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SHORT COMMUNICATION

New hosts for the mite *Ornithonyssus bursa* in Argentina

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Abstract. The mite *Ornithonyssus bursa* (Berlese) (Mesostigmata: Macronyssidae) is considered a poultry pest causing important infestations in chickens and it is considered a potential vector of arbovirus. Despite being considered a common parasite in wild birds, there is scarce published information about its potential hosts and effects on them. Here we present new bird hosts for *O. bursa*, assess the presence of Alphavirus, Flavivirus and Bunyavirus in mites from three host species, and discuss its potential impact on wild bird populations. We found *O. bursa* infecting five raptor and six passerine wild bird species. For nine of these species, this is the first record of infection by *O. bursa*. Although all analysed mites were negative for the examined arboviruses, the small sample size of mites does not allow further conclusions at the present moment. Because of the general nature of this ectoparasite, its presence in migratory long dispersal and endangered bird species, and the seropositivity for arboviruses in some of the species studied here, we consider it critical to assess the role of *O. bursa* and other ectoparasites as vectors and reservoirs of pathogens and as potential deleterious agents in wild bird populations.

Key words. *Ornithonyssus bursa*, birds, ectoparasites, mites, tropical fowl mite, Argentina.

Ectoparasites can potentially produce direct and indirect pathological effects on their hosts or act as vectors of infectious agents, such as blood protozoans, filarid nematodes, bacteria and viruses [e.g. Equine Encephalomyelitis Virus (EEV) and West Nile Virus (WNV); Turell, 2009].

Viruses and bacteria are the most diverse groups of pathogens transmitted by arthropods, followed by protozoa and filarial nematodes. A wide range of life-cycle patterns and degrees of host associations are characterized by arthropod vectors (Turell, 2009).

More than 250 species of mites have been reported as the causative agents of health-related problems for humans and animals, including the transmission of pathogenic microbial agents and metazoan parasites. Mites have been successful in exploiting vertebrate hosts, with some acting as disease vectors of domestic and wild animals (Mullen & O'Connor, 2009).

The genus *Ornithonyssus* includes two cosmopolitan species, the tropical fowl mite *Ornithonyssus sylviarum* (Canestrini & Fanzago) (Mesostigmata: Macronyssidae). Both are obligate haematophagous ectoparasites of domestic and wild birds, and

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can be found on bird's skin and nests (Philips, 1990; Mullen & O'Connor, 2009). *Ornithonyssus bursa* is widely distributed throughout subtropical and tropical areas (Philips, 1990; Mullen & O'Connor, 2009). It is considered a poultry pest causing ubiquitous infestations in chickens, and can cause anaemia, decreased weight gain and egg production, feather asymmetry, and occasionally death in newly hatched and young birds. In addition, it is considered a potential vector of encephalitis viruses such as Western Equine Encephalitis (WEE) and Saint-Louis Encephalitis virus (SLV) (Valiente Moro *et al.*, 2005; Mullen & O'Connor, 2009). Besides domestic fowl, it also parasitizes peridomestic birds such as ducks, pigeons, starlings, house sparrows and canaries (Philips, 1990; Mullen & O'Connor, 2009). Humans are occasionally bitten by the mites when bird nests are placed near human settlements and nest mites disperse in search of food after the chicks leave the nest (Philips, 1990; Mullen & O'Connor, 2009).

Despite that this ectoparasite is considered a common mite in wild birds, there is scarce published information about its potential hosts and about the effects they may have on them. Additionally, there is as yet no information on its capacity to effectively spread encephalitis viruses such as WEE, WNV and SLV (Miles, 1960; Valiente Moro *et al.*, 2005; Mullen & O'Connor, 2009). In Argentina, *O. bursa* has been recorded infecting wild birds and also humans (Liébana *et al.*, 2011; Arrabal *et al.*, 2012). To contribute to our understanding of *O. bursa*, we investigated its prevalence on bird hosts and assayed for arbovirus prevalence. Finally, its potential impact on wild bird populations for which there are conservation concerns is discussed.

