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1 **Fleas (Insecta: Siphonaptera) collected from some small mammals (Mammalia: Rodentia,**  
2 **Eulipotyphla) in Turkey, with new records and new host associations**

3

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18 **RH:** Fleas from some small mammals in Turkey

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## 1 **ABSTRACT**

2

3 Fleas (Insecta: Siphonaptera) are among the most common ectoparasites of small mammals.  
4 We investigated fleas infesting on the small mammals (Mammalia: Rodentia, Eulipotyphla)  
5 from 15 different localities in Turkey. A total of 276 flea (133 males and 143 females)  
6 specimens belonging to 32 different flea taxa were collected from 90 (42 males, 16 females and  
7 32 undetermined) small mammals belonging to 20 different species.

8 With many new flea-host associations, the first occurrences of *Ctenophthalmus agyrtes*  
9 *peusianus* Rosicky, *Ctenophthalmus golovi golovi* Ioff & Tiflov, *Ctenophthalmus secundus*  
10 *vicarius* Jordan & Rothschild, *Doratopsylla dasyncnema cuspis* Rothschild, *Leptopsylla algira*  
11 *popovi* (Wagner & Argyropulo) and *Rhadinopsylla pentacantha* (Rothschild) fleas were  
12 reported in Turkey. In addition, three flea species, *Ctenophthalmus coniunctus* Peus,  
13 *Ctenophthalmus contiger* Peus, and *Palaeopsylla incisa* Peus, are reported for only the second  
14 time since their original descriptions.

15 **Keywords:** Ectoparasite, first record, geographical distribution, host associations, rodents.

16

## 17 **INTRODUCTION**

18 Fleas (Insecta: Siphonaptera) comprise approximately 2700 described species and subspecies  
19 placed in 18 families and 220 genera (Durden and Hinkle, 2018). The majority (94%) of all  
20 known species of fleas are parasites of mammals; the remaining (6%) are parasites of birds.  
21 Some fleas (such as *Pulex irritans* Linnaeus, *Xenopsylla cheopis* Rothschild, *Ctenocephalides*  
22 *felis* Bouché, *Ctenocephalides canis* Curtis, and *Tunga penetrans* Linnaeus) have medical  
23 importance, and they are vectors for the several infectious diseases and can also cause serious  
24 skin infestation (such as tungiasis) (Bitam et al., 2010).

1 Except for the records of widespread flea species and descriptions of new taxa, the flea fauna  
2 of Turkey is poorly studied. Peus (1977, 1978a, 1978b) performed most detailed studies on  
3 fleas of Turkey and he reported a total of 83 flea species (with subspecies); of these, 22 species  
4 and 3 subspecies were newly described. Orhan & Beaucournu (1982, 1986) found a total of 22  
5 species of fleas infesting rodents in central and western Anatolia. Aktaş (1987a, 1987b, 1988,  
6 1989, 1990, 1999) contributed considerably to the flea fauna of Turkey. In his studies on the  
7 fleas infesting wild mammals, he described four new flea taxa (three new species and one new  
8 subspecies) and reported many new records for Turkey. From 2000 to 2018, systematic studies  
9 on fleas in Turkey almost stopped and were limited to reports of widespread fleas in some  
10 veterinary studies. Recently, Keskin and Beaucournu described five new taxa (Keskin and  
11 Beaucournu, 2019a, 2019b; Keskin, 2020) and reported several new flea records for Turkey  
12 (Keskin et al., 2019). However, we do not have enough information on the faunal composition  
13 of fleas in Turkey. Moreover, distributions and host associations of many flea species are poorly  
14 known.

15 From an epidemiological point of view, the global and regional distribution of fleas and flea-  
16 borne pathogens makes them emerging or re-emerging threats to the health of humans and  
17 animals. Therefore, studies on flea-host associations are essential to evaluate the ecology of  
18 fleas and their potential role in the transmission of zoonotic pathogens. In the present study, we  
19 investigated on fleas infesting small mammals in 15 different localities in Turkey. Here, we  
20 report many new flea-host associations for Turkey. Also, presence of some fleas in Turkey are  
21 documented for the first time. Three flea species are also reported for only the second time since  
22 their original descriptions. We believe the present study provides comprehensive information  
23 for further studies on fleas and flea-borne infectious agents.

