RESEARCH ARTICLE

Review of *Psenulus* species (Hymenoptera, Psenidae) in the Hong Kong SAR, with description of three new species

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Citation: Taylor CK, Barthélémy C, Chi RCS, Guénard B (2020) Review of *Psenulus* species (Hymenoptera, Psenidae) in the Hong Kong SAR, with description of three new species. Journal of Hymenoptera Research 79: 169–211. https://doi.org/10.3897/jhr.79.55832

Abstract

The wasp genus *Psenulus* is the most diverse genus of the family Psenidae in the superfamily Apoidea, with its diversity peaking in the Oriental realm. Six species of the genus are here recorded for the first time from the Hong Kong SAR. Three of these, *Psenulus ephippius* **sp. nov**., *Psenulus gibbus* **sp. nov**. and *Psenulus pallens* **sp. nov**. are described as new to science. An identification key, figures for all taxa recorded in Hong Kong and phenology of five of the six species are also provided.

Keywords

Apoid wasps, China, occurrence, taxonomy

Introduction

Psenulus Kohl, 1897 is a diverse genus of small apoid wasps, including over 160 species (Pulawski 2019). The genus is distributed on all continents with the exception of Antarctica. The greatest diversity is found in the Oriental realm where 110 nominotypical

species and 40 subspecies have been recorded (Pulawski 2019). The species in this realm were extensively reviewed by J. P. van Lith in the 1960s and 1970s (e.g. van Lith 1962, 1969, 1972), whereas Chinese species were revised more recently as part of a PhD thesis by Ma (2012), with the section of that thesis relating to *Psenulus* not being formally published yet. Nevertheless, no information about the presence, distribution or diversity of *Psenulus* is available for the Hong Kong SAR, located on the northern-eastern edge of the Oriental realm.

The higher classification of Apoidea outside Anthophila (bees) is currently in a state of flux. Historically, non-apiform Apoidea have been treated as a single family Sphecidae (e.g. Bohart and Menke 1976) but this group has long been recognised as paraphyletic. Recent classifications have included *Psenulus* in the tribe Psenini within the subfamily Pemphredoninae, family Crabronidae (Pulawski 2020). Molecular phylogenetic studies have indicated, however, that even the Crabronidae as recognised in this sense is not monophyletic (Branstetter et al. 2017; Peters et al. 2017; Sann et al. 2018). The most extensive of these studies by Sann et al. (2018) suggested a reclassification of Apoidea which, among other changes, treated the tribe Psenini sensu Bohart and Menke (1976) as a distinct family Psenidae. In the absence of morphological analyses of the relationships between basal apoids, it remains to be seen whether these revisions to the classification will be confirmed in future studies (see Pulawski 2020 for a dissenting opinion). Nevertheless, considering that the non-monophyly of Crabronidae at least might be considered as well supported, Sann et al.'s (2018) system is used here.

Morphologically, *Psenulus* can be recognised as a member of the Psenidae by the combination of an elongate metasomal petiole composed of S1 only, a single mid tibial spur, fore wing with three submarginal cells, and antennal sockets placed well above the clypeal margin. It differs from other genera of Psenidae in having a, hind wing with the media diverging beyond cross vein cu-a, and generally a distinctly raised subantennal carina (Bohart and Menke 1976). The identification of species in this genus is often challenging due to the high level of sexual dimorphism that sometimes occurs (van Lith 1962) and many species have only been described from single sexes.

The nesting biology of *Psenulus* remains poorly studied. Bohart and Menke (1976) give a good summary of the known biology with additional studies published since, providing complementary information (Matthews 2001; Bonelli 1988). Nonetheless, detailed knowledge on species biology is currently limited to less than 15 species including a handful of Palearctic and Nearctic species, such as *P. concolor* (Dahlbom, 1843), *P. schenki* (Tournier, 1889) and *P. fuscipennis* (Dahlbom, 1843, in Dahlbom 1843–1845), which have received repeated attention since the early 20th century (Maneval 1932; Pagden 1933; Grandi 1934, 1935, 1961; Yasumatsu 1934; Spooner 1948; van Lith 1951, 1962; Benno 1957; Krombein 1967). Of note are the ethological studies by Tsuneki (1970, 1973) on six Oriental species showing consistent intraspecific nesting habits (nest architecture, prey, development time, egg positioning, etc.). *Psenulus* species nest inside pre-existing cavities such as hollow or pithy plant stems, wood galleries dug by other insects (e.g. Coleoptera), crevices, etc (e.g. Maneval 1932; Spooner 1948; van

Lith 1951; Benno 1957; Tsuneki 1970, 1973). Brood cells are provisioned with nymphs or adults of Hemiptera (Sternorrhyncha and Auchenorrhyncha) (Bohart and Menke 1976; Matthews 2001). They are unusual among wasps in lining the cells of their nests with silk which the females produce from glands opening on S4 and S5 (Melo 1997).

A recent entomological survey of mangrove remnants in Hong Kong SAR provided numerous new records of arthropods and species new to science (e.g. Grootaert et al. 2019). Among these, *Psenulus* was found to be one of the most abundant wasp genera, with large numbers of specimens occasionally recovered from a single Malaise trap. Other sampling efforts within forested or more anthropogenic habitats have, over the past two decades, also provided numerous records which are summarized here. In total, six species were identified among the material collected by the authors from both intertidal (mangroves) and inland habitats (gardens and riparian bands). Three species are here described as new to science, *Psenulus ephippius* sp. nov., *Psenulus gibbus* sp. nov. and *P. pallens* sp. nov. Whereas *P. carinifrons rohweri* van Lith, 1962**,** has previously been recorded from Taiwan, the remaining two species are newly recorded for China. We also provide descriptions for the hitherto unknown males of *P. continentis* and *P. maculatus*. Specimens collected in Hong Kong also improve our understanding of variation within the last three species and full descriptions are provided for all species. A dichotomous key for the Psenulus species recorded from Hong Kong is provided. In addition, distribution maps of all species and insights into the phenology patterns of five of the six taxa recorded are provided.
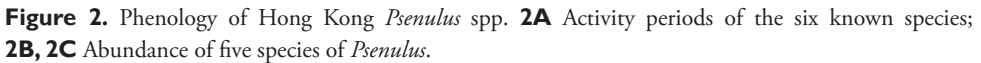
Materials and methods

The material used for this study was mostly obtained using Malaise traps set in various locations in the Hong Kong SAR. Between 2017 and 2018, members of the Insect Biodiversity and Biogeography Laboratory of the Hong Kong University (IBBL) conducted a survey of insect diversity in remnant mangrove forests in the Hong Kong SAR. Additionally, material recovered from traps placed in three inland locations and one mangrove forest from 2014 to 2020 by CB (Fig. 1B) and a suite of specimens of *P. gibbus* sp. nov. collected by CB by hand net in April of 2020 completed the specimens examined here.

The trapping efforts for the mangrove sites sampled by IBBL and the four sites sampled by CB are noticeably different. The seventeen sites sampled by IBBL (sites 1 to 17 of Fig. 1B) that yielded *Psenulus* spp., had each up to five traps, during two periods from October to December 2017 and May to July 2018 for a total sampling effort of 1414 trap days. The four sites sampled by CB (sites 7 and 18–20 of Fig. 1B) had Malaise traps set continuously as follows: Pak Sha O, one trap since 2004, but *Psenulus* content only recorded since 2014; Ping Shan Chai, one trap since 2014, Mang Kung Wo, one trap since 2018 and Mai Po Nature Reserve, two traps set between March 2014 and February 2015; for a total sampling effort of about 5800 trap days. In both sampling efforts, the collecting bottle was replaced on average every two weeks (14 days), its content sorted and databased. The large difference in trapping effort (trap
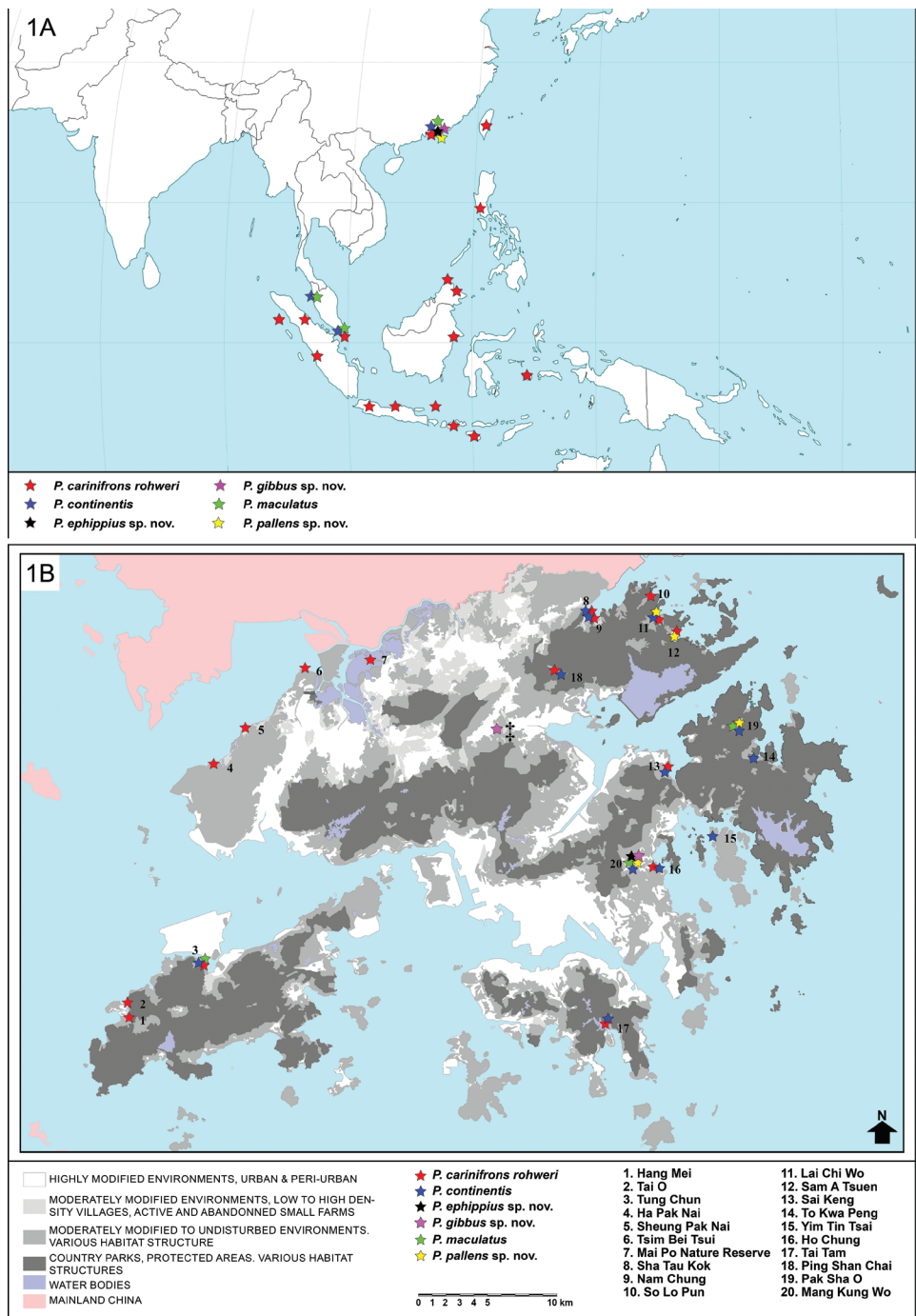
Figure 1. Distribution of the six species of *Psenulus* recorded from Hong Kong **1A** Southeast Asian distribution **1B** Hong Kong distribution. The numerals refer to site numbers as cited in the text. The "‡" represents a sighting at Ha Tin Liu Ha, Lam Tsuen valley posted on i-Naturalist at https://www.inatural-ist.org/observations/41796930.

Figure 2. Phenology of Hong Kong *Psenulus* spp. **2A** Activity periods of the six known species; **2B, 2C** Abundance of five species of *Psenulus*.

days but also temporal continuity) between the IBBL and CB sites renders abundance analysis problematic. Despite this heterogenous sampling, the data generated by these surveys, essentially presence/absence, allows us to propose activity periods of the six species of *Psenulus* recorded to date from Hong Kong and, the results are represented on figure 2A, where we have plotted the presence of *Psenulus* along a 52-weeks axis and the material used for this comprised of 394 specimens collected since 2006. On the other hand, trapping effort and methodology conducted between March 2018 and

present (Sep 2020) at three CB sites (Pak Sha O, Ping Shan Chai and Mang Kung Wo) have been consistent and standardised throughout this period and allows us to provide some insights into the abundance of five of the six species recorded in Hong Kong, *P. carinifrons rohweri* being excluded as it was never collected in inland sites. This subset of data includes 115 recorded occurrences; or about 29% of the records generated in this study, and the results are plotted on figs 2B and 2C along a 52-week horizonal axis, weeks noted as W1, W2, etc. on these figures and in the text.

The habitat structure for the trapping sites was as follows: sites 1–17 were characterised by intertidal habitats dominated by mangroves (*Kandelia obovata* Sheue, Liu & Yong, *Avicennia marina* (Forssk.) Vierh., *Bruguiera gymnorhiza* (L.) Savigny, etc.), these habitats are generally highly fragmented and surrounded by recent development (infrastructural or urban). Site 18 was an upland basin situated within a riparian band, its habitat composed of forest pioneers (herbs and bushes such as Euphorbiaceae, *Vitex negundo*, *Miscanthus* sp., etc.) and secondary evergreen forest (40+ years). Site 19 was in a garden reclaimed from an abandoned orchard; it had an early successional structure and was adjacent to a secondary evergreen forest (30+ years) to the south and a low-land marshland to the north. Site 20 was in a garden in a very low-density residential area, had an early successional structure and was adjacent to secondary evergreen forest. The anthropogenic disturbance of inland sites was highest at site 20 and lowest at site 18.

Identification of species were obtained using keys provided by van Lith (1962, 1969) and for comparison, descriptions provided by the same author were also used (van Lith 1972, 1973, 1976, 1978). All examined material is deposited at the Biological Sciences Museum of The University of Hong Kong and in CBs' private collection, while holotypes and some paratypes will be deposited at the California Academy of Sciences as indicated.

The terminology used mostly follows the Hymenoptera Glossary (HG). However, the location of two features characteristic of Psenulus but not recorded in HG, the inter-antennal carina and the episternal sulcus ("anterior oblique suture of the mesopleuron" of van Lith, 1962) are indicated on figs 3A and 3C, respectively and used throughout this study; see van Lith (1962) for further discussion of these features. We use the abbreviations T1, T 2, T3, etc., to denote the first, second, third, etc., metasomal terga, while S1, S2, S3, etc., denote the first, second, third, etc., metasomal sterna, and F1, F2, F3, etc., denote the antennal flagellomeres. In the Some morphological characters referred to in this work are illustrated in figures 3A–F. We have used a suite of standard measurements to produce ratios/indices for the specimens examined. Measurement values (except for specimen length) are relative values as measured in the stereomicroscope's reticule at various magnifications as indicated below in "[ ]". These measurements are referred to in figures 3A–G and detailed here and, the number of specimens measured is represented by the value "*n*" in the text:

H$_W$ Head width, measured frontally between external margin of the eyes [×60], see Fig. 3A;

H_H Head height, measured frontally between the apical margin of clypeus and the frons [×60], see Fig. 3A;

POD Post-ocellar distance, distance between the two posterior ocelli [×100], see Fig. 3B;

OOD Ocular-ocellar distance, distance between posterior ocellus and eye margin [×100], see Fig. 3B;

$F1_L$ F1 length, measured from base above torulus to apex [×100];

$F2_L$ F2 length, measured from base to apex [×100];

F_{W1} Minimum frons width, distance between the eyes above toruli measured frontally [×60], see Fig. 3A, B;

F_{W2} Maximum frons width, distance between the eyes measured dorsally across posterior ocelli [×60], see Fig. 3A, B;

M_L Mesosoma length, measured medially from pronotal carina to point of insertion of petiole in propodeum [×40], see Fig. 3C;

M_H Mesosomal height, measured vertically from mesoscutum to ventral side of mesopleuron [×40], see Fig. 3C;

O_W Occipital width, distance between posterior margins of eyes measured dorsally [×60], see Fig. 3D;

M_W Mesosomal width, maximum width of mesosoma measured dorsally between apices of tegulae [×60], see Fig. 3D;

TH_H Hight of the bump of T1 viewed laterally, measured from intersection of petiole with T1 to apex of T1 [×100], see Fig. 3F;

P_H Petiole height, measured vertically from dorsal side to ventral side of petiole at intersection of T1 [×100], see Fig. 3F;

P_L Petiole length, measured from base to point of intersection with T1 [×80], see Fig. 3F;

F_L Femur length, measured from base to apex dorsally [×80];

L Length of specimen in millimetres (mm), this is obtained by adding two measurements in lateral view, the first from frons to posterior apex of propodeum and the second from the petiole attachment to apical part of T1. This because (a) the petiole is often at awkward angles to the mesosoma in preserved specimens and, (b) metasomal segments after T1 tend to be either expanded or retracted in preserved specimens.

These dimensions are used to define the following eight ratios:

CR Cephalic ratio: $H_W \div H_H$;

OOR Ocellar-ocular ratio: POD $\div$ OOD;

FLR Flagellomere ratio: $F1_L \div F2_L$;

FRR Frons ratio: $F_{W1} \div F_{W1}$;

MR Mesosmal ratio: $M_L \div M_H$;

OMR Occipital-mesosomal ratio: $O_W \div M_W$;

PR Petiolar ratio: $TH_H \div P_H$;

PFR Petiolar-femoral ratio: $P_L \div HF_L$.

