

Lost in the city: discovery of the rare ant genus *Leptanilla* (Hymenoptera: Formicidae) in Macau with description of *Leptanilla macauensis* sp. nov.

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ABSTRACT. The rare ant genus *Leptanilla* was discovered in Macau SAR, China for the first time, which represents the second record for this genus in southeastern China. Through the detailed examination, the new species *Leptanilla macauensis* sp. nov. described here has unique character conditions particularly in the structure of the clypeus and subpetiolar process. Moreover, the discovery of *L. macauensis* sp. nov. within an island of vegetation surrounded by a dense urbanized matrix illustrates future possibilities for the discovery of new species in South East Asia, including within heavily disturbed environments.

Keywords: Leptanillinae, *Leptanilla*, Macao, new species, urbanized habitat

INTRODUCTION

The ant genus *Leptanilla* Emery, 1870 consists of 46 species globally (AntCat 2017). This genus belongs to the subfamily Leptanillinae, which is considered as one of the early ant lineages (Brady *et al.* 2006), and *Leptanilla* is characterized among Leptanillinae by the presence of a distinct postpetiole, subtriangular mandible with 3 to 5 teeth, exposed antennal insertion close to the anterior margin of clypeus, pronotum and mesonotum completely separated by promesonotal suture, and slender body shape (Bolton 1990), with peculiar subterranean life history (Brady *et al.* 2006). Masuko (1989, 1990) documented the feeding habits of *L. japonica* Baroni Urbani, 1977, with workers being specialized predators of geophilomorph centipedes, while the queen feeds on hemolymph produced by larvae from

specialized duct organs. The cryptobiotic and subterranean habits of *Leptanilla* ants limits the collection of the worker and queen castes (Baroni Urbani 1977; Bolton 1990; Wong & Guénard 2016), with the use of specific subterranean sampling methods increasing the capture of Leptanillinae workers (Man *et al.* 2017, Wong & Guénard 2017).

In the Oriental region, 17 species of *Leptanilla* have been recorded so far (antmaps.org 2017; Guénard *et al.* 2017). However, both the diversity and distribution of *Leptanilla* species are probably underestimated as shown by their patchy distribution in Asia and the recent records of new species or records collected through the use of leaf litter or subterranean sampling methods (Wong & Guénard 2016). For instance, Wong and Guénard (2016) used subterranean traps and Winkler extractors, and discovered a

new species, *L. hypodracos*, in Singapore and recorded a species *L. cf. japonica* from Hong Kong. However, until recently, these collecting methods have been seldom used in China (Liu *et al.* 2015; Man *et al.* 2017). *Leptanilla* species are generally collected from forested habitats, including within secondary forests (Masuko 1989, Wong & Guénard 2016, Man *et al.* 2017).

In the present study, a new species, *Leptanilla macauensis* sp. nov., is described based on workers recently collected using a Winkler extractor in a highly urbanized site on a small hill of Macau SAR, southeastern China. It can be distinguished from other Asian species by a combination of character conditions, particularly found in the structure of the clypeus and subpetiolar process. In addition, the updated key to the Oriental and Sino-Japanese species of *Leptanilla* is provided.

MATERIALS & METHODS

The holotype (worker) and three paratype workers were point-mounted, and used for morphological examination; one paratype worker is preserved in a vial within 95% ethanol. Type specimens are deposited in the following institutions/collections.

CAS	California Academy of Sciences, San Francisco, CA, USA
SBSHKU	Insect Biodiversity and Biogeography Laboratory, School of Biological Sciences, the University of Hong Kong, Hong Kong SAR
SKYC	Sk. Yamane collection, Kagoshima Prefecture, Japan

Terminology

The morphological terminology follows Baroni Urbani (1977) and Bolton (1990).

Measurements and indices definitions are described below and presented in Figure 1.

HL Head length. Maximum length of head in full-face view, measured from mid-point of anterior clypeal margin to mid-point of line across the posteriormost points of head.

HW	Head width. Maximum width of head in full-face view.
MaL	Mandible length. Maximum length of mandible in full-face view, measured from posterolateral base to apex of mandible.
SL	Scape length. Maximum length of scape excluding basal neck and condyle.
PnW	Pronotal width. Maximum width of pronotum in dorsal view.
PnH	Pronotal length. Maximum length of pronotum in dorsal view, measured between anterior and posterior margins.
MW	Mesonotal width. Maximum width of mesonotum in dorsal view.
PtL	Petiole length. Maximum length of petiole in dorsal view.
PtW	Petiole width. Maximum width of petiole in dorsal view.
PtH	Petiole height. Maximum height of petiole in lateral view, measured from dorsalmost point of node to ventralmost point of sternite.
PpL	Postpetiole length. Maximum length of postpetiole in dorsal view (excluding helcium).
PpW	Postpetiole width. Maximum width of postpetiole in dorsal view.
PpH	Postpetiole height. Maximum height of postpetiole in lateral view, measured from dorsalmost point of node to ventralmost point of sternite.
WL	Weber's Length of mesosoma, measured from the point between cervical shield and pronotum to posteroventral point of propodeum.

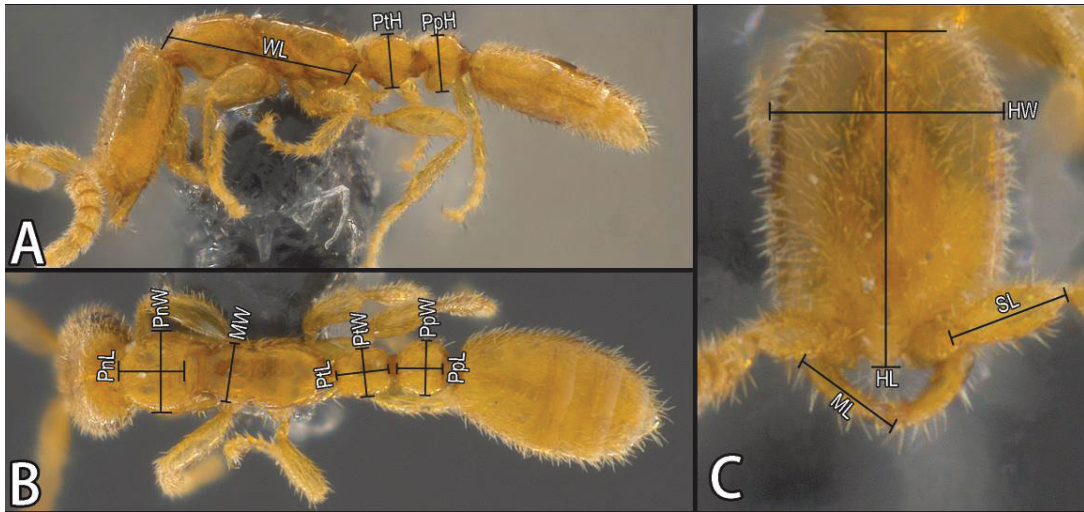


Fig. 1. Measurements of the *Leptanilla* worker caste: A: body, lateral view; B: body, dorsal view; C: head, full-face view. Abbreviations are shown in the section of Materials and Methods.



