



Two new Neotropical species of oak gall wasps of the genus *Loxaulus* Mayr (Hymenoptera: Cynipidae: Cynipini) from Panama

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Abstract

Two new species of *Loxaulus* Mayr, *Loxaulus championi* and *Loxaulus panamensis* (Hymenoptera: Cynipidae: Cynipini) are described from Panama. Both new species induce galls on *Quercus bumelioides* Liebm. (Fagaceae, sect. *Quercus*, White Oaks). The diagnostic characters, gall descriptions, distribution, biological data and a key for the identification of the new species are given. The new species represent the first records of the genus *Loxaulus* outside North America.

Key words: Cynipidae, oak gall wasps, *Quercus*, Chiriqui, Panama

Introduction

The Nearctic genus *Loxaulus* Mayr, with 14 described species, was previously only known from the United States (Melika & Abrahamson 2000). Galls, similar to those of *L. boharti* Dailey & Sprenger, known from California (USA), were collected in Baja California Norte (Mexico), however, no adults were reared (Dailey & Sprenger 1983) thus the distribution of the species in Mexico is still questionable. The representatives of the genus are distributed across USA: 5 species known only from California, 3 species from Arizona and New Mexico, the rest of species distributed from Texas to Florida and northward along the Eastern Coast. The genus was recently reviewed by Melika & Abrahamson (2000, 2002) and according to these authors *Loxaulus* form a distinct morphological entity, that can be morphologically characterized as follows: the head is massive, broader than the mesosoma in dorsal view and usually higher than broad in anterior view; the gena broadened, visible behind the compound eye in anterior view; the malar sulcus always present, distinct; antennae with 11–12 flagellomeres; the mesosoma slightly compressed in lateral view; the mesoscutum usually finely transversely coriaceous; the mesoscutellum without foveae, with a transverse shallow depression; the central propodeal area is narrow, limited by parallel or only slightly outward bent lateral carinae and with a median longitudinal carina and/or longitudinal striae; the median longitudinal carina in some species is indistinct, fragmented but always present at least in the anterior half; the radial cell of the forewing 2.5–3.8 times as long as broad, the forewing margin with or without cilia, usually with brown, smoky spots (or stripes) along the areolet, 2r, Rs, and M; tarsal claws are simple, without a basal lobe; the ventral spine of the hypopygium is short, slender or needle-like; subapical setae are short and sparse, not reaching beyond the apex of the spine and the prominent part is never more than 3.0–3.8 times as long as broad. The genus resembles the palaeartic *Plagiotrochus* Mayr and the nearctic *Bassettia* Ashmead. Recent analyses, however, doubts the monophyletic nature of *Loxaulus* (*J. Nicholls pers. comm.*) and its closer phylogenetic relation with *Plagiotrochus* and *Bassettia* we shall discuss below.

In the framework of a field study of the oak gall wasps (Cynipidae) of Panama (see also Medianero & Nieves-Aldrey 2010, Nieves-Aldrey & Medianero 2010, 2011), this paper contains the first report of the genus *Loxaulus* in Central America and includes the descriptions of two new species from Panama.

Material and methods

Study material. The adults studied were reared from galls collected on *Quercus bumelioides* Liebm. Samplings were made at Volcan Baru, Chiriquí Province, Panama and material was collected from December 2007 to August 2010. The adult insects emerged from the galls in rearing cages under laboratory conditions.

Specimen preparation. For observation under a scanning electron microscope (SEM), adult cynipids were observed without dissection using SEM at low vacuum, without coating. Micrographs were taken using an FEI QUANTA 200 microscope (low vacuum technique). Images of adult habitus, forewings and gall dissections were taken using a NIKON Coolpix 4500 digital camera attached to a Wild MZ8 stereo microscope. Measurements were made with a calibrated micrometer scale attached to an ocular of the light microscope. The terminology of morphological structures and abbreviations follows Ronquist & Nordlander (1989), Ronquist (1995), Nieves-Aldrey (2001) and Liljeblad *et al.* (2008).

Description of species

Loxaulus championi Medianero & Nieves-Aldrey sp. nov.

(Figs. 1, 2 & 5A–D)

Type material. Holotype ♀ (Fig. 5A) (in Museo Nacional de Ciencias Naturales, Madrid, Spain (MNCN), card-mounted. Cat. n° 2111). PANAMA, Chiriquí, Volcan Baru 8° 48' 03.5" N, 82° 30' 42.7" W, 2681 m; ex gall on stems of *Quercus bumelioides* Liebm. (Fagaceae), gall collected 17.vii.2008, insect emerged vii.08, E. Medianero leg. Paratypes: 1 ♀ PANAMA, Chiriquí, Volcan Baru 8° 47' 54.55" N, 82° 30' 32.5" W, 2447 m collected 26.xi.2008, insect emerged xii.08, E. Medianero leg. Paratype in Maestría en Entomología, Universidad de Panamá (MEUP).

Etymology. Named after George Champion (1851–1926) English entomologist, collector of the first cynipid galls from Panama.

