

Arthropod parasites of the red-bellied squirrel *Callosciurus erythraeus* introduced into Argentina

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Abstract. The introduction of an exotic species usually modifies parasite–host dynamics by the import of new parasites or the exotic species’ acquiral of local parasites. The loss of parasites may determine the outcome of an invasion if the introduced species is liberated from co-evolved parasites in its range of invasion. In addition, an introduced species may pose sanitary risks to humans and other mammals if it serves as a reservoir of pathogens or carries arthropod vectors. The red-bellied squirrel, *Callosciurus erythraeus* (Pallas) (Rodentia: Sciuridae), was introduced into Argentina in 1970, since when several foci of invasion have been closely associated with humans. Investigation of the parasitological fauna of *C. erythraeus* in Argentina will generate new information about novel parasite–host dynamics and may provide new insight into the reasons for the successful invasion of this species. The objective of this study was to describe the arthropod parasites of *C. erythraeus* in Argentina in comparison with previous studies of parasites of this species in its native habitat and in the ranges of its invasion. Occasional host–parasite associations with local arthropod parasites not previously described for *C. erythraeus* are reported; these include the mites *Androlaelaps fahrenheitzi* (Ewing) (Mesostigmata: Laelapidae) and *Ornithonyssus* cf. *bacoti* (Mesostigmata: Macronyssidae), the flea *Polygenis* (*Polygenis*) *rimatus* Jordan (Siphonaptera: Rhopalopsyllidae) and the botfly *Cuterebra* Clark (Diptera: Oestridae: Cuterebrinae). *Cheyletus* sp. mites (Trombidiformes: Cheyletidae) were also found. The low prevalence and mean intensity of ectoparasite species may influence invasion dynamics.

Key words. *Callosciurus erythraeus*, botfly, fleas, invasive species, mites, parasite–host dynamics.

Introduction

The introduction of an exotic species usually modifies existing parasite–host dynamics because new parasites are imported from their native range into the recipient community and because the exotic host may acquire new parasites from native hosts, especially if a parasite is able to expand its host range (Tompkins & Poulin, 2006). Parasites may also play an important role in the outcome of the invasion process, as

has been reported for several introduced species that have escaped the negative effects of parasitism (Torchin *et al.*, 2003). Introduced squirrels have been reported to pose sanitary risks to humans and native species by their carriage of arthropod vectors that may transmit pathogens (Craine *et al.*, 1995; Shinozaki *et al.*, 2004; Pisanu *et al.*, 2010; Marsot *et al.*, 2011). However, the role of these parasites in the success of an exotic species’ invasion is still unclear.

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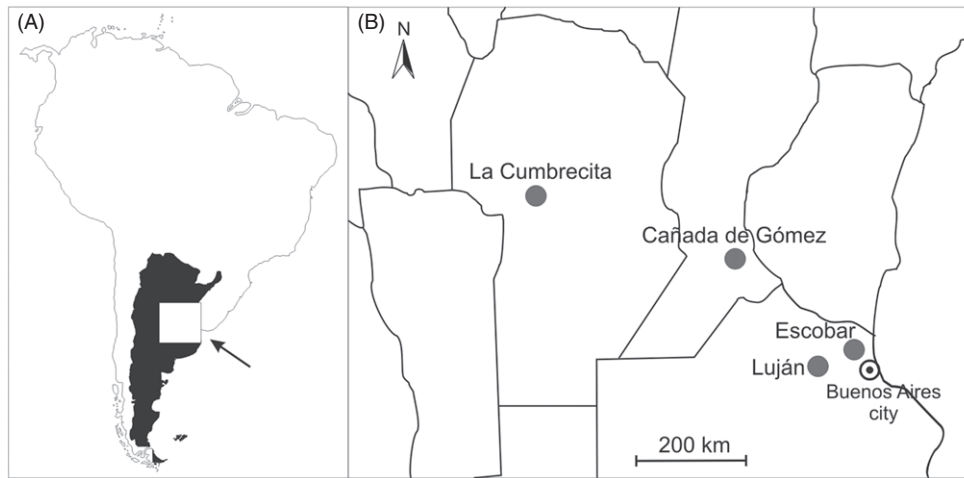


Fig. 1. (A) Location of the area of interest within Argentina, and (B) locations of the four invasion foci next to the cities of Luján and Escobar in Buenos Aires province, Cañada de Gómez in Santa Fé province, and La Cumbrecita in Córdoba province.

