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Review of the genus *Leptopilina* (Hymenoptera, Cynipoidea, Figitidae, Eucoilinae) from the Eastern United States, including three newly described species

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Abstract

The genus *Leptopilina* has historically been a poorly understood group. However, some species of *Leptopilina* are among the best-known model organisms for studying host-parasitoid interactions. As there is no identification system for *Leptopilina* in any part of the United States, we review species that were collected throughout their range in Eastern North America and those commonly used in laboratories. We provide a key for seven species, *L. boulardi*, *L. heterotoma*, *L. clavipes*, *L. victoriae*, *L. decemflagella* **sp. n.**, *L. maia* **sp. n.** and *L. leipsi* **sp. n.**, the last three of which are newly described here. This study is the first of its kind for *Leptopilina* species in North America, as our review and key were developed by examining a large number of specimens collected across broad chronological and geographic scales. This allowed us to account for the phenotypic variation within species, and helped us discover diagnostic characters. The geographic distribution and taxonomic information from this review provides a solid foundation for future research on *Leptopilina*.

Keywords

Parasitoid wasps, *Drosophila*, Nearctic Region, geographic distribution, DNA barcoding

Introduction

Parasitoid wasps (Hymenoptera: Apocrita) are a particularly speciose group of insects, potentially accounting for over 20% of all insect species (LaSalle and Gauld 1993). However, in some groups, more than 50% of the extant species still remain undescribed (Aguiar et al. 2013, Rodriguez et al. 2013). A primary reason for this lack of taxonomic information is the extensive amount of cryptic morphological variation among the species, and general lack of expertise focused on researching this group. One such group are species of *Leptopilina* Förster, 1869 (Cynipoidea: Figitidae: Eucoilinae). This is somewhat of an anachronism in entomological research, because on one hand, some species of *Leptopilina* are among the best-known model organisms for studying host-parasitoid interactions, and are easily cultivated in a laboratory setting. Species such as *Leptopilina boulardi* (Barbotin, Carton & Kelner-Pillault, 1979), *L. heterotoma* (Thomson, 1862), and *L. clavipes* (Hartig, 1841), are commonly reared koinobiont endoparasitoids of *Drosophila melanogaster* (Meigen, 1830) and *D. simulans* (Sturtevant, 1919) (Carton 1986). However, the overall taxonomic scope of this genus is rather cloudy to the non-specialist, leading several species belonging to this genus to be identified in other genera such as *Cothonaspis* and *Ganaspis*. Moreover, many species names within this genus, and their identity, are poorly known (Forshage et al. 2013).

The genus *Leptopilina* has historically been a poorly understood group, and it was not until the relatively recent revision by Nordlander (1980) that any species of *Leptopilina* could be identified with any degree of certainty. Nordlander's revision is the first and only complete study of this genus on a world-wide scale that included redescriptions, a key to European *Leptopilina* species and identified several type-species in other genera that were confused with *Leptopilina*. Later, Schilthuizen et al. (1998) used 23 morphological characteristics and DNA sequences of the ITS2 gene fragment to analyze the phylogenetic relationships among ten *Leptopilina* species from laboratory cultures. Their study provided much needed insight by interpreting the historical distribution of species as well as ecological and behavioral traits. A follow up study, Allemand et al. (2002) used morphological descriptions, crossing experiments, ITS2 sequences and RFLP data to describe the geographic distribution of six *Leptopilina* species in the Afrotropical region. Continuing this research, Novkovic et al. (2011) combined molecular evidence from, CO1, ITS1, and ITS2 sequences with hybridization experiments and morphological data to describe the taxonomic and phylogenetic relationships of five *Leptopilina* species attacking frugivorous *Drosophila* in Japan. Most recently, Wachi et al. (2015) reported three putative thelytokous species with two newly described species in central Japan and Tshushima Island in Japan.

Some species of *Leptopilina* are cosmopolitan and are present on all continents except Antarctica (Allemand et al. 2002, Buffington pers. obsv., Fontal-Cazalla et al. 1997). There are 29 *Leptopilina* species that have been described, mainly from the Neotropical, Afrotropical and Palearctic regions (Allemand et al. 2002, Nordlander

1980, Novkovic et al. 2011, Wachi et al. 2015). While this increased research on species of *Leptopilina* is desperately needed, similar research on the biogeographic and taxonomic concepts of Nearctic species are limited. Moreover, few North American specimens have been identified past the level of genus, and there is no key available for the identification of North American *Leptopilina* (nor for Eucoilinae, even at the generic level) (Forshage et al. 2013). We are aided, however, by Forshage et al. (2013), which provide a catalogue of *Leptopilina* species in North America, a good starting point for understanding the diversity of *Leptopilina* in North America. With this in mind, the present study aims to describe and clarify the identity of *Leptopilina* species that are routinely collected on the East Coast of the United States.

Materials and methods

Specimens

Specimens of *Leptopilina* for this study were obtained from two main resources. One was from freshly collected specimens by Lue and the other was from the extensive insect collections of the USNM (National Museum of Natural History, the Smithsonian Institution, Washington DC, United States). During the breeding season of *Drosophila* hosts in 2012 and 2013, seasonal surveys of *Leptopilina* species in Eastern North America were carried out. Samples were collected in various regions of North America (listed in the examined materials). Sites were chosen to obtain samples from a broad geographic distribution and cover most of the range of these species in the eastern U.S. Each site was sampled two to three times a year spanning the early to late portion of the *Drosophila* breeding season at each location. We obtained a large number of specimens from many locations throughout their geographic range, helping to ensure that the characters we used were of diagnostic value for a given species.

Parasitoids were collected in the field using yellow pan traps, or by hand-held electric vacuum from traps that were baited with fermented peaches. Wasps were collected two times per day (early a.m. and late p.m.) when wasps were most active/present on the baits. Samples of the fruit baits were placed in 25mm × 95mm polystyrene vials and returned to the laboratory. Additional wasps were collected as they emerged from hosts that had been parasitized in the field. All insects were placed in 95% ethanol either immediately upon collection from the vacuum and laboratory reared samples or within 12 hours from when the yellow pan traps were first set out. Parasitoids were dry mounted on acid-free cards for examination. To morphologically circumscribe species, we included individuals from field collections as well as, all the North American *Leptopilina* specimens housed at the USNM, and many North American species housed at MNHN (Natural History Museum, Paris, France), and BMNH (The Natural History Museum, London, United Kingdom).

Specimen examination and description

Specimens used in this study were dry mounted for long-term preservation and examined in the Hymenoptera Unit at the USNM. Morphological structures of insects were observed using a binocular stereomicroscope (using a Leica MZ9.5, M10 or M205c stereomicroscope) with incandescent and fluorescent light sources. Diagnostic characters for each species were illustrated by using a scanning electron microscope (Hitachi®™ TM3000) and an EntoVision®™ multiple-focus imaging system. Images were produced from image stack software with the program ComineZP®™. Techniques and methods for generating photographs follow those in Buffington et al. (2005), Buffington and van Noort (2009), Buffington and Gates (2009), and Kerr et al. (2009). For SEM images, samples were mounted to SEM stubs and sputter-coated with gold-palladium for three 30s intervals resulting in 25–30 nm of gold-palladium alloy (using a Cressington®™ 108 autosputtercoater).

Morphological terminology follows Fontal-Cazalla et al. (2002), Nordlander (1982), and Ronquist and Nordlander (1989). The description of species was generated using vSyslab (http://vsyslab.osu.edu/). The *Leptopilina* genus description was generated by modifying the 186 morphological characters of Figitidae housed in vSyslab curated by Buffington. Characters that were common to all seven *Leptopilina* species in this study were filtered out in the species level descriptions and are not repeated. This filtering resulted in 34 characters useful for species-level description/redescription (7 of which were newly created for this project). The geographic distribution and collecting event data of the examined specimens (1015 individuals) are available in HOL (Hymenoptera Online: http://hol.osu.edu/). All examined specimens and SEM stubs are deposited at the USNM. Most of the type specimens of the newly described species in this study also yielded DNA sequence data.

Molecular sequencing

The barcoding region of the mitochondrial cytochrome-*c* oxidase subunit I (CO1) was sequenced for this study (Suppl. material 1). DNA was extracted from three legs of each sequenced individual using the AutoGenPrep phenol-chloroform automated extractor (AutoGen) after digestion overnight in buffer containing proteinase-k. Amplification of CO1 was carried out using the primer pairs LCO1490/HCO2198 (Folmer et al. 1994) or LepF1/LepR1 (Hebert et al. 2004). A 10 μL reaction mix contained 2.5 mM $MgCl_{2,}$ 0.3 μM of each primer, 0.5 mM dNTPs, and 5 units of Biolase DNA polymerase (Bioline). Annealing temperatures ranged from 48-50 °C. PCR products were cleaned with ExoSAP-IT (Affymetrix), sequenced using Big Dyes (Life Technologies) and run on a 3730xl DNA sequencer (Applied Biosystems). Sequences were examined using the Sequencher 5.01 (Gene Codes) and Geneious 9.0. All information for the sequences of each individual in this study are deposited as DNA barcodes in GenBank. All voucher specimens for the CO1 database are housed at the USNM.

Results

Characterization of *Leptopilina*

Leptopilina Förster, 1869

Leptopilina Förster, 1869: 342, 348 (original description. Type: *Cothonaspis longipes* Hartig, by monotypy and original designation); Forshage & Nordlander, 2008: 350 (keyed); Novković, Mitsui, Suwito & Kimura, 2011: 337 (phylogenetic relationships of Japanese species); Forshage, Nordlander & Buffington, 2013: 233 (catalog of species of North America); Wachi, Nomano, Mitsui, Kasuya & Kimura, 2015: 48 (phylogenetic relationships); van Noort, Buffington & Forshage, 2015: 64, 73, 90 (diagnosis, keyed, new distribution record for Botswana, Burkina Faso, Burundi, Central African Republic, Ethiopia, Gabon, Ghana, Malawi, Rwanda, Tanzania and Yemen).

Diagnosis. *Leptopilina* are typically small wasps, less than 2mm in length, rather stout when compared with other eucoiline taxa, and have a worldwide distribution. Many species within this genus are easily confused with those in other genera, such as *Ganaspis*, *Kleidotoma*, *Rhoptromeris*, and *Trybliographa*. However, *Leptopilina* possess some unique morphological characteristics that allow them to be distinguished from other eucoiline genera. Generally speaking, in *Leptopilina*, the head narrows ventrally at the bottom of the eyes and forms a triangle. The petiole is enlarged posteriorly, and the broad posterior rim has varying sculptural patterns. The hairy ring at the base of the metasoma is more or less reduced in density with various lengths of setae, but there is no connection dorsally, leading to the common state of 'hairy ring broken'. The mesoscutum lacks notauli, and the subalar pits are moderately developed.

In *Leptopilina*, as in all other Eucoilinae, the scutellum is surmounted by a disc with a glandular pit close to the posterior margin of the disc. The posterior margin of the scutellum is usually rounded with punctate sculpture, reticulate sculpture, striate sculpture or a combination of these three. In some species of *Leptopilina*, the scutellum has ridges radiating from the scutellar disc; this state is similar to some species of *Hexacola* Föerster, but these *Leptopilina* can be differentiated by having an incomplete hairy ring on the metasoma (complete hairy ring in most *Hexacola*) and a glabrous postero-lateral corner of the metapleuron (setose posterolateral corner of metapleuron in *Hexacola*). Compared to *Rhoptromeris*, the basal part of the pronotal plate of *Leptopilina* is distinct and foveae on the pronotal plate are open laterally; by contrast, in *Rhoptromeris*, but the lateral foveae are closed. Compared to *Ganaspis*, males have the antennal F1 distinctly modified, whereas the F1 of *Leptopilina* is shorter than the F2, and F2 is distinctly modified by being curved outward and elongate. This flagellomere character is one of the main characteristics used to separate *Leptopilina* from *Ganaspis*. Another important characteristic used to distinguish between *Leptopilina* and *Ganaspis* is their metapleural corners: in *Leptopilina*, the corner is hairless (glabrous), and in *Ga-*

naspis, the corner is hairy (setose). Wing morphology can also be helpful in separating other genera from *Leptopilina*. *Leptopilina* wings are always covered with short hair, rounded apically, and typically have a long hair fringe on wing tip; the marginal cell is quadrangular in shape and may or may not be closed completely along the anterior margin. In *Rhoptromeris* the cell is always closed, and more triangular in shape: in *Kleidotoma* the cell is always open and apical margin is typically emarginate.

Description. Coloration with head, mesosoma, metasoma black to dark brown, legs light brown. Sculpture on vertex, lateral surface of pronotum and mesoscutum absent, surface smooth.

Head, in anterior view, broadly triangular. Pubescence on head sparse setae scattered over face. Sculpture along lateral margin of occiput absent. Gena (measured from compound eye to posterolateral margin of head) short, ratio of length of gena to length of compound eye in dorsal view <0.3. Sculpture of gena absent, smooth. Lateral margin of occiput evenly rounded, not well defined. Occiput (except extreme lateral margin) smooth. Carina issuing from lateral margin of postocciput absent. Ocelli small, ratio of maximum diameter of a lateral ocellus to shortest distance between lateral ocelli 0.2-0.4. Anterior ocellus far from posterior ocelli, clearly separate anterior ocelli to anterior margins of posterior ocelli. Relative position of antennal sockets intermediate, ratio of vertical distance between inner margin of antennal foramen and ventral margin of clypeus to vertical distance between anterior ocellus and antennal rim 2.0-4.0. Median keel absent. Vertical carina adjacent to ventral margin of antennal socket absent but present in *L. decemflagella*. Facial sculpture absent, surface smooth. Facial impression absent, face flat. Antennal scrobe absent. Anterior tentorial pits small. Vertical delineations on lower face absent. Ventral clypeal margin laterally, close to anterior mandibular articulation straight. Ventral clypeal margin medially with spatulate projection. Clypeus smooth with slight central spatulate projection. Malar space adjacent to anterior articulation of mandible evenly rounded, smooth. Malar sulcus present. Eye removed from ocelli, ratio of distance between compound eye and posterior mandibular articulation to distance between posterior ocellus and compound eye <1.2. Compound eyes, in dorsal view, not distinctly protruding from the surface of the head. Pubescence on compound eyes present, short. Orbital furrows absent. Lateral frontal carina of face absent. Dorsal aspect of vertex smooth. Posterior aspect of vertex smooth. Hair punctures on lateral aspect of vertex absent. Posterior surface of head deeply impressed around postocciput.

Apical segment of maxillary palp with pubescence, consisting one long erect setae. Apical seta on apical segment of maxillary palp longer than twice length of second longest apical seta. Maxillary palp composed of four segments. Last two segments of maxillary palp (in normal repose) straight. Apical segment of maxillary palp more than 1.5 times or 1-1.5 times as long as preceding segment.