Diagnosis and comments. The species resembles *L. illinoisensis* (Weld) from the United States, being similar in color and a majority of morphological characteristics. However, in *L. illinoisensis* the head is less massive from above, nearly 3.0 times or more as broad as long; the notauli are distinctly impressed at least in 2/3 of the mesoscutum length posteriorly; the radial cell of the forewing distinctly shorter, maximum 2.5 times as long as broad; the projecting part of the hypopygial spine 2.2–2.5 times as long as wide in lateral view; currently known only from Illinois, USA, induce subterranean stem swelling-like galls, usually at the base of young sprouts of *Q. macrocarpa* Michaux. The abrupt stem swelling induced by *L. illinoisensis* is approximately 4–5 times the normal diameter of the shoot and nearly 30 cm long. Galls mature in fall and adults emerge from the end of October through November (Weld 1921).

Description. Body length 2.55 mm (range 2.5 – 2.6; N = 2) for females. Mesosoma and metasoma dark reddish-brown. Head, antennae and legs yellowish-brown with the genae, ocellar triangle, occiput, distal half of antennae meso- and metacoxae, femora and tibiae, reddish-brown. Forewing hyaline with some light infumation in and below the areolet area and on 2r vein, veins light to dark brown, with the area of 2r vein and base of radial cell darkened and lightly infusate.

Female. Head finely coriaceous, in dorsal view about 2.0 times wider than long, 1.26 times broader than thorax. POL 1.7 times longer than OOL, posterior ocellus separated from inner orbit of eye by 2.3 times its longest diameter (Fig. 1A); a longitudinal line of sculpture visible between the lateral ocelli. Head in anterior view (Fig. 1B), 1.1 times wider than high, genae strongly broadened behind eyes. Vertex, frons, lower face, gena and occiput finely coriaceous with sparse very short gold setae and weak rugae on the face, radiating striae from clypeus delicate and short, not reaching ventral margin of compound eye and absent medially above clypeus. Clypeus square with ventral margin sinuate and strongly projecting over mandibles. Anterior tentorial pits well visible; with epistomal sulcus and clypeo-pleurostomal lines slightly marked. Malar space 0.4 times height of compound eye, with a distinctive malar sulcus. Toruli situated slightly above mid-height of compound eye; distance between antennal rim and compound eye one times width of antennal socket including rim. Ocellar plate not raised. Head without occipital carina posteriorly. Occiput slightly concave. Mouthparts: mandibles not being well visible in the examined specimens, but presumably as usual in Cynipini, right mandible with three teeth; left with two teeth.

