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Five New Species of *Leioproctus (Protomorpha)* Rayment (Hymenoptera: Colletidae)

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Abstract. Five new species of *Leioproctus (Protomorpha)* Rayment from western Queensland are described: *Leioproctus crispus* n.sp., *L. gibber* n.sp., *L. gurneyi* n.sp., *L. latifrons* n.sp. and *L. nix* n.sp. Females of all the new species, except *L. nix*, have specialized setae on the clypeus, frons or vertex of the head. A revised key to species is provided.

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Keywords: Anthophila, Colletidae, *Leioproctus*, *Protomorpha*, systematics, facial setae, Simpson Desert, nototribic flowers.

In the most recent revision of the subgenus *Leioproctus (Protomorpha*) (Maynard, 1991), nine species were recognized, but only five were named. The remaining four were known from females only. In a recent study of plant-pollinator networks in the arid-zone grassland of the north-eastern Simpson Desert (Popic *et al*., 2013), seven *L. (Protomorpha)* species were found, five of them undescribed. Four of the new species are the first in the subgenus to have specialized hairs on the head, a feature that has been suggested as indicative of particular pollen collecting behaviour (Müller, 1996; Thorp, 2000; Gonzalez & Chavez, 2004; Rightmyer *et al.*, 2011; Alqarni *et al.*, 2012).

Terminology, methods and measurements

The morphological terminology follows that used by Michener (Michener & Fraser, 1978; Michener, 2007) including use of the word hair and description of legs in their normal positions. Relative dimensions quoted in the descriptions were measured using an eye-piece graticule on a stereomicroscope with the zoom objective set to give a reading of 50 divisions for the head width. Abbreviations used for the measurements are those used by Houston (1990) and are as follows: *AOD,* antennocular distance; *ASD,* antennal socket diameter; *FL,* flagellum length; *HL,* head length; *HVO,* height of vertex above lateral ocelli; *HW,* head width; *IAD,* interantennal distance; *LID,* lower interorbital distance; *OOD,* ocellocular distance; *SL,* scape length; *SW,* scape width; *UFW,* upper width of face; *UID,* upper interorbital distance; *WOC,* width of ocellar cluster. Metasomal terga are referred to as *T1, T2* etc. and sterna as *S1, S2* etc. The "hidden sterna" of males, *S7* and *S8*, exhibit useful diagnostic characteristics and were extracted for examination. Geospatial coordinates are GPS readings. The following abbreviations are used for collections in which the specimens are lodged: *AM,* Australian Museum, Sydney; *ANIC*, Australian National Insect Collection, Canberra.

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Female specimens of the undescribed species A to D (Maynard, 1991) were compared by Dr Terry Houston of the Western Australian Museum with photographs of the new species. Pollen from bees and flowers was stained with Calberla's fluid and examined with a compound microscope. Descriptions are arranged alphabetically. Authorship of newly described species is in accordance with Article 50.1 and Recommendation 50A of International Code of Zoological Nomenclature. MB is designated as the author of the new names.

Some morphological features of diagnostic importance

Labrum. The labrum of four new species has an elongated apical area so that the labrum is divided horizontally by a strong carina (Fig. 1). The apical part is strongly concave while the basal part is either concave, medially depressed or, rarely, smoothly convex. The labrum of the fifth species has a very short apical area and appears smoothly convex.

Male hind tibia. Males of all the newly described species, and most of those previously described (Maynard, 1991), have a modified hind tibia, with the apical half compressed on the anterior side (Fig. 2). The narrow ridge thus formed bears six to eight stiff setae that are frequently hooked. The maximum width of the hind tibia relative to the tibial length is a useful external character for separating species.

Male hind tibial spurs. All males have two hind tibial spurs with minutely ciliate or finely pectinate margins. The outer spur is shorter than the inner, but difference in length varies between species. The shape of the inner spur varies from almost straight to flattened and strongly recurved (Fig. 3).

Male sterna. Males of the newly described species have apical fringes of hair on S3 and S4 and a raised longitudinal ridge basally on S6 (Fig. 4). The only noticeable variation between the species was in the density of the apical hair tuft on S6.

Systematics

Key to species of *Leioproctus (Protomorpha)* (modified from Maynard, 1991)

1	Male (hind tibia without scopa)	2
——	Female (hind tibia with scopa)	10
2(1)	Hind coxa covered with long, dense hair	3
——	Hind coxa lacking long, dense hair	4
3(2)	Anterior margin of hind basitarsus strongly curved; frons obscured by dense, white hair	*L. tarsalis* (Rayment)
——	Anterior margin of hind basitarsus almost straight; frons not obscured by hair	*L. plautus* Maynard
4(2)	Hind tibia with row of stout setae on anterior margin	5
——	Hind tibia unmodified	*L. minutus* (Cockerell)
5(4)	Hind basitarsus with narrow basal projection	*L. alloeopus* Maynard
——	Hind basitarsus without basal projection	6
6(5)	Anterior margin of hind basitarsus with large apical projection	*L. crispus* n.sp.
——	Hind basitarsus with at most a slight apical extension	7
7(6)	Hind tibial spurs flattened and strongly recurved	8
——	Hind tibial spurs not flattened, almost straight	9
8(7)	Hind femur with broad projection on outer face; outer hind tibial spur *ca* 0.3× as long as inner spur; lower gena concave	*L. nix* n.sp.
——	Hind femur without projection; outer hind tibial spur *ca* 0.7× as long as inner spur; lower gena convex	*L. latifrons* n.sp.
9(7)	Hind tibial setae weak; mandible with preapical tooth	*L. gurneyi* n.sp.
——	Hind tibial setae stout; mandible simple	*L. gibber* n.sp.
10(1)	Inner hind tibial spur strongly curved	11
——	Inner hind tibial spur almost straight	12

11(10) Apical margins of T1–4 transparent ..... *L. alloeopus* Maynard
—— Apical margins of T1–4 opaque ..... *Leioproctus* sp. A*

12(10) Frons entirely covered by dense, white, branched hair 13
—— Frons medially without dense, branched hair 14

13(12) Facial fovea obscured by hair, inner margins ill-defined ..... *L. tarsalis* (Rayment)
—— Facial fovea not obscured by hair, inner margins sharply defined ..... *Leioproctus* sp. B*

14(12) Frons and clypeus with long, weakly-branched, curly hair (Fig. 5) ..... *L. crispus* n.sp.
—— Frons and clypeus without curly hair 15

15(14) Frons and/or vertex with stiff, pale orange setae 16
—— Frons and vertex without stiff, pale orange setae 18

16(15) Vertex strongly protuberant medially ..... *L. gibber* n.sp.
—— Vertex not protuberant medially 17

17(16) Vertex with single row of stiff setae; clypeus convex ..... *L. gurneyi* n.sp.
—— Frons laterally and vertex with many stiff setae; clypeus flat ..... *L. latifrons* n.sp.