Terminal flagellomere with one to three basiconic sensillae. Basiconic sensillae present between F5-F11 and also on F1, F2 in *L. maia*. Articulation between flagellomeres in antenna moniliform, segments distinctly separated by narrow neck-like articulation. Female antenna composed of 11 flagellomeres, 10 flagellomeres in *L.*

decemflagella. Male antenna composed of 13 flagellomeres. Female F1 longer than F2. Flagellomeres of female antenna cylindrical, distinctly widened towards apex, semiclavate. Placoidal sensilla present between F5-11. Last antennal flagellomeres of female antenna not conspicuously enlarged compared to adjacent flagellomeres.

Macrosculpture on lateral surface of pronotum absent dorsally and laterally, in *L. decemflagella* with longitudinal ridge ventrally. Anteroventral inflection of pronotum narrow. Pubescence on lateral surface of pronotum present, sparse long hair. Number of ridges on pronotal plate in lateral view between 2 to 4. Anterior flange of pronotal plate distinctly protruding anteriorly, transversely strigate. Ridges extending posteriorly from lateral margin of pronotal plate distinct but short, not extending to the dorsal margin of pronotum; present. Lateral pronotal carina absent. Crest of pronotal plate absent. Dorsal margin of pronotal plate (in anterior view) spatulate. Submedian pronotal depressions open laterally, deep. Lateral margin of pronotal plate defined all the way to the dorsal margin of the pronotum. Width of pronotal plate narrow, not nearly as wide as head.

Mesoscutal surface convex, evenly curved. Sculpture on mesoscutum absent, entire surface smooth, shiny, with sparse long hairs. Notauli absent. Median mesoscutal carina absent. Anterior admedial lines absent. Median mesoscutal impression absent. Parascutal carina nearly straight.

Mesopleuron entirely smooth. Subpleuron entirely smooth, glabrous. Lower pleuron entirely smooth, glabrous. Epicnemial carina absent. Lateroventral mesopleural carina present, not marking abrupt change of slope of mesopectus. Mesopleural triangle absent. Subalar pit present, located under subalar area obscure to see. Speculum absent. Mesopleural carina present, complete, composed of one complete, uninterrupted carina. Anterior end of mesopleural carina inserting above notch in anterior margin of mesopleuron.

Dorsal surface of scutellum foveate-areolet, areolet - rugulose or irregularly striate. Circumscutellar carina present, complete, delimiting dorsal and ventral halves of scutellum, or incomplete, posteriorly. Posterior margin of axillula marked by distinct ledge, axillula distinctly impressed adjacent to ledge. Latero-ventral margin of scutellum posterior to axillula, smooth or with weakly rugulose. Dorsoposterior part of scutellum rounded. Transverse median carina on scutellar plate absent. Dorsal part of scutellum entirely rugose, foveate, or areolate. Scutellar plate, in dorsal view, medium sized, exposing about half of scutellum. Scutellar fovea present, two, distinctly margined posteriorly. Longitudinal scutellar carinae absent. Single longitudinal carina separating scutellar foveae present, short, ending at posterior margin of foveae. Postero-lateral margin of scutellum rounded. Lateral bar smooth, narrow.

Posterior impression of metepimeron absent or present. Metapectal cavity anterodorsal to metacoxal base present, well-defined. Anterior margin of metapectal-propodeal complex meeting mesopleuron at same level at point corresponding to anterior end of metapleural carina. Posteroventral corner of metapleuron (in lateral view) not extended posteriorly. Anterior impression of metepimeron absent. Posterior margin of metepimeron distinct, separating metepimeron from propodeum. Subalar area broad-

ened anteriorly, narrowed posteriorly. Prespiracular process present, blunt, lobe-like, polished. Dorsellum absent. Anterior impression of metepisternum, immediately beneath anterior end of metapleural carina, present. Pubescence consisting of few hairs on posterior part of metepisternum, few or dense hair on propodeum.

Pubescence posterolaterally on metacoxa, present, small, rounded, with adjacent sparse pubescence. Microsculpture on hind coxa absent. Longitudinal ridge on the posterior surface of metatibia absent. Metafemoral tooth present, elongate, with adjacent serrate ridge posteriorly. Ratio of first metatarsal segment to remaining 4 segments greater than 1.0.

Wing vein M absent or present but not well defined. Pubescence of fore wing present, long, dense on most of surface. Apical margin of female fore wing rounded. Rs+M of forewing defined but nebulous at point of origin from basal vein at posterior third. Mesal end of Rs+M vein situated closer to anterior margin of wing, directed towards middle of basalis. Vein R1 forming marginal cell completely. Basal abscissa of R1 (the abscissa between 2r and the wing margin) of fore wing as broad as adjacent wing veins. Coloration of wing absent, entire wing hyaline. Marginal cell of fore wing membranous, similar to other wing cells. Areolet absent. Hair fringe along apical margin of fore wing present, long or very long.

Propodeal spurs absent. Lateral propodeal carinae present, not reaching scutellum. Ventral end of lateral propodeal carina reaching nucha, carinae separated from each other. Inter propodeal carinae space lightly setose, or too dense to see underlying surface, in *L. boulardi* with a horizontal carina. Petiolar rim of uniform width along entire circumference. Petiolar foramen removed from metacoxae, directed posteriorly. Horizontal carina running anteriorly from lateral propodeal carina present, or not visible, setae too dense. Lateral propodeal carina, straight, sub-parallel, in *L. boulardi* distinctly angled. Calyptra, in lateral view, rounded. Propodeum neck-like, drawn out posteriorly. Calyptra, in posterior view, dorsoventrally elongate or rounded.

Petiole about as long as wide. Surface of petiole longitudinally costate, ventral keel absent. Posterior part of female petiole abruptly widened. Ventral and lateral parts of petiolar rim broad.

Setal band (hairy ring) at base of tergum 3 present, interrupted dorsally, ventrally. Tergum 3 indistinct, fused with syntergum. Posterior margin of tergum 3 indistinct, fused with tergum 4 in syntergum. Posterior margin of tergum 4 evenly rounded. Sternum 3 encompassed by syntergum. Sculpture on metasomal terga absent. Syntergum present with terga 3 to 5 fused, ventral margin rounded. Peglike setae on T6–T7 absent. Postero-ventral cavities of female metasoma T7 present, glabrous save for few, long setae. Female postero-ventral margin of T6–T7 straight, parallel. Terebrum and hypopygium (in lateral view) curved, pointing upward. Ovipositor clip, present.

Comments. It was difficult to locate type specimens before the revision of Nordlander (1980). Only one European species of *Leptopilina* (*Cothonaspis longipes* Hartig, 1841) was placed in this genus by Weld (1952). Nordlander (1980) suggested *Cothonaspis longipes* (Hartig, 1841) should be maintained as type species, and included a taxonomic history of *Leptopilina*. Many species belonging to this genus have also been treated

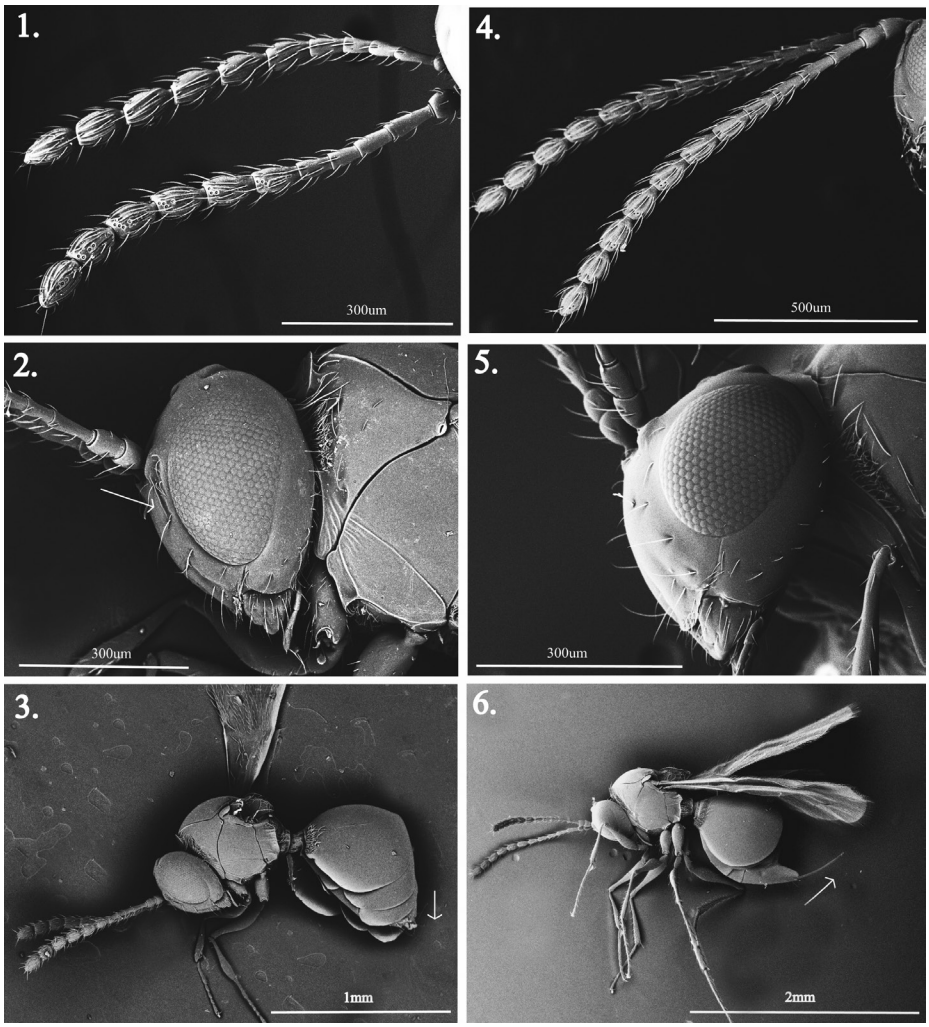
under various generic names for decades. Meanwhile, the true *Leptopilina* species had been assigned to other genera such as *Erisphagia* and *Cothonaspis* (Nordlander 1980).

Distribution. This genus has a worldwide distribution and is known from Europe, Africa, Asia, Australia, North America and South America.

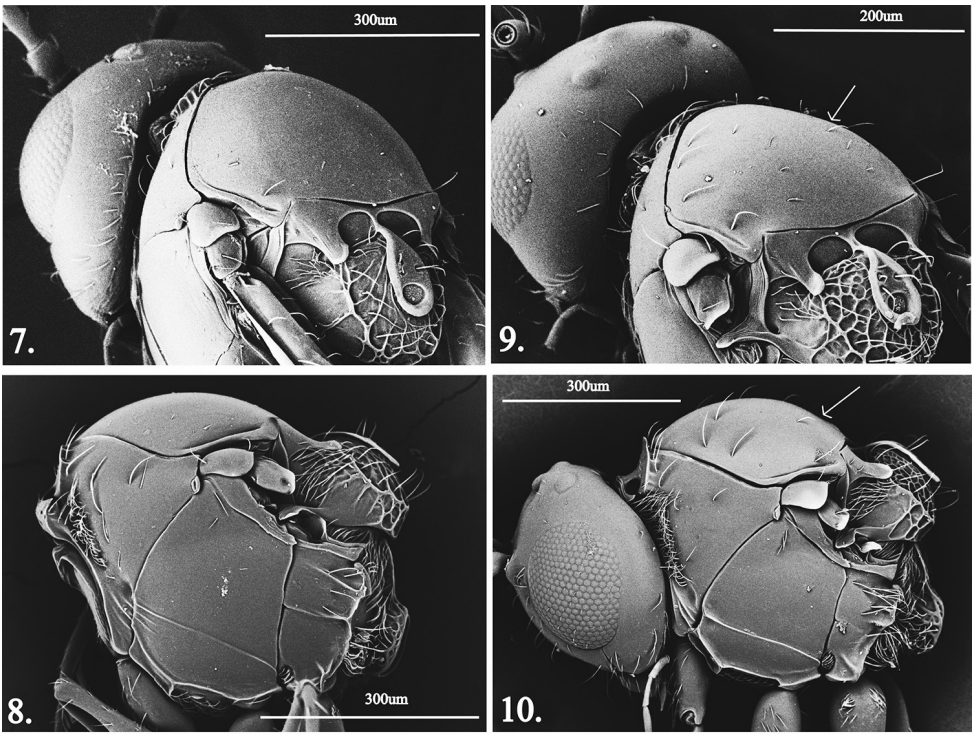
Key to Eastern North American *Leptopilina* species

1 Female with 10 flagellomeres on the antenna (Fig. 1); vertical carina present adjacent to ventral margin of antenna socket (arrow, Fig. 2); hypopygium pointing ventrally in lateral view (arrow, Fig. 3)..... ..... ***Leptopilina decemflagella*** **Lue & Buffington, sp. n.**

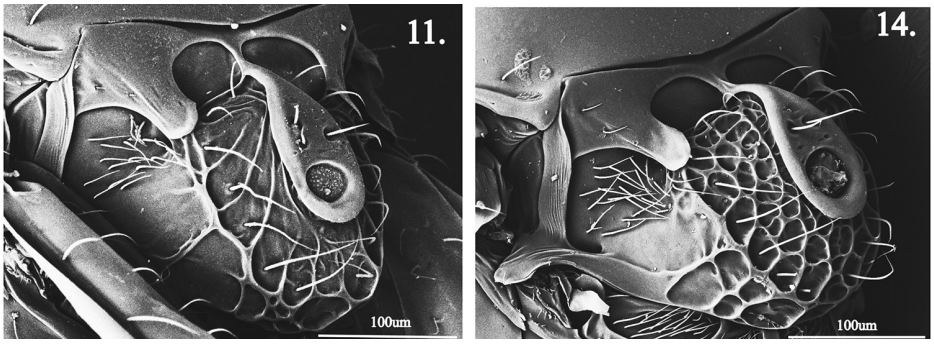
– Female with 11 flagellomeres (Fig. 4); no obvious carina adjacent to margin of antenna socket (Fig. 5); hypopygium pointing dorsally (arrow, Fig. 6) ... **2**

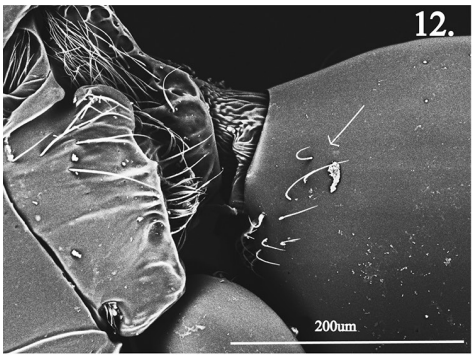


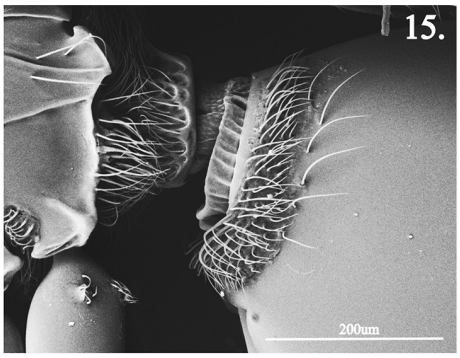
2 Mesoscutal hair absent (Figs 7–8) **3**
– Mesoscutal hair present, sometimes reduced (arrow, Figs 9–10) **5**