24

## 1 MATERIAL AND METHODS

2 From October 2017 to February 2019, fleas were collected from wild mammals (Mammalia:  
3 Rodentia, Eulipotyphla) from 15 different localities in Turkey (Fig. 1). Small mammals were  
4 captured from different habitats at each sampling locality with metal and plastic traps (Sherman  
5 and Economy Mammal Trip-Trap) baited with peanut butter. Traps were visited just twice a  
6 day (morning and evening). Captured hosts were anesthetized or killed with diethyl ether on a  
7 piece of cotton wool in a polythene bag. Hosts were carefully searched for fleas with the aid of  
8 a pair of tweezers. Fleas were stored in 70% ethanol and sent to the Parasitology Laboratory,  
9 Department of Biology, Tokat Gaziosmanpaşa University, Tokat Province, Turkey. All  
10 specimens were cleared in KOH and mounted according to the procedure of Smit (1957). Fleas  
11 were examined under the microscope (Olympus CX41, Tokyo, Japan). Fleas were identified  
12 using keys by Hopkins and Rothschild (1953, 1962, 1966, 1971) and Tiflov et al. (1977). All  
13 fleas were deposited to the flea collection of Parasitology Laboratory, Department of Biology,  
14 Tokat Gaziosmanpaşa University, Tokat, Turkey. Host mammals were identified according to  
15 morphological characters described by Tez (2000), Kryštufek and Vohralík (2001, 2005, 2009),  
16 Barčiová and Macholán, (2009) and Arslan and Zima (2014). For mammalian taxonomy,  
17 Wilson and Reeder (2005) was followed.

## 18 RESULTS

19 A total of 276 fleas (133 males and 143 females) specimen belonging to 32 different flea taxa  
20 (Table 1) were collected from 90 (42 males, 16 females and 32 undetermined) small mammals  
21 belonging to 20 different species (Table 2), captured from 15 different localities in Turkey. The  
22 most prevalent flea species was *Ctenophthalmus secundus vicarius* Jordan & Rothschild,  
23 (13.76%; n= 17 males, 21 females), followed by *Ctenophthalmus secundus asiaticus*  
24 Argyropulo (11.59%, n= 17 males, 15 females), *Palaeopsylla caucasica* Argyropulo (10.87%,

1 n= 13 males, 17 females), *Leptopsylla taschenbergi taschenbergi* (Wagner) (10.5%, n= 10  
2 males, 19 females). Single specimens belonging to *Ctenophthalmus fransmiti* Suciú,  
3 *Ctenophthalmus teres anatolicus* Keskin & Beaucournu, *Ctenophthalmus golovi golovi* Ioff &  
4 Tiflov, *Ctenophthalmus hypanis riciensis* Ioff, *Leptopsylla algira popovi* (Wagner &  
5 Argyropulo), *Nosopsyllus consimilis* (Wagner), *Palaeopsylla incisa* Peus, and *Rhadinopsylla*  
6 *pentacantha* (Rothschild) were found. The average number of collected fleas per small  
7 mammals was 3 (276 flea/90 small mammals); the ranging was from 1 to 28 flea specimens per  
8 host. Forty-two (46.66%) of 90 small mammals were infested by one flea specimen.  
9 *Ctenophthalmus agyrtes peusianus* Rosicky, *C. golovi golovi*, *C. secundus vicarius*,  
10 *Doratopsylla dasyncema cuspis* Rothschild, *L. algira popovi* and *R. pentacantha* were reported  
11 for the first time from Turkey. Also, three flea species, *Ctenophthalmus coniunctus* Peus,  
12 *Ctenophthalmus contiger* Peus, and *P. incisa* Peus are reported for only the second time since  
13 their original descriptions.

14 On the other hand, only nine species of small mammals (namely *Apodemus agrarius* Pallas,  
15 *Apodemus sylvaticus* Linnaeus, *Erinaceus roumanicus* Barrett-Hamilton, *Microtus guentheri*  
16 Danford & Alston, *Microtus levis* Miller, *Microtus subterraneus* (de Selys-Longchamps), *Mus*  
17 *musculus domesticus* Schwarz & Schwarz, *Neomys anomalus* Cabrera, and *Prometheomys*  
18 *schaposchnikowi* Satunin) were infested with one species of flea; the remaining small mammals  
19 were infested by two or more species of fleas (2 to 8 species). Co-infestations (by 2, 3 or 4  
20 different flea species) were observed in *Apodemus flavicollis* Melchior, *Apodemus uralensis*  
21 Pallas, *Apodemus witherbyi* Thomas, *Chionomys nivalis* Martins, *Crocidura suaveolens* Pallas,  
22 *Microtus arvalis* Pallas, *Mus macedonicus* Petrov & Ruzic, *Myodes glareolus* Schreber, and  
23 *Talpa levantis* Thomas. Co-infestations and new flea–host associations for Turkey were shown  
24 in Supplement 1.

25

1

## 2 **DISCUSSION**

3 Turkey lies at the junction of three continents. The unique location of Turkey provides different  
4 biogeographic regions, and wide variation in climate and habitat. Therefore, Turkey has a rich  
5 mammalian fauna (148 species within the seven order (Erinaceomorpha (n = 3), Soricomorpha  
6 (n = 15), Chiroptera (n = 37), Carnivora (n = 19), Artiodactyla (n = 8), Lagomorpha (n = 2),  
7 and Rodentia (n = 64) (Kryštufek and Vohralík, 2001, 2005, 2009). We have detailed  
8 information on several aspects of the ecology and biology of the majority of small mammals of  
9 Turkey; however, there is limited information on the ectoparasites of them.