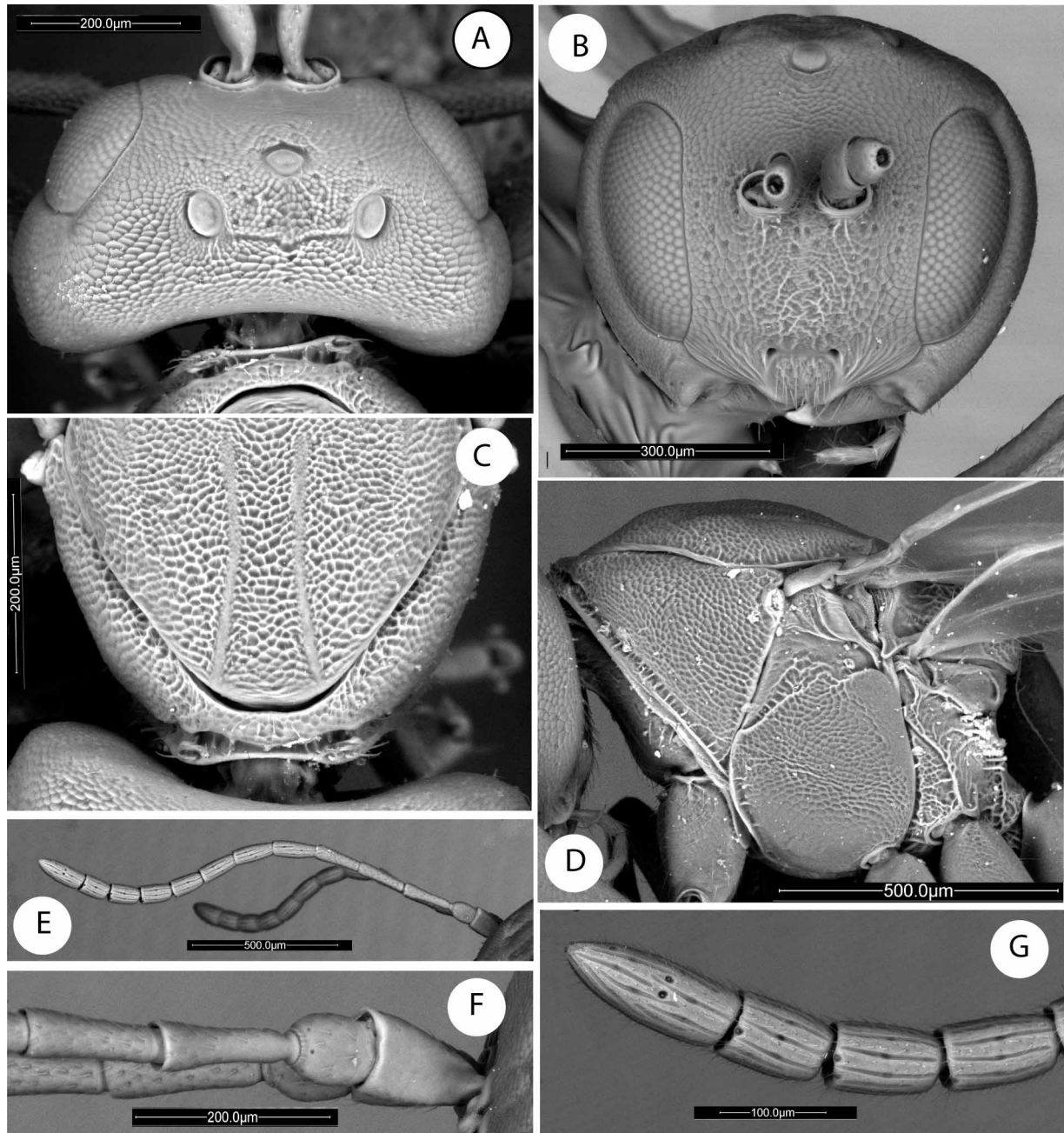


FIGURE 1. *Loxaulus championi*: (A) Head dorsal view. (B) Head anterior view. (C) Pronotum antero-dorsal view. (D) Mesosoma lateral view. (E) Female antenna. (F) Detail of basal flagellomeres. (G) Detail of ultimate flagellomeres.

Antenna (Fig. 1E–G) of moderate length, as long as 1/2 body length, with 13 antennomeres; flagellum not broadening towards apex; with short erect setae, and placodeal sensilla visible (Fig. 1G). Relative lengths of antennal segments: 17:13:26:25:23:21:20:18:16:15:15:13:25. Pedicel, sub-globose, small, 0.7 as long as scape; F1 only slightly longer as F2 (Fig. 1F). F4–F11 longer than wide, F11 2.7 times longer than wide, 2.2 times as long as F10 (Fig. 1G). Placodeal sensillae on F4–F11 disposed in one row of 5 sensillae in half dorsal area of each flagellomere.

Mesosoma. Slightly flattened dorso-ventrally; in lateral view 1.25 times as long as high. Pronotum, scarcely pubescent; lateral surface of pronotum coriaceous without longitudinal wrinkles dorsally (Fig. 1D). Pronotum short medially, ratio of length of pronotum medially/laterally = 0.3. Pronotal plate indistinct dorsally (Fig. 1C).

Mesonotum (Fig. 2A). Mesoscutum slightly longer than broad in dorsal view, finely coriaceous and barely pubescent. Notauli distinct in posterior one third of mesoscutum, faint anteriorly and medially, widely separated at meeting of transscutal fissure, median mesoscutal impression absent. Anteroadmedian signa and parapsidal signa

clearly visible. Scutellum (Fig. 2A), rounded, about 0.4 as long as mesoscutum, slightly reticulate. Scutellar foveae not well differentiated, shallow, confluent medially, with some longitudinal striae and indistinctly margined posteriorly; in lateral view the scutellum not overlapping the dorsellum. Axillula without setae, only their anterior margins marked. Mesopleuron medially with coriaceous reticulate sculpture, lacking in antero-posterior and ventral areas of mesopleuron (Fig. 1D).

Metanotum (Fig. 2B). Metapectal-propodeal complex. Metapleural sulcus reaching posterior margin of mesospectus at about two thirds height (Fig. 1D). Lateral propodeal carinae parallel, slightly branched posteriorly, a median longitudinal carina present and complete, median propodeal area with some secondary rugae (Fig. 2B), lateral propodeal area with reticulate carinae and almost bare.

Legs. Metatarsal claws simple, with a single curved apical tooth and without basal lobes (Fig. 2E).

Forewing (Fig. 5B) slightly longer than body, radial cell 3.1 times longer than wide; open along anterior margin; areolet small, triangular, closed and distinct. Rs depigmented apically, slightly bowed and not reaching margin of wing. Rs+M not reaching basalis. Apical margin of wing with a fringe of moderately long setae. Basal cell almost bare.

Metasoma (Fig. 2C) as long as mesosoma, as high as long in lateral view. Second metasomal tergite covering about two thirds of metasoma, with line of 6–7 setae in its anteromedial area. Projecting part of hypopygial spine (Fig. 2D) about 2.8 times as long as broad in lateral view, laterally with some short setae.

