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Four new species of Isepeolini (Hymenoptera; Apidae) from northern Chile

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Abstract

Background: Cleptoparasitic bees are less commonly collected than their hosts and often more difficult to identify and additional descriptions and treatment of diagnostic characteristics are needed.

Results: Four new species of Isepeolini are described from northern Chile: *Isepeolus mankalunthata* Packer & Graham, new species; *Melectoides licancabur* Packer & Graham, new species, *M. desiccata* Packer & Graham new species and *M. glaucodontus* Packer & Graham new species. Putative host information is provided where possible, comments on the habitats of these bees are made and additional records of the tribe from Chile are listed.

Conclusion: Using traps left out for weeks to months in areas where bees are sparse is proving a useful technique to catch rare and undescribed species.

Keywords: Cleptoparasite, *Colletes*, Phylogeny, Host associations, Identification

Background

Cleptoparasitic (cuckoo) bees are of interest because of their taxonomic complexity (e.g. [1]) and frequent rarity and potential to assess the quality of the environment [2]. There has also been some controversy over the number of independent origins of cleptoparasitism within the Apidae, the largest bee family (contrast Cardinal et al., [3] who suggested only four with Rozen [4] who suggested 11). The Isepeolini is one of the tribes reclassified from the Apinae to the Nomadinae based upon molecular data [3].

The purpose of this paper is to describe new species of Isepeolini from northern Chile; there have been no new descriptions of taxa in the tribe since Roig Alsina's revision [5]. We also provide additional records of the tribe from Chile. Roig Alsina [5] discussed the early history of the tribe and its two genera *Isepeolus* Cockerell 1907 [6] and *Melectoides* Taschenberg 1883 [7].

Isepeolini are readily identifiable in the female from inspection of the metasomal apex in which the sixth sternum (henceforth S6) bears a sclerotised apicomedian angulation (Fig. 1a and c) and additional modifications of the apex of the metasoma which differ between the two genera. In *Melectoides*, the female S6 has characteristically shaped and oriented long apical robust setae that are partially overlapped by a large membranous fold of the sternum (Fig. 1a) and the fifth terga (henceforth T5) has a membranous apical rim bordered by rows of erect hairs (Fig. 1b). *Isepeolus* lacks the long robust apical setae and large membranous fold to S6, instead having the apex of S6 pointed or narrowly rounded with or without small serrations (Fig. 1c) and lacks the rim to T5 (Fig. 1d). Males can be differentiated from other bees of similar appearance by the spatha of the genitalia almost reaching the apex of the penis valves (Fig. 2a). The two genera can be differentiated from each other in the female by the T5 and S6 characters just mentioned, both sexes differ in the degree of concavity of the ocellocular area which is distinctly concave in *Isepeolus* (Fig. 1e) but more or less flat in *Melectoides* (it is most concave in *M. niveiventris* (Friese 1925) [8] (Fig. 1f)). An additional feature that separates males of the former genus from those of the latter is the S6 which is modified into a transverse

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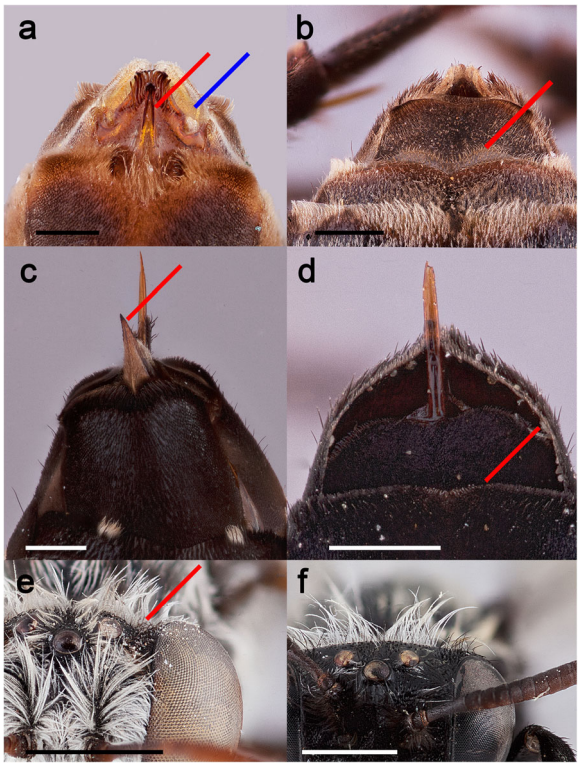

Fig. 1 Characteristics of Isepeolini and its constituent genera. **a** *Melectoides desiccata* Packer & Graham n. sp., allotype female apex of metasomal venter to show apical process of S6 (red line) with apicolateral rows of robust setae and overlapping membranous flap (blue line). Scale bar 0.5 mm (millimetre). **b** *M. desiccata* allotype female apex of metasomal dorsum to show membranous extension to posterior margin of T5 (red line). Scale bar 0.5 mm. **c** *Isepeolus luctuosus* apex of metasomal venter to show pointed apex to S6 (red line) and absence of both robust setae and large membranous flap. Scale bar 0.5 mm. **d** *I. luctuosus* to show absence of membranous extension to posterior margin of T5 (red line). Scale bar 0.5 mm. **e** *I. mankalunthata* Packer and Graham n. sp. holotype male face frontal view to show concavity of vertexal area between lateral ocellus and compound eye (red line). Scale bar 1 mm. **f** *M. niveiventris* male face frontal view to show lack of distinct concavity between lateral ocellus and compound eye. Scale bar 1 mm

ridge, conical lobe, narrow process or weakly bilobed swelling bearing distinct patterns of long hairs (Fig. 2b-d); both the protuberance(s) and long specialized hairs are absent in *Melectoides* (although the new species of the former genus described below seems to lack the cuticular convexity of S6 found in the other species, it does have the specialized hairs – see Fig. 3c-d).

Isepeolus as presently understood contains 12 species (including the species described herein) with most records from Chile and Argentina while *Melectoides* now comprises 13 species (including the three described here) similarly with most records from Chile and Argentina. Most species with host association

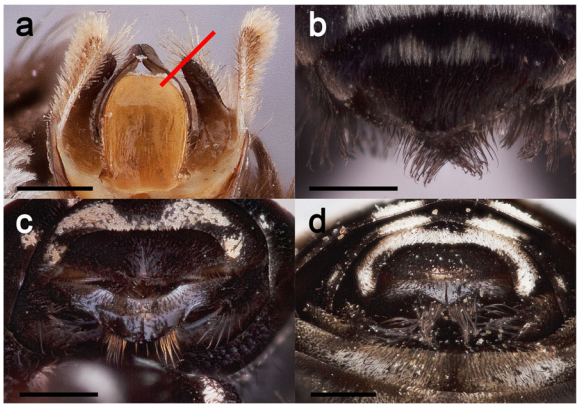

Fig. 2 Diagnostic feature for male Isepeolini and *Isepeolus* males. **a** *I. mankalunthata* n. sp. genital capsule to show spatha that almost attains apex of penis valves (red line). Scale bar 0.25 mm. **b-d** S6 apical view to show modifications that are different from those of *I. mankulantha* (see Fig. 3c, d), **b** *I. septemnotatus* to show narrow process and medially parted hairs. Scale bar 0.5 mm. **c** *I. luctuosus* to show very broad process. Scale bar 1 mm. **d** *I. vachali* to show intermediate process with medially parted hairs. Scale bar 1 mm

Fig. 3 *Isepeolus mankalunthata* Packer & Graham, new species, male holotype: **a** oblique dorso-lateral habitus. Scale bar 1 mm. **b** metasomal dorsum to show colour pattern. Scale bar 1 mm. **c** S6 lateral view. Scale bar 0.25 mm **d** S6 apical view. Scale bar 0.25 mm **e** genital capsule, dorsal view. Scale bar 0.5 mm

data have species of *Colletes* Latreille 1802 [9] as hosts (reviewed in [5]), although two are larger than are any of the *Colletes* species within their ranges and it is thought they may attack species of *Caupolicana* Spinola 1851 [5, 10].

Nomenclatural acts

The electronic edition of this article conforms to the requirements of the amended International Code of Zoological Nomenclature (ICZN), and hence the new species name contained herein is available under that Code from the electronic edition of this article. This published work and the nomenclatural acts it contains have been registered in ZooBank, the online registration system for the ICZN. The ZooBank Life Science Identifiers (LSID) can be resolved and the associated information viewed through any standard web browser by appending the LSID to the prefix "http://zoobank.org/". The LSID for this publication is: urn:lsid:zoobank.org:pub:4C2EE2EF-C581-49E4-AC48-2967179CC03F.

Results

Taxonomy

Isepeolus mankalunthata Packer & Graham sp. nov.

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(Figs. 1 e, 3a-e; 4a-d; 5)

Diagnosis The male can be differentiated from congeners by the form of S6 which seemingly lacks a distinct tubercle but has a weak transverse ridge that bears hairs that are S-shaped in lateral view and are not parted medially (Fig. 3c, d). Other species have a distinct lobe, or a weaker bilobed ridge without S-shaped hairs or with the hairs directed ventrolaterally and appearing "parted" as a result (Fig. 2b-d). The female can be differentiated from other *Isepeolus* species by the combination of scutellum and metanotum with integument black, mesopleuron with pale hairs, mesoscutum evenly punctate, hindwing cu-v approximately 0.5X as long as second abscissa of M + Cu (media and cubitus veins) and S6 process denticulate. The first two features separate it from all other *Isepeolus* species except *I. cortesi* Toro & Rojas 1980 [11], *I. luctuosus* (Spinola 1851) [10] and *I. vachali* Jörgensen 1912 [12]; *I. cortesi* lacks the last two characteristics and the other two species have impunctate areas anteriorly on the mesoscutum [5]; they also have a distinctly bigibbous scutellum, whereas that of *I. mankalunthata* is only weakly depressed medially (Fig. 4d). The new species also differs from *I. luctuosus* and *I. vachali* in the ocellocular area punctate and densely hairy more or less throughout (Fig. 4c), the other two species have an impunctate area to the side of the lateral ocellus that is at least as wide as the lateral ocellus [5] and devoid of hairs at least towards the ocellus (Fig. 4e).

