

***Plusaetis sibynus* (Siphonaptera: Ceratophyllidae): a new record of flea on *Didelphis virginiana*, with a checklist of fleas for this host**

***Plusaetis sibynus* (Siphonaptera: Ceratophyllidae): nuevo reporte de pulga en *Didelphis virginiana*, con lista de pulgas para este hospedero**

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Virginia opossums (*Didelphis virginiana*) are hosts to a variety of fleas that can be important vectors for diseases, including some zoonosis; therefore, it is important to generate knowledge about the fleas that parasite this animal. We present the list of all fleas found on opossums, and the discovery of a species that has not been previously found on *D. virginiana*, neither on other marsupials. We collected fleas from Virginia opossums in the urban area of México City, México, and performed a bibliographical search to determine which species of fleas were previously recorded. We found previous records of 26 species of fleas on opossums, and we added the flea species *Plusaetis sibynus* to this list. *Plusaetis sibynus* is a common flea of rodents (mainly *Peromyscus* and *Neotoma*), representing a potential vector of diseases from these rodents to the opossum and human populations. Further research is needed to assess the role of this flea as a vector of zoonotic diseases.

Key words: Diseases; new world marsupials; *Plusaetis sibynus*; opossum; zoonosis.

El tlacuache de Virginia (*Didelphis virginiana*) es hospedero para una variedad de pulgas que pueden ser importantes vectores para la transmisión de enfermedades, incluyendo zoonosis; por lo tanto, es importante generar conocimiento sobre las pulgas que parasitan a este animal. En este trabajo, presentamos la lista de pulgas que parasitan a los tlacuaches, con la adición de una especie que no ha sido registrada previamente en *D. virginiana*, ni en otros marsupiales. Colectamos pulgas de tlacuaches de Virginia en el área urbana de la Ciudad de México, México, y también realizamos una búsqueda bibliográfica para determinar las especies de pulgas reportadas previamente. Encontramos registros de 26 especies de pulgas en los tlacuaches y añadimos a esta lista la especie de pulga *Plusaetis sibynus*. *Plusaetis sibynus* es una pulga común en roedores (principalmente *Peromyscus* y *Neotoma*), por lo que representa un vector potencial para la transmisión de enfermedades de estos roedores a los tlacuaches, y posteriormente a las poblaciones humanas. Se requieren más estudios para determinar el papel de esta pulga como vector de enfermedades zoonóticas.

Palabras clave: Enfermedades; marsupiales del Nuevo Mundo; *Plusaetis sibynus*; tlacuaches, zoonosis.

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Fleas (Siphonaptera), among other parasites, are important vectors that transmit diseases (Krueger et al. 2016; Dean et al. 2018), both between individuals of the same species and between different species, including the transmission of significant zoonotic diseases like the bubonic plague (Dean et al. 2018). However, flea species have a certain range of host species on which they can inhabit, and between which they are likely to transmit the diseases. In this case, we studied fleas parasitizing the Virginia opossum, *Didelphis virginiana* Kerr, 1792, a very common and widely distributed marsupial (McManus 1974), adapted well to the urban environments (Wright et al. 2012). Such characteristics point out to the Virginia opossum as an important host of parasites

known as vectors of zoonotic diseases, so specific studies are needed. Previous studies show that opossums are vectors of several zoonotic diseases: leptospirosis, salmonellosis (Ruiz-Piña et al. 2002), toxoplasmosis (Torres-Castro et al. 2016), among others, including microorganisms transmitted by fleas, most remarkable *Rickettsia* (Krueger et al. 2016). Therefore, this work aims to report a new species of flea found on a Virginia opossum and offer a checklist of fleas reported previously on this host species.

From January to March 2020, we live-trapped Virginia opossums in six locations in southern parts of the urban area of México City, México (Figure 1), using pitfall traps consisting of plastic containers 75 cm in height and 50 cm

