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TWO NEW SPECIES OF
PALPIFER HAMPSON, 1893
FROM SOUTH EAST ASIA
(LEPIDOPTERA: HEPIALIDAE)

JOHN R. GREHAN &
CARLOS G.C. MIELKE



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Cover photo: *Palpifer boonei* Grehan & Mielke, sp. n. from Laos.

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Two new species of *Palpifer* Hampson, 1893 from South East Asia
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Two new species of *Palpifer* Hampson, 1893 from South East Asia (Lepidoptera: Hepialidae)

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Abstract. *Palpifer* Hampson, 1893 is a poorly known genus distributed across southern and eastern Asia. The new species *P. boonei*, **sp. n.** and *P. hylandae*, **sp. n.** are each described from a single male specimen, the first from Laos and the second from Malaysia. Their respective genitalia are shown to be distinct from each other and from the Indian species *P. murinus* (Moore, 1879), *P. sexnotatus* (Moore, 1879) and *P. falkneri* Viette, 1955. We also recognize *P. niphonica* (Butler, 1879), **stat. rev.** as a distinct species and suggest that *P. sexnotatus* can only be verifiably ascribed to populations from northern India. We identify about nine features that support the monophyly of *Palpifer*, including a unique forewing scent gland that is distinct from the FW scent gland of other Hepialidae. A unique elongate basal process of the valve present in the two new species along with *P. falkneri* and *P. sexnotatus* may represent a monophyletic subclade for the genus. The current taxonomic composition and geographic distribution of *Palpifer* species is described and primary types are illustrated for *Palpifer falkneri* Viette, 1968, *P. niphonica*, *P. hoppo-nis* Matsumura, 1931, *P. pellicia* Swinhoe, 1905, *P. sordida* Snellen, 1900, *P. taprobanus* Moore, 1887, and *P. umbrinus* (Moore, 1879).

INTRODUCTION

Among hepialids, *Palpifer* moths are relatively small (wingspan usually less than 30 mm) with subdued markings, the forewings being dark chocolate or greyish brown interspersed with small white and black markings. At rest, the males often strike a distinct pose by the dorsally curving posterior tip of the abdomen (Fig. 1). Larvae are recorded as subterranean root feeders of monocotyledonous plants in the Araceae, Dioscoreaceae, and Liliaceae (Maki 1919, Sonan 1938, Kalshoven 1951, 1965, Kodama 1978, Baker 1982) and some are known to be agricultural pests (Maki 1919, Kodama 1978).

At 10 previously described species (Nielsen *et al.* 2000), the genus *Palpifer* Hampson, 1893 has a low taxonomic diversity relative to the distribution range, with six being described at or before the end of the 19th century and the most recently named species was 50 years ago (Viette 1968). The broad distribution range across southern (sub-Himalayan) and eastern Asia is mostly made up of a small number of scattered specimens records separated by large geographic gaps.

In this paper we briefly review the species composition of *Palpifer* and propose two new species, each represented by a unique male specimen: one from the Malaysian peninsula; the other from northern Laos. These species each have distinct genitalia that are also

different from other species for which genitalic descriptions are available. We also illustrate most of the known species and characterize their distributions.

MATERIALS AND METHODS

The abdomen was removed and treated in a cold solution of 5% KOH. The abdominal integument was opened by a right lateral cut from the tergo-sternal bar to the genitalia which were then removed and stained in Chlorazol black. The prelabium and labial palps were removed following the method described by Grehan & Mielke (2018). Genitalic terminology follows that of Mielke & Casagrande (2013). Outline wing diagrams were made by tracing over photographs using InkScape Scalable Vector Graphics (SVG) 1.1 (Second Edition), version <http://www.w3.org/TR/2011/REC-SVG11-20110816/>.

Institutional Abbreviations

CMNH	Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, USA
BPBM	Bernice P. Bishop Museum, Honolulu, Hawai'i, USA
HUFA	Hokkaido University, Faculty of Agriculture, Sapporo, Japan
HUS	Hokkaido University, Sapporo, Japan
MNHN	Muséum National Histoire Naturelle, Paris, France
NFSF	Naturmuseum und Forschungsinstitut, Senckenberg, Frankfurt am Main, Germany
NHMHUK	Natural History Museum, London, United Kingdom
RMNH	Naturalis Biodiversity Centre, Leiden, Netherlands
UCDC	University of California, R.M. Bohart Museum of Entomology, Davis, California, USA
ZSBS	Zoologische Sammlungen des Bayerischen Staates, Munich, Germany
ZMHB	Museum für Naturkunde der Humboldt-Universität, Berlin, Germany

Other abbreviations

FW	Forewing
HT	Holotype
HW	Hindwing
LT	Lectotype

TAXONOMY

Palpifer Hampson, 1893

Palpifer Hampson in Hampson, 1893: 316. Type species: *Hepialus sexnotatus* Moore, 1879, by original designation.

Diagnosis. Small moths with dark chocolate-brown forewings suffused with scattered spots, sometimes indistinct or possibly absent, that are white, yellowish brown and dark brown to black (Fig. 1). This general external appearance serves to distinguish *Palpifer* from all other hepialid genera. Potentially diagnostic features for the genus (pending future confirmation for all species) include elongate three segmented labial palps covered by a dense layer of prominent ventral scales, the almost bifid prelabium, an elongate second palpomere subtending a very tiny knob-like terminal segment, a basal, triangular white FW discal stigma, and a basal FW scent gland dorso-longitudinally bisected by the A vein in the male. Arolium present, metaleg not reduced.



Fig. 1. Habitus of *Palpifer* sp., Hong Kong, China, 17 October 2014 (photo by Stefan Obenauer). <https://www.inaturalist.org/observations/6483804>

Species composition and distribution as recognized in this article:

Palpifer boonei Grehan & Mielke, sp. n. HT male: BPBM (Fig. 2).

Status: Genitalia described (this paper)

Distribution: Known from type locality only – Laos, Vientiane Province, Ban Van Eue village.

Palpifer falkneri Viette, 1968: 132. HT male: MNHN (Fig. 15).

Status: Geographically near northeastern species. Genitalia described.

Distribution: Known from type locality only – Nepal, Dudh Kosi Tal, 3500 m.

Palpifer hopponis Matsumura, 1931: 1889. HT: HUS (Fig. 17).

Status: Geographically allopatric and isolated from other species. Genitalia not described.

Distribution: Taiwan (Ueda 1999, Fu & Tzuoo 2004). Type locality – ‘Taiwan’, Hsinchu County, Beipu.

Palpifer hylandae Grehan & Mielke, sp. n. HT male: UCDC (Fig. 3).

Status: Geographically allopatric. Genitalia described (this paper).

Distribution: Known from type locality only – Malaysia, Selangor, Petaling Jaya.

Palpifer madurensis Pfitzner, 1914: 96. HT: NFSF [not located at present].

Status: Listed by Schröder (1967). Geographically allopatric and isolated, but proximate to distribution of *P. sordida* in Java. Genitalia not described.

Distribution: Known from type locality only – Indonesia, Java, Madura.

Palpifer murinus (Moore, 1879: 413). HT male: NHMUK (Fig. 18).

Synonymy: *Palpifer caerulescens* Swinhoe, 1894: 440 (Tindale 1942: 162).

Status: Geographically near or overlapping other northeastern sub-Himalayan species. Genitalia distinct from sub-Himalayan *P. falkneri* and *P. sexnotatus*.

Distribution: Sub-Himalayas (Grehan & Ismavel 2017). Type locality – India, Jalandhar, Dharmsala.

Palpifer nipponica (Butler, 1879: 357), **stat. rev.** HT male: NHMUK (Fig. 16).

Synonymy: *Palpifer ronin* Pfitzner, 1912: 437 (Nielsen *et al.* 2000).

Status: Geographically allopatric and isolated. Genitalia not described.

