Small Rodents Fleas from the Bubonic Plague Focus Located in the Serra dos Órgãos Mountain Range, State of Rio de Janeiro, Brazil

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Eleven species of fleas were collected from 601 small rodents, from November 1995 to October 1997, in areas of natural focus of bubonic plague, including the municipalities of Nova Friburgo, Sumidouro and Teresópolis, State of Rio de Janeiro, Brazil. Among 924 fleas collected, Polygenis (Polygenis) rimatus *(Rhopalopsyllidae) was the predominant species regarding the frequency, representing 41.3% (N:382), followed by* P. (Neopolygenis) pradoi, *representing 20% (N:185) and* Craneopsylla minerva minerva *(Stephanocircidae), representing 18.9% (N:175). The host* Akodon cursor *harbored 47.9% of these fleas. Other six host species were infested by 52.1% of the remaining fleas. Fleas were found on hosts and in places within the focus not previously reported by the literature.*

Key words: Siphonaptera - small rodent fleas - bubonic plague focus - Rio de Janeiro - Brazil

Rodent fleas are biological vectors of bubonic plague, as demonstrated 100 years ago (Simond et al. 1998). Although the order Siphonaptera includes approximately 3,000 species (Lewis 1998) and at least 100 of them can transmit plague, only 59 species were recorded in Brazil up to now (Linardi & Guimarães 2000). According to Marshall (1981), fleas infest exclusively mammals (94%) and birds (6%). In Brazil, rodents are the preferred hosts, among 12 orders of mammals found to be parasitized (Linardi 1999).

After arriving in Brazil in 1899 by the Santos seaport, State of São Paulo, the plague dispersed in rural zones, exhibiting periodicity as a wild enzootic and rural zoonosis due to the persistence in natural foci in the northeast and southeast Brazilian regions (Freitas 1969). Within the southeast region there is a focus located in the Serra dos Órgãos mountain range which, although not being the most important focus in Brazil, has been of great scientific interest due to its geographic location.

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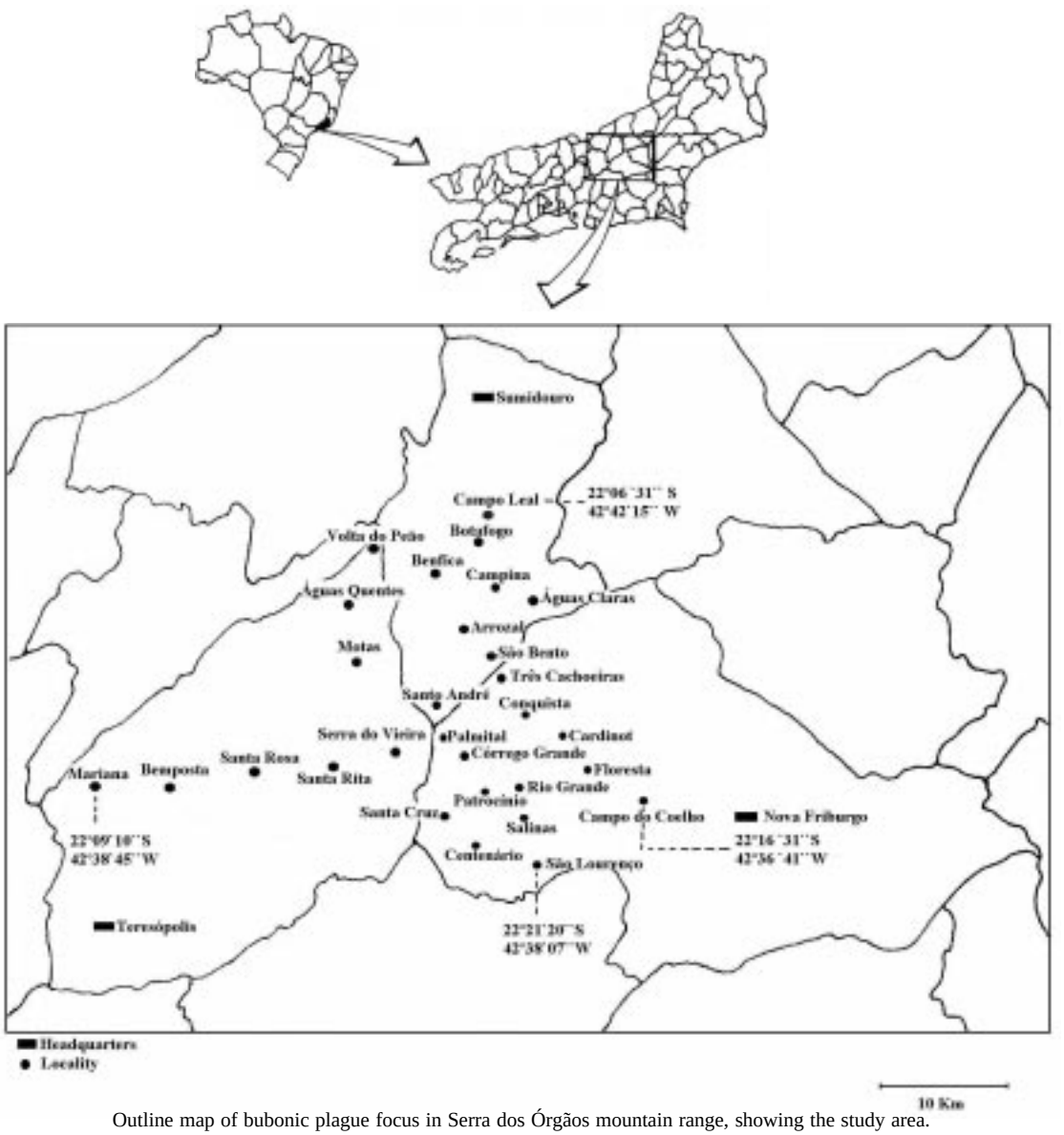
Due to two human plague deaths recorded, studies in this focus have been intensified since 1967. Serologic surveys by hemaglutination demonstrated the circulation of *Yersinia pestis* among small rodents and dogs (Almeida et al. 1985, Vieira et al. 1994). Excepting the reports of fleas in Teresópolis, State of Rio de Janeiro (Gomes 1969), the potential vectors of the plague in this area have been poorly studied and fleas have been misidentified. The present study reviews the flea fauna and verify the abundance of fleas on hosts from the focus of Serra dos Órgãos mountain range, State of Rio de Janeiro.