Fig. 4. *I. mankalunthata* Packer & Graham, new species female allotype **a-d**, and *I. luctuosus* **e**: **a** lateral habitus. Scale bar 1 mm. **b** face, frontal view. Scale bar 1 mm. **c** Ocellocular area in oblique dorsal view to show lack of distinct impunctate glabrous area between lateral ocellus and compound eye. Scale bar 0.25 mm. **d** scutellum to show absence of distinct medial depression. Scale bar 0.25 mm. **e** Ocellocular area in oblique dorsal view to show distinct impunctate glabrous area between lateral ocellus and compound eye (red line). Scale bar 0.5 mm

Description

Male holotype Head width, 2.55 mm, ITW 1.9 mm, wing length 5.8 mm, body length 7.3 mm.

Colouration: Integument black to brownish black with following parts orange-brown: apex of labrum, mandible for middle third (apical third red brown), apex of pedicel, F1 base narrowly apex broadly (rest of flagellum gradually darkening towards apex), broad apical rings on all tibiae, all tarsi (suffused with darker brown especially protarsus); tegula and veins mostly dark brown, stigma red brown centrally; apical impressed areas of metasomal terga yellow brown.

Pubescence: primarily white with numerous short branches, obscuring underlying integument except on frontal area medially, vertexal area, most of mesoscutum,

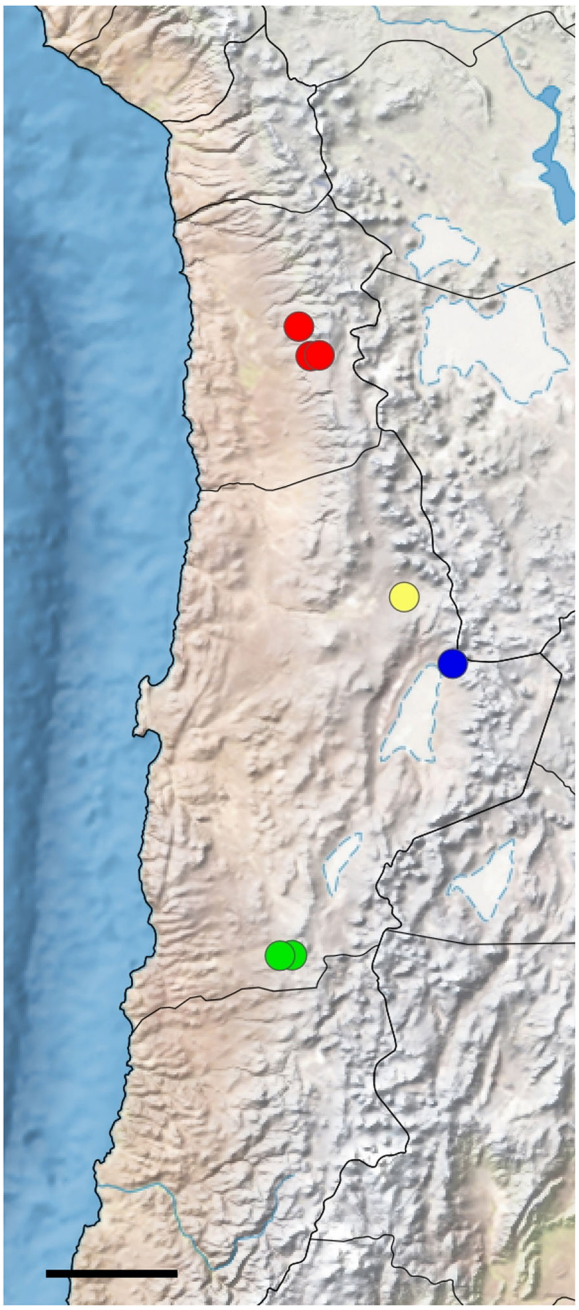

Fig. 5 Map of northern Chile to show collecting localities for the four species described herein; red – *I. mankalunthata*; green – *M. desiccata*; blue – *M. licancabur*; yellow *M. glaucodontus*. Scale bar 120 km (kilometres)

scutellum, mesopleuron, procoxa, posterior surface of meso- and metacoxae, femora, metapostnotum, lateral surface of propodeum, dark portions of T2-T4, S1-S3; long ≤2MOD (diameter of median ocellus) on face below median ocellus, hypostomal area, scutellum posteriorly, metanotum laterally, lateral surface of propodeum; ~ 2 MOD tinged with brown and sparse at base on interocellar and vertexal areas; <2MOD on genal area, mesoscutum anteromedially, side of mesopleuron (sparse above), pro- and metacoxae; short <1MOD on mesosomal venter, mesoscutum laterally and posterolaterally, anterior declivitous surface of T1; < 0.5MOD on labrum, base of mandible, apical bands on metasomal terga interrupted medially except on T6, narrowly so on T2 and T5; band broadest laterally on T1 and T2, divided into four spots on T3, two large spots on T4 and T5. Following parts with short, plumose dark brown to black hairs: ocellocular area, dark areas of mesoscutum and scutellum, metapleuron, side of propodeum, dark areas of metasomal terga. Meso- and metatibiae with dense short plumose hairs, white except mesotibia with hairs brownish basally and on small dorsal patch before midlength, small patch of longer orange simple hairs on anterior surface beyond midlength; metatibia with dark brown hairs at base and small dorsal patch of black hairs before midlength, hairs on basal half off white. Pale greyish brown, short, plumose hairs on metasomal sterna; S3-S5 apical fringes of brown intermixed with black, long posteromedially oriented hairs, longest on S5 1.5MOD, shorter on S2 ~ 0.5MOD. S6 with large median patch of S-shaped erect hairs < 1.5MOD.

Surface sculpture: mostly not detectable beneath dense pubescence, where visible punctures small dense with interspaces shining, i < d; somewhat coarser and irregularly spaced dorsally on mesopleuron; labrum punctures small and dense basally, increasingly larger towards apex; ocellocular area with triangular impunctate area posterolaterally, at < 0.5MOD, punctures attaining lateral ocellus anterolaterally; metapostnotum weakly imbricate towards base, lacking microsculpture towards apex, shiny.

Structure. Head shorter than wide 49:65. Labrum strongly depressed subapicomedially, concave apicomedially, concavity margined with weak angulations. Mandible with one subapical tooth, second tooth indicated by weak convexity (stronger in some individuals). Malar area twice as long anteriorly as posteriorly 7:3.5, greatest length < 1/3 basal depth of mandible 19. Inner margin of compound eye weakly sinuate UOD:MINOD:LOD 66:58:68; IOD:OOD 21:12.5. F1 almost 4X as long as maximum width (at apex), 28:7.5; F1-F5 profile undulate dorsally. Mesoscutum shorter than ITW 33:48. Scutellum evenly rounded, median longitudinal furrow absent. Metasoma relatively narrow, length to maximum width (at apex of T2) 91:61. Vein cu-v of hind wing ~ 0.5X as long as 2nd abscissa of M + Cu 10:19. Dorsal gonostylus shorter than gonocoxa 18:24, longer than ventral gonostylus 11.

Female Head width 2.75 mm, ITW 1.7 mm, wing length 5.8 mm, body length 7.2 mm.

Colouration: Integument black except red- to orange brown as follows: mandible middle third (apex dark red

brown), pedicel apically, F1 apically and basally, successive flagellomeres with orange brown increasingly restricted, apical mark on all tibiae, all tarsi (often suffused with darker brown); following parts dark yellow brown: reflexed sides of T1-T5, S2-S3 basally, S2 apicomedially, sterna otherwise dark brown.

Pubescence: primarily white with numerous short branches, obscuring underlying integument except for areas listed under male; longest ≤2MOD on face below median ocellus and sides of propodeum; long < 1.5MOD on hypostomal area, vertex (where white hairs intermixed with brownish and a few black hairs), scutellum posteriorly, metanotum laterally; <MOD on face below antennae, genal area, mesopleuron above, metacoxa laterally; short ≤ 0.5MOD on labrum, base of mandible, mesoscutum laterally, posterolaterally and around median line, mesosomal venter (where mostly sparse except posteriorly), tibiae, apical bands on T1-T5 these interrupted medially except for short apical fringe on T1, bands broadest laterally on T1 and T2, anterior margins of T2 and T3 concave more narrowly so on T2, T4 and T5 anterior margins convex; S1 and S2 medially, S3 and S4 apicolaterally. Following parts with plumose dark brown to black hairs ≤ 0.5MOD: ocellocular area, metapleuron, side of propodeum, remaining areas of metasomal sterna (except apex of S5 hairs pale brown laterally darkening to blackish medially); blackish minute hairs on dark areas of mesoscutum and scutellum and metasomal terga (on T5 these hairs increasingly pale from black at midlength through brown to whitish apically).

Surface sculpture: mostly not detectable beneath dense pubescence, where visible punctures small dense with interspaces shining, i ≤ d; labrum punctures small and dense basally, increasingly larger towards apex; shiny impunctate area lateral to lateral ocellus tiny; metapostnotum imbricate towards base, microsculpture weakening towards apex, shiny.

Structure. Head shorter than wide 51:70. Labrum shallowly concave apicomedially. Mandible with one subapical tooth (additional weak angulation on right mandible). Malar area more than twice as long anteriorly as posteriorly 10:4, greatest length ~ 1/4 basal depth of mandible 40. Inner margin of compound eye weakly sinuate UOD:MINOD:LOD 87: 63:68; IOD:OOD 23:16. F1 almost 3X as long as maximum width (at apex), 28:10. Mesoscutum shorter than ITW 40:56. Scutellum median longitudinal furrow absent. Vein cu-v of hind wing < 0.5X as long as 2nd abscissa of M + Cu 17:45. Apical point of S6 dentate.