Distribution: Japan (Inoue 1982, Hirowatari *et al.* 2013). Type locality – Japan.

Palpifer pellicia Swinhoe, 1905: 152. LT male (Tindale 1942): NHMUK (Fig. 19).

Status: Geographically proximate or overlapping other northeastern Indian species. Genitalia not described.

Distribution: Known from type locality only – India, Meghalaya, Khasia Hills.

Palpifer sexnotatus (Moore, 1879: 413). HT: NHMUK (Fig. 20).

Synonymy: *Palpifer sexnotatus*; Pfitzner, 1912: 437, misspelling.

Status: Geographically proximate or overlapping other northeastern Indian species. Genitalia not described for type (abdomen missing). Bright and extensive yellowish orange markings appear distinct from other named species in the region.

Distribution: sub-Himalayan India (Grehan & Ismavel 2017). Type locality – India, Sikkim, Darjeeling.

Palpifer sordida Snellen, 1900: 30. HT: RMNH (Fig. 21).

Status: Geographically allopatric, but proximate to *P. madurensis*. Genitalia not described.

Synonymy: *Palpifer notatus* Pfitzner in Pfitzner & Gaede, 1933: 845 (Nielsen *et al.* 2000). Originally named as a form of *P. sordida*.

Distribution: Java (Kalshoven 1951, 1965). Type locality – Indonesia (Java), Rembang Province and Batavia.

Palpifer taprobanus (Moore, 1887: 545). HT female: NHMUK (Fig. 22).

Status: Geographically allopatric. Genitalia not described.

Distribution: Known from type locality only – Sri Lanka, Wattergama.

Palpifer tavoyanus (Moore, 1886: 98). HT: NHMUK [not located (David Lees, pers. comm. 2018)].

Status: Tindale (1942: 161) suggested “The generic placement may be in error”.

Distribution: Known from type locality only – Myanmar, Tavoy [Dawei].

Palpifer umbrinus (Moore, 1879: 88). HT female: NHMUK (Fig. 23).

Status: Geographically close to other northeastern sub-Himalayan species for which descriptions of female genitalia are unavailable.

Distribution: known from type locality only – India, Sikkim, Darjeeling.

Genitalic key to *Palpifer* species

In the absence of externally distinguishable features for any species in the genus, the following key represents a preliminary approach to species identification for those five species for which the male genitalia are described and illustrated.

- 1. Basal projection of valve a short tooth (Fig 13b) *murinus*
 – Basal projection of valve subequal or longer than valve 2
- 2. Anterior margin of valve straight (Figs. 13a, c) 3
 – Anterior margin of valve concave (Figs. 11, 12) 4
- 3. Pseudoteguminal apex forming short digitiform projection (Fig. 13c) *falkneri*
 – Pseudoteguminal apex without distinct apical tooth (Fig. 13a) *sexnotatus*
- 4. Fultura inferior posterior margin apex forming an acute angle (Fig. 11)
 *boonei*, **sp. n.**
 – Fultura inferior posterior margin apex forming a rounded obtuse angle
 *hylandae*, **sp. n.**

***Palpifer boonei* Grehan & Mielke, sp. n.**

(Figs. 2, 4b, 5, 6a, 8, 10, 11)

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Diagnosis. General size and colour pattern similar to other *Palpifer* species. Basal yellowish brown HW, and metathorax shared in common with *P. falkneri*, *P. sexnotatus*, *P. taprobanus*, and *P. umbrinus*. Male genitalia share presence of elongate digitiform and glabrous projection with *P. falkneri*, *P. hylandae*, sp. n. and *P. sexnotatus*, but distinct from these species and *P. murinus* by posteriorly curved valves, and posterior margin of saccus with shallow central spine. Northern Laos, allopatric and geographically disjunct from all other published *Palpifer* species.

Description. Male. Wingspan: 32 mm; FW length: 19 mm, width: 6 mm, ratio 3.1:1; HW length: 13 mm, width: 6 mm, ratio 2.2:1.

Head. Scales of frons and vertex piliform, greyish brown; inter ocular-antennal scales appear to be absent. Eyes prominent, about 2/3 of head width. Antenna filiform with 35 flagellomeres, annuli covered with numerous sensilla caetica, each annulus with ventral lobe; scape barrel shaped covered with piliform scales; pedicel ovoid and subequal to flagellomeres. Prelabium forming a bilobed structure; palpomeres covered with pale yellowish brown to pale greyish brown scales, laterally as short lamellar scales, ventrally and dorsally as upright piliform scales, long, three segmented, extending dorsally to base of antennae; second palpomere longest, about twice the length of basal palpomere; distal palpomere a small knob positioned subapically (Fig. 4a).

Thorax. Scales piliform, coloured as for the head.

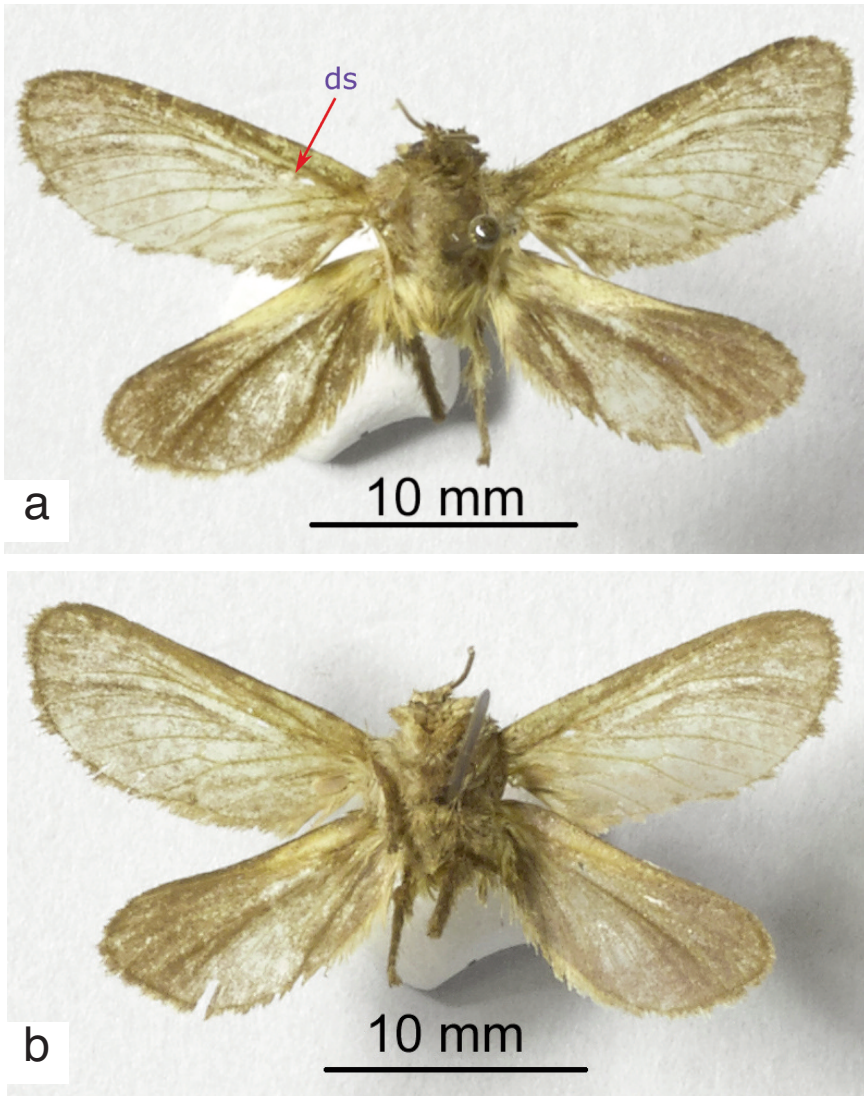


Fig. 2. *Palpifer boonei*, sp. n. HT male; (a) dorsal, ds = discal stigma, (b) ventral (photos by Neal Evenhuis).