T*hese measurements wer*e tak*en from a rand*om sample of ten specimens for those species represented by large series, i.e. P. carinifrons roh*weri and P. continenti*s. We measured all material available for the other four speci*es, except f*or one male specimen of P. maculatus maculatus that was lost before measurements and one female specimen of P. ephippius that was destroyed at mounting before measurements. A total 83 specimens were measured.

We have felt compelled to add descriptions of all species listed in this work, because past descriptions (mainly by van Lith 1962, 1969, 1972, 1973, 1976, 1978) have been scattered and inconsistent in their presentation, primarily diagnostic rather than descriptive in nature an*d we have noted greater colour variability than what van Lith (1962, 1969, 1972, 1973, 1976, 1978) proposed, mainly for P. continentis* and *P maculatus.* In addition, we provide the first descriptions of the males of the latter two species. Following the descriptive sections of each species we also provide notes with taxonomic and distributional discussion, as well as a brief account on ethology. The distributional map (Fig. 1A) is based on records from van Lith's descriptions, our own Hong Kong records and additional distributional records as noted by Pulawski (2019) in his species file and covers only those species that have been recorded from the Hong Kong SAR. In the distribution section for the taxa previously described, "*" refers to a new record. The acronyms of collections where material is deposited are as follows:

CBC   Christophe Barthélémy's private collection, Hong Kong SAR, China.
CAS   California Academy of Science, San Francisco, California, USA.
HKU   Biological Sciences Museum, University of Hong Kong, Hong Kong SAR, China.
NHMUK The Natural History Museum, London, UK.
RMNH   Nationaal Natuurhistorisch Museum (formerly Rijksmuseum van Natuurlijke Historie), Leiden, Netherlands.

Results

Key to species

Correct identi*fication* of the sex of a Psenulus specimen is essential for its identification. An interesting feature of this genus, as in most other genera of the Psenidae, is the extension of S8 in the male into an acute, up-turned process that protrudes past the remainder of the metasoma (Bohart and Menke 1976). Together with T7 being small and easily overlooked, this 'pseudo-sting' can easily lead those unfamiliar with this genus to mistake males f*or females. The sexes of Psenulus* are most reliably distinguished by examination of the antennae: as in most other Apoidea, male *Psenulus* possess eleven flagellomeres whereas females have ten. The antennae of females are also somewhat clavate whereas those of males are more moniliform.
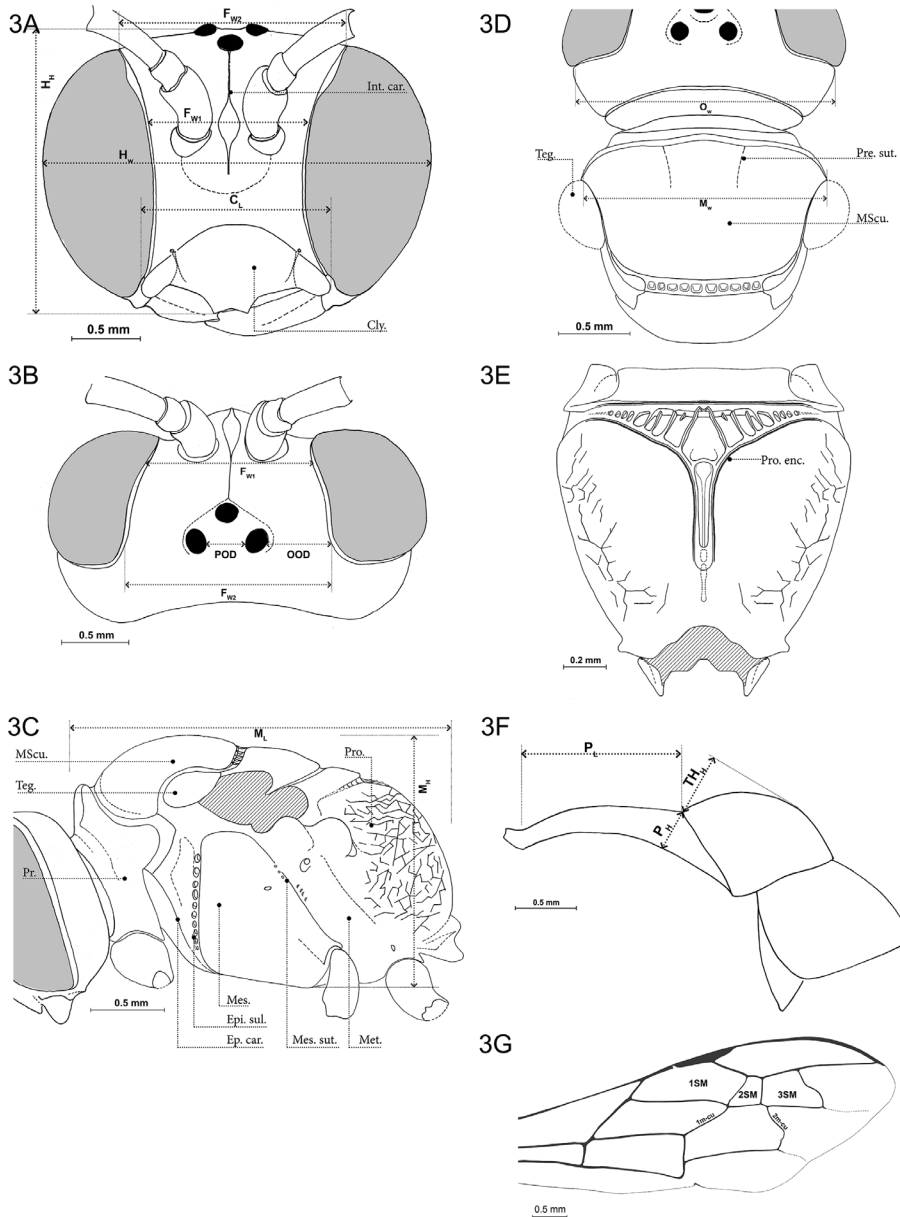
Figure 3. *Psenulus* spp. measurements and morphological terms, ♀ **3A** Face frontal view, *Psenulus gibbus*, C_L: Clypeus length, F_{w1}: Frons ventral width, F_{w2}: Frons dorsal width, Int. car.: Interantennal carina, Cly.: Clypeus **3B** Vertex *Psenulus gibbus*, POD: Post-ocellar distance, OOD: Ocellar-ocular distance **3C** Mesosoma lateral view, *P. continentis*, M_H: Mesosoma height, M_L: Mesosoma length, MScu: Mesoscutum, Teg.: tegula, Pr.: Pronotum, Mes.: Mesopleuron, Epi. sul.: Episternal sulcus, Ep. car.: Epicnemial carina, Mes. sut.: Mesopleural suture, Met.: Metanotum, Pro.: Propodeum **3D** Mesoscutum dorsal view, *P. pallens*, O_w: Occipital width, M_W: Mesosoma width, Pre. sut.: Prescutal suture **3E** Propodeum dorsal view, *P. pallens*, Pro. Enc.: Propodeal enclosure **3F** Petiole and T1, lateral view, *P. continentis*, P_L: Petiole length, P_H: Petiole height, TH_H: T1 hump height **3G** Fore wing, *P. continentis*, 1SM: 1st Submarginal cell, 2SM: 2nd Submarginal cell, etc., 1m-cu: 1st recurrent vein, 2m-cu: 2nd recurrent vein.

1 Petiole markedly elongate, distinctly longer than length of hind femur (PFR > 1.2); metasoma mostly or entirely black (red spots may be present on T2 and S2; Figs 4A, 5A) ....***Psenulus carinifrons rohweri* van Lith**

– Petiole shorter, at most subequal in length to hind femur (PFR < 1.2); metasoma mostly reddish or orangish (if black in part, then reddish coloration not restricted to T2 and S2; Figs 4B–F, 22A)..**2**

2 Interantennal carina broadened between antennal sockets and deeply excavated dorsally, forming a pit, legs yellow/orangish (Fig. 3A).. ***Psenulus gibbus* sp. nov**.

– Interantennal carina not broadened between antennal sockets, legs dark brown (Fig. 6A) **3**

3 Mesosoma entirely black (Figs 4C, 5C, 12C, 13C, 14C, 15C) ....
....***Psenulus ephippius* sp. nov**.

– Mesosoma in largely yellow (Figs 4B, E, F, 5B, E, F, 10B, E, F, 11B, E, F, 22A, B **4**

4 Male with tyloids on F7 to F11; female with subantennal carina well developed (Fig. 6E), hind tibia with dorsobasal array of long red spines associated with short denticles (Fig. 18I) ....***Psenulus maculatus maculatus* van Lith**

– Male flagellomeres lacking tyloids; female with subantennal carina inconspicuous (not protruding beyond covering pubescence; Fig. 6A, B, C, D, 6F) or absent, hind tibia with dorsobasal array of small, short red denticles only (Fig. 18C, G, K) **5**

5 Postocellar distance greater, OOR = 0.62–0.79; antero-ventral part of mesopleuron and metapleuron black (Figs 4B, 12B); male with longitudinal black marks on mesoscutum extending to posterior margin (Fig. 11B); female with T1 swollen, PR = 0.59–1.62 .... ***Psenulus continentis* van Lith**

– Postocellar distance smaller, OOR = 0.46–0.65; antero-ventral part of mesopleuron and metapleuron mostly yellow (Figs 4F, 5F, 12F, 22A, B); longitudinal black marks on mesoscutum reduced in both sexes (Figs 10F, 11F, 22B), ending well before posterior margin; female with T1 less swollen PR = 0.83–1.29 .... ***Psenulus pallens* sp. nov.**

## Species descriptions

Psenulus carinifrons rohweri van Lith, 1962
Figs 4A–17A, 18A, B, 19A, B, 20A, 21A

Psenulus carinifrons rohweri van Lith 1962: 108. Holotype: ♀; Indonesia, Java, Reserve Semarang, Tjandi; RMNH.

Material examined. China, Hong Kong • 1♂; Sha Tau Kok (Hoi Pui Leng); 22°31'48"N, 114°12'27"E; 24 May–9 Jun. 2018; C. Taylor and Cheung Shun Chi leg.; Malaise trap; HKU • 1♂; Nam Chung, 22°31'32"N, 114°12'29"E; 27 Jun.–11 Jul. 2018; ibid. • 1♂; Lai Chi Wo, 22°31'38"N, 114°15'44"E; 29 Jun.–16 Jul. 2018; ibid. • 13♀; So Lo Pun, 22°32'16"N, 114°15'22"E; 29 Jun.–16 Jul. 2018; ibid. • 1♂; So Lo Pun; 22°32'15"N,
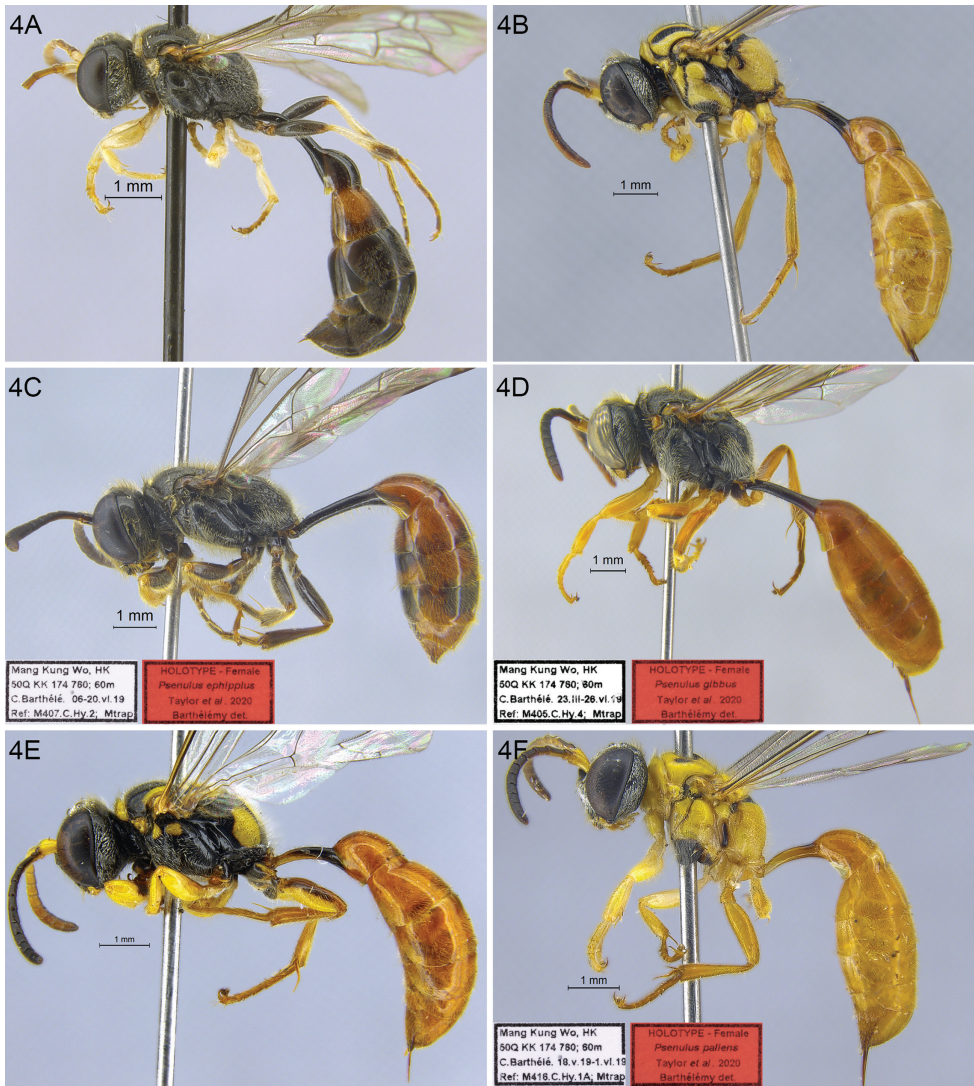
Figure 4. Females, lateral habitus **4A** *P. carinifrons rohweri* **4B** *P. continentis* **4C** *P. ephippius* sp. nov., holotype **4D** *P. gibbus* sp. nov., holotype **4E** *P. maculatus maculatus* **4F** *P. pallens* sp. nov., holotype.

114°15'22"E; 16–27 Jul. 2018; ibid. • 1♀; Sam A Tsuen; 22°30'54"N, 114°16'15"E; 17–30 May 2018; ibid. • 1♂; Sam A Tsuen; 22°30'54"N, 114°16'15"E; 30 May–13 Jun. 2018; ibid. • 1♀; Sam A Chung; 22°30'30"N, 114°16'21"E; 30 May–13 Jun. 2018; ibid. • 1♀; Tsim Bei Tsui, Sha Kiu Tsuen; 22°29'23"N, 113°59'59"E; 14–28 May 2018 ; ibid. • 1♂; Tsim Bei Tsui, Sha Kiu Tsuen; 22°29'21"N, 113°59'55"E; 14–28 May 2018 ; ibid. • 2♀; Tsim Bei Tsui, Sha Kiu Tsuen; 22°29'22"N, 113°59'57"E; 28 May–11 Jun. 2018; ibid. • 3♂2♀; Tsim Bei Tsui, Sha Kiu Tsuen; 22°29'21"N, 113°59'54"E; 28 May–11 Jun. 2018; ibid. • 1♀; Sheung Pak Nai; 22°27'09"N 113°57'47"E; 14–28 May 2018; ibid. • 1♂2♀; Sheung Pak Nai; 22°27'07"N, 113°57'45"E; 14–28 May 18;

ibid • 1♀, Sheung Pak Nai; 22°27'08"N, 113°57'47"E; 28 May–11 Jun. 2018; ibid. • 1♀; Sheung Pak Nai; 22°27'05"N, 113°57'44"E; 28 May–11 Jun. 2018; ibid. • 1♀; Ha Pak Nai, near Western New Territories Landfill, 22°25'30"N, 113°56'22"E; 7–21 May 2018; ibid. • 1♂5♀; Ha Pak Nai ,near Western New Territories Landfill; 22°25'31"N 113°56'21"E; 7–21 May 2018; ibid. • 1♂1♀; Ha Pak Nai, near Western New Territories Landfill; 22°25'31"N, 113°56'20"E; 21 May–5 Jun. 2018; ibid. • 2♀; Ha Pak Nai, near Western New Territories Landfill; 22°25'30"N, 113°56'21"E; 21 May–5 Jun. 2018; ibid. • 1♀, Tung Chung; 22°16'52"N, 113°55'40"E; 15–29 May 2018; ibid. • 10♂35♀; Tung Chung; 22°16'55"N, 113°55'43"E; 29 May–12 Jun. 2018; ibid. • 2♀; Hang Mei; 22°15'07"N, 113°52'06"E; 23 May–6 Jun. 2018; ibid. • 2♂4♀; Tai O; 22°15'27"N 113°51'49"E; 9–23 May 2018; ibid. • 1♂1♀; Tai Tam; 22°14'45"N, 114°13'23"E; 28 Jun.–12 Jul. 2018; ibid. • 1♀; Ho Chung; 22°21'12"N, 114°15'09"E; 26 Jun.–10 Jul. 2018; ibid. • 1♀; Ho Chung; 22°21'16"N, 114°15'09"E; 26 Jun.–10 Jul. 2018; ibid. • 1♂; Ho Chung; 22°21'13"N, 114°15'07"E; 10–24 Jul. 2018; ibid. • 1♂; Sai Keng; 22°25'06"N, 114°16'11"E; 26 Jun.–10 Jul. 2018; ibid. • 4♂1♀; Sai Keng; 22°25'12"N, 114°16'06"E; 26 Jun.–10 Jul. 2018; ibid. • 11♂, New Territories; May–July 2018; ibid. • 1♀; Mai Po Nature Reserve; 22°29'11"N, 114°02'14"E; 1 m a.s.l.; 29 Mar.–12 Apr. 2014; C. Barthélémy leg.; Malaise trap, ref.: MPNRM003GHy4; CBC • 1♀; ibid.; 10–24 May 2014; ibid.; ref.: MPNRM010GHy6; CBC • 1♀; ibid.; 24 May–07 Jun. 2014; ibid.; ref.: MPNRM012GHy7; CBC • 1♀; ibid.; 25 Oct.–01 Nov. 2016; WWF Hong Kong leg.; Malaise trap, ref.: WWF-M00GHy3; CBC • 1♀; Mai Po Nature Reserve; 22°29'23"N, 114°01'53"E; 1 m a.s.l.; 05–19 Jul. 2014; C. Barthélémy leg.; Malaise trap, ref.: MPNRM017GHy11; CBC.

