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Species composition and host preference of fleas (Insecta: Siphonaptera) on rodent and domestic animals in Tamil Nadu, India

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ABSTRACT: The species composition and host preference of medically important fleas monitored in urban, semi-urban, and rural revealed 412(65%) and 222(35%) fleas. From urban and rural habitats 90 and 345 fleas were collected respectively. There was a significant difference between urban and rural habitats in flea abundance. From rodents and domestic animals 209 (33%) *Xenopsylla cheopis*, 203 (32%) *X. astia* and 222 (35%) *Ctenocephalides felis* fleas were recorded. Fleas were predominantly found on *Rattus rattus* 45(83.3%) and *Canis familiaris* 31(83.8%). Among the habitats, there was no significant difference in rodent flea positivity and dog/cat flea positivity.

KEYWORDS: Habitats, abundance, positivity, flea infestation rate, flea index

INTRODUCTION

Pulicidae (with genus *Pulex, Ctenocephalides, Pilopsyllus* and *Archaeopsyllus*) and Ceratophyllidae (with genus *Ceratophyllus* and *Nosopsyllus*) are important fleas distributed worldwide (Durden and Hinkle, 2009). About 2652 species belonging to 18 families, 27 subfamilies, and 238 genera have been described (Hastriter and Bossard, 2018). Fleas are important vectors to plague and murine typhus diseases in many parts of the world (Durden and Hinkle, 2009). Fleas prefer the blood of warm-blood mammals and birds. Both sexes of fleas are obligate hematophagous prefers blood from the host animals, act as an ectoparasitic vector. A total of 46 species and 5 subspecies belonging to 24 genera under eight families were described in India (Chandra *et al.*, 2018). In the Indian Himalayan region, 38 species of fleas belonging to 22 genera of seven families were described which were sylvatic, collected from the wild rodents and animals (Chandra *et al*., 2018). Fleas associated with human dwellings act as vectors and transmit flea-borne diseases to humans. This study was planned to find out the species composition of the fleas and vertebrate host preference of medically important fleas in the Madurai district south Tamil Nadu.

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MATERIALS AND METHODS

Study sites: Madurai district is located in south Tamil Nadu of India, lies between 9°33'30''N to 10°18'50'' N latitude, 77°29'10' 'E to 78°28'45'' E longitude and has an area extent of 3710 sq. km (https://madurai.nic.in/district-profile/). Nine study sites were selected, grouped into urban, semi-urban, and rural habitats with three sites each as B.B.Kulam, Tirumangalam, Usilampatti (all three in urban habitats), Peraiyur, Keelaiyur, Sholavandan (all three in semi-urban habitats), Vadapalanji, Katchaikatti, and Chatrapatti (all three in rural habitats).

Collection of fleas

From rodents: At every site, before the dusk hours (5-6 pm), Sherman traps (width 7.5 cm, length 18.5 cm, and depth 9 cm) (Sadanandane *et al.,* 2016; Philip Samuel *et al*., 2020, 2021a,c) were kept in and around residential areas in indoor and outdoor households and withdrawn after dawn (6-7 am) in the next day. All the rodents were attracted by fried eatables smeared with coconut oil kept within the Sherman traps and captured. The design of the Sherman trap was made to capture only a single rodent at a time and, after trapping a single rodent, the door of the trap will close automatically (Philip Samuel *et al*., 2020; 2021a). Captured pest rodents and shrews were identified based on external morphology (Shakunthala and Tripathi, 2005; Martin, 2011).

To collect various small rodents, 1080 Sherman traps were placed in the study sites during the study period from July 2017 to June 2018, as a total of 360 Sherman traps were placed in each urban, semi-urban and, rural habitat (i.e., 120 traps were placed/site/year in the 9 study sites). For every month, 9 visits were made with three sites each from the urban, semi-urban, and rural habitats selected, for the collection of rodent fleas. All the trapped rodents were placed in separate cloth bags and brought to the laboratory. Captured rodents were anesthetized for the collection of fleas (Kreeger and Arenemo, 2012; Philip Samuel *et al.,* 2020, 2021 a,b,c).