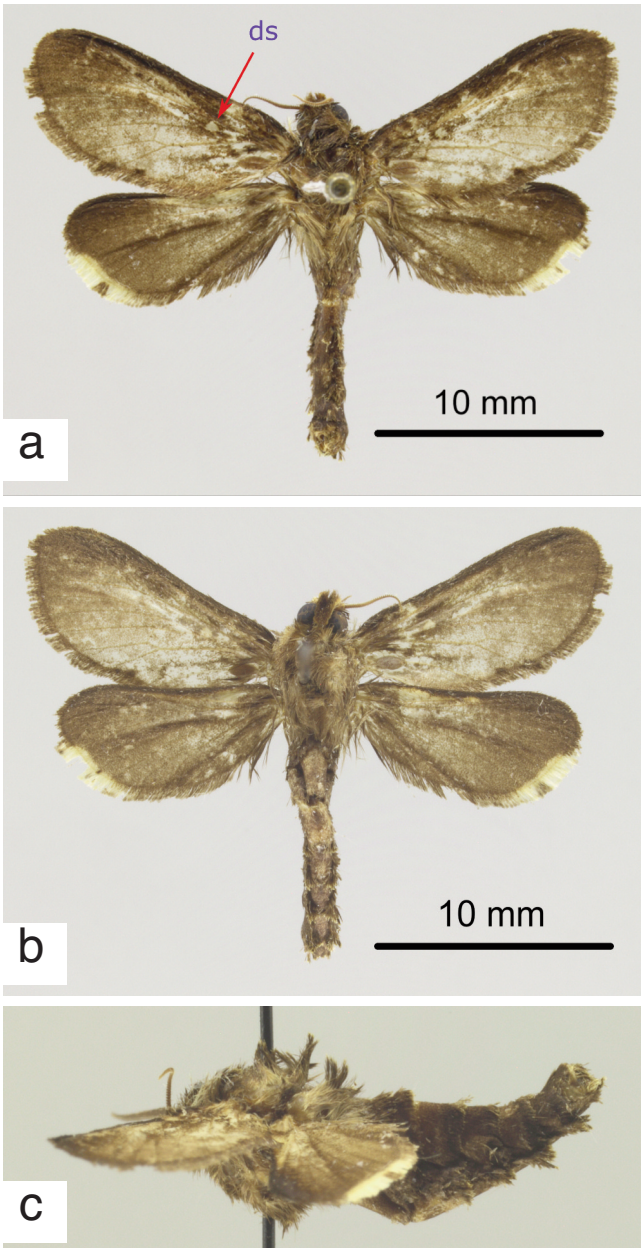


Fig. 3. *Palpifer hylandae*, sp. n. HT male; (a) dorsal, ds = discal stigma, (b) ventral, (c) lateral (photos by Jane Hyland).

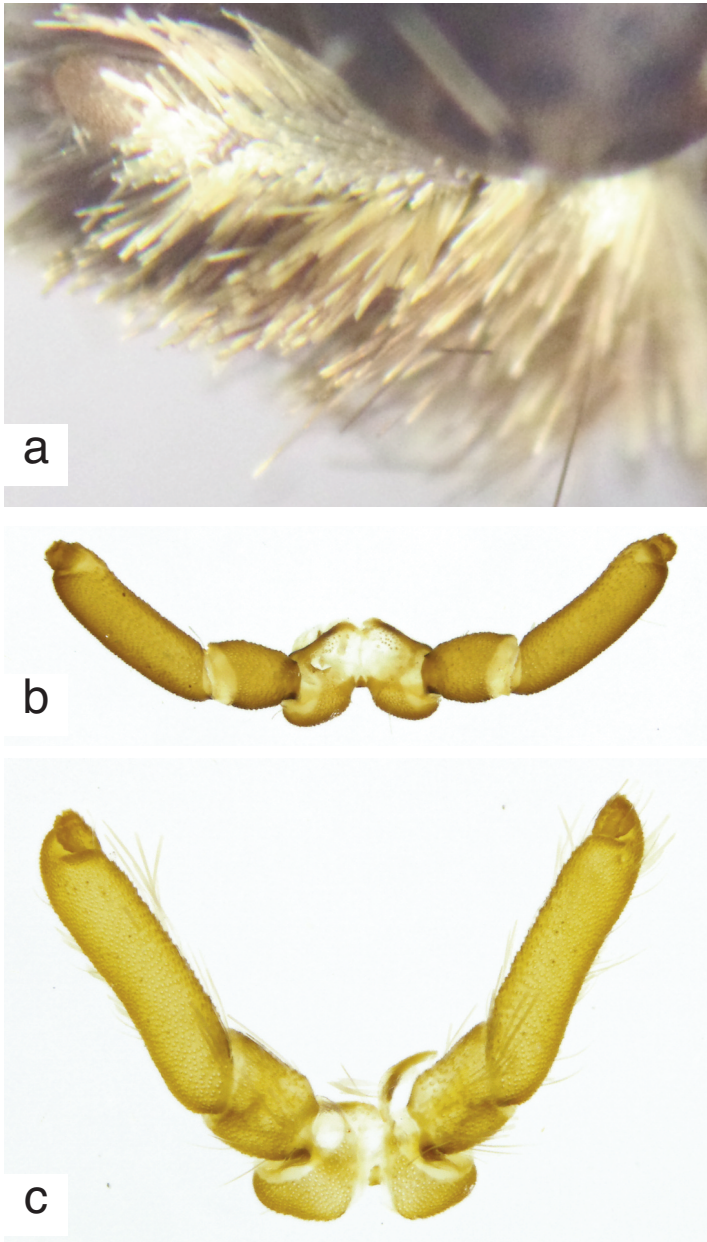


Fig. 4. Mouthparts (all from HT): (a) ventral view showing erect scales projecting ventrally from palps of *Palpifer hylandae*, sp. n. (photo by John Grehan); (b) labium and palps of *Palpifer boonei*, sp. n.; (c) labium and palps of *Palpifer hylandae*, sp. n. (photos by Neal Evenhuis).



Fig. 5. Legs: complete set (a) and metaleg with scales (b) for *Palpifer boonei*, sp. n. (HT); partial proleg (c) of *P. hylandae*, sp. n. (HT); ep – epiphysis folded over against tibia (photos a, c by Neal Evenhuis, b by John Grehan).

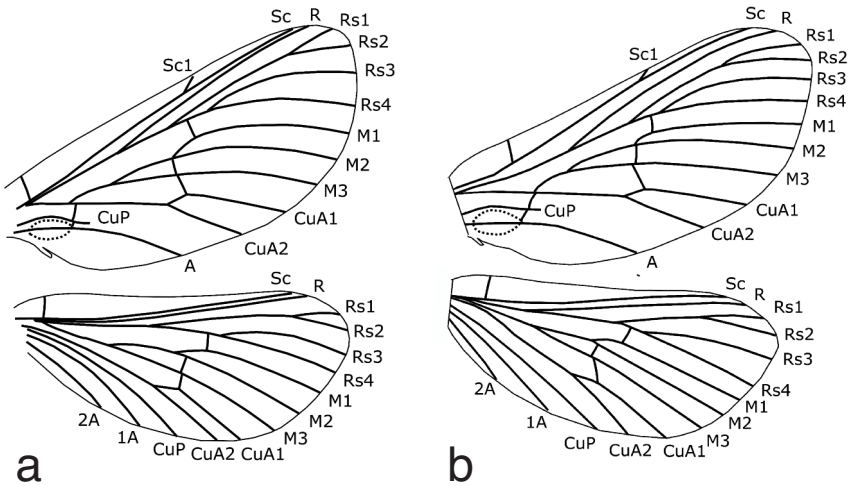


Fig. 6. Wing venation, (a) *Palpifer boonei*, sp. n., (b) *Palpifer hylandae*, sp. n.