10

11 Fleas are one of the common ectoparasites of small mammals. The flea fauna of Turkey is  
12 composed of 123 taxa (89 species and 34 subspecies in 37 genera) (Keskin et al., 2018, 2019,  
13 2020; Keskin and Beaucournu, 2019a, 2019b). However, the number of flea species found in  
14 Turkey and host associations of many fleas are poorly known.

15 *Amphipsylla rossica* Wagner has a wide eastern distribution throughout the Palaearctic Region.  
16 *Microtus arvalis* is thought to be the preferred host, but it can be frequently collected on  
17 *Apodemus* and *Microtus* species (Lewis, 1973; Beaucournu and Launay, 1990; Brinck-Lindroth  
18 and Smit, 2007). In Turkey, *A. rossica* has been collected on many species of rodents (*A.*  
19 *sylvaticus*, *Chionomys roberti* Thomas, *C. nivalis*, *Cricetulus* sp., *M. arvalis*, *M. guentheri*, and  
20 *Microtus majori* Thomas) and soricomorphs (*Crocidura leucodon* Hermann, *Crocidura* sp., and  
21 *Sorex satunini* Ognev) (Keskin et al., 2018). We collected this flea on *A. witherbyi* and *C.*  
22 *nivalis*. *Apodemus witherbyi* is new host for *A. rossica* for Turkey.

23 The genus *Frontopsylla* Wagner & Ioff includes more than 50 species (including subspecies)  
24 that occur exclusively in the various subregions of the Palaearctic Region. Apart from the

1 members of the subgenus *Orfrontia* Ioff (which are parasites of birds), the remaining three  
2 subgenera (*Frontopsylla* Wagner & Ioff, *Mafrontia* Ioff, and *Profrontia* Ioff) are mainly infest  
3 small mammals. *Frontopsylla elata caucasica* Ioff & Argyropulo is a parasite of voles in the  
4 mountainous regions of the Caucasus, Central Asia, Kazakhstan, and the southern part of  
5 Western Siberia (Kotti, 2014). The previous report of this flea in Turkey was from *Cricetulus*  
6 sp. in Ardahan Province of Turkey. We collected this flea from *M. arvalis* in Ardahan and Kars  
7 Provinces; it is a new host record for *F. elata caucasica* in Turkey.

8 The genus *Leptopsylla* Jordan & Rothschild is represented by only three taxa, namely  
9 *Leptopsylla algira costai* Smit, *Leptopsylla segnis* (Schönherr), and *L. taschenbergi*  
10 *taschenbergi* in Turkey. The members of the genus *Leptopsylla* mainly infest rodents, but there  
11 are also some reports from erinaceomorphs and soricomorphs in Turkey (Keskin et al., 2018,  
12 2019). We collected *L. taschenbergi taschenbergi* on several species of rodents; of them, *A.*  
13 *uralensis* and *A. witherbyi* are new host records for *L. taschenbergi taschenbergi*. On the other  
14 hand, *L. algira popovi* was described as a new subspecies from *Microtus socialis* Pallas in  
15 Azerbaijan. Later, Ioff and Tiflov (1954) and Tiflov et al. (1977) accepted it as an independent  
16 species. Its status was adopted at the subspecies level by Smit and Wright (1965), Hopkins and  
17 Rothschild (1971), and (Lewis, 2009). This flea is widely distributed in the lowland, foothills  
18 and mountains in Caucasus (Armenia, Azerbaijan, Dagestan, and Nakhichevan). We found this  
19 flea infesting *C. suaveolens* in Iğdır Province (border of Caucasus); this is the first record of  
20 this flea in Turkey.

21 *Megabothris turbidus* (Rothschild) is a common flea species parasitizing *Microtus* and  
22 *Apodemus* species. It can be also found on other small mammals in Middle Europe and Turkey  
23 (Peus, 1977). We collected this flea from *A. uralensis*, *A. witherbyi*, *Apodemus* sp., *M. arvalis*,  
24 *M. glareolus*, and *M. macedonicus*. Except for *M. arvalis* and *M. glareolus*, all hosts of *M.*  
25 *turbidus* reported in the present study are new host records for Turkey.