Fleas from domestic and companion animals: From each habitat, 100 households were selected randomly. The study incorporated different households with domestic and companion animals like cats, dogs, goats, and fowls were sampled for flea collection. Fleas were collected manually from the body of the host animals by combing the hair using an aspirator or fine brush and kept separately in sample vials containing 70 per cent alcohol for identification provided with thelocation and date of fleas collected. Fleas were identified using available identification keys (Shariff, 1930; Iyenger 1973). Fleas were mounted with Hoyer's medium (Taylor *et al.,* 2007; Ashwini *et al.,* 2017a) and all collected specimens were deposited in the Mosquito and Ectoparasite Museum, Entomology laboratory of ICMR-Vector Control Research Centre Field station, Madurai, Tamil Nadu, India. This study was approved by the Institutional Animal Ethical Committee (IAEC) of ICMR-Vector Control Research Centre, Puducherry.

Data analysis: Data were analyzed by using computer software IBM SPSS Statistics Ver.25, applied for statistical calculations like chi-square analysis to test significant differences in species distribution and host preference in the study locations. Estimation of rodent flea and domestic animal flea infestations were calculated based on the calculated index (Shelly *et al.,* 2013). Flea infestation rate and flea index were calculated as -

$$\text{Flea infestation rate (FIR)} = \frac{\text{Total number of animals with flea}}{\text{The total number of animals examined}} \times 100$$

$$\text{Flea index (FI)} = \frac{\text{Total number of flea collected}}{\text{The total number of animals examined}} \times 100$$

For GPS-based spot mapping, study site distance and location measure, Epi Map of Epi Info Ver. 7.2.2.6 of CDC, Atlanta, USA powered by ESRI was used. Indian states and district-level maps were downloaded from the website of www.d-map.com.

RESULTS AND DISCUSSION

From the trapped 151 rodents, 35(23%), 51(34%), and 65(43%) rodents were collected from urban, semi-urban, and rural sites respectively. Only 54 rodents were positive for fleas (36%). *Rattus rattus* (Linnaeus, 1758) was trapped more in urban (69%), semi-urban(59%), and rural (63%) sites respectively. *Tatera indica* Hardwicke, 1807 trapped in rural areas only. *Bandicota bengalensis* (Gray and Hardwicke, 1833) collected at rural sites and *R. norvigecus* (Berkenhout, 1769) collected at semi-urban areas showed high flea infestation rate and high flea index there was no significant difference in rodent flea positivity at three different habitats ($\chi^2 = 3.9008$, df = 2, P>0.05). In all the habitats, a high number of rodent flea was collected from *R. rattus.* A total of 412 (65%) of *Xenopsylla cheopis* (Rothschild, 1903) and *X.astia* Rothschild, 1911) were collected from all study sites. From all the study sites, a total of 412 fleas were collected from positive rodents trapped. Fleas were collected as 60 (14.56%) from urban, 139 (33.73%) from semi-urban, and 213 (51.70%) from rural areas (Fig. 1). Flea infestation rate was 6.00, 8.69, and 7.61, and the flea index was 1.71, 2.73, and 3.28 for urban, semi-urban, and rural sites respectively (Table 1 & 2). The rural site was showing a high flea index (3.28).