Legs. Coloured as the thorax; pro-, meso-, and metalegs length subequal, ratio 1:1.2:1.1; epiphysis present (Fig. 5a); tibial scales not obscuring tarsomeres, dorsal scales of tarsi about twice segment length, ventral tarsal scales short, arolium present (Fig. 5b).

Wings. (Fig. 6) Forewing subrectangular with nearly straight costal margin, apex rounded, outer margin almost straight between R_{s3} and M_2 , then convex to near its base or continuously to base of HW. Wing venation (Fig. 6a) hepaline (*sensu* Dumbleton 1966), FW with Sc_1 present, CuP very short beyond cross veins A-CuA₂; HW lacking Sc_1 , two anal veins present, R and Sc widely separated. FW extensively rubbed in specimen, dorsal ground colour greyish brown (probably chocolate brown in fresh specimen), anterior discal cell with white discal stigma anterior to M_3 and basal to M_2 ; dark marginal spot between CuA₂ and A; outer and inner margin fringes long (most missing in specimen); ventral surface greyish brown. FW scent gland near base anterior to cross vein A-CuA₂ and posterior to CuP, longitudinally bisected dorsally by vein A. HW dorsal and ventral ground colour as for FW, indication of whitish yellow fringe between R_{s4} and CuA₂, and whitish yellow region along costa to outer 2/3 of wing, wider at base, tapering distally. Ventral whitish yellow region basally between Sc and costal margin.

Abdomen (Fig. 8). Coloured as for thorax, dorsoventrally tall from first to posterior of second segment then height narrowing posteriorly (see Fig. 3c for *P. hylandae*, sp. n. in lateral view), each segment with prominent row of protruding scales. Tergosternal connection narrow; tergosternal bar curving dorso-anteriorly to junction with lateral tergal brace with no discernible central region, angled antero-ventrally to form an acute angle with lateral tergal arm; medial posterior edge with short and narrow posteriorly projecting lateral ridge; lateral arm subequal in length to tergosternal bar; tergal knob absent; dorsal tergal arm lightly sclerotized, narrowing to point of contact with anterior ridge of tergum II anterior of tuberculate plate. Abdominal segments lightly sclerotized; tergum II with narrow, lightly sclerotized lateral ridge extending posteriorly from ventral corner of lateral

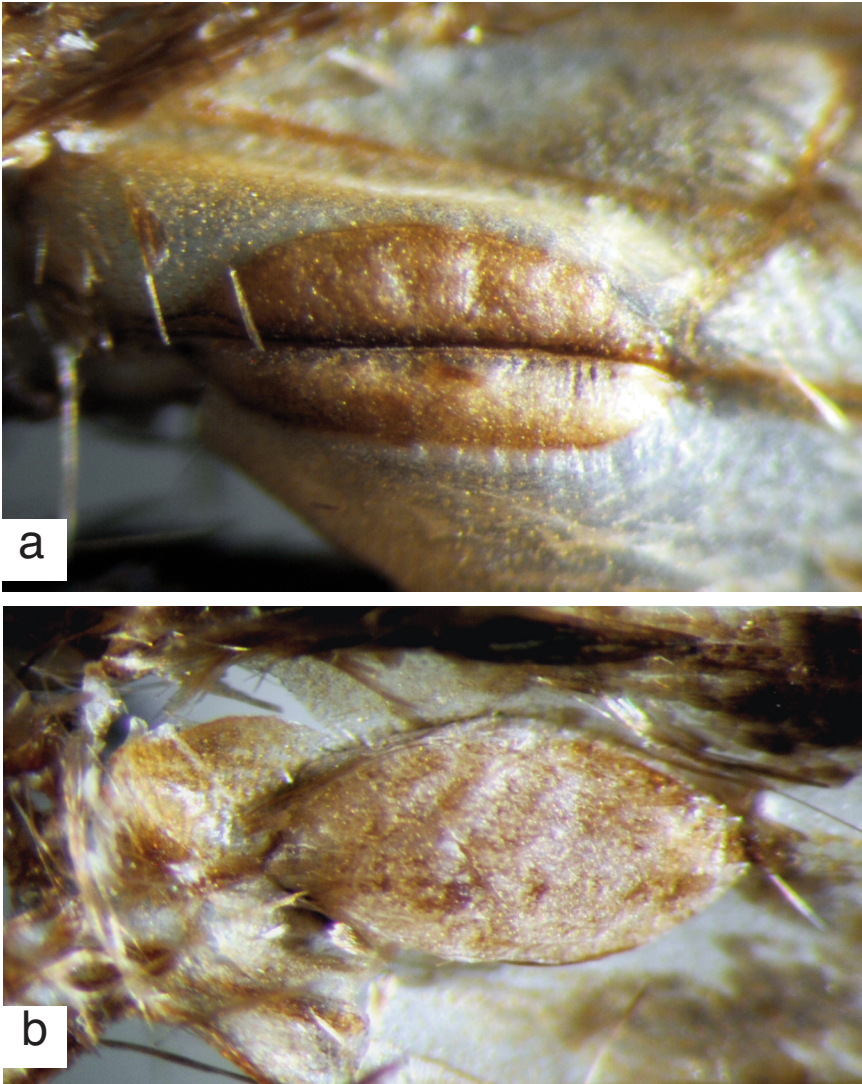


Fig. 7. *Palpifer hylandae*, sp. n. (HT). FW scent gland, (a) dorsal, (b) ventral (photos by John Grehan).

tuberculate plate, but not reaching posterior margin, anterior ridge not fused medially; sternum II subrectangular, lateral arms broad, laterally edged with sclerotized ridge angled medially to posterior half sternum length; terga III–VII wider than long, length increasing posteriorly; sternum III subsquare; sterna IV–VII subtriangular, slightly concave laterally, decreasing width posteriorly; tergum VIII rectangular, narrow, length double width, tapered posteriorly, sternum VIII triangular with lateral edges concave.

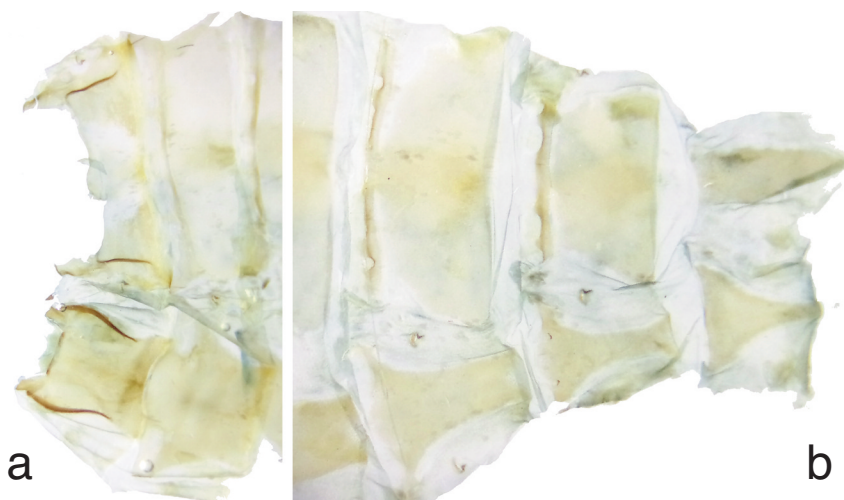


Fig. 8. *Palpifer boonei*, sp. n. abdomen (HT), (a) anterior segments [tergosternal connection missing], (b) posterior segments.