Fig. 2. Holotype worker-LCM00039 *L. macauensis* sp. nov., head in full-face view.

- TL Total length. Total length = HL + ML (mesosoma length, measured from anterior-most point of pronotum to posteriormost point of propodeum) + PtL + PpL + GL (gastral length, excluding sting).
- CI Cephalic Index. $(HW \div HL) \times 100$
- SI Scape Index. $(SL \div HW) \times 100$
- MaL Mandibular Index. $(MaL \div HW) \times 100$
- PI Petiolar Index. $(PtW \div PtL) \times 100$
- PHI Petiolar Height Index. $(PtW \div PtH) \times 100$
- PPI Postpetiolar Index. $(PpW \div PpL) \times 100$
- PPHI Postpetiolar Height Index. $(PpW \div PpH) \times 100$

All specimens were examined under stereomicroscopes (Leica M205C; Leica Z16 APO, Wetzlar, Germany; Nikon SMZ18, Japan), and photographed using digital cameras (Leica DFC450 or DFC490, Wetzlar, Germany), with a total of 25 to 30 images per view taken, then post-processed by the software Helicon Focus 6.3.5 (Helicon Soft., Kharkiv, Ukraine) or Leica Application Suite V4 software. SEM images were taken by a scanning electron microscope (JSEM-5600, JEOL); specimens were sputter-coated using a sputter coater (SPI Module). Finally, the pictures were typeset by Photoshop CC (Adobe® Photoshop® software). The measurements of specimens were firstly accurate to 0.001 mm and secondarily rounded to the nearest 0.01 mm by the software ImageJ (Schindelin *et al.* 2012). In addition to comparing other *Leptanilla* species from Oceania, Oriental and Sino-Japanese regions, images of types of *Leptanilla* species (*L. butteli* CASENT0901484, *L. escheri* CASENT0907607, *L. japonica* CASENT0902775, *L. lamellata* AN-TWEB1008004, *L. oceanica* CASENT0911452, *L. taiwanensis* CASENT0902777, *L. tanakai* CASENT0911453, *L. thai* CASENT0911455, *L. havilandi* CASENT0907032, *L. yunnanensis* CASENT0235340) were examined when available in Antweb.org (2017); the specimens (*L. clypeata*, *L. hypodracos* MW150615-1.2); and the original descriptions.

TAXONOMY

Leptanilla macauensis Leong, Yamane & Guénard, **sp. nov.**

<http://zoobank.org/DCE005C4-CF69-4A3F-A94F-DB0F47C17FD6>

(Figs. 2, 5, and 7: holotype (worker), Figs. 3, 4, 6, 8, and 9: paratype workers)

Leptanilla sp. mo01: Leong *et al.* 2017: 12

Holotype. Worker, Macau SAR, Ilha Verde Hill, 22.21191°N, 113.53778°E, 21 m elevation, 25.I.2017, Winkler extractor set up for seven days, leg. C. M. Leong, specimen ID and depository: “CML20170125a, LCM00039” in SBSHKU.

Paratypes. Four workers from the same Winkler extractor sample as the holotype, “CML20170125a, LCM00003” in SKYC, “CML20170125a, LCM00001” in CAS, “CML20170125a, LCM00002” in SBSHKU, “CML20170125a, LCM00040 in SBSHKU (kept in 95% alcohol; head separated with the mesosoma and bited on a minor of *Pheidole megacephala*).

Measurements (mm) and indices. Holotype (worker): HL: 0.25; HW: 0.18; MaL: 0.09; SL: 0.10; PnW: 0.13; PnH: 0.12; MW: 0.10; PtL: 0.09; PtW: 0.07; PtH: 0.09; PpL: 0.07; PpW: 0.08; PpH: 0.10; WL: 0.32; TL: 1.12; CI: 72, SI: 49, MaL: 55, PI: 84, PHI: 78, PPI: 118, PPHI: 80.

Paratype workers (n=3): HL: 0.25–0.26; HW: 0.18–0.19; MaL: 0.10–0.11; SL: 0.09–0.11; PnW: 0.12–0.13; PnH: 0.09–0.11; MW: 0.10–0.11; PtL: 0.08; PtW: 0.07; PtH: 0.09; PpL: 0.07; PpW: 0.08; PpH: 0.10; WL: 0.31–0.33; TL: 1.12–1.14; CI: 72–74, SI: 49–56, MaL: 51–56, PI: 84–88, PHI: 78–81, PPI: 118–124, PPHI: 80–86.

Description of worker. Head. In full-face view (Fig. 2), head rectangular, distinctly longer than broad (CI: 72–74), with moderately concave posterior margin and weakly convex lateral margin, with posterolateral corners rounded. Clypeus (Fig. 3) not posteriorly separating from frons; anteromedian portion of clypeus forming a roundly raised disc of which anteromedian margin is

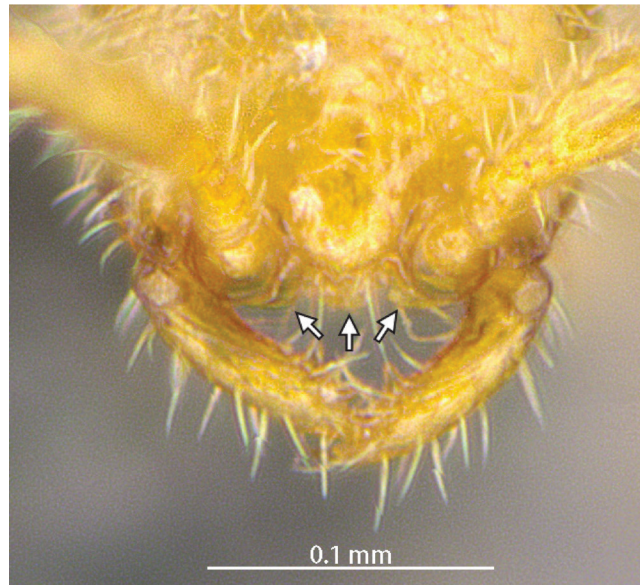


Fig. 3. Paratype worker-LCM00002 *L. macauensis* sp. nov., clypeus (the arrows indicate the clypeal lobes).