The sampling was conducted in two different ecosystems located in La Pampa province in central Argentina, the xerophytic open forests of caldén *Prosopis caldenia* (Linneo) (Fabales: Fabaceae) in the centre of the province, and in agroecosystems in the transition between the forests to the Pampas grasslands in the northeastern part of the province. Mites were collected from raptors and songbirds (from both young and adult birds). Adult songbirds were captured with mist nets whereas adult raptors were captured using different methods (mist-nets, bal-chatri and walk-in traps). Most young birds were captured at the nest (nest-boxes and natural nests). All captures were performed during the austral breeding seasons (August to February) between 2007 and 2012. Birds were aged, sexed, banded and handled for 10–60 min (depending on the species), during which time ectoparasites were visually detected. Some species were fumigated for 5 min in a plastic bag containing cotton soaked in ethyl acetate to kill and remove all the different ectoparasites (lice, louse-fly and mites). All the ectoparasites were stored in vials with 70% ethanol. Mites were cleared using lactic acid (75% aqueous solution) and gently heated (45 °C) on a hot plate; they were then mounted in temporary preparations in cavity slides and observed under a light microscope at 100× and 400× magnification (Grandjean, 1949; Krantz & Walter, 2009). Species level identifications were made according to Micherdzinski (1980).

For the identification of mites, the following characteristics were used: adult mites have a single back plate tapering gradually towards the distal end; the anal opening is located near the proximal border of the anal plate; the chelicerae are not turned distally and have a small chelae; three pairs of sternal hairs are inserted on the sternal plate; idiosomal hairs have a subterminal barbule. These typical characters coincide with descriptions of *O. bursa* by Micherdzinski (1980) and Krantz & Walter (2009).

We calculated prevalence (P) according to Bush *et al.* (1997) as: $P = (\text{number of sampling units infested with one or more mites})/(\text{number of sampling units examined}) \times 100$. For fledglings, we considered the nest as a sampling unit to unify criteria among species, whereas for adults we were able to consider each individual as a sampling unit. The mean, standard deviation and range were calculated for those cases where data belongs to more than a single breeding season and values were rounded to the nearest.

After identification, mites from three host species, Crowned Eagle *Harpyhaliaetus coronatus* (Vieillot) (Falconiformes: Accipitridae), Chimango Caracara *Milvago chimango* (Vieillot) (Falconiformes: Falconidae) and American Kestrel [*Falco sparverius* (Linneo) (Falconiformes: Falconidae); from Liébana *et al.*, 2011] were analysed by generic RT-Nested-PCR to detect Alphavirus, Flavivirus and Bunyavirus (Kuno *et al.*, 1996; Sánchez-Seco *et al.*, 2001, 2005). Pools were homogenized, centrifuged and the supernatant used for RNA extraction. Capture, banding and manipulation of birds were conducted under permits from the Dirección de Recursos Naturales and Subsecretaria de Ecología of La Pampa province. These agencies and the owners of private properties made this work possible by giving us permission to carry out fieldwork in the Parque Luro Reserve and on their lands in La Pampa province.

We examined 1590 birds representing 11 families (Tyrannidae, $n = 62$; Strigidae, $n = 6$; Falconidae, $n = 639$; Icteridae, $n = 1$; Picidae, $n = 2$; Emberizidae, $n = 21$; Dendrocolaptidae, $n = 14$; Furnariidae, $n = 55$; Accipitridae, $n = 6$; Troglodytidae, $n = 783$; Vireonidae, $n = 1$). *Ornithonyssus bursa* was found on 11 wild bird species from eight different families, on nestlings, adults and nests. Among passerines birds, *O. bursa* was found in six species from five families, and among raptorial birds it was found in five species from three families (Tables 1 and 2). The infestation prevalence varied between host species (Tables 1 and 2) and in some cases across years. For instance, in nestlings of Chimango Caracara (*Milvago chimango*), the prevalence was lower during 2007/2008 and 2009/2010 (6.25 and 4.34, respectively) than in 2011/2012 (11.32). In nestlings of Aplomado Falcon *Falco femoralis* (Temminck) (Falconiformes: Falconidae), House Wren *Troglodytes aedon* (Vieillot) (Passeriformes: Troglodytidae) and Tuffed Tit-Spinetail *Lepthastenura platensis* (Reichenbach) (Passeriformes: Furnariidae) the prevalence was higher in the 2010/2011 season (100, 30.64 and 25, respectively) and decreased sharply in the following season 2011/2012 (Aplomado Falcon: 40, House Wren: 2.85 and Tuffed Tit-Spinetail: 8.33). For the 2011/2012 season, the prevalence in Saffron Yellow-Finch *Sicalis flaveola* (Linneo) (Passeriformes: Thraupidae) nestlings was 66.66 and 36.67 for American Kestrel (*Falco sparverius*); for Crowned Eagle (*Harpyhaliaetus coronatus*) nestlings in 2008/2009 it was 50. The prevalence in all the sampled adults was very low, even for those species whose sample size was quite high (Table 2).