The red-bellied squirrel, *Callosciurus erythraeus* (Pallas), is native to Southeast Asia and was intentionally introduced into Argentina, Belgium, France, Japan and the Netherlands (Tamura, 2009). The origin of the first wild population in Argentina is well known: in 1970 10 red-bellied squirrels were obtained from a pet shop in the Netherlands and taken to a ranch near the town of Jáuregui (34°34' S, 59°11' W), Luján district, Buenos Aires province (Aprile & Chicco, 1999). By 1973, about five individuals had escaped or had been released from captivity; these animals initiated a population that has increased in abundance and range distribution to manifest in a predicted invasion of major proportions (Guichón & Doncaster, 2008). This arboreal squirrel inhabits rural and urban areas in close association with humans and domestic animals (Guichón *et al.*, 2005) and has spread successfully, creating new foci of invasion, by virtue of repeated translocations and the trade in exotic pets (Benitez *et al.*, 2010).

No previous parasitological studies have been conducted on the red-bellied squirrel in Argentina. Therefore, the aim of this study was to describe the fauna of arthropod parasites associated with this species in all invasion foci confirmed in Argentina. The results are interpreted in the context of the

invasion process according to previous findings in native and other introduced ranges.

Materials and methods

Between November 2008 and March 2010, red-bellied squirrels were trapped alive in all invasion foci in Argentina: (a) Luján, Buenos Aires province, where two study sites located 10 km apart were sampled: National University of Luján (34°33' S, 59°07' W) and Open Door (34°30' S, 59°04' W); (b) Escobar (34°21' S, 58°48' W), Buenos Aires province, 35 km from Luján; (c) Cañada de Gómez (32°48' S, 61°23' W), Santa Fe province, 290 km from Luján, and (d) La Cumbrecita (31°53' S, 64°46' W), Córdoba province, 610 km from Luján (Fig. 1). Distances amongst study sites exceeded the daily movements and the expected dispersal distances of this species (Guichón & Doncaster, 2008). Squirrels inhabit rural, suburban and urban habitats where they live in highly fragmented woodland patches mainly composed of introduced tree species. In each study site, 30–50 cage traps were set at fixed points 40 m apart on tree branches for 4 days consecutively. All captured squirrels were anaesthetized

Table 1. Arthropod parasites recovered from 437 red-bellied squirrels, *Callosciurus erythraeus*, captured between November 2008 and March 2010 in four invasion foci in Argentina.

Arthropods	Squirrels, <i>n</i>	Arthropods collected, <i>n</i>	Prevalence	Intensity, mean (range)	Invasion foci
Siphonaptera (fleas)					
<i>Polygenis (Polygenis) rimatus</i> (Jordan, 1932)	3	4	0.68%	1.3 (1–2)	Lu
Diptera (botflies)					
<i>Cuterebra</i> sp.	4	4	0.91%	1.0	Lu, Es
Acari (mites)					
Mesostigmata <i>Androlaelaps fahrenheitsi</i> (Ewing, 1925)	3	4	0.68%	1.3 (1–2)	Lu, CG
<i>Ornithonyssus</i> cf. <i>bacoti</i>	1	1	0.23%	–	Lu
Trombidiformes <i>Cheyletus</i> sp. (group <i>eruditus</i>)	26	41	5.90%	1.6 (1–6)	Lu, Es, CG, LC

CG, Cañada de Gómez, *n* = 28; Es, Escobar, *n* = 39; LC, La Cumbrecita, *n* = 10; Lu, Luján, *n* = 390).

Table 2. Arthropod parasites reported for *Callosciurus erythraeus* indicating known parasite distribution and squirrels' site of collection.