Genitalia (Figs. 10, 11). Tegumen reduced, extending from base of valve and weakly fused with pseudotegumen. Saccus broadly U-shaped with almost straight anterior margin, apodemal suture close to anterior margin. Tergal lobes absent or not identified. Pseudotegumen rim bordering anogenital field with single densely sclerotized and curved posterior ventral spur (ps), ventral apex strongly sclerotized, pointed, meeting at median, but not fused, subtended by pale sclerotized area (vpp) with anterior margin in contact with fultura superior. Valve broad, sclerotized, glabrous, obtusely angled pointed apex, posterior basal margin with elongate digitiform projection or spur (bp) about twice the length of valve, curving medially, apex expanded as a flattened lobe (dl) covered with numerous short setae, setae also extending basally along inner surface. Fultura superior (fs) sclerotized, forming a 'V' with apex articulating dorsally with pseudotegumen and ventrally with fultura inferior. Latter forming a vertically elongate, tongue-like sclerite (fi), length almost double maximum basal width, sides tapering posteriorly to junction with fultura superior; medial and posterior ridge forming an inverted 'T'. Phallus membranous without cornutus.

Distribution. Northern Laos, known only from the type locality (Fig. 14).

Type. *Holotype* ♂ (BPBM 17,843) (with the following labels separated by forward slashes): / LAOS: Vientiane Prov. Ban Van Eue, 15.V.1966 / Native Collector, BISHOP / Holotypus, *Palpifer boonei* ♂, Grehan & C. Mielke des. 2018/. Dissection JRG 284 (BPBM). Figs 2a, 2b. Holotype in BPBM.

Etymology. This species is named for James Boone (BPBM) for his kind assistance in providing access to specimens of Hepialidae and for past assistance with entomological projects.

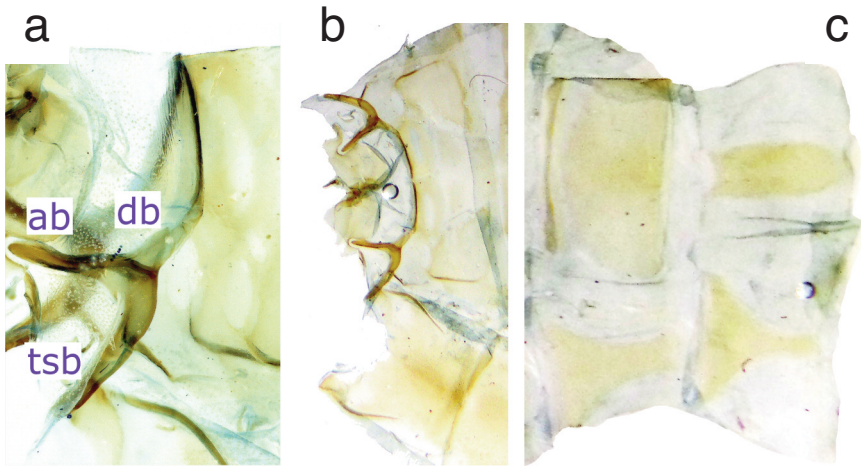


Fig. 9. *Palpifer hylandae*, sp. n. abdomen (HT), (a) tergosternal connection; ab – anterior brace; db – dorsal brace; tsb – tergosternal bar, (b) anterior segments for terga and sternum II, (c) posterior segments for terga and sternum VII and VIII.

***Palpifer hylandae* Grehan & Mielke, sp. n.**

(Figs. 3, 4a, 4c, 6b, 7, 9, 10, 12)

lsid:zoobank.org:act:4BDE9C74-2538-40BF-8C6E-AD2084FB42C4

Diagnosis. General size and colour pattern similar to other *Palpifer* species. Lack of yellowish brown basal wing and metathoracic colour shared with *P. murinus*, *P. nipponica*, *P. pellicia*, and *P. sordida*. Male genitalia share presence of elongate digitiform and glabrous basal valve projection with *P. falkneri*, *P. boonei*, sp. n. and *P. sexnotatus*, but distinct from these species and *P. murinus* by a narrowly lobate pseudotegumen apex in contrast to the other species where the apex is strongly sclerotized and pointed. Southern Malaysia, allopatric and distinct from all other published *Palpifer* species.

Description. Male. Wingspan: 25 mm; FW length: 10 mm, width: 5 mm, ratio 2: 1; HW length: 9 mm, width: 4 mm, ratio 2.2: 1.

Head. Scales piliform, presence or absence of inter ocular-antennal scales undetermined [due to position of antennae], greyish brown. Eyes prominent, over 2/3 total head width. Antenna filiform with 36 flagellomeres; annuli with ventral lobe, covered with numerous sensilla caetica; scape barrel shaped, covered with piliform scales, basal tuft extending over eye; pedicel subequal to flagellomeres, ovoid. Prelabium forming a bilobed structure, palps long, three-segmented, extending dorsally to base of antennae; palpomeres covered with pale yellowish brown to pale greyish brown scales, laterally as short lamellar scales, ventrally and dorsally as upright piliform scales (Fig. 4a); second palpomere long, almost 3 × length of basal segment; distal palpomere small, positioned subapically, giving a ‘thumbnail’ appearance (Fig. 4c).

Thorax. Scales piliform, coloured as the head.

Legs. Only forelegs intact, coloured as the head; epiphysis present (Fig. 5c).

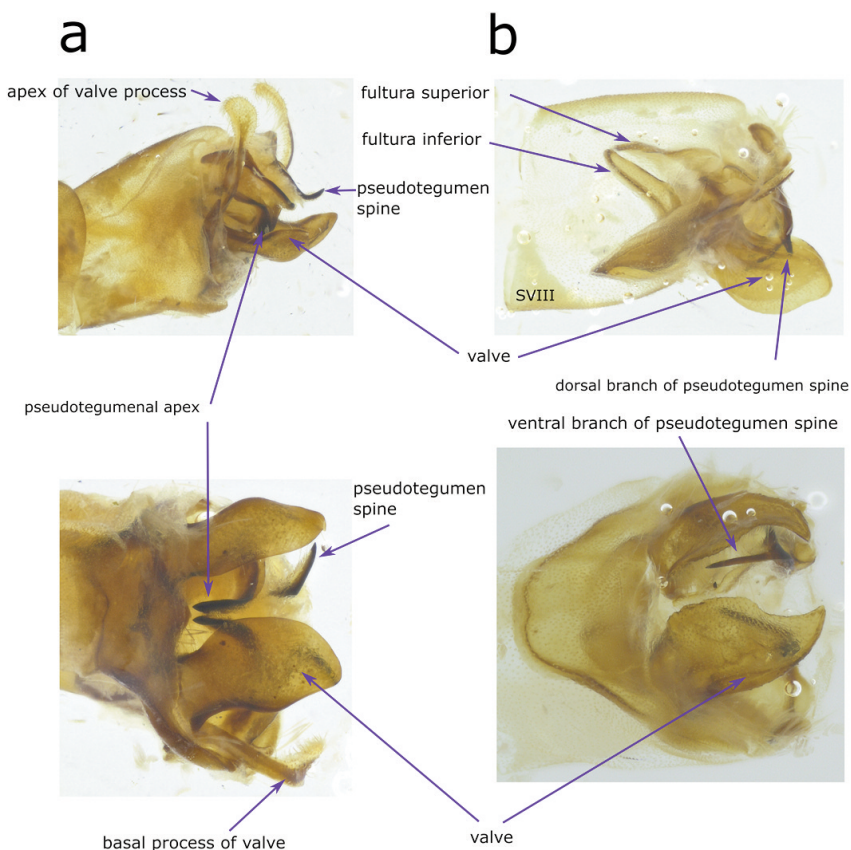


Fig. 10. Habitus position of genitalia in lateral and ventral views: (a) *Palpifer boonei*, sp. n. (HT), (b) *P. hylandae*, sp. n. (HT) (b).

Wings. Wing shape subrectangular with nearly straight costal margin, apical margin rounded, outer margin almost straight between Rs_3 and M_2 , then shallow continuous curve to posterior margin. Wing venation (Fig. 6b) as for *P. boonei*, sp. n. Dorsal ground colour dark chocolate to greyish brown with white discal stigma anterior to M_3 and basal to M_2 and dark marginal spot basal of CuA_2 ; outer and inner margin fringe with long scales; ventral surface greyish brown. HW ground colour as for FW, outer fringe whitish yellow between Rs_4 and CuA_2 , and wing margin between Rs_4 and M_3 , with patch of distally greyish brown fringing scales between M_1 and M_2 . FW scent gland as for *P. boonei*, sp. n.