MATERIALS AND METHODS

Rodents were trapped in the municipalities of Nova Friburgo, Sumidouro and Teresópolis, between November 1995 and October 1997. The study areas are constituted by Atlantic forest of super humid tropical climate, presenting a high pluviometric index (2250 mm/year), without dry months and with mean temperature in the summer of 22ºC and minimum daily average in the winter varying from 15 to 0ºC (IBGE 1992, Sepla 1996). The study area comprises a polygon which includes 29 study points (Figure), according to the bubonic plague control program criteria from the Brazilian National Health Foundation (Ministério da Saúde 1994).

Rodents were captured during 24 field phases, using 50 live traps in each field phase, baited with



Outline map of bubonic plague focus in Serra dos Órgãos mountain range, showing the study area.

corncobs, during four consecutive nights/phase, investigating four different localities in peridomiciliary area in a week by month. The trapping effort consisted of 4,800 trap-nights. The criteria of choice of the collecting points were that proposed by the Ministério da Saúde (1994) resulting in different trapping success to each place. They were identified based on morphology and karyotypes, following the nomenclature proposed by Musser and Carleton (1993) and the karyotypes according to Yonenaga et al. (1974) to yield precise host identifications.

After anesthetizing the rodents with ether, the fleas were recovered by combing and brushing. After preservation in 70º ethanol they were mounted on slides for taxonomic identification. Voucher specimens of fleas were deposited in the Laboratory of Ixodides of the Oswaldo Cruz Institute. Skin and skulls of the rodents are deposited in the National Museum, Rio de Janeiro, Brazil.

RESULTS AND DISCUSSION

In total, 924 flea specimens representing 11 species were taken from 601 small rodents, being 149 (24.8%) of two commensal species and 452 (75.2%) of eight wild species (Table I).