1 The genus *Nosopsyllus* Jordan comprises approximately 70 taxa distributed in Palaearctic,  
2 Afrotropical, and Oriental Regions. In Turkey, this genus represented by 10 taxa (five species  
3 and five subspecies), and many of them are parasites of rodents (Keskin et al., 2018).  
4 *Nosopsyllus consimilis* (Wagner) is widespread in southern Europe, the Caucasus, and central  
5 Asia (Lewis, 1975; Kotti, 2013). It is a typical parasite of *Microtus* species, but we found this  
6 flea on an *Apodemus* species in Iğdır Province of Turkey. *Nosopsyllus durii* Hubbard was  
7 described from Iraq but is also common in Syria and Lebanon (Lewis, 1975). Peus (1977,  
8 1978b) reported this flea from Turkey and Greece from several hosts. We collected this flea on  
9 *A. flavicollis*, *C. suaveolens*, *N. anomalus*, and *M. macedonicus* in Ardahan and Edirne  
10 Provinces. All hosts of *N. durii* reported in the present study are new host records for Turkey.  
11 The type series (1 male and 2 females) of *Nosopsyllus sarinus* (Jordan & Rothschild) originally  
12 collected from *Mus* sp. in Adana Province, Turkey. Later, Smit (1960b) described two new  
13 subspecies of *N. sarinus* from Iran, namely *Nosopsyllus sarinus aryanus* Smit (type locality  
14 Abadan, south-west Iran) and *Nosopsyllus sarinus parthius* Smit (type locality Mahan, Kirman,  
15 Iran). We collected two males and a female from Iğdır Province of Turkey. Our examined male  
16 specimens of *N. sarinus* have mixed characters of the subspecies *sarinus* and *aryanus*. Sternum  
17 IX of the males of our *N. sarinus* specimens was identical with the subspecies *aryanus*, whereas  
18 their telomeres were identical with the subspecies *sarinus*. Therefore, it is probable that the  
19 population of the subspecies *aryanus* in north-west Iran is intersecting with the population of  
20 the nominative subspecies *sarinus* along the Turkey-Iran border.

21 A total of 163 specimens (87 males, 76 females) belonging to 16 taxa of the genus  
22 *Ctenophthalmus* were collected from 16 different species of small mammals in this study. The  
23 most common flea was *C. secundus vicarius*. This is the first record of this subspecies in  
24 Turkey. Indeed, Peus (1978b) created *Ctenophthalmus secundus thracicus* Peus based on only  
25 telomere. Peus tended to apply subspecific names to each separate population of *C. secundus*

1 in Turkey. We collected a number of specimens from the type locality of *C. secundus thracicus*  
2 and compared them with the Romanian specimens of *C. secundus vicarius*. We believe *C.*  
3 *secundus thracicus* should be a junior synonym of *C. secundus vicarius*; however, until a more  
4 detailed comparison of phallosome of the holotype of *C. secundus thracicus* can be made, it  
5 would be inopportune to synonymize formally.

6 *Ctenophthalmus secundus asiaticus*, *Ctenophthalmus proximus* (Wagner), and *Ctenophthalmus*  
7 *agyrtes peusianus* Rosicky were other commonly collected fleas in this genus. *Ctenophthalmus*  
8 *agyrtes* (Heller) has 24 valid subspecies from continental Europe. Until this study, only one  
9 subspecies, *Ctenophthalmus agrytes ropotamensis* Rosicky, had been reported from the  
10 European part of Turkey. With the present study, *C. agrytes peusianus* is reported for the first  
11 time. For *C. agrytes* and its other subspecies, there is no strict host relationship. *Ctenophthalmus*  
12 *agyrtes* and its subspecies are primarily associated with *Apodemus* species. We collected them  
13 primarily from *A. sylvaticus* and *A. flavicollis*, as well as on *M. glareolus* and other species of  
14 Arvicolinae, and secondarily on various small mammal species, including insectivores (Brinck-  
15 Lindroth and Smit, 2007). *Ctenophthalmus coniunctus* and *C. contiger* were collected for only  
16 the second time since they were described. The type locality of *C. coniunctus* is the Rize  
17 Province of Turkey and its type host is *Chionomys* sp.. In addition, some paratypes were  
18 collected from *Apodemus* sp., *C. roberti*, and *M. majori* in Ordu and Rize Provinces of Turkey.  
19 We collected *C. coniunctus* from *M. glareolus* in Bolu Province of Turkey. This is a new  
20 locality and new host record for this species in Turkey. The type host of *C. contiger* is *M. majori*  
21 and type locality is Artvin Province of Turkey. We collected *C. contiger* from *A. uralensis*, *M.*  
22 *arvalis*, *M. macedonicus*, and *T. levantis* in original type locality (Artvin) and vicinity  
23 (Ardahan); these hosts are new host records for *C. contiger* in Turkey. Except for the  
24 aforementioned *Ctenophthalmus* species, new host records for the members of this genus  
25 reported in this study were shown in Supplement 1.

