*Zootaxa* 5296 (1): 031–044
https://www.mapress.com/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.5296.1.3
http://zoobank.org/urn:lsid:zoobank.org:pub:DD80DABB-0E86-481E-AAC4-C912911D071B

# A taxonomic revision of *Neodietrichia* (Araneae: Linyphiidae), a rarely encountered but widespread spider taxon

MARC A. MILNE[1*], CAYLIE O'NEIL[2] & JAMES BERTAUX[3]
*Department of Biology, Shaheen College of Arts and Sciences, University of Indianapolis, 1400 E. Hanna Ave., Indianapolis, IN, USA 46227*
[1] *milnem@uindy.edu; https://orcid.org/0000-0002-1943-0161*
[2] *cmwimmers@gmail.com; https://orcid.org/0009-0003-4980-0025*
[3] *bertauxj@uindy.edu; https://orcid.org/0009-0008-6352-8482*
[*] *Corresponding author. milnem@uindy.edu*

## Abstract

The linyphiid spider *Dietrichia hesperia* was described from California in 1933 by Crosby and Bishop. The genus was renamed to *Neodietrichia* in 2008 by Özdikmen since *Dietrichia* was already occupied by a fossil bivalve. Until now, this rarely collected arboreal spider was the sole member of *Neodietrichia*. Herein we revise the genus by redescribing *Neodietrichia hesperia* (Crosby and Bishop, 1933), transferring *Lophomma depressum* (Emerton, 1882) to *Neodietrichia* as *Neodietrichia depressum* **n. comb.**, and provide the first description of the female of this species.

**Key words:** Erigoninae, sheet-web weaver, arboreal, balloon, new combination

## Introduction

The erigonine linyphiid genus *Neodietrichia* is currently monotypic (World Spider Catalog 2023). Its sole species, *Neodietrichia hesperia* (Crosby and Bishop, 1933) was originally placed in *Dietrichia*. Because that name was already in use for a fossil bivalve, Özdikmen renamed *Dietrichia* as *Neodietrichia*. Crosby and Bishop's (1933) description was based on a single male and a single female of this species collected from North Fork, California in 1920. They cited the uniqueness of the male genital bulb as justification for the creation of the new genus. No habitat or capture method information was given for the specimens.

Subsequently Hackman (1954) examined a single specimen caught in Newfoundland, Canada in 1947 by Robert Traub and compared it to the California paratype of *N. hesperia* given to him by Willis Gertsch. Although Hackman (1954) stated that the single Newfoundland specimen was a female, all his illustrations are of a male specimen. Hackman noted several morphological differences between this Newfoundland spider and *N. hesperia*, including the shape of the male palpal tibial apophysis (TbA), the length and width of the carapace, and minor differences in the male palpal structure. Based on these differences, Hackman (1954) suggested that the Newfoundland specimen might represent a subspecies of *N. hesperia*. Hackman (1954) claimed that the "species new to the science" (we assume he meant this "new subspecies") was deposited at the Canadian National Collection of Insects, Arachnids and Nematodes (CNC). This specimen was then loaned to Scott Carlton, who has stated it was likely destroyed in a fire and therefore presumed lost (S. Carlton, personal communication). In efforts to locate similar specimens of *Neodietrichia*, we examined hundreds of erigonine specimens from various North American museums and collected new specimens. By comparing these specimens with Hackman's (1954) illustrations (and eventually to holotypes), we have determined that Hackman's (1954) undescribed *Neodietrichia* "subspecies" is a specimen of *Lophomma depressum* (Emerton 1882).

*Lophomma* was erected in 1868 by Menge based on *Lophomma stictocephalum* Menge 1868, a junior synonym of *Lophomma punctatum* (Blackwall 1841). *Lophomma depressum* (Emerton 1882) (originally *Lophocarenum depressum*) was described from a single male found in moss on Mt. Washington in New Hampshire (Emerton

*Accepted by G. Hormiga: 4 May 2023; published: 25 May 2023*

1882). Marx (1890) transferred this species to *Erigone* after which Simon (1894) transferred it to *Diplocephalus*. Subsequently Crosby and Bishop (1933) redescribed the species and transferred it to *Lophomma* (where it is currently placed) without recognizing its close resemblance to their new species *Neodietrichia hesperia*, described in the same paper. Marusik *et al.* (2006) revised *Lophomma* and, upon examination of specimens of *L. depressum*, believed this species is incorrectly placed in *Lophomma* because it lacked several diagnostic *Lophomma* characters such as cephalic punctation and the male palpal tibia with 2–3 apophyses. However, they were unsure of its true taxonomic placement and thus dubbed it "*Lophomma*" *depressum* (Marusik *et al.* 2006). Other researchers have indicated that *L. depressum* belongs in *Neodietrichia* (Nadine Dupérré, Pierre Paquin, and Don Buckle, personal communication). It is the aim of this study to update the taxonomy of *Neodietrichia* by redescribing *N. hesperia*, transferring *L. depressum* into this genus as *Neodietrichia depressum* **n. comb.**, and describing the previously undescribed female of *L. depressum*.

## Methods

**Sampling.** Spiders were collected from Blossom Hollow Nature Preserve in Johnson County, Indiana, USA on 15 December 2017 by litter sifting large handfuls of leaves from valleys and ridges near the main trail. Sifted spiders were immediately preserved in 95% ethanol and returned to the lab for sorting and examination. Spiders were collected from the same location again between 22 February–15 March 2020 by placing sticky traps (plastic wrap coated in a thin layer of Tanglefoot (Scotts Tanglefoot tangle-trap sticky coating, model no. 0461612) and secured around the circumference of individual trees) at chest-height on *Fagus grandifolia* and allowing the traps to collect for approximately three weeks. Traps were then removed from the trees and placed on large pieces of cardboard for transport back to the lab. Spiders were then removed from the traps with forceps and rinsed in a solution of citrus solvent (Milk Paint, Real Milk Paint Co., model no. |SG_B007RO1VIM_US) for 30 minutes to remove the Tanglefoot from the specimens. Spiders were then preserved in 95% ethanol for examination. Collecting via sticky trap for *Neodietrichia* was also done at Southeastway Park, IN and Ginn Woods Nature Preserve, IN, but failed to capture any specimens of this genus. Leaf litter sifting and hand collecting were carried out at Penobscot Experimental Forest, Maine, and Coldbrook Provincial Park, Nova Scotia as well, but also failed to find any specimens. *Neodietrichia* specimens collected were deposited in FMNH, Chicago, Illinois, USA.

Due to the dearth of *Neodietrichia* specimens in museums and the widespread nature of the species within this group, we also attempted to acquire more specimens by beginning a community scientist project (https://scistarter.org/the-search-for-neodietrichia) in September 2020. Volunteers who signed up to participate were sent Tanglefoot, plastic wrap, vials of ethanol and citrus solvent, and detailed instructions on how to set up and process their own sticky traps. Between September 2020 and September 2021, we sent out 33 kits of supplies to volunteers and received spiders back from 12 respondents. The respondents placed sticky traps on *F. grandifolia* at various times of the year in forests and parks in California, Florida, Georgia, Kentucky, Maine, Maryland, Minnesota, North Carolina, Nova Scotia, Ohio, Pennsylvania, Rhode Island, Tennessee, Vermont, Virginia, and West Virginia and sent back 223 spiders from all of these locations. However, no *Neodietrichia* specimens were collected from these efforts.

**Descriptions.** Comparative material from the American Museum of Natural History (AMNH), the Field Museum of Natural History (FMNH), the Canadian National Collection of Insects, Arachnids & Nematodes (CNC), the Museum of Comparative Zoology (MCZ), the University of Guelph (UG), and the private collections of Rich Bradley, Don J. Buckle, Michael Draney, and Pierre Paquin were examined and compared to our specimens. Spiders were examined in 95% ethanol using a Leica M165C stereomicroscope. Measurements and photographs were taken using the same stereomicroscope and a Leica DMC2900 attached digital camera with the associated Leica Application Software (LAS X Ver. 3.0.12.21488, Leica Microsystems, Switzerland) at the University of Indianapolis. Epigyna were dissected from female abdomens using forceps and temporarily cleared for photography using clove oil. Embolic divisions were dissected from the male palps of specimens that were disposable or for which there were replicates and with permission from collection managers. Due to these constraints, no *N. hesperia* palps were available for embolic division dissection.

**Images and illustrations.** Photographs were taken with specimens placed in glass dishes containing white sand and 95% ethanol. Specimens were prepared for SEM photography by dehydration using ethanol solutions that graduated from 70% to 100%. Specimens were then placed in Hexamethyldisilazane (HMDS; 99+%; Alfa

Aesar, Heysham, England) for 5 minutes before being removed and placed on filter paper to dry for 5 minutes. Specimens were then mounted on SEM stubs using 12 mm Pelco TabsTM (TED PELLA, Inc.-carbon conductive tabs), sputter coated in gold (Cressington Scientific Instruments, Model No. 108) and photographed using a JEOL JCM-6000 NeoScope benchtop scanning electron microscope. All measurements are in millimeters. Carapace width was measured at the widest part of the carapace. All images, illustrations, and descriptions of male pedipalps are of the left palp. Specimens were illustrated by tracing over photographs of specimens taken using the light microscope mentioned above and then modified free-hand by visual inspection of specimens. Illustrations were done using a combination of pencil and ink (Sakura PIGMA Micron pens) and Photoshop computer software (Adobe Photoshop Version 23.4.2) paired with an XP-PEN Artist 13.3 Pro drawing tablet (XP-PEN Artist 13.3 Pro, B07VPHR6GD). Character abbreviations used in text: AME, anterior median eyes, ALE, anterior lateral eyes; PLE, posterior lateral eyes, PME, posterior median eyes; TmI, position of trichobothrium on metatarsus I.

