasitic prevalence in Meriones shawi at the 6 study sites, calculated according to Margolis *et al*. (1982) for each parasite species on the sampled Meriones populations, ranges from 8.3% to 72.2% successively for Ain Khadra and Zerarka.

However, these values differ slightly if we consider that the three ectoparasites belong to the same taxonomic group (Bush *et al*., 1997). Indeed, the prevalence values range from 33.3% in Slim (9 parasitized individuals out of 15 examined individuals) to 83.3% in Zerarka (15 parasitized individuals out of 18 examined individuals). The highest parasitic intensity is that of *X. remesis* at the Boussaada site with 5.2.

Xenopsylla ramesis has been considered to be a parasite of *Meriones tristrami* and *M. lybicus* in less arid dry steppes (Lewis, 1982; Adams *et al*., 1995). Hastriter and Tipton (1975) considered this species to be restricted to the coastal countries of North Africa, from the Western Sahara to Egypt.

Conclusions

Despite the ecological and epidemiological importance of Shaw's gerbil, little is known

about the ectoparasites associated with this species in many regions of Algeria. Notably, this is the first reported instance of *Synosternus cleopatrae* on *M. shawi*. Further investigation is highly recommended to study this unexplored area of Algeria and compile a comprehensive list of Algerian Siphonaptera fauna.

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