1 *Doratopsylla dasyncnema* (Rothschild) is widespread in Europe and divided into three  
2 subspecies. Principal hosts of this species are shrews, but they can be incidentally found on  
3 other small mammals. The subspecies *dasyncnema* occurs in northern countries of Europe, while  
4 the subspecies *cuspis* Rothschild occurs in parts of France, Italy, Switzerland, and southeast  
5 Europe. The subspecies *giloti* Beaucournu was described from Spain (Smit, 1960a; Beaucournu  
6 and Launay, 1990). We collected two male specimens of *D. dasyncnema cuspis* from *T. levantis*  
7 in the Bolu Province of Turkey. This is the first record of this flea in Turkey.

8 The majority of the member of genus *Palaeopsylla* Wagner occur in the Palaearctic Region but  
9 a few are found in the Oriental Region. Members of the genus are parasites of Talpidae and  
10 Soricidae. According to the classification of Smit (1960c), the genus *Palaeopsylla* is divided  
11 into four species groups: *klebsiana*-group, *soricis*-group, *minor*-group, and *remota*-group. In  
12 Turkey, the genus is represented by eight species. Of them, *Palaeopsylla alpestris* Argyropulo,  
13 *Palaeopsylla aysenurae* Keskin & Beaucournu, *Palaeopsylla beaucournui* Keskin, and *P.*  
14 *caucasica* Argyropulo are members of *minor*-group, while *P. incisa* Peus, *Palaeopsylla obliqua*  
15 Peus, *Palaeopsylla obtusa* Peus, and *Palaeopsylla soricis* (Dale) are belong to the *soricis*-  
16 group. In the present study, we collected *P. alpestris* and *P. caucasica* from *T. levantis*, but also  
17 found a male specimen of *P. incisa* from *A. witherbyi*. We collected *P. incisa* for the first time  
18 since its original description. Members of the genus are specific parasites of Talpidae and  
19 Soricidae; therefore, we think *A. witherbyi* is probably an accidental host for *P. incisa*. Here, *T.*  
20 *levantis* was also reported as a new host record for *P. alpestris* in Turkey.

21 *Rhadinopsylla pentacantha* (Rothschild) is a parasite of microtines and one of the most widely  
22 distributed flea species of Europe. This flea is mainly accepted as autumn-winter flea, but  
23 Beaucournu (1974) noted that *R. pentacantha* can be collected in the Atlantic climate during  
24 the whole year. Haitlinger (1973) considered that this flea may occur throughout the year in  
25 Poland. Beaucournu (1974) collected *R. pentacantha* at 1600 and 1850 m in the Pyrenees and

1 supplied detailed information about its ecology, distribution, and ecology. Hopkins and  
2 Rothschild (1962) emphasized that *R. pentacantha* is not found further east than about the  
3 latitude of Moscow. We collected only one female *R. pentacantha* from *M. arvalis* at a  
4 mountain meadow habitat (altitude 2400 m) in Ardahan (Posof) Province, which is located at  
5 the border of Caucasia. This location is about 350 km further east from the latitude of Moscow.  
6 *Rhadinopsylla pentacantha* is reported for the first time in Turkey.

7 *Stenoponia tripectinata* (Tiraboschi) is the only representative of the genus in Turkey and  
8 mainly reported in Western Anatolia (Keskin et al., 2018). The distribution range of *S.*  
9 *tripectinata* is limited to the North Mediterranean countries (including the various islands,  
10 Corsica, Sicily, Balearic Islands), and some West Atlantic islands (Canary, Madeira, Azores),  
11 but it can be also found in the coastal areas of northern Africa (Morocco, Algeria, Tunisia).  
12 Arvicolid and murid rodents are the main hosts of *S. tripectinata* (Beaucournu and Launay,  
13 1990; Beaucournu, 2011). We collected this flea from *A. flavicollis* and *M. macedonicus* in the  
14 European part of Turkey (Edirne Province). *Stenoponia tripectinata* is reported in the European  
15 part of Turkey for the first time and *A. flavicollis* is recorded as a new host for *S. tripectinata*  
16 in Turkey.

17 *Hystrihopsylla orientalis* Smit is polytypic flea species, currently divided into two subspecies.  
18 The nominative subspecies is known among others from Greece, Romania, and the western part  
19 of Russia (extends eastwards of Siberia) (Beaucournu and Launay, 1979; Brinck-Lindroth and  
20 Smit, 2007), whereas the other subspecies, *guentheri* Peus, is known only from Anatolia  
21 (Keskin et al., 2018). We collected this flea from *A. witherbyi* and *M. glareolus*; these hosts are  
22 new host records for *H. orientalis guentheri*.