18(15) Facial fovea medially narrower than base of scape 19
—— Facial fovea medially as wide as, or wider than, base of scape 20

19(18) Hair of medial clypeus branched ..... *L. minutus* (Cockerell)
—— Hair of medial clypeus simple ..... *Leioproctus* sp. C*

20(18) Pygidial plate not striate; body length *ca* 9 mm ..... *L. fallax* (Cockerell)
—— Pygidial plate striate 21

21(20) Paraocular area with dense, white plumose hair; body length *ca* 7 mm ..... *L. nix* n.sp.
—— Paraocular area with sparse hair; body length *ca* 5 mm ..... *Leioproctus* sp. D*

* Species reported, but not named, by Maynard (1991).

Descriptions of new species

Leioproctus (Protomorpha) crispus Batley n.sp.

Type specimens. Holotype ♂ 24 km SW Charleville, Queensland (26.532°S 146.036°E), 28 Aug 2009, M. Batley, *ex Eremophila gilesii*, in AM (K273317).

Paratypes (10, all deposited in AM): **Queensland**: ♀ 8 km E Charleville (26.415°S 146.306°E), 27 Aug 2009, M. Batley, *ex Petalostylis labicheoides* (K273301); ♂, 68 km S Charleville (26.988°S 146.032°E), 29 Aug 2009, M. Batley, *ex Stemodia glabella* (K273393); 2♂♂, 6♀♀ Kunnamuka Swamp (23.353°S 138.261°E), 25–28 Apr 2010, T. Popic, *ex* pan trap (K362301–8).

Diagnosis

Males with flagellum longer than head width, hind basitarsus with large apical projection and hind tibia with weak setae. Female frons and clypeus closely covered with erect, weakly-branched, curly hair. The labrum of both sexes smoothly convex.

Descriptions

Male.—*Head* width 2.1 mm, body length 6.8 mm. Relative dimensions: HW 50, HL 46, UID 39, UFW 36, LID 30, HVO 3, WOC 21, OOD 10, IAD 8, ASD 5, AOD 7, SL 18, SW 5, FL 71.—*Inner* orbits strongly convergent ventrally; clypeus transversely convex, longitudinally almost flat; labrum smoothly convex; flagellum longer than head width; metanotum with weak nodule; propodeal triangle subhorizontal basally, rounding smoothly onto vertical half. Hind tibia slender, maximum width 0.22× length, bearing 7 stiff setae, weaker than those of other species and inclined apically; hind tibial spurs large, weakly recurved, outer 0.83× as long as inner; hind basitarsus flat, narrow, width 0.25× length, with large distal projection on anterior margin (Fig. 11). Metasomal T2 with postgradular area weakly depressed; S6 with polished medial ridge; S7,8 and genitalia as in Figs. 21–23.—*Integument* black except flagellum brown becoming orange-brown towards apex,

mandible orange-brown with dark red tip, anterior faces of fore and mid tibia and inner faces fore and mid tarsi yellow-brown, tarsi with outer faces brown, metasomal terga with posterior margins translucent brown, sterna dark brown.—*Clypeus* densely punctate, supraclypeal area impunctate, polished; frons with strong, dense, medium punctures, fovea not impressed; scutum, scutellum and mesepisternum strongly and densely punctate, polished; metanotum with fine contiguous punctures; propodeal triangle coarsely rugose basally, propodeum laterally with large, contiguous punctures; metasomal terga strongly punctate except wide apical margins.—*Face* below mid frons densely covered with adpressed, silver-white pubescence; vertex with close, pale brown, erect, plumose hair; gena with similar white hair; scutal hair long, open, white and finely plumose; scutellum and metanotum with long, sparse, pale brown, finely plumose hair, denser around margins; metasomal T1 with long, open, white hair on basal half, T1,2 with white hair apicolaterally, T2–4 with broad basal bands of close white hair; S3,4 with long apical fringes, slightly shorter medially, S6 with weak fringe around apex but no apical tuft.

Female.—*Head* width 2.3 mm, body length 7.5 mm. Relative measurements: HW 50, HL 46, UID 38, UFW 40, LID 33, HVO 2, WOC 19, OOD 10, IAD 9, ASD 4, AOD 9, SL 16, SW 4, FL 27.—*Inner* orbits convergent ventrally; clypeus transversely convex, base protruding in front of eye viewed laterally; labrum uniformly convex, smooth and polished (Fig. 5); mandible narrow with weak, rounded outer ridge; flagellum 0.54× as long as head width; metanotum with weak nodule; propodeum subhorizontal basally, rounding smoothly onto vertical half. Hind basitibial plate carinate, apically rounded; inner hind tibial spur with *ca* 5 well-spaced teeth; pygidial plate emarginate.—*Integument* black except flagellum brown, mandible amber with dark red tip, tibiae and tarsi with interior faces brown, metasomal terga with posterior margins translucent brown.—*Clypeus* polished, densely punctured except apically and along medial line; supraclypeal area impunctate, polished; frons with smaller contiguous punctures; fovea weakly impressed with indistinct margins, impunctate and dull, reaching lateral ocellus, as wide as basal width scape; scutum and scutellum densely punctate; metanotum with fine contiguous punctures; propodeal triangle coarsely rugose basally, propodeum laterally with dense, round punctures; metasomal terga polished, densely punctate except on broad posterior margins; sterna with punctures sparse basally becoming dense apically; pygidial plate not striate, but with fine, whorled lineolation like a fingerprint.—*Face* with small area of dense, plumose, white pubescence between antennal socket and eye margin; frons and clypeus closely covered with weakly-branched, erect, fine, curly hair (Fig. 5); vertex sparsely covered with weakly-branched, straight hair; scutum and scutellum closely to densely covered with very short, tightly-branched brown hair, becoming paler and longer around margins; mesepisternum closely covered with long, white, plumose hair; hind tibial scopa white; hind basitarsus with fringe of long white plumose hair on posterior margin; metasomal T1 with dense white hair apicolaterally, T2–4 with close white hair bands basally (usually obscured by preceding tergum) and broad, dense, white, apical hair bands, interrupted medially on T2; prepygidial fimbria brown; S5 with dense, pale brown apical fringe.

Remarks. The sexes were associated by the shape of the labrum. A male and 3 females were taken in a single pan trap left in place for six hours, and specimens from the Charleville area were collected within days and a few kilometres of each other.

Etymology. The specific name is a Latin adjective meaning curly, referring to the facial hair of the female.

Leioproctus (Protomorpha) gibber Batley n.sp.

Type specimens. Holotype ♂ Ethabuka Station, Queensland (23.756°S 138.474°E), 21 Apr 2012, M. Batley, *ex Scaevola parvibarbata*, in AM (K362309).