We counted the total number of mites present on nestlings from one nest from four different species. There were 1300 mites on 5 House Wrens nestlings, 1800 mites on 3 Aplomado Falcon

Table 1. Nestling avian host species and prevalence of Tropical Fowl Mites.

Avian host	Nestlings	Total nests examined	Prevalence (%) ± SD (range)
Accipitridae			
Crowned Eagle (*Harpyhaliaetus coronatus*)∗†	2	2	50
Falconidae			
Chimango Caracara (*Milvago chimango*)†	186	92	8 ± 4 (4–12)
Aplomado Falcon (*Falco femoralis*)†	24	9	70 ± 42 (40–100)
American Kestrel (*Falco sparverius*)‡§	114	30	37
Furnaridae			
Tuffed Tit-Spinetail (*Lepthastenura platensis*)‡§	42	16	17 ± 12 (8–25)
Troglodytidae			
House Wren (*Troglodytes aedon*)‡§	699	167	17 ± 20 (3–31)
Emberizidae			
Saffron Yellow-Finch (*Sicalis flaveola*)‡§	11	3	67

∗Breeding season 2008/2009.
†Open cup nest.
‡Breeding season 2011/2012.
§Nest-boxes.

Table 2. Adults avian host species infested with Tropical Fowl Mites, including host weights, the number of captured individuals and prevalence.

Avian Host	Weight (g)	Captures	Prevalence (%)
Falconidae			
Chimango Caracara (*Milvago chimango*)	300	278	1
Strigidae			
Ferruginous Pygmy-Owl *Glaucidium brasilianum* (Gmelin) (Strigiformes: Strigidae)	78	6	17
Troglodytidae			
House Wren (*Troglodytes aedon*)	10	84	2
Tyrannidae			
Vermilion Flycatcher *Pyrocephalus rubinus* (Boddaert) (Passeriformes: Tyrannidae)	13	50	2
Vireonidae			
Rufous-browed Peppershrike *Cyclarhis gujanensis* (Gmelin) (Passeriformes: Vireonidae)	35	1	100
Emberizidae			
Rufous-collared Sparrow *Zonotrichia capensis* (Muller) (Passeriformes: Emberizidae)	18	8	12

nestlings, 35 on 3 Tuffed Tit-Spinetail nestlings and 46 on 3 Saffron Yellow-Finch nestlings.

Mites from three host species, Crowned Eagle ($n = 3$ mites), Chimango Caracara ($n = 17$ mites) and American Kestrel ($n = 3$ mites from Liébana *et al.*, 2011), were negative for Alphavirus, Flavivirus and Bunyavirus.

Preceding this study, *O. bursa* had been reported from bird species in Argentina: Chickens *Gallus gallus* (Linneo) (Galliformes: Phasianidae), pigeons and doves (*Patagioenas livia* (Gmelin) (Columbiformes: Columbidae), *Zenaida auriculata* (Des Murs) (Columbiformes: Columbidae) and *Columbina picui* (Temminck) (Columbiformes: Columbidae), Monk Parakeet *Myiopsitta monachus* (Boddaert) (Pittaciformes: Psittacidae), Blue-fronted Parrot *Amazona aestiva* (Linneo) (Psittaciformes: Psittacidae), Guira Cuckoo *Guira guira* (Gmelin) (Cuculiformes: Coculidae), Green-Barred Woodpecker *Colaptes melanochloros* (Gmelin) (Piciformes: Picidae), American Kestrel (*Falco sparverius*) and diverse passerine birds (Liébana *et al.*, 2011; Arrabal *et al.*, 2012). However, the present study is the first record of *O. bursa* infecting the passerines Tuffed Tit-Spinetail (*Lestapthesnura platensis*), Vermilion Flycatcher (*Pyrocephalus rubinus*), Rufous-browed Peppershrike (*Cyclarhis gujanensis*) and Rufous-collared Sparrow (*Zonotrichia capensis*) (Wolf & Jones, 2000; Remsen, 2003; Arrabal *et al.*, 2012).