23 *Archaeopsylla erinacei erinacei* (Bouché) most probably occurs within most areas in Europe  
24 and the Middle East where the hedgehog is found. Its primary host is hedgehogs, but there are

1 reports from hares, carnivores, and even humans. One hedgehog may harbor numerous (more  
2 than 1000) specimens of this flea (Beaucournu and Launay, 1990). Several bacteria of medical  
3 and veterinary interest (*Rickettsia felis*, *R. helvetica*, *Bartonella henselae*, *B. clarridgeiae*, and  
4 *B. elizabethae*) have been detected from *A. erinacei* collected from hedgehogs (Greigert et al.,  
5 2019). This flea was collected from *Erinaceus concolor* Martin and *Vulpes vulpes* Linnaeus in  
6 Turkey and all known reports are only from the Anatolian peninsula. We reported this flea from  
7 *E. roumanicus*, which was a new host record, in the European part of Turkey.

8 We report many new flea-host associations for Turkey and contribute to flea fauna of Turkey  
9 by reporting six additional species of fleas, *C. agyrtes peusianus*, *C. golovi golovi*, *C. secundus*  
10 *vicarius*, *D. dasyncnema cuspis*, *L. algira popovi*, and *R. pentacantha*. Three flea species (*C.*  
11 *coniunctus*, *C. contiger*, and *P. incisa*) were collected for only the second time since their  
12 original descriptions. We have increased the number of flea taxa in Turkey to 129 (90 species,  
13 39 subspecies). We expect that this number will be increased in the future with additional  
14 detailed studies.

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## TABLES

**Table 1.** Species of fleas collected from small mammals in Turkey, 2017-2019.

Fleas	Male	Female	Total
<b>CERATOPHYLLIDAE</b>			
<i>Amphipsylla rossica</i> Wagner 1912	2	1	3
<i>Frontopsylla (Frontopsylla) elata caucasica</i> Ioff & Argyropulo, 1934		2	2
<i>Leptopsylla (Leptopsylla) algira popovi</i> (Wagner & Argyropulo, 1934) <sup>a</sup>	1		1
<i>Leptopsylla (Leptopsylla) taschenbergi taschenbergi</i> (Wagner, 1898)	10	19	29
<i>Megabothris (Gebiella) turbidus</i> (Rothschild, 1909)	7	12	19
<i>Nosopsyllus (Nosopsyllus) consimilis</i> (Wagner, 1898)		1	1
<i>Nosopsyllus (Nosopsyllus) durii</i> Hubbard, 1956	4	7	11
<i>Nosopsyllus (Nosopsyllus) sarinus</i> (Jordan & Rothschild, 1921)	2	1	3
<b>CTENOPHTHALMIDAE</b>			
<i>Ctenophthalmus (Ctenophthalmus) agyrtes peusianus</i> Rosicky, 1955 <sup>a</sup>	11	8	19
<i>Ctenophthalmus (Ctenophthalmus) bifidatus bifidatus</i> Smit, 1960	2	7	9
<i>Ctenophthalmus (Ctenophthalmus) fransmiti</i> Suci, 1969	1		1
<i>Ctenophthalmus (Ctenophthalmus) proximus</i> (Wagner, 1903)	12	7	19
<i>Ctenophthalmus (Ctenophthalmus) stirps</i> Beaucournu & Orhan, 1983	2	1	3
<i>Ctenophthalmus (Euctenophthalmus) coniunctus</i> Peus, 1977 <sup>b</sup>	2	4	6
<i>Ctenophthalmus (Euctenophthalmus) contiger</i> Peus, 1977 <sup>b</sup>	4	2	6
<i>Ctenophthalmus (Euctenophthalmus) euxinicus</i> Rostigayev & Alaniya, 1963	1	1	2
<i>Ctenophthalmus (Euctenophthalmus) secundus asiaticus</i> Argyropulo, 1935	17	15	32
<i>Ctenophthalmus (Euctenophthalmus) secundus vicarius</i> Jordan & Rothschild, 1921 <sup>a</sup>	17	21	38
<i>Ctenophthalmus (Euctenophthalmus) teres anatolicus</i> Keskin & Beaucournu, 2019		1	1
<i>Ctenophthalmus (Medioctenophthalmus) golovi golovi</i> Ioff & Tiflov, 1930 <sup>a</sup>		1	1
<i>Ctenophthalmus (Metactenophthalmus) hypanis riciensis</i> Ioff, 1953	1		1
<i>Ctenophthalmus (Palaeoctenophthalmus) fissurus</i> Wagner, 1928	5	3	8
<i>Ctenophthalmus (Palaeoctenophthalmus) inornatus</i> Wagner, 1916	2	4	6
<i>Ctenophthalmus (Palaeoctenophthalmus) reconditus</i> Peus, 1977	10	1	11
<i>Doratopsylla dasyncema cuspis</i> Rothschild, 1915 <sup>a</sup>	2		2
<i>Palaeopsylla (Palaeopsylla) alpestris</i> Argyropulo, 1946	1	1	2
<i>Palaeopsylla (Palaeopsylla) caucasica</i> Argyropulo, 1946	13	17	30
<i>Palaeopsylla (Palaeopsylla) incisa</i> Peus, 1977 <sup>b</sup>	1		1
<i>Rhadinopsylla (Actenophthalmus) pentacantha</i> (Rothschild, 1897) <sup>a</sup>		1	1
<i>Stenoponia tripectinata</i> (Tiraboschi, 1902)	2	2	4
<b>HYSTRICHOPSYLLIDAE</b>			
<i>Hystrichopsylla (Hystrichopsylla) orientalis guentheri</i> Peus, 1977	1	1	2
<b>PULICIDAE</b>			
<i>Archaeopsylla erinacei erinacei</i> (Bouché, 1835)		2	2
<b>Total</b>	133	143	276