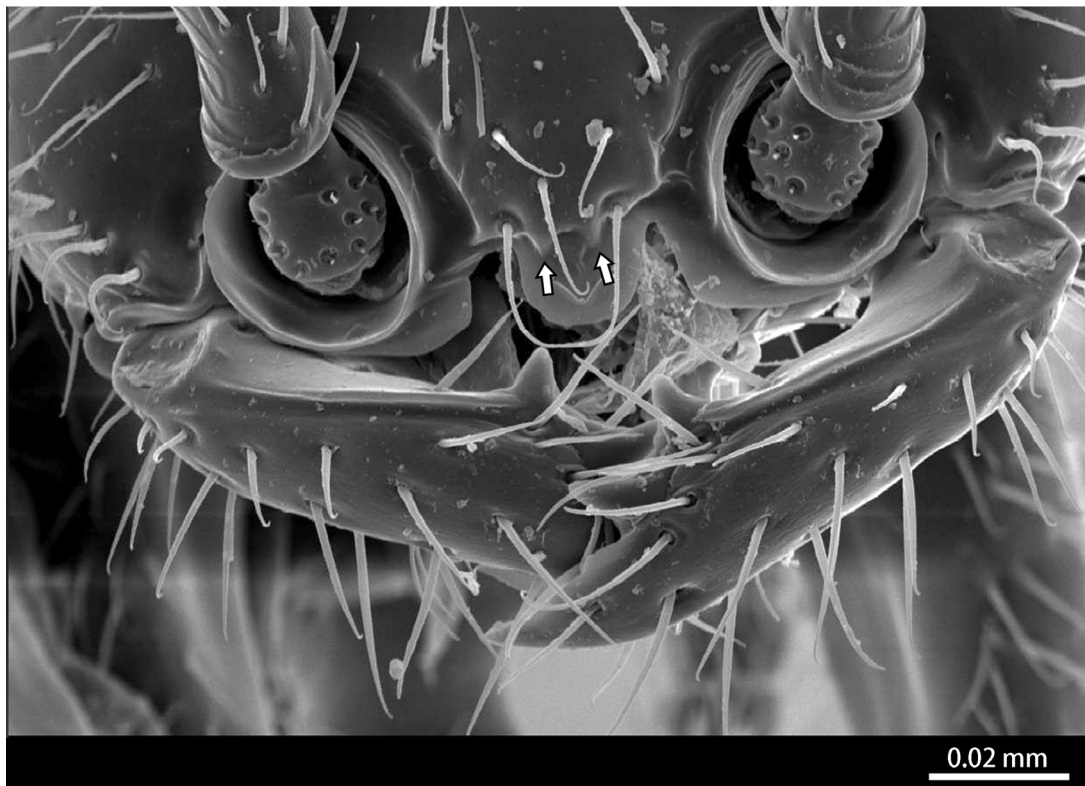


Fig. 4. Paratype worker-LCM00001 *L. macauensis* sp. nov., clypeus (the arrows indicate the extensions).

armed with a pair of triangular extensions (Fig. 4); the disc separated from antennal socket by deep furrow: three short anterior lobes extended from clypeus, clearly differentiated from raised disc; the median lobe separated by distinct gap from lateral lobes (Fig. 3). Eyes absent. Masticatory margin of mandible (Fig. 4) with a total of three distinct teeth; basal tooth strong and upward-directed; preapical tooth almost as large as basal tooth; apical tooth very strong. Antenna 12-segmented; scape rather short and widest at its middle portion, not reaching mid-length of head; pedicel cone-shaped, distinctly narrowed toward base; each of 3rd to 11th segments very short, distinctly broader than long; 12th segment almost twice as long as broad, 2.7 times as long as each of 10th and 11th segments.

Mesosoma. Mesosoma with promesonotal suture deeply incised, without metanotal groove, with dorsum in lateral view flat but interrupted by promesonotal suture. Pronotal neck in dorsal view gradually narrowed anteriorly, with weakly convex anterior margin; pronotal disc (pronotum excluding the neck) in dorsal view almost as long as broad, with weakly convex anterior margin, roundly convex lateral margin, and weakly convex posterior margin; posterolateral corner of the disc produced posteriorly (Fig. 6A). Propleuron in lateral view (Fig. 7) triangular in shape. Mesonotum in dorsal view with round anterolateral corner and straight lateral margin. Metapleuron clearly separated from mesopleuron by distinctly incised suture, with a deep pit at upper most point, but not demarcated from lateral face of propodeum; metapleural gland orifice large and oval (Fig. 8).

Metasoma. Petiolar node (abdominal segment II) in dorsal view (Fig. 5) rectangular, clearly longer than broad (PI: 84–88), with weakly concave straight anterior, moderately convex posterior, and convex lateral margins; petiolar node in lateral view (Fig. 7) with steep and slightly convex anterior and posterior margins, and with roundly convex dorsal margin; petiolar spiracle located close to anterior margin of tergite; ventral margin of sternite convex, with shallow median indentation; subpetiolar process poorly developed as a small and hook-like spine (Fig. 9). Postpetiolar node (abdominal segment III) in dorsal view sub-

circular, broader than long (PPI: 118–124), with almost straight anterior margin and weakly convex posterior margin, in lateral view sub-round dorsally; sternite large, bulging ventrally, not clearly differentiated from tergite, but postpetiole with anterior incision; spiracle located behind the incision. Abdominal segment IV (gastral segment I) in dorsal view slightly longer than broad, narrowed anteriorly; anterior margin widely concave and notched; lateral margin convex.

Sculpture. Body extensively smooth and shining; punctation generally sparse and superficial. Head superficially punctate, with smooth interspace; disc of clypeus smooth; mandible deeply punctate on outer surface; antenna densely punctate, with interspaces smooth. Pronotal neck with about 10 transverse striae (Fig. 6A); antermost section of mesonotum bearing some strong and transverse striae; upper half of mesopleuron, metapleuron and lateral face of propodeum with superficial punctuation; lower half of mesopleuron reticulate-striate; area around metapleural gland orifice nearly transversely striate; petiolar node superficially punctate on its dorsum; lower half of the node and pre- and poststernite of petiole reticulate-punctate; postpetiolar node superficially punctate on dorsum; pre- and poststernite of postpetiole transversely striate; gastral tergites almost smooth, at most with sparse and superficial punctuation.