Standard ratios. Males (n = 10): L = 4–4.9 mm (mean = 4.53 mm); CR = 1.16–1.23 (mean = 1.21); OOR = 0.76–0.88 (mean = 0.83; FLR = 1.05–1.12 (mean = 1.08); FRR = 0.64–0.72 (mean = 0.67); MR = 1.1–1.55 (mean = 1.51); OMR = 0.83 –0.94 (mean = 0.89); PR = 0.65–0.94 (mean = 0.83); PFR = 1.24–1.48 (mean = 1.35). Females (n = 10): L = 4.00–5.7 mm (mean = 4.81 mm); CR = 1.2–1.32 (mean = 1.23); OOR = 0.7–0.88 (mean = 0.83); FLR = 1.4–1.6 (mean = 1.51); FRR = 0.62–0.74 (mean = 0.67); MR = 1.12–1.56 (mean = 1.37); OMR = 0.84–0.92 (mean = 0.88); PR = 0.92–1.43 (mean = 1.10); PFR = 1.13–1.3 (mean = 1.23).

Description. Male: Antenna without tyloids. Clypeus (Fig. 21A) with median section of anterior margin protruding, medially straight. Subantennal carina well developed; interantennal carina narrow, not broadened dorsally. Mesosoma mostly polished, mesoscutum moderately punctate with punctures mostly separated by at least their own diameter, punctures more closely spaced medially (Fig. 11A); prescutal sutures short, extending to level of anterior margin of tegula; episternal sulcus broadly foveolate (Fig. 13A); propodeal enclosure with several pairs of longitudinal carinae (Fig. 15A); propodeum laterally and posteriorly coarsely reticulate. Petiole subcylindrical; T1 relatively low (Fig. 5A). Fore wing (Fig. 19B) with first recurrent vein interstitial with first and second submarginal cells, second recurrent vein interstitial with second and third submarginal cells.

Head black with appressed silvery pubescence (Figs 7A, 9A); antenna with scape yellow, remainder of antenna black except yellowish on venter of pedicel and very base

Figure 5. Males, lateral habitus of males **5A** *P. carinifrons rohweri* **5B** *P. continentis* **5C** *P. ephippius* sp. nov., paratype **5D** *P. gibbus* sp. nov.; paratype **5E** *P. maculatus maculatus* **5F** *P. pallens* sp. nov., paratype.

of flagellum; mandible yellow with black tip. Mesosoma black with tegula yellowish brown (Fig. 11A), following yellow: pronotal collar, pronotal lobe, scutellum except scutellar groove, metanotum. Fore and mid legs with coxae black, remainder yellow except ends of tarsi brownish; hind leg black except basal half to two-thirds of tibia white, tarsus brown. Metasoma black except T7 brown.

Female: Clypeus (Fig. 21A) with median section of anterior margin protruding, medially straight. Subantennal carina absent (Fig. 6A). Mesosoma mostly polished, mesoscutum moderately punctate with punctures mostly separated by at least their own diameter, punctures more closely spaced medially (Fig. 11A); prescutal sutures short, extending to

level of anterior margin of tegula; episternal sulcus broadly foveolate (Fig. 13A); propodeal enclosure with several pairs of longitudinal carinae (Fig. 15A); propodeum laterally and posteriorly coarsely reticulate. Petiole subcylindrical; T1 relatively low (Fig. 5A). Fore wing (Fig. 19B) with first recurrent vein interstitial with first and second submarginal cells, second recurrent vein interstitial with second and third submarginal cells.

Head black with appressed silvery pubescence (Figs 7A, 9A); antenna with scape yellow, remainder of antenna black except yellowish on venter of pedicel and very base of flagellum; mandible yellow with black tip. Mesosoma black with tegula yellowish brown (Fig. 11A), following yellow: pronotal collar, pronotal lobe, scutellum except scutellar groove, metanotum. Fore and mid legs with coxae black, remainder yellow except ends of tarsi brownish; hind leg black except basal half to two-thirds of tibia white, tarsus brown. Metasoma black with T2 and S2 black or with more or less well demarcated, large, lateral red spots.

Distribution. China (*Hong Kong, Taiwan); Singapore; Indonesia (Sumatra, Java, Sumba, Pulau Buru, Kangean Islands, East Kalimantan), Malaysia (Sabah), Philippines (Luzon). (van Lith 1962, 1969, 1976).

Notes. *Psenulus carinifrons rohweri* is readily distinguished from others *Psenulus* in the Hong Kong SAR by its mostly black coloration. The Hong Kong specimens are here assigned to *P. carinifrons rohweri* which they resemble in sculpture of the propodeum and mesoscutum, as well as the entirely yellow fore and mid trochanters and femora (van Lith 1969). However, they do differ from previous descriptions of this subspecies in the occasional presence of a pair of large red spots on the T2 of the female, a character that appears variable in the Hong Kong population.

Psenulus carinifrons has an extensive distribution extending between India, Japan and north-eastern Australia (van Lith 1962, 1969).

It may be notable that this species has to date only been collected in the Hong Kong SAR among mangroves; apart from one single "older" (2006) record in a terrestrial habitat at Ping Shan Chai. Unfortunately, there appears to be no record of its habitat preferences in other parts of its range, although all records attributed to van Lith are from littoral localities; save for one in Bogor, which are commonly colonised by mangroves in Southeast Asia. It has a long activity period spanning from March (W13) to end of November (W47).

Psenulus continentis van Lith, 1962
Figs 4B–17B, 18C, D, 19C, D, 20B, 21B

Psenulus continentis van Lith 1962: 97–98. Holotype: ♀; Malaysia, Penang, Batu Feringgi; NHMUK.

Material examined. Сᴀɪɴᴀ, Hᴏɴɢ Kᴏɴɢ • 1♂; Sha Tau Kok, Hoi Pui Leng; 22°31'47"N, 114°12'28"E; 10–24 May 2018; C. Taylor and Cheung Shun Chi leg.; HKU • 1♀; Nam Chung; 22°31'32"N, 114°12'29"E; 27 Jun.–11 Jul. 2018; ibid •
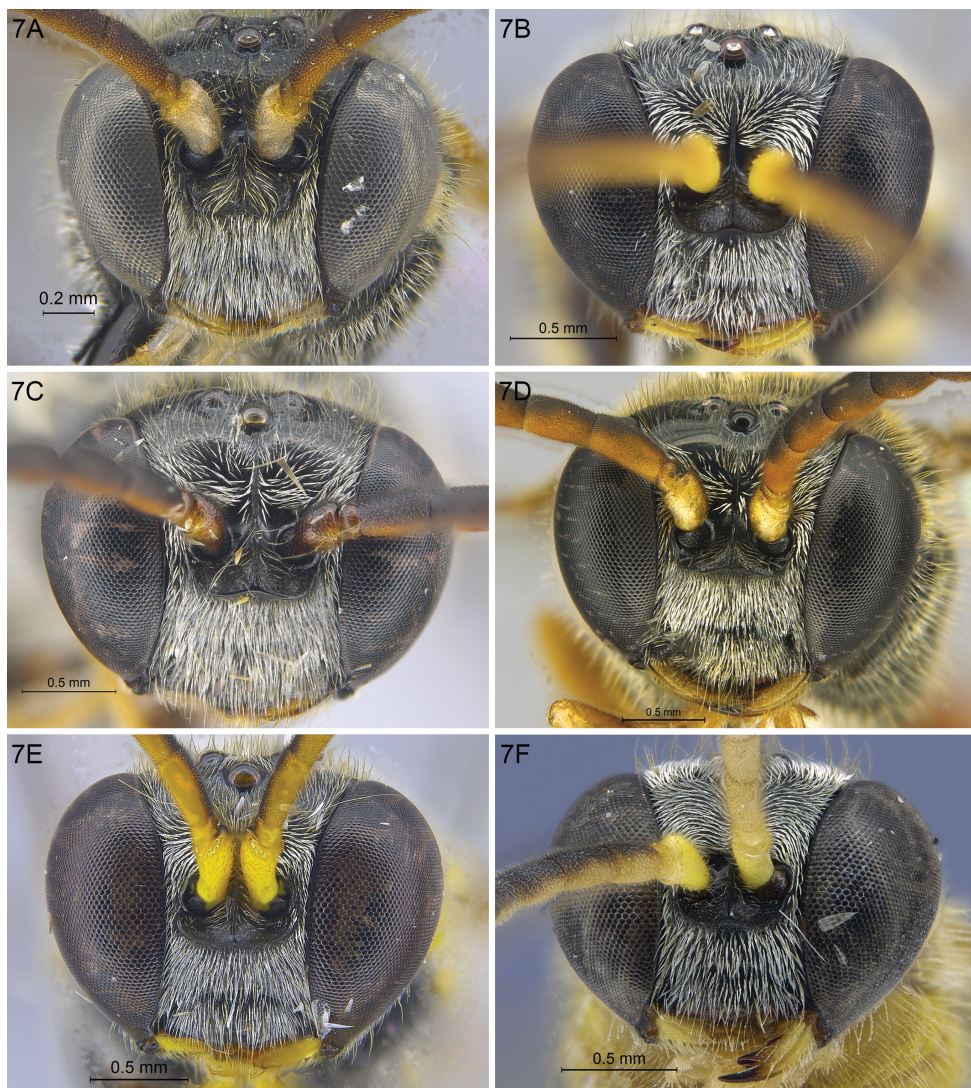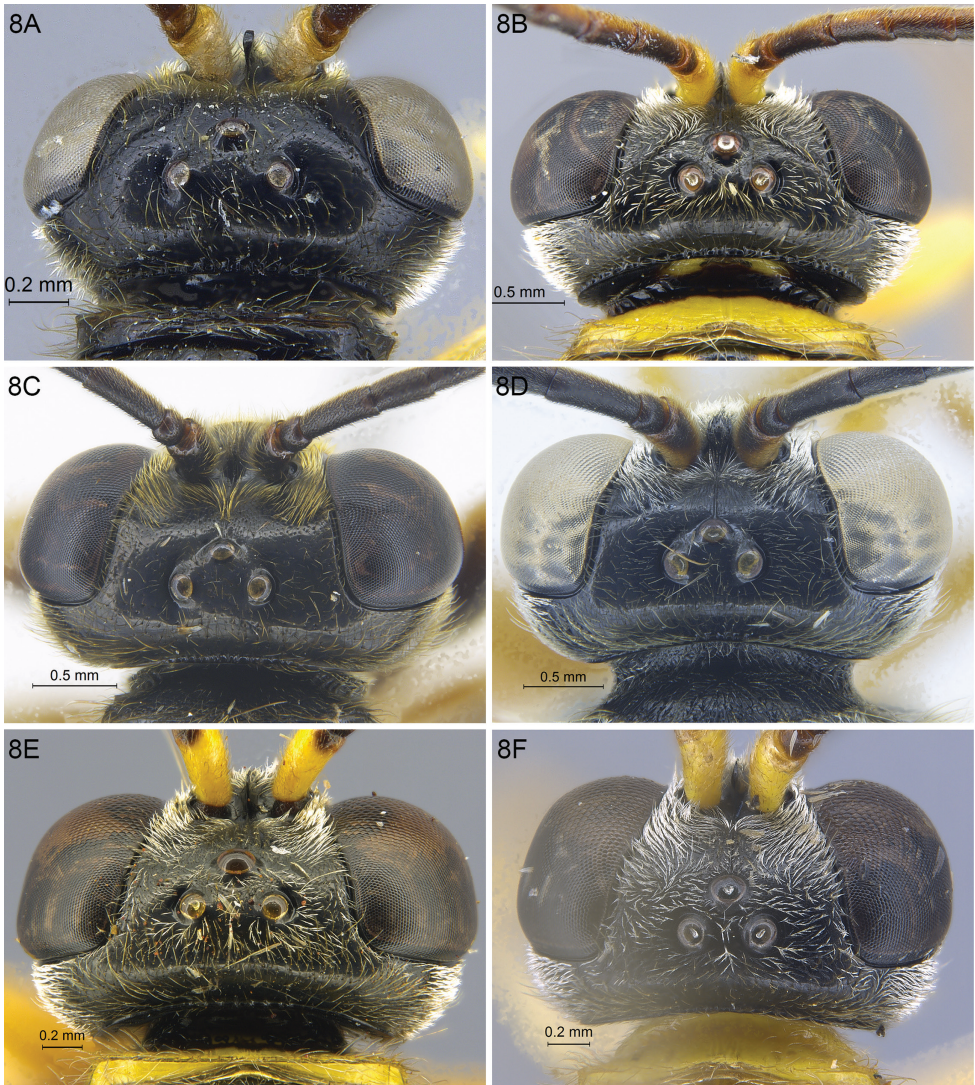
Figure 6. Females, head in frontal view **6A** *P. carinifrons rohweri* **6B** *P. continentis* **6C** *P. ephippius* sp. nov., holotype **6D** *P. gibbus* sp. nov.; holotype **6E** *P. maculatus maculatus* **6F** *P. pallens* sp. nov., holotype.

1♀; Sam A Tsuen; 22°30'54"N, 114°16'15"E; 17–30 May 2018; ibid • 3♂; Tung Chung; 22°16'55"N, 113°55'43"E; 29 May–12 Jun. 2018; ibid • 2♂1♀; Tai Tam; 22°14'45"N, 114°13'23"E; 28 Jun.–12 Jul. 2018; ibid • 7♂; To Kwa Peng; 22°25'43"N, 114°20'01"E; 8–25 May 2018; ibid • 6♂; To Kwa Peng; 22°25'45"N, 114°20'00"E; 8–25 May 2018; ibid • 3♂; To Kwa Peng; 22°25'41"N, 114°20'05"E; 25 May–10 Jun. 2018; ibid • 5♂8♀; Ho Chung; 22°21'12"N, 114°15'09"E; 26 Jun.–10 Jul. 2018; ibid • 2♂; Sai Keng; 22°25'06"N, 114°16'11"E; 26 Jun.–10 Jul. 2018; ibid • 3♂; Yim Tin Tsai; 22°22'32"N, 114°18'04"E; 1–15 Jun. 2018; ibid • 3♂; New Territories;
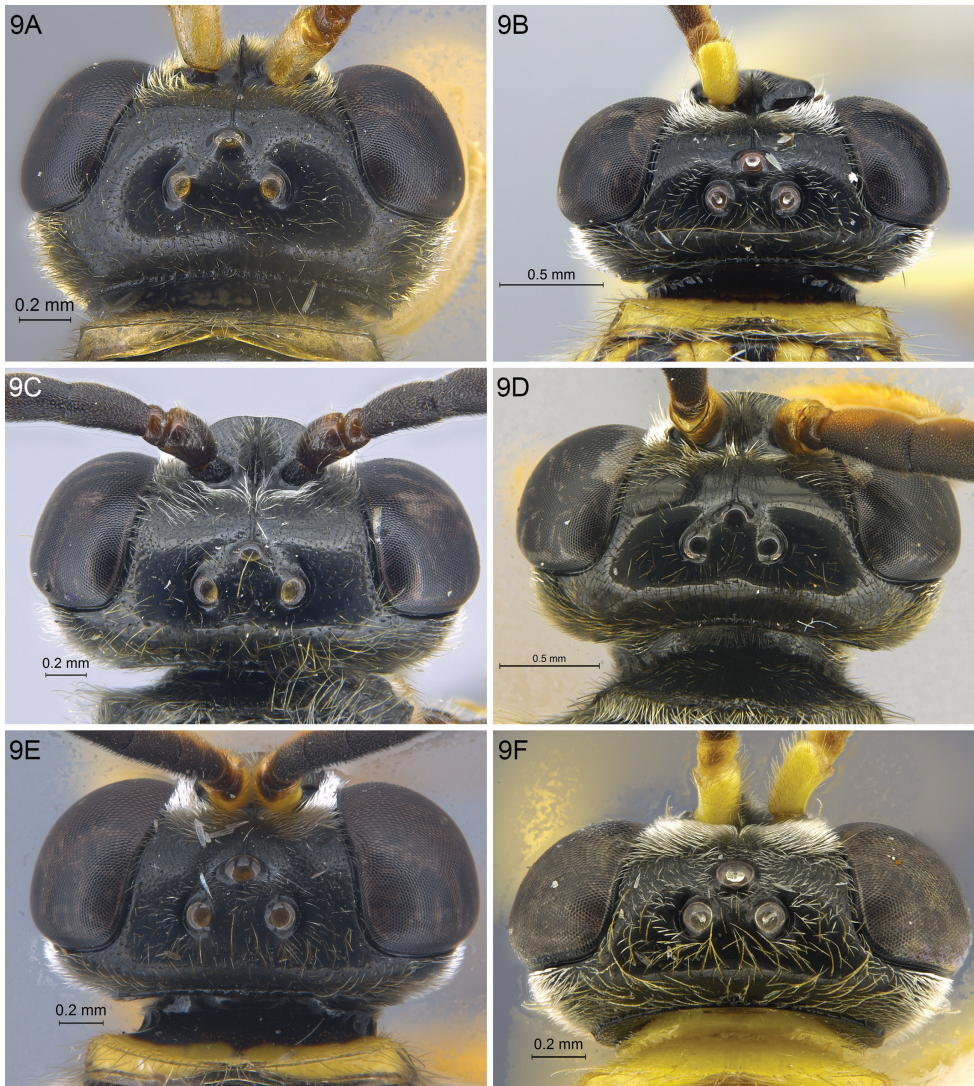
Figure 7. Males, head in frontal view **7A** *P. carinifrons rohweri* **7B** *P. continentis* **7C** *P. ephippius* sp. nov., paratype **7D** P. gibbus sp. nov.; paratype **7E** *P. maculatus maculatus* **7F** *P. pallens* sp. nov., paratype.