Metasoma relatively narrow, length to maximum width (at apex of T2) 89:61.

Material studied Holotype male and two female paratypes: CHILE: Region I, W. of Mamigna, Parca turnoff, – 20.06308 -69.22899, 2722 m, 27.iv.2013, L. Packer & L. Packer Smith. Additional paratypes as follows: CHILE: Region I, 5 km along rd to Parca, – 20.043 -69.232, 2630 m, 2.v.2015, L. Packer. CHILE: Region I, 73 km *E. Pozo* Almonte, – 20.31233, – 69.12930, 3137 m, 16.iv.2012, L. Packer, three females; CHILE, Region I, 83.5 km ESE Pozo Almonte, – 20.306 69.054, 3930 m, 8–20.iv.2004, L. Packer, pan trap, one male. All specimens at PCYU except holotype and allotype will be sent to MNHN pending completion of ongoing studies of the chilean melittofauna and one female will be sent to PUCV.

Variation The development of the second mandibular tooth is variable, sometimes within an individual. It varies from being entirely absent (represented by a weak convexity) to being quite distinct. The latter condition being more typical for the genus [5]. Some paratypes have the antennal flagellum paler than in the holo- or allotype and/or the metasomal sterna darker. Some individuals have the concavity of the anterior margin of the apical band of T3 so deep as to attain the posterior margin of the tergum thereby dividing the band into four transverse patches.

Etymology The specific epithet is derived from the Aymara words for thief – *manka*, and food – *lunthata*, in reference to the cleptoparasitic nature of the bee.

Comments Several females were caught flying low over a sandy slope with sparse vegetation East of Pozo Almonte. *Colletes arthuri* Ferrari 2017 [13] was abundant at the same time and was also found at the cuckoo bee's type locality [13] and is believed to be the host. *Colletes gilvus* Vachal 1909 [14] has also been found in the same area [13], but not during the same collecting events and much less commonly.

Using Roig-Alsina's key [5] for the identification of *Isepeolus* species, the male most easily comes out as *I. vachali* but lacks the triangular tubercle on S6 (Fig. 2d). The female fails at couplet 10 as the mesoscutum is relatively evenly punctate as required by the first lead, but the hind wing cu-v is short and the apical point of S6 dentate as required by the second. The species seems most similar to *I. vachali* with which the male shares the bare basal band to T7 (also found in *I. wagenknechti* Toro & Rojas 1968 [5, 11]). *Isepeolus vachali* is very variable in the degree of white versus black pubescence but the S6 of the male of the new species is distinctly different (Fig. 3c-d) and the impunctate area lateral to the lateral ocellus in the female is almost absent in the new species, but extensive in *I. vachali* [5] (as in Fig. 4e).

Roig-Alsina's [5] key can be modified to permit identification of this new species as follows. For males, couplet 5 should be replaced:

5. S6 lacking tubercle of any shape and with hairs that are S-shaped in profile (Fig. 3c, d) ….. *I. mankalunthata* Packer and Graham

S6 with tubercle (sometimes bilobed) or transverse carina, lacking S-shaped hairs in profile (Fig. 2b-d) ... Roig-Alsina's original couplet 5.

For females, couplet 10 should be emended and an additional couplet added as follows:

10. Mesoscutum lacking impunctate areas anteriorly (Fig. 6a)….. 10A

Mesoscutum with impunctate areas anteriorly (Fig. 6b) … Roig-Alsina's original couplet 11.

10A. Hindwing cu-v approximately 0.5 times as long as second abscissa of vein M + Cu (Fig. 6c)… *I. mankalunthata* Packer and Graham.

Hindwing cu-v at least 0.7–0.85 times as long as second abscissa of vein M + Cu (Fig. 6d) …. *I. cortesi* Toro and Rojas.

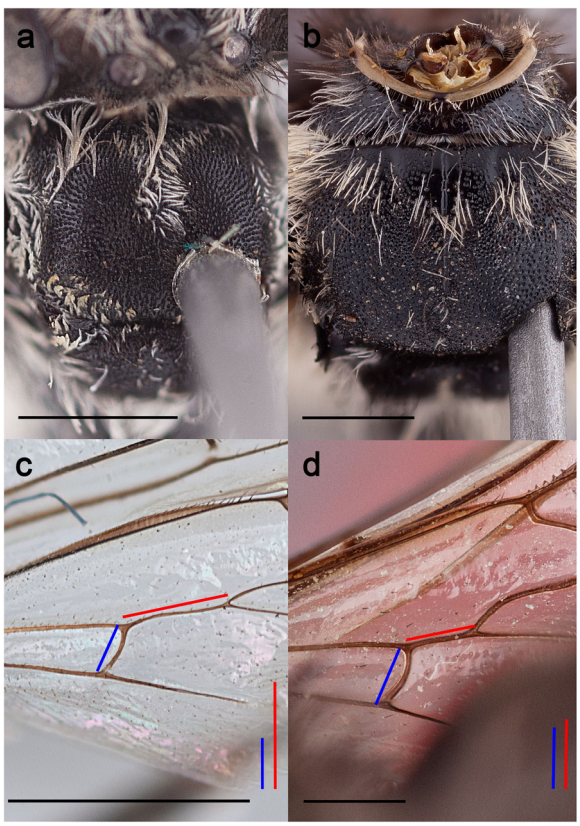

Fig. 6 Identification key characters to permit identification of *I. mankalunthata*: **a** Mesoscutum of *I. mankulanthata* to show absence of impunctate areas anteriorly. Scale bar 1 mm. **b** Mesoscutum of *I. luctuosus* to show impunctate areas anteriorly. Scale bar 1 mm. **c** Hindwing of *I. mankalunthata* to show relatively short cu-v (blue line) compared to second abscissa of M + Cu (red line). Scale bar 0.5 mm. **d** Hindwing of *I. cortesi* to show relatively short cu-v (blue line) compared to second abscissa of M + Cu (red line). Scale bar 0.5 mm

Melectoides desiccata Packer & Graham, sp. nov.

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(Figs. 1a; 7a-d, 8a- c; 9)

Diagnosis The combination of scutellum and metanotum with integument black (Fig. 7a), T1-T3 not entirely covered in white hairs (Fig. 8b), face and mesopleuron with pale brown hairs and parapsidal line not on a raised ridge (Fig. 7b) is sufficient to identify both the male and female of this species among all congeners. *Melectoides triseriatus* (Friese 1908) [15] shares all these characters except that its parapsidal line is on a raised ridge (Fig. 7c). *Melectoides licancabur* described below and known only from the female shares all of these features except that the hairs on the face and mesopleuron are white (Fig. 10a). Additionally, the S5 of *M. desiccata* (Fig. 8c) lacks pale hairs on the disc and its T5 has the apicolateral fringe brownish (Fig. 8 c) whereas *M. licancabur* has pale hairs on S6 (Fig. 10c) and the T5 fringe is pale yellow (Fig. 10 c).

Male holotype Head width 3.3 mm, ITW 2.45 mm, [wing length not measurable because of damage], body length 10.9 mm.

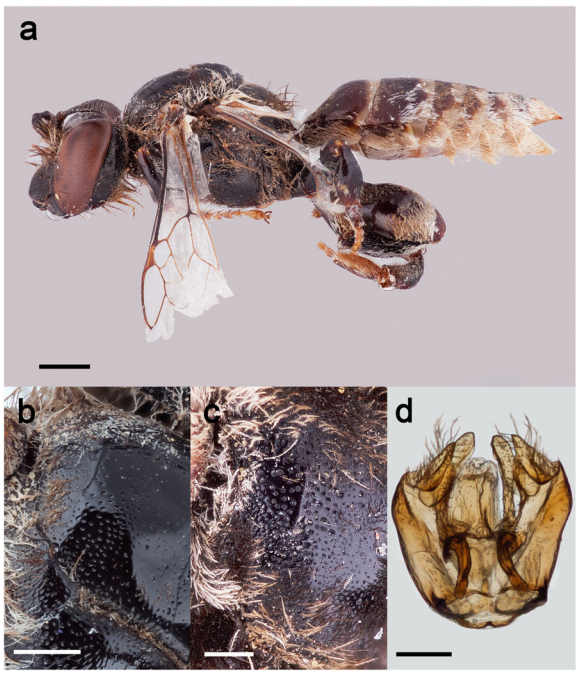

Fig. 7 Male holotype of *M. desiccata* Packer new species (**a, b** and **d**) and *M. triseriatus* **c**. **a** Lateral habitus. Scale bar 1 mm. **b** Mesoscutum detail to show absence of ridge around parapsidal line. Scale bar 0.5 mm. **c** *M. triseriatus* mesosoma to show parapsidal line on raised ridge. Scale bar 0.25 mm. **d** genital capsule. Scale bar 0.25 mm

Fig. 8 Female allotype of *M. desiccata* Packer new species **a** Lateral habitus. Scale bar 1 mm. **b** metasoma dorsal view to show colour pattern. Scale bar 1 mm. **c** apex of metasoma ventral view to show dark fringe of hairs on T6 (red line) and absence of pale hairs on disc of S5. Scale bar 1 mm

Fig. 9 The type locality for *M. desiccata*. The plants visible are thorny perennial *Adesmia* sp. (Fabaceae) and *Acantholippia* sp. (Verbenaceae). Image taken 16.ii.2016 by the senior author