Pilosity. Head including mandible with dense hairs, with some portions glabrous (Fig. 6C, condition can be variable among specimens); antenna with dense short erect and suberect hairs. Hair condition on mesosoma heterogeneous; pronotum with dense short hairs mixed with sparser, longer hairs; mesonotum, and dorsa of propodeum and waist with most hairs relatively long and often slanting, with reduced pilosity of short hairs; venter of waist with sparse, relatively long hairs. Gastral tergites with dense suberect hairs and few short decumbent hairs; sternites with sparsely distributed and long suberect hairs. Fore-leg with a few decumbent hairs on outer surface of femur, and scattered hairs on tibia; basitarsus with about 10 thick and suberect hairs on ventral surface (Fig. 6D). Mid- and hind legs with dense decumbent hairs on femora (more hairs on outer



Fig. 5. Holotype worker-LCM00039 *L. macauensis* sp. nov. in dorsal view.

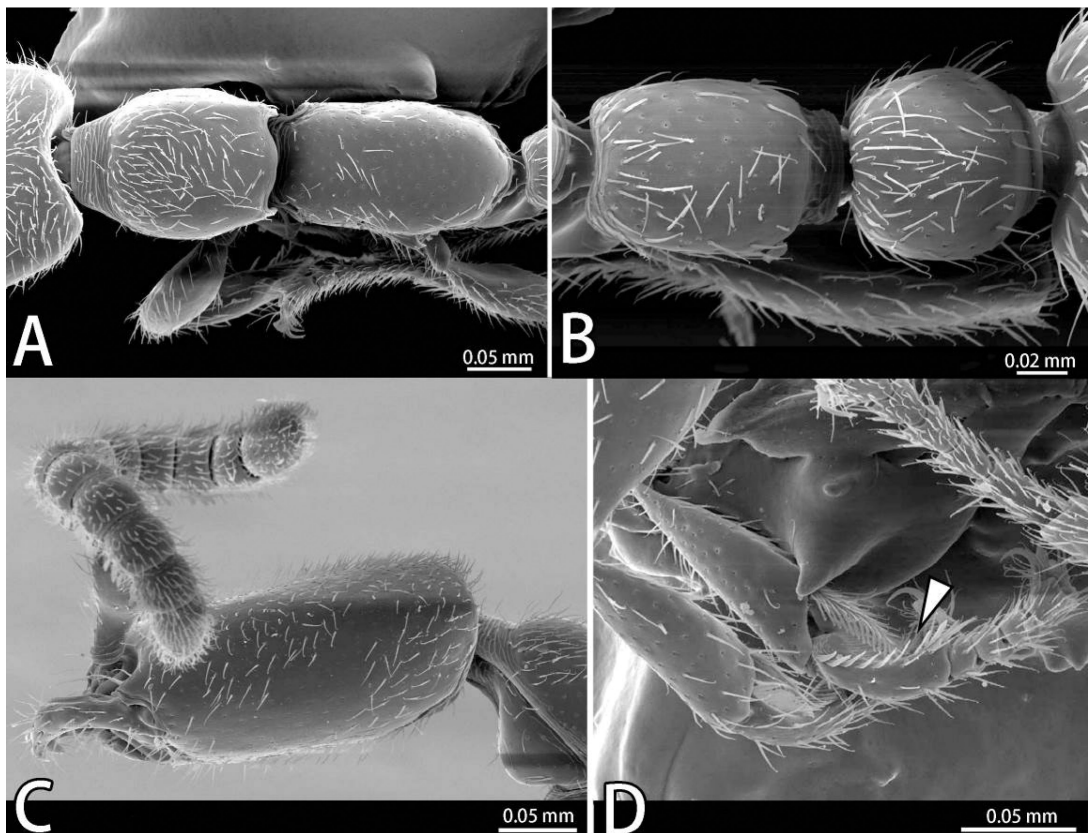


Fig. 6. Paratype worker-LCM00001 *L. macauensis* sp. nov., A: mesosoma, dorsal view; B: petiole and postpetiole, dorsal view; C: head, lateral view; D: basitarsus, lateral view (the arrow indicate the basitarsus of foreleg).



Fig. 7. Holotype worker-LCM00039 *L. macauensis* sp. nov. in lateral view.

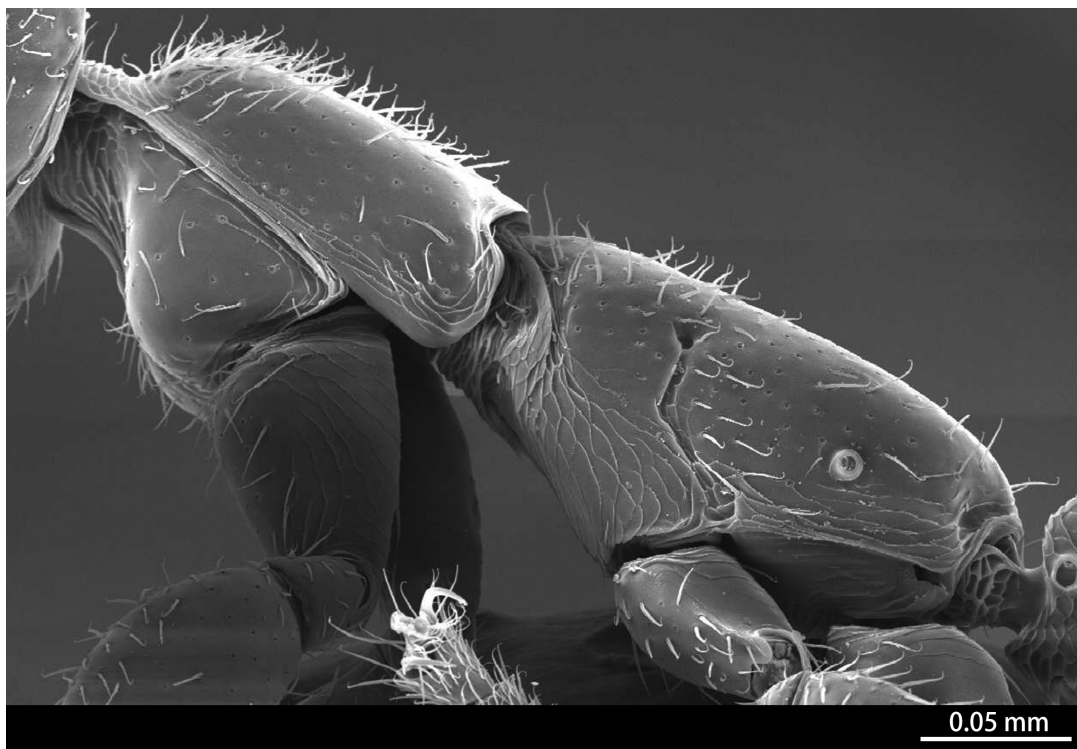


Fig. 8. Paratype worker-LCM00001 *L. macauensis* sp. nov. mesosoma in lateral view.

face), and extremely dense hairs on tibiae.