May–July 2018; ibid • 4♂1♀; To Kwa Peng; 22°25'43"N, 114°19'59"E; 21 Nov.–5 Dec. 2017; C. Taylor and U. Chang; HKU • 1♀; Ping Shan Chai; 22°29'14"N, 114°11'06"E; 140 m a.s.l.; 30 Jul.–03 Sep. 2016; C. Barthélémy leg.; Malaise trap, ref.: M258CHy7; CBC • 1♀; Pak Sha O; 22°26'59"N, 114°19'04"E; 70 m a.s.l.; 22 Mar.–05 Apr. 2014; ibid.; ref.: PSOM152CHy1; CBC • 1♀; ibid..; 05–19 Apr. 2014; ibid; ref.: PSOM153CHy3; CBC • 1♀; ibid; 31 May–14 Jun. 2014; ibid.; ref.: M162CHy2; CBC • 1♀; ibid..; 19 Sep.–03 Oct. 2015; ibid.; ref.: M220CHy1; CBC • 1♀; ibid.; 11–25 Jun. 2016; ibid.; ref.: M250CHy2; CBC • 1♂; ibid.; 18 May–01

Figure 8. Females, head in dorsal view **8A** *P. carinifrons rohweri* **8B** *P. continentis* **8C** *P. ephippius* sp. nov., holotype **8D** *P. gibbus* sp. nov.; holotype **8E** *P. maculatus maculatus* **8F** *P. pallens* sp. nov., holotype.

Jun. 2013; ibid.; ref.: M131CHy1; CBC • 1♂; ibid.; 13–27 Jul. 2013; ibid.; ref.: M135CHy3; CBC • 1♀; ibid.; 01–15 Jun. 2019; ibid.; ref.: M418CHy4; CBC • 1♂; Mang Kung Wo; 22°22'06"N, 114°15'12"E; 60 m a.s.l.; 28 Apr.–12 May 2018; ibid.; ref.: M345CHy3; CBC • 1♂; ibid.; 01–15 Jun. 2019; ibid.; ref.: M419CHy5, CBC • 2♂; ibid.; 13–27 Jul. 2019; ibid; refs: M425CHy2A and 2B; CBC •

Standard ratios. Males (n = 10): L = 5.5–6.40 mm (mean = 5.8 mm); CR = 1.29–1.37 (mean = 1.33); OOR = 0.62–0.79 (mean = 0.71); FLR = 0.8–1.23 (mean = 1.06); FRR = 0.55–0.71 (mean = 0.68); MR = 1.36–1.51 (mean = 1.43); OMR =

Figure 9. Males, head in dorsal view **9A** *P. carinifrons rohweri* **9B** *P. continentis* **9C** *P. ephippius* sp. nov., paratype **9D** *P. gibbus* sp. nov.; paratype **9E** *P. maculatus maculatus* **9F** *P. pallens* sp. nov., paratype.

0.91–1.00 (mean = 0.95); PR = 0.59–1.91 (mean = 1.20); PFR = 0.887–1.08 (mean = 1.01). Females (n = 10): L = 5.7–6.9 mm (mean = 6.26 mm); CR = 1.23–1.47 (mean = 1. 32); OOR = 0.63–0.73 (mean = 0.68); FLR = 1.26–1.43 (mean = 1.36); FRR = 0.63–0.69 (mean = 0.65); MR = 1.18–1.57 (mean = 1.38); OMR = 0.85–1.00 (mean = 0.92); PR = 0.59–1.62 (mean = 1.20); PFR = 0.87–1.11 (mean = 1.02).

Description. Male: Antenna without tyloids. Clypeus (Fig. 21B) with two blunt ventral teeth separated by a shallow rounded emargination, remainder of clypeal margin largely straight. Subantennal carina well developed (Fig. 7B); interantennal carina

narrow, not broadened dorsally. Mesosoma mostly polished, mesoscutum moderately punctate with intermixed larger and smaller punctures mostly separated by at least their own diameter (Fig. 11B); prescutal sutures short, not extending beyond anterior level of tegula; episternal sulcus broadly foveolate (Fig. 13B); propodeal enclosure with several pairs of longitudinal carinae; propodeum laterally and posteriorly coarsely reticulate (Fig. 15B). Petiole subcylindrical, T1 relatively low (Fig. 5B). Fore wing (Fig. 19D) with first recurrent vein interstitial or reaching second submarginal cell near base, second recurrent vein reaching third submarginal cell near the base.

Head black with appressed silvery pubescence (Figs 7B, 9B); antenna with scape, venter of pedicel and base of venter of flagellum yellow, dorsum of pedicel and remainder of flagellum blackish; mandible yellow with black tip. Mesosoma black with following areas yellow (Figs 5B, 11B, 13B): pronotal collar, pronotal lobe, mesoscutum with two broad yellow submedial longitudinal stripes reaching almost to posterior margin (Fig. 11B), as well as broad marginal stripe laterally; scutellum except scutellar groove and small triangular median spot posteriorly; metanotum; mesopleuron anterior to anterior oblique suture, as well as small spot at top of hypoepimeral area and larger patch behind junction of anterior oblique suture and epicnemial crest; large paired patches laterally and posteriorly on propodeum. Legs mostly yellow, hind trochanter and base of hind coxa dark brown, hind femur, tibia and tarsus reddish. Petiole basally yellow, distally black; remainder of metasoma mostly reddish, S7 dark brown (Fig. 5B).

Female: Clypeus (Fig. 21B) with two blunt ventral teeth separated by a shallow rounded emargination, remainder of clypeal margin largely straight. Subantennal carina absent (Fig. 6B); interantennal carina narrow, not broadened dorsally. Mesosoma mostly polished, mesoscutum moderately punctate with intermixed larger and smaller punctures mostly separated by at least their own diameter (Fig. 11B); prescutal sutures short, not extending beyond anterior level of tegula; episternal sulcus narrowly foveolate (Fig. 12B); propodeal enclosure with several pairs of longitudinal carinae; propodeum laterally and posteriorly coarsely reticulate (Fig. 15B). Hind tibia with cluster of small dark denticles dorsobasally (Fig. 18C) and transverse row of three short spines dorsoapically. T1 swollen, nearly twice as high above dorsum of petiole as maximum height of petiole (Fig. 4B). Fore wing (Fig. 19D) with first recurrent vein interstitial or reaching second submarginal cell near base, second recurrent vein reaching third submarginal cell near the base.

Head black with appressed silvery pubescence (Figs 7B, 9B). Antenna paler than male, pedicel and flagellum mostly brown except dorsum of flagellum blackish. Mesosoma yellow with following black (Figs 4B, 10B, 12B): lower part of pronotum, three longitudinal spots anteriorly on mesoscutum, extending about two-thirds of length, low triangular patch on posterior margin of mesoscutum; scutellar groove and lateral pocket of scutellum; epicnemial area, episternal sulcus and around posterior end of mesopleural scrobe; mesoscutum with spot roundly extending onto base of mesopleuron; metapleuron dorsal enclosed area and median posterior groove of propodeum. Legs yellow except hind femur to tarsus reddish. Petiole basally yellow, distally black; remainder of metasoma mostly reddish, S7 dark brown (Fig. 5B).

Distribution. *China (Hong Kong); Malaysia (Penang); Singapore (van Lith 1962, 1976).

Notes. *Psenulus continentis* was described by van Lith (1962) from a single female specimen and the male had not previously been described. Males here assigned to *P. continentis* are identified on the basis of their association with females of the species as well as their close similarity to males of the related species *P. interstitialis*. van Lith (1962) did not specify his reasons for regarding *P. continentis* as a distinct species from *P. interstitialis* but comparison of the descriptions of the two species indicates that *P. continentis* has the mesopleural suture foveolate (vs. simple in *P. interstitialis*) and numerous longitudinal carinae in the propodeal enclosure (vs 'only a few').

The discovery of *P. continentis* in Hong Kong represents a new taxon for the territory and China and a significant extension of the known range of this species previously recorded only from the Malaysian Peninsula (van Lith 1962, 1976).

It is a common taxon, found at 12 of the 20 sites surveyed and it is abundant throughout these sites. It has one of the longest activity period of all Hong Kong *Psenulus*, spanning from February (W7) to end of November (W47).

Psenulus ephippius sp. nov.

http://zoobank.org/1FA5CE44-CE84-4CEA-A73C-D53257CDF1CF

Figs 4C–17C, 18E, F, 19E, F, 20C, 21C

Diagnosis. In its entirely black mesosoma (Figs 4C, 5C) with a polished horizontal area behind the propodeal enclosure (Figs 14C, 15C), narrow interantennal carina (Figs 6C, 7C), and indistinct pygidial plate (Figs 16C, 17C), this species comes closest to the *Psenulus crabroniformis* species group as defined by van Lith (1962). However, the species assigned to that group, *P. crabroniformis* (Smith, 1858) of western Indonesia and *P. philippinensis* (Rohwer, 1921) of the Philippines, have a well-developed subantennal carina in the female (in contrast to the notably weak carina in the current species), and the first recurrent vein is received by the first submarginal cell as opposed to being interstitial to first and second submarginal cell. *Psenulus crabroniformis* further differs in having the antennal scape yellow whereas *P. philippinensis* possesses a pair of well-developed frontal tubercles (van Lith 1962), both absent in *P. ephippius* sp. nov. The new species also resembles *P. decipiens* van Lith, 1976 in overall coloration and lack of antennal tyloids in the male but the latter species has longer prescutal sutures, as long as the scutum, and the position of the first recurrent vein is as in *P. crabroniformis* and *P. philippinensis*.

Material examined. *Holotype*: CHINA, HONG KONG • ♀; Mang Kung Wo; 22°22'06"N, 114°15'12"E; 60 m a.s.l.; 06–20 Apr. 2019; C. Barthélémy leg.; Malaise trap, ref.: M407.C.Hy.2; CAS. *Paratypes*: CHINA, HONG KONG • 1♂; ibid.; 31 Mar.–14 Apr. 18; ibid.; ref.: M339.C.Hy.4; CBC • 1♀; ibid.; 28 Apr.–12 May 2018; ibid.; ref.: M345CHy4; [specimen destroyed at mounting] • 1 ♀; ibid; 20 Apr.–04 May 2019; ibid.; ref.: M411.C.Hy.2; CAS • 1♀; ibid.; 11 Apr.–25 May 2020; ibid.; ref.: M483.C.Hy.3; CBC.
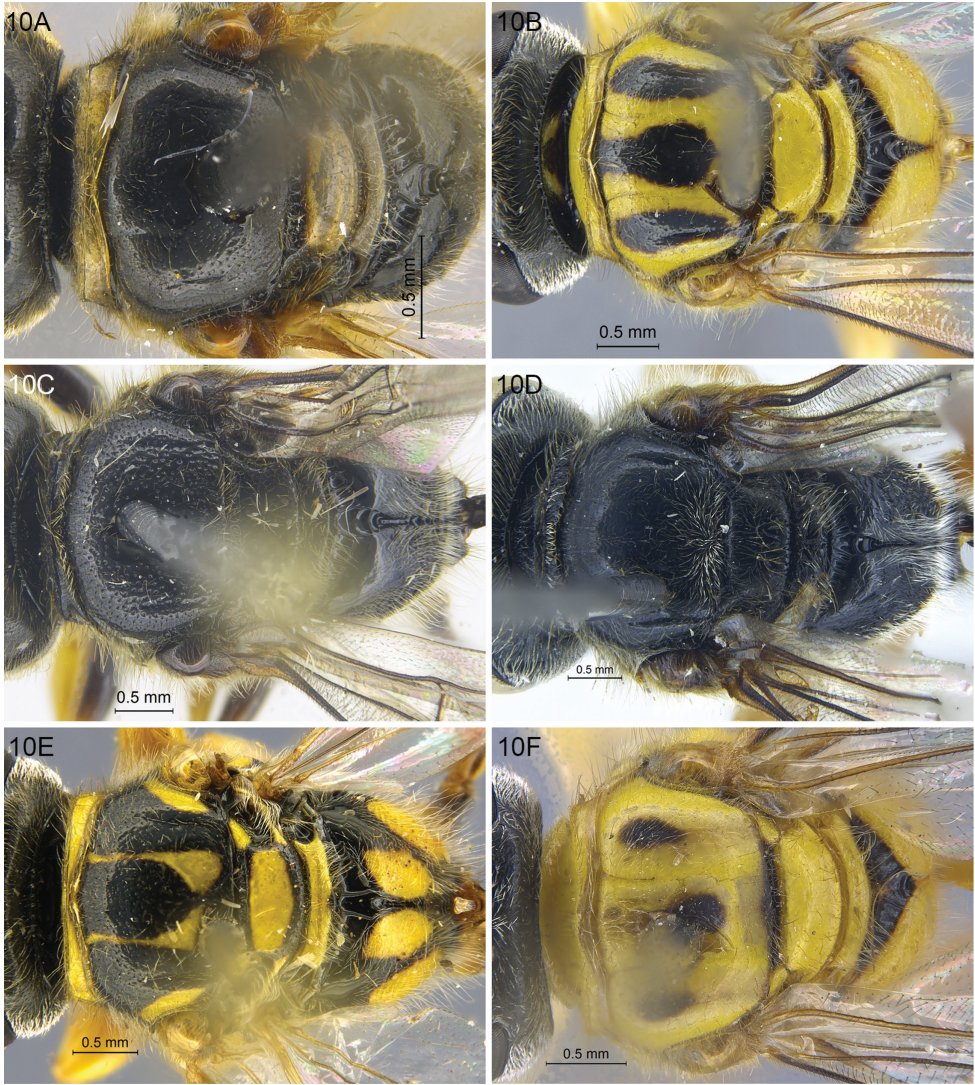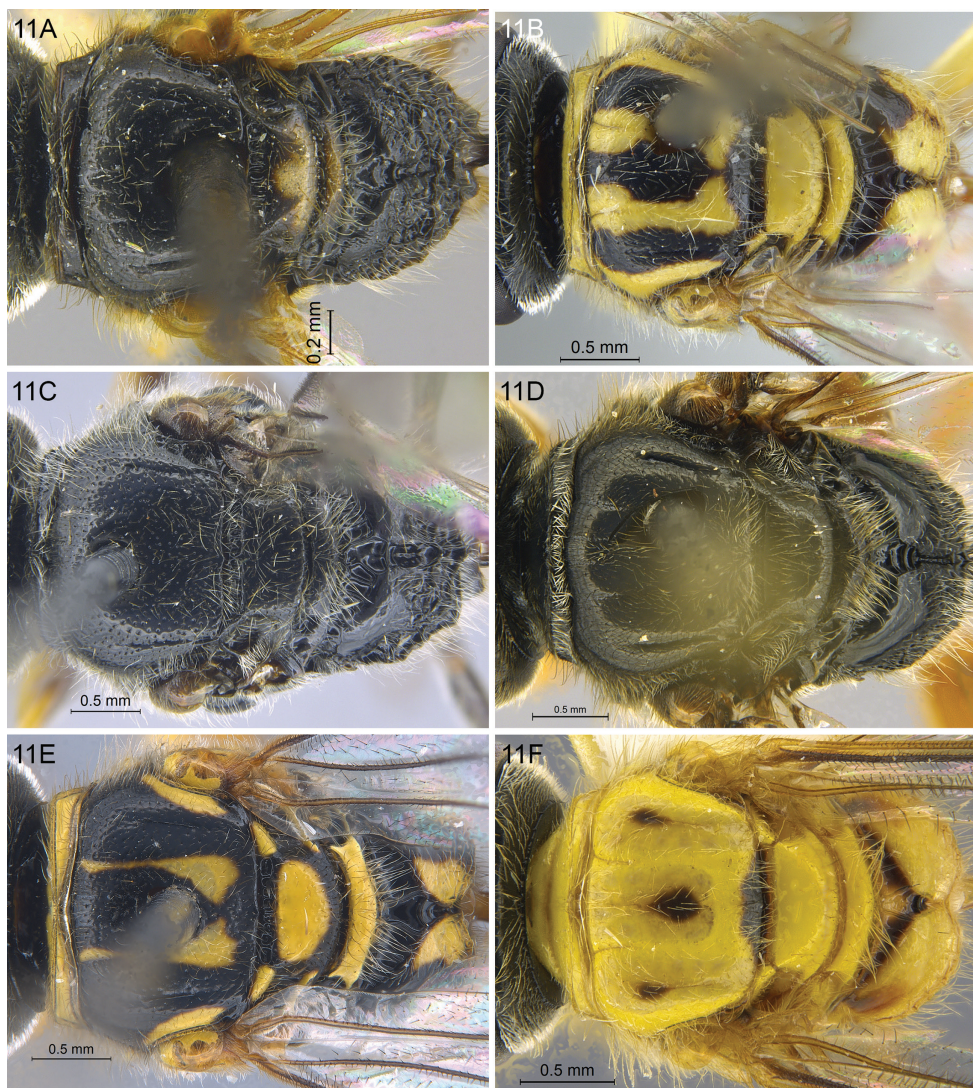
Figure 10. Females, mesosoma in dorsal view **10A** *P. carinifrons rohweri* **10B** *P. continentis* **10C** *P. ephippius* sp. nov., holotype **10D** *P. gibbus* sp. nov.; holotype **10E** *P. maculatus maculatus* **10F** *P. pallens* sp. nov., holotype.