By contrast, this ectoparasite has been previously recorded infecting nests of House Wren (*Troglodytes aedon*), but not adults (Arrabal *et al.*, 2012). The prevalence of infested nests in this study is similar to that found by Arrabal *et al.* (2012). For House Wren, there are records of other haematophagous mite species infections [*Dermanyssus gallinae* (Degeer) (Mesostigmata: Dermanyssidae), *Dermanyssus hirundinus* (Hermann) (Mesostigmata: Dermanyssidae), *Liponyssus sylviarum* (Canestrini & Fanzago) (Mesostigmata: Macronyssidae), *Trombicula whartoni* (Ewins) (Trombidiformes: Trombiculidae), *Androlaelaps casalis* (Berlesse) (Mesostigmata: Laelapidae) and *Ornithonyssus sylviarum*] (Johnson, 1998; Knee & Proctor, 2007).

In the case of raptors, *O. bursa* has been reported from several species of the families Accipitridae, Cathartidae and Strigidae (Philips, 2000). The Aplomado Falcon and the Ferruginous Pygmy-Owl are widely distributed in the Americas, whereas the Chimango Caracara and the Crowned Eagle exclusively inhabit the Neotropics (Proudfoot & Johnson, 2000; Fergunson-Lees & Christie, 2001). The Crowned Eagle has been included in the lists of threatened fauna of Argentina as an endangered species and is currently considered a globally endangered species (IUCN, 2012).

Liébana *et al.* (2011) reported *O. bursa* from American Kestrel adults in Argentina, but in recent research from Chile, *O. bursa* was not found (González-Acuña *et al.*, 2011) possibly because in the last case the birds were dead when studied. In this study, we confirm its presence also in fledglings and nesting sites (nest-boxes).

The ectoparasite community affecting these raptorial birds is also scarcely known (Philips, 2000; Fergunson-Lees & Christie, 2001). Our records confirm the Aplomado Falcon, the Ferruginous Pygmy-Owl, the Chimango Caracara and the Crowned Eagle as new hosts of *O. bursa* (Philips, 2000).

As far as its occurrence in owl species, *O. bursa* has been found only in the Barn Owl *Tyto alba* (Scopoli) (Strigiformes: Tytonidae) and Indian Scops-Owl *Otus bakkamoena* (Pennant) (Strigiformes: Strigidae), but this is the first record for the Ferruginous Pygmy-Owl, for which to date the only mite species known to infect it is *Eutrombicula alfreddugesi* (Oudemans) (Acari: Trombiculidae) (Philips, 2000).

The number of mites found in a single host nest can range from 14 000 to 71 000 (Moller, 1990; Philips, 1990). In our study, the values of individuals of *O. bursa* were appreciably lower (from 3 to 1800 individuals), although this is probably because we only counted the parasites attached to the fledglings and not those hiding in the matrix of the nests.