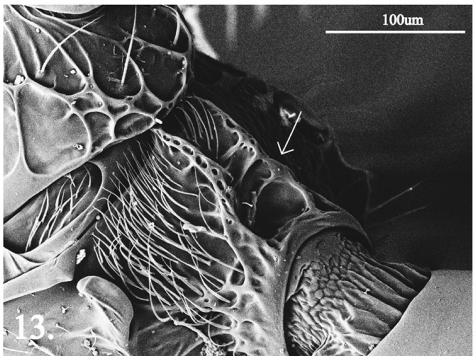


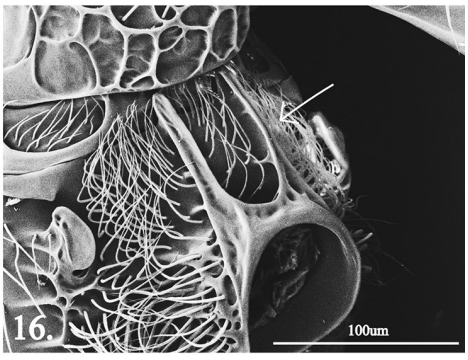
3 Scutellum with semi-parallel to slightly radiating ridges running the length of the dorsal surface of the scutellum, totally lacking foveate-areolet or rugulose pattern (Fig. 11); metasomal hairy ring scarce and only has few long hairs (arrow, Fig. 12); propodeal carinae angled and with horizontal carinae in between (when viewed from postero-dorsal angle) (arrow, Fig. 13)..... ..... ***Leptopilina boulardi*** **(Barbotin, Carton & Kelner-Pillault, 1979)**
– Scutellum with foveate-areolet or rugulose pattern on the dorsal surface of the scutellum (Fig. 14); metasomal hairy ring dense (Fig. 15); propodeal carinae sub-parallel and without a horizontal carina in between propodeal carinae (when viewed from postero-dorsal angle) (arrow, Fig. 16) **4**









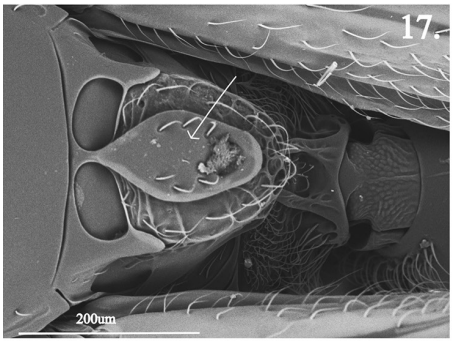


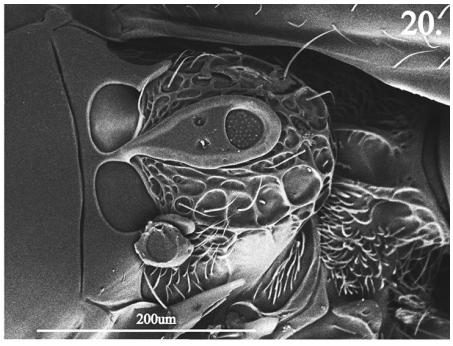
4 Scutellar cup large, covering most of the surface of the scutellum, rhomboid shaped (arrow, Figs 17–18); metasomal hairy ring dense and long (Fig. 19) ... . ***Leptopilina heterotoma*** **(Thomson, 1862)**

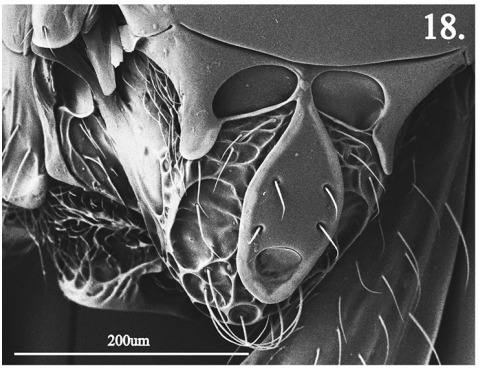
– Scutellar cup smaller, exposing more than half of the dorsal surface of the scutellum, tear-drop in shape (Figs 20–21); metasomal hairy ring thinner, hairs shorter, composed by one or two rows of hairs, narrowly broken dorsally (Fig. 22) ..... ***Leptopilina victoriae*** **Nordlander, 1980**

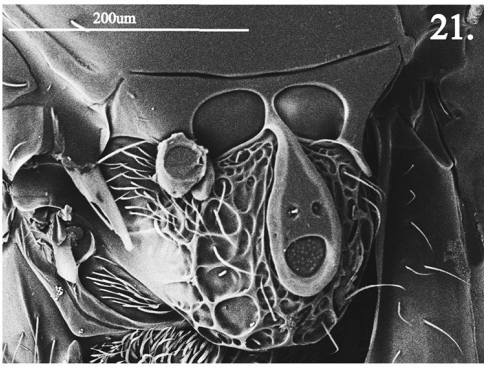
5 Metapleuron, posteriorly, with a deep depression that is continuous with propodeum (arrow, Fig. 23); wing vein M without clear trace line on fore wing (Fig. 24) .....***Leptopilina clavipes*** **(Hartig, 1841)**

– Metapleuron, posteriorly, not continuous with propodeum but with distinct posterior border (arrow, Fig. 25); wing vein M with or without a clear trace line on fore wing (Figs 27, 26) **6**






18.
200um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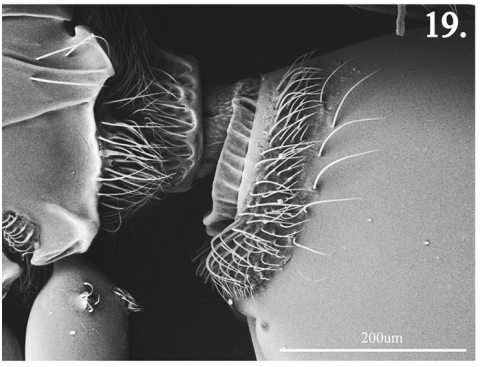
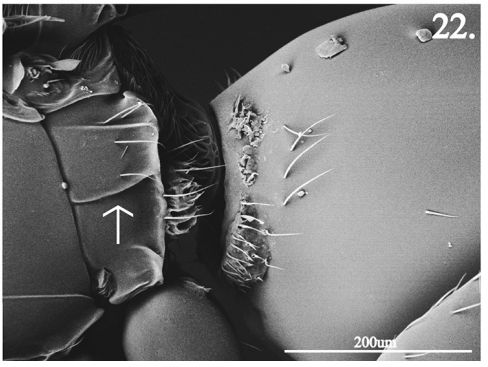
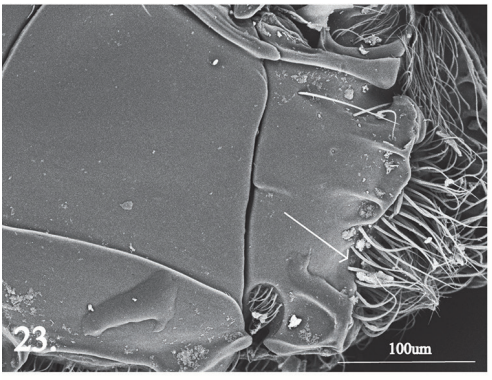
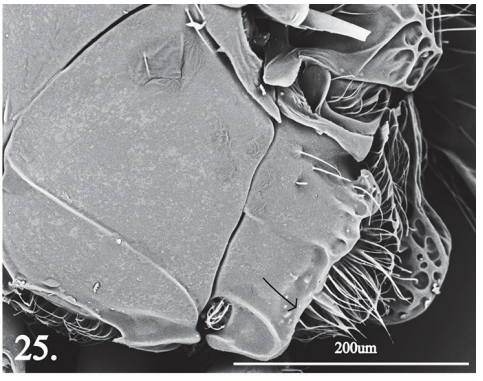
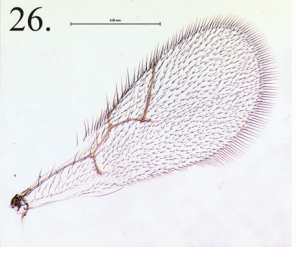

19.
200um

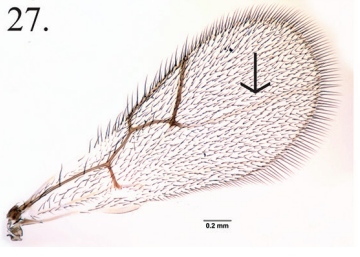

22.
200um


23.
100um


25.
200um

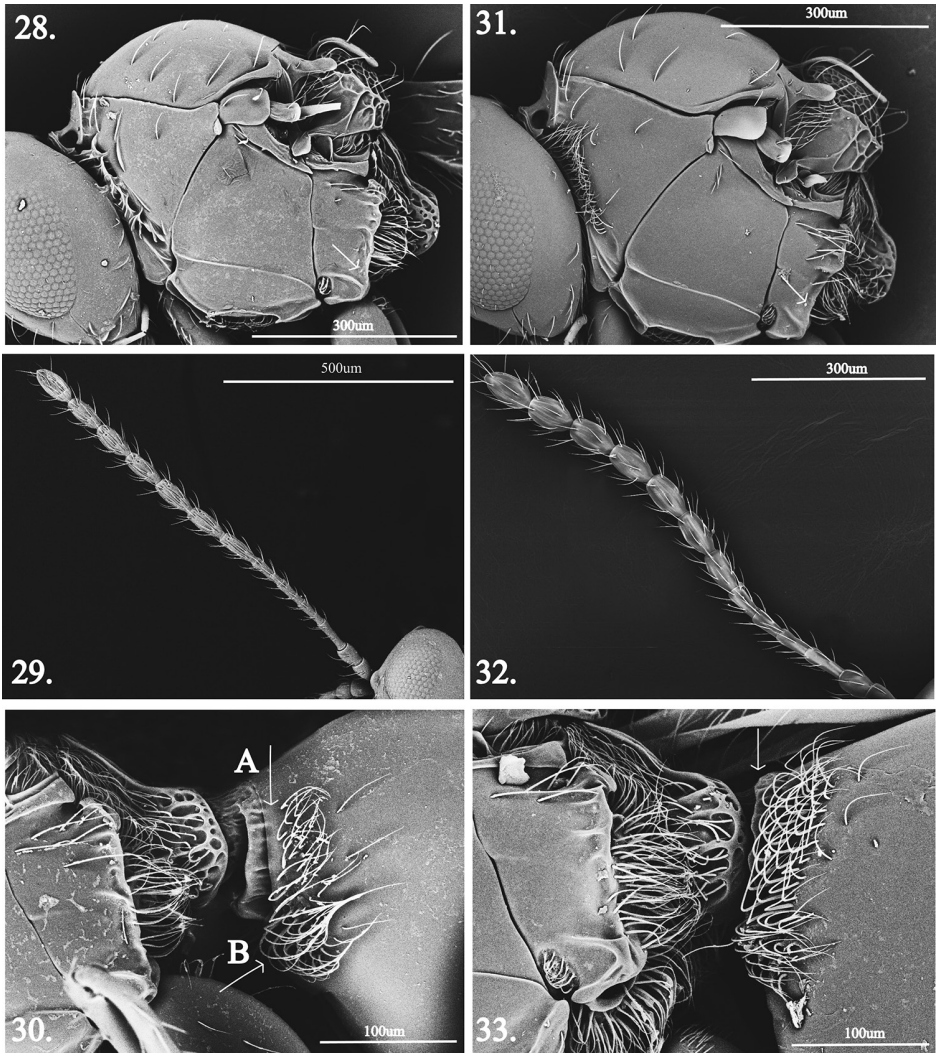

24.


26.


27.

6 Metapleuron, posteriorly, without a deep depression (arrow, Fig. 28); in flagellomeres F5-F10, the length is twice the width of each flagellomere (Fig. 29); hairy ring is widely broken dorsally, not directly connected to anterior margin of metasoma (arrow A, Fig. 30), dense and long ventrally (arrow B, Fig. 30); wing vein M without a clear trace line (Fig. 26).....
.....***Leptopilina leipsi* Lue & Buffington, sp. n.**

– Metapleuron, posteriorly, with a deep depression (arrow, Fig. 31); in flagellomeres F5-F10, the length is 1 to 1.5 times longer than width of each flagellomere (Fig. 32); hairy ring is widely or slightly broken dorsally, and all hairs are about equal in length, directly attached to anterior margin of metasoma (arrow, Fig. 33); wing vein M present, with a clear trace line (arrow, Fig. 27).....***Leptopilina maia* Lue & Buffington, sp. n.**



Taxonomic treatment of species

Leptopilina boulardi (Barbotin, Carton & Kelner-Pillault, 1979)

Charips mahensis Kieffer, 1911: 312 (original description); Forshage, Nordlander & Buffington, 2013: 233 (synonym of *Leptopilina boulardi* (Barbotin, Carton & Kelner-Pillault), type information).

Erisphagia mahensis Kieffer, 1911: 312 (original description).

Cothonaspis (*Cothonaspis*) *boulardi* Barbotin, Carton & Kelner-Pillault, 1979: 22 (original description).

Leptopilina boulardi (Barbotin, Carton & Kelner-Pillault): Nordlander, 1980: 432 (generic transfer); Paretas-Martínez, Forshage, Buffington, Fisher, La Salle & Pujade-Villar, 2013: 80 (new distribution record for Australia, listed); Forshage, Nordlander & Buffington, 2013: 233 (cataloged, type information, synonymy); van Noort, Buffington & Forshage, 2015: 92 (listed).

Diagnosis. *Leptopilina boulardi* (Figs 34–35) is the most common species in our collections. This species is distinguishable by the patterns on the scutellum that are smooth in the background with irregular striae (Fig. 11), whereas the scutellar patterns of many other *Leptopilina* species are entirely foveollate or areollate (Fig. 14). Most of *Leptopilina* species have a dense hairy ring on the metasoma (Fig. 15), but the hairy ring in *L. boulardi* is thin, consisting of scarce hairs (Fig. 12). The propodeal carina from the lateral view are distinctly angled and with horizontal carinae between them (Fig. 13). This differs from the propodeal carina in other species which are straight, sub-parallel and without a horizontal carina between them (Fig. 16).