Among 735 domestic and companion animals examined, only 37 (5%) animals were found positive for fleas; 31 (83.8%) dogs *Canis familiaris* Linneaus, 1758 and 6 (16.2%) cats (*Felis catus* Linnaeus, 1758) were positive for fleas. A total of 222 fleas were collected from these 37 animals and all the collected fleas were *Ctenocephalides felis* (Bouché, 1835). From urban, semi-urban and rural habitats *C. felis* collection was 13.51, 27.03 and 60.05 percent respectively. Rural dogs showed high flea index of 1.88 (Table 2) and there was no significant difference in fleas collection from dogs and cats at different sites ($\chi^2 = 0.4884$, df = 2, P>0.05) Fowls and goats were tested negative for all the fleas. In all the study sites, 20 *X. cheopis* (33%), 203 *X. astia* (32%) and 222 *C. felis* fleas (35%) were collected and *X. astia* was collected more in rural sites. Only 90 fleas were in the urban site. However, 345 fleas (54%) were collected in rural, which was 3.83 times higher than the urban collection and showed a significant difference between urban and rural fleas

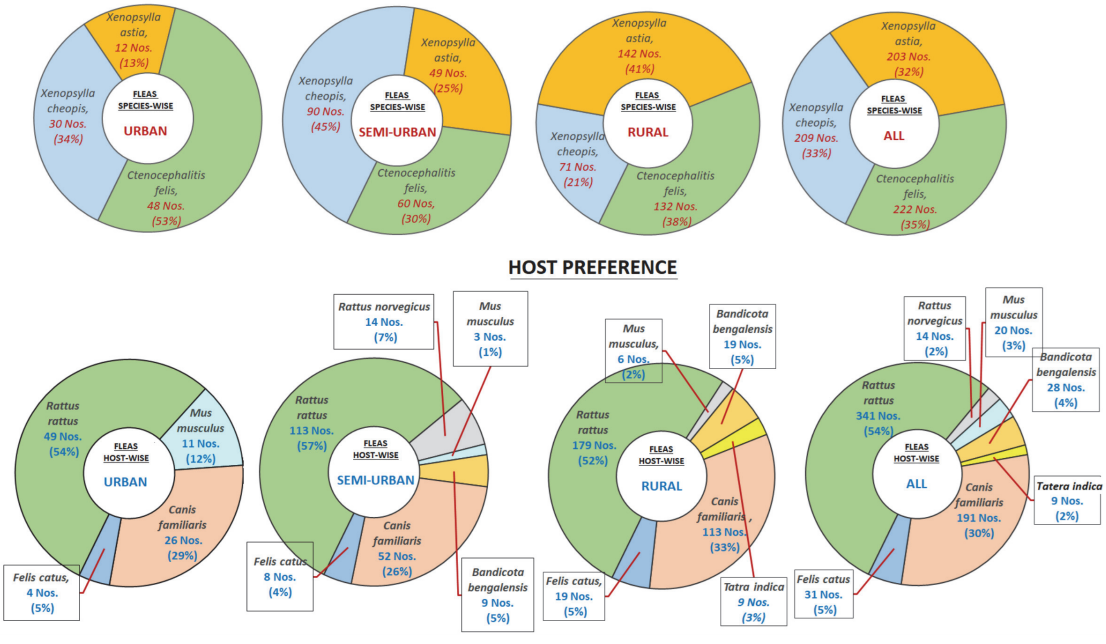

Fig. 1 Species composition and host preference of fleas collected in south India

Table 1. Rodents trapped and flea positivity in south Tamil Nadu (July 2017– June 2018)

Areas	Rodents / shrews	Trap positivity rate	Flea infestation rate	Flea index
Urban	*Rattus rattus*	6.67	6.13	2.04
	Rattus norvigecus	0.28	0.00	0.00
	Mus musculus	1.11	5.50	2.75
	Suncus murinus	1.39	0.00	0.00
	Bandicota bengalensis	0.28	0.00	0.00
	Total	9.72	6.00	1.71
Semi Urban	*Rattus rattus*	8.33	8.69	3.77
	Rattus norvigecus	0.28	14.00	14.00
	Mus musculus	1.39	3.00	0.60
	Suncus murinus	3.61	0.00	0.00
	Bandicota bengalensis	0.56	9.00	4.50
	Total	14.17	8.69	2.73
Rural	*Rattus rattus*	11.39	7.46	4.37
	Rattus norvigecus	0.28	0.00	0.00
	Mus musculus	0.83	6.00	2.00
	Suncus murinus	3.89	0.00	0.00
	Bandicota bengalensis	0.83	9.50	6.33
	Tatera indica	0.83	9.00	3.00
	Total	18.06	7.61	3.28

collected ($t = 2.229$, $df = 33$, $p < 0.05$). But, there was no significant differences between semi-urban and rural fleas collected ($t = 1.127$, $df = 542$, $p > 0.05$) and semi-urban and urban fleas collected ($t = 1.593$, $df = 287$, $p > 0.05$).

