

# Revision of the North American species of *Promicrogaster* (Hymenoptera, Braconidae, Microgastrinae), with an updated key to all described species in North and Meso America

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## Abstract

The genus *Promicrogaster* (Hymenoptera, Braconidae, Microgastrinae) in North America is revised and seven new species are described: *floridakeys*, *gainesvillensis*, *huachuca*, *jaymeae*, *madreanensis*, *rondeau* and *virginianus*. All but one have so far been found in protected areas of Canada and the USA, with two species collected at rather high altitudes of over 1,600 m.a.s.l. (Arizona, southwestern USA), whereas the other five were found in Eastern North America (southern Ontario and several USA states) at relatively lower altitudes (less than 150 m.a.s.l.). A key to all 31 described species in North and Meso America is provided. A species from **Costa Rica** previously described in *Promicrogaster* is here transferred to a different genus as *Hypomicrogaster pablouzagai* (Fernandez-Triana & Boudreault, 2016), **comb. nov.**

## Keywords

Microgastrinae, *Promicrogaster*, Nearctic, taxonomic key

## Introduction

The genus *Promicrogaster* (Hymenoptera: Braconidae, Microgastrinae) comprises a very distinctive group of microgastrine wasps, on account of its very long, strongly curved ovipositor with its apex sinuate. It is widely distributed in the New World, with 32 currently described species (Fernandez-Triana et al. 2016), and a probable species-richness estimated by Mason (1981) to be over 100 species. In spite of that, specimens are rare in

collections, and very few details of its biology are presently known. All of the verified host records for *Promicrogaster* are from caterpillars of the Lepidoptera families Sesiidae and Tineidae living deeply inside more or less woody plant material (reviewed by Fernandez-Triana et al. 2016), suggesting that the sinuate ovipositor tip is an adaptation to steer it through fissures in harder/more woody structures than mere leaf rolls (e.g., Quicke 2015).

Until now, no species of *Promicrogaster* had been reported from North America, although Mason (1981) and Fernandez-Triana et al. (2016) mentioned a few undescribed specimens present in collections. Seven sp. nov. from Canada and the United States are described below, increasing the total of known *Promicrogaster* species in the New World to 38. A recent key to Meso American species by Fernandez-Triana et al. (2016) is updated and modified below to accommodate the new North American species.

## Methods

*Promicrogaster* is a very rarely collected genus (Mason 1981, Fernandez-Triana et al. 2016), and it is poorly represented in collections. This study is based on 10 specimens available for study in the Canadian National Collection of Insects (CNC) in Ottawa, out of thousands of Nearctic Microgastrinae specimens that were examined.

Morphological terms and measurements of structures are mostly as used by Mason (1981), Huber and Sharkey (1993), Whitfield (1997), Karlsson and Ronquist (2012), and Fernández-Triana et al. (2014a). Mediotergites 1, 2, etc., are abbreviated as T1, T2, etc. Flagellomere 1 is the closest to the pedicel while flagellomere 16 is the apical one. Because the ovipositor in *Promicrogaster* is curved and crooked at the very apex, its length is difficult to measure accurately; the ovipositor length measurements provided for each sp. nov. are only intended as an approximation. In any case, the ovipositor and its sheaths are some of the longest observed in any Microgastrinae genera; they are usually two times longer than the metatibia length. The descriptions include characters that are commonly used in describing Microgastrinae (e.g., body measurements such as length of body and fore wing, ovipositor sheath; and also color of particular body areas). These characters follow a recent revision of the Mesoamerican *Promicrogaster* (Fernández-Triana et al. 2016), so as to facilitate future comparisons between species in the New World.

The dichotomous key is based on that provided by Fernández-Triana et al. (2016), expanded to accommodate the new North American species, and revised to correct some previous inaccuracies. In a few couplets of the key, some qualifiers (“*either*”, “*and*”, “*or*”, “*and/or*”) are shown in bold and italic to be explicit that in those cases more than one character state must be considered.

The key mostly uses morphological characters, but in one couplet molecular characters are provided to differentiate species that are morphologically similar to each other. In that case, characteristic loci in the DNA barcoding region are detailed. The bases are numbered from the start of the COI gene according to the reference sequence U37541 (*Drosophila melanogaster*), and are only diagnostic within that couplet. The letters A, C, G, and T correspond to adenine, cytosine, guanine, and thymine respectively.

Photos were taken with a Keyence VHX-1000 Digital Microscope, using a lens with a range of 13–130×. Multiple images through the focal plane were taken of a structure and these were combined to produce a single in-focus image, using the software associated with the Keyence System.

For two species molecular data was available (DNA barcodes, the 5' region of the cytochrome c oxidase I (CO1) gene, Hebert et al. (2003)). Information for those sequences can be retrieved from the Barcode of Life Data System (BOLD) (Ratnasingham and Hebert 2007).

## Results

Detailed morphological characterization of *Promicrogaster* was provided in Fernández-Triana et al. (2016). It is a very distinctive genus defined by the combination of elongate and bilobate glossa, large polished areas on lateral face of scutellum, and ovipositor shape and length. Within Microgastrinae, it can only be confused with *Sendaphne*, but the later has a much less transverse mediotergite 2, the apex of the ovipositor is not sinuate, the propodeum is entirely or mostly smooth, and the first discal cell is much wider (e.g., Fernández-Triana et al. 2014b).

A total of seven *Promicrogaster* species, all new and described below, are here recognized for North America (Table 1). All but one have so far been found in protected areas of Canada and the USA. Two species were collected in Southwestern USA (Arizona) at rather high altitudes (over 1,600 m.a.s.l.); the other five were collected in Eastern North America (southern Ontario and several USA states), at relatively lower altitudes (less than 150 m.a.s.l.). Although a few additional species are expected to be found in North America, especially when other collections are studied as comprehensively as that of the CNC has been, most of the undescribed species in this genus will probably be found in South America.

Five of the seven sp. nov. described below are only represented by a single specimen, in spite of the studied region having tens of thousands of specimens of Microgastrinae in the CNC collection that were examined for this paper. The relative scarcity of *Promicrogaster* specimens from North America is similar to what was found when studying the Costa Rican fauna (Fernández-Triana et al. 2016), when very few specimens of the genus were available among tens of thousands of specimens of Microgastrinae examined. Whether *Promicrogaster* is indeed rare in nature or just not commonly collected is still unknown.

As was the case for species described from Costa Rica (Fernández-Triana et al. 2016), no biological information is available at present for the North American species.

Only two of the sp. nov. (*jaymeae* and *madreanensis*) have some molecular data associated (DNA barcodes), in one case only a minibarcode of 165 base pairs.

Further study revealed that one of the species from Costa Rica described in Fernández-Triana et al. (2016), the nominal *Promicrogaster pablouzagai* Fernández-Triana & Boudreault, 2016, is better placed in *Hypomicrogaster*, with the comb. nov. proposed below (see section “Taxonomic treatment of species, in alphabetical order”), and it is excluded from the key.

**Table 1.** North American species of *Promicrogaster* and their known distribution. Data from present paper.

Species	Known distribution in North America (approximate altitude in m)
<i>Promicrogaster floridakeys</i> Fernandez-Triana, sp. nov.	USA, Florida, protected areas of the Lower and Middle Florida Keys, less than 5 m.a.s.l.
<i>Promicrogaster gainesvillensis</i> Fernandez-Triana, sp. nov.	USA: Florida, Gainesville, 50 m.a.s.l.
<i>Promicrogaster huachuca</i> Fernandez-Triana, sp. nov.	USA, Arizona, protected area in the Huachuca Mountains, 1830 m.a.s.l.
<i>Promicrogaster jaymeae</i> Fernandez-Triana, sp. nov.	Canada, Ontario, Thousand Islands National Park, 120 m.a.s.l.; USA: Massachusetts, Blue Hills Reservation State Park, 55 m.a.s.l.
<i>Promicrogaster madreanensis</i> Fernandez-Triana, sp. nov.	USA, Arizona, protected area in the Patagonia Mountains, 1680 m.a.s.l.
<i>Promicrogaster rondeau</i> Fernandez-Triana, sp. nov.	Canada, Ontario, Rondeau Provincial Park, 150 m.a.s.l.
<i>Promicrogaster virginianus</i> Fernandez-Triana, sp. nov.	USA, Virginia, no further data.

The updated key below covers all 32 species so far described from North America and Meso America and believed to be correctly placed in *Promicrogaster*. Detailed images and full descriptions of the Mesoamerican species are not repeated here as they can be freely accessed in Fernández-Triana et al. (2016). South America is the only remaining area in the New World pending study and description of its species, most of them undescribed.