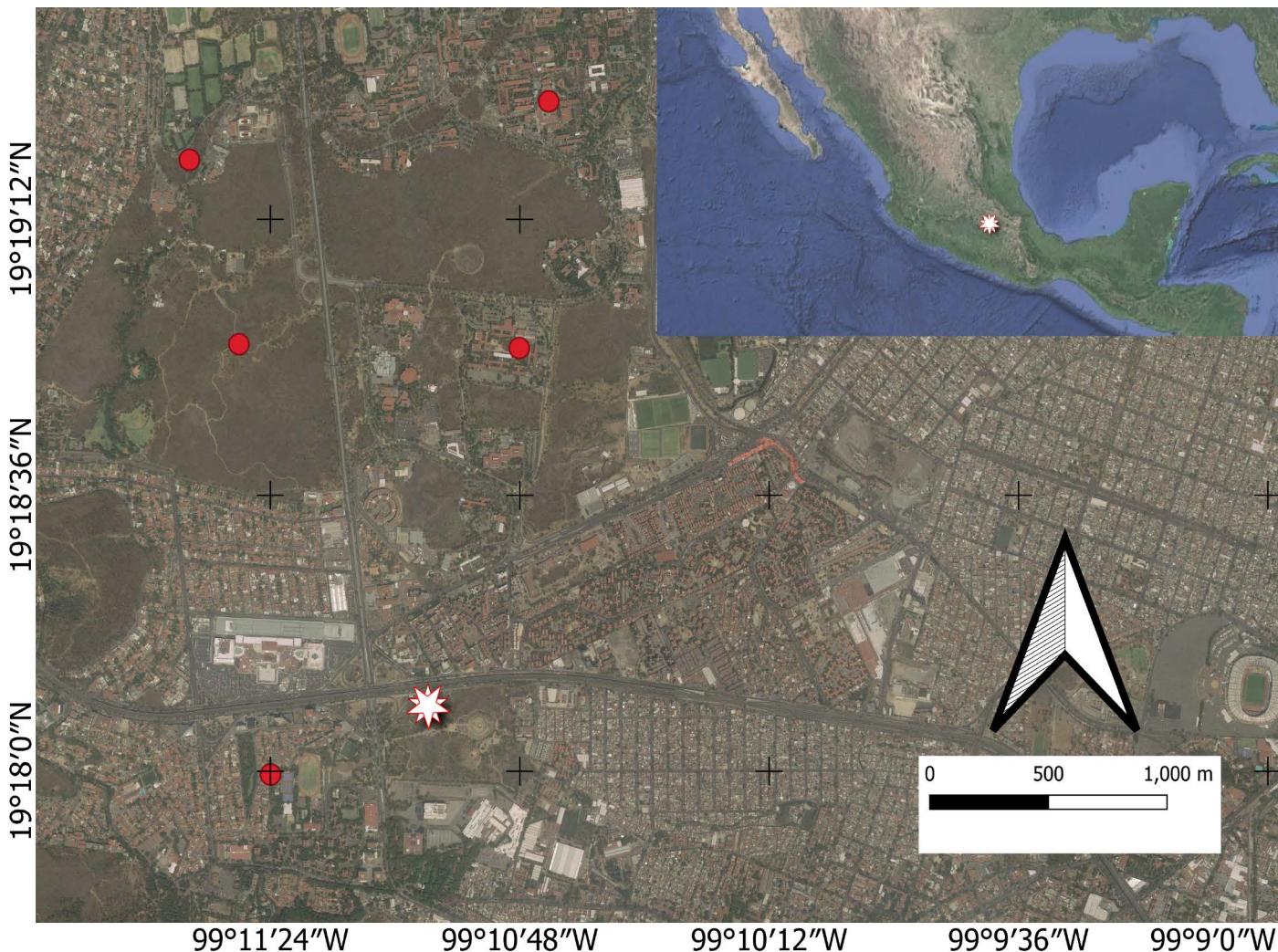


Figure 1. Map of the study sites (red dots). The white star shows the location where *Plusaetis sibynus* was found, notice that this location is surrounded by urban areas.

in diameter. We made a total effort of 144 trap-nights, and fleas were collected from Virginia opossums and stored in vials with 70 % ethanol and labeled (all captured opossums were released). Fleas were identified following [Traub \(1950\)](#), [Acosta and Morrone \(2003\)](#), and [Salceda-Sánchez \(2004\)](#).

Complementarily, we performed a bibliographical search of parasites hosted by the Virginia opossum, using the following terms: "pulga + *Didelphis virginiana*", "flea + *Didelphis virginiana*", and "Siphonaptera + *Didelphis virginiana*".

We captured a total of 32 specimens of Virginia opossums and collected a total of 18 fleas on 12 individuals. Out of the total, 17 fleas were identified as *Ctenocephalides felis* (Bouché, 1835; Pulicidae) by the presence of the genal comb horizontal, usually extending entire length of lower margin of head and located below of eye, the genal spines are equal, and has a low sloping forehead ([Salceda-Sánchez 2004](#)), and 1 male individual of *Plusaetis sibynus* (Jordan, 1925) (Ceratophyllidae; Figure 2), by an occiput (in post antennal region) with 2 or more longish bristles behind base of antennal groove and 3 or more in the mid-

dle, arranged in rows; eighth tergum with 5 or 6 median and 2 ventral lateral bristles; and the eighth sternum ([Traub 1950](#)). This representing the first time *P. sibynus* is found on a Virginia opossum, or any other marsupial.