**DNA sequencing.** DNA was extracted from spiders using the entire body or multiple legs from various specimens (CANADA: *New Brunswick:* Madawaska Co., 30 mi. N. Edmunston, coll. T. R. Renault (CNC 1030077), 19 August 1968, 1 male; U.S.A.: *Indiana:* Johnson Co., Blossom Hollow Nature Preserve, coll. M. A. Milne, C. Wimmersberger, E. Mullins, C. Venable (MM, specimen 12A8), 22 February–15 March 2020, 1 male; *Ohio:* Vinton Co., Vinton Furnace near Dundas, coll. M. A. Ivie (RB), 5 March 1983, 1 female) using the DNEasy Blood and Tissue Kit (Qiagen, Inc., Cat. No. 69504) following the standard protocol. We amplified ~600bp of the cytochrome c oxidase subunit I (COI) gene by polymerase chain reaction (PCR) using the primers L-COI-1490 (5'-GGTCAACAAATCATAAAGATATTGG-3') and H-CO1-2198 (5'-TAAACTTCAGGGTGACCAAAAAATCA-3'). The PCR conditions were 2 minutes at 94°C, followed by 34 cycles of 20 seconds at 94°C, 35 seconds at 49°C, and 30 seconds at 65°C. The PCRs finished with 3 minutes at 72°C. PCR results were visualized on 1% agarose gels. Successful PCR products were purified using the PCR Purification Kit (Qiagen, Inc., Cat. No. 28104). DNA sequencing of purified PCR products was carried out at an offsite sequencing facility (Genewiz, South Plainfield, NJ). The sequences have been submitted to GenBank (GenBank Accession Nos. OQ884023, OQ884024, and OQ884025).

**Phylogenetic analyses.** DNA sequences were imported into MEGA X for trimming and aligned using the MUSCLE algorithm and for phylogenetic analyses. We imported previously published COI sequences from GenBank of *Lophomma depressum* from Edson, Alberta (GenBank Accession #JF884548.1 and #JF886146.1), Elk Island National Park, Alberta (KM833851.1 and KP648498.1), Whitecourt, Alberta (MG049132.1), Riding Mountain National Park, Manitoba (MF812537.1), Petitcodiac, New Brunswick (MG047758.1), Kejimkujik National Park, Nova Scotia (KP646112.1), Pukaskwa National Park, Ontario (KP650517.1), and Smith Falls, Ontario (MG048204.1). We used another erigonine, *Mermessus maculatus* (Banks, 1892) (HQ979210.1), as an outgroup. We used MEGA X to calculate p-distances between sequences and to conduct phylogenetic analyses using parsimony and neighbor-joining methods.

**Collections.** AMNH—American Museum of Natural History, New York, USA, CNC—Canadian National Collection of Insects, Arachnids & Nematodes, Ottawa, Canada, DB—private collection of Don Buckle, FMNH—Field Museum of Natural History, Chicago, USA, MCZ—Museum of Comparative Zoology, Boston, USA, MD—private collection of Michael Draney, MM—private collection of Marc A. Milne, PP—private collection of Pierre Paquin, RB—private collection of Rich Bradley, UG—University of Guelph.

## Taxonomy

### Linyphiidae Blackwall, 1859

### *Neodietrichia* Özdikmen, 2008

*Neodietrichia* Özdikmen, 2008: 537.

**Type species:** *Dietrichia hesperia* Crosby & Bishop, 1933, by monotypy. *Neodietrichia* Özdikmen, 2008 replacement name for *Dietrichia* Crosby & Bishop, 1933 preoccupied in Bivalvia by *Dietrichia* Reck, 1921.

**Etymology.** The original name, *Dietrichia*, was a patronym in honor of Henry Dietrich, a colleague of Crosby and Bishop at Cornell University (Cameron 2005). The replacement name, *Neodietrichia*, literally translates to "New *Dietrichia*".

**Diagnosis.** *Neodietrichia* males possess dual cephalic sulci on the sides of the carapace behind the PLE, the most anterior of which leads to a pit and the posterior sulci extend posteriorly from the median part of the anterior sulci and taper distally (Fig. 1). *Neodietrichia* males may also be distinguished from those of other similar erigonine genera (e.g., *Mecynargus* and *Semljicola*) by the presence of a large, anteriad, scimitar-shaped radical apophysis unlike any other erigonine genus (Figs. 2B, C, 3A, E, 4B, C, 5A, D; Crosby and Bishop 1933, fig. 202; Hackman 1954, fig. 55; Marusik *et al.* 2006, figs. 46 and 79). Moreover, males of *Neodietrichia* possess a longer tibial apophysis than any of the aforementioned genera, often accompanied by distal teeth (Figs. 2C–E, 3C, D, 4C–E, 5C, E, F; Crosby and Bishop 1933, fig. 201 and 203; Hackman 1954, fig. 53–57; Marusik *et al.* 2006, figs. 45, 47, 81, and 82). Unlike most erigonines, *Neodietrichia* females possess epigyna with a sclerotized hood (somewhat similar to *Masoncus*). Similar to *Masoncus*, a median lobe exists posterior to the hood. However, unlike *Masoncus* in which the hood is near the midline of the epigynum (Chamberlin 1949, figs. 95, 100, 103; Cushing 1995, fig. 5), the hood in *Neodietrichia* epigyna is anterior to all other epigynal parts (Figs. 2G, H, 3F, G, 4G, H, 5G, H). Moreover, the median plate in *Neodietrichia* epigyna is wider posteriorly and narrows anteriorly (Figs. 2G, H, 3F, G, 4G, H, 5G, H) unlike the square-shaped median plate in most *Masoncus* (Chamberlin 1949, figs. 95, 103; Cushing 1995, fig. 5).

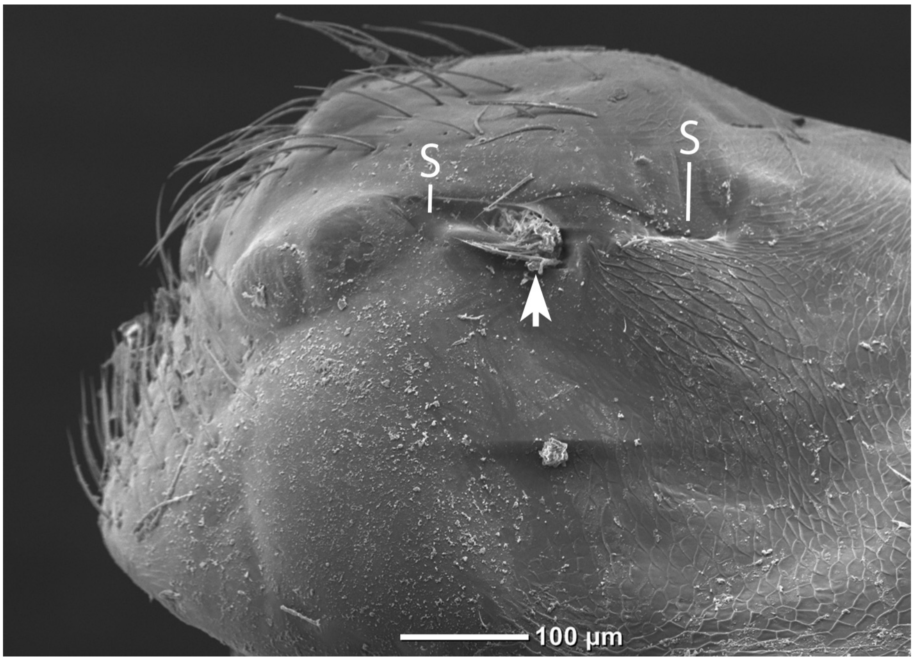

**FIGURE 1.** SEM micrograph of the lateral view of the carapace of *Neodietrichia depressum* **n. comb.** (MM 6D15, Indiana, Johnson Co.). Arrow indicates substance filling pit. S, sulci.

**Description** (Figs. 1–5). Medium-sized (1.38–2.83) erigonines with dusky orange to brown cephalothoraxes and gray to black abdomens. Eight eyes ringed in black. AME slightly smaller than the other subequal eyes. Posterior eye row slightly procurved, anterior eye row slightly recurved so that lateral eyes from both rows are touching. Chelicerae with 5 promarginal teeth and 4–5 retromarginal teeth; small mastidion present; cheliceral file with 8–20 ridges. Carapace oval, slightly less than half as wide as long with 2–3 hairs along midline. Males with many hairs on clypeus just below AME, between AME and ALE, between AME and PME, and some behind PME. Males also possess pits and dual elongated sulci on the carapace behind PLE; anterior sulci shallow just behind PLE and deepen as they extend posteriorly, often curving ventrally, to pit; posterior sulci extend posteriorly from median part of anterior sulci and taper distally. As in many erigonine males (Schaible *et al.* 1986), pits in *Neodietrichia* demonstrate the production of a substance that is assumed to be a nuptial gift for mating females (see arrow in Fig. 1). When viewed laterally, carapace is slightly concave from PLE to approximately 1/2 to 2/3rds towards posterior end of carapace at which point it declines to pedicel. Carapace dusky orange to brown; sternum slightly longer than wide, pointed posteriorly between coxae of leg IV. Abdomen oval, covered with simple setae, color ranges from light gray to black, sometimes mottled with four points of muscle attachment darker. Venter color and pattern similar to dorsal side. Epiandrous fusules absent; colulus approximately twice as long as wide; anterior spinnerets longer and wider than posterior ones, cone-shaped. Legs slightly lighter than carapace color, concolorous, relative length 4, 1, 2, 3; femur I approximately 3/4 as long as carapace; metatarsi I–III each with a single trichobothrium; metatarsus IV lacking trichobothrium; paired tarsal claws and median claw without teeth. Tibia I–III each with a single trichobothrium; tibia IV with 1–4 trichobothria of varying lengths; trichobothrium on metatarsus I distal (n = 68, min = 0.52, max = 0.85, median = 0.75). TmI (n=67), 0.52–0.85 (mean = 0.74). Tibial macrosetae 2221 (1 distal and 1 proximal on legs I–III) with distal macrosetae on legs I–III greatly reduced. Patellar macrosetae 2222 (1 distal and 1 proximal) with the proximal macrosetae greatly reduced. Male palp simple, possessing a large, anteriad, scimitar-shaped radical apophysis; embolus often curved and directed towards central radical apophysis from retrolateral edge; tegulum with distal protegulum retrolateral to radical apophysis; large prolateral radix; palpal tibial apophysis long, pointed, and occasionally with spines in various arrangements (Figs. 2B–E, 3A, C–E, 4B–E, 5A, C–F, Crosby and Bishop 1933, fig. 201 and 203; Hackman 1954: figs 53–54 and 56–57; Marusik *et al.* 2006, figs. 45, 47, 81, and 82). Epigynum (Figs. 2G, H, 3F, G, 4G, H, 5G, H, Crosby and Bishop 1933, fig. 204) with median plate that widens posteriorly; concave anterior hood either single (*N. hesperia*) or doubled (*N. depressum* **n. comb.**); both spermathecae visible ventrally, present medially, either directed anteriorly, lateral to median plate (*N. depressum* **n. comb.**) or directed centrally, underneath median plate (*N. hesperia*); dual copulatory openings located centrally lateral to median plate.