Arthropod species	Known geographical distribution	Site of collection	References
Insecta			
Siphonaptera (fleas)			
Stivaliidae			
<i>Medwayella robinsoni</i> (Rothschild, 1905)	Malayan and Indo-Chinese subregions; Malaysia, Thailand*	Malayan peninsula	Shinozaki <i>et al.</i> (2004)
Ceratophyllidae			
<i>Monopsyllus anisus</i> Rothschild, 1907	Central and East Asia, Siberian province; Japan, China, Russia*	Japan	Shinozaki <i>et al.</i> (2004)
<i>Nosopsyllus fasciatus</i> (Bosc, 1800)	Worldwide*	France	Dozières <i>et al.</i> (2010)
<i>Ceratophyllus euteles</i> (Jordan & Rothschild, 1911)	Indo-Chinese and East Asian subregions; China*	China	Jordan (1932)
<i>Macrosylophora bispiniflora</i> Li <i>et al.</i> 1976	East Asian subregion; China*	China	Li <i>et al.</i> (1976)
<i>Macrosylophoralia</i> (Wang Dwenching, 1957)	East Asian subregion; China*	Southeast Asia	Traub (1972)
<i>Megathoracipsylla pentagonia</i> Liu <i>et al.</i> 1980	East Asian subregion; China*	China	Liu <i>et al.</i> (1982)
Rhopalopsyllidae			
<i>Polygenis</i> (<i>Polygenis</i>) <i>rimatus</i> (Jordan, 1932)	Patagonian, Andean and Brazilian subregions Argentina, Brazil*	Argentina	Present study
Phthiraptera (lice) Anoplura			
Enderleinellidae			
<i>Enderleinellus kumadai</i> Kaneko, 1954	Borneo, Malaysia, Taiwan, Thailand (southern Asia†‡)	Belgium, France, Japan	Durden & Musser (1994); Dozières <i>et al.</i> (2010)
<i>Enderleinellus corrugatus</i> Johnson, 1959	China, Hainan Island, Thailand (southern Asia†‡)	China, Thailand	Chin (1979); Durden & Musser (1994)
Hoplopleuridae			
<i>Hoplopleura erismata</i> Ferris, 1921	India, Malaysia, China, Thailand (southern Asia†‡)	Belgium, China	Blagoveshchenskiy (1972); Durden & Musser (1994); Dozières <i>et al.</i> (2010)
Polyplocidae			
<i>Neohaematopinus callosciuri</i> Johnson, 1959	Borneo, Malaysia, China, Taiwan, Thailand (southern Asia†‡)	Japan, Thailand, China	Blagoveshchenskiy (1972); Durden & Musser (1994); Shinozaki <i>et al.</i> (2004); Zuo <i>et al.</i> (2011)
Diptera (botflies)			
Oestridae (Cuterebrinae)			
<i>Cuterebra</i> sp.	America§	Argentina	Present study
Arachnida			
Acari (mites and ticks)			
Mesostigmata (mites)			
Laelapidae			
<i>Laelaps nuttalli</i> Hirst, 1915	Worldwide¶	China	Huang <i>et al.</i> (2010)
<i>Laelaps turkestanicus</i> Lange, 1955	Asia, former USSR¶, China**	China	Huang <i>et al.</i> (2010)
<i>Laelaps traubi</i> Domrow, 1962	China**	China	Huang <i>et al.</i> (2010)
<i>Eulaelaps dremomydis</i> Gu & Wang, 1984	China**	China	Huang <i>et al.</i> (2010)
<i>Androlaelaps fahrenheitzi</i> (Ewing, 1925)	Worldwide¶	Argentina	Present study
<i>Hypoaspis pavlovskii</i> (Bregestova, 1955)	China**	China	Huang <i>et al.</i> (2010)
Macronyssidae			
<i>Ornithonyssus cf. bacoti</i>	Worldwide¶	Argentina	Present study

Table 2. Continued

Arthropod species	Known geographical distribution	Site of collection	References
Haemogamasidae (mites)			
<i>Haemogamasus kitanoi</i> Asanuma, 1948	Asia, Russia	Taiwan	Allred (1969) in Shinozaki <i>et al.</i> (2004)
<i>Haemogamasus dorsalis</i> Teng & Pan, 1964	China**	China	Huang <i>et al.</i> (2010)
<i>Haemogamasus oliviformis</i> Teng & Pan, 1964	China**	China	Huang <i>et al.</i> (2010)
Ixodida (ticks) Ixodidae			
<i>Haemaphysalis flava</i> Neumann, 1897	Japan, China, Taiwan, South Korea, Russia††††	Japan	Shinozaki <i>et al.</i> (2004)
<i>Ixodes kunitzi</i> Hoogstraal & Kohls, 1965	Nepal, Taiwan††††	Taiwan	Hoogstraal & Kohls (1965)
Trombidiformes (mites)			
Cheyletidae			
<i>Cheyletus</i> sp. (group <i>eruditus</i>)	Worldwide§§	Argentina	Present study