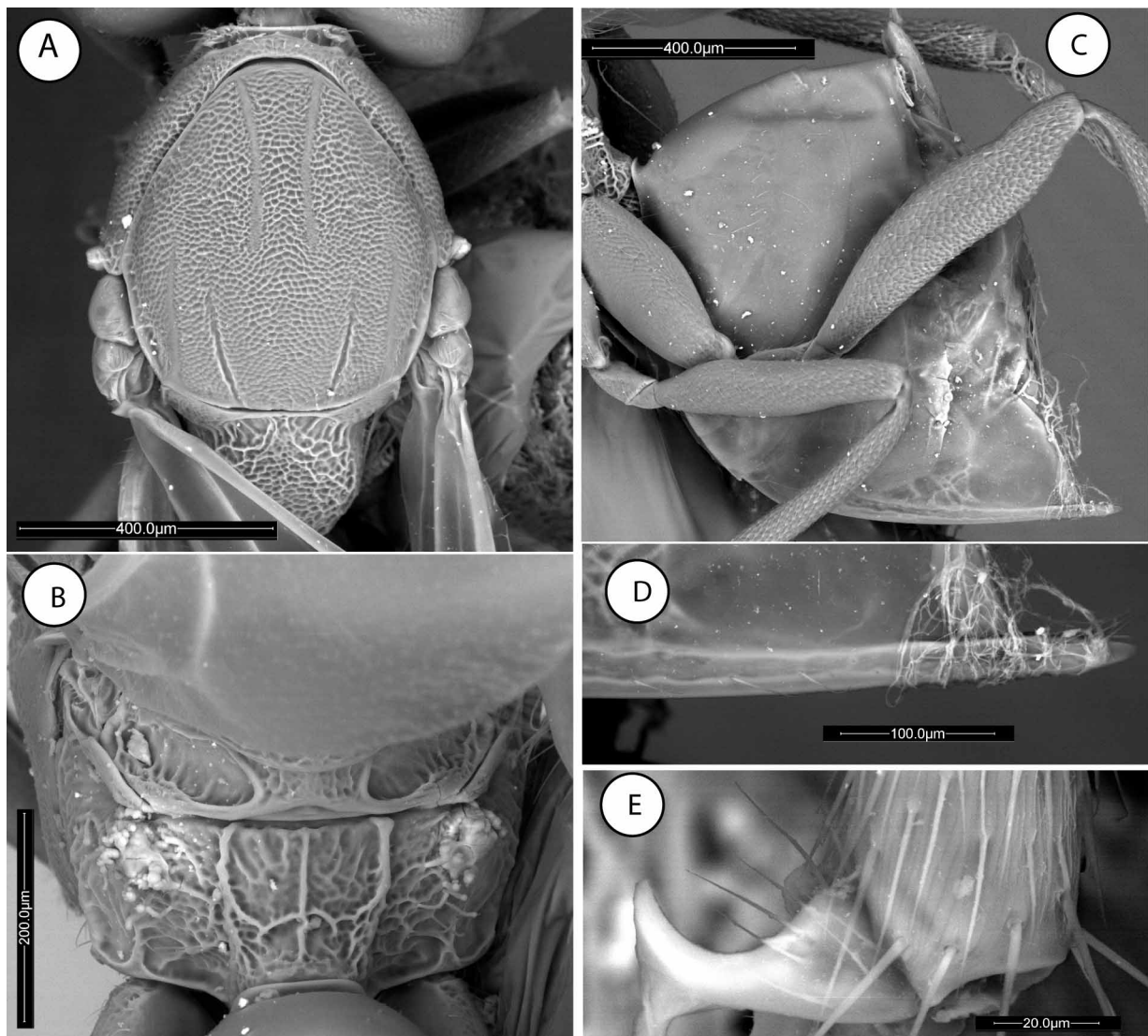


FIGURE 2. *Loxaulus championi*: (A) Mesosoma dorsal view. (B) Propodeum. (C) Metasoma lateral view. (D) Detail of ventral spine of hypopygium, lateral view. (E) Metatarsal claw.

Gall (Fig. 5C–D). Elongated slight swellings of twigs (Fig. 5C). The gall surface rough, of the same colour as the bark. The swellings have at least two times the diameter of a normal stem. Larval chambers are arranged longitudinally in rows under the surface of the bark (Fig. 5D). The galled stems are barely recognizable before the emergence of the adults.

Distribution. *Loxaulus championi* was found between 2400 and 2700 m a.s.l. at Volcan Baru, Chiriqui, Panama.

Biology. Only the asexual generation is known, inducing galls on *Quercus bumelioides* Liebm. (section *Quercus*). The galls are found between July and December during the rain season in Panama.

***Loxaulus panamensis* Medianero & Nieves-Aldrey sp. nov.**

(Figs. 3, 4 & 5E–G)

Type material. Holotype ♀ (Fig. 5E) (in Museo Nacional de Ciencias Naturales, Madrid, Spain, card mounted. Cat n° 2112). PANAMA, Chiriquí, Volcan Baru, 8°46'36.8"N, 82°31'39.3"W, 3079 m; ex gall on stems of *Quercus bumelioides* Liebm. (Fagaceae), gall collected 26.v.2010, insect emerged vi.10, E. Medianero leg. Paratypes: 1 ♀, same data as holotype. Paratypes: 1 ♀, PANAMA, Chiriquí, Volcan Baru, on *Quercus bumelioides* Liebm. (Fagaceae), collected 22.vii.2008, E. Medianero leg. One paratypes in MNCN, one paratype in Maestría en Entomología, Universidad de Panamá (MEUP).

Etymology. Named after the country where the new species was collected.

Diagnosis and comments. Closely resembles *L. championi* described above in majority of morphological characteristics. The species differs mainly by the relative length of notauli and the length of F1 and F2. *L. championi* have F2 as long as F1, whereas F2 is 1.2 times as long as F1 in *L. panamensis*. *L. championi* have notauli distinct only in posterior one third of mesoscutum whereas the notauli are nearly complete wider and deeper in *L. panamensis*. Additionally, *L. championi* have the lateral propodeal carinae parallel and slightly branched posteriorly, and the area between the median and the lateral propodeal carinae is rugose, whereas the lateral propodeal carinae are slightly convergent posteriorly in *L. panamensis*, and the surface between lateral and medial carinae is smooth. Another minor differences can be noted as follows: *L. panamensis* has the lateral surface of the pronotum with some longitudinal wrinkles, radial cell 3.8 times longer than wide, with well visible infuscation below areolet, and body mostly yellowish brown, while *L. championi* has a coriaceous lateral surface of the pronotum, radial cell only 3.1 times longer than wide, with very diffuse infuscate area below areolet, and the body is mostly dark reddish-brown.