Paratypes (9, all deposited in AM): **Queensland**: ♂, 3♀♀ Ethabuka Station (23.748°S 138.474°E and 23.758°S 138.483°E), 14 Apr 2012, M. Batley, *ex Scaevola depauperata* (K362310, K362311, K362354, K362355); ♀ Field River (23.922°S 138.119°E), 18 Apr 2012, M. Batley, *ex Scaevola depauperata* (K362312); ♀, Ethabuka Station (23.738°S 138.467°E), 21 Apr 2012, M. Batley, *ex Scaevola depauperata* (K362356); 2♀♀ Field River (23.804°S 138.055°E), 22 Apr 2010, T. Popic, *ex Scaevola parvibarbata* (K362313–4); ♀ Kunnamuka Swamp (23.355°S 138.230°E), 23 Nov 2010, T. Popic, *ex Scaevola parvibarbata* (K362315).

Diagnosis

Female with large protuberance on vertex and stiff, pale orange setae across frons (Fig. 6). Male with slight projection on vertex, hind tibia with two large, almost straight spurs. Both sexes have mandibles with a prominent outer ridge and no preapical tooth.

Descriptions

Male.—*Head* width 1.9 mm, body length 5.7 mm. Relative measurements: HW 50, HL 44, UID 34, UFW 30, LID 23, HVO 0.7, WOC 19, OOD 9, IAD 8, AOD 6, SL 14, SW 4, FL 34. *Vertex* of head weakly elevated medially; inner orbits strongly convergent ventrally; clypeus almost flat basally, gently convex on apical quarter; antennal sockets level with front of eye viewed laterally; mandible simple with prominent outer ridge; labrum basally, convex with medial depression, apically concave; flagellum 0.68× as long as head width; metanotum with weak nodule; propodeal triangle subhorizontal basally, separated abruptly from vertical half but not carinate. Hind femur almost flat ventrally; hind tibia moderately broad, maximum width 0.27× length, bearing 8 stiff, apically bent setae, the most distal being particularly large and flattened (Fig. 12); hind tibial spurs large, almost straight, inner distinctly pectinate, outer 0.75× as long as inner; hind basitarsus dished, width 0.40× length, with small apical extension of anterior margin. Metasomal T2 with postgradular area weakly depressed; S6 with polished medial ridge; S7,8 and genitalia as in Figs. 24–26.—*Integument* black except flagellum brown, mandibles orange-brown with dark red tips, anterior face fore tibia and fore tarsus yellow-brown, mid and hind tarsi dark brown, metasomal terga dark brown or black with posterior margins translucent brown, sterna dark

brown or black.—*Clypeus* densely punctate, supraclypeal area medially impunctate and polished; frons with strong, dense, medium punctures, fovea obscured by tomentum; scutum and scutellum polished and closely punctate; mesepisternum densely punctate; metanotum with fine contiguous punctures; propodeal triangle coarsely rugose basally, laterally propodeum densely punctate; metasomal terga densely punctate except for wide impunctate apical margins.—*Face* densely covered with adpressed, silver-white pubescence; vertex with close, erect, white setae between ocelli, weakly branched laterally; gena with open, white, plumose hair; scutum and scutellum openly covered with white, finely plumose hair, longer around margin of scutellum; metanotum with similar long hair medially; metasomal T1 with open, long, white hair on basal half, T1,2 with white hair apicolaterally (possible basal hair bands hidden), hair sparse elsewhere; S3,4 with long apical fringes, S6 with dense apical tuft.

Female—*Head* width 2.3 mm, body length 7.2 mm. Relative measurements: HW 50, HL 43, UID 36, UFW 34, LID 26, HVO 4, WOC 17, OOD 10, IAD 8, AOD 8, SL 16, SW 3, FL 23. *Vertex* of head with large medial protuberance (Fig. 6), inner orbits convergent ventrally; clypeus flat except at extreme ventrolateral corners, apical margin straight with minute medial projection; mandible with prominent outer ridge and no preapical tooth; labrum strongly carinate, basally and apically concave; flagellum less than ½ as long as head width; metanotum and propodeum as for male. Hind basitibial plate carinate, apex bluntly acute; inner hind tibial spur gently curved with *ca* 10 strong teeth; pygidial plate emarginate.—*Integument* black except labrum and flagellum brown, mandibles amber with dark red tips, metasomal terga with posterior margins translucent brown; sterna dark brown.—*Clypeus* dull, densely punctate, except ventrolateral corner impunctate and polished; interantennal area with small impunctate region; frons and vertex densely punctate; fovea slightly narrower than base of scape not reaching lateral ocellus; scutum and scutellum densely punctate; metanotum with fine contiguous punctures; propodeal triangle irregularly rugose basally, propodeum laterally with dense round punctures; metasomal terga polished and densely punctate except on posterior margins; sterna with punctures sparse basally becoming dense apically; pygidial plate coarsely striate.—*Face* with small area of dense, white pubescence in paraocular area to just above antennal sockets; vertex and frons with close, stiff, pale orange setae; clypeus with close, fine simple hair; scutum and scutellum closely covered with short, densely-branched, cream hair, becoming dense around margins; metanotum with slightly longer hair near tubercle; hind tibial scopa white; hind basitarsus with open fringe of long white plumose hair on posterior margin; metasomal T1 with dense white hair apicolaterally, T2–4 with close white hair bands basally and broad, dense white hair bands apically, interrupted medially on T2; prepygidial fimbria white; S5 with dense, white apical fringe.

Remarks. The sexes were associated by the protruding vertex and coincident collection.

Etymology. The specific name is a Latin noun in apposition meaning hump, referring to the vertex of the female.

Leioproctus (Protomorpha) gurneyi Batley n.sp.

Type specimens. Holotype ♂ Ethabuka Station, Queensland (23.753°S 138.493°E), 20 Apr 2012, M. Batley, *ex Lechenaultia divaricata*, in AM (K362316).

Paratypes: 3♀♀ same data as holotype, in AM (K362317–9).

Diagnosis

Both sexes with face convex viewed laterally. Female vertex with a single row of stiff, curved, pale orange setae. Male hind tibia slender with weak setae, and large, almost straight spurs.