In the bibliographical search, we found 26 species of fleas belonging to 18 genera, and 5 families, which were previously reported on the Virginia opossum across 4 countries (Table 1). *Plusaetis sibynus* represents species number 27 in the checklist.

Before this work, *P. sibynus* was only reported for rodent species of the genera *Peromyscus*, *Neotoma*, and *Reithrodontomys* ([Acosta 2005](#); [Montiel et al. 2019](#)). This report unveils a possible vector of zoonotic diseases between the rodents and opossums, and it is especially important since the host rodent genera are common in natural areas (or their remnants, such as parks inside urban areas), but not in the urbanized areas ([Bolger et al. 1997](#); [Harris et al. 2016](#)), so their contact with humans is limited, yet opossums can occur in both ([Wright et al. 2012](#)). Therefore, hypothetically, the Virginia opossums could act as a bridge for microorganisms of public health concern, between the field rodents and the urban human populations. However,

further studies are needed to truly assess the potential of disease transmission via this vector parasitizing Virginia opossums, and the identity of such diseases, especially considering that other species of the genus *Plusaetis* have proven to carry zoonotic bacteria like *Bartonella* ([Sánchez-Montes et al. 2019](#)).

When analyzing the historical records of fleas on Virginia opossums (Table 1), we found that the most common flea in geographical range, number of reports, and abundance, is the cat flea, *Ctenocephalides felis* ([Hernández-Camacho et al. 2014; Krueger et al. 2016](#); this study). This finding is relevant since it is a very common flea that can be hosted by many species, including domestic animals ([Maina et al. 2016](#)); therefore, it can move diseases even closer to human populations. We conclude that the Virginia opossum has an important potential for spreading diseases, and the vectors connecting this species to other animals should be carefully studied.



Figure 2. Photograph of the specimen of *Plusaetis sibynus* (male) found on *Didelphis virginiana*. Occiput, upper arrow. Sternal VIII, right arrow.

Table 1. List of families and flea species on the Virginia opossum, *Didelphis virginiana*, and the countries where they are reported.

Species	Country	Reference
Ceratophyllidae		
<i>Nosopsyllus fasciatus</i> (Bosc, 1800)	USA	Elbel 1951
<i>Orchopeas howardi</i> (Baker, 1895)	USA	Mohr and Morlan 1959
<i>Orchopeas leucopus</i> (Baker, 1904)	USA	Whitaker et al. 1976
<i>Orchopeas wickhami</i> (Baker, 1895)	USA	Shaftesbury 1934
<i>Oropsylla arctomys</i> (Baker, 1904)	USA	Holland and Benton 1968
<i>Plusaetis sibynus</i> (Jordan, 1925)	México	This study
Hystrichopsyllidae		
<i>Corrodopsylla hamiltoni</i> (Traub, 1944)	USA	Schiefer and Lancaster 1970
<i>Ctenophthalmus pseudagyrtes</i> Baker, 1904	USA	Whitaker et al. 1976
<i>Epitedia neotomae</i> Jameson, 1946	USA	McAllister et al. 2017
Leptopsyllidae		
<i>Ctenopsyllus catatina</i> (Jordan 1928)	USA	Shaftesbury 1934
<i>Leptopsylla segnis</i> (Schonherr, 1811)	USA	Mohr and Morlan 1959
<i>Odontopsyllus multispinosus</i> (Baker, 1898)	USA	Mohr and Morlan 1959
Pulicidae		
<i>Cediopsylla simplex</i> (Baker, 1895)	USA	Whitaker et al. 1976
<i>Ctenocephalides canis</i> (Curtis, 1826)	USA	Whitaker et al. 1976
<i>Ctenocephalides felis</i> (Bouche, 1835)	Guatemala, México, USA	Mohr and Morlan 1959; Villalobos-Cuevas et al. 2016; Escobar et al. 2011; this study
<i>Echidnophaga gallinacea</i> (Westwood, 1875)	USA	Mohr and Morlan 1959
<i>Hoplopsyllus glacialis</i> (Taschenberg, 1880)	México, USA	Schiefer and Lancaster 1970; Hernández-Camacho et al. 2014
<i>Pulex irritans</i> Linnaeus, 1759	México, USA	Mohr and Morlan 1959; Villalobos-Cuevas et al. 2016
<i>Pulex porcinus</i> Jordan & Rothschild, 1924	México	Villalobos-Cuevas et al. 2016
<i>Pulex simulans</i> Baker, 1895	México, USA	Wilson and Bishop 1966
<i>Xenopsylla cheopis</i> (Rothschild, 1903)	USA	Mohr and Morlan 1959
Rhopalopsyllidae		
<i>Polygenis gwyni</i> (C. Fox, 1914)	USA	McAllister et al. 2017
<i>Polygenis martinezbaezi</i> Vargas, 1951	México	Hernández-Camacho et al. 2014
<i>Rhopalopsyllus australis</i> (Rothschild, 1904)	México	Villalobos-Cuevas et al. 2016
<i>Rhopalopsyllus coxi</i> Eads, 1946	USA	Randolph and Eads 1946
<i>Rhopalopsyllus lugubris</i> Jordan & Rothschild, 1908	Costa Rica	Durden and Campbell 2016
<i>Chaetopsylla lotoris</i> (Stewart, 1926)	USA	Whitaker et al. 1976