Female fleas were more than males, in all sites. But, there was no significant difference between a sex-wise collection of fleas ($t = 1.535$, $df = 632$, $p < 0.05$). In all habitats, 248 male (39%) and 386 female fleas (61%) were collected which showed there was no significant difference between male and female fleas collection ($t = 0.477$, $df = 632$, $p < 0.05$). *Xenopsyalla astia, X. cheopis,* and *C. felis* were collected more or less equally from all study sites (Table 3a). However rural habitat showed high flea infestation as high as 345 fleas (54%) (Table 3b). Flea infestation by *X. astia, cheopis* and *C. felis* was 16.6, 14.8, and 11.5 percent respectively (Table 4).

Plague outbreaks were observed during 1994 in Maharashtra, Gujarat, Uttar Pradesh, and Delhi by commensal rodents like *R. rattus, R. norvegicus, M. musculus, T. indica, S. murinus, B. bengalensis,* and *B. indica* and only 41.64 of rodents were found positive for plague vectors, *X. astia,* and *X. cheopis*. In the Chittoor district, Andhra Pradesh 62 per cent *X. astia* and 38 per cent *X. cheopis* were reported from rural, semi-urban, and urban habitats during the plague outbreak (Shelly *et al*., 2013). *X. cheopis* fleas also act as a vector for Murine typhus (Azad, 1990). The fleas, *X. cheopis*, and *X. astia* were reported from the commensal rodents (Kumar *et.al*, 1997). *X. cheopis* and *X. astia* are now common in Indian rodents. In India, many studies were also carried on the diversity and bionomics of rodent fleas, their host preference and plague disease (Shelly *et al*., 2013). Plague and Murine typhus is still the major vector-borne disease transmitted by rodent fleas

Table 2. Flea infestation (%) and index on domestic animals in south Tamil Nadu (July 2017 –June 2018)

Areas	Host	Infestation	Index
Urban	Dog	11.90	0.62
	Goat	0.00	0.00
	Cat	11.11	0.44
	Fowls	0.00	0.00
	Total	3.70	0.19
Semi-Urban	Dog	15.69	1.02
	Goat	0.00	0.00
	Cat	33.33	1.33
	Fowls	0.00	0.00
	Total	4.72	0.28
Rural	Dog	30.00	1.88
	Goat	0.00	0.00
	Cat	27.27	1.73
	Fowls	0.00	0.00
	Total	5.82	0.37

Table 3a. Sex-wise flea species collected (number/ per cent) in south Tamil Nadu

Species	Male	Female
Xenopsylla astia	85(42%)	118(58%)
Xenopsylla cheopis	86(42%)	123(58%)
Ctenophalides felis	77(35%)	145(65%)
Total	248(39%)	386(61%)

Table 3b. Distribution of fleas (number and per cent wise) at the different habitats in south Tamil Nadu

Habitat	Male	Female
Urban	33(37%)	57(63%)
Semi-urban	78(39%)	121(61%)
Rural	137(40%)	208(60%)
Total	248(39%)	386(61%)

Table 4. Prevalence of flea species and host preference in south India

Host	Flea species					
	Xenopsylla astia		*X. cheopis*		*Ctenophalides felis*	
	No. host positive (%)	No. fleas	No. host positive (%)	No. fleas	No. host positive (%)	No. fleas
Rattus rattus	27(14.5)	186	18(11.6)	155	0	0
Rattus norvigecus	0	0	1(7.1)	14	0	0
Mus musculus	1(3.0)	3	3(17.6)	17	0	0
Bandicota bengalensis	1 (5.0)	5	2(8.7)	23	0	0
Tatera indica	1(9.0)	9	0	0	0	0
Canis familiaris	0	0	0	0	31 (16.0)	191
Felis catus	0	0	0	0	6 (19.3)	31
Total	30 (14.8)	203	24 (11.5)	209	37(16.6)	222