Descriptions

Male.—*Head* width 1.9 mm, body length 5.6 mm. Relative measurements: HW 50, HL 41, UID 32, UFW 32, LID 23, HVO 1, WOC 20, OOD 7, IAD 10, AOD 6, SL 13, SW 4, FL 34. *Inner* orbits strongly convergent ventrally; face convex, antennal sockets in front of eye viewed laterally; clypeus transversely convex; basal part of labrum convex with small medial depression, apical part concave, less than half as long as basal part; flagellum 0.68× as long as head width; metanotum with weak tubercle; propodeal triangle subhorizontal basally, vertical apically with a sharp change of slope but no carina. Hind tibia slender (Fig. 13), maximum width 0.22× length, with 6 stiff setae; hind tibial spurs large, almost straight, outer 0.85× as long as inner; hind basitarsus dished, width 0.30× length, with small, spathulate, projection from distal end. Metasomal T2 with postgradular area depressed; S6 with very weak medial ridge; S7,8 and genitalia as in Figs. 27–29.—*Integument* black except flagellum brown, mandibles orange-brown with dark red tips, labrum dark brown basally, orange-brown apically, metasomal terga with posterior margins translucent brown, sterna dark brown, anterior face fore tibia and fore tarsi yellow-brown, mid and hind tarsi brown.—*Clypeus* densely punctate; supraclypeal area dull, punctate; frons with strong, dense, medium punctures, fovea obscured by tomentum; scutum and scutellum polished, closely to openly punctate; mesepisternum densely punctate; metanotum with fine contiguous punctures; propodeal triangle coarsely rugose basally, laterally propodeum densely punctate; metasomal terga densely punctate except for wide impunctate apical margins.—*Face* densely covered with adpressed, silver-white pubescence; vertex with close, erect, plumose, white hair; gena with similar hair; scutum and scutellum openly covered with long, finely plumose, white hair, longer and denser around margins; metasomal T1 with open, long, white hair on basal half, T1,2 with dense, white hair apicolaterally, T3,4 with sparse, white apical hair bands, T2–4 with bands of close white hair basally; S3,4 with long apical fringes; S6 with weak apical hair tuft.

Female—*Head* width 2.3 mm, body length 7.5 mm. Relative measurements: HW 50, HL 42, UID 34, UFW 35, LID 25, HVO 1, WOC 21, OOD 7, IAD 9, AOD 8, SL 14, SW 3, FL 25.—*Inner* orbits convergent ventrally; face convex, antennal sockets in front of eyes viewed laterally; clypeus convex with convex apical margin; labrum strongly carinate, basally convex with a large medial depression, apically concave; mandible narrow with preapical tooth and weak, rounded outer ridge; flagellum ½ as long as head width;

metanotum and propodeum as for male. Hind basitibial plate strongly carinate, apically rounded; inner hind tibial spur gently curved with 5 well-spaced teeth; pygidial plate striolate, apex rounded, entire.—*Integument* black except flagellum brown, mandibles amber with dark red tips, labrum brown basally, apically amber; metasomal terga with posterior margins translucent brown, sterna black or dark brown, anterior face fore tibia yellow-brown.—*Clypeus,* interantennal area, frons and vertex densely punctate; fovea strongly impressed, impunctate, *ca* ⅔ width of scape basally, curving towards but not reaching lateral ocellus; scutum and scutellum densely punctate; metanotum with fine contiguous punctures; propodeal triangle irregularly rugose basally, propodeum laterally densely punctate; metasomal terga polished and densely punctate except on posterior margins; sterna with punctures sparse basally becoming dense apically; pygidial plate striolate.—*Face* with dense, adpressed, white pubescence in paraocular areas almost reaching top of eye; vertex with a row of *ca* 12 pale orange, erect, curved setae (Fig. 7); frons and clypeus openly covered with finer, unbranched setae; scutum and scutellum closely covered with short, densely-branched, erect, white hair, becoming dense around margins; metanotum with slightly longer hair near tubercle; hind tibial scopa white, sparsely branched; hind basitarsus with open fringe of long white plumose hair on posterior margin; metasomal T1,2 with dense white hair apicolaterally, T3,4 with broad, dense white apical hair bands, T2–4 basally with close white hair bands, usually obscured by preceding tergum; prepygidial fimbria pale brown; S5 with dense, white apical fringe.

Remarks. The sexes were associated by coincident collection and the convex face.

Etymology. The species is named after Alex Gurney, creator of the comic strip "Bluey and Curley".

Leioproctus (Protomorpha) latifrons Batley n.sp.

Type specimens. Holotype ♂ Kunnamuka Swamp, Queensland (23.353°S 138.260°E), 22 Nov 2010, T. Popic, *ex Scaevola parvibarbata*, in AM (K362320).

Paratypes (7, all deposited in AM): **Queensland**: ♀, Kunnamuka Swamp (23.353°S 138.260°E), 15 Apr 2012, M. Batley, *ex Scaevola depauperata* (K362321); 5♀♀, Ethabuka Station (23.756°S 138.474°E), 21 Apr 2012, M. Batley, *ex Scaevola depauperata* (K362322–6); ♀ Ethabuka Station (23.740°S 138.466°E), 14 Nov 2010, T. Popic, *ex Scaevola parvibarbata* (K362327).

Other specimens examined. **New South Wales**: ♀, Milparinka, 17 Nov 1949, E. F. Reik, in ANIC. **Northern Territory**: 2♀♀, Plenty River, 245 km ENE Alice Springs, 14 Oct 1978, J. C. Cardale, in ANIC. **Queensland**: ♀, Lawn Hill Gorge, 16–18 May 1995, I. D. Naumann, in ANIC. **Western Australia**: ♀, 13 km N Nerren Nerren HS, 15 Sep 1981, L. Kelsey, in ANIC.

Diagnosis

Female with vertex broadly elevated, bigibbous, bearing stiff orange setae, frons with lateral patches of similar setae, clypeus flat. Male with vertex weakly bigibbous, hind tibia with hooked setae, basitarsus broad (width 0.32× length) with moderately long spurs, inner recurved near base, outer 0.7× as long as inner.

Descriptions

Male—*Head* width 1.9 mm, body length 5.7 mm. Relative measurements: HW 50, HL 42, UID 32, UFW 33, LID 23, HVO 3, WOC 20, OOD 8, IAD 7, AOD 7, SL 15, SW 4, FL 38.—*Inner* orbits strongly convergent; clypeus almost flat, apical ¼ gently convex; labrum strongly carinate, basal part smoothly convex, apical part not visible; flagellum 0.75× as long as head width; propodeal triangle subhorizontal basally, vertical apically with a sharp change of slope but no carina. Hind tibia broad (Fig. 14), maximum width 0.32× length, with 7 stiff, apically hooked setae and two large spurs, inner recurved near base, outer 0.7× as long as inner; hind basitarsus weakly concave, width 0.34× length, with a short apical extension of anterior margin (Fig. 15). Metasomal T2 with postgradular area depressed; S6 with strong medial ridge; S7,8 and genitalia as in Figs. 30–32.—*Integument* black except flagellum dull orange-brown, mandibles orange-brown with dark red tips, labrum orange-brown, metasomal terga with posterior margins translucent brown, sterna dark brown, anterior face fore tibia, distal ends of all tibiae and all tarsi orange-brown, S6 brown.—*Clypeus,* supraclypeal area and frons densely punctate, fovea obscured by tomentum; scutum and scutellum polished, closely punctate; mesepisternum densely punctate; metanotum with weak tubercle; propodeal triangle coarsely rugose basally, laterally propodeum with large, contiguous punctures; metasoma strongly punctate except for wide impunctate apical margins.—*Face* below mid frons densely covered with adpressed, silver-white pubescence; vertex with open, erect, plumose pale brown hair; gena with open, white, plumose hair; scutum and scutellum openly covered with long, white, finely plumose hair; metasomal T1 with open, long, white hair on basal half, T1,2 apicolaterally with weak white hair patches; T2–4 basally with bands of close white hair; S3,4 with long apical fringes; S6 with dense apical hair tuft.