Redescription. Coloration with head, mesosoma, metasoma black to dark brown, legs light brown. Malar sulcus present, with adjacent groove. Apical segment of maxillary palp more than 1.5 times as long as preceding segment. Terminal flagellomere with two basiconic sensillae. Basiconic sensillae present on F5-F11. Placoidal sensilla present on F6-11. Number of ridges on pronotal plate in lateral view 3. Sculpture on mesoscutum absent, entire surface smooth, shiny. Dorsal surface of scutellum irregularly striate, space between striate smooth. Circumscutellar carina present, incomplete, laterally delimiting dorsal and ventral halves of scutellum, not present posteriorly. Latero-ventral margin of scutellum posterior to axillula entirely smooth. Dorsal part of scutellum entirely rugose. Scutellar plate, in dorsal view, medium sized, exposing about half of scutellum. Posterior impression of metepimeron absent. Anterior impression of metepisternum, immediately beneath anterior end of metapleural carina, present, small and narrow. Pubescence consisting of few scattered hairs on posterior part of metapleuron and lateral part of propodeum. Wing vein M: absent. Inter propodeal carinae space smooth with a horizontal carina. Horizontal carina running anteriorly from lateral propodeal carina not visible, setae too dense. Lateral propodeal carina distinctly angled. Surface of petiole longitudinally costate, ventral keel absent. Setal band (hairy ring) at base of tergum 3 present, few scattered hairs.

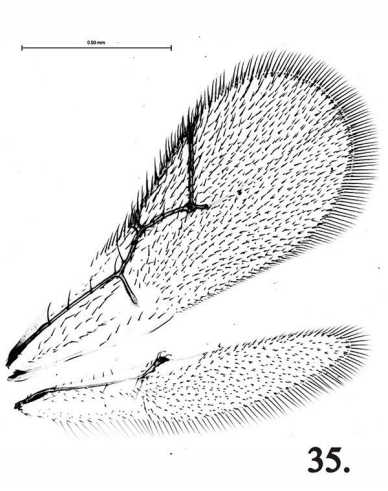


Figure 34–35. *Leptopilina boulardi*.

Distribution in Eastern North America. Maryland, Virginia, South Carolina, and Florida. [http://hol.osu.edu/map-full.html?id=323700]

Material examined. United States. FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 14.X-18.X.2013, bait trap, C.-H. Lue (46 females, USNMENT00917557, 00917581, 00917596, 00917608, 00917618, 00917634, 00917640, 00917645, 00917672, 00917686, 00917717, 00917723, 00917726-00917727, 00917734-00917736, 00917766, 00917822, 00917827, 01022149, 01022151, 01022210, 01022219, 01022254, 01022303, 01022371, 01022385, 01022409, 01022439-01022440, 01022473, 01022483, 01022500, 01022521, 01022610, 01022619, 01022660, 01022710, 01022730, 01022756, 01022769, 01022785, 01022860, 01022887, 01022974 (USNM)). FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 15.X-18.X.2013, bait trap, C.-H. Lue (17 females, USNMENT01022153, 01022295, 01022319, 01022346, 01022379, 01022384, 01022421, 01022469, 01022534, 01022672, 01022684, 01022735, 01022779, 01022814, 01022851, 01022854, 01022984 (USNM)). FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 18.VIII-19.VIII.2012, bait trap, C.-H. Lue (3 females, USNMENT00917868, 00917907, 00917920 (USNM)). FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 26.X-30.X.2012, bait trap, C.-H. Lue (1 female, USNMENT01022927 (USNM)). FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 27.V.2012, yellow pan trap, C.-H. Lue (2 females, USNMENT00917936, 01022900 (USNM)). FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 28.V.2012, bait trap, C.-H. Lue (13 females, USNMENT00917878, 00917921, 00917960, 01022367, 01022548, 01022553, 01022561, 01022576, 01022593, 01022596, 01022898, 01022901, 01022929 (USNM)). FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 29.V.2012, bait trap, C.-H. Lue (7 females, USNMENT00917895, 00917899, 00917905,

00917908, 00917926, 00917931, 00917940 (USNM)). FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 29.V.2012, yellow pan trap, C.-H. Lue (7 females, USNMENT01022139, 01022251, 01022361, 01022450, 01022628, 01022742, 01022752 (USNM)). FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 30.V.2012, bait trap, C.-H. Lue (17 females, USNMENT00917550-00917551, 00917863, 00917874, 00917888-00917889, 00917891, 00917903-00917904, 00917919, 00917927, 00917930, 00917946, 00917971, 00917975, 00917999, 01022546 (USNM)). FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 30.V.2012, yellow pan trap, C.-H. Lue (5 females, USNMENT01022313, 01022410, 01022648, 01022833, 01022866 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 12.VIII-15.VIII.2012, bait trap, C.-H. Lue (1 female, USNMENT01022923 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 16.V.2012, bait trap, C.-H. Lue (4 females, USNMENT00917900, 00917902, 00917906, 00917951 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 16.V.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022937 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 17.V.2012, bait trap, C.-H. Lue (26 females, USNMENT00917850, 00917853, 00917858, 00917865, 00917875, 00917879, 00917884, 00917913, 00917915, 00917922, 00917976, 00917990, 00917995, 01022540, 01022544, 01022568, 01022572, 01022585, 01022587-01022588, 01022595, 01022599, 01022605-01022606, 01022905, 01022907 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 17.V.2012, yellow pan trap, C.-H. Lue (13 females, USNMENT00917869, 00917885, 00917912, 00917955, 00917985, 01022549, 01022577, 01022601, 01022902, 01022912, 01022919, 01022925, 01022930 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 18.V.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022574 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 22.X-24.X.2013, bait trap, C.-H. Lue (2 females, USNMENT01022651, 01022791 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 23.X.2013, bait trap, C.-H. Lue (4 females, USNMENT00917535, 00917569, 00917667, 00917965 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 26.I-28.I.2013, bait trap, C.-H. Lue (3 females, USNMENT01022920, 01022933-01022934 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 26.I-28.I.2013, yellow pan trap, C.-H. Lue (2 females, USNMENT01022220, 01022274 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 26.V-28.V.2013, bait trap, C.-H. Lue (35 females, USNMENT00917559, 00917575, 00917584, 00917598, 00917605, 00917619, 00917623-00917624, 00917636, 00917639, 00917643, 00917651, 00917659, 00917669, 00917675, 00917683, 00917704, 01022141, 01022172, 01022224, 01022247, 01022262, 01022285, 01022309, 01022317, 01022406, 01022444, 01022484, 01022523, 01022635, 01022659, 01022701, 01022810, 01022847, 01022991 (USNM)). FL, Miami-Dade Co., Homestead, I-1967, R. Baranowski (1 female, USNMENT01197560 (USNM)). MD, Baltimore Co., 39.435145°N

76.487226°W, Glen Arm Site, 1.X.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022166 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 10.VI.2012, bait trap, C.-H. Lue (48 females, USNMENT00877590-00877599, 00877605-00877610, 00917755, 00917771, 00917789, 00917800, 00917815, 01022142, 01022302, 01022336, 01022338, 01022442, 01022489, 01022537, 01022539, 01022545, 01022551, 01022558, 01022564-01022565, 01022570, 01022575, 01022589, 01022602-01022603, 01022627, 01022693, 01022894, 01022908, 01022913-01022914, 01022928, 01022931, 01022936 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 11.VI.2012, yellow pan trap, C.-H. Lue (3 females, USNMENT01022238, 01022330, 01022983 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 13.VI.2012, bait trap, C.-H. Lue (6 females, USNMENT00877600, 00877602, 00877616-00877617, 00877623, 00877629 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 13.VI.2012, yellow pan trap, C.-H. Lue (15 females, USNMENT00877620-00877621, 00877625-00877628, 00877630-00877632, 00877635-00877639, 00877720 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 14.VI.2012, yellow pan trap, C.-H. Lue (2 females, USNMENT01022320, 01022827 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 2.VIII-4.VIII.2012, bait trap, C.-H. Lue (31 females, USNMENT00917538, 00917545, 00917547, 00917707, 00917722, 00917729-00917730, 00917756, 00917767, 00917787, 00917801, 00917804, 00917807, 00917819, 00917829-00917830, 00917838, 00917854, 00917857, 01022560, 01022562, 01022597, 01022604, 01022897, 01022904, 01022911, 01022916, 01022921-01022922, 01022935, 01022940 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 2.VIII.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022154 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 29.IX.2012, bait trap, C.-H. Lue (8 females, USNMENT00917552, 00917866, 00917871, 00917873, 00917886, 00917923, 00917925, 00917986 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 29.IX.2012, yellow pan trap, C.-H. Lue (8 females, USNMENT01022148, 01022369, 01022641, 01022664, 01022700, 01022797, 01022825, 01022842 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 6.IX-9.IX.2013, bait trap, C.-H. Lue (21 females, USNMENT00917564, 00917567-00917568, 00917578, 00917580, 00917582, 00917587, 00917599, 00917606, 00917615-00917616, 00917633, 00917635, 00917637-00917638, 00917644, 00917646, 00917653, 00917665, 00917687, 00917695 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 9.IX-12.IX.2013, yellow pan trap, C.-H. Lue (12 females, USNMENT01022199, 01022236, 01022413, 01022454, 01022480, 01022689, 01022706, 01022744, 01022829, 01022846, 01022867, 01022958 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 1.X-4.X.2013, bait trap, C.-H. Lue (1 female, USNMENT01022183 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 17.VI.2012, bait trap, C.-H. Lue (1 female, USN-

MENT00917890 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 17.VI.2012, yellow pan trap, C.-H. Lue (2 females, USNMENT01022449, 01022709 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 19.VI.2012, bait trap, C.-H. Lue (7 females, USNMENT00917544, 00917883, 00917893, 00917896, 00917981, 01022536, 01022578 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 19.VI.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022235 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 2.IX.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022481 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 2.VII-5.VII.2013, bait trap, C.-H. Lue (2 females, USNMENT01022757, 01022969 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 2.VII-5.VII.2013, yellow pan trap, C.-H. Lue (1 female, USNMENT01022490 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 2.X.2013, bait trap, C.-H. Lue (14 females, USNMENT00917560, 00917570, 00917576, 00917592-00917593, 00917595, 00917610, 00917620, 00917627, 00917647, 00917656-00917657, 00917676, 00917702 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 20.VI-23.VI.2012, bait trap, C.-H. Lue (7 females, USNMENT00917894, 00917898, 00917911, 00917914, 00917929, 01022567, 01022938 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 20.VI.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022204 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 22.VI.2012, yellow pan trap, C.-H. Lue (2 females, USNMENT01022496, 01022768 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 3.IX.2012, yellow pan trap, C.-H. Lue (4 females, USNMENT01022189, 01022399, 01022711, 01022960 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 3.VII.2013, bait trap, C.-H. Lue (16 females, USNMENT00917574, 00917583, 00917589, 00917601, 00917607, 00917611-00917612, 00917614, 00917625, 00917629-00917630, 00917654, 00917682, 00917688-00917689, 00917700 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 4.IX.2012, yellow pan trap, C.-H. Lue (8 females, USNMENT01022342, 01022513, 01022616, 01022623, 01022639, 01022698, 01022799, 01022832 (USNM)). SC, Oconee Co., 34.605204°N 82.877996°W, Clemson Site, 11.VII-14.VII.2013, bait trap, C.-H. Lue (8 females, USNMENT01022130, 01022132-01022134, 01022304, 01022839, 01022973, 01022986 (USNM)). SC, Oconee Co., 34.605204°N 82.877996°W, Clemson Site, 11.VII-14.VII.2013, yellow pan trap, C.-H. Lue (2 females, USNMENT01022122, 01022771 (USNM)). SC, Oconee Co., 34.605204°N 82.877996°W, Clemson Site, 8.X-11.X.2013, bait trap, C.-H. Lue (31 females, USNMENT00917706, 00917709-00917712, 00917715-00917716, 00917720-00917721, 00917725, 00917731, 00917741, 00917744, 00917748-00917749, 00917762, 00917765, 00917780, 00917782, 00917786, 00917795, 00917798, 00917805, 00917817, 00917823, 00917834, 00917839, 00917862, 00917872, 00917882, 01022209 (USNM)). SC, Oconee Co., 34.605204°N

82.877996°W, Clemson Site, 8.X-11.X.2013, yellow pan trap, C.-H. Lue (11 females, USNMENT01022152, 01022253, 01022263, 01022294, 01022420, 01022514, 01022634, 01022640, 01022762, 01022773, 01022956 (USNM)). SC, Oconee Co., 34.605204°N 82.877996°W, Clemson Site, 9.X-11.X.2013, bait trap, C.-H. Lue (1 female, USNMENT01022127 (USNM)). VA, Fairfax Co., 38°50'N, 77°12'W, nr. Annandale, 10.VI-16.VI.2006, Malaise trap, D. Smith (1 female, USNMENT01197502 (USNM)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 10.VIII-16.VIII.2008, Malaise trap, D. Smith (3 females, USNMENT01197559, 01197566, 01197572 (USNM)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 13.VII-19.VII.2008, Malaise trap, D. Smith (3 females, USNMENT01197514, 01197555, 01197558 (USNM)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 13.VIII-19.VIII.2008, Malaise trap, D. Smith (1 female, USNMENT01197554 (USNM)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 17.VIII-23.VIII.2008, Malaise trap, D. Smith (7 females, USNMENT01197553, 01197561, 01197564-01197565, 01197570-01197571, 01197574 (USNM)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 20.VII-26.VII.2008, Malaise trap, D. Smith (2 females, USNMENT01197557, 01197569 (USNM)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 24.IV-7.V.2006, Malaise trap, D. Smith (1 female, USNMENT01197550 (USNM)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 3.VIII-9.VIII.2008, Malaise trap, D. Smith (1 female, USNMENT01197547 (USNM)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 6.VIII-12.VIII.2008, Malaise trap, D. Smith (2 females, USNMENT01197567-01197568 (USNM)).

Leptopilina clavipes (Hartig, 1841)

Cothonaspis clavipes Hartig, 1841: 357 (original description); Nordlander, 1978: 50 (lectotype designation).

Leptopilina clavipes (Hartig): Nordlander, 1980: 430 (generic transfer, description); van Alphen, Nordlander & Eijs, 1991: 325 (diagnosis); Forshage, Nordlander & Buffington, 2013: 233 (cataloged, type information).

Diagnosis. *Leptopilina clavipes* (Figs 36–37) could be easily misidentified as *L. maia* or *L. leipsi*. *L. clavipes* differs from these species by having a strong impression on the lower posterior metepimeron that is continuous with the propodeum (Fig. 23). By contrast, the metapleural impression on *L. maia* (Fig. 31) and *L. leipsi* (Fig. 28) separates the metepimeron from the propodeum. The other character that can be used to distinguish *L. clavipes* is that the M-vein trace line is absent, and 2r-m vein is short (Fig. 24).