**Key to *Promicrogaster* species in North and Meso America (female specimens)**

- 1 Lighter coloured species; clypeus entirely or mostly yellow to orange-yellow; all sternites and hypopygium yellow to orange-yellow; metasoma dorsally with T1–T4 entirely (rarely mostly) yellow, orange or red..... **2**
- Darker coloured species; most sternites (usually) and hypopygium (partially to entirely) dark brown; metasoma dorsally mostly dark brown to black (rarely some tergites with small areas orange to light brown); clypeus coloration variable, usually dark brown to black, rarely mostly yellow to orange-yellow ..... **5**
- 2(1) Propodeum with complete, raised, and strongly defined median carina; *and* T1 entirely smooth; *and* malar line more than half eye length; *and* clypeus large and entirely orange-yellow [Panama, Trinidad] ..... *Promicrogaster miranda* Muesebeck, 1958
- Propodeum without a median carina but with central depression; *either* with T1 mostly rugose *and* with malar line less than half eye length; *or* with clypeus smaller and not entirely yellow-red [other Mesoamerican countries, mostly Costa Rica]..... **3**
- 3(2) Metasoma dorsally entirely yellow-orange; T1 with coarse sculpture on 0.7 or more of its length; T2 relatively narrow, its width at posterior margin more

- than 3.0 × its length centrally; scape entirely to mostly black to dark brown [Costa Rica, Honduras, Mexico, Panama, mostly found at elevations over 1,000 m.a.s.l.]..... ***Promicrogaster munda* Muesebeck, 1958**
- Metasoma dorsally with some red, brown or black coloration; T1 comparatively smoother, at most with sculpture on posterior 0.5 of its length; T2 broader, its width at posterior margin usually less than 3.0 × its length centrally; scape mostly yellow [Costa Rica (ACG), dry forest, under 300 m.a.s.l.]..... **4**
- 4(3) Posterior margin of clypeus strongly concave; lower face clearly elongate, malar line at least 1.5 × mandible width; fore wing vein 1M transparent; T1 shape more or less rectangular (width at middle length, anterior and posterior margins about the same); T1–T4 entirely orange-yellow, T5+ mostly dark brown to black ..... ***Promicrogaster fabriciocambroneroi* Fernandez-Triana & Boudreault, 2016**
- Posterior margin of clypeus very slightly concave, almost straight; lower face of normal length, malar line 1.0 × mandible width; fore wing with vein 1M brown; T1 narrowing towards posterior margin; T1 mostly red with black margins (posterior 0.3 of T1 sometimes black), T2–T4 red-orange or yellow-orange, T5+ yellow with small central band brown ..... ***Promicrogaster alexmartinezi* Fernandez-Triana & Boudreault, 2016**
- 5(1) Antenna with most of flagellomeres 10–16 yellow-white ..... **6**
- Antenna entirely dark brown to black (rarely with flagellomeres 1–4 lighter in colour than rest of antenna) ..... **7**
- 6(5) Antenna with flagellomeres 11–16 yellow-white; propleuron, anterior 0.5 of metacoxa, sternites and hypopygium dark brown; ovipositor strongly down curved on posterior 0.2 [Costa Rica (ACG), cloud forest over 1000m] ..... ***Promicrogaster leilycastilloae* Fernandez-Triana & Boudreault, 2016**
- Antenna with flagellomeres 1–8 and 15–16 dark brown, and flagellomeres 9–14 (sometimes only 10–14) yellow white; propleuron, metacoxa, sternites and hypopygium mostly yellow to orange-yellow; ovipositor relatively straight [Costa Rica (ACG), mid-elevation rain forests, 500–800m] ..... ***Promicrogaster daretrizoi* Fernandez-Triana & Boudreault, 2016**
- 7(5) Fore wing without areolet, **and** hypopygium and sternites almost always entirely dark brown (at most hypopygium with small pale spot basally, and/or anterior 2–3 sternites yellow), **and** smaller size (body length 1.8–2.4 mm, fore wing length 2.0–2.6 mm) ..... **8**
- Fore wing with small areolet, **and/or** hypopygium and sternites usually mostly to entirely yellow, **and/or** larger size (body and fore wing lengths usually 3.0–4.0 mm) ..... **16**
- 8(7) Propodeum mostly sculptured (except for polished areas postero-laterally) ..... **9**
- Propodeum mostly smooth (except for small striae around nucha)..... **14**
- 9(8) Propodeum with almost complete areola (clearly defined posteriorly by carinae, definition anteriorly more obscured by surrounding sculpture); T2 mostly smooth [United States (Florida Keys), mangrove-hammock forest

- transition, at around sea level].....
- .....***Promicrogaster floridakeys* Fernandez-Triana, sp. nov.**
- Propodeum without defined areola (with longitudinal sculpture, mostly near posterior half of propodeum); T2 mostly sculptured, except for smooth central area [species either from Canada or from **Costa Rica**, found at much higher altitudes and/or completely different ecosystems] ..... **10**
- 10(9) Ocelli comparatively smaller: ocular-ocellar line 2.8 × posterior ocellus diameter, ocular-ocellar line 2.0 × interocellar distance; ovipositor length 2.0 × metatibia length [Canada (Ontario), 42°N, sand dunes, at around 170 m.a.s.l.].....***Promicrogaster rondeau* Fernandez-Triana, sp. nov.**
- Ocelli comparatively larger: ocular-ocellar line 1.6–2.0 × (very rarely 2.3 ×) posterior ocellus diameter, ocular-ocellar line 0.9–1.6 × interocellar distance; ovipositor length more than 2.0 × metatibia length [**Costa Rica** (ACG), 10–11°N, rainforest, at 1,000–1,100 m.a.s.l.)]..... **11**
- 11(10) Smaller size, body length 2.0–2.1 mm, fore wing length 2.2 mm, metacoxa 0.45–0.46 mm; ocular–ocellar line 0.08–0.09 mm; T1 width/length 0.4–0.5 ×; ten diagnostic characters in the DNA barcoding region: 79C, 235C, 346C, 364C, 386A, 415A, 421G, 562A, 607G, 622C .....  
..... ***Promicrogaster fabiancastroi* Fernandez-Triana & Boudreault, 2016**
- Larger size, body length 2.3–2.4 mm, fore wing length 2.4–2.6 mm, metacoxa 0.47–0.56 mm; ocular–ocellar line 0.11–0.15 mm (rarely 0.08); T1 width/length 0.5–0.7 ×; different base pairs in the barcoding region: 79A or 79T, 235T, 346A or 346T, 364A or 364T, 386T, 415G, 421A or 421T, 562G or 562T, 607A or 607T, 622A or 622T ..... **12**
- 12(11) Ocular–ocellar line shorter than interocellar distance (0.9 ×); T1 posterior width 1.3 × T2 central length; T2 width 3.2 × its length centrally .....  
..... ***Promicrogaster luismendezi* Fernandez-Triana & Boudreault, 2016**
- Ocular–ocellar line longer than interocellar distance (1.4–1.6 ×); T1 posterior width 1.8–2.0 × T2 central length; T2 width 3.5–4.9 × (usually more than 4.0 ×) its length centrally ..... **13**
- 13(12) T2 width 4.9 × its length centrally; T1 length 1.9 × its posterior width; larger species, fore wing length 2.6 mm, metacoxa length 0.6 mm, metafemur length 0.7 mm, metatibia 0.9 mm .....  
.....***Promicrogaster eddycastroi* Fernandez-Triana & Boudreault, 2016**
- T2 width 3.5–4.0 × its length centrally; T1 length 1.5–1.7 × its posterior width; smaller species, fore wing length 2.3–2.4 mm, metacoxa length 0.5 mm, metafemur length 0.5–0.6 mm, metatibia 0.7–0.8 mm .....  
... ***Promicrogaster naomiduarteae* Fernandez-Triana & Boudreault, 2016**
- 14(8) Pterostigma with anterior 0.3 or more white, most veins of fore wing transparent or white [**Costa Rica** (ACG), dry forest under 300 m.a.s.l.] .....  
.....***Promicrogaster daniellopezi* Fernandez-Triana & Boudreault, 2016**
- Pterostigma entirely brown or at most with anterior 0.1 pale, fore wing with veins mostly brown [**Costa Rica** (ACG), cloud forests over 1,000 m.a.s.l.] ...  
..... **15**

- 15(14) Posterior 0.6 of T1 sculptured; clypeus, procoxa, most of sternites and laterotergites brown .....  
 ..... ***Promicrogaster ronycastilloi* Fernandez-Triana & Boudreault, 2016**
- Posterior 0.6 of T1 mostly smooth (at most with sculpture restricted to margins); labrum yellow-orange, procoxa yellow, sternites and laterotergites mostly to partially yellow .....  
 ... ***Promicrogaster sebastiancambroneroi* Fernandez-Triana & Boudreault, 2016**
- 16(7) Posterolateral corners of anteromesoscutum orange; hypopygium and sternites dark brown; T1 hardly narrowing towards posterior margins; T1 relatively wide, its medial length barely longer than its width at anterior margin [Panama] ..... ***Promicrogaster polyporicola* Muesebeck, 1958**
- Anteromesoscutum entirely black; hypopygium and sternites usually mostly to entirely yellow; T1 usually narrowing towards posterior margin; T1 relatively narrower, its medial length much longer than its width at anterior margin [Brazil, Canada, Costa Rica, Mexico, United States] ..... **17**
- 17(16) Propleuron almost entirely yellow, except for anterior 0.2 near head yellow-white (rarely propleuron partially yellow, partially light-brown); hypopygium, sternites and most laterotergites entirely yellow (hypopygium may have a dark spot on posterior 0.1 or less)..... **18**
- Propleuron almost entirely dark brown to black, except for anterior 0.2 near head yellow; hypopygium, sternites and laterotergites at least partially dark brown ..... **20**
- 18(17) Metacoxa dark brown on anterior 0.6; tegula brown; propleuron partially yellow, partially light-brown.....  
 ... ***Promicrogaster kiralycastilloae* Fernandez-Triana & Boudreault, 2016**
- Metacoxa, tegula and propleuron entirely yellow (propleuron with anterior 0.2 near head yellow-white) ..... **19**
- 19(18) T3 mostly yellow-white, with anterior 0.4 light brown, T4–7 brown anteriorly, white on posterior 0.3–0.5 [Costa Rica (ACG), cloud forest over 1,000 m.a.s.l.].....  
 ... ***Promicrogaster kevinmartinezi* Fernandez-Triana & Boudreault, 2016**
- All tergites dark brown to black [Costa Rica (ACG), mid-elevation rain forest, 500 m.a.s.l.].....  
 ... ***Promicrogaster einyobandoae* Fernandez-Triana & Boudreault, 2016**
- 20(17) Fore wing without areolet .....  
 ... ***Promicrogaster andrevallejosi* Fernandez-Triana & Boudreault, 2016**
- Fore wing with small areolet ..... **21**
- 21(20) Flagellomeres 1–4 yellow-brown, clearly paler than rest of entirely brown flagellomeres ; orange-yellow areas on metapleuron posterior 0.4, T1 anterior 0.6, T3 anterior 0.5 and small spot on mesopleuron posteriorly .....  
 ... ***Promicrogaster hillaryvillafuerteae* Fernandez-Triana & Boudreault, 2016**
- All flagellomeres same color (brown to dark brown); meso- and metapleuron entirely dark brown to black, coloration of T1 and T3 variable but not as above ..... **22**