Description. Female body length 2.0 mm (N = 3). Head, mesosoma, and metasoma yellowish brown with ocellar triangle, lateral surface of pronotum, scutellum (except by medial area), mesopleuron, metapectal-propodeal complex, distal half of antennae, metafemora and tibiae dark brown to black. Forewing hyaline with some very light infumation below the areolet area, veins light to dark brown, with the area of 2r vein and basalis slightly darkened.

Female. Head coriaceous, in dorsal view about 2.2 times wider than long, 1.14 times broader than thorax. Genae strongly broadened behind eyes. POL 1.3 times longer than OOL, posterior ocellus separated from inner orbit of eye by 2.6 times its longest diameter (Fig. 3A). Head in anterior view (Fig. 3B), ovate, 1.3 times wider than high. Vertex, frons, face, gena and occiput coriaceous with sparse gold setae on the face and vertex, radiating striae from clypeus absent. Clypeus square, coriaceous and moderately pubescent with ventral margin sinuate and slightly projecting over mandibles. Anterior tentorial pits well visible with epistomal sulcus and clypeo-pleurostomal lines slightly marked. Malar space 0.4 times height of compound eye, with a distinctive malar sulcus. Toruli situated slightly above mid-height of compound eye; distance between antennal rim and compound eye one times width of antennal socket including rim. Ocellar plate not raised. Head, posterior view without occipital carina. Mouthparts (Fig. 3B): mandibles strong, exposed; with dense setae at base.

Antenna (Fig. 3C–E) of moderate length, as long as 1/2 body length, with 13 antennomeres; flagellum not broadening towards apex; with short erect setae, and elongate placodeal sensilla visible (Fig. 3C). Relative lengths of antennal segments: 16:15:20:25:21:21:19:18:17:17:16:15:29. Pedicel, 0.9 as long as scape, 1.4 as long as wide;. F1 0.8 times as long as F2 (Fig. 3D). F4–F11 longer than wide, F11 2.9 times longer than wide, 2.1 times as long as F10 (Fig. 3E). Placodeal sensillae on F3–F11 disposed in one row of 5 sensillae in half dorsal area of each flagellomere.

Mesosoma. Coriaceous, in lateral view 1.25 times as long as high, slightly convex dorsally (Fig. 4A). Pronotum, scarcely pubescent; lateral surface of pronotum coriaceous with longitudinal wrinkles dorsally (Fig. 4A). Pronotum short medially, ratio of length of pronotum medially/laterally = 0.4. Pronotal plate indistinct dorsally (Fig. 3F).