Rodents were identified according to the nomenclature proposed by Musser and Carleton (1993) representing the following species and respective karyotypes: *Akodon cursor* (Winge),

TABLE I

Frequency of the rodent species according to municipal districts and prevalency of infested species, captured in the focus of the Serra dos Órgãos mountain range, from November 1995 to October 1997

Municipalities and localities	Wild rodents																Commensal rodents							
	Total		*Akodon cursor*		*Cavia aperea*		*Delomys sublineatus*		*Nectomys squamipes*		*Oligoryzomys nigripes*		*Oryzomys angoya*		*Oxymycterus judex*		*Thaptomys nigrita*		Total		*Mus musculus*		*Rattus rattus*		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Nova Friburgo	308	68.1	136	67	-	-	-	-	36	63.1	76	67.9	4	66.7	48	76.2	8	88.9	93	62.4	1	33.3	92	63	401	66.7
Campo do Coelho	34	7.5	20	9.9	-	-	-	-	5	8.8	2	1.8	-	-	7	11.1	-	-	15	10.1	-	-	15	10.3	49	8.2
Cardinot	17	3.8	8	3,9	-	-	-	-	-	-	8	7.1	-	-	1	1.6	-	-	-	-	-	-	-	-	17	2.8
Conquista	7	1.5	3	1.5	-	-	-	-	4	7	-	-	-	-	-	-	-	-	8	5.4	-	-	8	5.5	15	2.5
Centenário	11	2.4	3	1.5	-	-	-	-	-	-	5	4.5	-	-	2	3.2	1	11.1	6	4	-	-	6	4.1	17	2.8
Córrego Grande	52	11.6	30	14.8	-	-	-	-	8	14	1	0.9	-	-	8	12.7	5	55.6	3	2	-	-	3	2.1	55	9.2
Floresta	12	2.7	5	2.5	-	-	-	-	2	3.5	4	3.6	-	-	1	1.6	-	-	-	-	-	-	-	-	12	2
Palmital	16	3.5	14	6.9	-	-	-	-	-	-	-	-	1	16.7	1	1.6	-	-	5	3.4	-	-	5	3.4	21	3.5
Patrocínio	11	2.4	3	1.5	-	-	-	-	-	-	4	3.6	-	-	4	6.4	-	-	11	7.4	-	-	11	7.5	22	3.7
Rio Grande	57	12.6	20	9.9	-	-	-	-	7	12.2	24	21.5	2	33.3	2	3.2	2	22.2	16	10.7	-	-	16	11	73	12.2
Salinas	28	6.2	7	3.5	-	-	-	-	5	8.8	10	8.9	-	-	6	9.5	-	-	21	14.1	1	33.3	20	13.7	49	8.2
Santa Cruz	34	7.5	9	4.4	-	-	-	-	-	-	17	15,2	1	16.7	7	11.1	-	-	3	2	-	-	3	2.1	37	6.2
São Lourenço	4	0.9	2	1	-	-	-	-	-	-	-	-	-	-	2	3.2	-	-	5	3.4	-	-	5	3.4	9	1.5
Três Cachoeiras	25	5.5	12	5.9	-	-	-	-	5	8.8	1	0.9	-	-	7	11.1	-	-	-	-	-	-	-	-	25	4.2
Sumidouro	59	13.1	32	15.8	1	100	1	100	9	15.8	5	4.5	-	-	11	17.4	-	-	14	9.4	-	-	14	9.6	73	12.1
Águas Claras	5	1.1	5	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.7	-	-	1	0.7	6	1
Arrozal	7	1.5	5	2.5	-	-	-	-	2	3.5	-	-	-	-	-	-	-	-	1	0.7	-	-	1	0.7	8	1.3
Benfica	15	3.3	9	4.5	-	-	-	-	1	1.8	3	2.7	-	-	2	3.2	-	-	-	-	-	-	-	-	15	2.5
Botafogo	9	2	4	2	-	-	-	-	-	-	-	-	-	-	5	7.9	-	-	2	1.4	-	-	2	1.4	11	1.8
Campinas	12	2.7	5	2.5	1	100	1	100	4	7	1	0.9	-	-	-	-	-	-	7	4.7	-	-	7	4.8	19	3.2
Campo Leal	3	0.8	1	0.5	-	-	-	-	-	-	1	0.9	-	-	1	1.6	-	-	-	-	-	-	-	-	3	0.5
Santo André	6	1.3	2	1	-	-	-	-	2	3.5	-	-	-	-	2	3.2	-	-	3	2	-	-	3	2.1	9	1.5
São Bento	2	0.4	1	0.5	-	-	-	-	-	-	-	-	-	-	1	1.6	-	-	-	-	-	-	-	-	2	0.3
Teresópolis	85	18.8	35	17.2	-	-	-	-	12	21.1	31	27.7	2	33.3	4	6.4	1	11.1	42	28.2	2	66.7	40	27.4	127	21.1
Águas Quentes	4	0.9	2	1	-	-	-	-	2	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0.7
Fazenda Bemposta	7	1.5	1	0.5	-	-	-	-	1	1.8	5	4.5	-	-	-	-	-	-	2	1.4	-	-	2	1.4	9	1.5
Mariana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	4	-	-	6	4.1	6	1
Motas	12	2.7	6	3	-	-	-	-	-	-	3	2.7	1	16.7	2	3.2	-	-	6	4	-	-	6	4.1	18	3
Santa Rita	30	6.7	7	3.5	-	-	-	-	6	10.5	16	14.3	-	-	-	-	1	11.1	-	-	-	-	-	-	30	5
Santa Rosa	6	1.3	3	1.5	-	-	-	-	3	5.3	-	-	-	-	-	-	-	-	2	1.4	-	-	2	1.4	8	1.3
Serra do Vieira	25	5.5	15	7.4	-	-	-	-	-	-	7	6.3	1	16.7	2	3.2	-	-	26	17.4	2	66.7	24	16.5	51	8.5
Volta do Peão	1	0.2	1	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.2
Total	452	100	203	100	1	100	1	100	57	100	112	100	6	100	63	100	9	100	149	100	3	100	146	100	601	100
(%)	75.2		33.8		0.2		0.2		9.5		18.7		1.2		10.5		1.5		24.8		0.5		24.3		100	
Infested			159		-		-		34		40		5		51		8		61		-		61		358	
Prevalence			78.3		-		-		59.6		35.7		83.3		81.0		88.9		40.9		-		41.8		59.6	