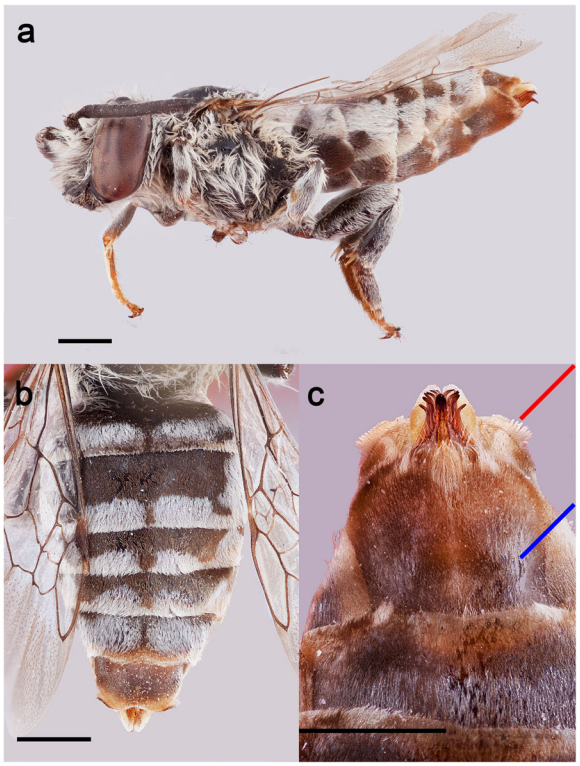

Fig. 10 *Melectoides licancabur* female holotype. **a** lateral habitus. Scale bar 1 mm. **b** metasoma dorsal view to show colour pattern. Scale bar 1 mm. **c** apex of metasoma, ventral view to show pale apical fringe to T6 (red line) and patch of pale hairs on S6 (blue line). Scale bar 1 mm

Colouration: Integument of head and mesosoma black except as follows: following parts orange-brown: mandible around midlength (apex grey brown, base dark brown), F2-F11 ventrally (rest of flagellum mostly dark brown), apical rings on all femora, basal and apical rings on pro- and mesotibiae, all basitarsi (other tarsomeres yellow brown); wing veins (except radial and costal veins blackish); tegula pale straw suffused with red brown basally. Metasomal T1-T6 and S1-S3 dark red brown (S4-S6 colour indetectable as integument hidden beneath dense hairs), T7 yellow brown, apical impressed areas translucent amber; apical impressed areas of metasomal terga orange brown anteriorly, fading to colourless posteriorly.

Pubescence: [pubescence abraded from some parts of body, especially genal area, mesoscutal disc, T2 and T3] primarily pale brown somewhat darker below antennal sockets and paler toward sides of mesosoma and on most of metasoma, with numerous short branches. Longest $\underline{\leq}$3MOD towards sides and posteriorly on metanotum, ~2MOD on head below antennae, hypostomal area and sides of mesosoma; shorter $\underline{\leq}$ 1MOD and more plumose on sides of mesoscutum; T1 with fine whitish hairs on anterior declivitous

surface, short < 1MOD plumose brown hairs medially on disc; T2-T6 hairs short <1 MOD plumose brownish anteriorly, white apically and laterally; T7 covered in pale yellowish hairs. Metasomal sterna with appressed short white to cream hairs <1MOD, S3-S5 apical fringes long, whitish to pale brown < 2MOD.

Surface sculpture: Microsculpture absent and surface shiny except when stated otherwise. Punctures small and dense i ≤ d on labrum basally and towards sides, head below antennal sockets and upper paraocular area, except clypeus impunctate apically more narrowly so medially, broadly laterally; frontal area punctures less regularly spaced, longitudinally or transversely elongate; vertexal areas more coarsely punctate i = 0.2–1.5d, area posterolateral to lateral ocellus impunctate to occiput; genal area punctures i~d except impunctate broadly adjacent to posterior margin of compound eye, hypostomal area puncturs sparse i > d; mesoscutum punctures bimodal in size, many minute punctures and few larger ones on disc and posteriorly, smaller punctures absent towards side, irregularly spaced i = 0.5-5d, densest towards side of disc; metanotum with small punctures i = 1-5d except sparser medially; metapostnotum weakly imbricate anterolaterally otherwise smooth; hypoepimeral area impunctate, rest of side of mesosoma distinctly punctate i~d; posterior surface of propodeum shallowly punctate, i~d; metasomal terga minutely punctate i = 1-2d (punctures indetectable beneath dense hairs on T7).

Structure. Head shorter than wide 56:83. Labrum with strong shallowly m-shaped ridge delimiting a deep depression ventrally with a large medial protuberance U-shaped in profile, with median sulcus. Malar area short, not markedly longer anteriorly than posteriorly but shortest near mid-depth of mandible greatest to shortest lengths 11:7, greatest length ~ 1/5 basal depth of mandible 56. Clypeus apicolaterally lamellate, extending slightly over anterior mandibular articulation and attaining margin of compound eye. Frontal line distinct, a strongly raised ridge from mid-level of antennal socket to 2/3 distance between socket and lower tangent of median ocellus, below median ocellus frontal ridge carinate in triangular depression broadest above. Inner margin of compound eye weakly sinuate UOD:MINOD:LOD 55:42:46; IOD:OOD 29:21. F1 ~ 2.5X as long as maximum width (at apex), 26:10; entire flagellar profile weakly undulate dorsally, anteroposteriorly compressed. Mesoscutum shorter than ITW 42:62. Scutellum not biggibous, longitudinal median depression narrow. Metafemur strongly swollen, length to maximum width 53:29; metabasitarsus broad, L:W (length to width) 26:11. Metasoma somewhat oval, length to maximum width (at apex of T2) 53:33. Pygidial plate distinct, apex broadly rounded. Dorsal gonostylus narrow ~ 1/7th the length of gonocoxa 4:26 with dense short hairs laterally, ventral gonostylus longer 10 with sparse longer hairs dorsally.

Female Head width 3.7 mm, ITW 2.45 mm, wing length 6.7 mm, body length 11.4 mm.

As in male except as follows:

Colouration: Antenna entirely blackish; legs darker, orange-brown restricted to apical mark on protibia and most of protarsus (remaining tarsi red brown except basitarsi dark brown); metasomal T1-T5 blackish, apical impressed areas amber, apex of T5 and base and apex of T6 orange brown, rest of T6 red brown; metasomal sterna dark brown except as follows: S1-S4 suffused with orange brown apically, S5 orange brown medially and apically, yellow brown laterally.

Pubescence: pale brown except where noted, inner margins of compound eye with erect simple sparse black hairs ~ 1.5MOD admixed with brown ones; T1-T5 hairs plumose appressed ~ 0.5MOD, T1 horizontal surface covered, T2-T4 with apical bands narrowly interrupted medially, extending for almost full length of postgradular part of terga laterally, anterior margins concave on T2 and T3, transverse on T4; dark portions of terga with short black to brown black plumose hairs; apex of T5 with two parallel rows of erect short hairs; T6 with posteriorly oriented orange hairs except apex with fringe of hairs with dark tips and for most of length ventrally longest apicolaterally 0.5MOD, median portion of extreme apex lacking hairs but recurved portion with minute anteriorly oriented white hairs. Metasomal sterna with appressed short white to cream hairs < 0.3MOD, hairs becoming pale brown towards apex of S1-S4 and more extensively so on S5 except for small patch of dark hairs either side of middle of apex.

Surface sculpture: As in male except punctures somewhat denser, also somewhat larger on metasomal terga; T5 densely minutely punctate with scattered larger (but still small) punctures.

Structure. Head shorter than wide 50:74. Labrum with irregularly [–shaped ridge delimiting a depression ventrally with a short obliquely truncate medial protuberance which bears a median groove. Frontal line less distinctly ridge-like, below median ocellus frontal line a blunt carina in a narrowly triangular depression broadest above. Inner margin of compound eye weakly sinuate UOD:MINOD:LOD 66:49:50; IOD:OOD 35:31. F1 ~ 1.5X as long as maximum width (at apex), 24:15; flagellomeres cylindrical except posterior surface slightly flattened. Mesoscutum shorter than ITW 46:59. Scutellum longitudinal median depression shallow. S6 with 8 robust sinuate spinose bristles, first most robust and first and second oriented more mesally and obscured by more apical spines for most of their lengths; apex of median process stongly curved ventrally.

Material examined Holotype male: CHILE, Region II, Rd. to Aguas Calientes, km 62.7, – 25.37517 -69.28808,

3356 m, 31.x.2015–6.ii.2016, bvt (blue vane trap), L. Packer. Allotype female: CHILE, Region II, Rd. to Aguas Calientes, km 51.2, – 25.37907 -69.38825, 3037 m, 31.x.2015–6.ii.2016, bvt, L. Packer. Both specimens are at PCYU but will be sent to MNHN upon completion of ongoing research.

Etymology The type locality is in the driest desert in the world. Although the rainfall at this locality occurs regularly enough for some perennials to grow, annual amounts are very low and the vegetation extremely sparse (Fig. 9). Hence, the specific epithet refers to this degree of aridity.

Comments No potential *Colletes* hosts were found at either of the type localities which are separated by approximately 10 km. This putative host genus is known to be relatively uncommonly collected in pan and vane traps.

The male is in relatively poor condition as a result of the method of capture.

With Roig-Alsina's key [5], this species fails at couplet 8 for both sexes. It has the pale hairs on the face and mesosomal pleura of the first lead (which identifies *M. triseriatus*) but the metapostnotum is shiny and not rugulose and the parapsidal line is not on a raised ridge (Fig. 7b), as required to lead to couplet 9 (see diagnosis above). This and the following species are not either of the species that are identified with couplet 9 as is most readily seen from the pale mesopleural and metatibial hairs (Fig. 7a-b) and scutellum very weakly depressed medially. The two species identified in couplet 9, *M. cockerelli* (Jörgensen 1912) [12]) and *M. polita* Roig-Alsina 1991 [5], have at least some of the aforementioned areas covered in black hairs and *M. cockerelli* has the scutellum strongly bigibbous. Roig-Alsina's [5] key is emended to permit identification of this and the following new species in the comments section of the next description.

Melectoides licancabur Packer & Graham, sp. nov.

LSID urn:lsid:zoobank.org:act:164C880E-2136-40B8-927A-7EEA6541A57E

(Figs. 10a-c, 11)

Diagnosis The combination of labrum with a distinct ridge, weakly m-shaped; scutellum and metanotum black; T1-T3 not entirely covered in white hairs (Fig. 8b) and face and mesopleuron with white hairs (Fig. 8a-b) is sufficient to identify this species, which is known only in the female. It is most similar to *M. desiccata* described above but differs in the features outlined in the diagnosis of that species.