- 22(21) Tegula and wing base dark brown to black; clypeus black (same color as face); clypeus slightly protruding and labrum slightly depressed, giving the appearance of a circular opening between the margin of clypeus and mandibles.....  
 ... ***Promicrogaster monteverdensis* Fernandez-Triana & Boudreault, 2016**
- Tegula and wing base yellow; clypeus entirely to partially orange-yellow or orange-brown (clearer than face); clypeus not protruding and labrum not depressed, not giving the appearance of a circular opening.....**23**
- 23(22) Flagellomere 15 length 1.6–1.7 × its width; **and** ovipositor tip strongly bent downwards; **and** clypeus entirely orange-yellow (different from dark brown to black face); **and** body length and fore wing length 4.0 mm; **and** T1 almost parallel-sided, very slightly narrowing towards posterior margin; **and** T2 mostly sculptured; **and** T3 with small yellow spot laterally [Brazil, Mexico]...  
 ..... ***Promicrogaster apharea* Nixon, 1965**
- Flagellomere 15 length 1.0–1.3 × its width; **and/or** ovipositor tip less strongly bent downwards; **and/or** clypeus entirely to partially dark brown to black (same color as face); **and/or** body length and fore wing length less than 4.0 mm; **and/or** T1 clearly narrowing towards posterior margin; **and/or** T2 mostly smooth; **and/or** T3 entirely dark brown to black [Canada, Costa Rica, United States] .....**24**
- 24(23) Metacoxa with at least anterior 0.6 (usually more) dark brown to black [United States; Costa Rican specimens running through this couplet come from cloud forests over 1,000 m.a.s.l. in ACG] .....**25**
- Metacoxa mostly to entirely yellow (at most with small, dark spot on anterior 0.1–0.3 dorsally) [United States; Costa Rican specimens running through this couplet come from dry forest or mid-elevation rainforests at 300–500 m.a.s.l. in ACG] .....**26**
- 25(24) Smaller ocelli, ocular–ocellar line 2.6 × as long as posterior ocellus diameter; more rounded head, its maximum width 1.15 × its height; smaller body length (2.5 mm) and fore wing length (2.6 mm); tegula yellow [United States] .....***Promicrogaster virginianus* Fernandez-Triana, sp. nov.**
- Bigger ocelli, ocular–ocellar line 1.9–2.0 × as long as posterior ocellus diameter; more ovoid head, its maximum width 1.3 × its height; larger body length (3.3–3.5 mm) and fore wing length (3.7 mm); tegula brown [Costa Rica (ACG), cloud forests over 1,000 m.a.s.l.] .....  
***Promicrogaster brandondinartei* Fernandez-Triana & Boudreault, 2016\***
- 26(24) T3 with yellow spots laterally; T2 mostly sculptured (but sometimes smooth centrally) **and/or** T1 clearly narrowing towards posterior margin, its length at least 2.0 × its width at posterior margin .....**27**
- T3 entirely dark brown to black; T2 smooth **and** T1 usually barrel-shaped to almost parallel-sided, rarely slightly narrowing towards posterior margin, its length 1.7 × its width at posterior margin .....**30**

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\* In the original description of this species the color of metacoxa was wrongly described as ‘yellow’ but after re-examining all specimens is evident that was an error, as all specimens have metacoxa with anterior 0.5–0.6 dark brown to black



- 27(26) Fore wing vein R1 pale (yellow-white); metasoma with T3+ yellow-orange on posterior 0.2–0.5 [Canada (ON); United States (Massachusetts); 42–44°N].  
 ..... ***Promicrogaster jaymeae* Fernandez-Triana, sp. nov.**
- Fore wing vein R1 dark brown; metasoma mostly dark brown to black, at most T3 with yellow spots laterally [Costa Rica (ACG); United States (AZ), 31°N] ..... **28**
- 28(27) Clypeus almost entirely black (at most with very small yellow spots on postero-lateral margins); fore wing with most veins dark brown; hypopygium partially yellow; ovipositor length 2.50–2.60 × metatibia length; tip of antenna with shorter flagellomeres (flagellomere 14 1.3–1.4 × as long as wide, flagellomere 15 1.2 × as long as wide) [Costa Rica (ACG), 280–300 m.a.s.l.] .....  
 ..... ***Promicrogaster liagranae* Fernandez-Triana & Boudreault, 2016**
- Clypeus entirely to mostly orange; fore wing with most veins light yellow to almost transparent; hypopygium dark brown to brown; ovipositor length 1.97–2.14 × metatibia length; tip of antenna (when known) with longer flagellomeres (flagellomere 14 1.6 × as long as wide, flagellomere 15 1.5 × as long as wide) [United States] ..... **29**
- 29(28) Comparatively smaller species (body length: 3.10 mm, fore wing length: 3.00 mm); T1 length 1.9 × its width at posterior margin; T2 posterior margin width 3.2 × its length medially and slightly more sculptured; head and mesosoma mostly dark reddish-brown; fore wing areolet almost obliterated [Florida, 50 m.a.s.l.] .....  
 ..... ***Promicrogaster gainesvillensis* Fernandez-Triana, sp. nov.**
- Comparatively larger species (body length: 3.70 mm, fore wing length: 3.80 mm); T1 length 2.7 × its width at posterior margin; T2 posterior margin width 4.4 × its length medially and mostly smooth (except for sculpture near posterior margin); head and mesosoma mostly black; fore wing areolet clearly visible and defined [Arizona (Huachuca Mountains), 1830 m.a.s.l.] .....  
 ..... ***Promicrogaster huachuca* Fernandez-Triana, sp. nov.**
- 30(26) Clypeus with strong notch centrally on posterior margin; T1 and T2 almost entirely smooth; metapleuron relatively more sculptured on posterior 0.4; body and fore wing length over 4.5 mm [United States (AZ, Patagonia Mountains), 1,675 m.a.s.l.] .....  
 ..... ***Promicrogaster madreanensis* Fernandez-Triana, sp. nov.**
- Clypeus without notch centrally on posterior margin; T1 with some sculpture on posterior 0.4–0.5, T2 with some punctuation on margins; metapleuron relatively less sculptured, almost smooth on posterior 0.4; body and fore wing lengths 3.6–4.0 mm [Costa Rica (ACG), 400–520 m.a.s.l.] .....  
 ..... ***Promicrogaster tracyvindasae* Fernandez-Triana & Boudreault, 2016**

### Taxonomic treatment of species, in alphabetical order

#### *Hypomicrogaster pablouzagai* (Fernandez-Triana & Boudreault, 2016), comb. nov.

*Promicrogaster pablouzagai* Fernandez-Triana & Boudreault, 2016.

**Notes.** A critical re-examination of the available specimens (including the holotype) as well as the numerous DNA barcodes available, clearly indicate that this species is better placed within *Hypomicrogaster*. The propodeum has an irregular pattern of carinae around the median longitudinal carina, but still it is possible to distinguish a partially defined areola (at least apically) which is similar to other known species of *Hypomicrogaster*. The head is also considerably transverse (i.e., significantly much wider than high in frontal view), another morphological feature that is typical in this genus. The DNA barcodes cluster close to many other species of *Hypomicrogaster* and relatively distant from *Promicrogaster*, further supporting transferring the species here.