<sup>a</sup> new record for Turkey

<sup>b</sup> the second record subsequent to original description

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**Table 2.** Small mammals infested by fleas, their localities, habitat(s) and host-associations collected in Turkey, 2017-2019.

Host	Host gender	Locality/Localities	Habitat(s)	Flea species
<b><u>EULIPOTYPHILA</u></b>				
<i>Crocidura suaveolens</i> Pallas	4U	Edirne (Centre)	MUAL, GFSE	<i>Ctenophthalmus secundus vicarius</i> (3M, 3F) <i>Nosopsyllus durii</i> (1M, 2F)
	2U	Iğdır (Aralık)	AL	<i>Leptopsylla algira popovi</i> (1M) <i>Nosopsyllus sarinus</i> (1F)
<i>Erinaceus roumanicus</i> Barrett-Hamilton	1U	Kırklareli	AL	<i>Archaeopsylla erinacei erinacei</i> (2F)
<i>Neomys anomalus</i> Cabrera	1U	Edirne (Centre)	GFSE	<i>Nosopsyllus durii</i> (1F)
<i>Talpa levantis</i> Thomas	2U	Artvin (Şavşat)	DF	<i>Ctenophthalmus contiger</i> (2M) <i>Ctenophthalmus proximus</i> (1M, 1F) <i>Palaeopsylla caucasica</i> (13M, 17F)
	1U	Balıkesir (Erdek)	DF	<i>Ctenophthalmus reconditus</i> (1M)
	1M	Bolu (Abant)	DF	<i>Palaeopsylla alpestris</i> (1M)
				<i>Doratopsylla dasyncema cuspis</i> (2M)
	1U	Giresun (Ülper)	HG	<i>Palaeopsylla alpestris</i> (1F)
<b><u>RODENTIA</u></b>				
<i>Apodemus agrarius</i> Pallas	1U	Kırklareli (Demirköy)	DF	<i>Ctenophthalmus agyrtes peusianus</i> (11M, 8F)
<i>Apodemus flavicollis</i> Melchior	1F	Bolu (Abant)	DF	<i>Ctenophthalmus proximus</i> (2F)
	2M, 1F, 1U	Bursa (Uludağ)	DF	<i>Ctenophthalmus bifidatus bifidatus</i> (1F) <i>Ctenophthalmus golovi golovi</i> (1F)
				<i>Leptopsylla taschenbergi taschenbergi</i> (1M, 2F)
	8M, 2F, 1U	Edirne (Centre)	MUAL	<i>Ctenophthalmus secundus vicarius</i> (5M, 10F) <i>Nosopsyllus durii</i> (3M, 2F) <i>Stenoponia tripectinata</i> (1F)
	1U	Iğdır (Aralık)	AL	<i>Leptopsylla taschenbergi taschenbergi</i> (1F)
<i>Apodemus sp.</i>	1F	Bursa (Uludağ)	DF	<i>Ctenophthalmus stirps</i> (2M, 1F) <i>Megabothris turbidus</i> (1M)
	1U	Iğdır (Aralık)	WE	<i>Nosopsyllus consimilis</i> (1F)
<i>Apodemus sylvaticus</i> Linnaeus	1F	Edirne (Centre)	MUAL	<i>Ctenophthalmus secundus vicarius</i> (1F)
<i>Apodemus uralensis</i> Pallas	1M	Ardahan (Posof)	MM	<i>Megabothris turbidus</i> (2F)
				<i>Ctenophthalmus contiger</i> (1F)
	2M, 2F	Artvin (Şavşat)	DF	<i>Ctenophthalmus proximus</i> (3M, 3F)
	1F	Bolu (Abant)	DF	<i>Ctenophthalmus bifidatus bifidatus</i> (1F)
	1M	Bursa (Uludağ)	DF	<i>Leptopsylla taschenbergi taschenbergi</i> (1F)
<i>Apodemus witherbyi</i> Thomas	1M	Ardahan (Posof)	MM	<i>Amphipsylla rossica</i> (1M)
	4M	Artvin (Şavşat)	DF	<i>Ctenophthalmus proximus</i> (7M, 1F) <i>Palaeopsylla incisa</i> (1M)
				<i>Ctenophthalmus bifidatus bifidatus</i> (2M)
				<i>Ctenophthalmus proximus</i> (1M)
	2M	Bolu (Abant)	DF	<i>Hystrichopsylla orientalis guentheri</i> (1F)

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Table 2. Continued.