Standard ratios. Males (n = 1): L = 7.00 mm; CR = 1.28; OOR = 0.89; FLR = 1.1; FRR = 0.79; MR = 1.58; OMR = 0.95; PR = 0.68; PFR = 1.18. Females (n = 3): L = 7.4–7.9 mm (mean = 7.7 mm); CR = 1.27–1.3 (mean = 1.29); OOR = 0.73–0.75 (mean = 0.73); FLR = 1.63–1.73 (mean = 1.66); FRR = 0.70–0.85 (mean = 0.80); MR = 1.49–1.77 (mean = 1.68); OMR = 0.89–0.9 (mean = 0.89); PR = 0.30–0.36 (mean = 0.34); PFR = 1.15–1.19 (mean = 1.17).

Description. Male: Antenna without tyloids. Clypeus (Fig. 21C) with two blunt ventral teeth separated by a rounded emargination, remainder of clypeal margin more or less straight on the first two-fifths and terminated by a flattened lobe on the last

Figure 11. Males, mesosoma in dorsal view **11A** *P. carinifrons rohweri* **11B** *P. continentis* **11C** *P. ephippius* sp. nov., paratype **11D** *P. gibbus* sp. nov.; paratype **11E** *P. maculatus maculatus* **11F** *P. pallens* sp. nov., paratype.

two-fifths of the margin. Subantennal carina well developed; interantennal carina narrow, not broadened dorsally. Mesoscutum moderately punctate with small punctures separated by at least their own diameter (Fig. 11C); prescutal sutures short, not extending beyond anterior level of tegula; episternal sulcus broadly foveolate, mesopleural suture with small fovea on dorsal half; propodeal enclosure with marked fovea (Fig. 15C); propodeum laterally and posteriorly coarsely reticulate, dorsally narrowly polished with very small and largely interspaced punctures (Fig. 15C). Petiole subcylin-

drical; T1 swollen (Fig. 4C). Fore wing (Fig. 19F) with first recurrent vein interstitial or reaching second submarginal cell near base, second recurrent vein reaching third submarginal cell at about one-sixth (0.17×) of cell length from base.

Head entirely black with appressed silvery pubescence (Figs 7C, 9C); antenna with scape dark brown, venter of pedicel and venter of flagellum of a lighter brown, dorsum of pedicel and remainder of flagellum dark brown; mandible black on the apical third and basal sixth, the remainder yellow. Mesosoma entirely black (Fig. 5C). Femurs, trochanters and coxae black, tibiae and tarsi light brown/yellow. Petiole mostly black, distally red/orange; remainder of gaster mostly reddish but T2–T5 and S3–S7 with large dark brown/black areas (Fig. 5C).

Female: Clypeus ventrally (Fig. 20C) with two blunt/rounded teeth, separated by a deep rounded emargination, the remainder of the clypeal margin forming a shallow concavity extending across half of margin and terminated on last third with a blunt lobe intersecting eye margin; dorsal margin flattened on central third of transverse length of clypeus, the remainder reaching ventral margin along a shallow convex line. Subantennal carina weak, extending about one-third of distance between interantennal carina and eye; interantennal carina narrow, not broadened dorsally. Mesoscutum moderately punctate with small punctures separated by at least their own diameter (Fig. 11C); prescutal sutures short, not extending beyond anterior level of tegula; episternal sulcus and mesopleural suture narrowly foveolate along entire length (Fig. 12C). Propodeum laterally and posteriorly weakly reticulate, dorsal half polished with very small and largely interspaced punctures (Fig. 14C). Dorsal part of hind tibia, normal, no polished area and no small denticles dorsobasally (Fig. 18E). Petiole subcylindrical; tergum I low (Fig. 5C). Pygidial plate with very faint medial carina extending about half length of T6 (Fig. 16C). Fore wing (Fig. 19F) with first recurrent vein interstitial or reaching second submarginal cell near base, second recurrent vein reaching third submarginal cell at about one-sixth (0.17×) of cell length from base.

Head entirely black with appressed silvery pubescence (Figs 7C, 9C); antenna entirely dark brown/black. Mandible yellow on basal half and then gradually darkening to become black at the apex. Mesosoma entirely black (Fig. 5C). Femurs, trochanters and coxae black, tibiae and tarsi light brown/yellow except hind tibia dark brown/black. Petiole mostly black, distally red/orange; remainder of metasoma mostly reddish but T2–T5 and S3–S7 with large dark brown/black areas (Fig. 5C).

Etymology. Species named as a toponomy in reference to the mountain facing the type locality, Ma On Shan or Horse Saddle Mountain in Chinese (*ephippium* = saddle in Latin).

Notes. This species has only been recorded so far from one site in the SAR, at Mang Kung Wo which presents the highest anthropogenic disturbance of all our sampled sites. It remains uncommon, having only been recorded from five specimens since the beginning of continuous sampling at this site in March 2018. This species has apparently the shortest activity period of all Hong Kong *Psenulus* and is recorded from end of March (W13) to September (W37).

Psenulus gibbus sp. nov.

http://zoobank.org/D331DAB3-DF24-494C-95A7-8B5E8E003FF6
Figs 4D–17D, 18G, H, 19G, H, 20D, 21D

Diagnosis. Based on a dorsally broadened interantennal carina (Figs 6D, 7D), bidentate clypeus (Figs 20D, 21D), short prescutal sutures (Figs 10D, 11D), hind tibia lacking basal spines (Figs 18G, 19G), and a well-defined pygidial plate, this species may be placed in the *P. quadridentatus* species group of van Lith (1962). The specimen resembles *Psenulus compactus* van Lith, 1962 (from Sumatra) but differs in the broadened excavation of the interantennal carina being less extensive (not extending below the antennal sockets), the subantennal carina being absent, and the mesosoma being less densely punctate. *Psenulus gibbus* sp. nov., superficially resembles *P. ephippius* sp. nov. but is readily differentiated by the yellow legs (Figs 4D, 5D) and the reticulate dorsal surface of the propodeum (Figs 14D, 15D) in the former and dark/brown legs (Figs 4C, 5C) and polished dorsal surface of the propodeum (Figs 14C, 15C) in the latter.

Material examined. *Holotype*: China, Hong Kong • ♀; Mang Kung Wo; 22°22'06"N, 114°15'12"E; 60 m a.s.l.; 23 Mar.–06 Apr. 2018; C. Barthélémy leg.; Malaise trap, ref.: M405CHy4; CAS. *Paratypes*: China, Hong Kong • 1 ♀; ibid.; 11–25 Apr. 2020; ibid; ref.: M483CHy2; CBC • 1 ♀; ibid.;25 Apr. 2020–09 May 2020; ibid; ref.: M485CHy5 • 2♀4♂; ibid.; 09 Mar. 2020; same collector; hand net, refs: 0708AHy1, 0708AHy2A, 2B and 2C; CAS and CBC • 1 ♀; ibid.; 10 Mar. 2020; ibid.; ref.: 0709AHy1; CBC • 1♀1♂; ibid.; 13 Mar. 2020; ibid..; refs: 0710AHy1 and 0710AHy2; CBC.

Standard ratios. Male (n = 4): L = 5.9–6.9 mm (mean = 6.3 mm); CR = 1.24–1.27 (mean = 1.26); OOR = 0.48–0.76 (mean = 0.64); FLR = 1.08–1.19 (mean = 1.14); FRR = 0.66–0.74 (mean = 0.71); MR = 1.41–1.59 (mean = 1.50); OMR = 0.82–0.92 (mean = 0.88); PR = 0.35–0.62 (mean = 0.49); PFR = 1.15–1.30 (mean = 1.20). Female (n = 6): L = 6.8–8.4 mm (mean = 7.55 mm); CR = 1.32–1.4 (mean = 1.36); OOR = 0.62–0.75 (mean = 0.67); FLR = 1.28–1.57 (mean = 1.44); FRR = 0.65–0.79 (mean = 0.73); MR = 1.30–1.64 (mean = 1.44); OMR = 0.82–0.93 (mean = 0.86); PR = 0.4–0.88 (mean = 0.66); PFR = 1.13–1.28 (mean = 1.18).

Description. Male: Antenna with tyloids on F1 to F11. Ventral margin of clypeus with two rounded teeth separated by a rounded emargination (Fig. 21D), remainder of the ventral margin straight for half of width, terminated on last third with a rounded lobe intersecting eye margin; dorsal margin concave on the central third of transverse width of clypeus, remainder reaching ventral margin along a shallow convex line. Subantennal carina well developed nearly reaching toruli (Fig. 7D); interantennal carina dorsally moderately broadened and slightly excavated on its basal part only (Fig. 9D). Mesosoma with very small largely interspaced punctures bearing numerous long and fine appressed setae; mesoscutum with the same texture (Fig. 11D); prescutal sutures extending beyond anterior level of tegula; episternal sulcus broadly foveolate (Fig. 13D), mesopleural suture simple; propodeal enclosure well defined with large fovea (Fig. 15D). Propodeum laterally and posteriorly weakly reticulate with long appressed setae, dorsal half polished with very small and largely interspaced punctures (Fig. 15D).
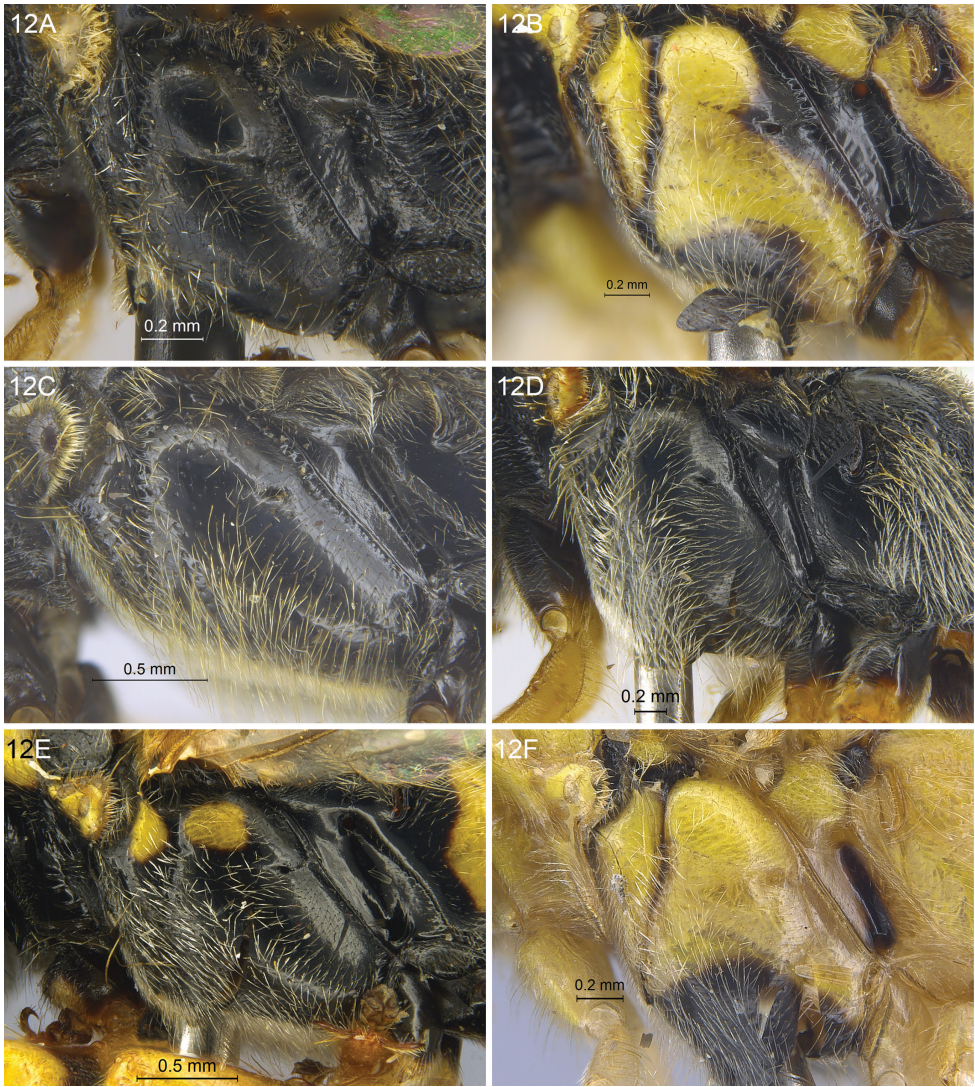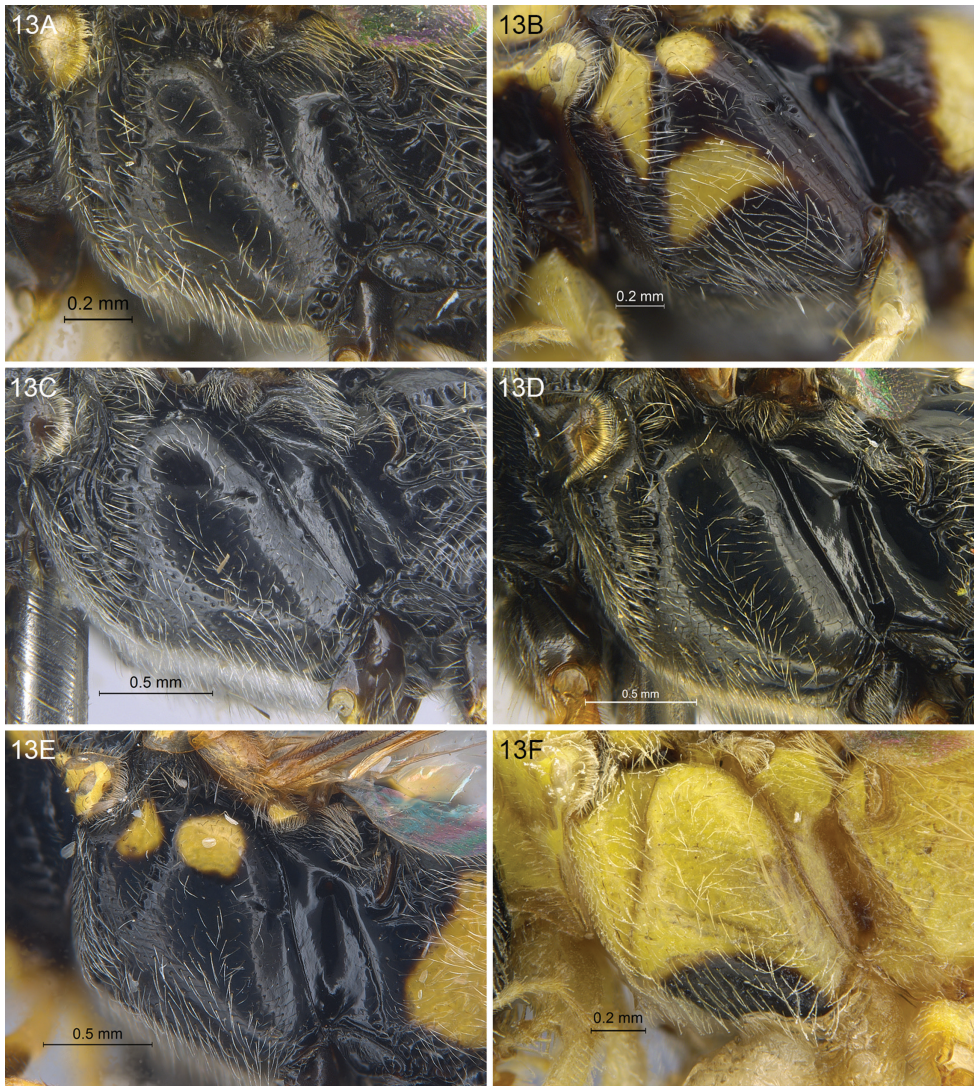
Figure 12. Females, mesopleuron **12A** *P. carinifrons rohweri* **12B** *P. continentis* **12C** *P. ephippius* sp. nov., holotype **12D** *P. gibbus* sp. nov.; holotype **12E** *P. maculatus maculatus* **12F** *P. pallens* sp. nov., holotype.

Petiole subcylindrical, T1 low (Fig. 5D). Hind tibia without denticles dorsobasally (Fig.19G). Pygidial plate simple (Fig. 17D). Fore wing (Fig. 19H) with first recurrent vein more or less interstitial with first and second submarginal cells, second recurrent vein meeting third submarginal cell at about $^1/_5$ (0.18×) of cell length from base.

Head entirely black with appressed silvery pubescence (Figs 7D, 9D); antenna with scape mostly yellow, venter of pedicel and venter of flagellum of a lighter brown, dorsum of pedicel and remainder of flagellum dark brown; mandible black on the apical third, the remainder yellow. Mesosoma entirely black (Fig. 7D) but pronotal lobe and tegulae dark yellow/red. Trochanter, femurs, tibiae and tarsus yellow/orange, coxae

Figure 13. Males, mesopleuron **13A** *P. carinifrons rohweri* **13B** *P. continentis* **13C** *P. ephippius* sp. nov., paratype **13D** *P. gibbus* sp. nov.; paratype **13E** *P. maculatus maculatus* **13F** *P. pallens* sp. nov., paratype.

black. Petiole black, remainder of metasoma mostly reddish but T2–T5 and S3–S7 with large dark brown/black areas (Fig. 7D).

