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First Records of the Neotropical Deer Ked *Lipoptena mazamae* Róndani (Diptera: Hippoboscidae) from Virginia

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ABSTRACT

We report the first definitive records of *Lipoptena mazamae* Róndani, a hematophagous ectoparasite of cervids, from the Piedmont of Virginia based on recently collected specimens. The collection localities in Henry and Pittsylvania counties represent the northernmost known occurrence of this species in eastern North America.

Keywords: eastern United States, ectoparasites, range extension, zoonotic diseases.

INTRODUCTION

Louse flies (Diptera: Hippoboscidae) are a small group of obligate hematophagous ectoparasites of birds and mammals represented in the world's fauna by more than 210 species in three subfamilies (Ornithomyinae, Hippoboscinae, and Lipopteninae) (Dick, 2006). These unusual flies are easily recognized by their robust, dorsoventrally flattened bodies, "leathery" appearance, and highly modified antennae and mouthparts (Maa & Peterson, 1987). Most hippoboscids retain functional wings throughout their life, while members of Lipopteninae are either wingless or shed their wings upon locating a host.

Lipopteninae are normally parasitic on cervids (Artiodactyla: Cervidae), while most members of the remaining two subfamilies primarily parasitize birds (Maa, 1969; Maa & Peterson, 1987). Both sexes readily take blood meals and some species are known, or suspected, vectors of etiological agents such as viruses, bacteria, protozoans, and helminths associated with a variety of conditions including bluetongue, West Nile fever, anaplasmosis, bartonellosis, borreliosis, ehrlichiosis, pseudomalaria, and trypanosomiasis (Farajollahi et al., 2005; Small, 2005; de Bruin et al., 2015; Liu et al., 2016; Kelsey & Finch, 2018; Moreira et al., 2019; Skvarla & Machtinger, 2019). The pigeon fly, *Pseudolynchia canariensis* (Macquart), an obligate parasite of pigeons, is the definitive host and the only known vector of the protozoan *Haemoproteus columbae* Kruse (Moreira et al., 2019). The bluetongue virus is transmitted by the sheep ked, *Melophagus ovinus* (Linnaeus), to its main host the domestic sheep, *Ovis aries* Linnaeus (Small, 2005). In addition, RNA of the West Nile virus was recently detected in *Icosta americana* (Leach) on birds of prey (Farajollahi et al., 2005). Although the actual transfer of pathogens by many of these flies is not completely understood, vertical transmission of *Bartonella* spp. recently has been shown between generations of the sheep ked, *M. ovinus*, and the deer ked, *Lipoptena cervi* (Linnaeus), (Halos et al., 2004; de Bruin et al., 2015).

The subfamily Lipopteninae includes three genera and 34 recognized species (Dick, 2006). Three native (*Lipoptena depressa* [Say], *L. mazamae* Róndani, and *Neolipoptena ferrisi* [Bequaert]) and two introduced (*L. cervi* and *M. ovinus*) species are known from the Nearctic (Maa, 1969; Dick, 2006; Skvarla & Machtinger, 2019). The Neotropical deer ked, *L. mazamae*, the introduced deer ked, *L. cervi*, and the sheep ked, *M. ovinus*, are the only members of Lipopteninae known to occur in eastern North America, the last two of which have been previously reported from Virginia based on verified records (Bequaert, 1957; Small, 2005; Skvarla & Machtinger, 2019). *Lipoptena mazamae* was first reported as occurring in Virginia by Kern (2003),

a record subsequently cited in Skvarla & Machtinger (2019), but neither study included examination of specimens from Virginia (M. J. Skvarla, pers. comm. to LJH, 4 February 2019; W. H. Kern, pers. comm. to LJH, 26 February 2019).

Here we report the first definitive records of *L. mazamae* from Virginia based on recently collected specimens, and discuss the potential range overlap and interaction between *L. mazamae* and *L. cervi*.

MATERIALS

During routine processing of an adult female and a juvenile male White-tailed Deer, *Odocoileus virginianus* (Zimmermann), at the Virginia Museum of Natural History, the first author observed numerous dealate hippoboscid flies, which were collected, mounted, and subsequently identified as *L. mazamae* (Fig. 1).