#### *Promicrogaster floridakeys* Fernandez-Triana, sp. nov.

<http://zoobank.org/24EBD28C-19D2-4FAE-8DA5-10E26CB39103>

Fig. 1 A–G

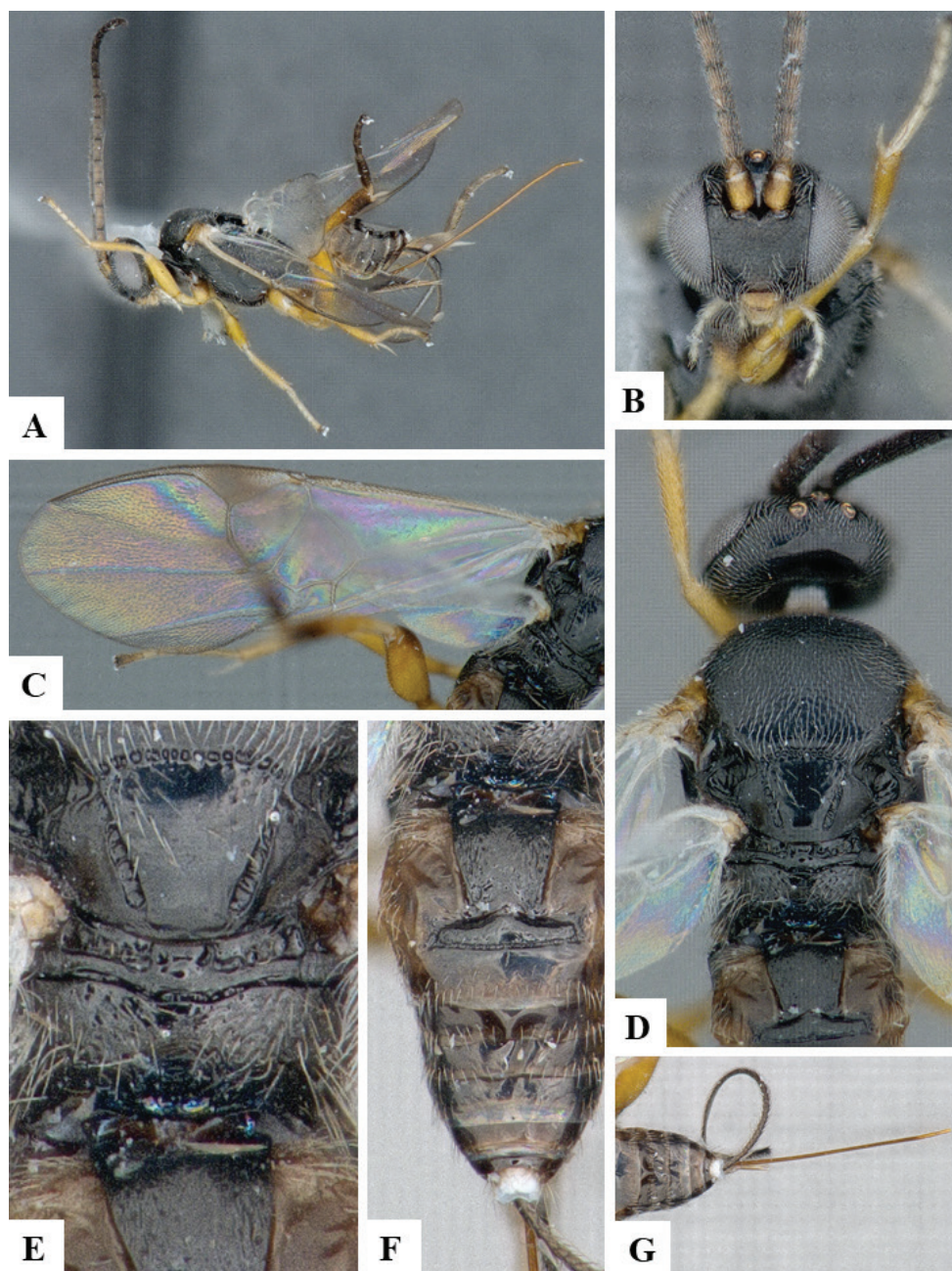
**Material examined. Holotype.** UNITED STATES • ♀, CNC; Florida, Long Key State Park; 24.8127N, 80.8231W; 24 Aug–26 Oct 2016; J McIntosh leg; Malaise trap; CNC634252.

**Paratypes.** UNITED STATES • ♀, CNC; Florida, Monroe County, Middle Torch Key; 1–30 Jun 1985; S & J Peck leg; Malaise trap; mangrove-hardwood transition; CNC505706 • ♀, CNC; Florida, Monroe County, Big Pine Key; 1–30 Mar 1986; S & J Peck leg; Malaise trap; CNC526849.

**Diagnosis.** Among the darker coloured species with unicolorous (brown to black) flagellomeres, *P. floridakeys* is unique in having the propodeum with an almost complete areola (all other species lack an areola).

**Description.** Head: mostly black, labrum and mandibles yellow. Flagellomeres: dark brown. Mesosoma: black. Tegula: yellow. Metasoma (dorsally): black to dark brown. Metacoxa: mostly black to dark brown (posterior 0.1–0.2 yellow). Malar distance: less than 0.2 × eye length. Fore wing areolet: absent. T1 sculpture: anterior 0.5 smooth, posterior 0.5 sculptured. T2 sculpture: mostly smooth. Body length: 2.30–2.50 mm. Fore wing length: 2.40–2.55 mm. Ovipositor length: 1.50–1.70 mm. Ocular-ocellar line: 0.12 mm. Interocellar distance: 0.09 mm. Posterior ocellus diameter: 0.06 mm. Metacoxa length: 0.51–0.56 mm. Metafemur length: 0.61–0.65 mm. Metatibia length: 0.71–0.77 mm. T1 length/width at posterior margin: 0.33–0.35 mm/ 0.14 mm. T2 length/width at posterior margin: 0.07–0.08 mm/ 0.30–0.32 mm.

**Distribution.** UNITED STATES, Florida, protected areas of the Lower and Middle Florida Keys (less than 5 m.a.s.l.). Specimens have been caught at mangrove or hardwood habitats.



**Figure 1.** *Promicrogaster floridakeys*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** head and mesosoma, dorsal **E** scutellar complex and propodeum, dorsal **F** metasoma, dorsal **G** ovipositor.

**Biology.** Unknown.

**Molecular data.** Not available.

**Etymology.** Named after the Florida Keys, with the intention to recognize the beautiful yet fragile ecosystems present there.

***Promicrogaster gainesvillensis* Fernandez-Triana, sp. nov.**

<http://zoobank.org/9AD19A17-D8CB-411D-A150-D820C342AA18>

Fig. 2 A–E

**Material examined. Holotype.** UNITED STATES • ♀, CNC; Florida, Gainesville, Doyle Conner Building; 09 Oct 1973; E.E. Grissell leg; Malaise trap; CNCHYM 01987.

**Diagnosis.** This species is morphologically similar to *P. huachuca* (Arizona), *P. jaymeae* (Canada), and *P. liagranta* (Costa Rica), but there are enough morphological differences (see key above for details on how to separate those four species) and disparate geographical distributions (including different ecosystems and considerable variation in altitude) to consider all of them as different.

**Description.** Head: mostly dark reddish-brown, labrum and mandibles yellow, clypeus mostly dark reddish-brown but with comparatively large yellow spots on postero-lateral margins. Flagellomeres: dark brown. Mesosoma: mostly dark reddish-brown laterally, dorsally mostly black (but with faint reddish-brown spots on posterolateral margins of anteromesoscutum). Tegula: yellow. Metasoma (dorsally): mostly dark brown to black, T3 with yellow spots laterally. Metacoxa: yellow. Malar distance: less than  $0.2 \times$  eye length. Fore wing areolet: present. T1 sculpture: anterior 0.5 smooth, posterior 0.5 sculptured. T2 sculpture: mostly sculptured, except for smooth central area. Body length: 3.10 mm. Fore wing length: 3.00 mm. Ovipositor length: 2.25 mm. Ocular–ocellar line: 0.15 mm. Interocellar distance: 0.08 mm. Posterior ocellus diameter: 0.07 mm. Metacoxa length: 0.75 mm. Metafemur length: 0.85 mm. Metatibia length: 1.05 mm. T1 length/width at posterior margin: 0.48 mm/ 0.25 mm. T2 length/width at posterior margin: 0.12 mm/ 0.38 mm.

**Distribution.** UNITED STATES, Florida, Gainesville, 50 m.a.s.l.

**Biology.** Unknown.

**Molecular data.** Not available.

**Etymology.** Named after the type locality, as a recognition to the important insect collections hosted in that city and the vibrant entomological community living there.

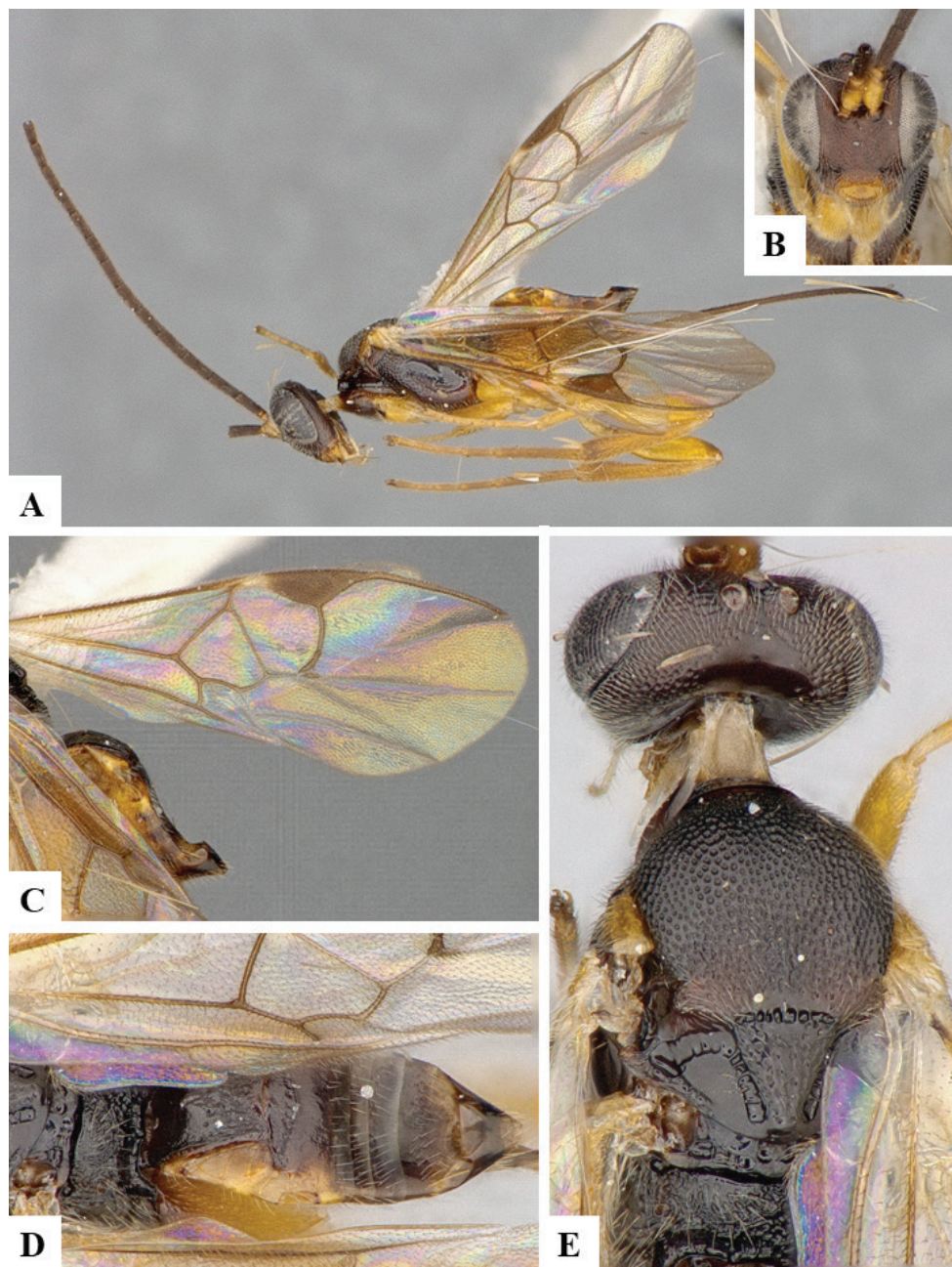
***Promicrogaster huachuca* Fernandez-Triana, sp. nov.**