**Distribution.** California and British Columbia east to Nova Scotia and south to South Carolina; likely exists throughout North America (Fig. 7).

**Natural History.** May be found on the trunks, under the bark, or on upper branches (~5m) of various species of trees within undisturbed forests with deep leaf litter. Specimens have also been found in the leaf litter of older forests, agricultural fields, in lichen, bird nests, on buildings, and in swamps. There is strong evidence that this species frequently balloons as many examined specimens were captured in malaise traps, flight intercept traps, and Lindgren traps. In fact, one specimen was collected after it ballooned onto the shirt of the wife of a prominent linyphiid-specializing arachnologist (Dr. Michael Draney, U. Wisconsin Green Bay).

### ***Neodietrichia hesperia*** **(Crosby & Bishop, 1933)**

(Figs. 2, 3, 6, 7)

*Dietrichia hesperia* Crosby & Bishop 1933: 160, figs. 199–204 (Description of male and female).
*Dietrichia hesperia* Hackman 1954: 17, figs. 51–57.
*Neodietrichia hesperia* Özdikmen 2008: 537 (transferred from *Dietrichia*).

**Types.** *Holotype male.* U.S.A.: *California*: 1 male, Madera County, North Fork, 1 March 1920, H. Dietrich (AMNH ID AMNH_IZC 00328051). *Paratype*.—U.S.A.: *California*: 1 female, same data as holotype [lost, see type data remarks];

**Type data remarks.** Holotype and paratype originally deposited in the collection of Cornell University and then transferred to the American Museum of Natural History. Female paratype not examined, missing from collection, presumed lost during transfer (Draney 1998).

**Diagnosis.** Males of *N. hesperia* differ from *N. depressum* **n. comb.** in that the embolus of *N. hesperia* visibly projects anteriorly behind the protegulum towards the central radical apophysis while in *N. depressum* **n. comb.**, much of the embolus is not visible but possesses a distal portion that projects ventrally (Figs. 2B, E, 3A, 4B, E, 5A). Moreover, the palpal tibial apophysis in *N. hesperia* is thinner than in *N. depressum* **n. comb.** and is relatively straight and flat except for the existence of one to two spines whereas in *N. depressum* **n. comb.** it possesses a median keel in addition to smaller distal spines (Figs. 2C–E, 3C, D, 4C–E, 5C, E, F). The female epigynum in *N. hesperia* possesses spermathecae that are directed centrally, underneath the median plate whereas in *N. depressum* **n. comb.** they are lateral to the median septum and directed anteriorly. Moreover, the epigynum in *N. hesperia* possesses a single concave anterior hood whereas in *N. depressum* **n. comb.** a dual-lobed concave anterior hood is present (Figs. 2G, H, 3F, G, 4G, H, 5G, H).

**Description.** *Male* (AMNH_IZC 00328051, holotype; Figs. 2A–E, 3A–E). Smaller sized (1.38–1.70 total length) erigonines with carapace dusky dark orange to light brown, black around eyes, legs dark yellow in color, and abdomen dark gray to black, often with lighter mottling. Eyes, teeth, pits, anterior and posterior sulci, venter, and spinnerets typical of genus. Chelicerae with 10–13 stridulatory ridges. Clypeus with slight anterior bulge and hairs present. Leg lengths, macrosetae, and claw teeth typical of genus. Metatarsi I–III each with single trichobothrium;

metatarsus IV lacking trichobothrium; tibia I–III each with single trichobothrium; tibia IV with 1–3 trichobothria. Pedipalp with large medial radical apophysis that, when viewed ventrally, angles prolaterally and then bends inward distally. Embolus long and extends anteriorly along the retrolateral side of the palp with the point converging near the apex of the radical apophysis. Protegulum extends anteriorly, adjacent to the radical apophysis, but exterior to the distal part of the embolus. Paracymbium small and rounded at the tip (Figs. 2B, E, 3A). Palpal tibial apophysis long, thin, straight, and relatively flat with one or two distal or semi-distal spines (Figs. 2C–E, 3C, D).

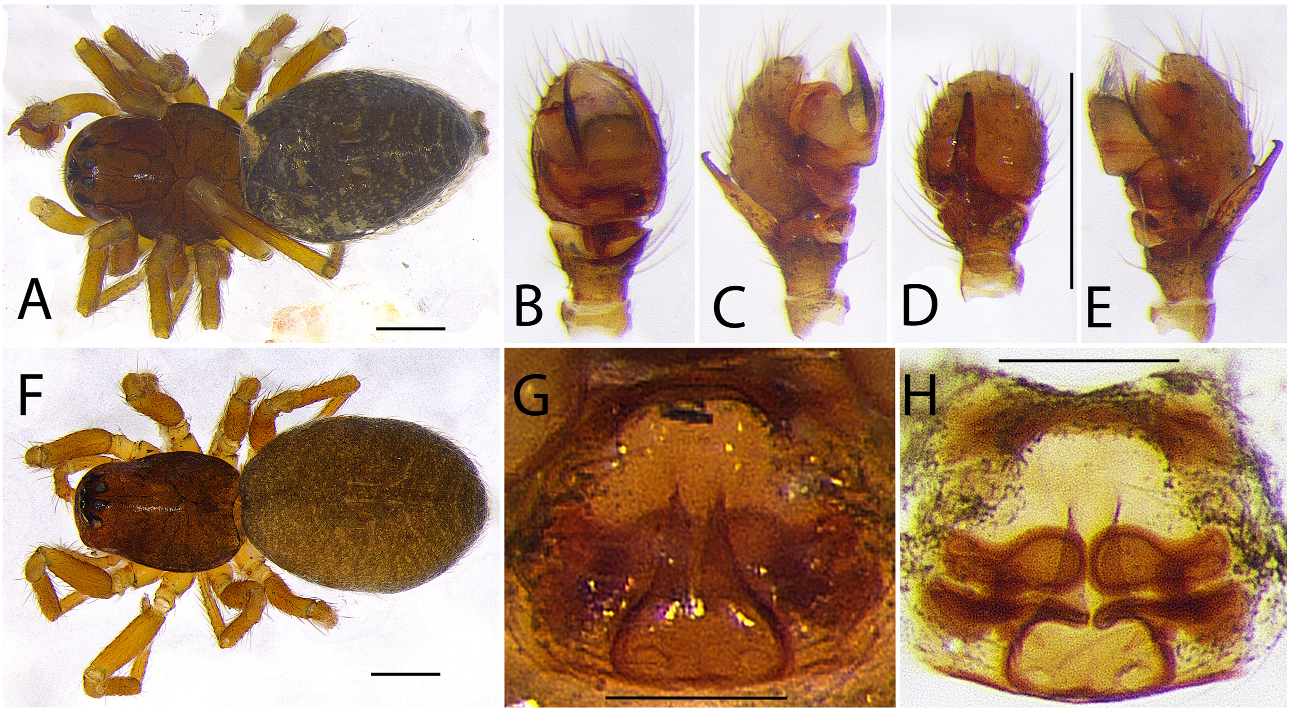

**FIGURE 2.** Photographs of *Neodietrichia hesperia* (Male: MCZ 140958, Maine: Washington Co.; Female: RB, Ohio: Vinton Co.). A, Male habitus; B, male left palp, ventral view; C, male left palp, prolateral view; D, male left palp, dorsal view; E, male left palp, retrolateral view; F, female habitus; G, epigynum, ventral view; H, epigynum, cleared dorsal view. Scale bars represent 0.25mm.

*Female* (RB, Ohio: Vinton Co.; Figs. 2F–H, 3F, G). Smaller sized (1.48–1.80) erigonines with coloration of carapace and legs as in male. Abdomen gray as in some of the lighter-colored males. Females lack sulci and pits. Clypeus not bulged and lacking large numbers of clypeal hairs as in male. Eyes, teeth, venter, spinnerets, chelicerae, leg lengths, macrosetae, trichobothria, and claw teeth as in male. Epigynum with single concave anterior hood and dual, ventrally-visible spermathecae. Median plate wide posteriorly and narrows anteriorly. Spermathecae directed centrally, underneath thinner part of median plate. Dual copulatory openings exist medially near narrowing of median plate. Fertilization and copulatory ducts coiled laterally to spermathecae (Figs. 2H, 3G).