Ornithonyssus bursa is considered and discussed as a potential vector of encephalitis viruses, such as WEE, WNV and SLV, because of *O. bursa*'s haematophagous feeding habits and because it usually feeds near the bird's vent (Miles, 1960; Valiente Moro *et al.*, 2005; Mullen & O'Connor). Among the viruses searched in this study, WNV is a novel virus to the Americas. This was first detected in North America in 1999, where it caused significant morbidity and mortality in native birds (Marra *et al.*, 2004). Since 2005, this flavivirus has been detected in free-ranging birds in Argentina, including some of the bird species sampled in the present study, such as the House Wren and the American Kestrel (Diaz *et al.*, 2008, 2011). The low number of mites analysed in this study does not allow us to draw a conclusion on the potential role of these mites as hosts and transmitters of these viruses in Argentina. Some authors, such as Miles (1960), have claimed that mites such as *O. bursa* and others such as *Dermanyssus gallinae* are probably of little importance as reservoirs and vectors of equine encephalitis viruses. Actually, some other mite species such as *O. sylviarum* and *Ornithonyssus bacoti* (Hirts) (Mesostigmata: Macronyssidae) are considered reservoirs of diseases such as Hantavirus and Korean haemorrhagic fever, Fowl pox, Newcastle disease viruses, WNV, SLV, nematodes *Litomosoides carinii* (Travassos) (Spirurida: Filarioidea), protozoa *Trypanozoma cruzi* (Chagas) (Trypanosomatida: Trypanosomatidae), bacterium *Rickettsia akari* (Huebner)(Rickettsiales: Rickettsiaceae) (under laboratory conditions), *Francisella tularensis* (McCoy and Chapin) (Thiotrichales: Francisellaceae) (Turalemia) and *Borrelia burgdorferi* (Johnson 1998 (Spirochaetales: Spirochaetaceae) (Lyme disease). *Dermanyssus gallinae* is a known vector of Fowl pox, St. Louis Encephalitis, Eastern Equine Encephalitis, West Nile Viruses, Venezuelan Equine Encephalitis, Western Equine Encephalitis, Newcastle disease viruses, bacteria as such *Salmonella Gallinarum* and *S. Enteriditis* (Kauffmann and Edwards) (Enterobacteriales: Enterobacteriaceae), *Erysopelothrix rhusiopathiae* (Migula) (Erysipelotrichales: Erysipelotrichidae), *Bacillus thuringiensis* (Berliner) (Bacillales: Bacillaceae), *Listeria monocytogenes* (Murray) (Bacillales: Lactobacilaceae) and *Coxiella burnetii* (Derrick) (Legionellales: Coxiellaceae) (Valiente Moro *et al.*, 2005; Mullen & O'Connor, 2009).

Our results thus add several new host species and confirm the general nature of this ectoparasite. Some of the bird species sampled here are migratory or disperse long distances, and have been registered as seropositives in North America and Argentina for some arboviruses (Medica & Bildstein, 2009; Reisen *et al.*, 2010; Diaz *et al.*, 2011). Therefore, more studies are needed to continue and intensify viral detection and to determine the possible deleterious effects of this mite on wild bird populations (e.g. breeding success or fitness), assessing also the potential role of other ectoparasites as effective vectors and reservoirs of pathogens to understand the persistence and transmission cycles of viruses in nature.

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References

Arrabal, J.P., Manzoli, D.E., Antoniazzi, L.R., Lareschi, M. & Beldomenico, P.M. (2012) Prevalencia del ácaro *Ornithonyssus bursa* Berlese, 1888 (Mesostigamata: Macronyssidae) en un ensamble de aves (Passeriformes) de bosques del centro de la provincia de Santa Fé, Argentina. *Revista Ibero-Latinoamérica de Parasitología*, **71**, 172–178.

Bush, A.O., Lafferty, K.D., Lozt, J.M. & Shostack, A.W. (1997) Parasitology meets ecology on its own terms: Margolis et al. revisited. *Journal of Parasitology*, **83**, 575–583.

Diaz, L.A., Komar, N., Visintin, A. *et al.* (2008) West Nile Virus in birds, Argentina. *Emerging Infectious Diseases*, **14**, 689–691.

Diaz, L.A., Quaglia, A., Flores, F.S. & Contigiani, M.S. (2011) Virus West Nile en Argentina: un agente infeccioso emergente que plantea nuevos desafíos. *Hornero*, **26**, 5–28.

Fergunson-Lees, J. & Christie, D.A. (2001) *Raptors of the World*. Christopher Helm, London.

González-Acuña, D., Lohse, E., Cicchino, A. *et al.* (2011) Parasites of the American Kestrel (*Falco sparverius*) in South-Central Chile. *Journal of Raptor Research*, **45**, 188–193.

Grandjean, F. (1949) Observation et conservation des trés petit arthropodes. *Bulletin du Muséum d'Histoire Naturelle, Paris*, **21**, 363–370.

IUCN (2012) *IUCN Red List of Threatened Species*. Version 2012.2. www.iucnredlist.org [accessed on 27 May 2013].

Johnson, L.S. (1998) House Wren (*Troglodytes aedon*). *The Birds of North America, No. 380* (ed. by A. Poole & F. Gill), p. 32. The Birds of North America, Inc., Philadelphia, PA.

Knee, W. & Proctor, H. (2007) Host records of *Ornithonyssus sylviarum* (Mesostigmata: Macronyssidae) from birds of North America (Canada, United States, and Mexico). *Journal of Medical Entomology*, **44**, 709–713.