Abdomen (Fig. 9). As with the previous species except for the following: Tergosternal connection (Fig. 9a) with narrow tergosternal bar curving dorso-anteriorly to junction with lateral tergal arm without a discernible central region, angled antero-ventrally to form an acute angle with lateral tergal arm, medial posterior edge with short and narrow posteriorly projecting lateral ridge; lateral brace subequal in length to tergosternal bar; tergal knob absent; dorsal tergal arm lightly sclerotized, narrowing to point of contact with anterior ridge of tergum II anterior of tuberculate plate.

Table 1. Character differences between *P. boonei*, sp. n. and *P. hylandae*, sp. n. supporting their respective status as different species.

character	<i>P. boonei</i> , sp. n.	<i>P. hylandae</i> , sp. n.
valve distal anterior margin	convex	concave
valve apex angle	blunt	narrowly acute
pseudotegumen spine	single	bifurcated
fultura inferior length/width	elongate	subequal
pseudotegumen apex	pointed	lobate
saccus posterior margin	central spine	spine absent
saccus anterior margin	squared	rounded
labial palp distal palpomere	apical	sub apical
relative FW Rs3-Rs4 length	short	long

Genitalia. (Figs. 10, 12) Tegumen weakly fused to pseudotegumen. Saccus with broadly U-shaped anterior margin and parallel apodemal suture. Tergal lobes absent or not identified. Pseudotegumen unfused dorsally and ventrally, with sclerotized rim around anogenital field; rim with a strongly sclerotized bifurcated spine (ps), ventral branch (Fig. 10) long, straight, angled medially; ventrally extended as narrow, elongate apical lobe (pa). Valve broad, sclerotized, glabrous, pointed apically, posterior basal margin with digitiform extension or spur that is broken off, but predicted to be similar in size and shape to that of *P. boonei*, sp. n. Fultura superior sclerotized, triangular, narrowing ventrally to junction with fultura inferior; fultura inferior subrectangular, dorsal margins convex, curving to apex; medial and posterior ridge forming an inverted 'T' (Fig. 12). Phallus membranous without cornutus.

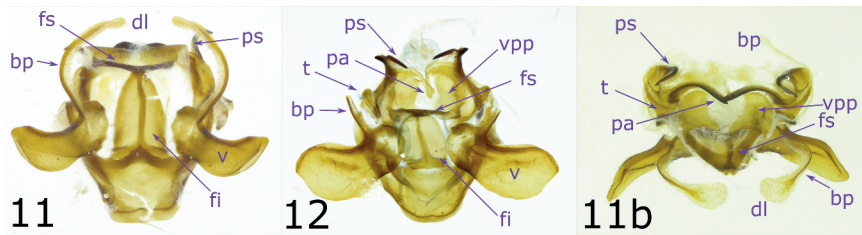
Distribution. Malaysian peninsula, known from the type locality of Petaling Jaya, which was originally a satellite township of Kuala Lumpur but now part of the greater Klang Valley Metropolitan Area in the state of Selangor (Fig. 14).

Type. *Holotype* ♂ (with the following labels separated by forward slashes): / Petaling Jaya, Selangor, Malaysia, X-1-1967 / M.G. Groves, Colr. / Holotypus, *Palpifer hylandae* ♂, Grehan & C. Mielke des. 2018/. Dissection JRG 252 (UCDC). Figs. 3a, 3b. Holotype in UCDC.

Etymology. Named for Jane Hyland (CMNH) in appreciation for photographing specimens of Hepialidae used in various other taxonomic works.

Remarks

Taxonomy: The new species from Laos and Malaysia are distinct from each other in at least six features of the genitalia as well as differences in distal palpomere and FW Rs3-Rs4 length (Table 1). The genitalia of the new species from Laos and Malaysia are distinct from each other, and also *P. sexnotatus* from northeastern India (Fig. 13a), *P. murinus* from the Khasia Hills in northeastern India (Fig. 13b), and *P. falkneri* from Nepal (Fig. 13c). The bifurcate pseudotegumen spine in *P. hylandae*, sp. n. (Fig. 12) is shared with *P. sexnotatus* (Fig. 13a), although the ventral branch appears to be longer in *P. hylandae*, sp. n.



Figs. 11–12. *Palpifer* male genitalia (HT). **11.** *P. boonei*, sp. n., (a) ventral view, (b) posterior view. **12.** *Palpifer hylandae*, sp. n. male genitalia (HT), ventral view (photos by Neal Evenhuis). bp – basal process of valve, dl – dorsal lobe, fi – fultura inferior, fs – fultura superior, pa – pseudotegumen apex, ps – posterior-ventral spur, t – tegumen, v – valve, vpp – ventro-posterior pseudotegumen.

The pseudotegumen apex of *P. hylandae*, sp. n. is narrowly elongate and lobed rather than forming a strongly sclerotized spine as in *P. sexnotatus*. The elongate posterior process of the valve is absent from *P. murinus* where there is instead, a shallow spine (Fig. 13b). The elongate process is considered to represent a uniquely derived feature within *Palpifer*, and therefore potentially define a subclade that excludes *P. murinus* since the elongate process is absent from other Hepialidae (JRG & CGCM, pers. observ.) and other hepialoid families (cf. Davis *et al.* 1991, Davis 1996) although a similar elongate basal valve process in the form of an expanding lobe is recorded for *Palaeoses scholastica* Turner, 1922 (Davis 1996) and as a distally expanded falcate blade in *Paratheora speideli* Simonsen & Kristensen, 2017 (Simonsen & Kristensen 2017).

Of the remaining nine species that lack published genitalic descriptions for the male, the geographically nearest mainland species is *P. tavoyanus*, from Tavoy, Myanmar (Fig. 14), 1260 km and 760 km from the Malaysian and Laotian species, respectively. The brief description by Moore (1886) is insufficient to provide distinctive species characteristics for *P. tavoyanus* and direct comparison is not possible as the type specimen has been missing for at least 77 years (Tindale 1942; David Lees, pers. comm.). The next two geographically proximate species are from northeastern India where *Palpifer pellicia* (Fig. 19) is known for a male and a female from the Khasia Hills, Meghalaya (Fig. 14) (Swinhoe 1905) and *Palpifer umbrinus* known for single female (Fig. 23) from Darjeeling, Sikkim (Fig. 14) (Moore 1879). The description of *P. pellicia* by Moore (1879) refers to a uniform dull brown FW with a small white discal stigma that is not visible in all specimens, and a yellow fringe on the outer margin of the HW. These characteristics are applicable to all other species and do not, therefore, allow individual comparison with *P. boonei*, sp. n. and *P. hylandae*, sp. n. The lectotype of *P. pellicia* (Fig. 19) lacks the basal yellowish basal HW colour of *P. boonei*, sp. n. (Fig. 2a) while the FW apex appears to be narrower than in *P. hylandae*, sp. n. (Fig. 3a). The female type of *P. umbrinus* is not directly comparable to the male genitalia of *P. boonei*, sp. n. and *P. hylandae*, sp. n. and the almost complete loss of wing scales from the *P. umbrinus* type also precludes comparison of wing pattern.