**Measurements.** *Male:* (n=3): Total length, 1.38–1.70 (mean=1.53); carapace length, 0.66–0.76 (mean=0.71); carapace width, 0.51–0.53 (mean=0.52); femur I length, 0.44–0.52 (mean=0.47); TmI (n=2), 0.59–0.63 (mean = 0.61). *Female*: (n=3): Total length, 1.48–1.8 (mean=1.66); carapace length (n=4), 0.62–0.72 (mean=0.67); carapace width, 0.49–0.53, (mean=0.51); femur I length, 0.42–0.45 (mean=0.44); TmI (n=3), 0.62–0.65 (mean = 0.63).

**Variation.** The three male specimens that are known all slightly differ in the shape (width and orientation) and number and/or location of spines on the tibial apophysis (Fig. 6). There was no morphological variation seen in the four females examined.

**Distribution.** Known from only four locations: California (holotype), Maine, Ohio, and Quebec. Likely distributed throughout North America (Fig. 7).

**Natural history.** Adults have been collected from March - July. Adults have been collected from sweeping low-bush blueberry in agricultural fields, from flight-intercept traps placed 5m up in spruce/fir/hardwood mix forests, under the bark of trees, and from the Berlese extraction of specimens in a broom of *Picea mariana*.

**Other material examined.** CANADA: *Quebec*: Abitibi-Témiscamingue Region, Abitibi-Ouest, coll. P. Paquin and N. Dupérré (PP, 519), 19–26 June 1994, 1 female; Eeyou Istchee James Bay Territory, 87 km. N of LaSarre, coll. P. Paquin and N. Dupérré (PP, 9384), 4 July 1997, 1 female. U.S.A.: *Maine*: Hancock Co., Bradley Penobscot Experimental Forest, coll. J. Jaros-Su (MCZ, 104521), 1997, 1 male; Washington Co., T30 MD BPP, EBB Survey, coll. J. Crowe (MCZ, 140958), 20 May 2008, 1 male; Cocoa Mountain, coll. J. Collins (MCZ, 151767), 14 May 1993, 1 female. *Ohio*: Vinton Co., Vinton Furnace near Dundas, coll. M. A. Ivie (RB), 5 March 1983, 1 female.

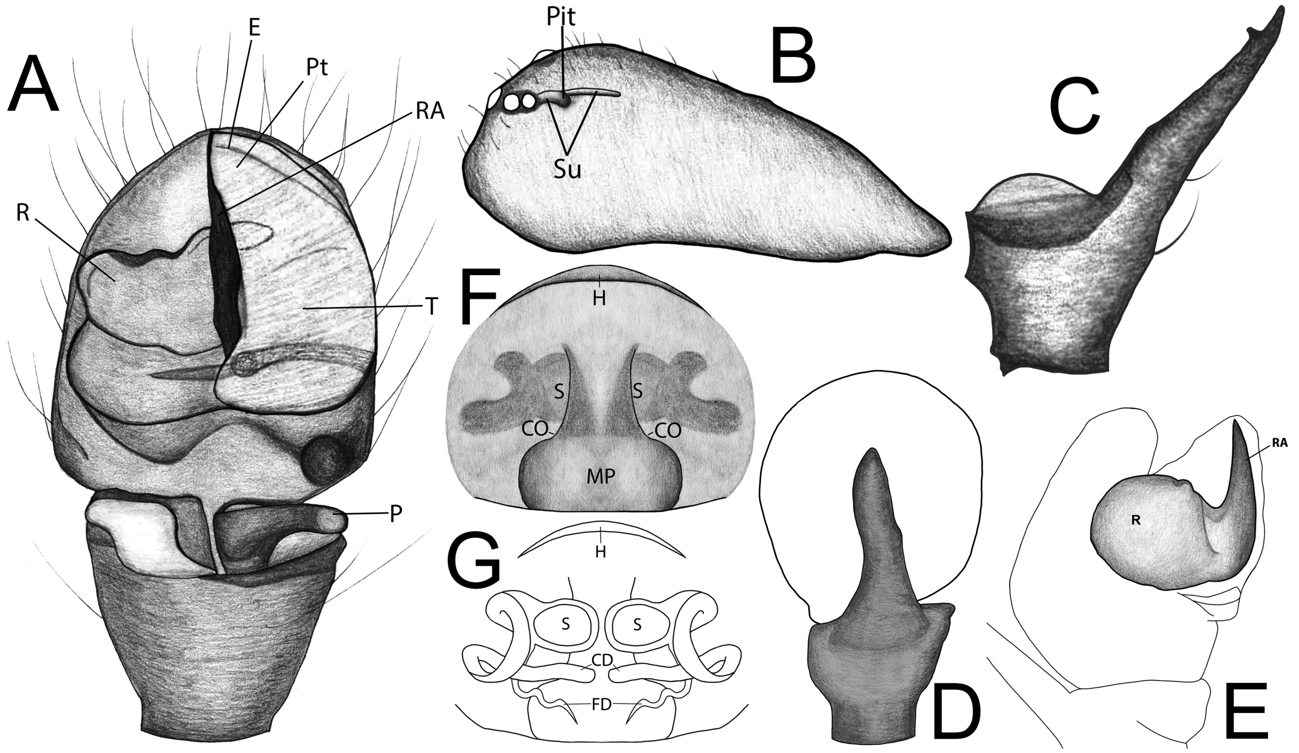

**FIGURE 3.** Illustrations of *Neodietrichia hesperia* (Male: AMNH_IZC 00328051, holotype; Female: RB, Ohio: Vinton Co.). A, Holotype male left palp, ventral view; B, male carapace, lateral view; C, holotype male left palpal tibial apophysis, retrolateral view; D, holotype male left palp, dorsal view; E, holotype male left palpal embolic division, prolateral view; F, epigynum, ventral view; G, epigynum, cleared dorsal view. R, radix; E, embolus; Pt, protegulum; RA, radical apophysis; T, tegulum; Pc, paracymbium; Su, sulci; H, hood; S, spermathecae; CO, copulatory openings; MP, median plate; CD, copulation ducts; FD, fertilization ducts.

## *Neodietrichia depressum* (Emerton, 1882) new combination

(Figs. 1, 4, 5, 8, 9)

*Lophocarenum depressum* Emerton 1882: 50, fig. 6 (Description of male).
*Erigone depressa* Marx 1890: 533.
*Diplocephalus depressus* Simon 1894: 615.
*Lophomma depressum* Crosby & Bishop 1933: 125, figs. 64–68.
"*Lophomma*" *depressum* Marusik, Gnelitsa & Koponen, 2006: 166, figs. 43–48, 78–83 (misplaced in this genus).

**Type.** *Holotype male.* U.S.A.: *New Hampshire*: 1 male, Coös County, Mount Washington, June 1874, J. H. Emerton (MCZ 21047).

**Diagnosis.** Males of *N. depressum* **n. comb.** possess a palp with a ventrally-projecting distal portion of the embolus with most of the embolus hidden while the embolus in *N. hesperia* visibly projects anteriorly towards the radical apophysis (Figs. 2B, E, 3A, 4B, E, 5A). Moreover, the palpal tibial apophysis in *N. depressum* **n. comb.** is wider than that of *N. hesperia* and possesses a median keel in addition to smaller distal spines, which differs from the straight and flat palpal tibial apophysis in *N. hesperia* that possesses 1–2 large spines (Figs. 2C–E, 3C, D, 4C–E, 5C, E, F). Females of *N. depressum* **n. comb.** may be distinguished from those of *N. hesperia* by the epigynum, which possesses a doubly-lobed concave anterior hood versus the single hood in *N. hesperia*. Moreover, the epigynum in *N. depressum* **n. comb.** possesses anteriorly-directed spermathecae that are lateral to the wide median lobe whereas in *N. hesperia*, these spermathecae are centrally-directed underneath the thinner part of the median lobe (Figs. 2G, H, 3F, G, 4G, H, 5G, H).