Female—*Head* width 2.2 mm, body length 6.8 mm. Relative measurements: HW 50, HL 40, UID 35, UFW 34, LID 26, HVO 2, WOC 21, OOD 7, IAD 8, AOD 8, SL 15, SW 3, FL 22.—*Inner* orbits convergent ventrally; clypeus flat, except ventrolateral corners strongly convex, apical margin gently sinuous with small medial projection; labrum strongly carinate, basal and apical areas concave; mandibles narrow with no preapical tooth (Fig. 1) and weak, rounded outer ridge; flagellum <½ as long as head width; propodeum as for male. Hind basitibial plate strongly carinate; inner hind tibial spur gently curved with 8 strong teeth; pygidial plate striate with small apical emargination.—*Integument* black, except labrum and marginal area of clypeus amber, flagellum brown, mandibles amber with dark red tips, metasomal terga with posterior margins translucent brown, sterna dark brown, anterior face fore tibia yellow-brown.—*Clypeus* densely punctate except ventrolateral corner impunctate and polished; frons and vertex densely punctate; fovea impressed, impunctate and dull, about as wide as base of scape, almost reaching lateral ocellus; scutum and scutellum densely punctate; metanotum with fine contiguous punctures; propodeal triangle irregularly rugose basally, propodeum

laterally densely punctate; metasomal terga polished and densely punctate except on posterior margins; sterna with punctures sparse basally becoming dense apically, pygidial plate striate.—*Face* with dense, adpressed, white pubescence covering a triangular part of paraocular area from bottom of eye to level of mid frons; vertex and upper frons laterally with stiff orange setae (Figs. 8, 9); clypeus and frons medially with close, fine simple hair; scutum covered with short, densely-branched, erect, white hair, open anteriorly, close medially, dense around margins; scutellum with similar, pale brown hair; hind tibial scopa white, plumose; hind basitarsus with open fringe of long white plumose hair on posterior margin; metasomal T1,2 with dense white hair apicolaterally, T3,4 with broad, dense white apical hair bands, T2–4 basally with close white hair bands; prepygidial fimbria white; S5 with dense, white apical fringe.

Remarks. The sexes were associated on the basis of the biggibous vertex. A male and female were collected within days from the same plant species in neighbouring locations.

Etymology. The specific name is a Latin noun in apposition meaning broad brow.

Leioproctus (Protomorpha) nix Batley n.sp.

Type specimens. Holotype ♂ Field River, Queensland (23.808°S 138.058°E), 19 Nov 2010, T. Popic, *ex* pan trap, in AM (K362330).

Paratypes (23, all deposited in AM): **Queensland**: ♀ Field River (23.804°S 138.055°E), 24 Jun 2010, T. Popic (K362353); ♂, 6♀♀ Ethabuka Station (23.745°S 138.470°E), 12–14 Nov 2010, T. Popic, pan trap and *ex Trachymene glaucifolia* (K362331–7); ♀ Field River (23.808°S 138.058°E), 17 Nov 2010, T. Popic, *ex Dicrastylis costelloi* (K362338); ♀ Field River (23.808°S 138.058°E), 19 Nov 2010, T. Popic, *ex Brunonia australis* (K362339); 13♀♀ Kunnamuka Swamp (23.361°S 138.264°E), 22–24 Nov 2010, T. Popic, *ex Brunonia australis*, *Dicrastylis costelloi, Trachymene glaucifolia* & *Trianthema pilosa* (K362340–52).

Diagnosis

Female with hair on clypeus and frons simple, pygidial plate striolate, fovea *ca* as wide as base of scape, but obscured by pubescence. Male hind femur with broad ventral projection of anterior face, inner hind tibial spur flattened and strongly recurved, outer spur short, 0.3× as long as inner (Fig. 3), lower gena concave.

Descriptions

Male—*Head* width 2 mm, body length 6.9 mm. Relative measurements: HW 50, HL 48, UID 33, UFW 33, LID 24, HVO 4, WOC 19, OOD 8, IAD 8, AOD 7, SL 15, SW 4, FL 41.—*Inner* orbits convergent ventrally; clypeus transversely convex; interantennal area raised; labrum strongly carinate, basal part convex with medial depression, apical part concave; lower gena concave; flagellum 0.8× times as long as head width; metanotum with distinct tubercle; propodeal triangle subhorizontal basally, vertical apically with a sharp change of slope but no carina. Hind femur swollen ventrally on anterior face (Fig. 17); hind tibia moderately broadened, maximum width 0.27× length, with 8 stiff, curved setae and two spurs, inner flattened and strongly recurved, outer only 0.3× as long as inner; hind basitarsus shallowly concave with short apical extension of anterior margin (Fig. 16), width 0.43× length. Metasomal T2,3 with postgradular area depressed; S6 with strong medial ridge; S7,8 and genitalia as in Figs. 33–35.—*Integument* black except flagellum mostly orange-brown, labrum and mandibles orange-brown, metasomal terga with posterior margins translucent brown, sterna dark brown, tarsi dull orange-brown.—*Clypeus* densely punctate; supraclypeal area polished and impunctate on upper half; frons densely punctate, fovea obscured by pubescence; scutum and scutellum polished, closely punctate; metanotum with fine contiguous punctures; propodeal triangle coarsely rugose basally, propodeum laterally with contiguous punctures; metasomal terga closely punctate except for wide impunctate apical margins.—*Face* below mid frons densely covered with adpressed, silver-white pubescence; vertex with open, long, erect, plumose, white hair; gena with open, white, plumose hair; scutum and scutellum openly covered with long, white, finely plumose hair; metasomal T1 with open, long, white hair on basal half, T2–6 basally with broad bands close white hair; S3,4 with long, even fringes; S6 with relatively weak apical tuft.