*Medvedev *et al.* (2011); †Durdan & Musser (1994); ‡Orrell (2011); §Pape (2001); ¶Strandtmann & Wharton (1958); **Huang *et al.* (2010); ††Kolonin (2009); †††Guglielmone *et al.* (2003); ††††Fain & Bochkov (2001).

subcutaneously using a ketamine–acepromazine mixture and their fur was combed and brushed. Squirrels were released after each trapping session and ectoparasites were recovered only at first capture. Samples of arthropods were filtered and stored in 96% ethyl alcohol. Filter papers were examined using a stereomicroscope and arthropods were individually prepared for identification. Mites were cleared in lactophenol and slide-mounted in Hoyer's medium; fleas were cleared in potassium hydroxide, dehydrated in ethanol of consecutive grades (80%, 90% and 100%) and slide-mounted on Canada Balsam. An optic microscope (10× and 40×) was used for taxonomic identification carried out in accordance with related keys and descriptions (Strandtmann & Wharton, 1958; Furman, 1972; Smit, 1987; Welbourn, 2006). Krantz and Walter (2009) was followed for higher taxa of Acari. Botfly larvae were removed with forceps and stored in 96% ethyl alcohol before identification using a stereomicroscope.

The prevalence of each arthropod species was calculated as the percentage of the total number of hosts examined that were parasitized with that species. Mean intensity was calculated as the total number of individuals of a particular parasite species over the total number of parasitized hosts (Bush *et al.*, 1997).

Results

A total of 437 red-bellied squirrels were captured in the four invasion foci in Argentina during the study period. This allowed the description of parasites belonging to three taxa of arthropods (Table 1). The flea *Polygenis (Polygenis) rimatus* Jordan, the mites *Androlaelaps fahrenheiti* (Ewing) and *Ornithonyssus* cf. *bacoti*, and the botfly larvae *Cuterebra* Clark were each identified in one or two invasion foci. Mites *Cheyletus* sp. group *eruditus* were found in the four invasion foci established in Argentina. Cheyletidae mites showed a higher prevalence (5.9%) than the parasitic arthropods (<1%). A relatively low mean intensity of one to two arthropods per squirrel was recorded in all groups (Table 1).

Discussion

The parasites reported in this study have not been previously listed for the red-bellied squirrel in either its native habitat or in areas to which it has been introduced (Table 2). Arthropod parasites associated with this species in its native range include several species of Siphonaptera and Laelapidae, three species of lice (Phthiraptera: Anoplura) and one species of tick (Ixodida: Ixodidae) (Table 2). None of the genera of laepid mites associated with the red-bellied squirrel in southwest China have ever been reported in Argentina, except for *Laelaps nuttalli* (Hirst, 1915) (Lareschi & Mauri, 1998). In other areas into which red-bellied squirrels have been introduced, such as in Belgium, France and Japan, these squirrels have been found to have carried parasites from their native range into the recipient community and also to have acquired new parasites from co-inhabiting native hosts (Table 2) (Shinozaki *et al.*, 2004; Dozières *et al.*, 2010).

The mites *A. fahrenheiti* and *O. cf. bacoti*, and the flea *P. (P.) rimatus* have worldwide or American distributions (Lareschi & Mauri, 1998; Linardi & Guimarães, 2000) and are usually associated with sigmodontine rodents and marsupials (Autino & Lareschi, 1998; Lareschi & Mauri, 1998), which are native hosts sympatric with the red-bellied squirrel in Argentina. *Cheyletus* sp. mites have a worldwide distribution, are predators and are mostly associated with nests of birds and mammals or grain stores (Fain & Bochkov, 2001). *Cheyletus* sp. (group *eruditus*) mites are associated with nests of squirrels, including *Callosciurus* squirrels (Fain & Bochkov, 2001), although this is the first record of their association with *C. erythraeus*. *Cuterebra* is a Neotropical genus of an obligate subcutaneous parasite botfly (Colwell *et al.*, 2006). In Argentina, these larvae have been reported in sigmodontine rodents (Zuleta & Vignau, 1990) and a native squirrel [Berg, 1876 in Guimarães *et al.*, 1983; see Pape (2001) for synonymia].