Fig. 11 Type locality of *M. licancabur* – Hwy 27 east of San Pedro de Atacama (visible in the background). The specimen was caught just to the right of the foreground. The large shrub in the foreground is *Acantholippia*. 7.xii.2014, taken by the senior author

Female Head width 3.3 mm, ITW 2.1 mm, wing length 6.0 mm, body length 9.2 mm.

Colouration: Integument black except red- to orange brown as follows: mandible middle third (apex grey brown, base red brown), apical mark on all tibiae, base and apex of probasitarsus, protarsomeres 2–4, apex of mesobasitarsus and mesotarsomeres 2–4, most of metatarsomeres 3 and 4, tegula (paler towards outer margin); following parts yellow brown: apices of T5 and T6, S2-S4 towards apex, S5 extensively, dark brown anterolaterally.

Pubescence: white with numerous short branches, long $\leq$ 1.5MOD as follows: on face below frontal area, genal, vertexal and hypostomal areas, sides of scutellum, posteriorly on metanotum, sides of mesosoma, metacoxa; somewhat shorter around margins of mesoscutum < 1MOD; short appressed white plumose hairs along inner margin of compound eye and lateral and anterior to lateral ocellus; brown short appressed plumose hairs between white patch and inner margin of compound eye above; tibial hairs whitish except: protibia dark brown at base and midlength of dorsal surface; mesotibia with patch of coppery hairs near apical 1/3 on anterior surface and small patch of brown hairs at basal 1/3 on dorsal surface; metatibia with keritrichiae orange brown. Metasomal hair bands whitish grey as follows: T1 most of horizontal surface except narrowly interrupted medially and briefly subapically where hairs brown; T2-T4 with whitish-grey hairs extensive laterally (with brown patches basolaterally) and apical bands narrowly interrupted medially except on T4, transverse portion of bands parallel-sided except T2 with narrow comma-shaped dark marking sublaterally and anterior margins of T3 and T4 bands concave, T4 band longest submedially, T5 mostly pale haired except midline, apical rows of specialized hairs pale yellow, T6 hairs whitish except

apical fringe pale brown with tips darker above but entirely yellow below, longer towards sides; other areas of terga with short plumose dark brown hairs. Sterna hairs brown to grey short plumose and appressed except white on apical margins of S1 and S2, posterolaterally on S3 and small sublateral spots on apex of S4, S5 apical hairs pale brown with sparse dark brown simple hairs intermixed.

Surface sculpture: punctures dense with interspaces shining, i ≤ d on clypeus (except apex impunctate, most narrowly so medially), lower paraocular, frontal, genal and ocellocular areas; sparser on vertexal and hypostomal areas; mesoscutum punctures irregular in size and spacing, i = 0.2-4d; scutellum punctures longitudinally to obliquely elongate except rounded anteriorly, i~d; metanotum punctures shallow i ≥ d; sides of thorax distinctly punctate i~d except posteroventral portion of hypoepimeral area and metapleuron near lower half impunctate. Metasomal terga and sterna weakly imbricate, punctures small dense i < d where visible beneath pubescence.

Structure. Head shorter than wide 44:66. Labrum with weakly m-shaped ridge delimiting a depression ventrally with a deeply grooved tubercle, approximately D-shaped in profile. Mandible with one subapical tooth. Frontal line strongly carinate from mid length of antennal socket, carina weakened towards median ocellus where it is situated in a narrow shallow elongate depression. Inner margin of compound eye almost straight UOD:MINOD:LOD 71:50:54; IOD:OOD 29:25. F1 almost twice as long as maximum width (at apex), 24:14; flagellomeres slightly anteroposteriorly compressed. Mesoscutum shorter than ITW 82:100. Scutellum broadly shallowly depressed posteromedially, depression narrowing anteriorly. S6 with 7 robust sinuate spinose bristles, first most robust and most of length of first and second oriented more mesally and obscured by more apical spines; apex of median process curved ventrally almost at a right angle.

Material studied Holotype: CHILE, Region II, approximately 26 km E. of San Pedro de Atacama, − 22.91188 -67.93230 3580 m, 5–7.xii.2014, L. Packer, pan trap (PCYU). The holotype will be sent to MNHN pending completion of ongoing studies of the Chilean melittofauna.

Etymology The species is named after Volcan Licancabur as the type locality is just beyond the northern slopes of the volcano which exceeds 5900 m in altitude. Licancabur means “mountain of the people” in the Atacameñan language.

Comments We have located one additional female that mostly, but not entirely, agrees with the description of *M. licancabur* above. It differs in having the integument of the metasoma somewhat paler, but the pubescence on the head and metasomal sterna somewhat darker in addition to some minor details of the setation in the ocellocular area. [CHILE, Region II] Talabre, 6.xi.1992, E. Chiappa (AMNH), GUI: AMNH_IZC 002914901. The two localities are approximately 50 km apart and at almost identical altitudes. In the absence of additional material that might indicate intermediate states for the variation we have observed, we are not assigning paratype status to this specimen, which is currently labelled *Melectoides lincancabur*?

Five species of *Colletes*, potential hosts of *M. licancabur*, have been found near, but not exactly at, the type locality: *C. alocochila* Moure 1956 [16], *C. atacamensis* Janvier 1955 [17], *C. gilvus*, *C. murinus* Friese 1900 [18] and *C. rutilans* Vachal 1909 [13, 14]. It is not known which among these might serve as the host for the cleptoparasite.

The senior author has spent a considerable amount of time collecting at the type locality over many years with considerable pan trapping in addition to sampling with nets but has caught just one specimen.

With Roig-Alsina’s key [5] to *Melectoides* species, *M. licancabur* fails at couplet 8 in the same manner as does *M. desiccata* described above. Both can be identified by the following emendation to that key.

8. Pubescence of face and mesosomal pleura black (Fig. 12)…. *M. cockerelli* (Jörgensen)

8. Pubescence of face and mesosomal pleura pale, whitish to pale brown (Fig. 7a, and Fig. 10a) … 10A

8A. Parapsidal line on a raised ridge (Fig. 7c) … *M. triseriatus* (Friese).

Parapsidal line not on a raised ridge (Fig. 7b) … 8B.

8B(8A) Hairs on face and mesopleuron pale brown (Figs. 7a, b, 8a); T5 apicolateral fringe brownish (Fig. 8c); S6 without pale hairs on disc (Fig. 8c) … *M. dessicata* Packer and Graham.

Hairs on face and mesopleuron whitish (Fig. 10a); T6 apicolateral fringe pale yellow (Fig. 10c); S6 with pale hairs on disc (Fig. 10c)… *M. licancabur* Packer and Graham.

Fig. 12 Figure to aid identification of *M. dessicata* and *M. licancabur*. Head and mesosoma of *M. cockerelli* to show dark pubescence in contrast with that of the new species. Scale bar 1 mm

Melectoides glaucodontus Packer & Graham, sp. nov.

LSID urn:lsid:zoobank.org:act:E109EA1E-2 AD3-4091-B3EB-1964930B0FAE.
(Figs. 13a-c, 14)

Diagnosis The white pubescence covering T1-T3 except for the reflexed lateral portions is shared among *Melectoides* only with *M. niveiventris* [8] (Fig. 13a). *Melectoides glaucodontus* can be differentiated from *M. niveiventris* by considerable differences in the genitalia (Fig. 13b and c). The apex of the gonocoxa is narrower in the former, its dorsal gonostylus is parallel-sided but narrowed towards the base in *M. niveiventris*, the dorsomedial carinate margin of the ventral gonostylus does not extend onto the dorsal surface anteriorly in the former as it does in the latter and the apex of the penis valve is narrowly swollen in *M. glaucodontus* but not in the earlier-described species.

Male holotype Head width 3.25 mm, ITW 2.45 mm, wing length > 7.0 mm (wings damaged), body length 10.5 mm.

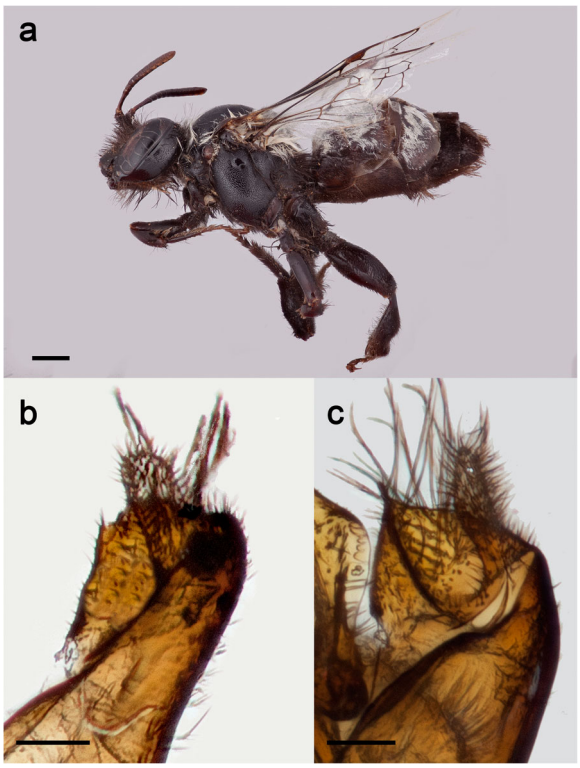

Fig. 13 *Melectoides glaucodontus* Packer & Graham new species holotype **a** and **b**, and *M. niveiventris* **c**. **a**. lateral habitus. Scale bar 1 mm. **b**. apex of right gonocoxa and gonostyli. Scale bar 0.1 mm. **c**. apex of right gonocoxa and gonostyli of *M. niveiventris* to show differences to *M. glaucodontus* (see diagnosis above). Scale bar 0.1 mm

Fig. 14 Type locality for *M. glaucodontus* Packer & Graham, new species – to the back left of the image. The cacti are *Echinopsis atacamensis* (Phil.) H. Friedrich & G.D. Rowley. Image taken by Spencer K. Monckton, 25.x.2013

Colouration: Black except as follows: apex of mandible greyish, all tarsi gradually paler from blackish basitarsi to red-brown pretarsus; tegula dark brown; apical impressed areas of T1 and T2 amber, of T3 yellowish brown, T4-T6 dark brown; metasomal venter including reflexed portion of terga dark yellowish brown.