Coloration. Body yellowish brown; antennae and legs lighter.

Entomology. The specific epithet is given after the type locality (Macau).

Distribution. Macau SAR, China.

Diagnosis of worker. *Leptanilla macauensis* sp. nov. can be easily distinguished from other species in the Oceanian, Oriental and Sino-Japanese regions (Holt *et al.* 2013) by a combination of the following characteristics: clypeus posteriorly

not demarcated from frons; clypeal margin with a distinct median lobe and two developed lateral lobes; a total of 3 distinct teeth present on masticatory margin of mandible; metanotal groove absent; subpetiolar process forming a small and hook-like spine. Moreover, basitarsus of foreleg with about 10 thick and erect hairs on the ventral

surface, whereas basitarsus of foreleg with densely comb-like hairs in *L. morimotoi*, which is similar in some aspects to the new species. Furthermore, *L. macauensis* sp. nov. is relatively small compared with other congeners from the Oriental and Sino-Japanese regions based on average head width (Figure 10).

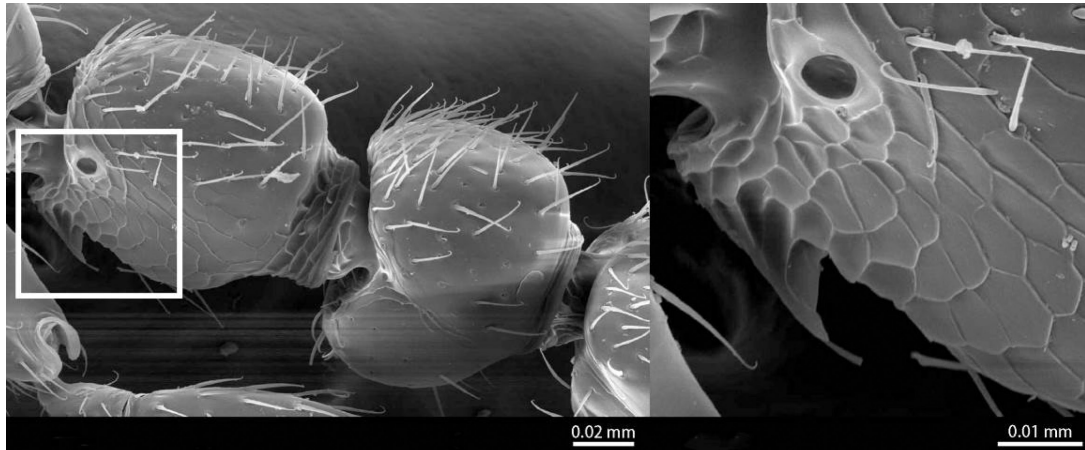


Fig. 9. Paratype worker-LCM00001 *L. macauensis* sp. nov. Petiole and postpetiole, lateral view.

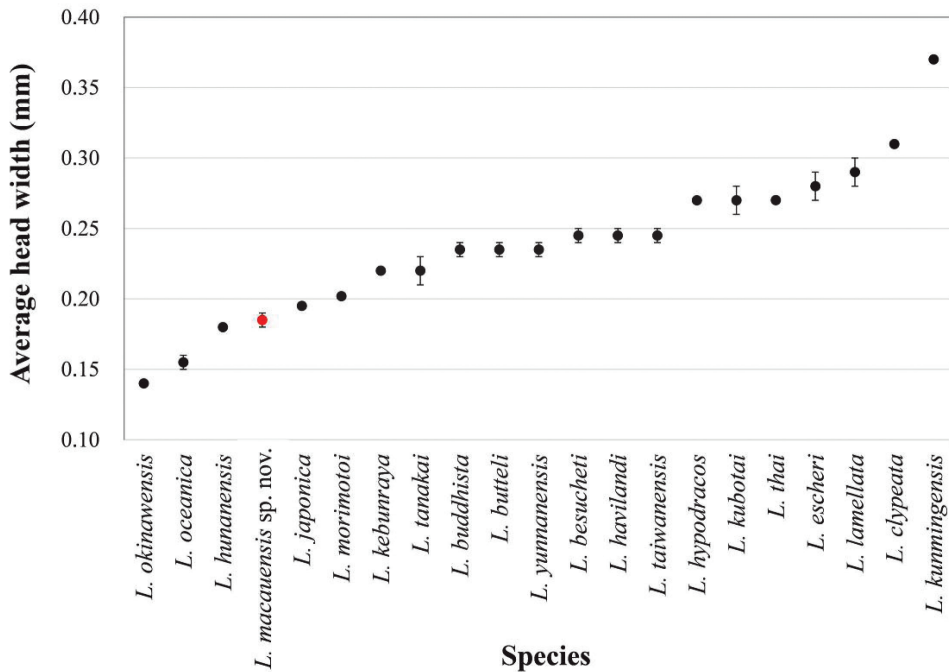


Fig. 10. Average head width of twenty one *Leptanilla* species from the Oriental and Sino-Japanese regions; red color point represents *L. macauensis* sp. nov. and bars mean the range of head width when available (Data shown in appendix 1).

Remark. *Leptanilla macauensis* sp. nov. was collected with a Winkler extractor from the upper layer of soil consisting of fine sand, soil and leaf litter. It should be noted that within the same sample a geophilomorph centipede and two ant species (*Pheidole megacephala*, and *Tapinoma indicum*) were also collected. The sampling site was located near the stairs set on hillside in Ilha Verde Hill (Fig. 11A), which had a small secondary forest of about 4.3 ha in area. Moreover, the hill was surrounded by highly urbanized areas, isolated as an island, which is thought to be difficult for the permanently wingless *Leptanilla* queen to colonize (see Bolton 1990). Historically, the Ilha Verde Hill was a small island (based on the historical map of 1912; Fig. 11B), however, due to the expansion of reclamation area, became connected to the Macau Peninsula, and since 1986 the urbanization has constantly reduced the size of natural areas. Although the species of *Leptanilla* are often collected from relatively good forests (Wong & Guénard 2016; e.g. *L. hypodracos*), the case for *L. macauensis* sp. nov. suggests that some *Leptanilla* species can survive in small fragments of forest habitats surrounded by intense urbanization. Moreover, the results are consistent with previous studies in that the small forest/natural area might provide a niche for maintaining ant diversity within an urban matrix (Menke *et al.* 2011; Guénard *et al.* 2015), and also that peculiar collecting methods might provide an insight into how to discover cryptobiotic ants (Wong & Guénard 2017).