Female—*Head* width 2.4 mm, body length 7.3 mm. Relative measurements: HW 50, HL 47, UID 33, UFW 34, LID 27, HVO 3, WOC 18, OOD 8, IAD 8, AOD 9, SL 16, SW 3, FL 27.—*Inner* orbits convergent ventrally; clypeus weakly convex; labrum strongly carinate, basally convex with oval medial depression, apically concave; flagellum *ca* ½ as long as head width; mandible narrow, with rounded outer ridge and subapical tooth; propodeum as for male. Hind basitibial plate strongly carinate; inner hind tibial spur gently curved with 9 strong, well-spaced teeth; pygidial plate with irregular striae.—*Integument* black except flagellum dorsally dark brown with 4 apical flagellomeres orange-brown, ventrally orange-brown, labrum and mandibles orange-brown, metasomal T1,2 brown on apical half, all terga with posterior margins translucent brown.—*Clypeus* and frons densely punctate with polished interspaces; fovea impressed, about as wide as base of scape, upper end curving towards lateral ocellus; scutum and scutellum polished, closely punctate; metanotum with fine contiguous punctures; propodeal triangle rugose basally; propodeum laterally polished with close, even punctures; metasomal terga closely punctate except in apical marginal areas; sterna with punctures sparse basally becoming dense apically, pygidial plate striolate.—*Face* with dense white, pubescence in paraocular areas extending almost to top of eye and across lower ¼ of frons (Fig. 10); frons and clypeus with open to sparse simple hair; scutum and scutellum closely covered with short, densely-branched, white hair becoming dense around margins; metasomal T1–4 with dense white apical hair bands, interrupted medially on T1,2; T2,3 with close, white, basal hair bands; prepygidial fimbria pale brown.

Remarks. The sexes were associated by the shape of the clypeus and coincident collection.

Etymology. The specific name is a Latin noun in apposition meaning snow, referring to the colour of the facial hair of the female.

Pollen examination

Pollen was removed from the scopae of four female specimens: two *L. latifrons* collected from *Scaevola parvibarbata* Carolin, one *L. gibber* collected from *Scaevola depauperata* R.Br. and one *L. gurneyi* collected from *Lechenaultia divaricata* F. Muell.. Bees collected from *Scaevola* species carried tricolporate pollen indistinguishable by light microscopy from pollen taken from the flowers. The *L. gurneyi* specimen was carrying pollen tetrads indistinguishable from that taken from flowers and that illustrated in the Australasian Pollen and Spore Atlas (APSA 2013).

Discussion

Comparison of photographs of females of the above species with specimens of the unnamed species A to D (Maynard, 1991) by Dr Terry Houston, indicated that none of the new names applies to species A to D.

All five new species have the major characteristics that distinguish *Protomorpha* from other *Leioproctus*: small size (5–9 mm long); metasomal terga with strong, dense punctures and apical hair bands; females with impressed facial foveae and sparse, weakly branched hair on the metasomal sterna; and males with modified hind tibiae and basitarsi and elaborately shaped seventh sterna. The addition of new species will help any future redefinition of the diagnostic characteristics of the subgenus. Although the carinate labrum and preapical tooth on the mandibles are common features, they are absent in one or more species, just as it was previously demonstrated (Maynard, 1991) that the pygidial plate of the female was occasionally not striate. The newly described males consistently have strong apical hair fringes on S3 and S4, which suggests that this feature may be more common than previous thought.

The presence of several species of *L. (Protomorpha)* in a relatively limited area was unexpected. The specimens were collected from 5 locations in sand dune country with a total area of approximately 3,000 km^2. In addition to the five new species, females of two other species, *L. (P.) alloeopus* and *L. (P.) tarsalis,* were found in the area. Together with the known distributions of previously described species, this suggests that the subgenus is strongly adapted to life in arid environments with highly variable rainfall.

Females of four of the new species described herein have distinctive setae on the vertex or frons, a feature not previously found in the subgenus, but the integument of the head was not modified (Gonzalez & Griswold, 1913). The setae were well separated and quite unlike the fine combs found on oil-collecting bees (Michener, 2007). Specialized facial hairs have been suggested (Müller, 1996) as adaptations for collecting pollen from flowers that deposit pollen on dorsal areas of visitors. The small number of specimens and absence of behavioural observations (Müller, 1996; Gonzalez & Chavez, 2004) prevent the drawing of similar conclusions for our species, but the limited information available is consistent with this explanation for the facial setae. *(1)* Only females carry the modified setae. *(2)* Flowers visited by *L. gibber, L. gurneyi* and *L. latifrons*, the species with stiff facial setae, are members of the Goodeniaceae family which present pollen to the backs of visitors (Figs. 18, 19). Pollen removed from the scopae of all three species was indistinguishable by light microscopy from the pollen of the flowers they were visiting. *(3)* Flowers visited by *L. crispus* do not have specialized pollen presenters (Fig. 20), but are zygomorphic and present pollen where insect visitors would normally have their backs. *(4)* The flowers visited by *L. (Protomorpha)* species without special setae are more varied and less specialized (Table 1). *Leioproctus tarsalis* specimens were collected from *Tribulus terrestris* L. a few meters from where *L. gurneyi* were collected from *Lechenaultia divaricata* F.Muell.

Rainfall in the Lake Eyre Basin, in which these bees were found, is more variable and dry periods last longer than in any other part of the World (McMahon *et al.* 2008). Study of these morphologically similar species of *L. (Protomorpha)* could provide interesting insights into the effect of such "boom-bust" conditions on the evolution of and interactions between species.

Table 1. Flowers visited by *Leioproctus (Protomorpha)* species.

species	females with modified setae	flowers from which bees were collected	
		family	species
Leioproctus alloeopus Maynard	no	Proteaceae	*Grevillea stenobotrya* F.Muell.
		Goodeniaceae	*Scaevola depauperata* R.Br.
		Fabaceae	*Senna pleurocarpa* (F.Muell.) Randell
		Euphorbiaceae	*Euphorbia drummondii* Boiss.
		Zygophyllaceae	*Tribulus terrestris* L.
Leioproctus crispus Batley n.sp.	yes	Scrophulariaceae	*Eremophila gilesii* F.Muell.
		Plantaginaceae	*Stemodia glabella* W.R.Barker
		Fabaceae	*Petalostylis labicheoides* R.Br.
Leioproctus gibber Batley n.sp.	yes	Goodeniaceae	*Scaevola depauperata* R.Br.
		Goodeniaceae	*Scaevola parvibarbata* Carolin
Leioproctus gurneyi Batley n.sp.	yes	Goodeniaceae	*Lechenaultia divaricata* F.Muell.
Leioproctus latifrons Batley n.sp.	yes	Goodeniaceae	*Scaevola depauperata* R.Br.
Leioproctus nix Batley n.sp.	no	Araliaceae	*Trachymene glaucifolia* (F.Muell.) Benth.
		Lamiaceae	*Dicrastylis costelloi* F.M.Bailey
		Goodeniaceae	*Brunonia australis* Sm. ex R.Br.
Leioproctus tarsalis (Rayment)	no	Zygophyllaceae	*Tribulus terrestris* L.