The low prevalence and mean intensity values of parasitic arthropods of the red-bellied squirrel in Argentina may be explained by the history of its introduction, the lack of sympatric phylogenetically related mammals, and its highly arboreal habits. These prevalences and mean intensity values of parasitic arthropods were lower than those reported for the red-bellied squirrel in other areas to which it has been introduced (Shinozaki *et al.*, 2004; Dozières *et al.*, 2010), where the success of its invasion in terms of range expansion and abundance seems lower than in Argentina (Tamura, 2004; Gerriet, 2009; Benitez *et al.*, 2010). Community-scale comparisons (Colautti *et al.*, 2004) also suggest a lower level of parasitism in red-bellied squirrels than in other co-inhabiting mammals (Lareschi *et al.*, 2003; A. C. Gozzi *et al.*, unpublished data, 2011). These findings suggest that the successful invasion of this exotic species may have been, in part, supported by its release from natural parasites.

This study indicates that the red-bellied squirrel introduced into Argentina serves as an occasional host of local parasites acquired mainly from sympatric wild mammals. Some of the arthropod parasites of *C. erythraeus* in Japan are competent vectors of pathogens (Shinozaki *et al.*, 2004) and although the mite *O. cf. bacoti* and the flea *P. (P.) rimatus* were not tested for vector competence, the genus *Polygenis* Jordan is implicitly involved in the maintenance of sylvatic plague among wild rodents (Linardi & Guimarães, 2000), and the mite *Ornithonyssus bacoti* Hirst is known to be a potential vector of pathogens such as *Rickettsia* species (Reeves *et al.*, 2007). The sanitary risks posed by the red-bellied squirrel in Argentina to native fauna seem to be low at present; however, given this species' urban and rural habits and the fact that it is perceived as an attractive animal and is thus the object of an illegal pet trade, preventive measures should be put in place to limit potential sanitary risks until further parasitological and zoonotic studies are concluded.

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References

- Aprile, G. & Chicco, D. (1999) Nueva especie exótica de mamífero en la Argentina: la ardilla de vientre rojo (*Callosciurus erythraeus*). *Mastozoología Neotropical*, **6**, 7–14.
- Autino, A.G. & Lareschi, M. (1998) Siphonaptera. *Biodiversidad de Artrópodos Argentinos. Una Perspectiva Biotaxonomía* (ed. by J. J. Morrone & S. Coscarón), pp. 279–290. Ediciones Sur, La Plata.
- Benitez, V.V., Gozzi, A.C., Borgnia, M., Almada Chávez, S., Messetta, M.L., Clos Clos, G. & Guichón, M.L. (2010) La ardilla de vientre rojo en Argentina: investigación y educación, puntos clave para el manejo de una especie invasora. *Invasiones Biológicas: Avances 2009. Proceedings of the Third National Congress on Biological Invasions* [ed. by GEIB Grupo de Especialistas en Invasiones Biológicas]. Serie Técnica N. 4, pp. 255–260. Imprenta El Ejido, León.
- Blagoveshchenskiy, D.I. (1972) Mallophaga and Anoplura from some mammals of China and Vietnam. *Entomological Review*, **51**, 185–190.
- Bush, A.O., Lafferty, K.D., Lotz, J.M. & Shostak, A.W. (1997) Parasitology meets ecology on its own terms: Margolis *et al.* revisited. *Journal of Parasitology*, **83**, 575–583.
- Chin, T.H. (1979) A new species of the family Enderleinellidae Anoplura. *Entomotaxonomia*, **1**, 121–124.
- Colautti, R.I., Ricciardi, A., Grigorovich, I.A. & Macisaac, H.J. (2004) Is invasion success explained by the enemy release hypothesis? *Ecology Letters*, **7**, 721–733.
- Colwell, D.D., Hall, M.J.R. & Scholl, P.J. (eds) (2006) *The Oestrid Flies: Biology, Host-Parasite Relationships, Impact and Management*. CABI Publishing, Oxford.
- Craine, N.G., Randolph, S.E. & Nuttall, P.A. (1995) Seasonal variation in the role of grey squirrels as hosts of *Ixodes ricinus*, the tick vector of the Lyme disease spirochaete, in a British woodland. *Folia Parasitologica*, **42**, 73–80.
- Dozières, A., Pisanu, B., Gerriet, O., Lapeyre, C., Stuyck, J. & Chapuis, J.-L. (2010) Macroparasites of Pallas's squirrels, *Callosciurus erythraeus*, introduced into Europe. *Veterinary Parasitology*, **172**, 172–176.
- Durden, L.A. & Musser, G.G. (1994) The sucking lice (Insecta, Anoplura) of the world. A taxonomic checklist with records of mammalian hosts and geographical distributions. *Bulletin of the American Museum of Natural History*, **218**, 1–90.