So far, only two records of *Leptanilla* have been found in southeastern China. Regarding the first record, *Leptanilla* sp. cf. *japonica* from Hong Kong (CASENT0914941, Antweb.org 2017), *L. macauensis* sp. nov. can be distinguished from *Leptanilla* sp. cf. *japonica* by the combination of the following conditions; posterior margin of head concave in the former but almost straight in the latter; distinct median clypeal lobe present in the former but absent in the latter; propodeal dorsum glabrous in the former but with distinct hairs in the latter; and body larger in the former (HL: 0.25–0.26 mm, HW: 0.18–0.19 mm; n=4) than in the latter (HL: 0.19 mm, HW: 0.13 mm; n=1).

Updated worker key to *Leptanilla* species from the Oriental and Sino-Japanese regions:

This key is modified from the keys to the Oriental species constructed by Bharti and Kumar (2012), and Wong and Guénard (2016). To extend the key to include the Sino-Japanese species as well as the Oriental species (total 21 spp.) and prepare the scatter chart (Figure 10), previous publications were additionally consulted (Yasumatsu 1960; Baroni Urbani 1977; Tang *et al.* 1992; Ito *et al.* 2001; Xu 2002; Xu & Zhang 2002; Terayama 2013). In some critical cases, we use measurements and indices as a useful discriminating character, considering a large interspecific variation in body size as suggested by Baroni Urbani (1977).

- 1) Masticatory margin of mandible with 2 teeth..... 2
 - Masticatory margin of mandible with 3 teeth or more 3
- 2) Anterolateral lobes of clypeus present. 3rd antennal segment with a distinct basal peduncle. Dorsal view of petiolar node with arched anterior margin. Promesonotal suture narrow *L. kebunraya* Yamane & Ito
 - Anterolateral lobes of clypeus absent. 3rd antennal segment without distinct basal peduncle. Dorsal view of petiolar node rectangular. Promesonotal suture wide *L. butteli* Forel
- 3) Masticatory margin of mandible with 4 teeth.. 4
 - Masticatory margin of mandible with 3 teeth.... 5
- 4) Full face view of 3rd abdominal tergum strongly narrow in its anterior part (posterior margin more than two times as wide as anterior margin, and distinctly longer than its width (see Fig. 33 in Baroni-Urbani, 1977). The basal tooth of masticatory margin of mandible distinct *L. tanakai* Baroni Urbani

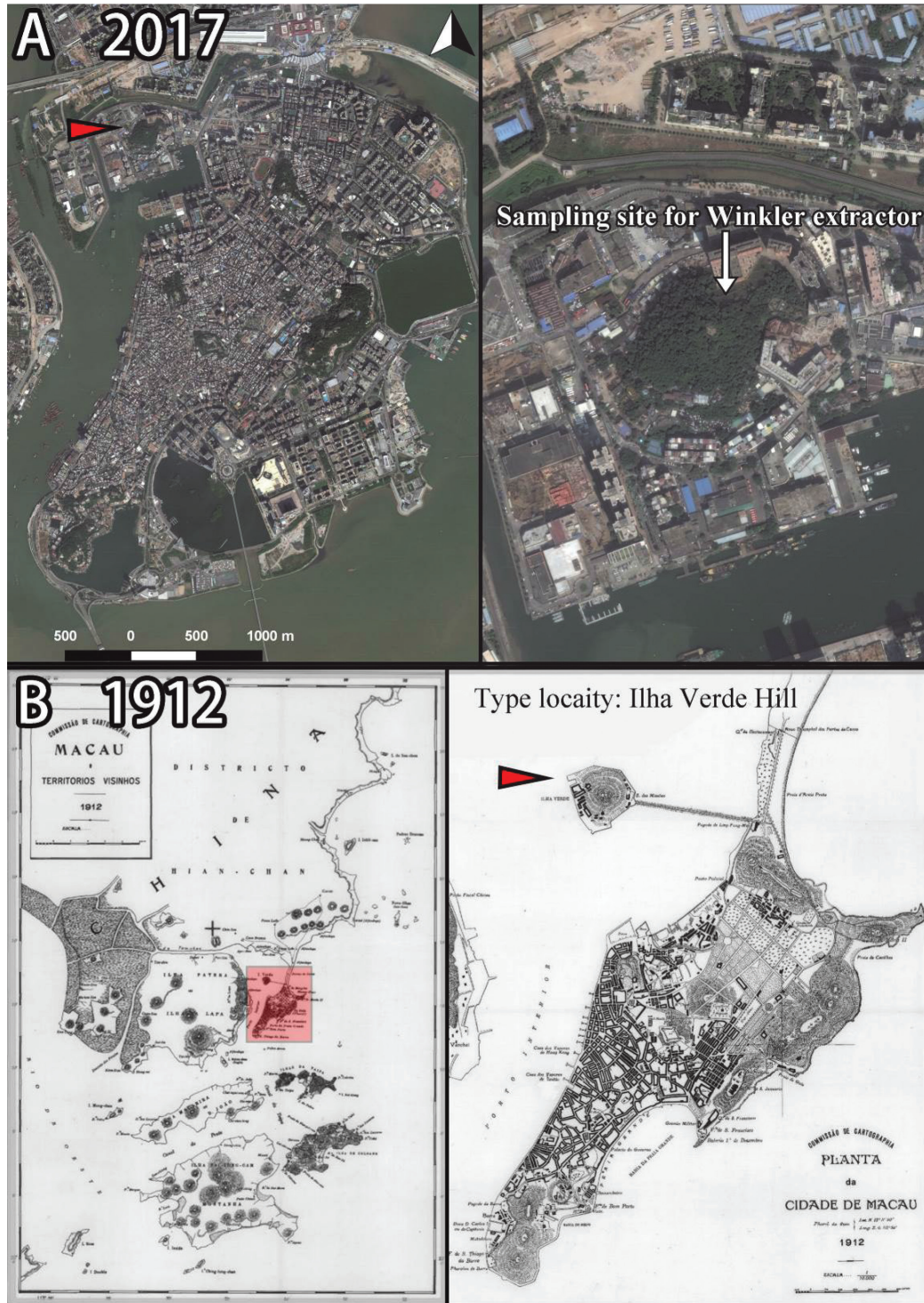


Fig. 11. A: Type locality of *L. macauensis* sp. nov. (red arrow; Ilha Verde Hill, Macau) and the right map shows Ilha Verde Hill with the sampling site for Winkler extractor (from Google Map 2017); B: Type locality (red arrow; Ilha Verde Hill, Macau) in 1912 (from David Rumsey Map Collection 2017); the red rectangular of left map shows the location of right map.