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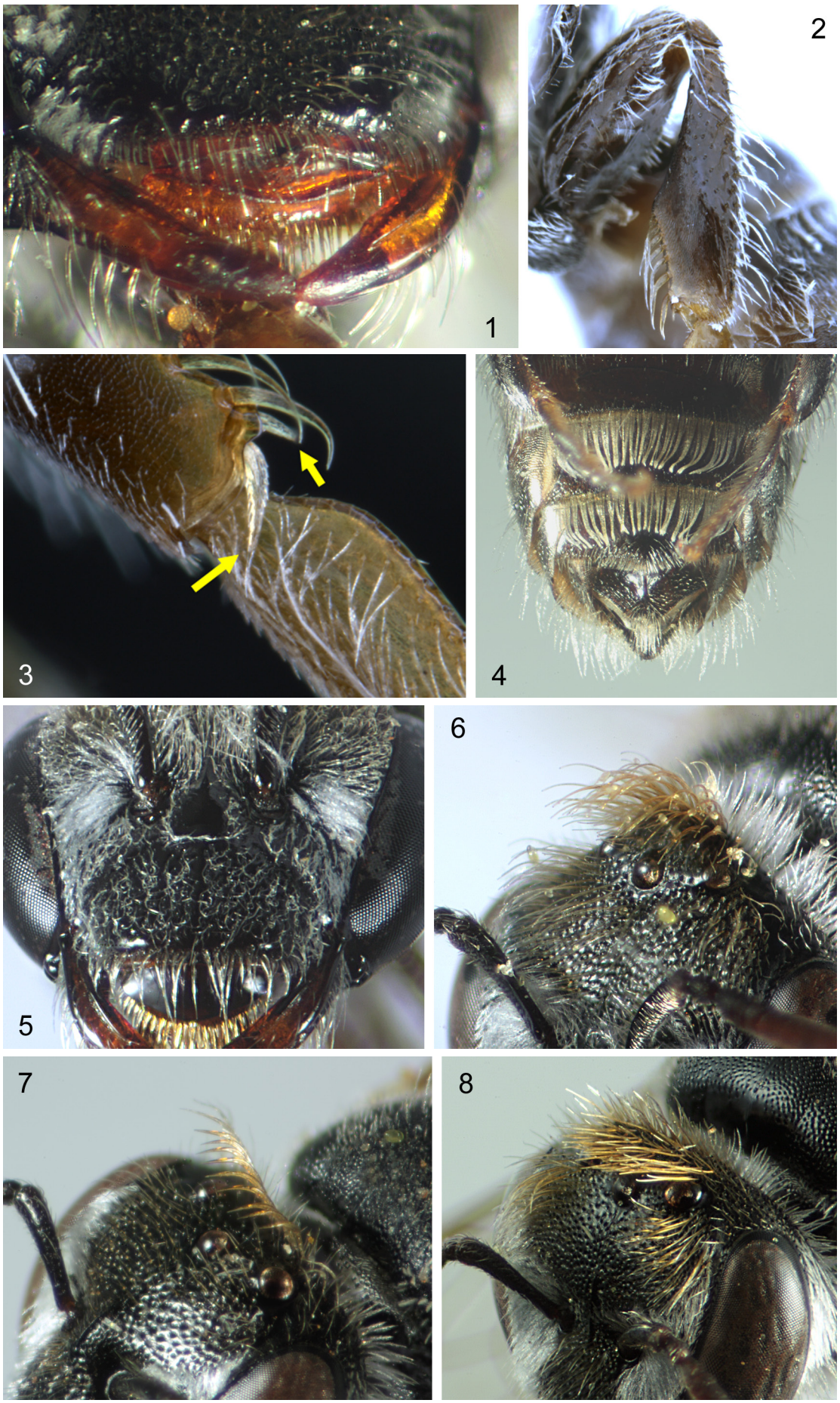
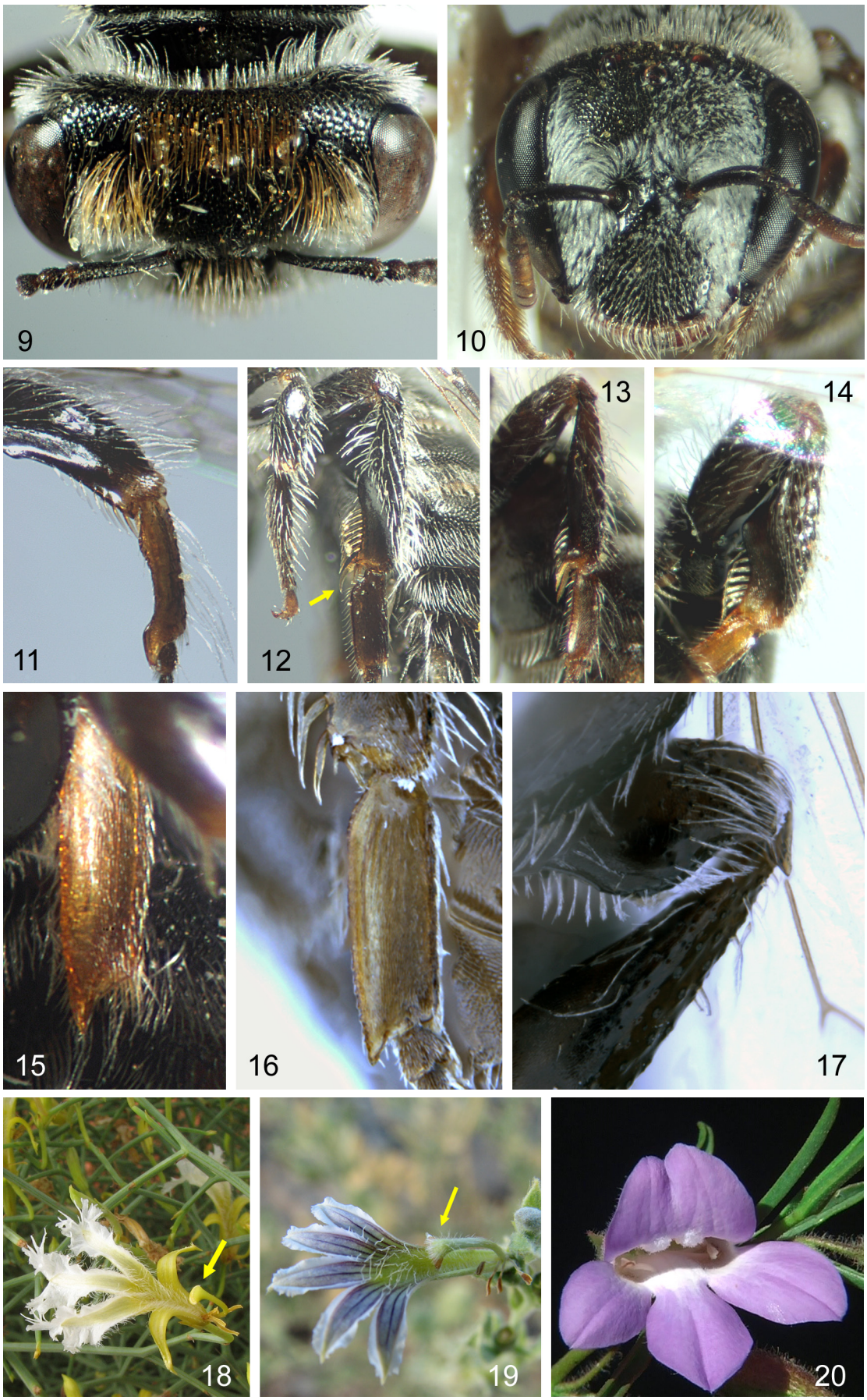
Figures 1–10. *(1) Leioproctus latifrons* n.sp., female, lower head showing labrum. *(2, 3) Leioproctus nix* n.sp., male: *(2)* part of hind leg showing tibia; *(3)* apex of inner face of hind tibia showing the spurs. *(4) Leioproctus gibber* n.sp., male, ventral view of metasoma showing shape and hair pattern of S3–S6. *(5–10)* Female heads: *(5) Leioproctus crispus* n.sp. front view showing labrum and clypeal hair; *(6) Leioproctus gibber* n.sp. vertex; *(7) Leioproctus gurneyi* n.sp. vertex; *(8) Leioproctus latifrons* n.sp. vertex, oblique view; *(9) Leioproctus latifrons* n.sp. vertex, dorsal view; *(10) Leioproctus nix* n.sp. front view.