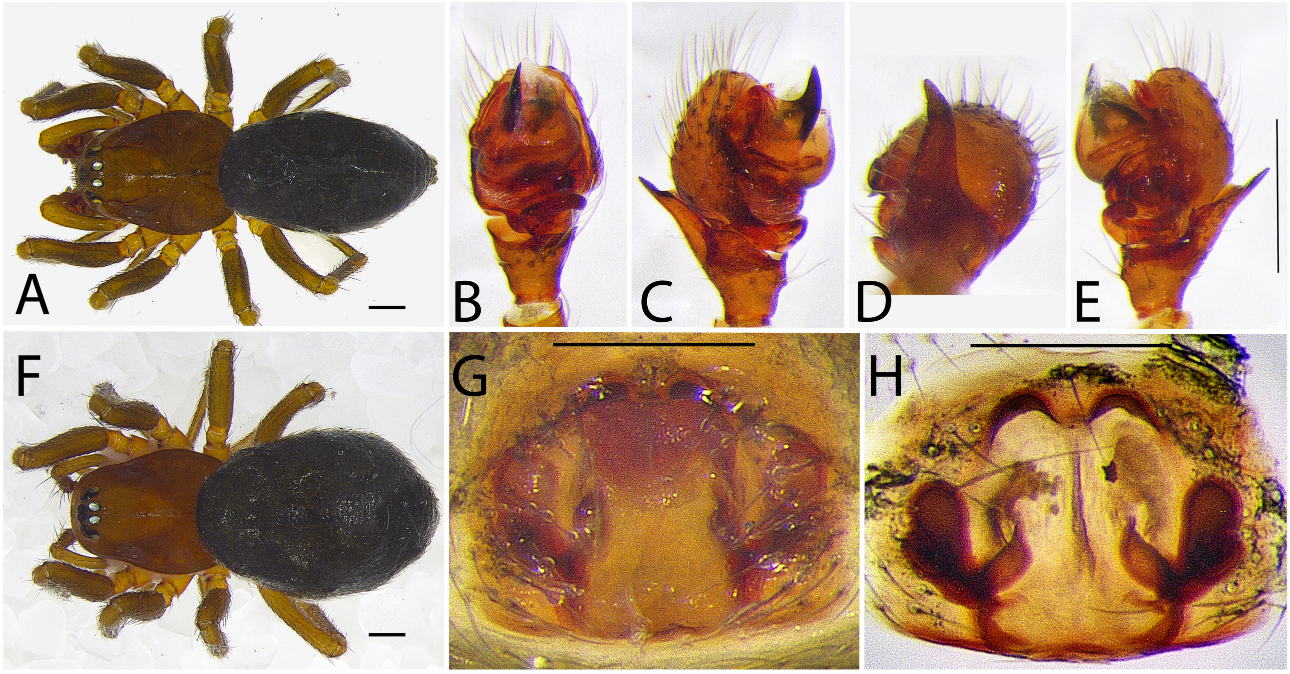

**FIGURE 4.** Photographs of *Neodietrichia depressum* **n. comb.** (MM 6D15, Indiana, Johnson Co.). A, Male habitus; B, male left palp, ventral view; C, male left palp, prolateral view; D, male left palp, dorsal view; E, male left palp, retrolateral view; F, female habitus; G, epigynum, ventral view; H, epigynum, cleared dorsal view. Scale bars represent 0.25mm.

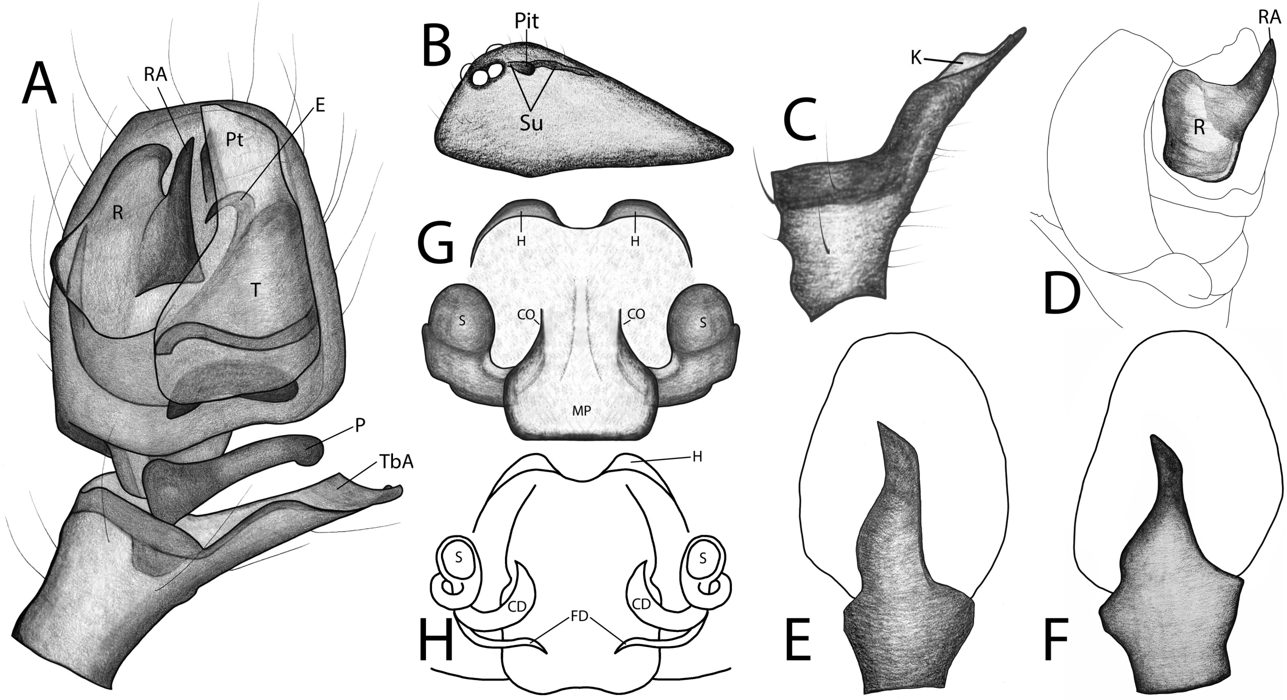

**FIGURE 5.** Illustrations of *Neodietrichia depressum* **n. comb.** (MM 6D15, Indiana, Johnson Co.). A, Male left palp, ventral view; B, male carapace, lateral view; C, male left palpal tibial apophysis, retrolateral view; D, male left palpal embolic division, prolateral view; E, male left palpal tibial apophysis, dorsal view; F, same, variation; G, epigynum, ventral view; H, epigynum, cleared dorsal view. R, radix; E, embolus; Pt, protegulum; RA, radical apophysis; T, tegulum; P, paracymbium; TbA, tibial apophysis; Su, sulci; K, keel; H, hood; S, spermathecae; CO, copulatory openings; MP, median plate; CD, copulation ducts; FD, fertilization ducts.

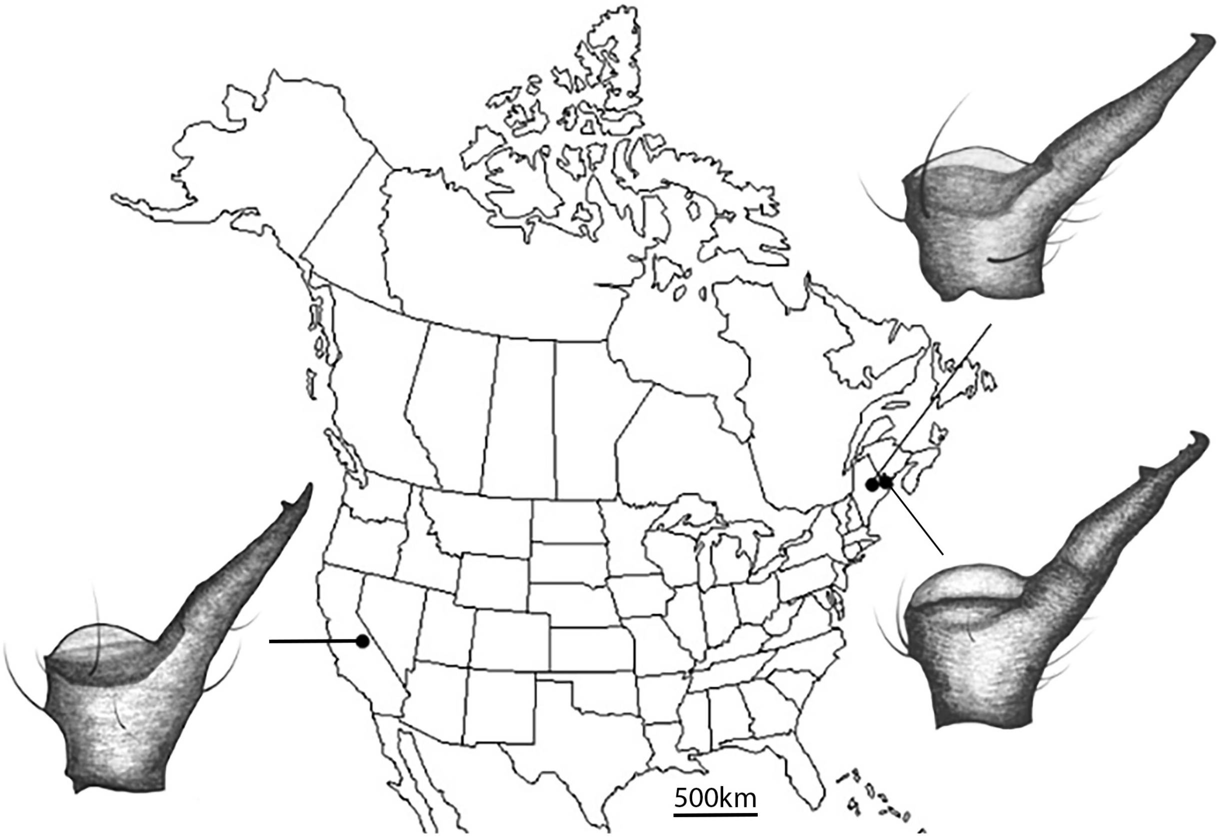

**FIGURE 6.** Variation in male palpal tibial apophyses in *Neodietrichia hesperia*. Illustrations represent retrolateral views.

**Description.** *Male* (MCZ 21047, holotype; Figs. 4A–E, 5A–F). Small to medium-sized (1.38–2.42) erigonines with carapace pale yellow to dark brown with black around eyes; legs slightly lighter in color than carapace; abdomen mottled light gray to concolorous black (Fig 4A). Eyes, teeth, pits, anterior and posterior sulci, venter, and spinnerets typical of genus. Clypeus with slight anterior bulge and many microsetae (Figs. 1, 5B). Leg lengths, macrosetae, and claw teeth typical of genus. Metatarsi I–III each with single trichobothrium; metatarsus IV lacking trichobothrium; tibia I–III each with single trichobothrium; tibia IV with 1–4 trichobothria. Pedipalp with large medial radical apophysis that, when viewed ventrally, is straight and shifted prolaterally of center (Figs. 4B, 5A). Distal portion of embolus projects ventrally retrolateral of radical apophysis though much of embolus is hidden behind tegulum. Protegulum extends anteriorly adjacent to and past tip of radical apophysis (Figs. 4B, E, 5A). Paracymbium rounded at tip (Figs. 4B, E, 5A).