Female: Ventral margin of clypeus with two relatively sharp teeth separated by a sub-triangular emargination (Fig. 20D), remainder of the ventral margin straight for half of width, terminated on last third with a blunt lobe intersecting eye margin; dorsal margin flattened for central third of transverse width of clypeus, remainder reaching ventral margin along a shallow convex line. Subantennal carina absent (Fig. 6D); interantennal carina dorsally broadened and deeply excavated (Fig. 8D); Mesosoma with

very small largely interspaced punctures bearing numerous long and fine appressed setae; mesoscutum with the same texture (Fig. 11D); prescutal sutures short, not extending beyond anterior level of tegula (Fig. 10D) episternal sulcus broadly foveolate (Fig. 13D), mesopleural suture simple; propodeal enclosure well defined with large fovea (Fig. 15D). Propodeum laterally and posteriorly weakly reticulate with long appressed setae, dorsal half polished with very small and largely interspaced punctures (Fig. 15D). Hind tibia with a cluster of 7–9 short brown denticles dorsobasally, but no spines (Fig. 18G). Petiole subcylindrical, T1 low (Fig. 5D). Pygidial plate with faint ventrolateral carinae extended basally (Fig. 16D). Fore wing (Fig. 18H) with second recurrent vein meeting third submarginal cell at about $^1/_5$ (0.22×) of cell length from base.

Etymology. Specific name derived from the prominent hump [= *gibbus* in Latin] formed by the interantennal ridge, extending below the antennal sockets and ending at middle of toruli.

Notes. By its marked differences with the other known *Psenulus* of similar coloration as detailed in the diagnosis section, we have concluded that this is in fact a new species to science.

The first collection of this species occurred in 2019 and thus far the distribution of this species is limited to a single location in Mang Kung Wo, which is the sampled site with the highest anthropogenic disturbance. In March 2020 a series of seven specimens (four males and three females) were collected by hand net. Nonetheless, this species is one of the least common *Psenulus* encountered in Hong Kong. With the limitations presented above, knowledge about its activity period is limited to March (W11–W13) and April (W15–W17).

Psenulus maculatus maculatus van Lith, 1962
Figs 4E–17E, 18I, J, 19I, J, 20E, 21E

Psenulus maculatus maculatus van Lith 1962: 61–62, figs 69–72. Holotype: ♀; Malaysia, Penang, 25 mi Sungai Penang Hills; type repository unknown, formerly H.T. Pagden coll.

Material examined. CHINA, HONG KONG • 1♂; Tung Chung; 22°16'55"N, 113°55'43"E; 29 May–12 Jun. 2018; C. Taylor and Cheung Shun Chi leg.; Malaise trap; HKU • 1♂; Pak Sha O; 22°26'59"N, 114°19'04"E; 70 m a.s.l.; 14 May–05 Jun. 2011; C. Barthélémy; Malaise trap, ref.: M092CHy19; CBC • 1♀; ibid.; 23 May 2020–06 Jun. 2020; ibid.; ref.: M492.C.Hy.1; CBC • 1♂; Mang Kung Wo; 22°22'06"N, 114°15'12"E; 60 m a.s.l.; 18 Aug.–01 Sep. 2018; ibid.; ref.: M362CHy8; CBC • 1♂; ibid.; 04–18 May 2019; ibid.; ref.: M413CHy5; CBC • 2♀; ibid.; 17–31 Mar. 2018; ibid.; ref.: M336CHy7A and B; CBC • 1♀; ibid.; 28 Apr.–12 May 2018; ibid.; ref.: M345CHy2; CBC • 1♀; ibid.; 4–18 Aug. 2019; ibid.; ref.: M359CHy7; CBC • 1♀; ibid.; 01–15 Sep. 2019; ibid.; ref.: M365CHy7; CBC • 1♀; ibid.; 9–23 May. 2020; ibid.; ref.: M489CHy2; CBC • 1♂; ibid.; 17 Aug. 2020–01 Sep. 2020; ibid.; ref.: M509CHy2; CBC.
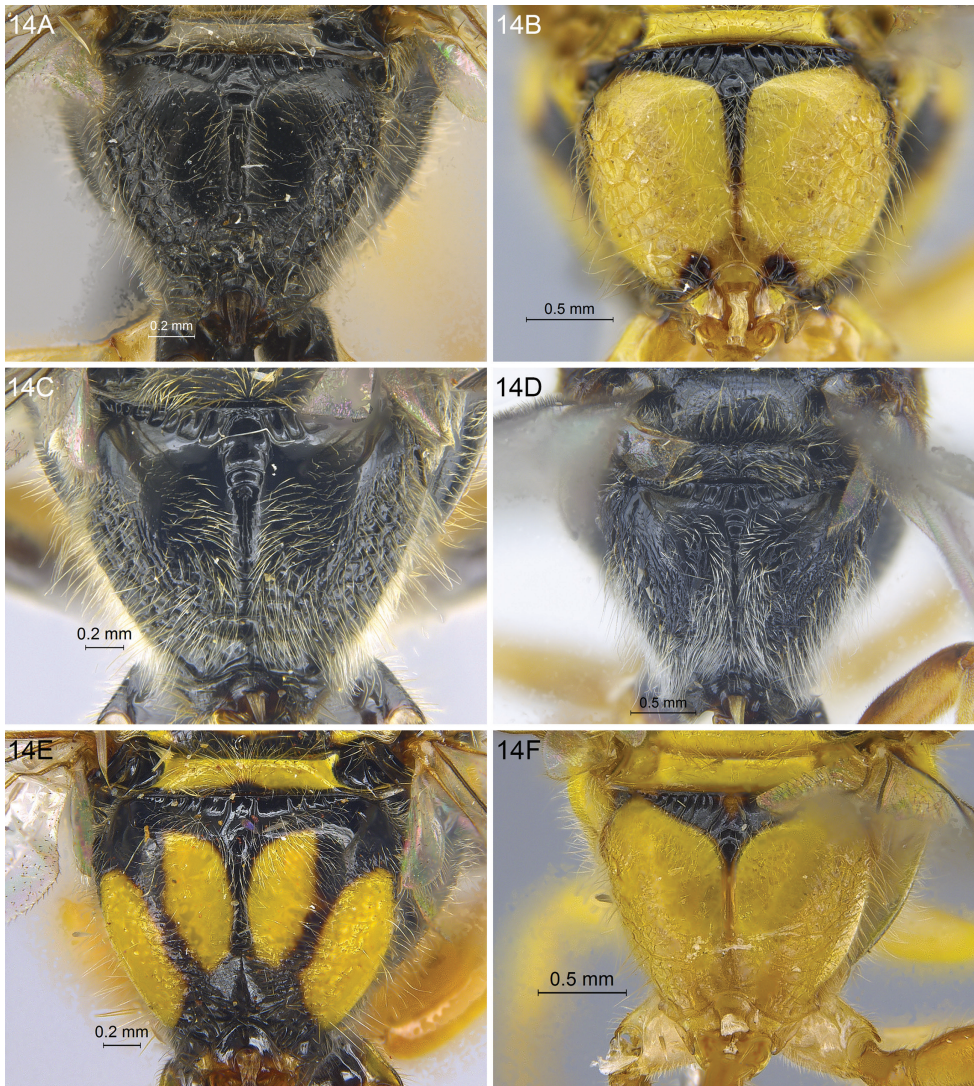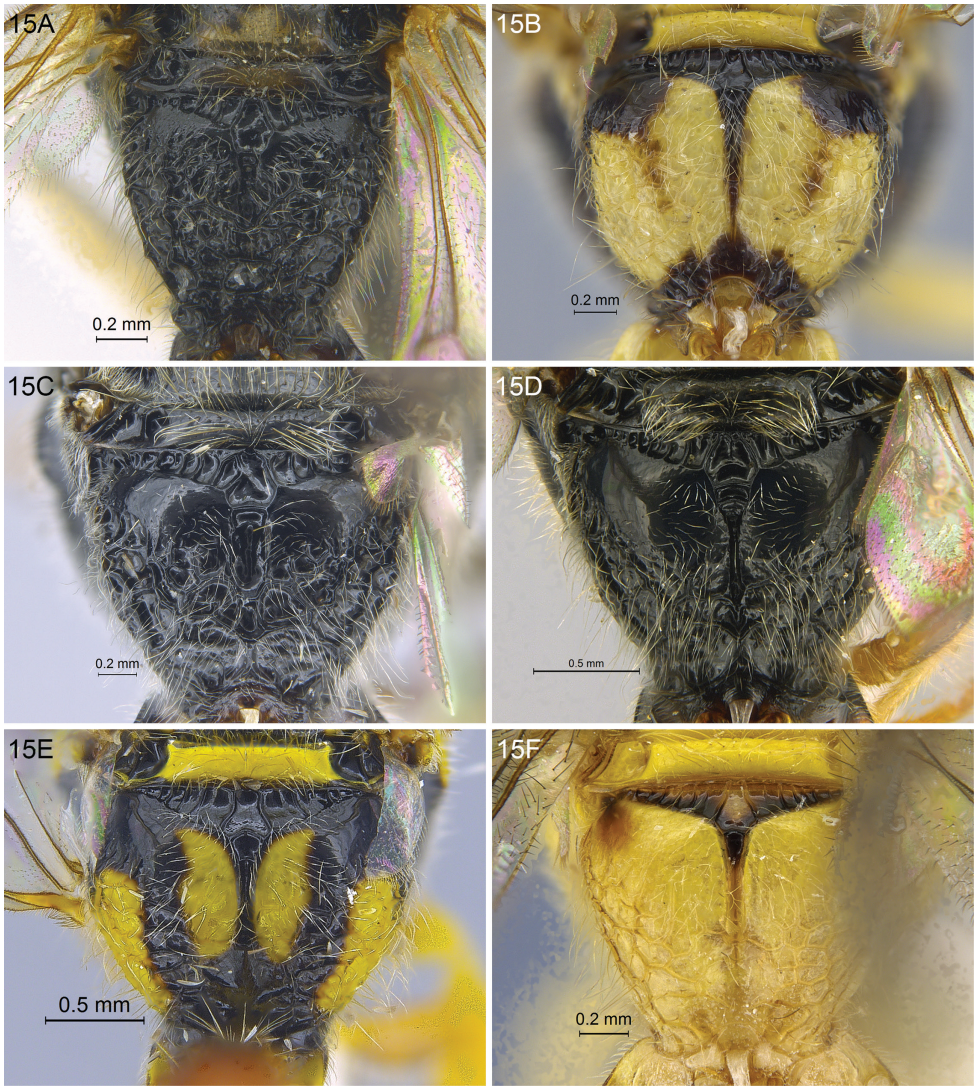
Figure 14. Females, propodeum in dorsal view **14A** *P. carinifrons rohweri* **14B** *P. continentis* **14C** *P. ephippius* sp. nov., holotype **14D** *P. gibbus* sp. nov.; holotype **14E** *P. maculatus maculatus* **14F** *P. pallens* sp. nov., holotype.

Standard ratios. Males (n = 5): L = 5.–6.6 mm (mean = 5.9 mm); CR = 1.21–1.33 (mean = 1.28); OOR = 0.76–0.89 (mean = 0.84); FLR = 1.00–1.23 (mean = 1.09); FRR = 0.66–0.70 (mean = 0.69); MR = 1.35–1.61 (mean = 1.54); OMR = 0.94–1.01 (mean = 0.97); PR = 0.7–2.53 (mean = 1.21); PFR = 0.88–1.05 (mean = 0.94). Females (n = 7): L = 6.4–7.1 mm (mean = 6.53 mm); CR = 1.22–1.35 (mean = 1. 28); OOR = 0.71–0.86 (mean = 0.77); FLR = 1.25–1.5 (mean = 1.38); FRR = 0.60–0.67 (mean = 0.64); MR = 1.36–1.64 (mean = 1.47); OMR = 0.89–0.99 (mean = 0.92); PR = 1.05–1.83 (mean = 1.32); PFR = 0.82–0.94 (mean = 0.87).

Figure 15. Males, propodeum in dorsal view **15A** *P. carinifrons rohweri* **15B** *P. continentis* **15C** *P. ephippius* sp. nov., paratype **15D** *P. gibbus* sp. nov.; paratype **15E** *P. maculatus maculatus* **15F** *P. pallens* sp. nov., paratype.

Description. Male: Antenna with small tyloids present on F7 to F11. Clypeus (Fig. 21E) with two acute ventral teeth separated by rounded emargination, remainder of clypeal margin evenly rounded. Subantennal carina well developed (Fig. 7E); interantennal carina narrow, not broadened dorsally, Mesosoma mostly polished, mesoscutum moderately punctate with punctures separated by about their own diameter (Fig. 11E), remainder of mesosoma more sparsely punctate; prescutal sutures short, ending about anterior level of tegula; episternal sulcus broadly foveolate (Fig. 13E); propodeal enclosure with few pairs of longitudinal carinae; remainder of propodeum coarsely reticulate
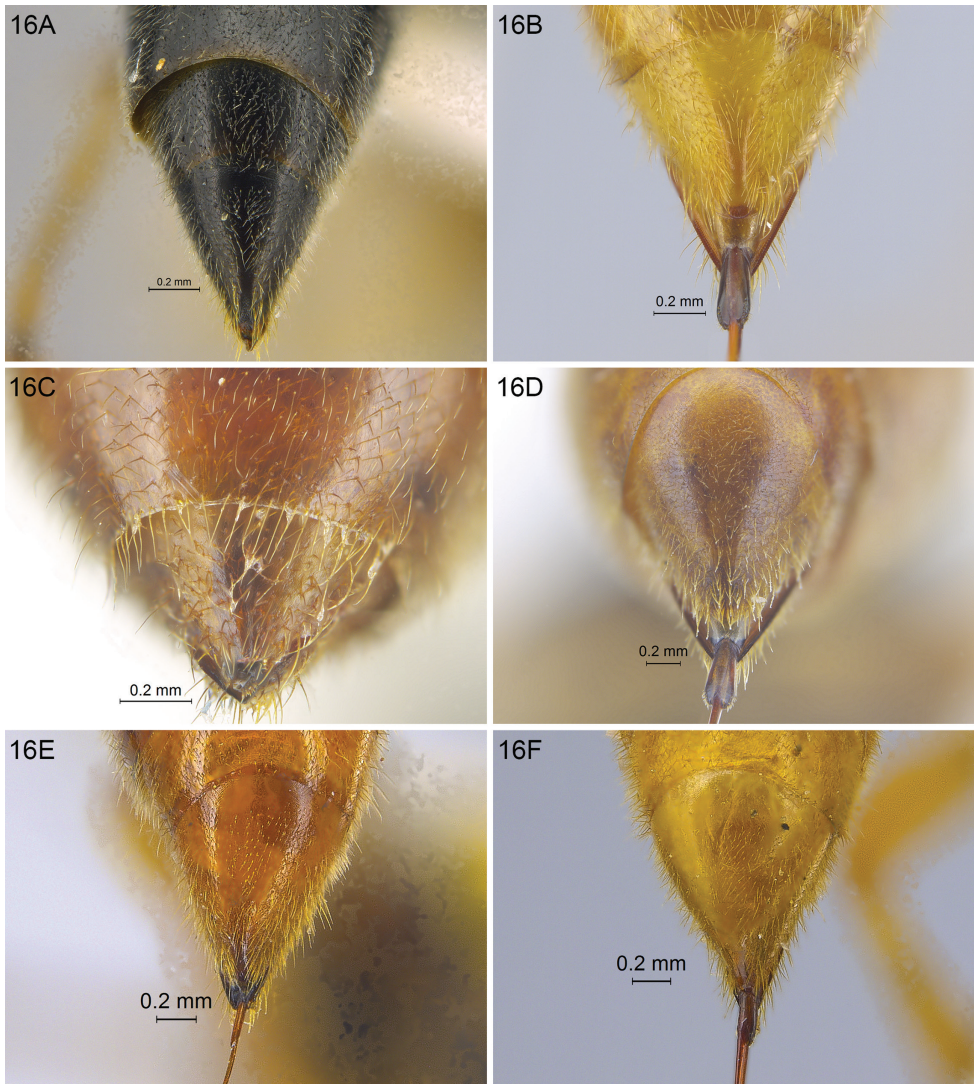
Figure 16. Females, posterior tergites in dorsal view **16A** *P. carinifrons rohweri* **16B** *P. continentis* **16C** *P. ephippius* sp. nov., holotype **16D** *P. gibbus* sp. nov.; holotype **16E** *P. maculatus maculatus* **16F** *P. pallens* sp. nov., holotype.

(Fig. 15E) except narrowly smooth anterolaterally. Petiole subcylindrical, T1 distinctly swollen (Fig. 5E). Fore wing (Fig. 19J) with first recurrent vein joining first submarginal cell near apex; second recurrent vein joining third submarginal cell near base.