Note: (%) indicates flea infestation percentage of hosts

and in India. *C. canis,* and *C. felis* were reported from dogs at Shimoga district, Karnataka (Krishna Murthy *et al.,* 2017). The fleas, *C. canis,* and *C. felis* are common in dogs and cats (Durden *et al*., 2005).

These flea species are occasionally found on other rodents and domesticated animals (Biswas, 2018). *X. astia* is restricted in its distribution mainly in India and the oriental region, distributed widely at peri-domestic areas and wild situations (Biswas, 2018;

Philip Samuel *et al*., 2020, 2021a). In the Madurai district, urban, semi-urban and rural habitats were rich with domestic and peri-domestic rodents favors to the distribution of *X. astia* and *X. cheopis* vector fleas. *X. astia* (49%) and *X. cheopis* (51%) were collected from all sites 412(65%) of *Xenopsyalla species* fleas and 222(35%) of *C. felis* fleas from dogs and cats were collected in all the study sites, indicating more rodent vector fleas distributed showing risk for rodent based vector-borne diseases. In Madurai study sites, *C. felis* in the dogs and *X. astia* in the rodents were collected abundantly which may cause flea-borne diseases at any time. *C. felis* is predominant in dogs and cats worldwide and in India, the prevalence of *C. felis* was also confirmed in the distribution (Iyengar, 1973). *Ctenocephalides* fleas are still the source of rickettsial diseases worldwide, particularly for *Rickettsia felis* (Hii *et al*., 2015). No published evidence is available distribution of *R. felis* in India till now.

Ctenocephalides orientis is the widely distributed on ruminants and less commonly on dogs and cats in India (Taylor *et al*., 2007). Likewise, many *Ctenocephalides* spp. were reported from the goats (Kaal *et al*., 2006, Obasaju and Otesile, 1980). Some fowls in Indian poultry farms were also severely affected by the bite of fleas, identified as *C. felis* (Joseph *et al*., 1987). *Ctenocephalide*s serve as vectors for *R. felis* which causing some rickettsial zoonotic diseases. *Rickettsia* sp. genotype RF 2125 is one of the dominant rickettsiae carried by Dog fleas *C. felis orientis* was confirmed in India for rickettsial zoonotic diseases (Hii *et al*., 2015). In Tamil Nadu, severe goat infestations by fleas were recorded (Soundararajan *et al*., 2018). Animal workers and even veterinarians were also affected by the fleas and flea bites with allergic dermatitis symptoms that were common, transmitted through the bite of goat fleas (Soundararajan *et al*., 2018).

Murine (endemic) typhus are flea-borne infectious disease caused by *R. typhi* transmitted by the rat flea, *X. cheopis* (Azad, 1990). Recent serological and molecular evidence confirmed the presence of Murine typhus pathogen, *R. typhi* in the fleas responding to the transmission of the disease to humans (Rakotonanahary *et al*., 2017) in India. The presence of Murine typhus pathogen was also observed as a cross-sectional survey, conducted in Vellore, Thiruvannamalai, and Salem districts, all in Tamil Nadu, India, at three different geographic areas such as urban, rural plains, and rural hill areas (Devamani *et al*., 2020).

Based on earlier records of fleas abundance and prevalence, outbreaks of plague coccured in India at different habitats. This study was carried out to observe the species composition and host preference of medically important fleas located in the Madurai district and showed flea species like *X. astia, X. cheopis,* and *C. felis* which were found associated with the transmission of the diseases like Plague, Murine typhus, and Flea-associated dermatitis.

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