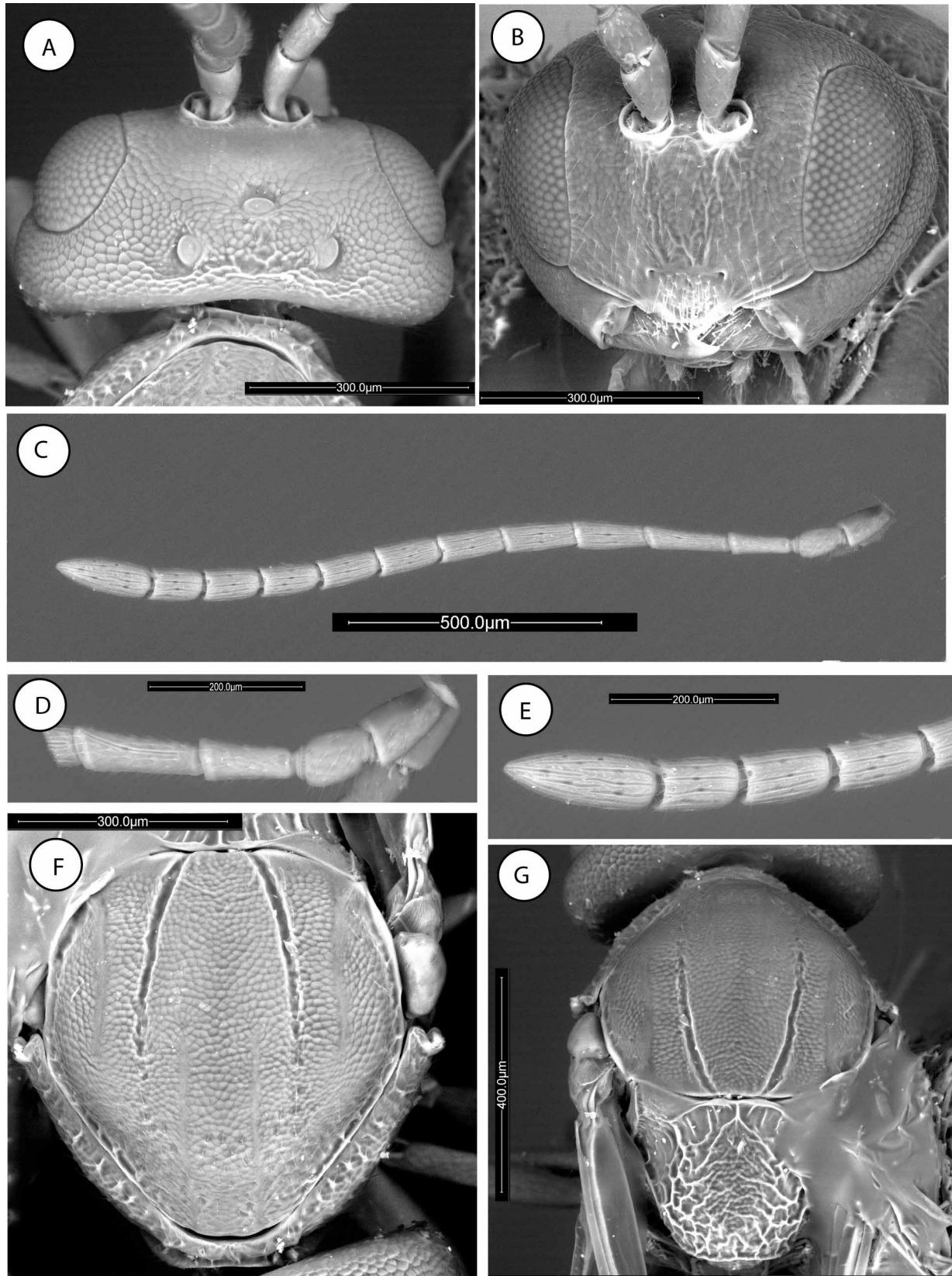


FIGURE 3. *Loxaulus panamensis*: (A) Head dorsal view. (B) Head anterior view. (C) Female antenna. (D) Detail of basal flagellomeres. (E) Detail of ultimate flagellomeres. (F) Pronotum antero-dorsal view. (G) Mesosoma dorsal view.