- Full face view of 3rd abdominal tergum weakly narrow in its anterior part (posterior margin almost one half times as wide as anterior margin, and as long as its width (see Fig. 32 in Baroni-Urbani, 1977). The basal tooth of masticatory margin of mandible very small and difficult to distinguish *L. japonica* Baroni Urbani
- 5) Metanotal groove present 6
- Metanotal groove absent 7
- 6) In full-face view head approximately rectangular. Clypeus not protruding, with anterior margin roundly convex. In profile view dorsum of petiole almost straight. In dorsal view postpetiolar node much wider than petiolar node. Smaller species; HW: ca. 0.180 mm *L. hunanensis* Tang, Li & Chen
- In full-face view head distinctly narrowed anteriorly. Clypeus protruding, with anterior margin concave. In profile view dorsum of petiole roundly convex. In dorsal view postpetiolar node as wide as petiolar node. Larger species; HW: ca. 0.370 mm *L. kunmingensis* Xu & Zhang
- 7) Anterior margin of clypeus more or less straight or weakly to strongly convex 8
- Anterior margin of clypeus medially incised, bilobed 14
- 8) Clypeus not protruding anteriorly, and with straight or weakly convex anterior clypeal lobe (Fig. 12A) 9
- Clypeus slightly or strongly protruding anteriorly, and with distinctly convex anterior clypeal lobe (Fig. 12B, C) 12
- 9) Ventral margin of petiolar sternite in lateral view without well developed projection *L. kubotai* Baroni Urbani
- Ventral margin of petiolar sternite in lateral view with well developed and convex projection 10
- 10) Petiolar node distinctly wider than long (PI \geq 138) 11
- Petiolar node distinctly longer than wide (PI \leq ca. 81) *L. morimotoi* Yasumatsu
- 11) Postpetiolar node wider than long (PPI = 163–171). Larger species; HW: ca. 0.235 mm *L. yunnanensis* Xu
- Postpetiolar node almost as long as wide (PPI = 88). Smaller species; HW: ca. 0.140 mm *L. okinawensis* Terayama
- 12) Larger species, with petiole longer than 0.13 mm *L. besucheti* Baroni Urbani
- Smaller species, with petiole shorter than 0.10 mm 13
- 13) Ventral margin of petiolar sternite with triangular projection. Subpetiolar process absent. PPI = 122–138; CI \geq 82; PI = 111–125 *L. buddhista* Baroni Urbani
- Ventral margin of petiolar sternite with sub-circular projection. Subpetiolar process present as a small and hook like spine. PPI = 80–86; CI \leq 74; PI = 117–124 *L. macauensis* sp. nov.
- 14) Petiole in dorsal view with sharp and protruding anterolateral corners, with well concave anterior margin (Fig. 13E, F) 15
- Petiole in dorsal view with blunt and non-protruding anterolateral corners, with slightly concave to convex anterior margin (Fig. 13 A, B, C, D) 16
- 15) Petiolar node almost twice as long as wide (PI = 60). Postpetiolar node almost as wide as long (PPI = 90) (Fig. 13F) Propodeal dorsum and declivity in lateral view meeting at an angular corner. Masticatory margin of mandibles with a long and well-defined basal tooth *L. hypodracos* Wong & Guénard



Fig. 12. Clypeus (worker) A: *L. yunnanensis*-CASENT0902777; B: holotype of *L. macauensis* sp. nov.; C: *L. hypodracos* (from Wong & Guénard 2016) (the arrow indicates the anterior clypeal lobe).

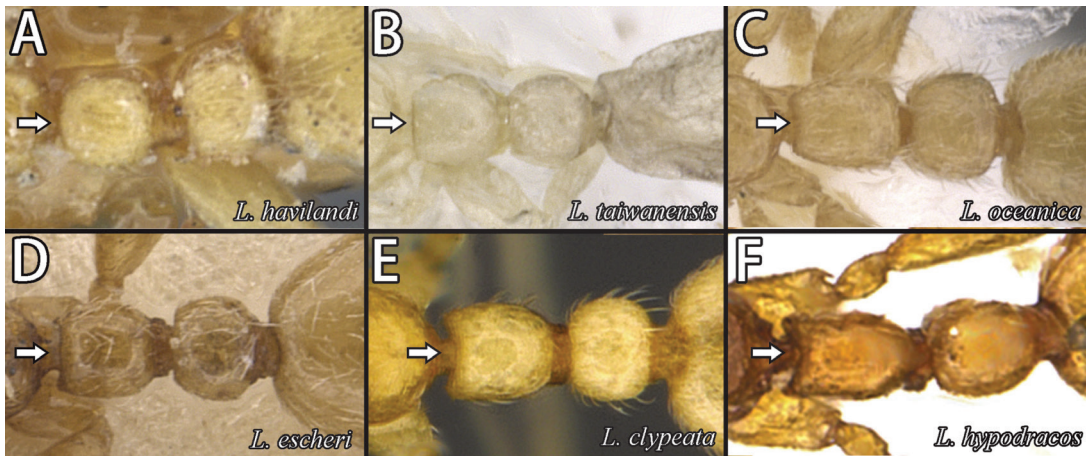


Fig. 13. Petiole in dorsal view (worker) A: *L. havilandi*-CASENT0907032; B: *L. taiwanensis*-CASENT0902777; C: *L. oceanica*-CASENT0911452; D: *L. escheri*-CASENT0907607; E: *L. hypodracos* (from Wong & Guénard 2016); F: *L. clypeata* (from Wong & Guénard 2016) (the arrow indicates the posterior margin of petiolar node).

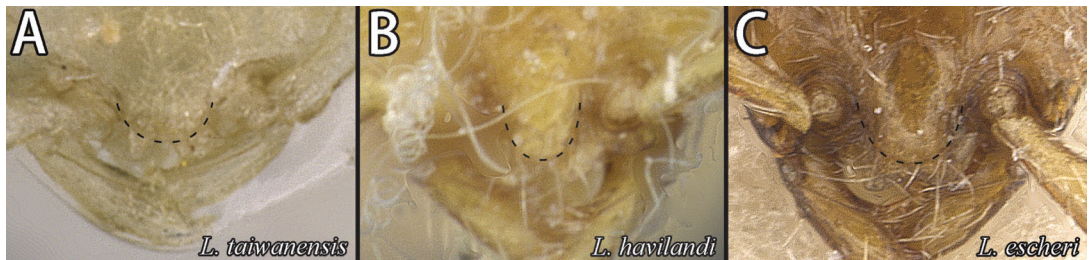


Fig. 14. Clypeus (worker) A: *L. taiwanensis*-CASENT0902777; B: *L. havilandi*-CASENT0907032; C: *L. escheri*-CASENT0907607 (the dotted line indicates the anterior clypeal margin).