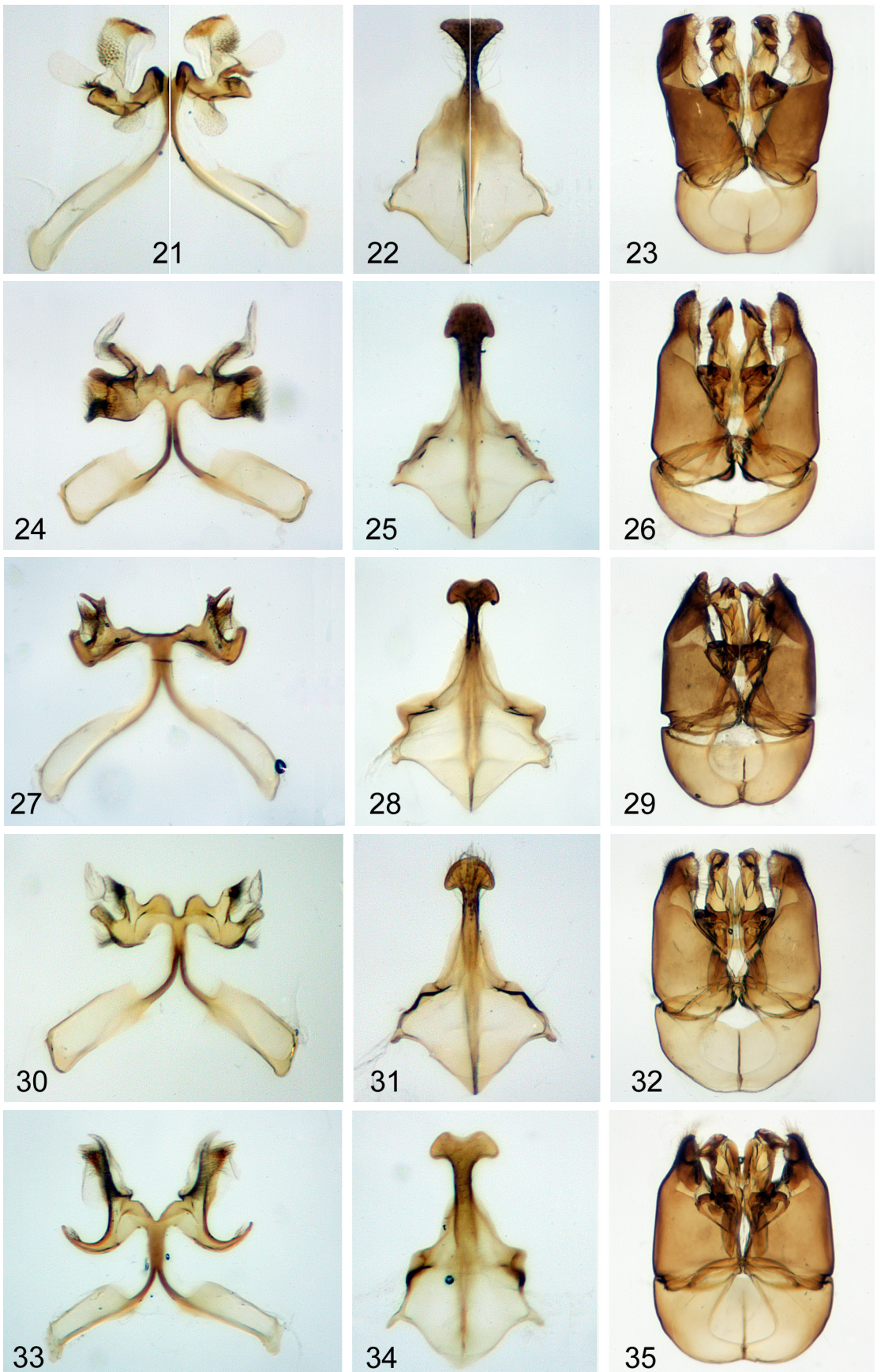
Figures 11–20. *(11–17)* Male hind legs: *(11) Leioproctus crispus* n.sp. tibia and basitarsus; *(12) Leioproctus gibber* n.sp. tibia and basitarsus, distal seta arrowed; *(13) Leioproctus gurneyi* n.sp. tibia and basitarsus; *(14) Leioproctus latifrons* n.sp. tibia; *(15) Leioproctus latifrons* n.sp. basitarsus; *(16) Leioproctus nix* n.sp. basitarsus outer view; *(17) Leioproctus nix* n.sp. femur anterior view. *(18–20)* Flowers of: *(18) Lechenaultia divaricata* F.Muell.; *(19) Scaevola parvibarbata* Carolin; *(20) Eremophila gilesii* F.Muell. Arrows in Fig. 18 and Fig. 19 indicate the pollen presenter.



Figures 1–8. See p. 47 for caption.



Figures 9–20. See p. 47 for caption.



Figures 21–35. Male hidden sterna and genital capsule. *Leioproctus crispus* n.sp.: *(21)* S7, ventral view on left; *(22)* S8, ventral view on left; *(23)* genital capsule, ventral view. *L. gibber* n.sp.: *(24)* S7, ventral view; *(25)* S8, ventral view; *(26)* genital capsule, ventral view. *L. gurneyi* n.sp.: *(27)* S7, ventral view; *(28)* S8, ventral view; *(29)* genital capsule, ventral view. *L. latifrons* n.sp.: *(30)* S7, ventral view; *(31)* S8, ventral view; *(32)* genital capsule, ventral view. *L. nix* n.sp.: *(33)* S7, ventral view; *(34)* S8, ventral view; *(35)* genital capsule, ventral view.