- Fain, A. & Bochkov, V. (2001) A review of the genus *Cheyletus* Latrielle, 1796 (Acari: Cheyletidae). *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique*, **71**, 83–114.
- Furman, D.P. (1972) Laelapid mites (Laelapidae: Laelapinae) of Venezuela. *Brigham Young Science Bulletin of Biological Series*, **27**, 1–58.
- Gerriet, O. (2009) Répartition de l'écureuil à ventre rouge *Callosciurus erythraeus* (Pallas, 1779) (Rodentia, Sciuridae) dans les Alpes-Maritimes (France). *Bioscience Méso-géén (Nice)*, **26**, 139–148.
- Guglielmone, A.A., Estrada-Peña, A., Keirans, J.E. & Robbins, R.G. (2003) Ticks (Acari: Ixodidae) of the Neotropical Zoogeographic Region. International Consortium on Ticks and Tick-Borne Diseases, Atlanta, Houten.
- Guichón, M.L. & Doncaster, C.P. (2008) Invasion dynamics of an introduced squirrel in Argentina. *Ecography*, **31**, 211–220.
- Guichón, M.L., Fasola, L. & Bello, M. (2005) Expansión poblacional de una especie introducida en la Argentina: la ardilla de vientre rojo *Callosciurus erythraeus*. *Maztozoología Neotropical*, **12**, 189–197.
- Guimarães, J.H., Papavero, N. & Pires do Prado, A. (1983) As míases na região neotropical (identificação, biologia, bibliografia). *Revista Brasileira de Zoologia*, **1**, 239–416.
- Hoogstraal, H. & Kohls, G.M. (1965) Description, hosts, and ecology of *Ixodes kuntzi* n. sp., Kuntz's Taiwan flying squirrel tick (Ixodoidea: Ixodidae). *Journal of Medical Entomology*, **2**, 209–214.
- Huang, L.-Q., Guo, X.-G., Wu, D. & Zhou, D.-H. (2010) Distribution and ecological niches of gamasid mites (Acari: Mesostigmata) on small mammals in southwest China. *Psyche*, 2010. doi:10.1155/2010/934508.
- Kolonin, G.V. (2009) Fauna of ixodid ticks of the world (Acari, Ixodidae). <http://www.kolonin.org> [Accessed 20 September 2011].
- Krantz, G.W. & Walter, D.E. (eds) (2009) *A Manual of Acarology*. Texas Tech University Press, Lubbock, Texas.
- Lareschi, M. & Mauri, R. (1998) Dermanysoidea. *Biodiversidad de Artrópodos Argentinos. Una Perspectiva Biotaxonómica* (ed. by J. J. Morrone & S. Coscarón), pp. 581–590. Ediciones Sur, La Plata.
- Lareschi, M., Notarnicola, J., Navone, G. & Linardi, P.M. (2003) Arthropod and filarioid parasites associated with wild rodents in the northeast marshes of Buenos Aires, Argentina. *Memórias do Instituto Oswaldo Cruz*, **98**, 673–677.
- Li, K.-C., Hsieh, P.-C. & Yang, H.-T. (1976) A new species of the genus *Macrostylophora* (Siphonaptera: Ceratophyllidae). *Acta Entomologica Sinica*, **19**, 345–347.
- Linardi, P.M. & Guimarães, L.R. (2000) *Siphonápteros do Brasil*. Museu de Zoologia Universidad de São Paulo/Fundação de Amparo à Pesquisa do Estado de São Paulo, São Paulo, SP.
- Liu, C.Y., Zhang, D. & Liu, Q. (1982) Notes on *Megathoracipsylla pentagonia* and its unknown female (Siphonaptera: Ceratophyllidae). *Entomotaxonomia*, **4**, 37–38.
- Marsot, M., Sigaud, M., Chapuis, J.-L., Ferquel, E., Cornet, M. & Vourc'h, G. (2011) Introduced Siberian chipmunks (*Tamias sibiricus barberi*) harbour more diverse *Borrelia burgdorferi sensu lato* genospecies than native bank voles (*Myodes glareolus*). *Applied and Environmental Microbiology*, **77**, 5716–5721.
- Medvedev, S., Lobanov, A. & Lyangouzov, I. (2011) Parhost: World Database of Fleas (Version 2, November 2005). *ITIS Catalogue of Life* (ed. by F. A. Bisby, Y. R. Roskov, T. M. Orrell et al.). Species 2000, Reading. <http://www.catalogueoflife.org/col> [Accessed 24 September 2011].