Pubescence: Black except white as follows: vertexal area, pronotum, mesoscutum margins (disc hairs abraded, colour unknown), scutellum laterally and posteriorly, metanotum, propodeum dorsally, T1-T3 except brown on reflexed lateral portions. Metasomal sterna with brown hairs. Longest white hairs ~3MOD on pronotum, anteriorly on mesoscutum, on metanotum and dorsally on propodeum; long black hairs ~3MOD around antennal sockets and posterolaterally on propodeum, shorter on mesopleuron 1.5MOD, shorter on disc of scutellum < 1MOD. White hairs on T1-T3 ~ 0.7MOD, black hairs on T4-T7 and brown hairs on S1 and most of S2 ~ 0.5MOD. Apical fringe of S2 blackish, ≤1MOD; fringes of S3-S5 brown, hairs paler towards apices more extensively so on more posterior sterna, ~2MOD; S6 hairs yellowish short <1MOD.

Surface sculpture: Microsculpture absent and surface shiny except dorsolaterally on propodeum, imbricate, somewhat dull. Punctures on head distinct and dense i < d on labrum (somewhat sparse in area subtended by carina), clypeus except apex impunctate, lower and upper paraocular, frontal and genal areas (except impunctate adjacent to posterior margin of compound eye); punctures somewhat less distinct on upper paraocular and frontal areas; areas below median ocellus and briefly lateral to lateral ocellus and extensively posterolaterally almost to occuput impunctate. Mesosoma punctures distinct i~d except as follows:

some areas on disc and posteriorly on mesoscutum i ≤ 2d; hypoepimeral area impunctate except dorsally and anteriorly where i < d; sides of propodeum punctures shallow, obscure. Metasomal punctures minute i~d, sparser on apical impressed areas.

Structure. Head shorter than wide 57:81. Labrum with strong (–shaped ridge with weak medial concavity delimiting a deep depression ventrally with a large medial protuberance truncate in profile with strong longitudinal median sulcus. Mandible with one subapical tooth. Malar area short, not longer anteriorly than posteriorly, shorter medially 14:10. Clypeus apicolaterally lamellate, extending over and somewhat above anterior mandibular articulation. Frontal line distinct, most strongly raised below from origin near mid-level of antennal socket, almost attaining lower tangent of median ocellus. Inner margin of compound eye weakly sinuate UOD:MINOD: LOD 90:68:79; IOD:OOD 21:17. F1 > 2.5X as long as maximum width (at apex), 48:18; F2-F5 weakly convex posteriorly making profile weakly undulate. Mesoscutum shorter than ITW 76:97. Scutellum longitudinal median depression very weak, narrow. Metafemur strongly swollen, length to maximum width 87:37; metabasitarsus broad, L:W 91:26. Metasoma somewhat oval, length to maximum width (at apex of T2) 68:48. Pygidial plate distinct, apex weakly concave medially. Dorsal gonostylus broad, parallel-sided, short ~ 1/5th the length of gonocoxa 15:75 with short hairs throughout; ventral gonostylus broad, apex weakly concave, dorsal surface and apex with sparse long strongly branched hairs such hairs shorter ventrally.

Material examined Holotype male: CHILE, Region II, E. of Calama, Hwy B-159 km7, – 22.34715 -68.34089, 3000 m, 2–27.iv.2013, S. Monckton and J. Postlethwaite.

Etymology The specific epithet refers to the greyish colour of the rutellum of the mandible.

Comments This species is clearly very similar to *M. niveiventris*, which it would be identified as using Roig-Alsina's key [5], but differs from it in the following features in addition to those mentioned in the diagnosis: frontal line much stronger especially below (in *M. niveiventris* it is no stronger below than at midlength), hairs of S2 fringe shorter, ~ 1MOD compared to 1.5MOD, hairs of S6 paler, yellowish compared to brown and metasomal sterna and reflexed sides of terga dark yellowish brown, reddish brown to black in *M. niveiventris* except S6 brownish.

Thus, couplet 7 of the key [5] can be modified to permit identification of the new species as follows (Figs. 13a and b, 14 and 15b):

T1-T3 (except laterally reflexed portion) covered in pale hairs (Fig. 13a); T4-T5 black (Fig. 13a) … 7A

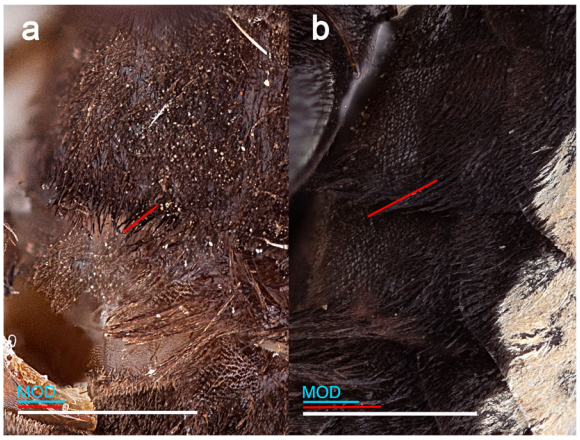

Fig. 15 Lateroventral area of S2 and S3 to show relative length of apical hairs of S2 (red lines) and MOD (blue lines). **a** *M. glaucodontus*. Scale bar 1 mm. **b** *M. niveiventris*. Scale bar 1 mm

T1-T3 with pale maculations on a dark background (as in Fig. 7a); T4-T5 also usually with pale marks (as in Fig. 7a) … Roig-Alsina's original couplet 8.

7A.(7) Gonocoxa narrow apically (Fig. 13b); dorsal gonostylus parallel-sided (Fig. 13b); S2 fringe hairs short <1MOD (Fig. 15a); … *M. glaucodontus* Packer and Graham.

Gonocoxa wider apically (Fig. 13c); dorsal gonostylus narrowed towards base (Fig. 13c); S2 fringe hairs longer ~ 1.5MOD (Fig. 15b); … *M. niveiventris* (Friese).

Figure 13 key characters to permit identification of *M. glaucodontus*. **a** *M. glaucodontus* oblique ventral view of S2 and S3 to show S2 apicomedial hair length (red line) similar in length to MOD (blue line). **b** *M. niveiventris* oblique ventral view of S2 AND S3 to show S2 apicomedial hair length (red line) markedly longer than MOD (blue line)

The only known specimen is in relatively poor condition as a result of the means of capture.

Annotated list of additional Chilean records of previously described Isepeolini

I. atripilis Roig Alsina 1991 [5]- CHILE, Region XI, Jineimeni, Rio Sucio, – 46.790 -71.915, 763 m, 17.xii.2017, Droege & Packer [PCYU].

I. luctuosus (Spinola 1851) [10] –CHILE, Region III, South of Caleta Totoral, – 27.932–71.092, 170 m, 4.xi.2015, L. Packer; CHILE, Region III, 2.4 km N. of Huasco Bajo, – 28.455 -71.185, 19.x.2009, J. Gibbs, one female; CHILE, Region III, 0.2 km E of Huasco, – 28.466 -71.205, 19.x.2009, J. Gibbs, one male; CHILE, Region III, Hwy 5 km 848, – 27.345 -70.693, 16.x.2009, J. Gibbs, one male; CHILE, Region III, Chuingo, – 28.825 -70.356, 963 m, 15.ix.2010 L. Packer, one female; CHILE, Region III, W. of Domeyko, – 28.942 -71.001, 5.x.2010, Packer and Fraser, one male; CHILE, Region III, 14.5 km W. of

Domeyko, – 28.968 -71.035, 570 m, 18.ix-5.x.2010, Packer and Fraser, one male one female; CHILE, Region IV, Parque Nacional Fray Jorge, 14.x.2000, L. Packer, one male, six females; same data except 20.x.2001 Packer & Fraser, one female; CHILE, Region IV, 1 km. E. of Parque Nacional Fray Jorge, 15.x.2000, L. Packer, three females; CHILE, Region IV, W. of Barrancas, 10.x.2000, L. Packer, three females; CHILE, Region IV, Playa la Despensa, Caleta Los Hornos, 11.xi.1997, L. Packer, one female; CHILE, Region IV, Los Lavadores, – 30.300 -70.6731396 m, 10–19.ix.2010, L. Packer, one female; CHILE, Region IV, Chañar, – 30.286 -70.634, 11.x.2009, J. Gibbs, one male; CHILE, region IV, Los Choros, 20.x.2002, J. Grixti & A. Zayed, bright yellow pan, one male; CHILE, Region IV, 1.1 km S. on road to Tololo Observatory, – 30.306 -70.815, 11–22.x.2009, J. Gibbs, one male; CHILE, Region IV, 3.5 km W. of Rivadavia, – 29.997 -70.586, 21.x.2009 J. Gibbs, one male; CHILE, Region IV, 7 km N. of La Higuera, 14.iv.2000, L. Packer, one male; CHILE, Region V, Quillota, Campana National Park, – 32°932–71°078, 250 m, 29.xi.1999, M. Irwin, malaise trap, one male, six females; CHILE, Region V, E. of Los Andes, Pte Los Azules, – 32.8999 -70.36516, 1302 m, 14.xii.2017, Droege & Packer, CHILE, Region Metropolitana, Las Canteras, 8.xii.2006, L. Packer, L. Packer, one male; CHILE, Region Metropolitana, W. of El Volcan, – 33.81453 -70.18591, 1411 m, 7.i.2009, L. Packer, two males; CHILE, Region Metropolitana, Farellones, 033.348–70.328, 1867 m, 8.i.2009, L. Packer, one male; CHILE, Region Metropolitana, Caleu, 1.i.2009, L. Packer, ex *Colletia spinosissima* J.F. Gmel., (Rhamnaceae), one female; [CHILE, Region VI,] La Leonera, 20.ii.1983, H. Larrain, four males; CHILE, Region VII, Vado Estero Los Molongos, – 35.011 -70.744, 835 m, 26.i.2016, L. Packer, two males, one female; CHILE, Region VII, NW of Laguna del Maule, – 35.551 -70.627, 1435 m, 4.i.2009, L. Packer, one female; CHILE, Region VII, Rio Teno, – 35.086, 70.497, 1457 m, 28.ii.2013, J. Postlethwaite & S. Monckton, net, one female; CHILE, Region VIII, 13 km E. of Santa Juana, 2.xii.1997, L. Packer, one male; CHILE, Region VIII, W. of Fundo Alicos, – 36.576 -71.560, 446 m, 1.xii.2017, L. Packer, one female; CHILE, Region IX, Parque Nacional Vista Hermosa, – 38°45′08″ -71°37′24″, 22–24.ii.2005, UCR AToL. All specimens at PCYU except the last, UCR.