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Literature cited

- ACOSTA, R., AND J. MORRONE.** 2003. Clave ilustrada para la identificación de los taxones supraespecíficos de Siphonaptera de México. *Acta Zoológica Mexicana* (Nueva Serie) 89:39-53.
- ACOSTA, R.** 2005. Relación huésped-parásito en pulgas (Insecta: Siphonaptera) y roedores (Mammalia: Rodentia) del estado de Querétaro, México. *Folia Entomológica Mexicana* 44:37-47.
- BOLGER, D. T., A. C. ALBERTS, R. M. SAUVAJOT, P. POTENZA, C. MC CALVIN, D. TRAN, S. MAZZONI, AND M. E. SOULÉ.** 1997. Response of rodents to habitat fragmentation in coastal southern California. *Ecological Applications* 7:552-563.
- DEAN, K. R., F. KRAUER, L. WALLØE, O. C. LINGJÆRDE, B. BRAMANTI, N. C. STENSETH, AND B. V. SCHMID.** 2018. Human ectoparasites and the spread of plague in Europe during the Second Pandemic. *Proceedings of the National Academy of Sciences* 115:1304-1309.
- DURDEN, L. A., AND D. C. CAMPBELL.** 2016. Fleas, Lice, and Epifaunistic Pseudoscorpions of Some Native Mammals in Northwestern Costa Rica. *Comparative Parasitology* 83:240-244.
- ELBEL, R. E.** 1951. Comparative studies on the larvae of certain species of fleas (Siphonaptera). *The Journal of Parasitology* 37:119-128.
- ESCOBAR, L. E., D. ALVAREZ, F. J. VILLATORO, D. MORAN, AND A. ESTEVEZ.** 2011. Two new flea records from Guatemala: *Pulex simulans* and *Echidnophaga gallinacea* (Siphonaptera: Pulicidae), and their host-parasite relationship. *Journal of Parasitology and Vector Biology* 3:40-43.
- HARRIS, S. E., A. T. XUE, D. ALVARADO-SERRANO, J. T. BOEHM, T. JOSEPH, M. J. HICKERSON, AND J. MUNSHI-SOUTH.** 2016. Urbanization shapes the demographic history of a native rodent (the white-footed mouse, *Peromyscus leucopus*) in New York City. *Biology Letters* 12:20150983.
- HERNÁNDEZ-CAMACHO, N., S. VERGARA-PINEDA, R. ACOSTA-GUTIÉRREZ, AND R. W. JONES.** 2014. Nuevos registros de pulgas de tlacuaches *Didelphis virginiana* (Kerr 1792) en Querétaro, México. *Therya* 5:347-353.
- HOLLAND, G. P., AND A. H. BENTON.** 1968. Siphonaptera from Pennsylvania mammals. *American Midland Naturalist* 252-261.
- KRUEGER, L., Y. BAI, S. BENNETT, C. FOGARTY, S. SUN, M. KOSOV, A. MAINA, K. NELSON, E. PLATZER, L. OSIKOWICZ, A. L. RICHARDS, F. SHARIAR, A. TRINIDAD, AND R. CUMMINGS.** 2016. Identification of Zoonotic and Vector-borne Infectious Agents Associated with Opossums (*Didelphis virginiana*) in Residential Neighborhoods of Orange County, California. *Proceedings of the Vertebrate Pest Conference* 27.
- MAINA, A. N., C. FOGARTY, L. KRUEGER, K. R. MACALUSO, A. ODHIAMBO, K. NGUYEN, C. M. FARRIS, A. LUCE-FEDOROW, J. BENNETT, S. JIANG, S. SUN, R. F. CUMMINGS, AND A. L. RICHARDS.** 2016. Rickettsial infections among *Ctenocephalides felis* and host animals during a flea-borne rickettsioses outbreak in Orange County, California. *PLoS One* 11:e0160604.
- MCALESTER, C. T., L. A. DURDEN, H. W. ROBISON, AND M. B. CONNIOR.** 2017. The fleas (Arthropoda: Insecta: Siphonaptera) of Arkansas. *Journal of the Arkansas Academy of Science* 71:69-76.
- MCMANUS, J. J.** 1974. *Didelphis virginiana*. *Mammalian Species* 40:1-6.