<http://zoobank.org/4DE29D6C-4FBA-47F9-A345-A62300595942>

Fig. 3 A–F

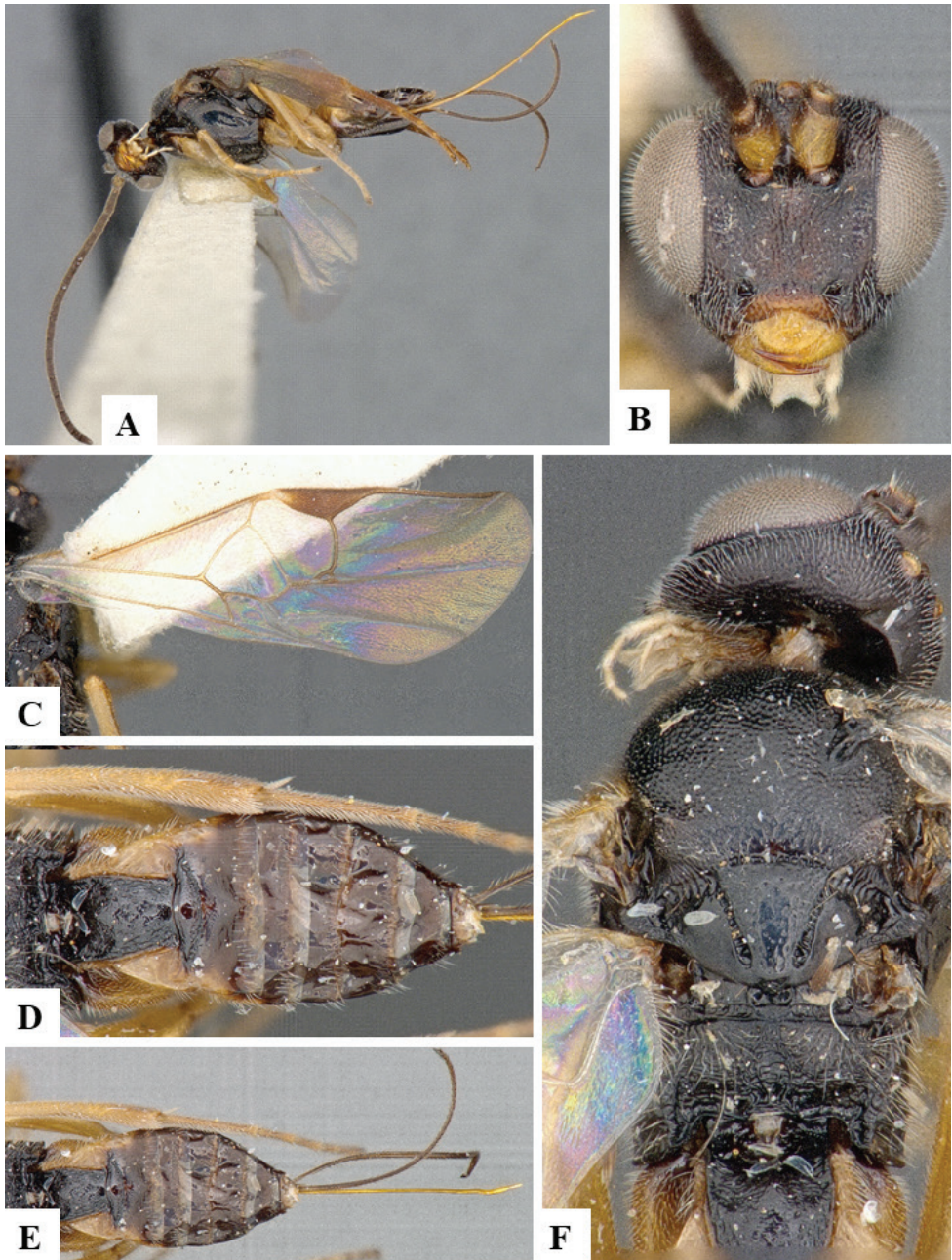
**Material examined. Holotype.** UNITED STATES • ♀, CNC; Arizona, Sierra Vista, Huachua Mountains, Ramsey Canyon; 1829 m.a.s.l.; 07 Nov 1967; Sternitzky leg; CNCHYM 01988.

**Diagnosis.** This species is morphologically similar to *P. gainesvillensis* (Florida), *P. jaymeae* (Canada), and *P. liagranta* (Costa Rica), but there are enough morphological differences (see key above for details on how to separate those four species) and disparate geographical distributions (including different ecosystems and considerable variation in altitude) to consider all of them as different.



**Figure 2.** *Promicrogaster gainesvillensis*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** propodeum and metasoma, dorsal **E** head and mesosoma, dorsal.

**Description.** Head: mostly black, labrum and mandibles yellow. Flagellomeres: dark brown. Mesosoma: black. Tegula: yellow. Metasoma (dorsally): mostly dark brown to black, T3 with yellow spots laterally. Metacoxa: yellow. Malar distance:  $0.3 \times$  eye length.



**Figure 3.** *Promicrogaster huachuca*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** propodeum and metasoma, dorsal **E** ovipositor **F** head and mesosoma, dorsal.

Fore wing areolet: present. T1 sculpture: anterior 0.5 smooth, posterior 0.5 sculptured. T2 sculpture: mostly smooth but with sculpture near margins. Body length: 3.70 mm. Fore wing length: 3.80 mm. Ovipositor length: 2.40 mm. Ocular–ocellar line: 0.17 mm.

Interocellar distance: 0.10 mm. Posterior ocellus diameter: 0.09 mm. Metacoxa length: 0.85 mm. Metafemur length: 0.95 mm. Metatibia length: 1.22. T1 length/width at posterior margin: 0.60/ 0.22 mm. T2 length/width at posterior margin: 0.12 mm/ 0.53 mm.

**Distribution.** UNITED STATES, Arizona, Huachuca Mountains, 1,829 m.a.s.l.

**Biology.** Unknown.

**Molecular data.** Not available.

**Etymology.** Named after the Huachuca Mountains, one of the major Madrean sky island ranges in Arizona. The Madrean sky islands are pine-oak woodlands found at higher elevations in Mexico, Arizona and New Mexico (USA); they are surrounded at lower elevations by the Sonoran and Chihuahuan deserts, and are important because of their endemism, and relict populations.