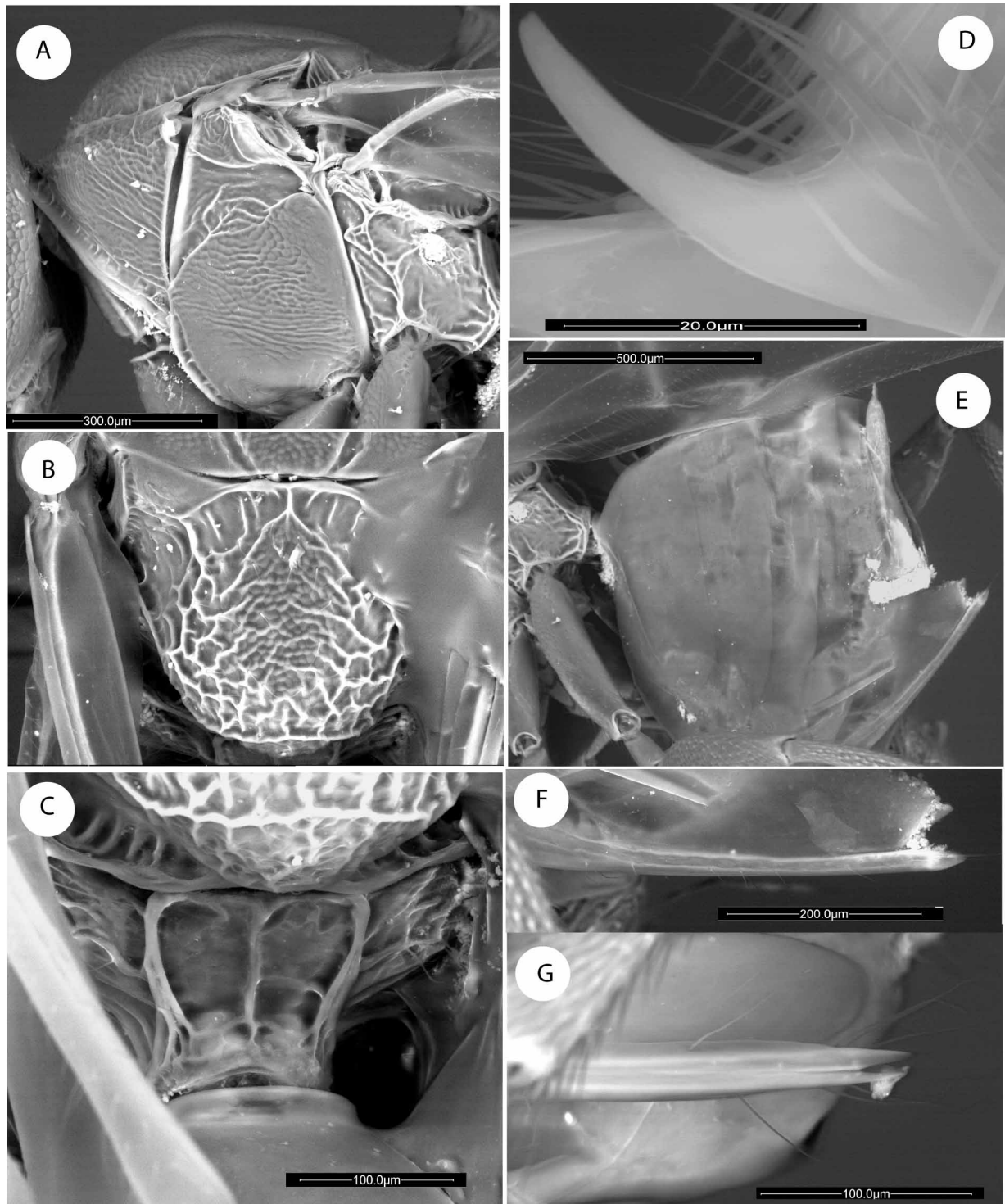


FIGURE 4. *Loxaulus panamensis*: (A) Mesosoma lateral view. (B) Scutellum. (C) Propodeum. (D) Metatarsal claw. (E) Mesosoma lateral view. (F) Detail of ventral spine of hypopygium, lateral view. (G) Detail of ventral spine of hypopygium.

Mesonotum (Fig. 3G). Mesoscutum coriaceous and barely pubescent, slightly longer than broad in dorsal view. Notauli nearly percurrent, only slightly faint in anterior one third of mesoscutum, slightly convergent posteriorly, at meeting of transscutal fissure; median mesoscutal impression absent. Anteroadmedian signa faint, not clearly marked, parapsidal signa clearly visible. Transscutal fissure narrow, well-visible, deeply impressed, slightly sinuate. Scutellum, scutellar foveae (Fig. 4B), axillula and mesopleuron (Fig. 4A) as in *L. championi*.

Metanotum (Fig. 4C). Metapectal-propodeal complex. Metapleural sulcus reaching posterior margin of mesoplectus at about two thirds height (Fig. 4A). Lateral propodeal carinae subparallel, slightly convergent and not

branched posteriorly, median longitudinal carinae present and complete, median propodeal area smooth (Fig. 4C), lateral propodeal area with reticulate carinae and almost bare.

Legs. metatarsal claws simple, without a strong triangular basal lobe or teeth (Fig. 4D).

Forewing (Fig. 5F) slightly longer than body, radial cell 3.8 times longer than wide; open along anterior margin; areolet small, triangular, closed and distinct. M nearly straight, not reaching wing margin. Rs slightly bowed. Rs+M not reaching basalis. Rs and M unpigmented. Apical margin of wing with hair fringe.

Metasoma (Fig. 4E) as in *L. championi*. Projecting part of hypopygial spine about 2.9 times as long as wide in lateral view (Fig. 4F), with some sparse long setae not reaching apex spine (Fig. 4G).

Gall (Fig. 5G). Cryptic, polythalamous in twigs. There is a only a slight stem hypertrophy and the galls are barely detected before adults emergence. The gall consist of small ellipsoidal larval cells inside of twigs.

Distribution. *Loxaulus panamensis* was found to 3079 m a.s.l. at Volcan Baru, Chiriqui, Panama.

Biology. Only the asexual generation is known, inducing galls on *Quercus bumelioides* Liebm. (section *Quercus*). The galls are found between May and July during the rain season in Panama.