Host	Host gender	Locality/Localities	Habitat(s)	Flea species
<b>RODENTIA</b>				
<i>Apodemus witherbyi</i> Thomas	7M, 1F, 1U	Bursa (Uludağ)	DF	<i>Ctenophthalmus bifidatus bifidatus</i> (2F) <i>Ctenophthalmus fransmiti</i> (1M) <i>Leptopsylla taschenbergi taschenbergi</i> (4M, 5F) <i>Megabothris turbidus</i> (2F)
<i>Chionomys nivalis</i> Martins	2U	Ardahan (Posof)	MM	<i>Amphipsylla rossica</i> (1M, 1F) <i>Ctenophthalmus teres anaticus</i> (1F)
<i>Microtus arvalis</i> Pallas	1M, 1U	Ardahan (Posof)	MM	<i>Ctenophthalmus contiger</i> (1M, 1F) <i>Ctenophthalmus hypanis riciensis</i> (1M) <i>Frontopsylla elata caucasica</i> (1F) <i>Megabothris turbidus</i> (2M, 2F) <i>Rhadinopsylla pentacantha</i> (1F)
	1U	Kars (Susuz)	MM	<i>Frontopsylla elata caucasica</i> (1F)
<i>Microtus guentheri</i> Danford & Alston	3 (U)	Aksaray (Ortaköy)	AL	<i>Ctenophthalmus secundus asiaticus</i> (17M, 15F)
<i>Microtus levis</i> Miller	1 (U)	Edirne (Centre)	GFSE	<i>Ctenophthalmus secundus vicarius</i> (6M, 3F)
<i>Microtus subterraneus</i> de Selys-Longchamps	1 (F)	Bursa (Uludağ)	DF	<i>Ctenophthalmus bifidatus bifidatus</i> (1F)
<i>Mus musculus domesticus</i> Schwarz & Schwarz	1 (U)	Iğdır (Aralık)	AL	<i>Leptopsylla taschenbergi taschenbergi</i> (5M, 10F) <i>Nosopsyllus sarinus</i> (1M)
<i>Mus macedonicus</i> Petrov & Ruzic	2M	Ardahan (Posof)	MM	<i>Ctenophthalmus contiger</i> (1M) <i>Megabothris turbidus</i> (1M, 4F)
	7M, 2F	Edirne (Centre/Süleymaniye)	MUAL, GFSE, BFNF	<i>Ctenophthalmus secundus vicarius</i> (3M, 4F) <i>Nosopsyllus durii</i> (1F) <i>Stenoponia tripectinata</i> (2M, 1F)
	1U	Iğdır (Aralık)	AL	<i>Nosopsyllus durii</i> (1F) <i>Nosopsyllus sarinus</i> (1M)
<i>Myodes glareolus</i> Schreber	1M, 3F, 1U	Bolu (Abant)	DF	<i>Ctenophthalmus bifidatus bifidatus</i> (2F) <i>Ctenophthalmus coniunctus</i> (2M, 4F) <i>Ctenophthalmus euxinicus</i> (1M, 1F) <i>Hystrihopsylla orientalis guentheri</i> (1M) <i>Megabothris turbidus</i> (3M, 2F)
<i>Nannospalax xanthodon</i> (Nordman)	2U	Bolu (Centre/Mengen)	MF	<i>Ctenophthalmus reconditus</i> (9M, 1F)
	1U	Kars (Susuz)	MM	<i>Ctenophthalmus fissurus</i> (5M, 3F)
<i>Prometheomys schaposchnikowi</i> Satunin	2M	Ardahan (Posof)	MM	<i>Ctenophthalmus inornatus</i> (2M, 4F)

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U: Unknown, M: Male, F: Female. AL: Agricultural Land, BFNF: Bushes Field Near the Farmland, DF: Deciduous Forest, GFSE: Grassy Field on the Stream Edge,  
 3 HG: Hazelnut Garden, MF: Mixed Forest, MM: Mountain Meadow, MUAL: Mix of Urban and Agricultural Land, SCF: Sparse Coniferous Forest, WE: Wetland

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1 **FIGURE LEGENDS**

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3 Figure 1. Localities for fleas collected from small mammals in Turkey, 2017-2019.