Isepeolus luctuosus is possibly the most commonly collected species in the genus with records from Regions III to IX in Chile and from Neuquén to Chubut in Argentina.

I. septemnotatus (Spinola 1851) [10] – CHILE, Region V, Cuesta la Dormida, – 33.060 -70.030, 800 m, 10.x.2013, S. Monckton; CHILE, Region V, Cuesta la Dormida, 033.063–71.016, 1234 m, 18.ix.2016, L. Packer, two females; CHILE, Region V, Las Palmas, km 4, – 32.210 -71.146, 675 m, 10.ix.2016, L. Packer, three males, two females; CHILE, Region V, SE of Reserva Nacional El Yali, – 33.800 -71.715, 93 m, 20.ix.2016, L. Packer, two males, two females; CHILE, Region V, nr. Pangue Alto, – 33.583 -70.592, 660 m, 8.ix.2016, L. Packer, ex. *Trevoa trinervis* Miers (Rhamnaceae); CHILE, Region Metropolitana, 2 km E of Espinalillo, – 33.008 -70.927, 874 m, 17.ix.2016, L. Packer, four males one female; CHILE, Region VII, 6 km W of La Suiza, – 35.715 -71.043, 640 m, 23.ix.2016, L. Packer, three males; CHILE, Region Metropolitana, Cuesta Zapata, – 33.388–71.267, 712 m, 8.ix.2016, L. Packer, one male; CHILE, Region Metropolitana, Cuesta Zapata, – 33.389 -71.265, 627 m, 10.x.-11.xi.[20]13, L. Packer, pan trap, one male; CHILE, [Region VIII], Nuble, 17 km W Valdivia, nr. Spanish fort, on bluff, 15.xi.[19]89, S.A. Marshall [DEBU]. All specimens at PCYU except the last.

This species is known from Chile and Argentina ranging from 33°S east of Valparaiso in Region V of the former to 43°S at Trevellin in Chubut in Argentina to the south.

I. wagenknechti Toro & Rojas 1968 [11]– CHILE, Region III, 1.8 km N. Huasco Bajo, – 28.459 -71.181, 19.x.2009, J. Gibbs, two males; CHILE, Region III, 2.4 km N. Huasco Bajo, – 28.455 -71.185, 19.x.2009, J. Gibbs, five males; CHILE, Region III, 1 km N. Caldera, – 27.057 -70.803, 14.x.2009, J. Gibbs, two males, four females; CHILE, Region III, Hwy 5 km848, – 27.345 -70.693, 16.x.2009, J. Gibbs, two males, one female; CHILE, Region III, Hwy 5 km908, 14.ix.2009, J. Gibbs, one female; CHILE, Region III, 7.3 km W. of Domeyko, – 28.978 -70.964, 648 m, 22.x.2010, L. Packer and R. Smith, one male, one female; CHILE, Region III, Hwy 5 km853, 11.xi.1997, L. Packer, one female; CHILE, Region III, 14.5 km W. of Domeyko, – 28.968 -71.035, 570 m, 18.ix-5.x.2010, Packer and Fraser, two males one female; CHILE, Region III, N. of Caldera, S27°00.52 W70°47.22, 27.ix.-6.x.2002, J. Grixti & A. Zayed, yellow pan trap, one female; CHILE, Region III, NW of Copiapo, 25.x.2000, L. Packer, one female; CHILE, Region III, 13.5 km W Los Sapos, – 28.019 -70.554, 488 m, 22–25.x.2010, L. Packer, pan trap, one female; CHILE, Region III, Los Medanos, 026.474–70.885, 29 m, L. Packer, ex *Cristaria*, one male; CHILE, Region III, Chañar de Aceituna, – 28°57′12.3″ -71°20′49.9″, 18.ix.2003, A. Ugarte one male, one female; CHILE, Region III, El Barratillo, N. of Huasco, 13.x.[20]00, L. Packer, one female; CHILE, Region IV, Playa la Despensa, Caleta los Hornos, 11.xi.1997, L. Packer, two females; CHILE, Region IV, Choros Bajos, 16.x.2000, L.. Packer; CHILE, Region IV, Chañar, – 30.2865 -70.6338, 20.x.2009, J. Gibbs, one female. All specimens at PCYU.

This species is known only from Regions III and IV in Chile with all records being from low altitudes and almost all of them very close to the coast.

M. niveiventris (Friese 1925) [8] – CHILE, Region Metropolitana, Valle Nevado, – 33.856 -69.980, 3000 m, 8.i.2009, L. Packer, one male one female; CHILE, Region

Metropolitana, Termas del Plomo, 2938 m, – 33.621 -69.920, pans, 31.xii.2012–26.ii.2013, Monckton Postlethwaite, one female. All at PCYU.

This species is known only from the west slopes of the Andes mountains from Regions IV to VII. All are from high altitude except the holotype which is from Baños de Cauquenes at around 1350 m.

M. rozeni (Toro 1971) [19]– CHILE, Region II, 29 km N of Taltal, – 24.737 -70.566, 43 m, 21.x.2014, S. Monckton & J. Postlethwaite; CHILE, Region II, SE of Taltal, Ruta 1, km 1, – 25.555 -70.360, 800 m, 20.x.2014, L. Packer, pans, two females; CHILE, Region II, SE of Taltal, B-902, km 1, – 25.502 -70.412, 564 m, 19.x.2014, L. Packer, pans, one male; CHILE, Region III, Hwy 5 km739, N. of Vallenar, – 27.940 -69.547, 450 m, 16.ix.2010, L. Packer, one female; CHILE, Region III, N. of Vallenar, 11–12.x.2000, L. Packer, one female CHILE, Region III, 10 km N. of Vallenar, 18.x.2010, L. Packer, one female; CHILE, Region III, Parque Nacional Llanos de Challe, 22.x.2000, L. Packer, one male, three females; CHILE, Region III, 13.5 km W Los Sapos, – 28.019 -70.554, 488 m, 22–25.x.2010, L. Packer, pan trap, one male. All at PCYU.

This species is only known from low altitude in regions II and III in Chile.

M. triseriatus (Friese 1908) [15] – CHILE, Region III, 14.5 km W. of Domeyko, – 28.968 -71.035, 570 m, 18.ix-5.x.2010, Packer and Fraser, one male; CHILE, Region IV, Los Vilos, no date or collector, one male one female; CHILE, Region IV, Chañar, – 30.286 -70.634, 11.x.2009, J. Gibbs, five males one female; CHILE, Region IV, Los Lavadores, – 30.300 -70.6731396 m, 10–19.ix.2010, L. Packer, one female; CHILE, Region IV, S. of Vicugna, 16.x.2015, L. Packer, ex *Calandrinia*, one female; CHILE, Region IV, 2 km S. of Vicugna, – 30.073 -70.727, 792 m, 11–21.ix.2010, L. Packer, pan trap, two males; CHILE, Region IV, Parque Nacional Fray Jorge, 14.x.2000, L. Packer, one male; same locality except 14.x.-14.xi. 2000, pan trap, one female; CHILE, Region IV, Puente El Ojo, – 32.146 -71.162, 999 m, 25.ix.2016, L. Packer, one female; CHILE, Region IV, 8 km W of Tilama, – 32.008 -71.236, 436 m, 15.ix.2016, L. Packer, one male; CHILE, Region Metropolitana, Cerro Roble nr. Til-til, 18.xi.2001, L. Packer, one female; CHILE, Region Metropolitana, Cuesta Zapata, – 3.388 -71.267, 712 m, 18.ix.2016, L. Packer, two females; CHILE, RM. Farellones, curva 18, – 33.335 -70.328, 1895 m, 14.ii.[20]13, L. Packer, yellow pan trap, one female; CHILE, Region V, Granizo, – 032.980 -71.170, 263 m, 9.ix.2016, L. Packer, one female; CHILE, Region Metropolitana, Espinalillo, – 33.004 -70.94241, 999 m, 17.ix.2016, L. Packer, two females; CHILE, Region VI, Cuesta La Lajuela, – 34.663 -71.418313 m, 21.ix.2016, L. Packer, one male. All at PCYU.

This Chilean endemic is the most commonly collected species in the genus and occurs from Vallenar in Region III to Temuco in Region IX.

Discussion

Cleptoparasitic bees arguably occupy a trophic level above that of other bees because they rely upon the activities of their host, rather than only plants, for their survival. Consequently, these bees are expected to persist at lower population sizes and likely be more sensitive to declining environmental conditions than are their hosts, especially if the cleptoparasites are host specific. Thus, they should be particularly sensitive indicators of the condition of their habitats [2]. Unfortunately, the taxonomic impediment is seemingly worse for cleptoparasitic bees than for their hosts [1, 20–22] making additional taxonomic studies important. In this paper we describe four new species of cleptoparasitic bee from the tribe Isepeolini, and only one of them is known from more than two specimens.