*Female* (MM 6D15, Indiana: Johnson Co.; Figs. 4F–H, 5G, H). Coloration of carapace, abdomen, and legs as in male. Females lack sulci and pits (Fig. 4F). Clypeus not bulged and lacking large numbers of clypeal hairs as in male. Eyes, teeth, venter, spinnerets, chelicerae, leg lengths, macrosetae, trichobothria, and claw teeth as in male. Epigynum with single concave anterior hood and dual, ventrally-visible spermathecae. Median plate wide posteriorly and narrows anteriorly (Figs. 4G, 5G). Spermathecae directed centrally, underneath thinner part of median plate. Dual copulatory openings exist medially near narrowing of median plate. Fertilization and copulatory ducts coiled laterally to spermathecae (Figs. 4H, 5H).

**Measurements.** *Male:* (n=27): Total length, 1.38–2.42 (mean=1.98); carapace length, 0.73–1.15 (mean=0.96); carapace width, 0.57–0.93 (mean=0.74); femur I length (n=26), 0.47–0.86 (mean=0.69); (n=2): TmI (n=28), 0.52–0.82 (mean = 0.74). *Female*: (n=40): Total length, 1.54–2.83 (mean=2.18); carapace length, 0.7–1.21 (mean=0.98); carapace width, 0.55–0.96, (mean=0.75); femur I length (n=39), 0.44–0.92 (mean=0.71); TmI (n=35), 0.63–0.85 (mean = 0.75).

**Variation.** Males showed some variation in their palpal tibial apophyses, especially in the number of distal small teeth present and the size and shape of the proximal keel (Fig. 8). Males also showed some variance in the shape (curvature and length) of their sulci and their embolic division (Fig. 9). Little to no morphological variation observed in the females.

**Distribution.** Known from British Columbia east to Nova Scotia and south to South Carolina. Likely distributed throughout North America (Fig. 7).

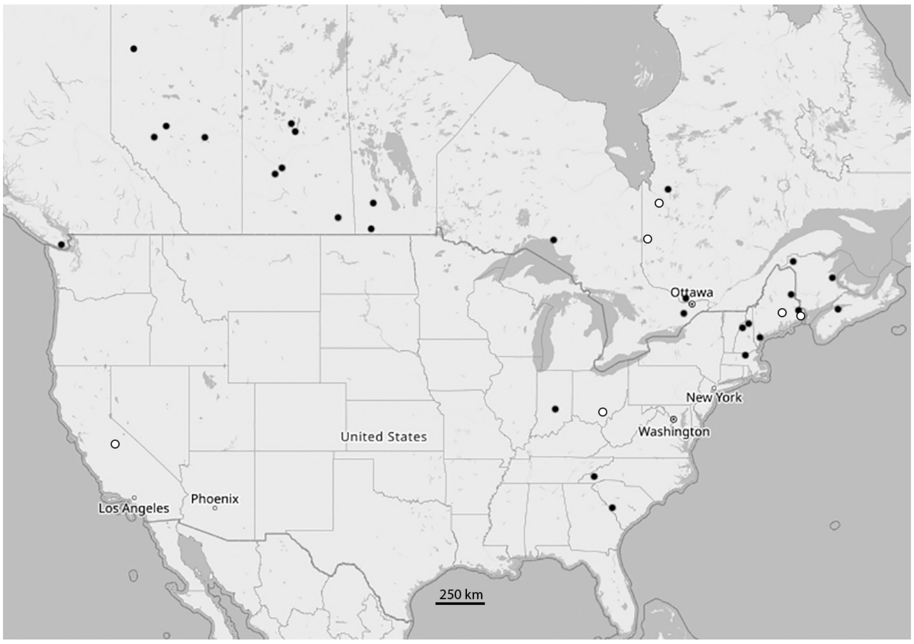

**FIGURE 7.** All known collection locations of *Neodietrichia*. Open circles represent *Neodietrichia hesperia*. Filled circles represent *Neodietrichia depressum* **n. comb.**

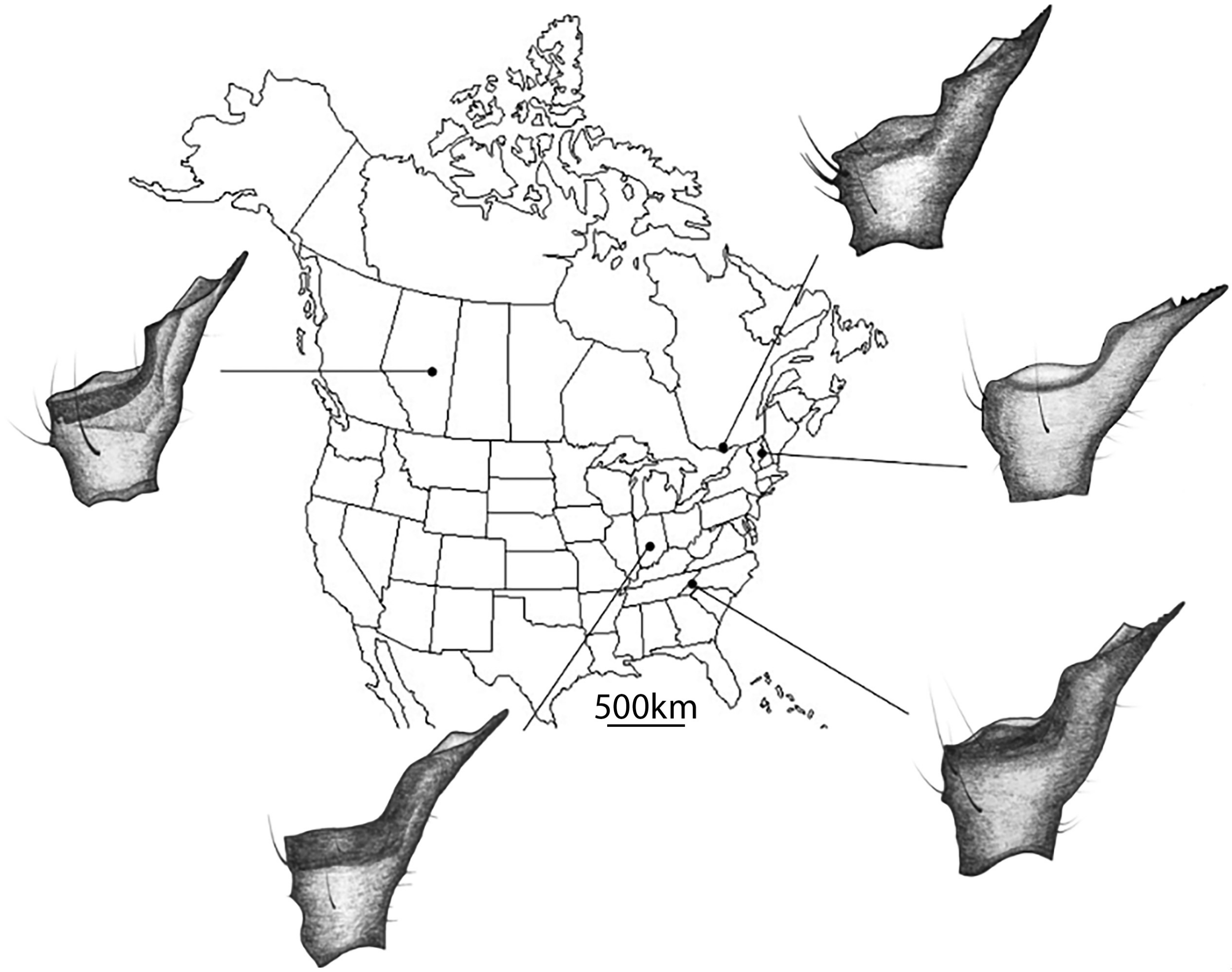

**FIGURE 8.** Variation in male palpal tibial apophyses in *Neodietrichia depressum* **n. comb.** Illustrations represent retrolateral views. The number of spines on the tibial apophysis is variable and does not appear to be geographically correlated.