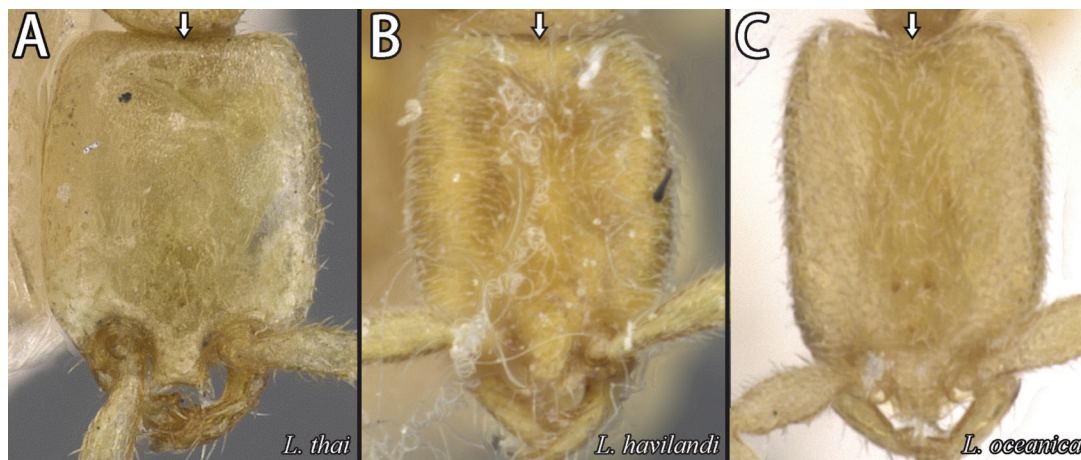


Fig. 15. Full-face view of head (worker) A: *L. thai*-CASENT0911455; B: *L. havilandi*-CASENT0907032; C: *L. oceanica*-CASENT0911452 (the arrow indicates the posterior margin of head).

- Petiolar node almost as long as wide (PI = 82–100). Postpetiolar node distinctly wider than long (PPI = 133–137) (Fig. 13E). Propodeal dorsum and declivity in lateral view meeting at a rather rounded corner. Masticatory margin of mandibles without a long and well-defined basal tooth
.....*L. clypeata* Yamane & Ito
- 16) Anterior margin of clypeal disc almost as high as the lower level of antennal insertion (Fig. 14A), with shallowly notched anterior lobe.....
.....*L. taiwanensis* Ogata, Terayama & Masuko
- Anterior margin of clypeal disc almost highly exceeding the lower level of antennal insertion (Fig. 14B, C), with distinctly bilobed anterior lobe..... 17
- 17) Posterior margin of head deeply concave in full-face view (Fig. 15C)..... 18
- Posterior margin of head almost straight in full-face view (Fig. 15A, B)..... 19
- 18) Petiolar node rectangular with slightly concave anterior margin in dorsal view; anterior distinctly shorter than posterior margin. Smaller species; HW: ca. 0.155 mm
..... *L. oceanica* Baroni Urbani
- Petiolar node square with straight anterior margin in dorsal view; anterior margin as long as posterior margin. Larger species; HW: ca. 0.29 mm.
..... *L. lamellata* Bharti & Kumar
- 19) Petiole sternite in lateral view distinctly protruding, with ventral margin bluntly angulate.....
..... 20
- Petiole sternite in lateral view indistinctly protruding, with ventral margin almost straight.....
..... *L. thai* Baroni Urbani
- 20) Masticatory margin of mandible with a total of 3 teeth; basal tooth short and not well-defined. Anterolateral corners of petiole roundly convex in dorsal view (Fig. 13A). HW: ca. 0.245 mm.....
..... *L. havilandi* Forel
- Masticatory margin of mandible with a total of 4 teeth; basal tooth long and well-defined. Anterolateral corners of petiole forming a small and sharp angle in dorsal view (Fig. 13D). HW: ca. 0.280 mm
..... *L. escheri* Kutter

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APPENDIX

Appendix 1. The head width of twenty one *Leptanilla* species from the Oriental and Sino-Japanese regions with associated reference.

Species	Average (mm)	Range (mm)	Reference
<i>L. okinawensis</i>	0.140	0.14	Terayama 2013
<i>L. oceanica</i>	0.155	0.15–0.16	Baroni Urbani 1977
<i>L. hunanensis</i>	0.180	0.18	Tang <i>et al.</i> 1992
<i>L. macauensis</i> sp. nov.	0.185	0.18–0.19	Present study
<i>L. japonica</i>	0.195	0.19–0.20	Baroni Urbani 1977
<i>L. morimotoi</i>	0.200	0.20	Yasumatsu 1960
<i>L. kebunraya</i>	0.220	0.22	Ito <i>et al.</i> 2001
<i>L. tanakai</i>	0.220	0.21–0.23	Baroni Urbani 1977
<i>L. buddhista</i>	0.235	0.23–0.24	Baroni Urbani 1977
<i>L. butteli</i>	0.235	0.23–0.24	Baroni Urbani 1977
<i>L. yunnanensis</i>	0.235	0.23–0.24	Xu 2002
<i>L. besucheti</i>	0.245	0.24–0.25	Baroni Urbani 1977
<i>L. havilandi</i>	0.245	0.24–0.25	Baroni Urbani 1977
<i>L. taiwanensis</i>	0.245	0.24–0.25	Ogata <i>et al.</i> 1995
<i>L. hypodracos</i>	0.270	0.27	Wong & Guénard 2016
<i>L. kubotai</i>	0.270	0.26–0.28	Baroni Urbani 1977
<i>L. thai</i>	0.270	0.27	Baroni Urbani 1977
<i>L. escheri</i>	0.280	0.27–0.29	Baroni Urbani 1977; Bharti & Kumar 2012
<i>L. lamellata</i>	0.290	0.28–0.30	Bharti & Kumar 2012
<i>L. clypeata</i>	0.310	0.31	Ito <i>et al.</i> 2001
<i>L. kunmingensis</i>	0.370	0.37	Xu & Zhang 2002