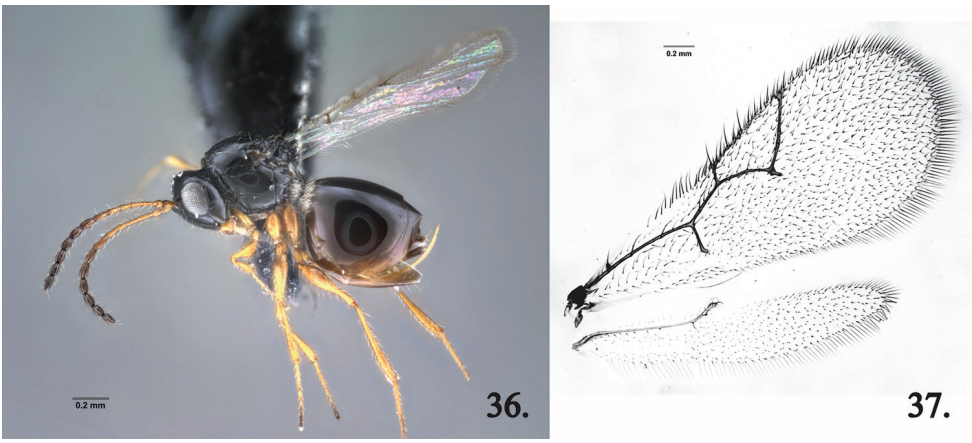


Figure 36–37. *Leptopilina clavipes*.

Redescription. Coloration with head, mesosoma, metasoma black to dark brown, legs light brown. Malar sulcus present. Apical segment of maxillary palp 1-1.5 times as long as preceding segment. Placoidal sensilla present on F5-11. Number of ridges on pronotal plate in lateral view 4. Sculpture on mesoscutum absent, with sparse long hairs. Dorsal surface of scutellum foveate-areolet. Circumscutellar carina present, incomplete, laterally delimiting dorsal and ventral halves of scutellum, not present posteriorly. Latero-ventral margin of scutellum posterior to axillula almost entirely smooth, weakly rugulose dorsally. Dorsal part of scutellum entirely areolate. Scutellar plate, in dorsal view, medium sized, exposing about half of scutellum. Lateral bar weakly strigate, narrow. Posterior impression of metepimeron present and well defined. Posterior margin of metepimeron distinct, has a strong impression continuous posterior propodeum. Anterior impression of metepisternum, immediately beneath anterior end of metapleural carina, present, large and wide. Wing vein M absent. Inter propodeal carinae space lightly setose, smooth. Horizontal carina running anteriorly from lateral propodeal carina not visible, setae too dense. Surface of petiole dorsally and laterally striate, ventral keel absent. Setal band (hairy ring) at base of tergum 3 present, interrupted dorsally, ventrally, dense hair.

Distribution in Eastern North America. Maine, New Hampshire, Massachusetts, Illinois, Maryland, Virginia, South Carolina, and Florida. [http://hol.osu.edu/map-full.html?id=323705]

Material examined. United States. FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 12.VI-17.VI.2013, yellow pan trap, C.-H. Lue (2 females, USNMENT01022195, 01022765 (USNM)). FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 29.V.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022740 (USNM)). FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, no date, C.-H. Lue (1 female, USNMENT01022243 (USNM)). VA, Falls Church, 15-VI (1 female, USNMENT01197513 (NMNH)). VA, Falls Church, 17-VI (1 female, USNMENT01119194 (NMNH)). VA, Falls Church, 28.V.1927

(1 female, USNMENT01119130 (NMNH)). IL, Ford Co., along railroad tracks, Pit Road & US-45, 2004, yellow pan trap (1 female, USNMENT01119193 (USNM)). MA, Hampden Co., Westfield, V-1970, F. A. Streams (1 female, USNMENT01197521 (NMNH)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 3.VI-6.VI.2013, yellow pan trap, C.-H. Lue (1 female, USNMENT01022268 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 9.IX-12.IX.2013, yellow pan trap, C.-H. Lue (5 females, USNMENT01022205, 01022284, 01022307, 01022734, 01022963 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 1.X-4.X.2013, yellow pan trap, C.-H. Lue (1 female, USNMENT01022657 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 17.VI.2012, bait trap, C.-H. Lue (3 females, USNMENT00917970, 00917997, 01022542 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 17.VI.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022493 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 19.VI.2012, bait trap, C.-H. Lue (1 female, USNMENT00917996 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 19.VI.2012, yellow pan trap, C.-H. Lue (2 females, USNMENT01022515, 01022680 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 2.VII-5.VII.2013, yellow pan trap, C.-H. Lue (6 females, USNMENT00917825, 01022126, 01022181, 01022477, 01022631, 01022824 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 20.VI-23.VI.2012, bait trap, C.-H. Lue (1 female, USNMENT00917928 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 20.VI.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022888 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 22.VI.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022819 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 3.VII.2013, bait trap, C.-H. Lue (1 female, USNMENT00917609 (USNM)). MD, Calvert Co., Warrior's Rest Sanctuary, "Oak", 38°32.006'N, 76°32.646'W, American Chestnut Land Trust, 12.VI-25.VI.2008, Malaise trap (1 female, USNMENT01197477 (NMNH)). MD, Montgomery Co., 4mi SW Ashton, 16.VIII.1986, G. F. Hevel & J. F. Hevel (1 female, USNMENT01197527 (NMNH)). MD, Montgomery Co., Cabin John, 12.VIII.1916, sweeping, R. M. Fouts (1 female, USNMENT01197526 (NMNH)). MD, Montgomery Co., Cabin John, 17.VII.1927, H. G. Dyar (1 female, USNMENT01197531 (NMNH)). MD, Montgomery Co., Plummers Island, IX-1922, J. R. Malloch (2 females, USNMENT01197541 (NMNH); USNMENT01119270 (USNM)). MD, Prince George's Co., Bowie, 7.VI.1945 (2 females, USNMENT01119178, 01119262 (USNM)). MD, Prince George's Co., Bowie, 9.VI.1945 (1 female, USNMENT01119187 (USNM)). ME, Washington Co., behind main lab building, next to mushroom refuse pile, 44.459827°N 67.932756°W, Eagle Hill Institute, 20.VIII-21.VIII.2014, yellow pan trap, M. Buffington (3 females, USNMENT01197510, 01197530, 01197539 (NMNH)). NH, Merrimack Co., 43.481918°N 71.647970°W, Franklin Site, 10.VIII.2014, bait trap, C.-H. Lue (2 females, USNMENT01022563,

01022590 (USNM)). NH, Merrimack Co., 43.481918°N 71.647970°W, Franklin Site, 10.VIII.2014, yellow pan trap, C.-H. Lue (4 females, USNMENT01022538, 01022566, 01022910, 01022942 (USNM)). NH, Merrimack Co., 43.481918°N 71.647970°W, Franklin Site, 29.VII-2.VIII.2013, bait trap, C.-H. Lue (1 female, USNMENT00917571 (USNM)). NH, Merrimack Co., 43.481918°N 71.647970°W, Franklin Site, 29.VII-2.VIII.2013, yellow pan trap, C.-H. Lue (5 females, USNMENT00917603, 00917631-00917632, 00917691, 01022670 (USNM)). SC, Oconee Co., 34.605204°N 82.877996°W, Clemson Site, 8.X-11.X.2013, yellow pan trap, C.-H. Lue (2 females, USNMENT01022296, 01022468 (USNM)). TN, Cocke Co., ATBI Plot, GRSM, MT 18, 35°43.60'N, 83°16.50'W, Albright Grove, 30.I-16.II.2001, Malaise trap, Parker, Stocks & Petersen (1 female, USNMENT01197497 (NMNH)). TN, Sevier Co., Gatlinburg, 2.VII.1947, R. H. Whittaker (1 female, USNMENT01119139 (NMNH)). VA, Arlington Co., Arlington, no date (1 female, USNMENT01197532 (NMNH)). VA, Fairfax Co., 38°50'N, 77°12'W, nr. Annandale, 10.VI-16.VI.2006, Malaise trap, D. Smith (1 female, USNMENT01197491 (NMNH)). VA, Fairfax Co., 38°50'N, 77°12'W, nr. Annandale, 27.V-2.VI.2007, Malaise trap, D. Smith (1 female, USNMENT01197461 (NMNH)). VA, Fairfax Co., Fairfax, 31.V.1927 (1 female, USNMENT01119110 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 12.VII-18.VII.2009, Malaise trap, D. Smith (1 female, USNMENT01197479 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 13.VIII-19.VIII.2008, Malaise trap, D. Smith (3 females, USNMENT01119257, 01119261, 01119302 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 20.VII-26.VII.2008, Malaise trap, D. Smith (5 females, USNMENT01119148, 01119255, 01119259, 01119263, 01119297 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 22.VI-28.VI.2008, Malaise trap, D. Smith (1 female, USNMENT01119300 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 29.VI-5.VII.2008, Malaise trap, D. Smith (1 female, USNMENT01119226 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 29.VI-5.VIII.2008, Malaise trap, D. Smith (6 females, USNMENT01119221, 01119236, 01119241, 01119243, 01119247, 01119296 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 6.VII-12.VII.2008, Malaise trap, D. Smith (6 females, USNMENT01119229, 01119235, 01119264, 01119272, 01119295, 01119304 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 6.VIII-12.VIII.2008, Malaise trap, D. Smith (1 female, USNMENT01119228 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 7.VI-13.VI.2009, Malaise trap, D. Smith (2 females, USNMENT01197451, 01197478 (NMNH)). VA, Giles Co., Hunters Branch, 37°22'21.50"N 80°31'31.79"W, Mountain Lake Biological Station, 9.VIII-10.VIII.2009, yellow pan trap, R. Kula (5 females, USNMENT01197403, 01197424, 01197441, 01197445, 01197450 (NMNH)). VA,

Prince William Co., Jackson Hollow Recreation Area, 38°52.645'N, 77°41.374'W, Bull Run Mountains, 11.VI-24.VI.2011, Malaise trap, D. Smith (1 female, USNMENT01197485 (NMNH)). VA, Prince William Co., Jackson Hollow Recreation Area, stream, 38°52.645'N, 77°41.374'W, Bull Run Mountains, 13.V-27.V.2011, Malaise trap, D. Smith (1 female, USNMENT01197434 (NMNH)). VA, Prince William Co., Jackson Hollow Recreation Area, stream, 38°52.645'N, 77°41.374'W, Bull Run Mountains, 25.VI-7.VII.2011, Malaise trap, D. Smith (3 females, USNMENT01197404, 01197412, 01197430 (NMNH)). WV, Hardy Co., 38°55'N, 78°49'W, 3mi NE Mathias, 19.VIII-8.IX.2008, Malaise trap, D. Smith (3 females, USNMENT01197509, 01197515, 01197537 (NMNH)). WV, Hardy Co., 38°55'N, 78°49'W, 3mi NE Mathias, 30.V-17.VI.2008, Malaise trap, D. Smith (1 female, USNMENT01197499 (NMNH)). Washington, IX (1 female, USNMENT01197524 (NMNH)).

Leptopilina decemflagella Lue & Buffington, sp. n.

http://zoobank.org/6486319D-5290-430D-97D7-D21ED355BB86

Diagnosis. Female *Leptopilina decemflagella* (Figs 38–39) are immediately distinguishable from other North Eastern US *Leptopilina* females by having 10 flagellomeres (Fig. 1). There are also several additional characters that separate this species from other *Leptopilina*; this species has an obvious vertical carina adjacent to the ventral margin of the antennal socket (Fig. 2); this character is not found in other *Leptopilina* species in the Eastern US. Finally in the lateral view, the hypopygium of *L. decemflagella* is pointing ventrally (Fig. 3); in other *Leptopilina* species their hypopygium is pointing upwards (Fig. 6). Male diagnostic characters are lacking as males for this species are as of yet unrecorded.

Description. Coloration with head, mesosoma, metasoma black, legs light brown. Vertical carina adjacent to ventral margin of antennal socket present. Malar sulcus present. Apical segment of maxillary palp more than 1.5 times as long as preceding segment. Terminal flagellomere with three basiconic sensillae. Basiconic sensillae present on F5-F10. Female antenna composed of 10 flagellomeres. Placoidal sensilla present on F6-10. Number of ridges on pronotal plate in lateral view 3. Sculpture on mesoscutum absent, entire surface smooth, shiny. Subpleuron entire smooth, anteriorly with transversely striate. Dorsal surface of scutellum foveate-areolet. Circumscutellar carina present, incomplete, laterally delimiting dorsal and ventral halves of scutellum, not present posteriorly. Latero-ventral margin of scutellum posterior to axillula entirely smooth. Dorsal part of scutellum entirely areolate. Scutellar plate, in dorsal view, medium sized, exposing about half of scutellum. Posterior impression of metepimeron absent. Anterior impression of metepisternum, immediately beneath anterior end of metapleural carina, absent. Wing vein M present but not well defined. Inter propodeal carinae space setose, too dense to see underlying surface. Horizontal carina running anteriorly from lateral propodeal carina, present. Surface of petiole longitudinally costate,

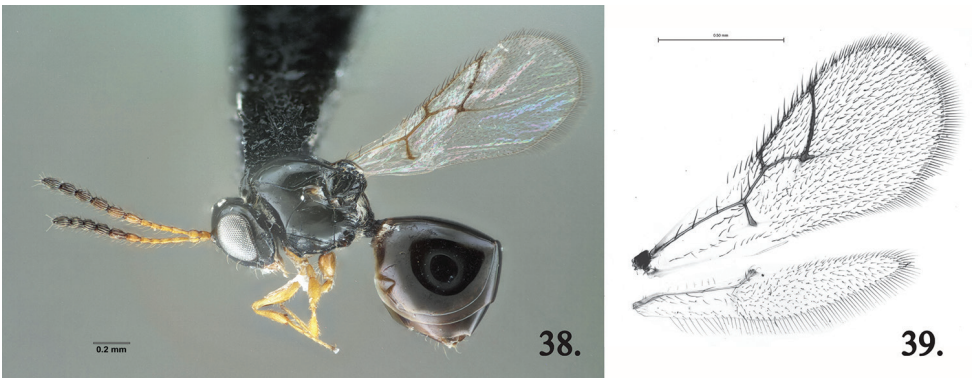


Figure 38–39. *Leptopilina decemflagella*.

ventral keel absent. Setal band (hairy ring) at base of tergum 3 present ventrolaterally, absent dorsally and ventrally. Terebrum and hypopygium (in lateral view) curved, pointing ventrally.

Distribution in Eastern North America. Florida. [http://hol.osu.edu/map-full.html?id=410492]

Etymology. The name *Leptopilina decemflagella* is based on the 10 flagellomeres of the female antenna. This feature is unique among female North American *Leptopilina* which all have 11 flagellomeres. We treat this name is a noun in apposition.