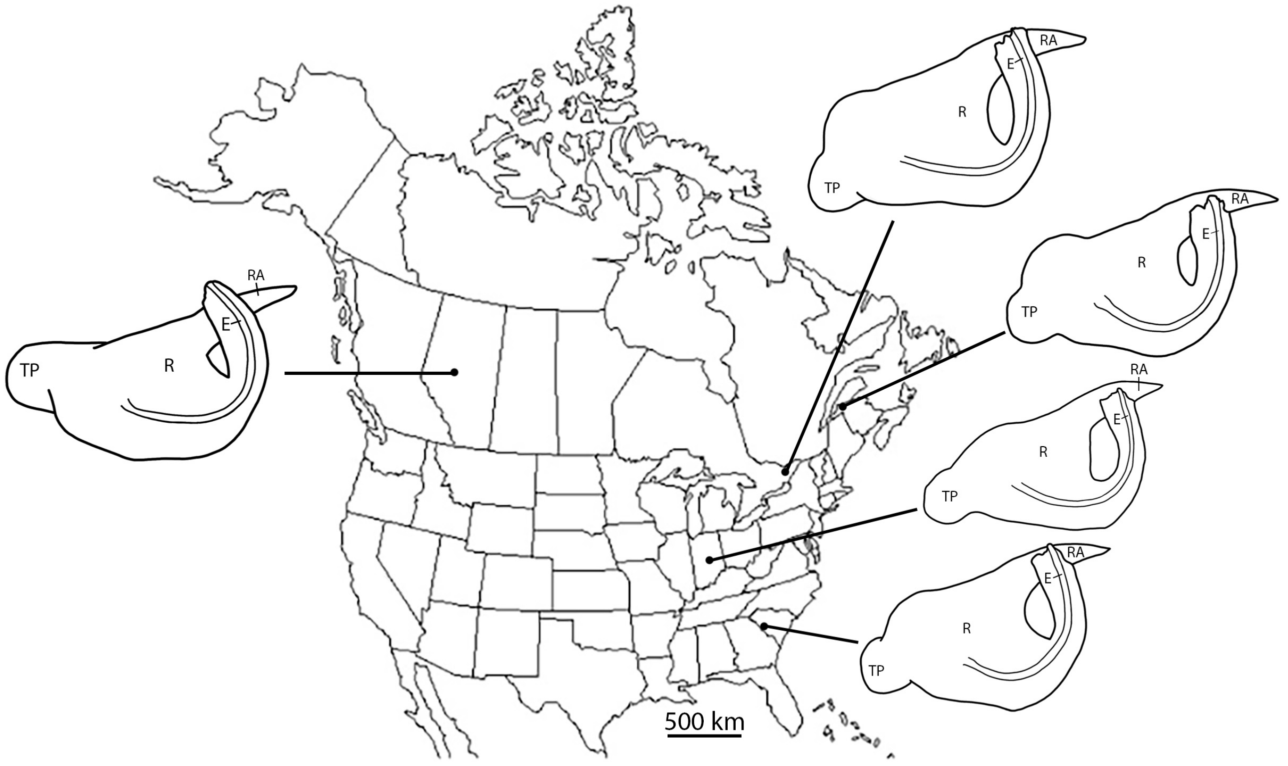

**FIGURE 9.** Variation in male palpal embolic divisions in *Neodietrichia depressum* **n. comb.** TP, tailpiece; R, radix; E, embolus; RA, radical apophysis.

**Natural history.** Adults have been collected year round from a variety of habitats, including on the trunks, underneath the bark, and lichen on trees, on buildings, within leaf litter in mature forests, in wetlands, in meadows, and sand pits. It has been found associated with a variety of trees, including aspen, poplar, white spruce, American elm, crab apple, birch, oak, maple, and jack pine.

**Other material examined.** CANADA: *New Brunswick*: 1 female, Kent County, Kouchibouguac National Park, in bird nest in jack pine, 10 August 1977, E.E. Lindquist (CNC 1044595); 1 male, Madawaska County, Green River, 48.3 km. N. Edmunston, 31 July 1968, T. R. Renault (CNC, 1030077); *Nova Scotia*: 1 male, Kings County, Kentville, 22 March 1957, unknown collector (CNC, 1030080); *Quebec*: 1 male, Les Collines-de-l'Outaouais Regional County, Gatineau Park, 1 April 2009, L. Masner (CNC, 1044584); 1 male, Les Collines-de-l'Outaouais, 26 June 1992, L. Lesage (PP, LL92-51); 1 male, Eeyou Istchee James Bay Territory, 119 km. N of LaSarre, 13–20 June 1997, P. Paquin and N. Dupérré (PP, 6677); *Ontario*: 1 female, Thunder Bay District, Pukaskwa National Park in Heron Bay near park office, 2 June 2013, C. Harpur (UG, BIOUG09421-D04); 1 male, Lanark County, Smith Falls Collegiate Institute, 8 May 2015, V. Currie (UG, BIOUG21961-E03); *Manitoba*: 1 male, Treaty 2 Territory, Riding Mountain National Park, Wasagaming, 21 August 1979, J. & M. Redner (CNC, 1030079); 1 female, Division No. 5, Turtle Mountain Provincial Park, Max Lake, 17 June - 21 August 1988, S. & J. Peck (CNC, 1044586); *Saskatchewan*: 1 female, Division No. 1, Moose Mountain Provincial Park, Moose Mountain, 4 June 1973, J. Redner & C. Starr (CNC, 1044591); 1 female, Division No. 15, Anglin Lake (53.73, -105.93), 4 May 1997, D. J. Buckle (DB, 7896); 1 female, Prince Albert National Park, Hwy 263, 17 May 2012, R. Thompson (UG, BIOUG03561-E11); 1 female, Division No. 11, 12 mi. SW Saskatoon, 24 March 1973, D. J. Buckle (DB, 7900); 1 female, 30 April 1973, (DB, 7901); 1 male, Saskatoon (52.117, -106.63), 3 October 1980, D. J. Buckle (DB, 7897); 7 males, 3 females, 21 April 1993, (DB, 7898); 1 male, 12 May 1996, (DB, 7899); *Alberta*: 1 female, Clear Hills County (56.77, -118.37), 30 May 2006, J. Pinzon (DB, 7892); 1 female, 2 August 2008, (DB, 7893); 1 female, summer 2008, (DB, 7894); 1 female, 25 July 2008, (DB, 7895); 1 male, Lamont, Elk Island National Park, Wood Bison Trail, 2 July 2012, unknown collector (UG, BIOUG05837-E08); 1 male, Hayburger Trail, 30 June 2012, unknown collector (UG, BIOUG12570-H05); 1 female, Woodlands County, Whitecourt, 11 April 2012, J. Sloan (UG, BIOUG20050-G08); 1 male, Yellowhead County, Edson, Edson Rest Stop, 5 August 2010, G. Blagoev (UG, BIOUG00511-C04); *British Columbia*: 1 female, Capital Regional District, Langford, Goldstream Provincial Park, 2 January 1975, A. P. Mackie

(CNC, 1044596); U. S. A.: *Maine*: 1 male, Washington County, Township 18 MD BPP, Field 18-HC-2A, 5 May 2003, D. T. Jennings (MCZ, 118484); 1 male, Aroostook County, New Limerick, 9 May 2008, F. M. Skinner (MCZ, 140959); 1 female, York Co., Wells, GCampground, 1 May 2007, W. Urquhart (MD); *New Hampshire*: 1 male, Grafton County, Grafton, Mt. Moosilauke, 4 July 1912, J. H. Emerton (MCZ, 154467); *Massachusetts*: 1 male, Middlesex County, Pepperell, October 1978, H. W. Levi, L. R. Levi, and F. Levi (MCZ, 47522); *North Carolina*: 1 male, Jackson County, Cullowhee, Cane Creek, 7 January 1984, R. G. Bennett (CNC, 1030078); *Indiana*: 3 males, 18 females, Johnson County, Blossom Hollow Nature Preserve, litter sift, 15 December 2017, M. A. Milne (MM, 6D15); 7 males, 13 females, sticky traps on *Fagus grandifolia*, 22 February - 15 March 2020, M. A. Milne, C. Wimmersberger, E. Mullins, and C. Venable (MM, 12A8); *South Carolina*: 1 male, Aiken Co., Jackson, 110 Cowden St., 24 November 1993, M. Draney and V. L. Medland (MD).

## Results

**Molecular results.** We successfully sequenced ~600bp of the *COI* gene from three spiders, though several other specimens failed to amplify and sequence properly. No indels or stop codons were observed in the successful sequences. *COI* p-distances between populations within species ranged from 0.000 to 0.010. *COI* p-distances between *N. hesperia* and *N. depressum* **n. comb.** ranged from 0.040 to 0.044. *COI* p-distances between *Neodietrichia* and the outgroup *M. maculatus* ranged from 0.044 to 0.057.

Phylogenetic analyses of the *COI* sequences grouped all *Neodietrichia depressum* **n. comb.** populations with 100% bootstrap support (Fig. 10). Relationships between species were not resolved (Fig. 10). Neighbor-joining (Fig. 10) and parsimony (not shown) analyses produced nearly identical results in terms of topology, though parsimony revealed slightly lower bootstrap support for the monophyly of all *N. depressum* **n. comb.** populations (91%).

## Discussion

The paucity of *Neodietrichia* specimens available in North American collections despite its apparently wide distribution is likely due to the arboreal nature of these species. Many specimens of both species have been found on trees, specifically on the trunks (including under the bark) of various deciduous and coniferous species in North America (Aitchison-Bennell and Dondale 1990) and traditional collection methods (e.g., litter sifting, pitfall trapping, sweep netting) during the traditional collection season (e.g., spring, summer, fall) would likely fail to collect them. More specifically, the arboreal collections of these species are all during the non-winter months while winter collections (including our own in central Indiana) include the leaf litter of deciduous forests, under logs, and wandering on the ground. These collection data, combined with detailed seasonally-specific observations (Don J. Buckle, personal communication), suggest that these species dwell in trees during the non-winter months and climb down during the fall to overwinter as adults among the leaf litter.

By using sticky traps on trees during the fall, it is possible to collect these species, but only in certain habitats. For example, we successfully captured them using sticky traps on beech in undisturbed deciduous hardwood forests in south-central Indiana but not on beech in undisturbed old growth forests in central Indiana. They have also been successfully captured using sticky traps on elm in the suburbs of Saskatoon, SK but not on birch or poplar in more natural areas (Don J. Buckle, personal communication). One possibility for this patchy distribution is that these species use ballooning as their main method for dispersal, the relatively random nature of which produces a patchy network of colonized and uncolonized habitats. While their propensity to balloon has likely contributed greatly to their large range, it's likely made their distribution within this range spotty, further contributing to their rarity in collections. Their arboreal nature may also increase their ballooning distance as they will begin their windswept journey from a relatively high location. A single direct observation of ballooning has been recorded for *N. depressum* **n. comb.** in the late autumn (November 24th by M. Draney and V. L. Medland), but a lack of other observations makes it difficult to determine if this single observation is indicative of the overarching ballooning seasonality.