***Promicrogaster jaymeae* Fernandez-Triana, sp. nov.**

<http://zoobank.org/D5ED2A45-7F43-4B1F-9813-88B7E73BB9E0>

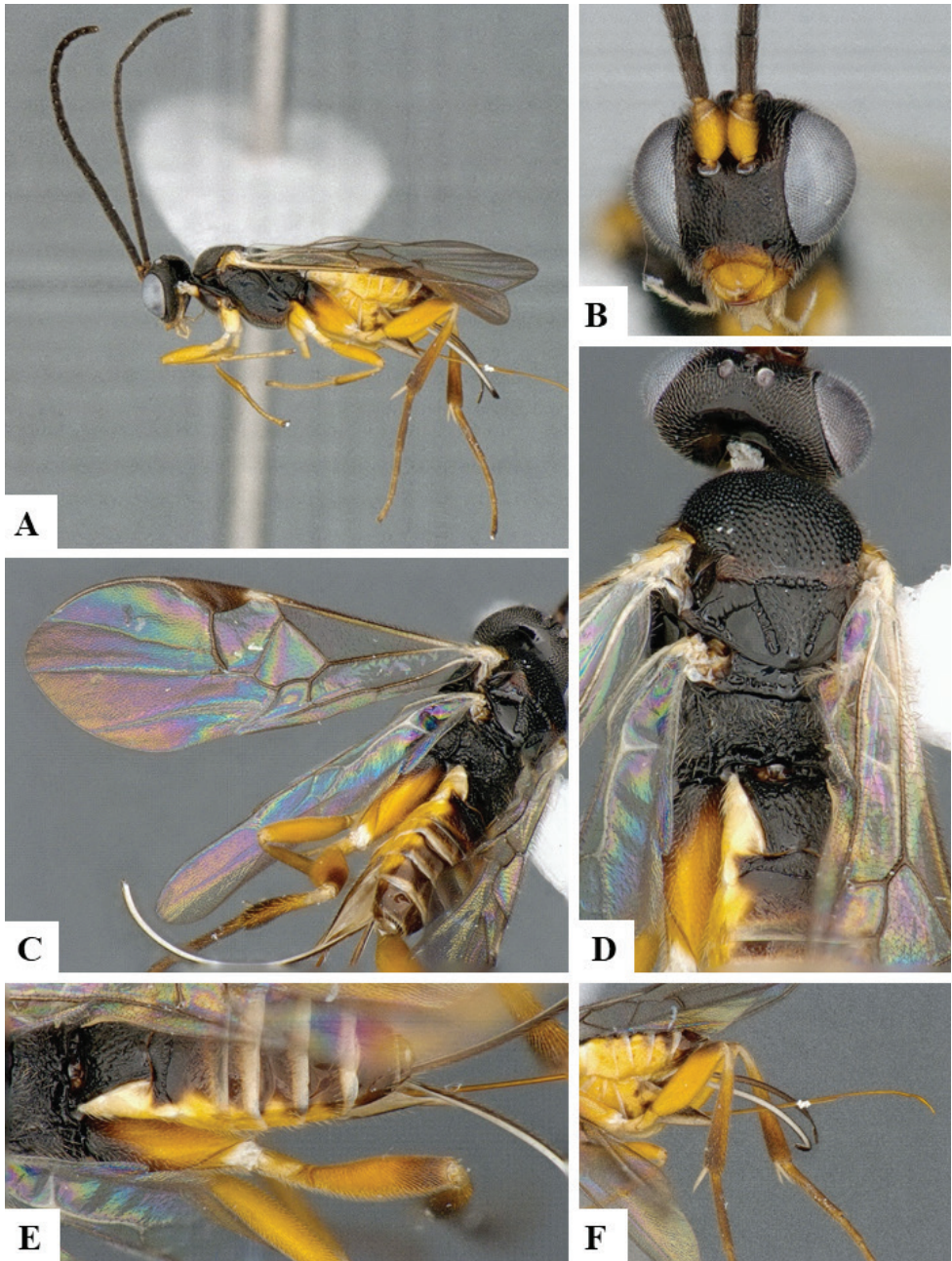
Figs 4 A–F, 5 A–G

**Material examined. Holotype.** CANADA • ♀, CNC; Ontario; St. Lawrence Islands National Park; Jones Creek by Mallory Town; Country Road 5; 44.4747N, 75.8652W; 117 m.a.s.l.; 19 Sep 2012; Mixed forest - sugar maple and white birch; St. Lawrence Islands National Park leg; BIOUG03887-G02.

**Paratype.** UNITED STATES • ♀, MCZ (Museum of Comparative Zoology, Harvard University, Cambridge, USA); Massachusetts, Blue Hills Reservation, Milton; 19 Aug 1963; H.E. Evans leg; CNC666703.

**Diagnosis.** This species is morphologically similar to *P. gainesvillensis* (Florida), *P. huachuca* (Arizona), and *P. liagranta* (Costa Rica), but there are enough morphological differences (see key above for details on how to separate those four species) and disparate geographical distributions (including different ecosystems and considerable variation in altitude) to consider all of them as different. The Canadian species can be separated based on its fore wing vein R1 yellow-white, T3+ yellow-orange on posterior 0.2–0.5, metacoxa dark brown on anterior 0.3, and T2 mostly sculptured (fore wing vein R1 dark brown; metasoma mostly dark brown to black, metacoxa entirely yellow, and T2 mostly smooth on *P. liagranta*).

**Description.** Head: mostly black, labrum and mandibles yellow. Flagellomeres: dark brown. Mesosoma: black. Tegula: yellow. Metasoma (dorsally): mostly dark brown, with T3+ yellow-orange on posterior 0.2–0.5. Metacoxa: mostly orange yellow, with black to dark brown spot on anterior 0.3 dorsally. Malar distance: less than 0.2 × eye length. Fore wing areolet: present. T1 sculpture: mostly sculptured. T2 sculpture: mostly smooth. Body length: 3.40–3.50 mm. Fore wing length: 3.40 mm. Ovipositor length: 2.10–2.30 mm. Ocular–ocellar line: 0.14 mm. Interocellar distance: 0.09–0.10 mm. Posterior ocellus diameter: 0.08–0.09 mm. Metacoxa length: 0.80–0.90 mm. Metafemur length: 0.90–1.02 mm. Metatibia length: 1.15–1.28. T1 length/width at posterior margin: 0.47–0.57/ 0.29 mm. T2 length/width at posterior margin: 0.11 mm/ 0.42–0.43 mm.

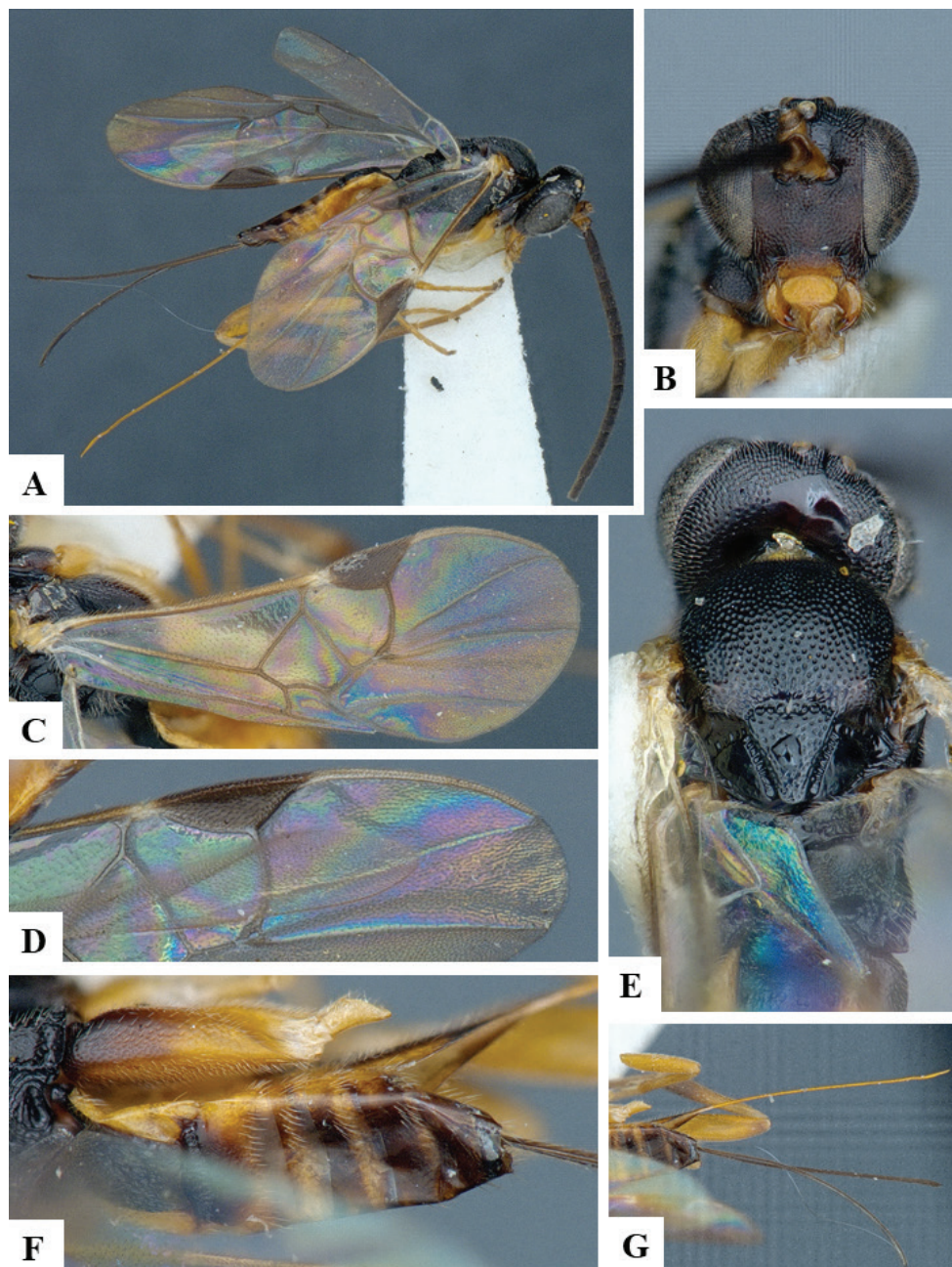


**Figure 4.** *Promicrogaster jaymeae*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** head and mesosoma, dorsal **E** propodeum and metasoma, dorsal **F** ovipositor.

**Distribution.** CANADA, Ontario; UNITED STATES, Florida, Massachusetts. Collected between 55 and 117 m.a.s.l.

**Biology.** Unknown.





**Figure 5.** *Promicrogaster jaymeae*, female paratype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** details of perostigma and fore wing areolet **E** head and mesosoma, dorsal **F** metasoma, dorsal **G** ovipositor.

**Molecular data.** The holotype rendered an almost complete DNA barcode (622 base pairs), the sequence page in BOLD is CNSLK014-12. It belongs to BIN BOLD:ADA9820, which contains another sequence, from *P. liagranta* (Costa Rica).

The two sequences are rather similar (1.73% base pairs difference) but represent different species.

**Etymology.** Named after Jayme Sones, Collections Manager of the Centre for Biodiversity Genomics (CBG), University of Guelph, Canada, in appreciation of the extraordinary work she has done for the CBG during the past 15 years, and as a big thanks for her support and help with many braconid loans and other topics over the years.

***Promicrogaster madreanensis* Fernandez-Triana, sp. nov.**

<http://zoobank.org/C3EE1313-A3D8-4865-96EA-3C5B9A620D38>

Fig. 6 A–F

**Material examined. Holotype.** UNITED STATES • ♀, CNC; Arizona, Patagonia Mountains; 1676 m.a.s.l.; 10 Jul 1962; H.E. Milliron leg; CNCHYM 01986.