All other published *Palpifer* species are island endemics: *P. nipponica* in Japan, *P.*

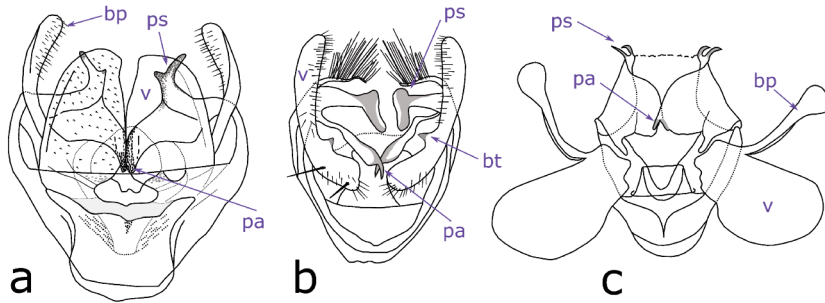


Fig. 13. Male genitalia: (a) *Palpifer sexnotatus*, (b) *P. murinus*, (c) *P. falkeri*. Redrawn from Tindale (1942, figs. 18–19) and Viette (1968, fig. 4). Labels as for Figs. 11–12; bt – basal tooth of valve.

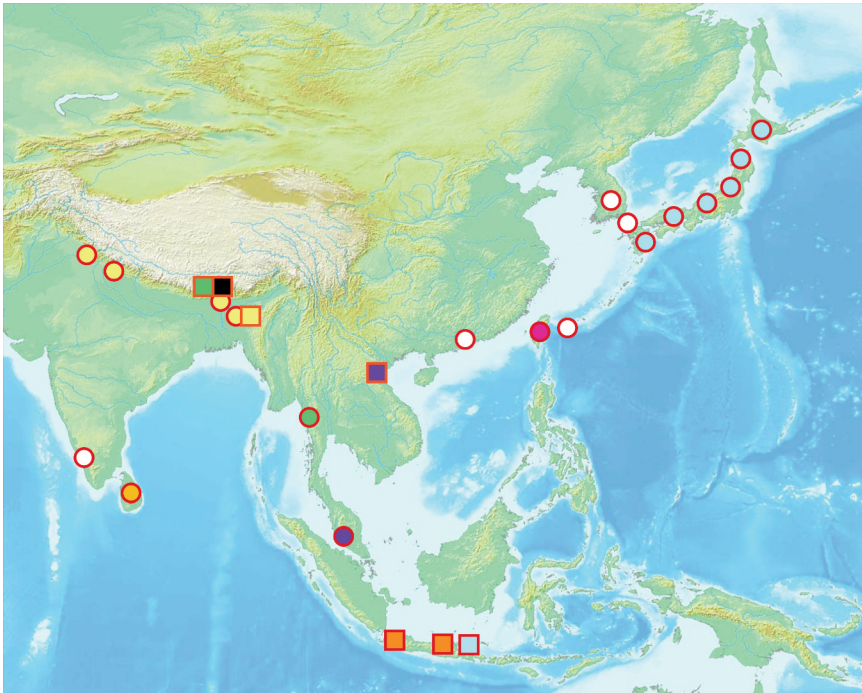
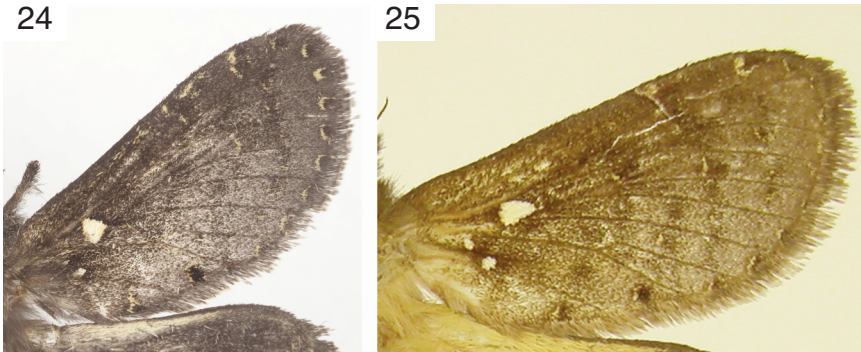


Fig. 14. Distribution of *Palpifer* species: *P. murinus* and *P. sexnotatus* (yellow circles), *P. pellicia* (yellow square), *Palpifer* species undetermined (white circles), *P. boonei*, sp. n. (dark blue square), *P. hylandae*, sp. n. (dark blue circle), *P. hopponis* (crimson circle), *P. falkneri* (pale green square), *P. madurensis* (pale blue square), *P. nipponica* (pale blue circles), *P. sordida* (red squares), *P. taprobanus* (red circle), *P. tavoyanus* (green circle), *P. umbrinus* (black square). Distribution data from type specimens, Grehan & Ismavel (2017), and personal communications from Jae-Dong Kim (South Korea), Kyoichiro Ueda (Tsushima and Ishigakijima islands), Siyad Karim (Kerela, India), and Hoi Ling Chen and Stefan Obenauer (Hong Kong, China).



Figs. 15–23. *Palpifer* species: 15, *P. falkneri* HT, ZSBS (photo, Ulf Buchsbaum); 16, *P. niponica* type, NHMUK (photo, David Lees, BMNH); 17a, *P. hopponis* type, HUS, (photo, Li-Cheng Shih); 17b, *P. hopponis* (photo, Li-Cheng Shih); 18, *P. murinus* (as *P. caeruleus* syntype, NHMUK (photo, David Lees); 19, *P. pellicia* type, NHMUK (photo David Lees); 20, *P. sexnotatus*, NHMUK (photo, Carlos Mielke); 21, *P. sordida* syntype, RMNH (photo, Rob de Vos); 22, *P. taprobanus* type, NHMUK (photo, David Lees); 23, *Palpifer umbrinus* type, NHMUK (photo, David Lees).



Figs. 24–25. *Palpifer* forewing patterns: **24**, *P. hopponis* (Li-Cheng Shih specimen); **25**, *P. sexnotatus* (NHMUK)

hopponis in Taiwan, *P. sordida* in Java, *P. madurensis* in Madura, and *P. taprobanus* in Sri Lanka (Fig. 14). This combination of geographic isolation and geographic distance lends confidence to our view that they are not conspecific with the Malaysian and Laotian populations represented by the new species designated here. Japanese *Palpifer* have been placed within *P. sexnotatus* in the literature (Nielsen *et al.* 2000, Hirowatari *et al.* 2013), sometimes as subspecies *P. sexnotatus ronin* (Esaki 1957, Matsumura 1931) or *P. sexnotatus niphonica* (Inoue 1982). The original description of *P. sexnotatus* by Moore (1879) was for a specimen from Darjeeling (northeastern India) that was characterized as having reddish brown (‘ochreous’) FW with four darker, indistinct maculated bands, a slightly yellow-speckled outer marginal band, a blackish spot in the middle of the FW margin, a yellow streak nearer the base, and a large round white discal spot. The base of the HW was described as reddish brown with a broad yellow band in the middle of the outer fringe. The body is reddish-brown with long reddish brown hairs at the base of the abdomen (cf. Fig. 20). In the first description of a Japanese specimen, Butler (1879) described *P. niphonica* as having olive-brown wings that were darkest sub-basally, an olivaceous thorax, and a greyish brown abdomen (Fig. 16). This description also conforms to illustrations of the male by Inoue (1982: pl. 3, fig. 7) and Hirowatari *et al.* (2013: fig. 3-02-9, 10). The female illustrated by Inoue (1982: pl. 3, fig. 8) has a lighter tone, particularly the antero-basal hindwings and anterior abdomen. Pfitzner (1912) also gave the name *ronin* in recognition that the Japanese form is distinguished from *sexnotatus* “by the hindwing being uniformly brown, not orange-yellow.” Given the contrasting illustrations and descriptions, and since there is no evidence for subsuming the Japanese *Palpifer* under *P. sexnotatus*, particularly in view of other *Palpifer* species being present in eastern mainland Asia (such as the new species described here), we take the conservative view of accepting *Palpifer niphonica* (Butler, 1879), **stat. rev.** as a distinct species. At present, we suggest that the name *P. sexnotatus* can only be confidently applied to moths conforming to the genitalic characteristics described by Tindale (1942) for specimens from northern India (Grehan & Ismavel 2016). Absence of the abdomen from the holotype of *Palpifer sexnotatus* (NHMUK) (Kyoichiro Ueda, pers. comm.) represents a future contingency for further comparisons between this and other species of *Palpifer*.