The female deer was collected on 1 January 2019, and the entire right rear leg (NDM 4488) was removed and placed in a plastic bag within 30 minutes of the animal's death. The leg was brought to the Virginia Museum of Natural History and placed in a -20º C freezer on 2 January 2019. On 25 January, the leg was thawed and all of the skin was removed as part of procedures to prepare the bones as an articulated partial skeleton. During skinning, three female deer keds were found concealed in the white fur of the inner leg near the top of the calcaneus. It is unknown whether this was the total number of keds present on the host, as only the right rear leg was available for examination. The host from which these keds were extracted was collected on private property in Pittsylvania Co., Virginia approximately 14 km west of the City of Danville (36.60457º, -79.55312º).

The male deer (NDM 4497) was collected on the morning of 9 October 2019, and the entire carcass was placed in a plastic bag within 12 hours of the animal's death. The carcass was brought to the Virginia Museum of Natural History and placed in a -20º C freezer on the same day. On 19 November the carcass was thawed and the skin was removed as part of procedures to prepare the bones as a skeleton. During skinning, 82 deer keds (39 males, 43 females) were found, most of which were

Fig. 1. Dorsal view of (left) dealate female *Lipoptena mazamae* (VMNH 110610) from Pittsylvania Co., Virginia; and (right) dealate male *Lipoptena mazamae* (VMNH 110619.1) from Henry Co., Virginia. Photographs by Lucy Treado, Virginia Museum of Natural History.

concealed in the white fur of the inner rear legs and groin area. Due to poor preservation, only 75 keds (37 males and 38 females) were retained for deposition as specimens. The host from which these keds were extracted was collected on private property in Henry Co., Virginia approximately 8.5 km east of the City of Martinsville (36.67623º, -79.77738º).

All specimens are deposited in the invertebrate collection at the Virginia Museum of Natural History (VMNH 110610-116012 from Pittsylvania Co., and VMNH 110619.1-110619.75 from Henry Co.).

IDENTIFICATION

Members of Lipopteninae are characterized by the fairly dense coverage of evenly spaced spiniform setae on the ventral surface of the thorax; the strongly concave posterior margin of the basal abdominal sternite (convex in *N. ferrisi*); and the greater size of the basal abdominal sternite which is distinctly larger than the scutellum (Maa & Peterson, 1987).

Among the three eastern members of Lipopteninae, *M. ovinus* is easily identified by its rudimentary wings, the absence of halteres, and the reduced eyes, which are each narrower than the antenna. The remaining two eastern taxa are separated based on the position of the median abdominal tergal plates (tergites 4–6 in males, 4–7 in females). In *L. cervi* these are evenly distributed over the abdomen, while they are crowded together in the posterior 1/3 of the abdomen in *L. mazamae* (Fig. 1; see also Figs. 1-5 in Skvarla & Machtinger, 2019).

Keys to the Nearctic Lipopteninae genera and species are found in Maa (1965) and Skvarla & Machtinger (2019).

DISCUSSION

Lipoptena mazamae is an ectoparasite of White-tailed Deer, South American Red Brocket Deer, *Mazama americana* (Erxleben), Central American Red Brocket Deer, *M. temama* (Kerr), and Gray Brocket Deer, *M. gouazoubira* Fisher (Bequaert, 1942; Maa 1969). Incidental hosts include cattle, *Bos taurus* Linnaeus, Tayra, *Eira barbara* (Linnaeus), Peccary, *Pecari tajacu* (Linnaeus), Cougar, *Puma concolor* (Linnaeus), Pampas Deer, *Ozotoceros bezoarticus* (Linnaeus), and humans, *Homo sapiens* Linnaeus (Bequaert, 1942; Bequaert, 1957; Reeves et al., 2006; Graciolli et al., 2011; Shock, 2014). The parasite is commonly found on the legs, abdomen, and genital areas of the host (Samuel & Trainer, 1972). Deer populations may have infestation rates of 60-80%, with individuals sometimes harboring hundreds of keds (Bequaert, 1952; Samuel & Trainer, 1972; Kern, 2003).

The known range of *L. mazamae* includes North, Central, and South America (Kennedy et al., 1987; Skvarla & Machtinger, 2019). South of the United States, this species occurs in Argentina, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, French Guiana, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad, Uruguay, and Venezuela (Bequart, 1957; Maa, 1969; Carreno et al., 2001; Deem et al., 2004; Genoways & Timm, 2005; Romero-Castañón et al., 2008; Graciolli et al., 2011). It reaches as far south as Uruguay and Santiago del Estero in northern Argentina (Bequaert, 1942; Maa, 1969).