Head black with appressed silvery pubescence (Figs 7E, 9E); antenna with most of scape, venter of pedicel and venter of flagellum basally yellow, dorsoapical spot on scape, dorsum of pedicel and remainder of flagellum blackish; mandible yellow with black tip. Mesosoma mostly black, the following yellow (Figs 5E, 11E, 13E): pronotal collar, pronotal lobe; mesoscutum with two longitudinal submedian stripes inside prescutal sutures, broadening posteriorly, ending prior to posterior margin of
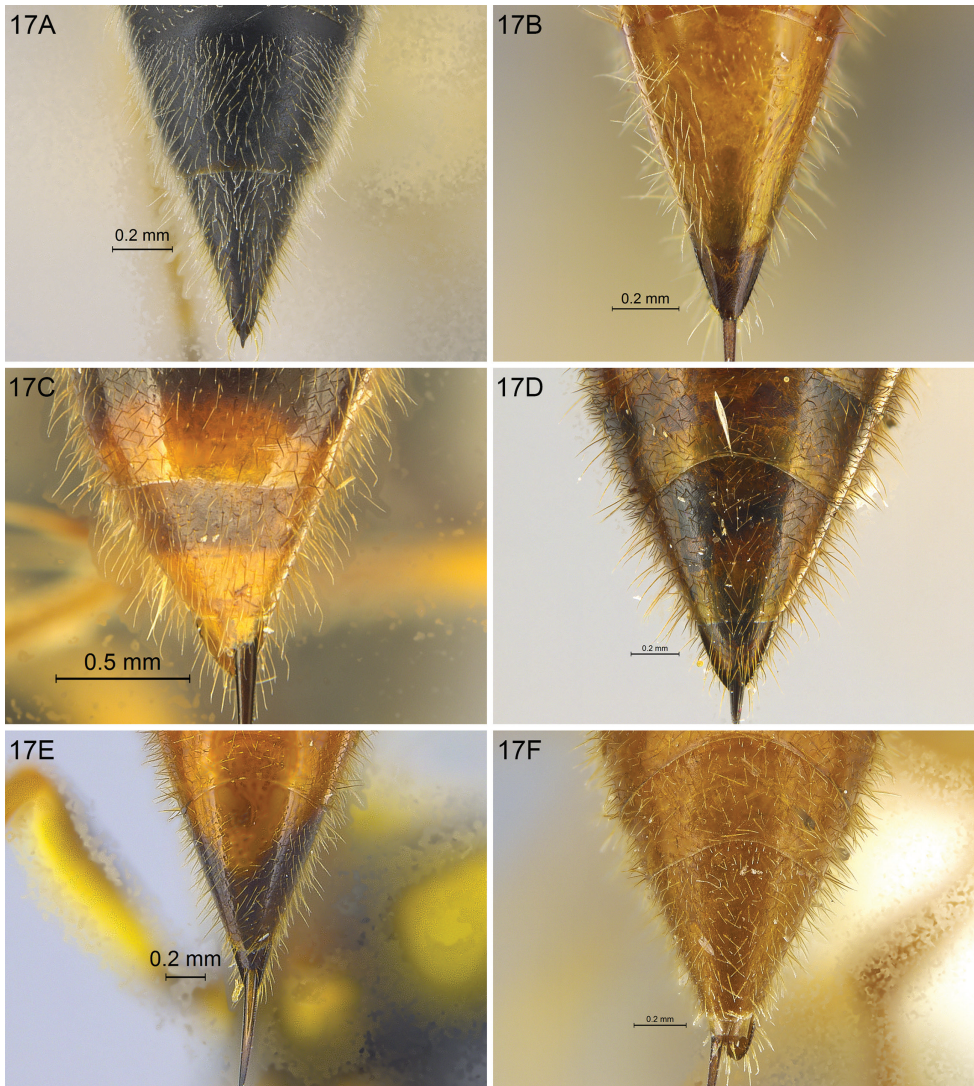
Figure 17. Males, posterior tergites in dorsal view **17A** *P. carinifrons rohweri* **17B** *P. continentis* **17C** *P. ephippius* sp. nov., paratype **17D** *P. gibbus* sp. nov.; paratype **17E** *P. maculatus maculatus* **17F** *P. pallens* sp. nov., paratype.paratype **17F** *P. gibbus* sp. nov., paratype.

mesoscutum, often narrowed or absent in anterior half of mesoscutum, long posterolateral spot also present on mesoscutum; tegula; large spot on axilla; broad anteromedian spot on scutellum, as well as narrow stripe along posterior margin laterally behind wing insertion; metanotum; mesopleuron with two spots dorsally anterior and posterior to oblique mesopleural suture; propodeum with paired spots posteriodorsally and laterally. Legs mostly yellow, coxae black basally; fore and mid femora posteriorly brown; hind trochanter and dorsum of hind femur brown; hind tibia and tarsus reddish. S1 yellow at very base of petiole, otherwise blackish; T1 dark brown mediobasally; remainder of metasoma mostly reddish except apex of metasoma dark brown.
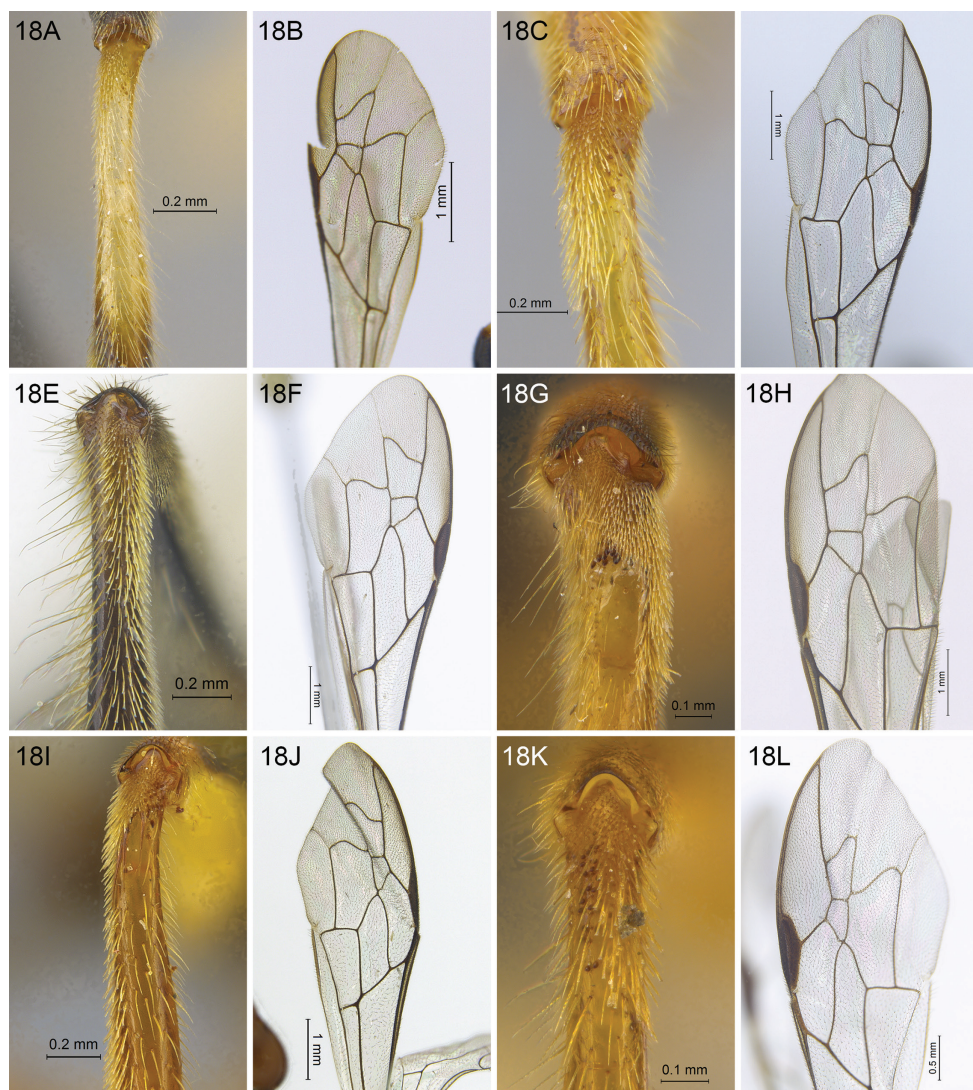
Figure 18. Females, dorsobasal view of hind tibiae and hind wings. **18A, 18B** *Psenulus carinifrons rohweri*; **18C, 18D** *P. continentis* **18E, 18F** *P. ephippius* sp. nov., holotype **18G, 18H** *P. gibbus* sp. nov., holotype **18I, 18J** *P. maculatus maculatus* **18K, 18L** *P. pallens* sp. nov., holotype.

Female: Clypeus with marginal teeth larger than in male (Fig. 20E). Subantennal carina well developed (Fig. 7E); interantennal carina narrow, not broadened dorsally, Mesosoma mostly polished, mesoscutum moderately punctate with punctures separated by about their own diameter (Fig. 11E), remainder of mesosoma more sparsely punctate; prescutal sutures short, ending about anterior level of tegula; episternal sulcus broadly foveolate (Fig. 13E), propodeal enclosure with few pairs of longitudinal carinae. Propodeum mostly smooth (Fig. 14E), coarse reticulations restricted to marginal ridge along transition between posterior and lateral surfaces. Hind tibia with
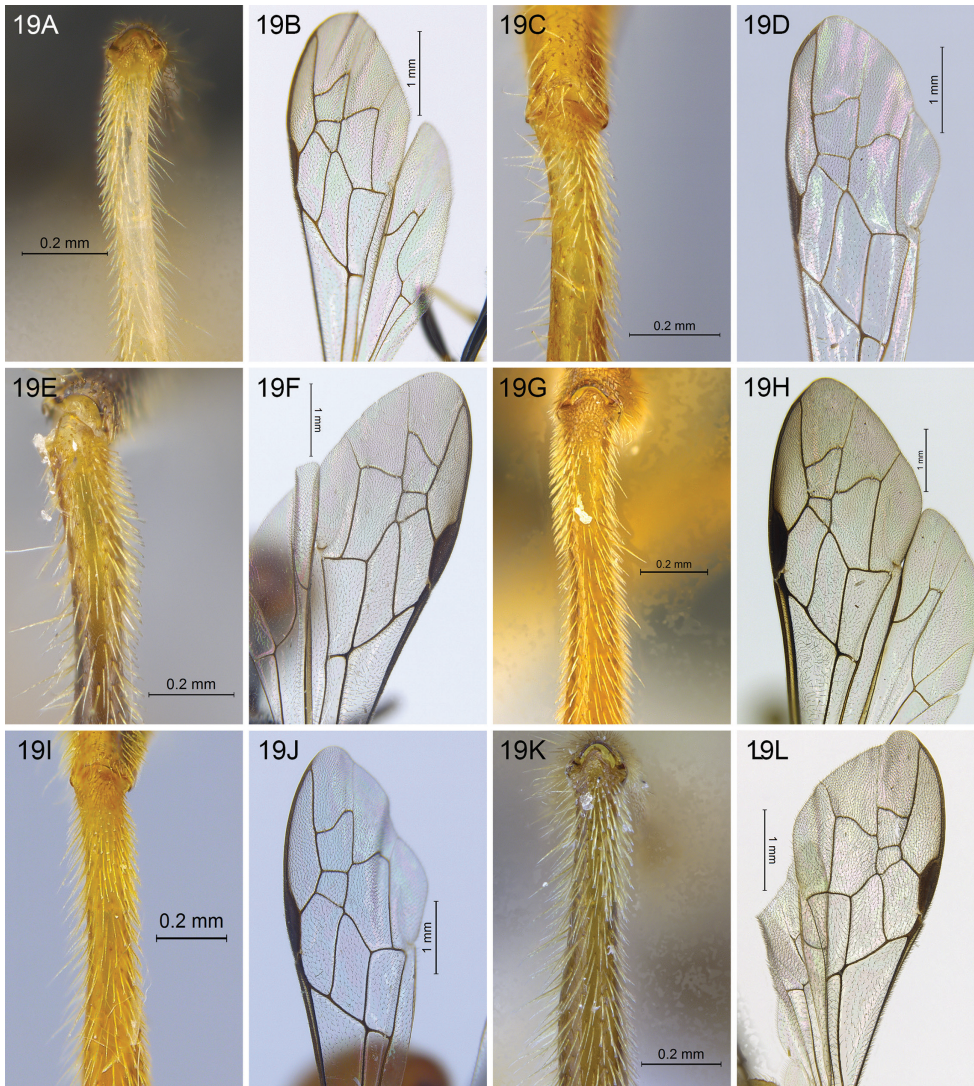
Figure 19. Males, dorsobasal view of hind tibiae and hind wings **19A, 19B** *Psenulus carinifrons rohweri* **19C, 19D** *P. continentis* **19E, 19F** *P. ephippius* sp. nov., holotype **19G, 19H** *P. gibbus* sp. nov., holotype **19I, 19J** *P. maculatus maculatus* **19K, 19L** *P. pallens* sp. nov., holotype.

dorsobasal array of short denticles associated with elongate red spines basad to distinct dorsal groove (Fig. 18I), and transverse row of short red spines antero-apically. Petiole subcylindrical, T1 distinctly swollen (Fig. 5E). Pygidial plate narrow, delineated by distinct carinae that diverge anteriorly (Fig. 16E). Fore wing (Fig. 19J) with first recurrent vein joining first submarginal cell near apex; second recurrent vein joining third submarginal cell near base.

Head black with appressed silvery pubescence (Figs 7E, 9E); antenna with most of scape, venter of pedicel and venter of flagellum basally yellow, dorsoapical spot

on scape, dorsum of pedicel and remainder of flagellum blackish; mandible yellow with black tip. Mesosoma mostly black, the following yellow (Figs 5E, 11E, 13E): pronotal collar, pronotal lobe; mesoscutum with two longitudinal submedian stripes inside prescutal sutures, broadening posteriorly, ending prior to posterior margin of mesoscutum, often narrowed or absent in anterior half of mesoscutum, long posterolateral spot also present on mesoscutum; tegula; large spot on axilla; broad anteromedian spot on scutellum, as well as narrow stripe along posterior margin laterally behind wing insertion; metanotum; mesopleuron with two spots dorsally anterior and posterior to oblique mesopleural suture; propodeum with paired spots posteriodorsally and laterally, larger than in male, may be merged into single posterior patch. Legs mostly yellow, coxae black basally; fore and mid femora posteriorly brown; hind trochanter and dorsum of hind femur brown; hind tibia and tarsus reddish. S1 yellow at very base of petiole, otherwise blackish; T1 dark brown mediobasally; remainder of metasoma mostly reddish except apex of metasoma dark brown.

Distribution. *China (Hong Kong); Malaysia (Penang), Singapore. (van Lith 1962, 1976).

Notes. The coloration of the mesoscutum has previously been described as having two submedian triangular marks in the posterior half but specimens from Hong Kong vary from as described to having longitudinal yellow stripes extending most of the length of the mesoscutum. Males of this species can readily be distinguished from other *Psenulus* in the Hong Kong SAR by the presence of tyloids on the underside of the distal antennal segments; females can be distinguished by their prominent subantennal carina and an array of long red spines dorsobasally on the hind femur. *Psenulus maculatus* also differs from other Hong Kong *Psenulus* in having the fore and mid femora partially brown instead of entirely yellow.

Psenulus maculatus maculatus was previously known from the Malaysian Peninsula with other subspecies known from Java and Sri Lanka (van Lith 1962, 1978). The discovery of this species in Hong Kong is a new record for China and also extends notably the known distribution of the taxon.

It is the least common of all species and its occurrence confirmed at only three of the 20 sites sampled and never very abundant at any of these sites. Its activity period is the second shortest (after *P. ephippius*) and spans from March (W11) to September (W38).

Psenulus pallens sp. nov.
http://zoobank.org/08453112-8D76-481C-B958-02AEC71AD76E
Figs 4F–17F, 18K, L, 19K, L, 20F, 21F, 22A–D

Diagnosis. *Psenulus pallens* sp. nov. is readily distinguishable from most other species of its genus by its remarkably light coloration with black patches restricted as described below (Figs 4F, 5F, 22A–22D). From other similarly light-coloured species, it differs from *P. lamprus* van Lith, 1972 of Sulawesi by its less reticulated propodeum with pol-
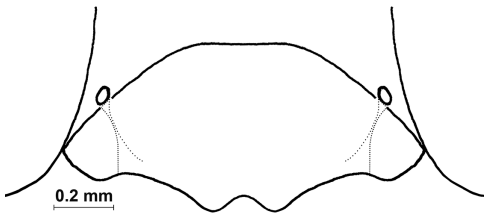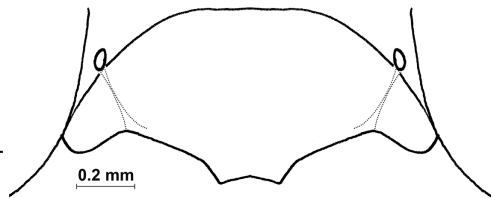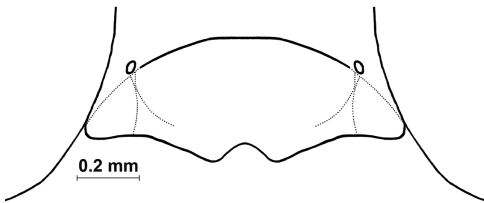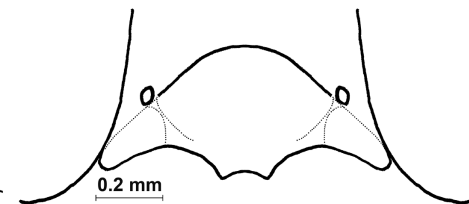
20A
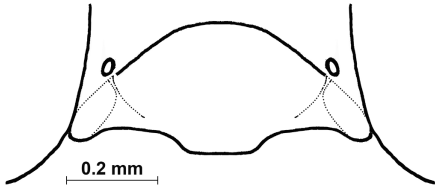
20B
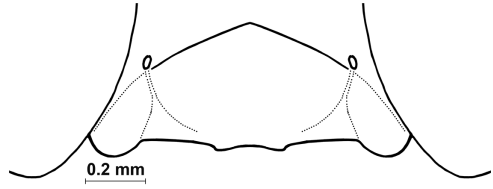
20C

20D

20E

20F

Figure 20. Females, frontal view of clypeus **20A** *P. carinifrons rohweri* **20B** *P. continentis* **20C** *P. ephippius* sp. nov., holotype **20D** *P. gibbus* sp. nov.; holotype **20E** *P. maculatus maculatus* **20F** *P. pallens* sp. nov., holotype.

ished area dorsally (Figs 14F, 15F); in the female of the latter (the male is unknown), the back and most of the sides of the propodeum are densely and coarsely reticulate. The female of *P. pallens* also differs from *P. lamprus* in its cluster of denticles on the apex of hind tibia (Fig. 18K) as opposed to three reddish spines in the latter. It shows also considerable difference in the shape of the ventral clypeal margin (Figs 20F, 21F) with that of similarly coloured *P. lamprus* and *P. interstitialis*, the latter two with small teeth, reduced to denticles and no emargination in-between. *Psenulus impressus* van Lith, 1976 of Luzon has the episternal sulcus foveolate. *Psenulus singularis* van Lith, 1962 also from Luzon has a distinctly shaped clypeus with the median section of the ventral margin bluntly protruding.
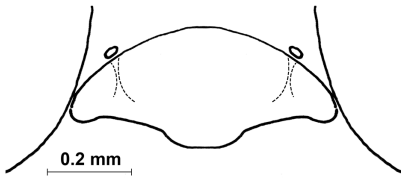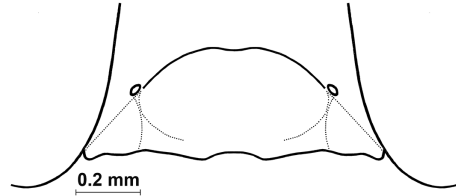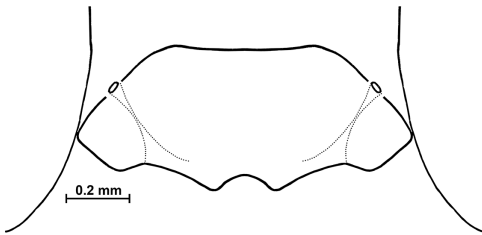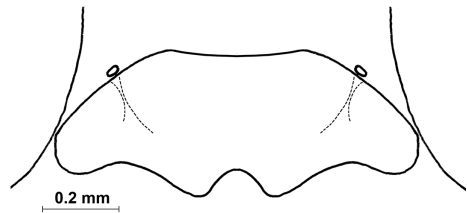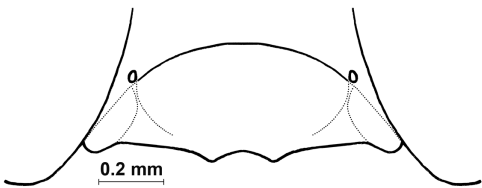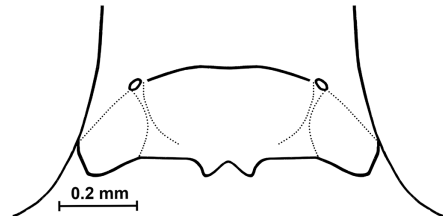
Figure 21. Males, frontal view of clypeus **21A** *P. carinifrons rohweri* **21B** *P. continentis* **21C** *P. ephippius* sp. nov., paratype **21D** *P. gibbus* sp. nov.; paratype **21E** *P. maculatus maculatus* **21F** *P. pallens* sp. nov., paratype.