Comments. *Leptopilina decemflagella*, shares some unique morphological characters with *L. tsushimaensis* Wachi and Kimura, 2015, a species described from Japan. These characters include an antenna with only 10 flagellomeres, and the presence of a vertical carina adjacent to the ventral margin of the antenna socket. However, the vertical carinae adjacent to the toruli in *L. decemflagella* do not extend to the mid-point of the eye (when viewed anteriorly); in *L. tsushimaensis*, the carinae extend to the mid-point of the eye. Furthermore, the clava in *L. decemflagella* is clearly five segmented, and the claval segments are about as long as wide; in *L. tsushimaensis*, the clava is six segmented, and each segment is longer than wide. Flagellomere 5 in *L. decemflagella* is the transition flagellomere between claval and non-claval portions of the antenna, and results in rather gradually defined clava; in *L. tsushimaensis*, flagellomere 5 is the first full claval segment, and there is no transitional segment, resulting in an abruptly defined clava. Finally, the COI barcode region was sequenced for *L. tsushimaensis*, and this data suggests more than a 5% divergence from *L. decemflagella* (data not presented). Ergo, we feel we have ample evidence to describe *L. decemflagella* as a distinct species from *L. tsushimaensis*.

Material examined. *Holotype*. *Leptopilina decemflagella* female: United States. FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead, 26.V-28.V.2013, bait trap, C.-H. Lue, USNMENT00917604 (deposited in USNM). Paratypes (5 females): United States. FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead, 26.V-28.V.2013, bait trap, C.-H. Lue, USNMENT 00917561, 00917602, 00917684

(deposited in USNM); 25.534444°N 80.492863°W, Homestead, 23.X.2013, USNMENT00971585-00917586 (DNA voucher only). *Other material.* United States. FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 16.V-17.V.2012, bait trap, C.-H. Lue (6 females, USNMENT01022432, 01022535, 01022557, 01022789, 01022903, 01022917 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 17.V.2012, bait trap, C.-H. Lue (4 females, USNMENT00917855, 01022554, 01022581, 01022939 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 22.X-24.X.2013, bait trap, C.-H. Lue (5 females, USNMENT01022335, 01022400, 01022461, 01022482, 01022714 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 23.X.2013, bait trap, C.-H. Lue (17 females, USNMENT00917536-00917537, 00917541, 00917546, 00917553-00917555, 00917563, 00917566, 00917577, 00917628, 00917661, 00917697, 00917699, 00917861 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 26.I-28.I.2013, bait trap, C.-H. Lue (2 females, USNMENT01022543, 01022583 (USNM)). FL, Miami-Dade Co., 25.534444°N 80.492863°W, Homestead Site, 26.V-28.V.2013, bait trap, C.-H. Lue (25 females, USNMENT00917572, 00917604, 00917617, 00917621, 00917626, 00917649, 00917673, 01022249, 01022279, 01022322, 01022377, 01022456, 01022467, 01022511, 01022547, 01022692, 01022719, 01022857, 01022885, 01022957, 01022961-01022962 (USNM)).

***Leptopilina heterotoma* (Thomson, 1862)**

Eucoila heterotoma Thomson, 1862: 403 (original description); Nordlander, 1978: 50 (lectotype designation).

Ganaspis subnuda Kieffer, 1904: 64 (original description); Forshage, Nordlander & Buffington, 2013: 233 (junior synonym of *Leptopilina heterotoma* (Thomson), type information).

Ganaspis monilicornis Kieffer, 1905: 623 (original description); Weld, 1952: 228 (junior synonym of *Ganaspis musti*).

Erisphagia philippinensis Kieffer, 1916: 282 (original description).

Pseudeucoila (*Pseudeucoila*) *bochei* Weld, 1944: 65-66 (original description).

Cothonaspis (*Erisphagia*) *philippinensis* (Kieffer): Weld, 1952: 244 (generic transfer).

Pseudeucoila bochei Weld: Nøstvik, 1954: 142 (description of early developmental stages); Forshage, Nordlander & Buffington, 2013: 233 (junior synonym of *Leptopilina heterotoma* (Thomson), type information).

Leptopilina monilicornis (Kieffer): Nordlander, 1980: 430 (removed from synonymy with *G. musti* and entered into synonymy with *Leptopilina heterotoma*).

Leptopilina philippinensis (Kieffer): Nordlander, 1980: 430 (junior synonym of *Leptopilina heterotoma*, lectotype designation).

Leptopilina subnuda (Kieffer): Nordlander, 1980: 430 (junior synonym of *Leptopilina heterotoma*).

Figure 40–41. *Leptopilina heterotoma*.

Leptopilina bochei (Weld): Nordlander, 1980: 431 (junior synonym of *Leptopilina heterotoma*).

Leptopilina heterotoma (Thomson): Nordlander, 1980: 430 (generic transfer); Paretas-Martínez, Forshage, Buffington, Fisher, La Salle & Pujade-Villar, 2013: 80 (new distribution record for Australia, listed); Forshage, Nordlander & Buffington, 2013: 233 (cataloged, type information, synonymy); Ward, 2014: 575 (keyed); van Noort, Buffington & Forshage, 2015: 92 (listed).

Diagnosis. *Leptopilina heterotoma* (Figs 40–41) is immediately distinguishable from other *Leptopilina* by their large and rhombus shaped scutellar plate (Fig. 17); other species have a smaller scutellar plate that is shaped like a tear drop (Fig. 20), and exposing at least half of the scutellum (in dorsal view).

Redescription. Coloration with head, mesosoma, metasoma black to dark brown, legs light brown. Malar sulcus present. Apical segment of maxillary palp 1–1.5 times as long as preceding segment. Terminal flagellomere with two basiconic sensillae. Basiconic sensillae present on F6–F11. Placoidal sensilla present on F6–F11. Number of ridges on pronotal plate in lateral view 3. Sculpture on mesoscutum absent, entire surface smooth, shiny. Parascutal carina curved mesally. Dorsal surface of scutellum areolet - rugulose. Circumscutellar carina present, incomplete, laterally delimiting dorsal and ventral halves of scutellum, not present posteriorly. Latero-ventral margin of scutellum posterior to axillula smooth ventrally, weakly rugulose dorsally. Dorsal part of scutellum entirely rugose. Scutellar plate, in dorsal view, large, rhombus shape, covering most of scutellum. Posterior impression of metepimeron absent. Anterior impression of metepisternum, immediately beneath anterior end of metapleural carina, present, small and narrow. Wing vein M absent. Inter propodeal carinae space setose, too dense to see underlying surface. Horizontal carina running anteriorly from lateral propodeal carina not visible, setae too dense. Surface of petiole longitudinally costate

laterally, shagreen dorsally. Setal band (hairy ring) at base of tergum 3 present, interrupted dorsally, ventrally, dense hair.

Distribution in Eastern North America. Maryland and Virginia. [http://hol.osu.edu/map-full.html?id=323709]

Material examined. United States. MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 17.VI.2012, bait trap, C.-H. Lue (5 females, USNMENT00917851, 00917918, 00917956, 00917980, 00917998 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 19.VI.2012, bait trap, C.-H. Lue (1 female, USNMENT00917991 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 19.VI.2012, yellow pan trap, C.-H. Lue (2 females, USNMENT01022188, 01022240 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 20.VI-23.VI.2012, bait trap, C.-H. Lue (3 females, USNMENT00917909-00917910, 00917941 (USNM)). VA, Arlington Co., Maywood, 20.XI.1921, W. L. McAtee (4 females, USNMENT01197507, 01197511, 01197525, 01197536 (USNM)).

Leptopilina leipsi Lue & Buffington, sp. n.

http://zoobank.org/A764DAAE-F90F-4A91-A540-77F239A00C36

Diagnosis. *Leptopilina leipsi* (Figs 42–43) is distinguishable by flagellomeres F5-F10, in that the length is more than twice long as width of each flagellomere (Fig. 29). In *L. clavipes* and *L. maia* the length is 1–1.5 times the width of the flagellomere (Fig. 32). Moreover, the hairy ring is wide broken dorsally, and long and dense ventrally in *L. leipsi* (Fig. 30). This differs from other *Leptopilina* species in which the hairy ring is equally dense and of equal length (Fig. 33).

Description. Coloration with head, mesosoma, metasoma black to dark brown, legs light brown. Malar sulcus present. Apical segment of maxillary palp 1–1.5 times as long as preceding segment. Terminal flagellomere with one basiconic sensillum. Basiconic sensillae present on F5–F11. Placoidal sensilla present on F5-11. Number of ridges on pronotal plate in lateral view 2. Sculpture on mesoscutum absent, with sparse long hairs. Dorsal surface of scutellum foveate-areoletate. Circumscutellar carina present, incomplete, laterally delimiting dorsal and ventral halves of scutellum, not present posteriorly. Latero-ventral margin of scutellum posterior to axillula smooth ventrally, weakly rugulose dorsally. Dorsal part of scutellum entirely foveate. Scutellar plate, in dorsal view, small to medium sized, exposing small part of scutellum. Posterior impression of metepimeron present but not well defined. Anterior impression of metepisternum, immediately beneath anterior end of metapleural carina, present, small and narrow. Wing vein M absent. Inter propodeal carinae space setose, too dense to see underlying surface. Horizontal carina running anteriorly from lateral propodeal carina not visible, setae too dense. Surface of petiole longitudinally costate, ventral keel absent. Setal band (hairy ring) at base of tergum 3 present, interrupted dorsally, ventrally, longer hairs at ventral part.

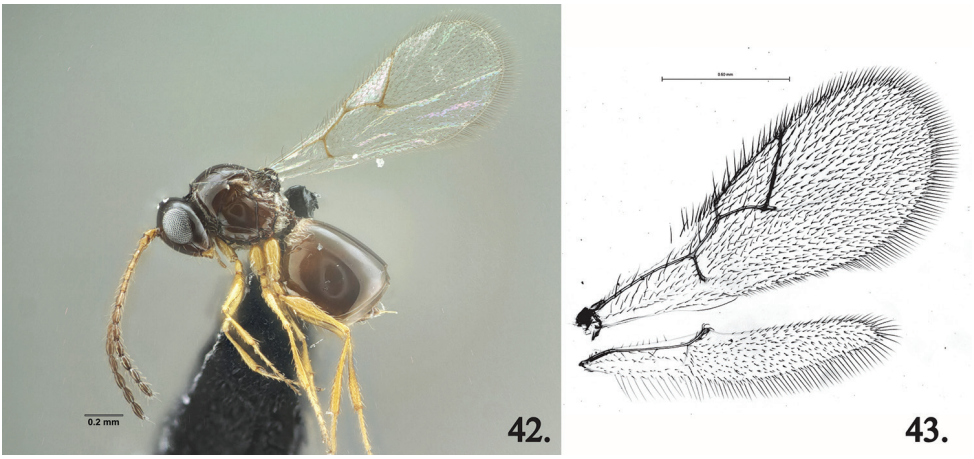


Figure 42–43. *Leptopilina leipsi*.

Distribution in Eastern North America. New Hampshire, Illinois, Maryland, and Virginia. [http://hol.osu.edu/map-full.html?id=417663]

Etymology. *Leptopilina leipsi* is named in honor of Dr. Jeff Leips (the PhD advisor of Lue) in appreciation for his support of her dissertation project.

Material examined. *Holotype. Leptopilina leipsi* female: United States. MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 1.X-4.X.2013, yellow trap, C.-H. Lue, USSMENT01022612 (deposited in USNM). *Paratypes* (7 females): United States. MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 1.X-4.X.2013, yellow trap, C.-H. Lue, USNMENT01022882 (depositd in USNM); 39.435145°N 76.487226°W, Glen Arm Site, 29.IX.2012, yellow pan trap, C.-H. Lue, USNMENT01022355 (deposited in USNM); 39.435145°N 76.487226°W, Glen Arm Site, 3.VI-6.VI.2013, yellow pan trap, C.-H. Lue, USNMENT01022504 (deposited in USNM); 39.668081°N 76.578860°W, White Hall Site, 1.X-4.X.2013, yellow pan trap, C.-H. Lue, USNMENT01022229, 01022452, 01022737 (deposit in USNM); 39.668081°N 76.578860°W, White Hall Site, 1.X-4.X.2013, yellow trap, C.-H. Lue, USNMENT 01022882 (deposit in USNM, no DNA voucher). *Other material.* United States. IL, Ford Co., along railroad tracks, Pit Road & US-45, 2004, yellow pan trap (1 female, USNMENT01119165 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 11.VI.2012, yellow pan trap, C.-H. Lue (2 females, USNMENT01022158, 01022767 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 13.VI.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022411 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 14.VI.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022812 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 3.VI-6.VI.2013, yellow pan trap, C.-H. Lue (4 females, USNMENT01022214, 01022259, 01022270 (USNM)). MD, Baltimore Co., 39.435145°N 76.487226°W, Glen Arm Site, 9.IX-12.IX.2013, yellow pan trap, C.-H. Lue (1 female, USNMENT01022430

(USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 1.X-4.X.2013, yellow pan trap, C.-H. Lue (16 females, USNMENT01022161, 01022267, 01022277, 01022389, 01022435, 01022520, 01022522, 01022643, 01022678, 01022715, 01022741, 01022786, 01022807, 01022855 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 17.VI.2012, yellow pan trap, C.-H. Lue (2 females, USNMENT01022159, 01022830 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 19.VI.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022288 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 2.VII-5.VII.2013, yellow pan trap, C.-H. Lue (2 females, USNMENT00917793, 00917803 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 22.VI.2012, yellow pan trap, C.-H. Lue (3 females, USNMENT01022171, 01022487, 01022876 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 24.VI.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022530 (USNM)). MD, Calvert Co., Warrior's Rest Sanctuary, "Oak", 38°32.006'N, 76°32.646'W, American Chestnut Land Trust, 29.VI-5.VII.2008, Malaise trap (1 female, USNMENT01119134 (USNM)). NH, Merrimack Co., 43.481918°N 71.647970°W, Franklin Site, 29.VII-2.VIII.2013, yellow pan trap, C.-H. Lue (1 female, USNMENT00917590 (USNM)). VA, Prince William Co., Conservancy Campground area, 38°49.484'N, 77°41.362'W, Bull Run Mountains, 24.IX-4.XI.2013, Malaise trap, D. Smith (1 female, USNMENT01119179 (USNM)).

***Leptopilina maia* Lue & Buffington, sp. n.**
http://zoobank.org/B205D950-8295-4267-88E1-9793D2134B21

Diagnosis. *Leptopilina maia* (Figs 44–45) is the second most common species in our collections and shares similar morphological characters with both *L. clavipes* and *L. leipsi*. In *L. maia*, the M vein is represented by a relatively clear trace vein that can be seen on the wing (arrow, Fig. 27). In *L. clavipes* and *L. leipsi* this trace vein is absent (Figs 24, 26). *Leptopilina maia* (Fig. 31) also has a deep impression on posterior margin of the metapleuron like *L. clavipes* (Fig. 23) but the edge of posterior metapleuron is clear and the impression not connected to the propodeum.