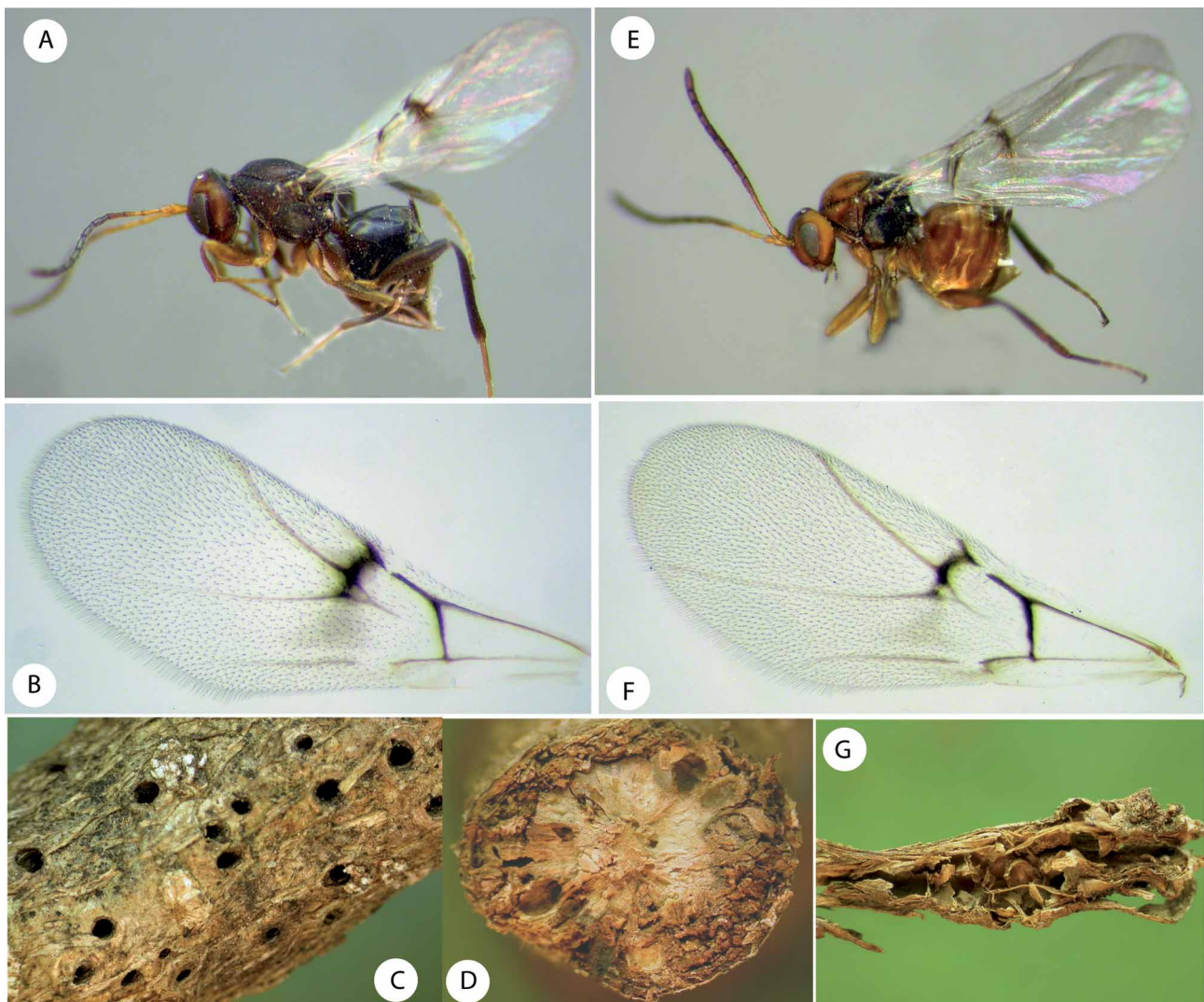


FIGURE 5. Habitus, forewings and galls of *Loxaulus* species: (A) *Loxaulus championi*, female (B) forewing of female. (C) mature galls of *Loxaulus championi*. (D) Section of a gall of *Loxaulus championi* showing the cells. (E) *Loxaulus panamensis*, female. (F) forewing of female. (G) mature galls of *Loxaulus panamensis* showing the cells.

Key for the identification of *Loxaulus* of Panama

1. Female antennae with first flagellomere as long as second (Fig. 1F). Notauli incomplete, distinct only in posterior one third of mesoscutum (Fig. 2A). Base of radial cell of fore wing and area below areolet clearly infuscated. Median propodeal area with rugose sculpture. Body mostly dark reddish-brown *L. championi*
- Female antenna with first flagellomere clearly shorter than second. (Fig. 3D). Notauli nearly percurrent, clearly impressed at least in posterior two thirds of mesoscutum (Fig. 3G). Base of radial cell of fore wing and area below areolet only weakly infuscated. Median propodeal area smooth (Fig. 4C). Body mostly yellowish brown *L. panamensis*

Final comments

Recent phylogenetic analyses show a deep evolutionary split between gallers on different oak sections (Stone *et al.* 2009; Melika *et al.* 2010). The genus *Loxaulus* closely resembles in its morphology the plesiomorphic traits of Palaearctic *Plagiotrochus* and the entire Nearctic *Bassettia* genus, especially what concern the massive head, dorso-laterally compressed mesosoma, usually transversely rugose mesoscutum, the structure of the central propodeal area and the structure and location of the galls they induce. All the species of *Plagiotrochus* are known to associate with the Cerris section of *Quercus* (*Q. cerris* L., *Q. brantii* Lindl., *Q. semicarpifoliae* Sm.) and the *Ilex* subgroup of evergreen oaks within the Cerris section in the Mediterranean region of Europe and together with the Palaearctic cerris-galling species of *Aphelonyx*, *Dryocosmus*, and *Pseudoneuroterus* genera forming the earlier named “Neuroterus” group (Liljeblad *et al.* 2008). *Loxaulus* [with *L. quercusmammula* (Bassett), involved in the analysis] was found outside of the above-mentioned group, with the European *Callirhytis* Förster (Liljeblad *et al.* 2008). The last one appeared to be nesting on the non-cerris host association side of the deep evolutionary split (Stone *et al.* 2009). The genus *Bassettia*, all species of which are known to induce stem swelling-like galls in twigs of white oaks only, might be a sister group to *Loxaulus*, at least to those species which are known to induce stem galls in white oaks across the USA (Liljeblad *et al.* 2008).

Based on the adult, gall morphology and host associations with section *Quercus* (white oaks) of *Quercus*, the two herein described species of *Loxaulus* from Panama, *L. championi* and *L. panamensis*, belong to the “core” species group of the genus, other words closely related to the type species *L. quercusmammula* and *Loxaulus* species associated with section *Quercus*. Adult morphology, the type and the location of galls, with host associations of currently known 16 *Loxaulus* species suggest that it might be a polyphyletic group. Twelve species out of 16, induce galls on white oaks, while one species, *L. beutenmuelleri* Weld, known to induce leaf galls on red oaks, *Q. rubra* L. and other 3 species, *L. boharti* Dailey & Sprenger, *L. brunneus* (Ashmead), and *L. trizonalis* Weld [all known exclusively from California (USA)] associate with golden cup oaks only. Thus, the genus *Loxaulus* and its limits must be carefully revised. Whether *Loxaulus* is a mono- or polyphyletic group [which is more probable], a further detail revision will show.

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