Material examined. *Holotype*: Cʜɪɴᴀ, Hᴏɴɢ Kᴏɴɢ • ♀; Mang Kung Wo; 22°22'06"N, 114°15'12"E; 60 m a.s.l.; 18 May–01 Jun. 2019; C. Barthélémy leg.; Malaise trap, ref.: M416CHy1A; CAS. *Paratypes*: Cʜɪɴᴀ, Hᴏɴɢ Kᴏɴɢ • 2♀; Sam A Tsuen; 22°30'55"N, 114°16'16"E; 11–27 Dec. 2017; C. Taylor and U. Chang leg.; Malaise trap; HKU • 1♀; Sam A Chung; 22°30'33"N, 114°16'20"E; 17–30 May 2018; ibid; HKU • 1♀; Mang Kung Wo; 22°22'06"N, 114°15'12"E; 60 m a.s.l.; 18 May–01 Jun. 2019; C. Barthélémy leg.; Malaise trap, ref.: M416CHy1B • 1♀; ibid; 29 Jun.–13 Jul. 2019; ibid; ref.: M423CHy1; CBC • 1♀; ibid.; 05–19 Oct. 2019; ibid.; ref.: M443CHy1; CAS • 1♀; ibid.; 19 Oct.–03 Nov. 2019; ibid.; ref.: M447CHy3; CAS • 1♀; ibid.; 03–16 Nov. 2019; ibid.; ref.: M449CHy1; CAS • 1♀; ibid.; 16–30
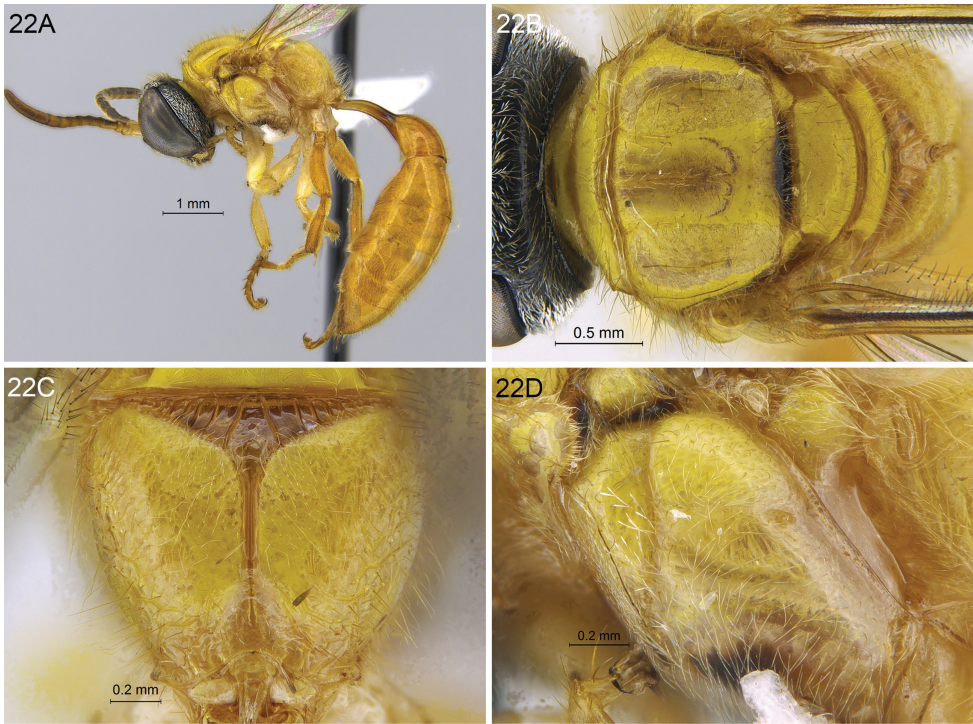
Figure 22. *Psenulus pallens* sp. nov. Paratype, light coloured form, ♀ **22A** lateral habitus **22B** Mesoscutum dorsal view **22C** Propodeum dorsal view **22D** Mesopleuron lateral view.

Nov. 2019; ibid.; ref.: M453CHy1; CBC • 2♀; ibid., 14–28 March 2020; ibid.; refs: M477CHy1A and 1B; CBC • 1♀; ibid., 11–25 Apr. 2020; ibid.; ref.: M483CHy1; CBC • 1♂; Pak Sha O; 22°26'59"N, 114°19'04"E; 70 m a.s.l.; 15–29 Sep. 2018; ibid.; ref.: M368CHy1; CBC • 1♀; ibid; 24 Aug. 07–Sep. 2019; ibid; ref.: M434CHy5; CBC • 1♀; ibid.; 21 Sep.–05 Oct. 2019; ibid.; ref.: M440CHy4; CBC • 1♀; ibid.; 28 Mar.–11 Apr. 2020; ibid.; ref.: M480CHy1; CBC.

Standard ratios. Males (n = 1): L = 4.6 mm; CR = 1.35; OOR = 0.46; FLR = 1.13; FRR = 0.59; MR = 1.65; OMR = 0.94; PR = 0.81; PFR = 0.81. Females (n = 16): L = 4.9–6.0 mm (mean = 5.45 mm); CR = 1.22–1.42 (mean = 1. 32); OOR = 0.47–0.65 (mean = 0.58); FLR = 1.22–1.67 (mean = 1.38); FRR = 0.42–0.63 (mean = 0.58); MR = 1.33–1.77 (mean = 1.55); OMR = 0.83–0.97 (mean = 0.89); PR = 0.82–1.29 (mean = 1.08); PFR = 0.75–0.97 (mean = 0.85).

Description. Male: Antenna without tyloids. Clypeus (Fig. 21F) with two well-developed ventral teeth separated by triangular emargination, remainder of clypeal margin straight. Subantennal carina well developed; interantennal carina narrow, not broadened dorsally (Fig. 7F). Mesosoma mostly polished, mesoscutum lightly and minutely punctate (Fig. 11F), punctures very sparse elsewhere on mesosoma; prescutal sutures short, extending shortly beyond anterior level of tegula; episternal sulcus simple (Fig. 13F); propodeal enclosure with several pairs of longitudinal carinae; rear of

propodeum (Fig. 15F) dorsally smooth, ventrally and laterally coarsely reticulate with reticulations encroaching on posterior part of side of propodeum. Petiole subcylindrical, T1 relatively low (Fig. 5F). Fore wing (Fig. 19L) with first recurrent vein more or less interstitial with first and second submarginal cells, second recurrent vein meeting third submarginal cell at about one-eighth of cell length from base.

Head black with silvery appressed pubescence (Figs 7F, 9F); antenna with scape, pedicel and base of flagellum ventrally yellow, dorsum and terminal segments of flagellum black; mandible yellow with black tip. Mesosoma and legs mostly yellow, hind legs reddish from trochanter to tarsus, the following black: three small spots on mesoscutum, along posterior margin of mesoscutum and scutellar groove; mesosternum, encroaching onto base of mesopleuron; propodeal enclosure posteriorly. Petiole basally yellow, becoming reddish apically; remainder of metasoma reddish.

Female: Clypeus with small ventral teeth separated by shallow emargination (Fig. 20F). Subantennal carina distinct but not protruding beyond pubescence (Fig. 6F). Mesosoma mostly polished, mesoscutum lightly and minutely punctate (Fig. 11F), punctures very sparse elsewhere on mesosoma; prescutal sutures short, extending shortly beyond anterior level of tegula; episternal sulcus simple (Fig. 13F); mesopleural suture narrowly foveolate (Fig.12F); propodeal enclosure with several pairs of longitudinal carinae; propodeum (Fig. 14F) polished and impunctate posteriorly and laterally, coarse reticulations restricted to marginal ridge along transition between posterior and lateral surfaces. Hind tibia with longitudinal cluster of dark denticles dorsobasally (Fig. 18K). Petiole subcylindrical, T1 relatively low (Fig. 5F). Pygidial plate narrow, delineated by distinct posteriorly parallel carinae (Fig. 16F). Fore wing (Fig. 19L) with first recurrent vein more or less interstitial with first and second submarginal cells, second recurrent vein meeting third submarginal cell at about one-eighth of cell length from base.

Head black with silvery appressed pubescence (Figs 7F, 9F); antenna with scape, pedicel and base of flagellum ventrally yellow, dorsum and terminal segments of flagellum black; mandible yellow with black tip. Mesosoma and legs mostly yellow, hind legs reddish from trochanter to tarsus, amount of black coloration on mesosoma varying from almost entirely absent with only black marks on scutellar groove and mesosternum (including base of mesopleuron) remaining to slightly more extensive than in male with black marks also present anteroventrally on epicnemium, on lower half of metapleuron, and over entire propodeal enclosure. Petiole basally yellow, becoming reddish apically; remainder of metasoma reddish.

Etymology. From the Latin for 'pale', in reference to this species' distinctive coloration.

Notes. Because of its marked differences with other known lightly coloured *Psenulus* we have concluded that this is a new species. We have collected females that show a great deal of discoloration and are even paler than the holotype, with hardly any black at all, save for a reduced band at intersection of the mesoscutum and scutum (Fig. 22B) and the head (Fig. 22A, B).

This species has been consistently collected at Mang Kung, the site with the highest anthropogenic disturbance, and was also found in mangroves (13.6% occurrence). It has the second longest (after *P. continentis*) recorded activity period, spanning from March (W10) to December (W50).

Discussion and conclusion

Van Lith (1962) regarded *Psenulus* as rare overall, noting the low number of specimens available for most Oriental species. In contrast, *Psenulus* species (at least *P. carinifrons* and *P. continentis*) were both commonly and abundantly collected in the Hong Kong SAR during the present study. *Psenulus* are apparently more cryptic and rarely seen rather than truly rare and may show a preference for particular habitats. Unfortunately, past descriptions of Oriental *Psenulus* species have not recorded the circumstances in which specimens were collected other than location, making it difficult to evaluate this possibility across the realm as a whole at this time. Nevertheless, it is notable that nests of *Psenulus interstitialis* studied by Matthews (2001) were found in bamboo stems in a coastal location and we also found *Psenulus* to be abundant in coastal mangroves. These habitats often comprise reeds and other pithy plants that might; along with the pithy core of some mangrove species, be expected to provide abundant nesting sites of the type favoured by *Psenulus* (Bohart and Menke 1976).

The phenology patterns extracted from our collection data (Fig. 2A) suggest that all species in Hong Kong have; generally speaking, a long activity period of six months or more, indicating that both nesting sites and larval food resources are available throughout the period. On the other hand, it could be hypothesised that the apparent shorter activity periods of *P. ephippius* sp. nov., and to a lesser extent of *P. maculatus maculatus*, is the result of either nesting site or larval food resource shortage/depletion.

In terms of abundance; as shown on figures 2B and 2C, we observe that *P. continentis* is the most abundant (66 occurrences) species at the inland sites sampled and was recorded for a long continuous period of time (Fig. 2A, B), with a peak of abundance observed between April and June. On the other hand, *P. ephippius* presents the second lowest abundance (six occurrences) (Fig. 2B) and had a rather discontinuous activity period (Fig. 2A). This taxon has only been collected recently from Mang Kung Wo and this discontinuity might be the result of interannual variations. *P. pallens*, although recorded only recently (Sep. 2018), shows the second highest abundance (23 occurrences) with a peak of abundance early in the year (March) (Fig. 2C) while having a long activity period extending from March to December (Fig. 2A). *P. maculatus* was recorded more or less continuously throughout its activity period (Fig. 2A) and was relatively abundant (17 occurrences) (Fig. 2C). The pattern observed for *P. gibbus* is less clear due to the recent collection of this species (since March 2019) and the relative low abundance recorded (three occurrences) (Fig. 2B) but is the likely result of interannual variations. Given the known development time of many species in the "Crabronidae" (sensu Pulawski 2020; Krombein 1967; Tsuneki 1970, 1973; Barthélémy 2012), we can hypothesise that all *Psenulus* species in Hong Kong are at minimum bivoltine, some likely multivoltine with 3–4 generations per year. A study focused on *Psenulus* nesting habits would represent a valuable contribution to answer these questions regarding activity patterns and voltinism.

Biogeographically, *Psenulus carinifrons rohweri* was the most commonly collected species at mangrove sites, being present in 15 out of 17 sites sampled, and for seven sites was the only *Psenulus* species collected. In contrast, this taxon was never caught in any of the inland sites, save for one occurrence at site 18 in 2006, suggesting that this

species may be specialised to use mangrove or coastal habitats. Further work in other regions of the Oriental realm could confirm this rather specialized ecology, underlying the importance for the conservation of coastal habitats.

While sampling effort needs to be accounted for, it should be noted that the maximum richness of *Psenulus* was recorded at the site with the highest anthropogenic disturbance (site 20: Mang Kung Wo) with five species recorded (all known species except *P. carinifrons rohweri*). On the other hand, the lowest richness was recorded at the site with the lowest apparent anthropogenic disturbance (site 18: Ping Chan Chai) with only two of the most common species, *P. continentis* and *P. c. rohweri*, collected. Although anecdotic, this might indicate that some *Psenulus* species could be favoured by disturbance (to a certain extent); and if confirmed, the underlining ecological processes sustaining this should be investigated further. In mangroves sites, a total of four species (sites 3 and 8 with the highest richness of three species per site) have been recorded; indicating the importance of these habitats in Hong Kong for *Psenulus* species, as previously shown for other insect families (e.g. Grootaert et al. 2019). It should be noted, however, that an important variability in the species richness observed among sites could be observed, with a single species (either *P. c. rohweri* or *P. continentis*) collected in 47% of the mangrove sites sampled (8 out of 17).

Interestingly, both *P. continentis* and *P. maculatus* represent species for which knowledge of distribution range is greatly expanded in this study. Overall, biogeographic information on Oriental *Psenulus* species is limited and here the geographic disjunction observed in both species is clearly illustrated (Fig. 1). Two hypotheses can be proposed to explain this remarkable biogeographic pattern. Firstly, one may consider this disjunction as a result of the poor collecting records and the paucity of works on the genus in the region, and it should be noted that the Hong Kong fauna contains essentially tropical taxa reaching their northern limit, with larger distribution known in the south either in Indonesia (*P. carinifrons*) or Singapore (*P. continentis* and *P. maculatus*). Furthermore, in view of the large distributional range of *P. carinifrons rohweri* (from Flores to Taiwan), some of these taxa present naturally a widespread range associated to good dispersal abilities. Secondly, and, alternatively, it could also be hypothesized that these two species have been introduced within Hong Kong. Indeed, Hong Kong is known as a major gateway for exotic species (Lu et al. 2018) with several examples illustrated in other Hymenoptera families (Tang et al. 2019). Interestingly, limited geographical overlap has been observed in the species described in the late 1960's and 1970's by van Lith (1969, 1972, 1976) from Vietnam, Laos and Thailand. Indeed, out of the 26 species reported from these countries, nearly 60% (57.7%) are unique to either country, potentially reflecting a high level of endemism in the genus, whereas none of these Indochinese species have been recorded from Hong Kong or China.

Future studies on the distribution of *Psenulus* species within Asia could thus provide valuable information about the native or potential introduced range of these species and elucidate these seemingly opposite hypotheses regarding the origin of these populations. Ideally, population genetic studies could provide important support but the apparent rarity and/or cryptic nature of some of these species in the regions in which they have been described might limit such studies.

Acknowledgements

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