In areas of low primary productivity, such as the deserts of northern Chile, resources to maintain wildlife populations are severely limited (see Figs. 9, 11 and 14) and species at higher trophic levels likely persist under precarious conditions. The type locality of *M. desiccata* in particular is sparsely vegetated (Fig. 9). Previously [22] the senior author described two cleptoparasitic species of the tribe Epeolini also from northern Chile, each known from only a single specimen. The areas where all six of these species have been collected have been the subject of extensive sampling, both with net and passive collecting methods such as pan traps and blue vane traps containing propylene glycol and left out in the field for periods from days to months (in a few instances for blue vane traps, more than a year). The fact that so few specimens have been obtained among these six species, a total of 16 individuals, suggests that they do indeed persist at low frequencies.

Conclusions

We have described four new species of Isepeolini from remote areas of Chile. Additional sampling in these areas will doubtless yield many more interesting new species.

Methods

Our decision to consider these species as previously undescribed is based on morphological features that are commonly used to differentiate bee species in general and species of Isepeolini in particular [5] as well as comparison of specimens to those of their closest relatives, including those identified by the previous revisor of the group [5]. These differences are outlined in the diagnoses and comments sections for each species separately.

The description follows the general outline of recent papers from our laboratory (e.g. [1, 23, 24] with the following acronyms: F, S and T for flagellum, sternum and

tergum followed by the relevant respective number; UOD, LOD, IOD and OOC for upper and lower ocular and interocellar and ocellocular distances respectively. Contrary to our previous usage, UOD and LOD are taken from the upper and lower tangents of the compound eyes in frontal view respectively (rather than being the minimum distances for the upper and lower convexities in the inner margin of the eyes as in earlier papers). This change necessitated by the less distinctly concave inner margins of the compound eyes of these bees. An additional acronym, MINOD, is used for the shortest distance between the inner margins of the compound eyes. ITW refers to the intertegular width of the mesoscutum. The apex of the genital capsule of males bears two processes. Roig-Alsina [5] termed the dorsal one the gonostylus and the ventral one the digitiform ventral lobe. Many bees similarly have two apical processes arising from the gonocoxa and these are often both referred to as "gonostyli" so we here refer to these as the dorsal and ventral gonostyli. The integumental surface of these bees is almost entirely lacking in microsculpture which is often limited to weak imbrication on the basal portion of the metapostnotum (this term is used rather than propodeum following general recent usage in melittology). Thus, in the descriptions that follow, the integumental surface is shiny and lacking microsculpture unless stated otherwise. Puncture spacing is given in terms of the relative distance between punctures (i) to the puncture diameters (d) and often given as ranges, e.g. i = 1-3d.

The specimens we have collected result from long term sampling in Chile, in which earlier work relied primarily on insect nets and pan traps (e.g. [24]), with the more recent addition of blue vane traps containing propylene glycol. These are sometimes left out for weeks or months at a time, especially in areas that are difficult to access and with unpredictable rainfall, as is usually the case in northern Chile. Unfortunately, some specimens were somewhat degraded as a result of being kept in liquid at high temperatures for an extended period. Nonetheless, two such poor quality specimens are described here because they clearly differ from previously described species and because extensive sampling has taken place at all localities since their collection dates with no further specimens being collected.

Locality coordinates for material we collected are given as decimal degrees as obtained with a Garmin etrex 30 GPS, rounded to three decimal figures except when the data are from other collectors where the method of georeferencing is unknown. The map in Fig. 5 was produced by the authors using SimpleMappr [25].

Images were taken with a Visionary Digital BK Plus imaging system using a Canon EOS 5D Mark II digital SLR camera and processed with Adobe Photoshop CS6 Extended.

Institutional acronyms are as follows: AMNH – American Museum of Natural History, New York, United States of America; DEBU – Department of Evolutionary Biology, University of Guelph, Guelph, Ontario, Canada; MNHN – National Museum of Natural History, Santiago, Chile; PCYU – Packer Collection at York University, Toronto, Ontario, Canada; PUCV – Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile; UCR – University of California Riverside, Riverside, USA.

Abbreviations

T: Terga; S: Sterna; n.: New; sp.: Species; F: Flagellum; UOD: Upper ocular distance; LOD: Lower ocular distance; IOD: Interocellar distance; OOD: Ocellocular distance; MINOD: Minimum distance between the inner margins of the compound eyes; ITW: Intertegular width of mesoscutum; d: Diameter of puncture;, i: Interpuncture space; mm: Millimetre; km: Kilometre; AMNH: American Museum of Natural History, New York, United States of America; DEBU: Department of Evolutionary Biology, University of Guelph, Guelph, Ontario, Canada; MNMH: National Museum of Natural History, Santiago, Chile; PCYU: Packer Collection at York University, Toronto, Ontario, Canada; PUCV: Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile; UCR: University of California Riverside, Riverside, USA; ICZN: International Code of Zoological Nomenclature; LSID: ZooBank Life Science Identifiers; M+Cu: Media and cubitus veins; MOD: Diameter of median ocellus; bvt: Blue vane trap; L: Length; W: Width

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Availability to data and materials

Not applicable.

Authors' contributions

LP collected the majority of the specimens described, wrote the descriptions and the dichotomous key. LG provided extensive revisions to the paper along with providing all the images used. The author(s) read and approved the final manuscript.

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Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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References

1. Onuferko TM. A revision of the cleptoparasitic bee genus *Epeolus* Latreille for Nearctic species, north of Mexico (Hymenoptera: Apidae). Zookeys. 2018;755:1–185.
2. Sheffield CS, Pindar A, Packer L, Kevan PG. The potential of cleptoparasitic bees as indicator taxa for assessing bee communities. Apidologie. 2013;44:501–10.

3. Cardinal S, Straka J, Danforth BN. Comprehensive phylogeny of apid bees reveals the evolutionary origins and antiquity of cleptoparasitism. Proc Natl Acad Sci. 2010;107:16207–11.
4. Rozen JG. Systematic and geographic distributions of Neotropical cleptoparasitic bees, with notes on their modes of parasitism. In: Hartfelder K, editor. Anais IV Encontro Sobre Abelhas. Ribeirão Preto: Bitondi MMG; 2000. p. 204–10.
5. Roig AA. Revision of the cleptoparasitic bee tribe Isepeolini. Univ Kans Sci Bull. 1991;54:257–88.
6. Cockerell TDA. Descriptions and records of bees – XV. Ann Mag Nat Hist. 1907;7(20):59–68.
7. Taschenberg E. Die Gattungen der Bienen (Anthophila). Berl Entomol Zeis. 1883;27:37–100.
8. Friese H. Neue Formen von Schmarotzerbienen besonders aus dem paläarktischen Gebiet. Konowia. 1925;4:27–42.
9. Latreille PA. Histoire naturelle des fourmis et recuei de mémoirs et d'observation sur les abeilles, les areignées, les faucheurs et autres insectes. Paris: Barrois; 1802.
10. Spinola M. Himenópteros. In: Gay C, editor. Historía física y política de Chile, vol. 6; 1851. p. 153–569.
11. Toro H, Rojas F. Dos nuevas especies de *Isepeolus* con clave de los especies chilenas. Rev Chil Ent. 1968;6:55–60.
12. Jörgensen P. Revision der Apiden der provinz Mendoza, Republica Argentina (Hym.). Zool Jahrb Abt Syst Geogr Biol Tiere. 1912;32:89–162.
13. Ferrari RR. Taxonomic revision of the species of *Colletes* Latreille, 1802 (Hymenoptera: Colletidae: Colletinae) found in Chile. Zootaxa. 2017;4364:1–137.
14. Vachal J. Espèces nouvelles ou litigieuses d' Apidae du haut Bassin du Parana et des régions contigües et délimitation d' une nouvelle sous-famille Diphaglossinae (Hym.). Revue d'Entomologie. 1909;28:5–64.
15. Friese H. Die Apidae (Blumenwespen) von Argentina nach den Reisenergebnissen der Herren A.C. jensen-Haarup und P. Jörgensen in der Jahren 1904-1907. Flora Fauna. 1908;10:1–94.
16. Moure JS. Algumas espécies novas de *Colletes* do Brasil e do Chile (Hymenopt.- Apoidea). Dusenia. 1956;7:197–210.
17. Janvier H. Le nid et la nidification chez quelques abeilles des Andes tropicales. Ann Sci Nat Zool Biol Anim. 1955;17:311–49.
18. Friese H. Neue Bienenarten Süd-America's. Ent Nachr. 1900;26:180–4.
19. Toro H. Una nueva especie de *Isepeolus* (Hym. Anthophoridae) de Chile. An Mus His Nat Valparaíso. 1971;4:261–5.
20. Magnacca KN, Brown MJ. DNA barcoding a regional fauna: Irish solitary bees. Mol Ecol Resour. 2012;9(6):196–207. https://doi.org/10.1111/j.1755-0998-2009.02645.x.
21. Engel MS, Packer L, Martins D. The cleptoparasitic bee genus *Chiasmognathus* (Hymenoptera: Apidae) in Kenya, wth the description of two new species. J East Afr Nat Hist Soc. 2019;108(1):17–36. https://doi.org/10.2982/028.108.0102.
22. Packer L. Two new species of Epeolini (Hymenoptera: Apoidea: Apidae) from Chile with the first record of *Triepeolus* from the country and a key to Chilean *Doeringiella* species. J Melittol. 2016;64:1–11.
23. Packer L, Dumesh S. Fifteen new species of *Chilicola (Oroediscelis)* (Hymenoptera: Colletidae, Xeromelissinae) with illustrated keys to the males and females of the subgenus. Zootaxa. 2019;4459:1–56.
24. Mir Sharifi N, Graham L, Packer L. Fifteen new species of *Liphanthus* Reed (Hymenoptera: Andrenidae) with two submarginal cells. Zootaxa. 2019; in press.
25. Shorthouse DP. SimpleMappr, an online tool to produce publication-quality point maps. 2010. https://www.simplemappr.net/. Accessed 22 Sept 2019.

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