- Orrell, T. (custodian) (2011) ITIS: The Integrated Taxonomic Information System (April 2011). *ITIS Catalogue of Life* (ed. by F. A. Bisby, Y. R. Roskov, T. M. Orrell et al.). Species 2000, Reading. <http://www.catalogueoflife.org/col> [Accessed 25 September 2011].
- Pape, T. (2001) Phylogeny of Oestridae (Insecta: Diptera). *Systematic Entomology*, **26**, 133–171.
- Pisanu, B., Marsot, M., Marmet, J., Chapuis, J.-L., Réale, D. & Vourc'h, G. (2010) Introduced Siberian chipmunks are more heavily infested by ixodid ticks than are native bank voles in a suburban forest in France. *International Journal of Parasitology*, **40**, 1277–1283.
- Reeves, W.K., Loftis, A.D., Szumlas, D.E., Abbassy, M.M., Helmy, I.M., Hanafi, H.A. & Dasch, G.A. (2007) Rickettsial pathogens in the tropical rat mite *Ornithonyssus bacoti* (Acari: Macronyssidae) from Egyptian rats (*Rattus* spp.). *Experimental and Applied Acarology*, **41**, 101–107.
- Shinozaki, Y., Shiibashi, T., Yoshizawa, K. et al. (2004) Ectoparasites of the Pallas squirrel, *Callosciurus erythraeus*, introduced to Japan. *Medical and Veterinary Entomology*, **18**, 61–63.
- Smit, F.G.A.M. (1987) *An Illustrated Catalogue of the Rothschild Collection of Fleas (Siphonaptera) in the British Museum (Natural History)*, Vol. 7: *Malacopsylloidea (Malacopsyllidae and Rhopalopsyllidae)*. Oxford University, London.
- Strandtmann, R.W. & Wharton, G.W. (1958) *A Manual of Mesostigmatid Mites* (ed. by E. Conrad & E. Yunker). Contribution Number 4, Institute of Acarology, Department of Zoology, University of Maryland, College Park, MD.
- Tamura, N. (2004) Population dynamics and expansion of introduced Formosan squirrels in Kanagawa Prefecture, Japan. *Japanese Journal of Conservation Ecology*, **9**, 37–44.
- Tamura, N. (2009) *Datasheet on Callosciurus erythraeus (Pallas's Squirrel)*. CAB International. <http://www.cabi.org/isc/> [Accessed 20 May 2012].
- Tompkins, D.M. & Poulin, R. (2006) Parasites and biological invasions. *Biological Invasions in New Zealand*, Vol. 186: *Ecological Studies* (ed. by R. B. Allen & W. G. Lee), pp. 67–84. Springer-Verlag, Berlin, Heidelberg.
- Torchin, M.E., Lafferty, K.D., Dobson, A.P., McKenzie, V.J. & Kuris, A.M. (2003) Introduced species and their missing parasites. *Nature*, **421**, 628–630.
- Traub, R. (1972) The Gunong Benom expedition 1967. Notes on zoogeography, convergent evolution and taxonomy of fleas (Siphonaptera), based on collections from Gunong Benom and elsewhere in Southeast Asia. III. Zoogeography. *Bulletin of the British Museum (Natural History) Zoology*, **23**, 389–450.
- Welbourn, W.C. (2006) Key to the subfamilies of Cheyletidae. Key to the Genera of Cheyletinae (Acari: Raphignata). Ohio State University Acarology Summer Programme, Soil Acarology, pp. 253–291.
- Zuleta, G.A. & Vignau, M.L. (1990) Botfly parasitism (*Rogenhofera bonaerensis*) (Diptera, Cuterebridae) in the Pampean grassland mouse (*Akodon azarae*), in Argentina. *Journal of Wildlife Diseases*, **26**, 11–17.
- Zuo, X.-H., Guo, X.-G., Zhan, Y.-Z. et al. (2011) Host selection and niche differentiation in sucking lice (Insecta: Anoplura) among small mammals in southwestern China. *Parasitology Research*, **108**, 1243–1251.

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