%: frequency of rodent species among municipalities and localities; (%): frequency among rodent species

2n=14, FN= 18; *Cavia aperea aperea* (Erxleben), karyotype not mounted; *Delomys sublineatus* (Thomas), karyotype not mounted; *Nectomys squamipes* (Brants), 2n= 56, FN= 56; *Oligoryzomys nigripes* (Olfers), 2n=62, FN=82; *Oryzomys angoya* (=*Oryzomys ratticeps*) (Hensel), 2n=58, FN=60; *Oxymycterus judex* Thomas, 2n=54, FN=62; *Thaptomys nigrita* (Lichstenstein), 2n=52, FN=52; *Mus musculus brevirostris* (Waterhouse) and *Rattus rattus* (L.) (Table I).

The prevalences are given in Table I. *T. nigrita* was the most infested host with 88.9% in spite of the low intensity (1.95) (Table III). It was followed by *O. angoya*, *O. judex*, *A. cursor*, *N. squamipes*, *R. rattus* and *O. nigripes* respectively. Due to the low number of hosts captured, *C. aperea*, *D. sublineatus* and *M. m. brevirostris* were not infested.

The differences of infestation between wild and commensal rodents were highly significant (χ^2=28.53, p<0.01). When considering each pair of rodents in samples with more than 50 specimens collected, also were highly significant (p<0.01) the differences between: *A. cursor* and *N. squamipes* (χ^2=8.11), *A. cursor* and *O. nigripes* (χ^2=56.30), *A. cursor* and *R. rattus* (χ^2=48.66), *O. nigripes* and *O. judex* (χ^2=33.04), *O. judex* and *R. rattus* (χ^2=27.09). Differences between *N. squamipes* and *O. judex* (χ^2=6.55), *N. squamipes* and *R. rattus* (χ^2=5.24), evidenced as significant (p< 0.05).

Siphonaptera nomenclature followed the proposal of Johnson (1957) and the revision of the subfamily Rhopalopsyllinae is according to the nomenclature proposed by Linardi and Guimarães (1993) representing the following family and species: Ctenophthalmidae, *Adoratopsylla (Adoratopsylla) antiquorum antiquorum* (Rothschild); Pulicidae, *Ctenocephalides felis felis* (Bouché), *Pulex irritans* L., *Xenopsylla cheopis* (Rothschild); Rhopalopsyllidae, *Polygenis (Neopolygenis) atopus* (Jordan and Rothschild), *Polygenis (Neopolygenis) pygaerus* (Wagner), *Polygenis (Neopolygenis) pradoi* (Wagner), *Polygenis (Polygenis) rimatus* (Jordan), *Polygenis (Polygenis) roberti roberti* (Rothschild), *Polygenis (Polygenis) tripus* (Jordan); Stephanocircidae, *Craneopsylla minerva minerva* (Rothschild) (Table II).