In the United States, *L. mazamae* records based on specimens and photo vouchers have been reported from Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas (Skvarla & Machtinger, 2019). The northernmost known localities of *L. mazamae* include St. Clair Co., MO in the West; and Anderson Co., TN and Iredell and Wake counties, NC in the East (Skvarla & Machtinger, 2019).

Our records of *L. mazamae* reported herein may be an indication that this species is naturally expanding its range northward. Climate, and not the absence of its primary host the White-tailed Deer, appears to be the limiting factor for northward expansion of *L. mazamae* (Bequaert, 1954). Bequaert (1954) reported reduction of *L. mazamae* numbers, even to the point of complete absence, during harsh winters when frost was common and below-freezing temperatures were frequent. Given current long-term climate change projections, it is likely that *L. mazamae* will continue to expand its range northward (Collins et al., 2013).

Alternatively, *L. mazamae* may have reached Virginia through human-mediated translocation of its host. White-tailed Deer were nearly extirpated from Virginia in the early 1900s (Handley & Patton, 1947). Between 1930 and 1950, at least 1,800 animals were translocated from Florida, Michigan, North Carolina, Pennsylvania, and Wisconsin into Virginia (Linzey, 1998). Deer from Florida, where the parasite has been present since at least the mid-1930s, could have harbored *L. mazamae* at the time of their relocation (Bequaert, 1935; 1942).

Potential overlap of the geographic ranges of *L. mazamae* and *L. cervi* in Virginia and the surrounding areas was suggested by Skvarla & Machtinger (2019). Our records provide further evidence to support this possibility. Such a scenario represents an interesting ecological situation in which two species that have evolved on different continents might co-occur on the same individual host animal. We can only speculate regarding any potential interactions between the two

taxa, which may range anywhere from exploitation competition to avoidance. It is, however, likely that under such circumstances, the two taxa might exploit different areas of the host's body, a situation previously observed in western deer keds and some ticks (Westrom & Anderson, 1992; Baer-Lehman et al., 2012; Skvarla & Machtinger, 2019).

Actual geographical overlap between the ranges of the two species has not yet been documented. *Lipoptena mazamae* is currently only known from the Piedmont of Virginia while *L. cervi* has been reported from Craig, Montgomery, Shenandoah, and Wythe counties in the Blue Ridge and Ridge & Valley physiographic regions in the mountainous, western part of the state (Skvarla & Machtinger, 2019). Given the close proximity (<80 km) of their currently known ranges, it is possible that a direct physical overlap might occur via natural dispersal of the host and/or the parasites. The annual home ranges of adult male deer in Virginia have been estimated at 2.5 km^2, with dispersing young moving 6.4 km on average (Batts, 2008). Thus, range expansion of *L. mazamae* and/or *L. cervi* via movements of White-tailed Deer, albeit not rapid, is possible.

Human-mediated dispersal (of host and parasites) represents another potential mechanism for bringing the ranges of the two species together. In most Virginia counties, except for areas in northwestern Virginia where chronic wasting disease has been reported, hunters harvesting deer are allowed to transport entire animals throughout the state (VDGIF, 2019-2020). As deer keds do not leave the host's body for several hours after death of the animal, hunters transporting deer carcasses also are likely to be inadvertently transporting their associated parasites (Samuel & Trainer, 1972).

DNA sequencing of *L. cervi* and its associated hosts has confirmed the presence of five bacterial pathogens (*Anaplasma*, *Bartonella*, *Borrelia*, *Ehrlichia*, and *Rickettsia*) and one protozoan parasite (*Trypanosoma*) in this species (Skvarla & Machtinger, 2019 and references therein). To date, *L. mazamae* has only been tested for and found to contain the Gram-negative bacterium *Bartonella* (Reeves et al., 2006; Souza et al. 2017). Transmission to hosts and spread of pathogens by deer keds is not yet fully understood for any of these disease agents (Skvarla & Machtinger, 2019). However, vertical transmission of *Bartonella schoenbuchensis* corrig. Dehio et al. to offspring has been recently confirmed in *L. cervi*, making it a potential vector for this pathogen (de Bruin et al., 2015).

The close proximity of the currently known ranges of *L. cervi* and *L. mazamae* in Virginia suggests that physical overlap in this state and the surrounding areas is likely, thus setting up an interesting ecological situation. The extent and strength of any potential interactions between these two species, and the possibility for pathogen exchange between the two taxa, merit further investigation.