- MOHR, C. O., AND H. B. MORLAN.** 1959. The nature of parasitism of the opossum by fleas in southwestern Georgia. *The Journal of Parasitology* 45:233-237.
- MONTIEL, F. A., A. ESTRADA-TORRES, R. ACOSTA, M. RUBIO-GODOY, AND J. VÁZQUEZ.** 2019. Host species influence on flea (Siphonaptera) infection parameters of terrestrial micromammals in a temperate forest of Mexico. *Parasitology* 146:670-677.
- RANDOLPH, N. M., AND R. B. EADS.** 1946. An ectoparasitic survey of mammals from Lavaca County, Texas. *Annals of the Entomological Society of America* 39:597-601.
- RUIZ-PIÑA, H. A., M. A. PUC-FRANCO, J. FLORES-ABUXAPQUI, I. VADO-SOLIS, AND M. F. CARDENAS-MARRUFO.** 2002. Isolation of *Salmonella enterica* and serologic reactivity to *Leptospira interrogans* in opossums (*Didelphis virginiana*) from Yucatán, México. *Revista do Instituto de Medicina Tropical de São Paulo* 44:235-237.
- SALCEDA-SÁNCHEZ, B.** 2004. Clave para la identificación de adultos de las especies de pulgas (Insecta: Siphonaptera), comunes y de mayor importancia médica en México. *Folia Entomológica Mexicana* 43:27-41.
- SÁNCHEZ-MONTES, S., M. Y. CABRERA-GARRIDO, C. A. RÍOS-MUÑOZ, A. Z. LIRA-OLGUÍN, R. ACOSTA-GUTIÉRREZ, M. MATA-GALINDO, K. HERNÁNDEZ-VILCHIS, D. M. NAVARRETE-SOTELO, P. COLUNGA-SALAS, L. LEÓN-PANIAGUA, AND I. BECKER.** 2019. Detection of *Bartonella* and *Rickettsia* in small mammals and their ectoparasites in México. *Therya* 10:69-79.
- SCHIEFER, B. A., AND J. L. LANCASTER JR.** 1970. Some Siphonaptera from Arkansas. *Journal of the Kansas Entomological Society* 43:177-181.
- SHAFTESBURY, A. D.** 1934. The Siphonaptera (fleas) of North Carolina, with special reference to sex ratios. *Journal of the Elisha Mitchell Scientific Society* 49:247-263.
- TORRES-CASTRO, M., H. NOH-PECH, R. PUERTO-HERNÁNDEZ, B. REYES-HERNÁNDEZ, A. PANTI-MAY, S. HERNÁNDEZ-BETANCOURT, A. YEH-GOROCICA, L. GONZALEZ-HERRERA, J. ZAVALA-CASTRO, AND F. I. PUERTO.** 2016. First molecular evidence of *Toxoplasma gondii* in opossums (*Didelphis virginiana*) from Yucatan, Mexico. *Open Veterinary Journal* 6:57-61.
- TRAUB, R.** 1950. Siphonaptera of Central America and Mexico: a morphological study of aedeagus with descriptions of new genera and species. *Fieldiana Zoology* 1:1-127 + 54 plates.
- VILLALOBOS-CUEVAS, V. A., M. WEBER, M. LARESCHI, AND R. ACOSTA.** 2016. Pulgas parásitas de mamíferos pequeños y medianos de Calakmul, Campeche, México y nuevos registros de localidades. *Revista Mexicana de Biodiversidad* 87:1372-1378.

- WHITAKER, JR., J. O., G. S. JONES, AND R. J. GOFF.** 1976. Ectoparasites and food habits of the opossum, *Didelphis virginiana*, in Indiana. Proceedings of the Indiana Academy of Science 86:501-507.
- WILSON, N., AND P. BISHOP.** 1966. A New Host and Range Extension for *Pulex simulans* Baker with a Summary of Published Records (Siphonaptera: Pulicidae). American Midland Naturalist 245-248.
- WRIGHT, J. D., M. S. BURT, AND V. L. JACKSON.** 2012. Influences of an urban environment on home range and body mass of Virginia opossums (*Didelphis virginiana*). Northeastern Naturalist 19:77-86.

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