Flea species and their distribution by municipalities are shown on Table II. Although only seven species have been found in Teresópolis, other six species of fleas were previously recorded in that municipality (Gomes 1969). So, all the fleas collected in Nova Friburgo and Sumidouro constitute new findings for those municipalities.

P. rimatus was observed in all three municipalities, representing more than 40% of the total samples. It was followed by *P. pradoi* and *P. atopus*, respectively. *C. minerva* was found in circa 20% of the samples. According to the literature, species of *Polygenis* are able to maintain plague among wild rodents (Brasil et al. 1989). This finding clearly shows that these species would represent the potential vectors of plague in this focus (Table II).

Species of fleas and their respective hosts are given in Table III. The mean number (intensity) of fleas per host (924/601=1.54) (Table III) was higher than the ones previously reported in other habitats in Brazil: 0.15 from Caatinga scrub forest in Brazilian northeast (Guimarães 1972) and 0.29 to 0.64 from Araucaria forest in State of Paraná (Barros et al. 1993, Barros-Battesti et al. 1998). In the Atlantic forest, this number was around 0.30 from Guaraqueçaba in State of Paraná (Bicho et al. 1999), 0.93 from Caratinga (Botelho & Linardi 1980); 1.06 from Juiz de Fora, both in the State of Minas Gerais (Linardi et al. 1987); 2.85 from Salesópolis, State of São Paulo (Linardi 1977) and 3.6 from Angra dos Reis, State of Rio de Janeiro (Guitton et al. 1986), in spite of methodological differences and capture efforts.

The following data represent new host records: *P. irritans* from *O. judex*, *P. r. roberti* from *T. nigrita*, *P. atopus* from *O. judex* and *R. rattus*, *P. pygaerus* from *O. judex* and *T. nigrita*, and *C. m. minerva* from *R. rattus*.

The interchange between fleas of wild and commensal rodents is an important parameter for studies concerning the epidemiology of plague, since, in this pathway, man can acquire it through flea bites. Species of Rhopalopsyllidae, Stephanocircidae and Ctenophthalmidae are frequently found on wild rodents, differently from the species of Pulicidae which infest mainly commensal rats and other domestic hosts (Azad et al. 1997). Nine hundred and ten out of 924 fleas collected were wild fleas and 14 cosmopolitan fleas (Table III). Among the wild fleas, 804 (88.4%) were found on wild rodents and 106 (11.6%) on commensal rats. Otherwise, while nine of the cosmopolitan fleas were observed on commensal rats (64.3%), only five were found on wild rodents (35.7%). So, in this interchange, wild fleas are most common on commensal rats, rather than cosmopolitan fleas on wild rodents, as demonstrated by Guimarães (1972) in the Brazilian northeast (Table III).

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TABLE II

Number of flea species according to municipal districts, captured in the focus of bubonic plague of the Serra dos Órgãos mountain range, from November 1995 to October 1997