Description. Coloration with head, mesosoma, metasoma black to dark brown, legs light brown. Malar sulcus present, with adjacent groove. Apical segment of maxillary palp 1–1.5 times as long as preceding segment. Terminal flagellomere with one basiconic sensillum. Basiconic sensillae present on F1, F2, and F5–F11. Placoidal sensilla present on F5–11. Number of ridges on pronotal plate in lateral view 2. Sculpture on mesoscutum absent, with sparse long hairs. Dorsal surface of scutellum foveate-areolet. Circumscutellar carina present, complete, delimiting dorsal and ventral halves of scutellum. Latero-ventral margin of scutellum posterior to axillula entirely smooth. Dorsal part of scutellum entirely areolate. Scutellar plate, in dorsal view, small or medium sized, exposing small part of scutellum. Posterior impression of metepimeron

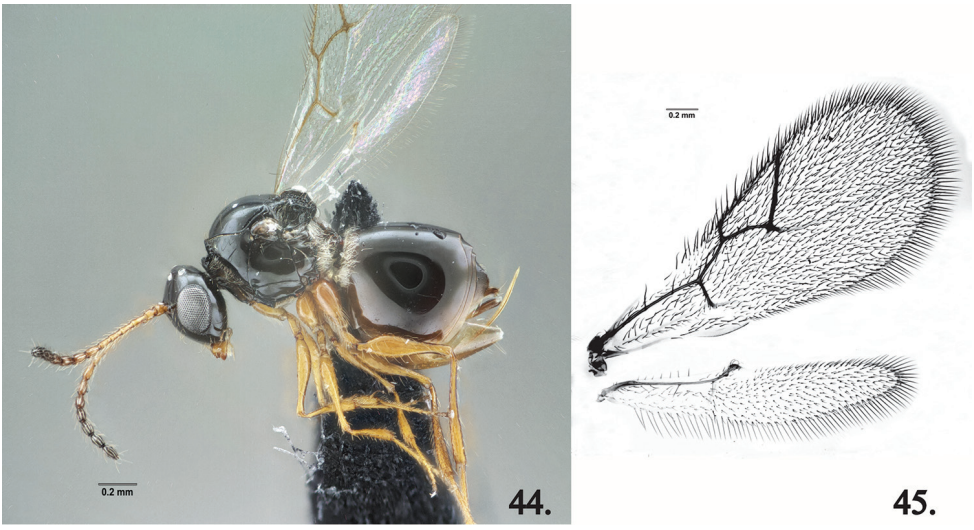


Figure 44–45. *Leptopilina maia*.

present but not well defined. Anterior impression of metepisternum, immediately beneath anterior end of metapleural carina, present, small and narrow. Wing vein M present but not well defined. Inter propodeal carinae space setose, too dense to see underlying surface. Horizontal carina running anteriorly from lateral propodeal carina not visible, setae too dense. Surface of petiole longitudinally costate, ventral keel absent. Setal band (hairy ring) at base of tergum 3 present, interrupted dorsally, ventrally, dense hair.

Distribution in Eastern North America. Maine, New Hampshire, Illinois, Arkansas, Massachusetts, Connecticut, Pennsylvania, Maryland, Virginia, North Carolina, and Florida. [http://hol.osu.edu/map-full.html?id=417662]

Etymology. *Leptopilina maia* is named in honor of the mother of the first author. The name *maia* means 'mother' in Greek form. Here we also use *maia* is to show our appreciation for Mother Nature and also the women who nurtured us growing up. Moreover, parasitoids, in general, are good mothers that have amazing strategies to find suitable hosts for their offspring. This name is a noun in apposition.

Material examined. *Holotype. Leptopilina maia* female: United States. MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 19.VI.2012, yellow pan trap, C.-H. Lue, USNMENT 01022751 (deposit in USNM). *Paratypes* (6 females): United States. MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 19.VI.2012, yellow pan trap, C.-H. Lue, USNMENT 01022333 (deposited in USNM); 2.VII-5.VII.2013, yellow pan trap, C.-H. Lue, 00917775, 00917832 (deposited in USNM); NH, Merrimack Co., 43.481918°N 71.647970°W, Franklin Site, 29.VII-2.VIII.2013, bait trap, C.-H. Lue, USNMENT00917642, 00917670, 00917698 (deposited in USNM). *Other material.* United States. AR, Montgomery Co., Ouachita National Forest, 3.VI-4.VI.2003, yellow pan trap, R. Kula & M. Yoder

(1 female, USNMENT01197540 (NMNH)). CT, Tolland Co., Storrs, IV-1970, F. A. Streams (1 female, USNMENT01197538 (NMNH)). FL, Duval Co., Jacksonville, no date (1 female, USNMENT01119105 (USNM)). FL, Leon Co., 30.580557°N 84.277435°W, Tallahassee Site, 29.V.2012, yellow pan trap, C.-H. Lue (1 female, USNMENT01022376 (USNM)). Falls Church City, 1.VI.1925 (1 female, USNMENT01119118 (USNM)). Falls Church City, 28.V.1927 (1 female, USNMENT01119122 (NMNH)). IL, Cook Co., Evanston, 13.VIII.1914 (1 female, USNMENT01119176 (USNM)). IL, Cook Co., Evanston, 17.IX.1914 (2 females, USNMENT01119133, 01119140 (USNM)). IL, Cook Co., on weed / by river, Evanston, 2.VIII.1914 (1 female, USNMENT01119198 (USNM)). IL, Lake Co., woods, Ravinia, 9.IV.1914 (1 female, USNMENT01119196 (USNM)). IL, McHenry Co., Algonquin, 13.V.1896, B. Ashmead (1 female, USNMENT01119206 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 17.VI.2012, bait trap, C.-H. Lue (1 female, USNMENT00917860 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 17.VI.2012, yellow pan trap, C.-H. Lue (4 females, USNMENT01022211, 01022213, 01022423, 01022427 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 19.VI.2012, bait trap, C.-H. Lue (1 female, USNMENT00917539 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 19.VI.2012, yellow pan trap, C.-H. Lue (12 females, USNMENT01022138, 01022232, 01022345, 01022363, 01022431, 01022717, 01022796, 01022805, 01022834, 01022856 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 2.VII-5.VII.2013, yellow pan trap, C.-H. Lue (7 females, USNMENT00917728, 00917769, 00917808, 01022370, 01022391 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 20.VI.2012, yellow pan trap, C.-H. Lue (2 females, USNMENT01022164, 01022241 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 22.VI.2012, yellow pan trap, C.-H. Lue (2 females, USNMENT01022525, 01022865 (USNM)). MD, Baltimore Co., 39.668081°N 76.578860°W, White Hall Site, 3.VII.2013, bait trap, C.-H. Lue (1 female, USNMENT00917663 (USNM)). MD, Calvert Co., Warrior's Rest Sanctuary, "Cuscuta Island", 38°31.952'N, 76°32.604'W, American Chestnut Land Trust, 12.VIII.2006, sweeping, R. Kula & M. Gates (2 females, USNMENT01197426 (NMNH); USNMENT01119284 (USNM)). MD, Calvert Co., Warrior's Rest Sanctuary, "Monster MT", 38°31'54.04"N 76°32'31.62"W, American Chestnut Land Trust, 8.VI-22.VI.2007, Malaise trap, M. Gates (1 female, USNMENT01119172 (USNM)). MD, Calvert Co., Warrior's Rest Sanctuary, "North Source", 38°31'58.97"N 76°32'30.99"W, American Chestnut Land Trust, 1.IX-14.IX.2007, canopy trap, M. Gates (1 female, USNMENT01197465 (NMNH)). MD, Calvert Co., Warrior's Rest Sanctuary, "Oak", 38°32.006'N, 76°32.646'W, American Chestnut Land Trust, 12.VI-25.VI.2008, Malaise trap (2 females, USNMENT01197425, 01197432 (NMNH)). MD, Montgomery Co., 4mi SW Ashton, 16.VIII.1986, G. F. Hevel & J. F. Hevel (2 females, USNMENT01197501, 01197542 (NMNH)). MD, Montgomery Co., Cabin John, 13.VIII.1914, R. M. Fouts (1 female, USNMENT01197406 (NMNH)). MD, Montgomery Co., Cabin

John, 26.V.1916, sweeping, R. M. Fouts (2 females, USNMENT01197512 (NMNH); USNMENT01119260 (USNM)). MD, Montgomery Co., Glen Echo, 10.VI.1917, R. M. Fouts (1 female, USNMENT01119114 (NMNH)). MD, Montgomery Co., Plummers Island, IX-1922, J. R. Malloch (1 female, USNMENT01197562 (USNM)). MD, Prince George's Co., Bowie, 2.VII.1945 (1 female, USNMENT01119185 (USNM)). MD, Prince George's Co., Bowie, 4.VII.1945 (1 female, USNMENT01119145 (USNM)). MD, Prince George's Co., Bowie, 7.VI.1945 (2 females, USNMENT01119197, 01119209 (USNM)). MD, Prince George's Co., Bowie, 9. VI.1945 (1 female, USNMENT01119144 (USNM)). ME, Washington Co., behind main lab building, next to mushroom refuse pile, 44.459827°N 67.932756°W, Eagle Hill Institute, 20.VIII-21.VIII.2014, yellow pan trap, M. Buffington (7 females, USNMENT01197516, 01197518, 01197520, 01197523, 01197528, 01197533, 01197544 (NMNH)). NC, Durham Co., 36.201°N 78.887°W (±500m), Hill Demonstration Forest, 19.VIII-2.IX.2008, Malaise trap, A. R. Deans & R. L. Blinn (1 female, USNMENT01197505 (NMNH)). NC, Haywood Co., nr. Big Creek Ranger Station, Chestnut Trail, 1725ft, 35°45'42"N 83°06'20"W, Great Smoky Mountains National Park, 6.VII-9.VII.2004, yellow pan trap, E. G. Riley (1 female, USNMENT01197508 (NMNH)). NH, Merrimack Co., 43.481918°N 71.647970°W, Franklin Site, 29.VII-2.VIII.2013, yellow pan trap, C.-H. Lue (2 females, USNMENT00917648, 00917677 (USNM)). PA, Cumberland Co., Carlisle, 1.VII.1918, R. M. Fouts (1 female, USNMENT01119199 (NMNH)). Riley Co., 06-VII, F. Marlatt (3 females, USNMENT01119171, 01119192, 01119201 (USNM)). TN, Sevier Co., Gatlinburg, cove forest, Great Smoky Mountains National Park, 3000ft, 13. VI.1947, sweeping, R. H. Whittaker (1 female, USNMENT01197519 (NMNH)). TN, Sevier Co., Gatlinburg, pine-oak forest, Great Smoky Mountains National Park, 1500ft, 26.VI.1947, R. H. Whittaker (1 female, USNMENT01197503 (NMNH)). TN, Sevier Co., cove forest, Gatlinburg, 20.VII.1947, R. H. Whittaker (1 female, USNMENT01119111 (USNM)). VA, Arlington Co., Arlington, no date (3 females, USNMENT01119136, 01197529, 01197535 (NMNH)). VA, Arlington Co., Maywood, 4.VI.1916, W. L. McAtee (1 female, USNMENT01197498 (NMNH)). VA, Arlington Co., Rosslyn, 22-VI (1 female, USNMENT01119211 (USNM)). VA, Fairfax Co., 38°50'N, 77°12'W, nr. Annandale, 10.VI-16.VI.2006, Malaise trap, D. Smith (3 females, USNMENT01197448, 01197454, 01197481 (NMNH)). VA, Fairfax Co., 38°50'N, 77°12'W, nr. Annandale, 13.VI-19.VI.2007, Malaise trap, D. Smith (1 female, USNMENT01197476 (NMNH)). VA, Fairfax Co., 38°50'N, 77°12'W, nr. Annandale, 3.VI-9.VI.2007, Malaise trap, D. Smith (3 females, USNMENT01197456, 01197480, 01197483 (NMNH)). VA, Fairfax Co., 38°50'N, 77°12'W, nr. Annandale, 8.V-21.V.2006, Malaise trap, D. Smith (1 female, USNMENT01197482 (NMNH)). VA, Fairfax Co., 38°58'N, 77°09.6'W, Turkey Run West, 31.V-13. VI.2007, Malaise trap, D. Smith (1 female, USNMENT01197452 (NMNH)). VA, Fairfax Co., 38°59.4'N, 77°15.2'W, Great Falls Park, 3.VII-17.VII.2008, Malaise trap, D. Smith (1 female, USNMENT01197408 (NMNH)). VA, Fairfax Co., Vienna, no date, J. C. Bridwell (1 female, USNMENT01197506 (NMNH)). VA, Fairfax Co.,

trap #2, 38°59.4'N, 77°15.26'W, Great Falls, 30.VI-13.VII.2006, Malaise trap, D. Smith (1 female, USNMENT01197457 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 10.V-16.V.2009, Malaise trap, D. Smith (1 female, USNMENT01197484 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 10.VIII-16.VIII.2008, Malaise trap, D. Smith (1 female, USNMENT01119234 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 12.VII-18.VII.2009, Malaise trap, D. Smith (2 females, USNMENT01197488, 01197493 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 13.VII-19.VII.2008, Malaise trap, D. Smith (2 females, USNMENT01197462, 01197471 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 13.VIII-19.VIII.2008, Malaise trap, D. Smith (6 females, USNMENT01081261, 01119253, 01119256, 01119258, 01119267, 01119276 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 14.IX-20.IX.2008, Malaise trap, D. Smith (1 female, USNMENT01197423 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 15.V-21.V.2011, Malaise trap, D. Smith (1 female, USNMENT01197494 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 16.VI-29.VI.2011, Malaise trap, D. Smith (1 female, USNMENT01197419 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 17.VII-23.VII.2011, Malaise trap, D. Smith (3 females, USNMENT01197431, 01197436, 01197467 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 2.VIII-8.VIII.2009, Malaise trap, D. Smith (1 female, USNMENT01197470 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 20.VII-26.VII.2008, Malaise trap, D. Smith (4 females, USNMENT01119223, 01119246, 01119280, 01119283 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 2009, Malaise trap, D. Smith (1 female, USNMENT01197490 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 21.VIII-27.VIII.2011, Malaise trap, D. Smith (1 female, USNMENT01197416 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 22.VI-28.VI.2008, Malaise trap, D. Smith (2 females, USNMENT01119245, 01119248 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 24.V-30.V.2009, Malaise trap, D. Smith (1 female, USNMENT01197413 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 27.VII-2.VIII.2008, Malaise trap, D. Smith (4 females, USNMENT01197411, 01197421, 01197438, 01197444 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 29.VI-5.VII.2008, Malaise trap, D. Smith (1 female, USNMENT01119298 (USNM)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 29.VI-5.VIII.2008, Malaise trap, D. Smith (3 females, USNMENT01119231,