Krantz, G.W. & Walter, D.E. (2009) *A Manual of Acarology*, 3rd edn. Texas Tech University Press, Lubbock, TX.

Kuno, G., Mitchell, C.J., Chang, G.J. & Smith, G.C. (1996) Detecting bunyaviruses of the Bunyamwera and California serogroups by a PCR technique. *Journal of Clinical Microbiology*, **34**, 1184–1188.

Liébana, M.S., Santillán, M.A., Armando, C. *et al.* (2011) Two new ectoparasites in free-ranging American Kestrels in Argentina: implications for the transmission of viral diseases. *Journal of Raptor Research*, **45**, 335–341.

Marra, P.P., Griffing, S., Caffrey, C. *et al.* (2004) West Nile virus and wildlife. *BioScience*, **54**, 393–402.

Medica, D.L. & Bildstein, K.L. (2009) Annual variation in West Nile virus antibodies in American kestrels (*Falco sparverius*) in eastern Pennsylvania. *Journal of Raptor Research*, **43**, 301–307.

Micherdzinski, W. (1980) *Eine taxonomische analyse der Familie Macronyssidae Oudemans, 1936. I. Subfamilie Ornithonyssinae Lange, 1958 (Acarina, Mesostigmata)*. Pañstwowe Wydawnictwo Naukowe, Warszawa, Kraków.

Miles, J.A.R. (1960) Epidemiology of the Arthropod-borne Encephalitides. *Bulletin of the World Health Organization*, **22**, 339–371.

Moller, A.P. (1990) Effects of parasitism by a haemotophagous mite on reproduction in the Barn Swallow. *Ecology*, **71**, 2345–2357.

Mullen, G.R. & O'Connor, B.M. (2009) Mites (Acari). *Medical and Veterinary Entomology*, 2nd edn (ed. by G.R. Mullen & L.A. Durden), pp. 433–492. Academic Press, San Diego, CA.

Philips, J.R. (1990) What's bugging your birds? Avian parasitic arthropods. *Wildlife Rehabilitation*, **8**, 155–203.

Philips, J.R. (2000) A review and checklist of the parasitic mites (Acarina) of the Falconiformes and Strigiformes. *Journal of Raptor Research*, **34**, 210–231.

Proudfoot, G.A. & Johnson, R.R. (2000) Ferruginous Pygmy-Owl (*Glaucidium brasilianum*). *The Birds of North America, No. 498* (ed. by A. Poole & F. Gill), p. 20. The Birds of North America, Inc., Philadelphia, PA.

Reisen, W.K., Wheeler, S.S., Garcia, S. & Fang, Y. (2010) Migratory birds and the dispersal of arbovirus in California. *American Journal of Tropical Medical Hygiene*, **83**, 808–815.

Remsen, J.V. (2003) Family Furnaridae (Ovenbirds). *Handbook of the Birds of the World*, *Vol. 8: Broadbills to Tapaculos* (ed. by J. del Hoyo, A. Elliott & J. Sargatal), pp. 162–357. Lynx Editions, Barcelona.

Sánchez-Seco, M.P., Rosario, D., Quiroz, E., Guzmán, G. & Tenorio, A. (2001) A generic nested-RT-PCR followed by sequencing for detection and identification of members of the alphavirus genus. *Journal of Virological Methods*, **95**, 153–161.

Sánchez-Seco, M.P., Rosario, D., Domingo, C. *et al.* (2005) Generic RT-nested-PCR for detection of flaviviruses using degenerated primers and internal control followed by sequencing for specific identification. *Journal of Virological Methods*, **126**, 101–109.

Turell, M.J. (2009) Arthropod-related viruses of medical and veterinary importance. *Medical and Veterinary Entomology*, 2nd edn (ed. by G.R. Mullen & L.A. Durden), pp. 557–564. Academic Press, San Diego, CA.

Valiente Moro, C., Chauve, C. & Zenner, L. (2005) Vectorial role of some dermanyssoid mites (Acari, Mesostigmata, Dermanyssoid). *Parasite*, **12**, 99–109.

Wolf, B.O. & Jones, S.L. (2000) Vermillion Flycatcher (*Pyrocephalus rubinus*). *The Birds of North America, No. 549* (ed. by A. Poole & F. Gill), p. 16. The Birds of North America, Inc., Philadelphia, PA.

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