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LITERATURE CITED

Batts, G. K. 2008. An assessment of Quality Deer Management on a private hunt club in the Virginia Piedmont. M.S. thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA. 111 pp.

Baer-Lehman, M. L., T. Light, N. W. Fuller, K. D. Barry-Landis, C. M. Kindlin, & R. L. Stewart. 2012. Evidence for competition between *Ixodes scapularis* and *Dermacentor albipictus* feeding concurrently on white-tailed deer. Experimental and Applied Acarology 58: 301–314.

Bequaert, J. 1935. The American species of *Lipoptena* (Diptera, Hippoboscidae). Bulletin of the Brooklyn Entomological Society 30: 170.

Bequaert, J. 1942. A monograph of the Melanophaginae, or ked-flies, of sheep, goats, deer and antelopes (Diptera, Hippoboscidae). Brooklyn Entomological Society, Brooklyn, NY. 220 pp.

Bequaert, J. 1952. The Hippoboscidae or louse-flies (Diptera) of mammals and birds. Part I. Structure, physiology and natural history. Entomologica Americana 32: 1–209.

Bequaert, J. 1954. The Hippoboscidae or louse-flies (Diptera) of mammals and birds. Part II. Taxonomy, evolution and revision of American genera and species. Entomologica Americana 34: 1–232.

Bequaert, J. 1957. The Hippoboscidae or louse-flies (Diptera) of mammals and birds. Part II. Taxonomy, evolution and revision of American genera and species. Entomologica Americana 36: 417–611.

Carreno, R. A., L. A. Durden, D. R. Brooks, A. Abrams, & E. P. Hoberg. 2001. *Parelaphostrongylus tenuis* (Nematoda: Protostrongylidae) and other parasites of

white-tailed deer (*Odocoileus virginianus*) in Costa Rica. Comparative Parasitology 68: 177–184.

Collins, M., R. Knutti, J. Arblaster, J.-L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W. J. Gutowski, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A. J. Weaver, & M. Wehner. 2013. Long-term climate change: Projections, commitments and irreversibility. Pp. 1029-1136 *In* T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, & P. M. Midgley (eds.), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA.

de Bruin, A., A. Docters van Leeuwen, S. Jahfari, W. Takken, M. Földvári, L. Dremmel, H. Sprong, & G. Földvári. 2015. Vertical transmission of *Bartonella schoenbuchensis* in *Lipoptena cervi*. Parasites & Vectors 8: 1–6.

Deem, S. L., A. J. Noss, R. Villarroel, M. M. Uhart, & W. B. Karesh. 2004. Disease survey of free-ranging grey brocket deer (*Mazama gouazoubira*) in the Gran Chaco, Bolivia. Journal of Wildlife Diseases 40: 92–98.

Dick, C. W. 2006. Checklist of world Hippoboscidae (Diptera: Hippoboscoidea). Field Museum of Natural History, Department of Zoology, Chicago. 8 pp.

Farajollahi, A., W. J. Crans, D. Nickerson, P. Bryant, B. Wolf, A. Glaser, & T. G. Andreadis. 2005. Detection of West Nile virus RNA from the louse fly *Icosta americana* (Diptera: Hippoboscidae). Journal of the American Mosquito Control Association 21: 474–477.

Genoways, H. H. & R. M. Timm. 2005. Mammals of the Cosigüina Peninsula of Nicaragua. Mastozoologia Neotropical 12: 153–179.

Graciolli, G., C. A. Zucco, P. H. Cançado, & G. Mourao. 2011. Parasitism rates of *Lipoptena guimaraesi* and a new record of *Lipoptena mazamae* on *Ozotoceros bezoarticus* from the Central Pantanal wetlands in Brazil. Revista Brasileira de Parasitologia Veterinária 20: 178–180.

Halos, L., T. Jamal, R. Maillard, B. Girard, J. Guillot, B. Chomel, M. Vayssier-Taussat, & H. Boulouis. 2004. Role of Hippoboscidae flies as potential vectors of *Bartonella* spp. infecting wild and domestic ruminants. Applied and Environmental Microbiology 70: 6302–6305.

Handley, C. O., Jr., & C. P. Patton. 1947. Wild Mammals of Virginia. Commonwealth of Virginia Commission of Game and Inland Fisheries, Richmond, VA. 220 pp.

Kelsey, A., & J. Finch. 2018. Deer ked: a Lyme-carrying ectoparasite on the move. Cutis 102: 121–122.