**Diagnosis.** This species is morphologically similar to *P. tracyvindasae* (Costa Rica), but can be distinguished from it (and from all other described species of *Promicrogaster* from North and Meso America) because of its clypeus with a strong notch centrally on posterior margin.

**Description.** Head: mostly dark reddish-brown, labrum and mandibles yellow, clypeus orange-yellow. Flagellomeres: dark brown. Mesosoma: mostly black but ventrolaterally reddish-brown. Tegula: yellow. Metasoma (dorsally): mostly dark brown to black. Metacoxa: yellow. Malar distance:  $0.3 \times$  eye length. Fore wing areolet: present. T1 sculpture: mostly smooth. T2 sculpture: mostly smooth but with sculpture near margins. Body length: 4.90 mm. Fore wing length: 4.90 mm. Ovipositor length: approximately 2.90 mm. Ocular–ocellar line: 0.20 mm. Interocellar distance: 0.12 mm. Posterior ocellus diameter: 0.10 mm. Metacoxa length: 1.10 mm. Metafemur length: 1.20 mm. Metatibia length: 1.50. T1 length/width at posterior margin: 0.65/ 0.40 mm. T2 length/width at posterior margin: 0.21 mm/ 0.80 mm.

**Distribution.** UNITED STATES, Arizona, Patagonia Mountains, 1,676 m.a.s.l.

**Biology.** Unknown.

**Molecular data.** The holotype rendered a partial DNA barcode (164 base pairs), the sequence page in BOLD is HYCNE1802-11.

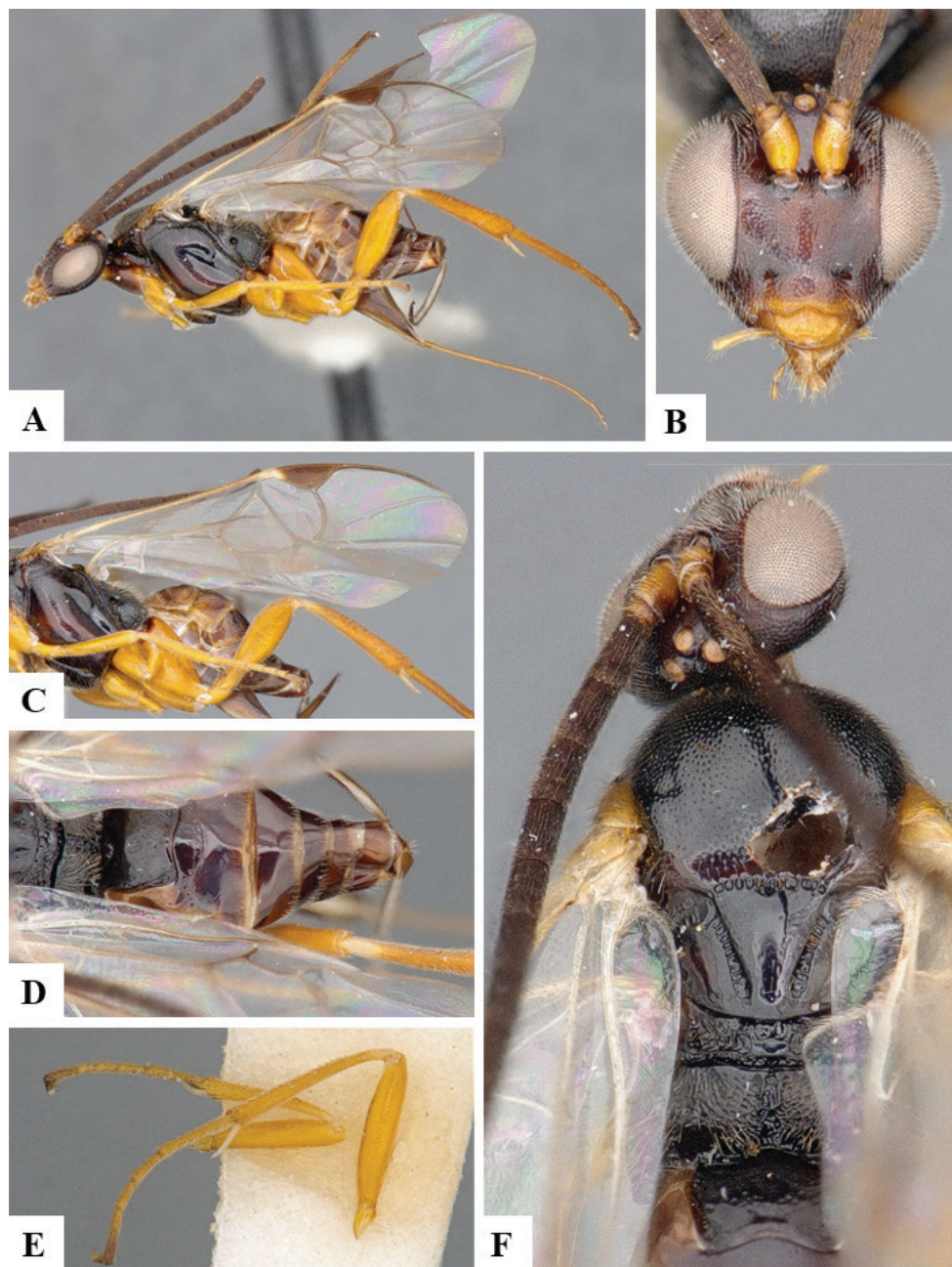
**Etymology.** Named after the Madrean sky island ranges in Arizona. The Madrean sky islands are pine-oak woodlands found at higher elevations in Mexico, Arizona and New Mexico (USA); they are surrounded at lower elevations by the Sonoran and Chihuahuan deserts, and are important because of their endemism and relict populations.

***Promicrogaster rondeau* Fernandez-Triana, sp. nov.**

<http://zoobank.org/8064D59E-A217-48F9-BFB6-752078A4540F>

Fig. 7 A–F

**Material examined. Holotype.** CANADA • ♀, CNC; Ontario; Rondeau Provincial Park; 12 Aug 1982; Sand dunes; M. Sharkey leg; CNC666701.



**Figure 6.** *Promicrogaster madreanensis*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** propodeum and metasoma, dorsal **E** middle legs **F** head and mesosoma, dorsal.

**Diagnosis.** This species is morphologically similar to four species described from Costa Rica (ACG). Apart from the disparate geographical distribution, there are several differences between them, which are best shown in Table 2 below.

**Table 2.** Differences between *Promicrogaster rondeau* (from Canada) and four morphologically related species from Costa Rica. OOL- Ocular-ocellar line; POL- Posterior ocellar line; POD- Posterior ocellus diameter; L- Length. All measurements in mm.

Species	OOL	POL	POD	Meta-coxa L	Meta-femur L	Meta-tibia L	Body L	Fore wing L	Ovipositor L
<i>P. rondeau</i>	0.14	0.07	0.05	0.44	0.51	0.65	2.20	2.30	1.30
<i>P. fabiancastroi</i>	0.08–0.10	0.08	0.05	0.45–0.47	0.52–0.56	0.65–0.69	1.98–2.14	2.23–2.25	1.40–1.57
<i>P. eddycastroi</i>	0.11	0.08	0.06	0.56	0.68	0.89	2.29	2.65	1.77
<i>P. luismendezi</i>	0.08	0.09	0.05	0.50	0.58	0.76	2.33	2.37	1.67
<i>P. naomiduarteae</i>	0.11–0.14	0.07–0.9	0.06	0.47–0.53	0.52–0.61	0.66–0.79	2.33–2.39	2.31–2.47	1.41–1.92

**Description.** Head: mostly dark reddish-brown, labrum and mandibles yellow. Flagellomeres: dark brown. Mesosoma: mostly dark reddish-brown laterally, dorsally mostly black (but with faint reddish-brown spots on posterolateral margins of anteromesoscutum). Tegula: yellow. Metasoma (dorsally): mostly dark brown to black. Metacoxa: brown. Malar distance: less than  $0.2 \times$  eye length. Fore wing areolet: absent. T1 sculpture: mostly sculptured. T2 sculpture: mostly sculptured, except for small, smooth central area. Body length: 2.20 mm. Fore wing length: 2.30 mm. Ovipositor length: 1.30 mm. Ocular–ocellar line: 0.14 mm. Interocellar distance: 0.07 mm. Posterior ocellus diameter: 0.05 mm. Metacoxa length: 0.44 mm. Metafemur length: 0.51 mm. Metatibia length: 0.65 mm. T1 length/width at posterior margin: 0.31 mm/ 0.17 mm. T2 length/width at posterior margin: 0.08 mm/ 0.32 mm.

**Distribution.** CANADA, Ontario, Rondeau Provincial Park.

**Biology.** Unknown.

**Molecular data.** Not available.

**Etymology.** Named after the type locality, in recognition of the natural values and uniqueness of the Rondeau Provincial Park.