01119240, 01119268 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 3.VII-9.VII.2011, Malaise trap, D. Smith (1 female, USNMENT01197489 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 3.VIII-9.VIII.2008, Malaise trap, D. Smith (1 female, USNMENT01197473 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 6.VII-12.VII.2008, Malaise trap, D. Smith (14 females, USNMENT01022993, 01119227, 01119230, 01119232, 01119237, 01119242, 01119244, 01119249-01119251, 01119277, 01119285, 01119289, 01197486 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 6.VIII-12.VIII.2008, Malaise trap, D. Smith (4 females, USNMENT01119233, 01119239, 01119252, 01119269 (NMNH)). VA, Fairfax Co., ~0.25mi NE jct. Gallows Road & I-495, 38°50'N, 77°12'W, Holmes Run, 7.VI-13.VI.2009, Malaise trap, D. Smith (1 female, USNMENT01197466 (NMNH)). VA, Giles Co., Hunters Branch, 37°22’21.50”N 80°31’31.79”W, Mountain Lake Biological Station, 9.VIII-10.VIII.2009, yellow pan trap, R. Kula (4 females, USNMENT01197414, 01197429, 01197458, 01197460 (NMNH)). VA, Prince William Co., Jackson Hollow Recreation Area, 38°52.645'N, 77°41.374'W, Bull Run Mountains, 1.IX-30.IX.2011, Malaise trap, D. Smith (1 male, USNMENT01197427 (NMNH)). VA, Prince William Co., Jackson Hollow Recreation Area, 38°52.645'N, 77°41.374'W, Bull Run Mountains, 11.VI-24.VI.2011, Malaise trap, D. Smith (2 females, 1 male, USNMENT01197407, 01197433, 01197474 (NMNH)). VA, Prince William Co., Jackson Hollow Recreation Area, 38°52.645'N, 77°41.374'W, Bull Run Mountains, 23.V-6.VI.2013, Malaise trap, D. Smith (1 female, USNMENT01197418 (NMNH)). VA, Prince William Co., Jackson Hollow Recreation Area, 38°52.645'N, 77°41.374'W, Bull Run Mountains, 29.VIII-23.IX.2013, Malaise trap, D. Smith (1 female, USNMENT01197420 (NMNH)). VA, Prince William Co., Jackson Hollow Recreation Area, stream, 38°52.645'N, 77°41.374'W, Bull Run Mountains, 13.V-27.V.2011, Malaise trap, D. Smith (2 females, USNMENT01197405, 01197415 (NMNH)). VA, Prince William Co., Jackson Hollow Recreation Area, stream, 38°52.645'N, 77°41.374'W, Bull Run Mountains, 22.VII-9.VIII.2011, Malaise trap, D. Smith (4 males, USNMENT01197410, 01197446, 01197487, 01197492 (NMNH)). VA, Prince William Co., Jackson Hollow Recreation Area, stream, 38°52.645'N, 77°41.374'W, Bull Run Mountains, 25.VI-7.VII.2011, Malaise trap, D. Smith (4 males, USNMENT01197400-01197401, 01197409, 01197417 (NMNH)). VA, Prince William Co., Jackson Hollow Recreation Area, stream, 38°52.645'N, 77°41.374'W, Bull Run Mountains, 7.VII-25.VII.2013, Malaise trap, D. Smith (1 female, USNMENT01197402 (NMNH)). VA, Prince William Co., Jackson Hollow Recreation Area, stream, 38°52.645'N, 77°41.374'W, Bull Run Mountains, 8.VII-21.VII.2011, Malaise trap, D. Smith (3 females, 9 males, USNMENT01197422, 01197435, 01197437, 01197439, 01197443, 01197447, 01197455, 01197463, 01197468-01197469, 01197472, 01197475 (NMNH)). VA, Rappahannock Co., 38.73817°N 78.15918°W, The Farm at Sunnyside, 30.VIII-13.IX.2014, SLAM trap, Kula et al. (1 female, USN-

MENT01197440 (NMNH)). WV, Hardy Co., 38°55'N, 78°49'W, 3mi NE Mathias, 1.VIII-18.VIII.2008, Malaise trap, D. Smith (1 female, USNMENT01197500 (NMNH)). WV, Hardy Co., 38°55'N, 78°49'W, 3mi NE Mathias, 24.IV-13.V.2008, Malaise trap, D. Smith (1 female, USNMENT01197522 (NMNH)). Washington, 30-VI (1 female, USNMENT01119123 (USNM)). Washington, 9.VIII.1917 (1 female, USNMENT01119098 (USNM)). Washington, no date (1 female, USNMENT01119121 (NMNH)).

Leptopilina victoriae Nordlander, 1980

Leptopilina victoriae Nordlander, 1980: 447 (original description); Novković, Mitsui, Suwito & Kimura, 2011: 344 (new distribution record from Japan, Indonesia and Malaysia, host association); van Noort, Buffington & Forshage, 2015: 92 (listed).

Diagnosis. The shape of antenna and metasoma of *Leptopilina victoriae* is similar to *L. boulardi*. However, the two species can be easily separate by the patterns of the scutellum (Figs 11, 20). In general, the hairy ring in *L. victoriae* (Figs 46–47) is dense and relatively shorter than other *Leptopilina* species (Fig. 22). This species also has a long horizontal ridge across middle of the metapleuron (arrow, Fig. 22). The ridge is parallel the upper ridge of metapleura and that different from other *Leptopilina* species the ridge is not display parallel.

Redescription. Coloration with head, mesosoma, metasoma black to dark brown, legs light brown. Malar sulcus present. Apical segment of maxillary palp more than 1.5 times as long as preceding segment. Terminal flagellomere with three basiconic sensillae. Basiconic sensillae present on F6–F11. Placoidal sensilla present on F7–11. Number of ridges on pronotal plate in lateral view 2. Sculpture on mesoscutum absent, entire surface smooth, shiny. Dorsal surface of scutellum areolet - rugulose. Circumscutellar carina present, complete, delimiting dorsal and ventral halves of scutellum. Latero-ventral margin of scutellum posterior to axillula smooth ventrally, weakly rugulose dorsally. Dorsal part of scutellum entirely areolate. Scutellar plate, in dorsal view, medium sized, exposing about half of scutellum. Posterior impression of metepimeron absent. Anterior impression of metepisternum, immediately beneath anterior end of metapleural carina, present, small and narrow. Wing vein M present but not well defined. Inter propodeal carinae space lightly setose, smooth. Horizontal carina running anteriorly from lateral propodeal carina, absent. Surface of petiole longitudinally costate, ventral keel absent. Setal band (hairy ring) at base of tergum 3 present, interrupted dorsally, ventrally, dense short hair.

Distribution in Eastern North America. Of the seven species in our identification key, *L. victoriae* did not appear in our field collections. However, because this species is commonly used in laboratory experiments we include this species in the identification key to assist with diagnosis of other *Leptopilina* species that are also commonly used as laboratory strains (e.g., *L. boulardi*, *L. heterotoma* and *L. clavipes*).

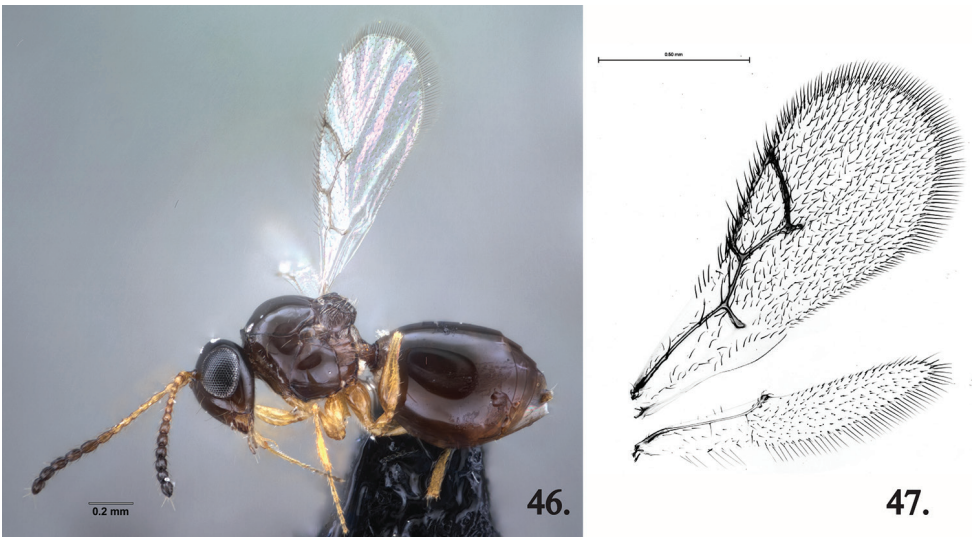


Figure 46–47. *Leptopilina victoriae.*

Material examined. Paratypes (2 females, 2 males, BMNH): Strain G 311-1, Seychelles. G. Nordlander. 1980. Es 551-552. BMNH(E) 970160-970161; Strain G 314-1, Seychelles. G. Nordlander. 1980. Es 553-554.

Discussion

Species of *Leptopilina* have been studied as *Drosophila* parasitoids for over five decades. However, knowledge of their natural history and taxonomic information remains limited for most species. None of this is too surprising when one considers the difficulties associated with identifying *Leptopilina* species. The cryptic morphological features among species, combined with geographic variation within species, could lead to the misidentification or description of species in this genus. Here we provide a key for identifying seven North American *Leptopilina* species associated with frugivorous hosts and within this group, describe three new species: *Leptopilina decemflagella* sp. n., *L. maia* sp. n., and *L. leipsi* n.sp. In addition to describing morphological characters that can be used for diagnosis, we also provide sequence data on CO1 for each species, in part to evaluate to what extant morphological divergence is reflected at the sequence level.

Molecular markers can be useful for distinguishing operational taxonomic units, especially for very small organisms that are difficult to separate morphologically due to their cryptic nature, or when species exhibit extensive intraspecific morphological variation. However, the high-efficiency associated with gathering sequence data poses a possible trade-off in accuracy for species that lack diagnostic data and/or lack trained taxonomists to develop character-based analysis to verify the molecular signal (Goldstein and DeSalle 2010, Smith et al. 2013). This situation was made apparent

in the current study. In *Leptopilina*, the DNA sequences downloadable from public databases such as GenBank, are lacking specific epithets or labeled as unknown species. Furthermore, many named species in Genbank are possibly mis-identified, as there is no solid identification system in place for *Leptopilina*. Perhaps most alarming are many sequences that are not backed up by morphological studies or voucher specimens. For this reason, it is difficult to find good reference specimens for the species in our study, and raises questions about whether the species name associated with the sequence provided in the online database is correct.

The ideal use of DNA barcoding for species identification is to complement the sequence data with other sources of information (Goldstein and DeSalle 2010). Also, in the process of delimiting or discovering an organism, the species needs a formal description. As such it is crucial to consider both molecular and morphological diagnostic criteria in these kinds of study. In the current study, sequences receiving the tag "DNA Barcode" in the Genbank database are associated with specified voucher specimens and specimen metadata, such as collection locality. These are ideally suited for use as reference sequences for future studies. Our sequences and associated information have been submitted to Genbank as DNA Barcodes. Deposited in GenBank with the accession numbers KY077389-KY077436.

Although the large size of our collection captures variation and allows us to identify diagnostic characters for most groups, difficulties delimiting cryptic species are still present in this study. In our collections some morphological characteristics (e.g., body size, scutellum size and ridge patterns on the metapleura) show high intraspecific variation but low interspecific divergence, and as a consequence, fail to consistently delimit species. For example, three *Leptopilina* species share similar morphological characters and habitats in this study, *L. clavipes*, *L. maia* and *L. leipsi* and the scutellum pattern, body size, and morphological characters that we commonly used to delimit other *Leptopilina* species, fail to discriminate *L. maia* from *L. leipsi*. We had to complement the consistent morphological characters (see results) with 5% genetic divergence in the CO1 sequence to be confident in assigning them to different species.

Two complicating factors often make it difficult to discriminate species in this group. First, parasitoid wasps often have limited ranges and small population size. As a result, parasitic life style can accelerate the rate of mitochondrial genetic divergence (Dowton and Austin 1999, Castro et al. 2002). If groups are undergoing rapid speciation, there may have not been sufficient time to accumulate differences in morphological traits among species (Kankare et al. 2005, Smith et al. 2008), yet biologically, these species might be quite isolated. This is where determining levels of sequence divergence among groups can be helpful in identifying OTUs. Second, is the reproductive mode of some parasitoids. Arrhenotoky (haplodiploid-diploid) and thelytoky (all haplodiploid eggs develop into females) are common reproductive modes in Hymenoptera species. The clone reproductive mode (thelytoky) could decrease the genetic diversity within a population and increase the genetic distance among different populations of the same species. As a result, populations of the same species might exhibit significant divergence at the molecular and morphological level and potentially mislead species determina-

tion. In addition, infection by *Wolbachia*, a common maternally transmitted bacteria in arthropods (Smith et al. 2012), can alter the reproductive mode from arrhenotoky to thelytoky in *L. clavipes*. Interestingly, this reproductive mode displays geographic variation in Europe (Pannebakker et al. 2004) and so the presence or absence of *Wolbachia* infection may also affect the degree of genetic and morphological divergence among populations, further complicating efforts to delimit parasitoid species.

Conclusion

This study is the first of its kind in North America, and in three ways, the first of its kind for *Leptopilina*. First, historically important museum specimens were augmented by specimens comprehensively collected across the *Drosophila* host breeding season and also across a broad geographic scale. Sampling across this geographic scale, and obtaining a large sample of individuals at each location throughout the breeding season, allowed us to account for intraspecific variation among *Leptopilina* when delimiting the species, something not possible when using a smaller pool of specimens. Consequently, we are able to describe morphological variation at the lowest taxonomic level. This is important because phenotypic variation is one of the main factors that reflects rapid evolution of parasitoid wasps. Within the framework of this new collecting paradigm, we also collected potential hosts at the same time we collected parasitoid wasps (Lue et al. in preparation). Secondly, sorting bulk, passively collected samples for *Leptopilina*, as well as direct rearing, allowed us to discover three new species. Finally, we consider this study especially critical at the present time, as the invasive Spotted Wing Drosophila (SWD; *Drosophila suzukii* Matsumura) has spread rapidly on the east coast of the US (Gabarra et al. 2015, Miller et al. 2015, Walsh et al. 2015), and *Leptopilina* spp. are routinely collected associated with this pest fly (Lue and Buffington, per. obsv.). As there had previously been no identification system for *Leptopilina* in any part of the United States, we hope that this review of the species and identification key for eastern North American species, will assist in future *Leptopilina* research in the United States.

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Supplementary material 1

Percent sequence difference among *Leptopilina* species.

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Data type: measurement

Explanation note: Percent sequence difference among species at the barcode region of the cytochrome oxidase subunit I gene. Values in bold are the percent sequence difference within each species. Sample sizes are in parentheses in the left-most column. The asterisk indicates the newly described species of *Leptopilina*.