Municipalities and localities	Families and species of fleas											Total	
	Ctenophthalmidae	Pulicidae			Rhopalopsyllidae						Stephanocircidae		
	Adoratopsylla a. antiquorum	*Ctenocephalides f. felis*	*Pulex irritans*	*Xenopsylla cheopis*	*Polygenis atopus*	*Polygenis pygaerus*	*Polygenis pradoi*	*Polygenis rimatus*	*Polygenis roberti*	*Polygenis tripus*	*Craneopsylla minerva*	No.	%
Nova Friburgo	1	4	2	6	100	17	129	249	1	-	100	609	66
Campo do Coelho	-	-	-	3	14	1	12	30	-	-	6	66	7.1
Cardinot	-	-	-	-	4	-	-	16	-	-	18	38	4.1
Conquista	-	-	-	-	1	-	2	2	-	-	2	7	0.8
Centenário	-	-	-	-	6	3	2	16	1	-	4	32	3.5
Córrego Grande	1	-	-	1	22	11	49	64	-	-	18	166	18
Floresta	-	-	-	-	1	-	3	1	-	-	2	7	0.8
Palmital	-	-	-	2	3	-	2	13	-	-	16	36	3.9
Patrocínio	-	-	-	-	1	-	2	3	-	-	1	7	0.8
Rio Grande	-	2	1	-	31	1	22	34	-	-	30	121	13
Salinas	-	2	1	-	4	-	5	20	-	-	-	32	3.5
Santa Cruz	-	-	-	-	3	1	8	13	-	-	1	26	2.8
São Lourenço	-	-	-	-	-	-	6	28	-	-	-	34	3.7
Três Cachoeiras	-	-	-	-	10	-	16	9	-	-	2	37	4
Sumidouro	-	-	-	-	12	5	33	61	-	-	39	150	16
Águas Claras	-	-	-	-	-	-	7	8	-	-	3	18	1.9
Arrozal	-	-	-	-	11	-	-	19	-	-	4	34	3.7
Benfica	-	-	-	-	-	-	15	7	-	-	16	38	4.1
Botafogo	-	-	-	-	1	3	2	7	-	-	12	25	2.7
Campinas	-	-	-	-	-	-	5	1	-	-	-	6	0.6
Campo Leal	-	-	-	-	-	-	-	3	-	-	-	3	0.3
Santo André	-	-	-	-	-	-	3	14	-	-	1	18	1.9
São Bento	-	-	-	-	-	2	1	2	-	-	3	8	0.9
Teresópolis	-	-	-	2	27	3	23	72	-	2	36	165	18
Águas Quentes	-	-	-	-	2	-	1	5	-	-	1	9	1
Fazenda Bemposta	-	-	-	-	2	-	-	-	-	-	-	2	0.2
Mariana	-	-	-	-	-	-	1	2	-	-	-	3	0.3
Motas	-	-	-	-	10	-	5	20	-	2	16	55	6
Santa Rita	-	-	-	-	9	1	2	18	-	-	1	31	3.4
Santa Rosa	-	-	-	-	1	2	7	10	-	-	4	24	2.6
Serra do Vieira	-	-	-	2	3	-	7	16	-	-	13	41	4.3
Volta do Pião	-	-	-	-	-	-	-	1	-	-	1	2	0.2
Total	1	4	2	8	139	25	185	382	1	2	175	924	100
(%)	0.1		1.5				79.5				18.9	100	

%: frequency of fleas in municipalities and in localities; (%): frequency of flea families

TABLE III

Frequency of the flea species collected from small rodents of the focus of bubonic plague of the Serra dos Órgãos mountain range, from November 1995 to October 1997

Flea species	Host species																							
	Akodon cursor			*Nectomys squamipes*			*Oligoryzomys nigripes*			*Oryzomys angoya*			*Oxymicterus judex*			*Thaptomys nigrita*			*Rattus rattus*			Total		
	No.	%	(%)	No.	%	(%)	No.	%	(%)	No.	%	(%)	No.	%	(%)	No.	%	(%)	No.	%	(%)	No.	%	(%)
A. antiquorum	-	-	-	1	100	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	0.1
C. minerva	123	70.3	27.8	2	1.1	2.3	9	5.1	12	1	0.6	10	26	14.8	14.7	6	3.4	33.3	8	4.6	6.9	175	100	18.9
C. felis	-	-	-	-	-	-	1	25	1.3	-	-	-	-	-	-	-	-	-	3	75	2.6	4	100	0.4
P. atopus	24	17.3	5.4	35	25.2	40.7	34	24.5	45.3	2	1.4	20	11	7.9	6.2	-	-	-	33	23.7	28.8	139	100	15
P. pygaerus	9	36	2	2	8	2.3	-	-	-	-	-	-	10	40	5.6	2	8	11.1	2	8	1.7	25	100	2.7
P. pradoi	153	82.7	34.6	3	1.6	3.5	1	0.5	1.3	-	-	-	14	7.6	7.9	1	0.5	5.6	13	7	11.3	185	100	20
P. rimatus	130	34	29.4	3	11.2	50	29	7.6	38.7	7	1.8	70	115	30.1	65	8	2.1	44.4	50	13.1	43.5	382	100	41.3
P. roberti	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	5.6	-	-	-	1	100	0.1
P. tripus	2	100	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	100	0.2
P. irritans	-	-	-	-	-	-	1	50	1.3	-	-	-	1	50	0.6	-	-	-	-	-	-	2	100	0.2
X. cheopis	2	25	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	75	5.2	8	100	0.9
Total	443	47.9	100	86	9.3	100	75	8.1	100	10	1.1	100	177	19.3	100	18	1.9	100	115	12.4	100	924	100	100

No.: number of caught fleas; %: frequency of fleas among rodent species; (%): frequency among flea species

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