***Promicrogaster virginianus* Fernandez-Triana, sp. nov.**

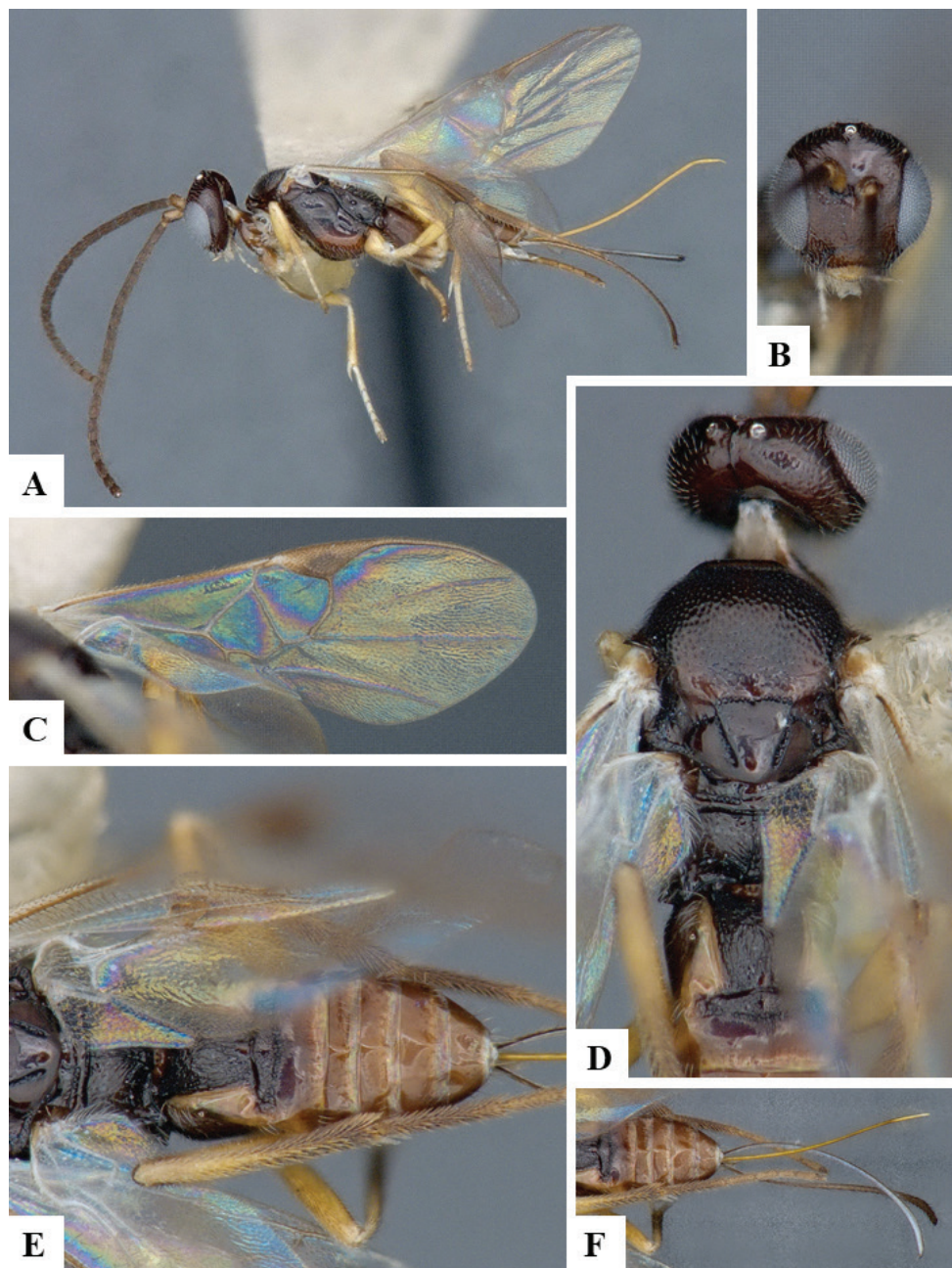
<http://zoobank.org/BF705DDC-8701-4A84-AB9F-38B737C9C39A>

Fig. 8 A–E

**Material examined. Holotype.** UNITED STATES • ♀, USNM; Virginia; 28 Aug 1884; CNC666702.

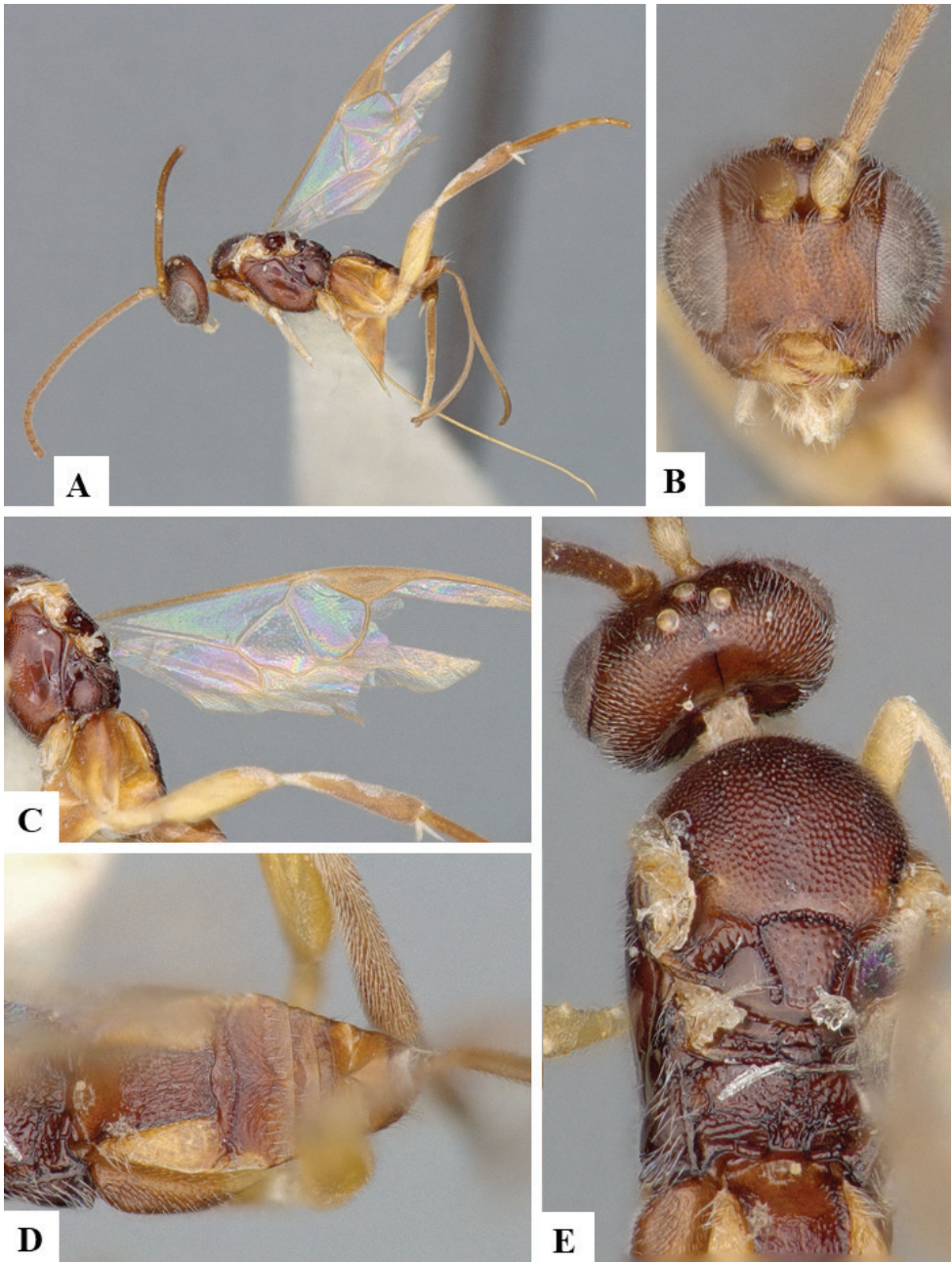
**Diagnosis.** Among the darker coloured species (with uniformly dark antenna and entirely dark brown propleuron), with small areolet in the fore wing and tegula and wing base yellow, this species can be distinguished by its relatively small size (body and fore wing length 2.5–2.6 mm) and smaller ocelli (ocular–ocellar line  $2.6 \times$  as long as posterior ocellus diameter). All other species with dark colouration are either substantially larger (body and fore wing length at least 3.3 mm, usually more), and/or have larger ocelli, lack an areolet or have some other differences (as stated in the key above).

**Description.** Head: mostly reddish-brown, labrum and mandibles yellow. Flagellomeres: brown. Mesosoma: reddish-brown. Tegula: yellow. Metasoma (dorsally): mostly reddish-brown. Metacoxa: mostly brown. Malar distance: less than  $0.2 \times$  eye length. Fore



**Figure 7.** *Promicrogaster rondeau*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** head and mesosoma, dorsal **E** propodeum and metasoma, dorsal **F** ovipositor.

wing areolet: present. T1 sculpture: : anterior 0.4 smooth, posterior 0.6 sculptured. T2 sculpture: mostly sculptured. Body length: 2.60 mm. Fore wing length: approximately 2.80 mm. Ovipositor length: 2.30 mm. Ocular-ocellar line: 0.17 mm. Interocellar



**Figure 8.** *Promicrogaster virginianus*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** propodeum and metasoma, dorsal **E** head and mesosoma, dorsal.

distance: 0.08 mm. Posterior ocellus diameter: 0.07 mm. Metacoxa length: 0.65 mm. Metafemur length: 0.75 mm. Metatibia length: 0.90 mm. T1 length/width at posterior margin: 0.43 mm/ 0.18 mm. T2 length/width at posterior margin: 0.08 mm/ 0.38 mm.

**Distribution.** UNITED STATES, Virginia.

**Biology.** Unknown.

**Molecular data.** Not available.

**Etymology.** Named after the state where it was collected.

**Notes.** This is the oldest known specimen of *Promicrogaster*, having been collected 135 years ago.

## Acknowledgements

I am very grateful for the editorial work of Gavin Broad (Natural History Museum, London, UK) and the review of Mark Shaw (National Museums of Scotland, Edinburgh) which significantly improved the final version of the manuscript. This work was supported by project 3199 “Systematics of beneficial arthropods in support of resilient agroecosystems”, Agriculture and Agri-Food Canada.

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