Kennedy, M. J., R. A. Newman, & G. A. Chalmers. 1987. First record of *Lipoptena depressa* (Diptera: Hippoboscidae) from Alberta, Canada. Journal of Wildlife Diseases 23: 506–507.

Kern, W. J., Jr. 2003. Neotropical deer ked or Neotropical deer louse fly, *Lipoptena mazamae* Rondani (Insecta: Diptera: Hippoboscidae). Featured Creatures from the Entomology & Nematology Department, Florida Cooperative Extension Service EENY-308: 1–3.

Linzey, D. W. 1998. The Mammals of Virginia. McDonald and Woodward Publishing Company, Blacksburg, VA. 459 pp.

Liu, D., Y. Z. Wang, H. Zhang, Z. Q. Liu, H. Z. Wureli, S. W. Wang, C. C. Tu, & C. F. Chen. 2016. First report of *Rickettsia raoultii* and *R. slovaca* in *Melophagus ovinus*, the sheep ked. Parasites and Vectors 9: 600.

Maa, T. C. 1965. A synopsis of the Lipopteninae (Diptera: Hippoboscidae). Journal of Medical Entomology 2: 233–248.

Maa, T. C. 1969. A revised checklist and concise host index of Hippoboscidae (Diptera). Pacific Insects Monographs 20: 261–299.

Maa, T. C., & B. V. Peterson. 1987. Hippoboscidae, Pp. 1271-1282 *In* J. F. McAlpine, B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, & D. M. Wood (eds.), Manual of Nearctic Diptera, Vol. 2, Monograph 28. Agriculture Canada, Ottawa, ON, Canada.

Moreira, R. F., L. D. C. Farezin, U. A. Souza, B. Z. D. Silva, D. B. Amorim, A. Girotto-Soares, L. E. Surita, M. M. Alievi, G. Graciolli, & J. F. Soares. 2019. Pupipara (Diptera, Hippoboscidae) in wild birds attended at a rehabilitation center in southern Brazil. Brazilian Journal of Veterinary Parasitology 28: 330–332.

Reeves, W. K., M. P. Nelder, K. D. Cobb, & G. A. Dasch. 2006. *Bartonella* spp. in deer keds, *Lipoptena*

mazamae (Diptera: Hippoboscidae), from Georgia and South Carolina, USA. Journal of Wildlife Diseases 42: 391–396.

Romero-Castañón, S., B. G. Ferguson, D. Güiris, D. González, S. López, A. Paredes, & M. Weber. 2008. Comparative parasitology of wild and domestic ungulates in the Selva Lacandona, Chiapas, Mexico. Comparative Parasitology 75: 115–127.

Samuel, W. M., & D. O. Trainer. 1972. *Lipoptena mazamae* Rondani, 1878 (Diptera: Hippoboscidae) on white-tailed deer in southern Texas. Journal of Medical Entomology 9: 104–106.

Shock, B. C. 2014. Studying the natural history of the Florida panther: ectoparasites, piroplasms, and genetic diversity. Ph.D. dissertation, University of Georgia, Athens, GA. 140 pp.

Skvarla, M. J., & E. T. Machtinger. 2019. Deer keds (Diptera: Hippoboscidae: *Lipoptena* and *Neolipoptena*) in the United States and Canada: New state and county records, pathogen records, and an illustrated key to species. Journal of Medical Entomology 56: 744–760.

Small, R. W. 2005. A review of *Melophagus ovinus* (L.), the sheep ked. Veterinary Parasitology 130: 141–155.

Souza, U., B. Dall'Agnol, T. Michel, A. Webster, G. Klafke, J. R. Martins, C. B. Kasper, T. C. Trigo, R. Ott, M. Maria de Assis Jardim, & J. Reck. 2017. Detection of *Bartonella* sp. in deer louse flies (*Lipoptena mazamae*) on gray brocket deer (*Mazama gouazoubira*) in the neotropics. Journal of Zoo and Wildlife Medicine 48: 532–535.

VDGIF [Virginia Department of Game and Inland Fisheries]. 2019-2020. Hunting & Trapping in Virginia. Virginia Department of Game and Inland Fisheries, Henrico, VA. 72 pp.

Westrom, D. R., & J. R. Anderson. 1992. The distribution and seasonal abundance of deer keds (Diptera: Hippoboscidae) on Columbian black-tailed deer (*Odocoileus hemionus columbianus*) in northern California. Bulletin of the Society of Vector Ecologists 17: 57–69.