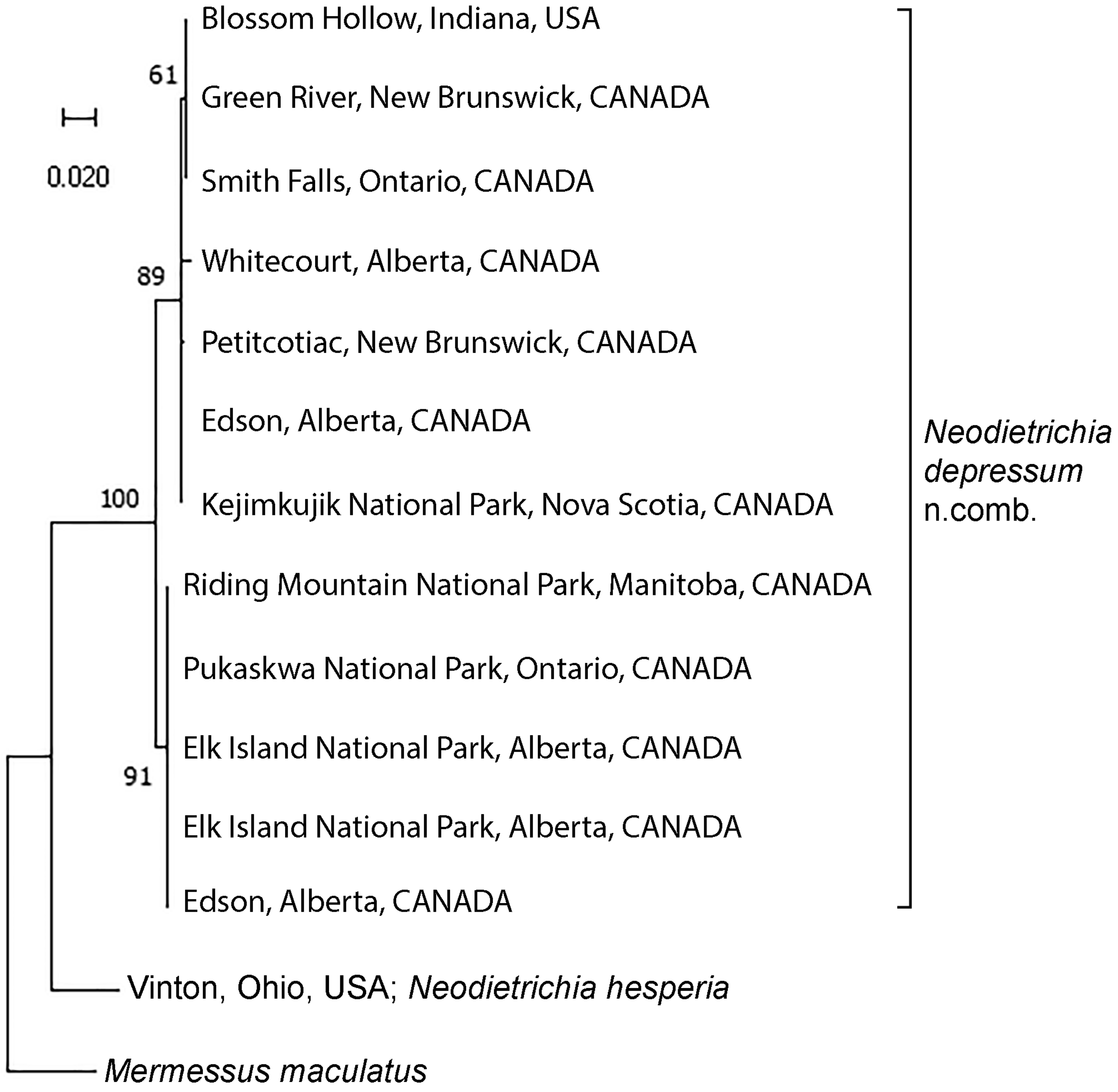

**FIGURE 10.** Neighbor-joining phylogenetic tree showing relationships between *Neodietrichia s*pecies and populations based on p-distances derived from cytochrome c oxidase subunit I sequences. Bootstrap values (from 500 replicates) are indicated on the branches.

**Acknowledgements**

We thank Robb Bennett, Gergin Blagoev, Don J. Buckle, Scott Carlton, Mike Draney, Nadine Dupérré, Pierre Paquin, Brian Patrick, and Nina Sandlin for conversations about the morphology, relationships, and placement of species. We also thank Gergin Blagoev for his extensive barcoding work, without which our phylogenetic analyses would be less complete. Thanks to Nina Sandlin, Petra Sierwald, and the collections staff at FMNH for hosting the lead author as part of a Visiting Scholar Grant. We also thank Shahan Derkarabetian for help with DNA extraction methodology and for reviewing an earlier version of this manuscript. We are grateful to Chris Schmidt and the University of Indianapolis anthropology department for providing use of their SEM. Thanks to Spencer Burton, Leah Milne, Ted Milne, Esther Mullins, Caitlin Stahl, Casey Venable, and the many participants in *The Search for Neodietrichia* community science project for help in field collections. We acknowledge Rich Bradley, Gergin Blagoev, Don J.

Buckle, Mike Draney, Nadine Dupérré, Pierre Paquin, and the collections staff at AMNH, MCZ, FMNH, and CNC for loaning us specimens. We would like to thank the Indiana Department of Natural Resources (permit #NP19-46 and #NP20-04 for Blossom Hollow and Glacier's End Nature Preserves and #NP22-10 for Ginn Woods Nature Preserve), the US Forest Service, Keith Kanoti and the University of Maine's School of Forest Resources (permit dated 8/14/2019 for Penobscot Experimental Forest), the Parks, Outreach, & Service Delivery Division of the Department of Lands & Forestry of Nova Scotia (permit #R-2019-07 for Coldbrook Provincial Park), Cliff Chapman, Joanna Woodruff, and the Central Indiana Land Trust (permits dated 8/24/2017 and 3/26/2018 for Blossom Hollow and Glacier's End Nature Preserves), John Taylor and Ball State University, and Caitlin Stahl and Southeastway Park for allowing us to collect on their properties. Finally, we are thankful to Robb Bennett and Andrei Tanasevitch for their helpful comments in reviews of this manuscript and to Gustavo Hormiga for his diligent editing.

## References

Aitchison-Bennell, C.W. & Dondale, C.D. (1990) A checklist of Manitoba spiders (Araneae) with notes on geographic relationships. *Canadian Naturalist*, 117 (4), 215–237.

Blackwall, J. (1841) The difference in the number of eyes with which spiders are provided proposed as the basis of their distribution into tribes; with descriptions of newly discovered species and the characters of a new family and three new genera of spiders. *Transactions of the Linnean Society of London*, 18 (4), 601–670.
https://doi.org/10.1111/j.1095-8339.1838.tb00210.x

Cameron, H.D. (2005) An entomological dictionary of North American spider genus names. *In*: Ubick, D., Paquin, P., Cushing, P.E. & Roth, V. (Eds.), *Spiders of North America: an identification manual*. American Arachnological Society, Gainesville, Florida, pp. 274–330.

Chamberlin, R.V. (1949) On some American spiders of the family Erigonidae. *Annals of the Entomological Society of America*, 14, 483–562.
https://doi.org/10.1093/aesa/41.4.483

Crosby, C.R. & Bishop, S.C. (1933) American spiders: Erigoneae, males with cephalic pits. *Annals of the Entomological Society of America*, 26, 105–172.
https://doi.org/10.1093/aesa/26.1.105

Cushing, P. E. (1995) Description of the spider *Masoncus pogonophilus* (Araneae: Linyphiidae), a harvester ant myrmecophile. *Journal of Arachnology*, 23, 55–59.

Draney, M. L. (1998) *Sougambus georgiensis* Chamberlin & Ivie, a junior synonym of *Goneatara platyrhinus* (Crosby & Bishop) (Araneae, Linyphiidae, Erigoninae). *Journal of Arachnology*, 26 (2), 247–248.

Emerton, J.H. (1882) New England spiders of the family Theridiidae. *Transactions of the Connecticut Academy of Arts and Sciences*, 6, 1–86.
https://doi.org/10.5962/bhl.part.7410

Hackman, W. (1954) The spiders of Newfoundland. *Acta Zoologica Fennica*, 79, 1–99.

Marusik, Y.M., Gnelitsa, V.A. & Koponen, S. (2006) A survey of Holarctic Linyphiidae (Aranei). 4. A review of the erigonine genus *Lophomma* Menge, 1868. *Arthropoda Selecta*, 15 (2), 153–171.

Marx, G. (1890) Catalogue of the described Araneae of temperate North America. *Proceedings of the United States National Museum*, 12, 497–594.
https://doi.org/10.5479/si.00963801.782.497

Menge, A. (1868) Preussische Spinnen. II. Abtheilung. *Schriften der Naturforschenden Gesellschaft in Danzig*, Neue Folge, 2, 153–218.

Özdikmen, H. (2008) *Neodietrichia* nom. nov., a replacement name for the genus *Dietrichia* Crosby & Bishop, 1933 (Araneae: Linyphiidae) non reck, 1921. *Munis Entomology & Zoology Journal*, 3 (1), 537–538.

Schaible, U., Gack, C. & Paulus, H.F. (1986) Zur Morphologie, Histologie und biologischen Bedeutung der Kopfstrukturen männlicher Zwergspinnen (Linyphiidae: Erigoninae). *Zoologisches Jahrbuch*, Abteilung für Systematik, 113, 389–408.

Simon, E. (1894) *Histoire naturelle des araignées. Deuxième Édition. Tome Premier*. Roret, Paris, pp. 489–760.

World Spider Catalog (2023) World Spider Catalog. Version 23.5. Natural History Museum Bern. Available from: http://wsc.nmbe.ch (accessed 1 January 2023)
https://doi.org/10.24436/2