In general colour tone and appearance, the new species are both very similar to the

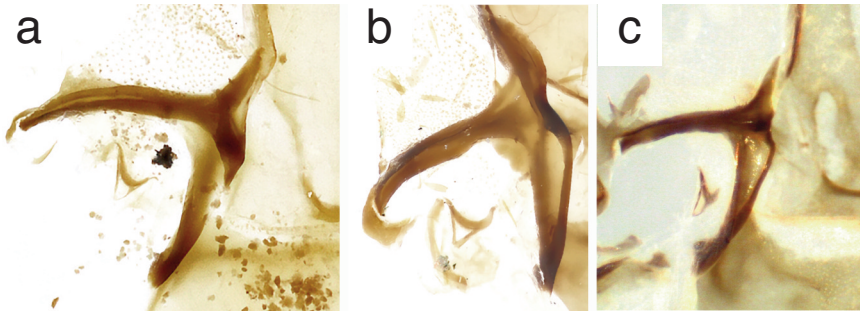


Fig. 26. Tergosternal connection. (a), *Kozloviella gortovannyii*; (b), *Pfitzneriella yuliyakovalevae*; (c), *Pfitzneriella rawlinsi* (from Grehan & Mielke 2018).

other members of *Palpifer*. Visual comparison with the types of nine other species (Figs. 15–23) show the shared presence of an anterior discal stigma basal to M_2 or close by. In the type of *P. umbrinus* the wing pattern is not visible as the scales have been rubbed away (Fig. 23). A basal FW stigma does occur in various other genera of Hepialidae, but the stigma in *Palpifer* appears to be unique in its large size relative to the wing and its triangular-ovoid shape with a transverse base (see Figs. 24, 25 for detail). All the illustrated specimens show a predominantly dark, chocolate to dark greyish brown ground colour in the wings, and all species (except *P. umbrinus* where the fringing scales are missing) have yellowish scales for at least a portion of the outer margin. Precise differences in the extent of this colouration between species will require study of fresh material. Pale yellowish to orangish brown basal wings and metathoracic region is present in *P. boonei*, sp. n., *P. falkneri*, *P. sexnotatus*, *P. taprobanus* and *P. umbrinus*, but appears to be absent from *P. hylandae*, sp. n., *P. murinus*, *P. nipponica*, *P. pellicia*, and *P. sordida*. This contrast is regarded as tentative due to the faded condition of some species illustrated here. In *P. hopponis* there is yellowish band between costa and R in HW but this does not extend to the thorax. A further feature of FW colour pattern found in some *Palpifer* species is the presence of scattered spots as shown in a specimen of *P. hopponis* (Fig. 24) and *P. sexnotatus* (Fig. 25) where thin yellowish markings occur along the margins that form crescent shapes curving around black patches along the outer and posterior margins in particular. This pattern appears to be unique to *Palpifer*, but fresh material for all species is required to ascertain its extent within the genus.

The structure of the prelabium and palpi is one of the most distinct features found in *Palpifer*. The prelabium is slightly bilobed, almost giving the appearance of two semi fused basal palpomeres. Tindale (1942) referred to the labial palps as three segmented, consisting of two spherical basal segments and a third elongated segment. It is apparent that he misinterpreted the bilobed prelabium for a palpomere. Instead there is a single ovoid palpomere subtending an elongate palpomere. Tindale (1942) also referred to an ill-defined suture near the apex. This suture may be subtending a small, rounded terminal structure that is apical in *P. boonei*, sp. n. (Fig. 4a) or slightly subapical and offset to one side in *P. hylandae*, sp. n. (Fig. 4b). The prelabium and palpi are otherwise very similar in shape between the two species. We were unable to definitively conclude whether the apical structure is a reduced segment or a specialized sensory organ.

Systematics: Phylogenetic affinities between *Palpifer* other genera of Hepialidae are not resolved. A FW scent gland also occurs in the Western Pacific *Phassodes* Bethune-Baker, 1905 (Solomon Islands, Fiji, Samoan islands), the South American *Puermytrans* Viette, 1951 (Chile), and *Viridigigas* Grehan & Rawlins, 2016 (Peru). This similarity could be phylogenetically informative (derived) as the structure is absent in the other five Exoporia families – Anomosetidae, Prototheoridae, Mnesarchaeidae, Neotheoridae, and Palaeosetidae. But the *Palpifer* gland is also morphologically distinct due to the anal vein bisecting the dorsal surface in a straight line rather than forming an anteriorly projecting curve as in the other genera which may indicate that the evolution of the gland in *Palpifer* is not phylogenetically homologous with the gland in the other genera. The tergo-sternal connection in *Palpifer* (as sampled for *P. hylandae*, sp. n.) is also phylogenetically interesting as it has a long anterior and dorsal brace and narrow tergo-sternal bar which is also found in some other hepialid genera. An elongate anterior and dorsal brace occur in *Afrotheora jordani* (Viette, 1956), *Eudalaca infumata* (Janse, 1942), and *Fraus simulans* Walker, 1856, but the tergo-sternal bar is strongly curved (Grehan 2010) rather than straight as in *Palpifer*. The closest matching structure was found to be in a South American clade (Grehan & Mielke 2018) comprising *Kozloviella* Grehan & Mielke, 2018 and *Pfitzneriella* Viette, 1951 where the tergo-sternal bar is also straight and at right angle to an elongate anterior brace (Fig. 26).

In the FW and HW of both new species, as well as *P. sexnotatus* (Tindale 1942, fig. 16), Rs3 separates from the common stalk with Rs4 distal to the r-m crossvein. This appears to be an uncommon feature in Hepialidae where in most species Rs3 separates basal to the r-m crossvein. We presume that Nielsen & Kristensen (1989) were referring to Rs3 separating distally when stating that a stalked Rs3 and Rs4 (as R₄ and R₅) occurred in *Palpifer*, *Bipectilus* Chu & Wang, 1985, *Gorgopsis* Hübner, [1820], *Eudalaca* Viette, 1950 and some *Antihepialus* Janse, 1942. This mixed occurrence, especially within a single genus (*Antihepialus*) suggests that in most Hepialidae, Rs3 branches from the common stalk before the r-m crossvein. There may be variability in the position of this branching (JRG & CGCM, pers. observ.) so whether the pattern seen here is consistent within *Palpifer* will require detailed examination of further species.

Biogeography: The western distributional limits of *Palpifer* (Fig. 14) closely match the range of the other widespread Asian genus, *Endoclita* C. & R. Felder, 1874, but to the east the range of *Endoclita* extends further to include Bali, Borneo and Philippines and north to the Russian Far East (Grehan 2011, Grehan & Mielke 2018). It would be no surprise, therefore, to also find that *Palpifer* has a similar distribution range as its species are much smaller than most of the usually large bodied *Endoclita* moths. Web-based records indicate that *Palpifer* can persist in human modified habitats. In addition to the urban context of the *P. hylandae*, sp. n. record from Malaysia, specimens of *Palpifer* sp. in Hong Kong have been photographed from within densely built up areas less than half a kilometer from forested hillsides (<https://www.inaturalist.org/observations/6483804>, last accessed 30 May 2018), at the Hong Kong University campus less than quarter of kilometer from a forested hillside (<https://www.inaturalist.org/observations/2389370>, last accessed 30 May 2018), and in a small public toilet with 24-hr lighting next to a patch of woodland within an area of commercial fishponds just outside the Mai Po Nature Reserve (Hoi Ling Cheng, pers. comm.) (<https://www.inaturalist.org/observations/5635991>, last accessed 30 May 2018). Some species such as *P. sordida* in Java (Kalshoven 1951, 1965) and *P. nipponica* in Japan (Maki 1919, Kodama 1978) appear to thrive sufficiently well in cultivated areas to be considered crop pests.

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