

Identification key to Nephtyidae (Annelida) of the Sea of Okhotsk

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Abstract

Currently, 15 species of Nephtyidae (Annelida) are known from the Sea of Okhotsk (north-western Pacific). A new user-friendly identification key is presented with a brief description for each species. The taxonomic positions of three closely related species, *Nephtys brachycephala* Moore, 1903, *N. schmitti* Hartman, 1938 and *N. paradoxa* Malm, 1874, are revised. The distributions of two species, *Nephtys discors* Ehlers, 1968 and *N. assignis* Hartman, 1950, are discussed.

Keywords

Aglaophamus, *Micronephthys*, *Nephtys*, Polychaeta, north-western Pacific

Introduction

Nephtyids are benthic polychaetes occurring worldwide from the intertidal to abyssal depths and mainly inhabiting soft sediments. Most of them are actively burrowing carnivores, although several species may be subsurface deposit feeders (Jumars et al. 2015). The smallest species are less than 10 mm long, while others can be rather large: the largest species from the Sea of Okhotsk may grow up to 300 mm long.

The family Nephtyidae includes approximately 140 species (Read and Fauchald 2017). More than 90 species occur in Pacific waters (Hartman 1938, 1950, Hilbig 1997, Murray et al. 2015). The first species of this family known from the Sea of Okhotsk was *Nephtys ciliata* (O.F. Müller, 1789), collected by Moore (1903) off the west coast of Kamchatka onboard the R/V “Albatross”. Later, Uschakov (1950, 1953, 1955), Imajima (1961) and Buzhinskaja (1985) added several more species to the local nephtyid fauna.

At present, 15 species of Nephtyidae are known from the Sea of Okhotsk. Thirteen of them belong to the most diverse genus *Nephtys*: *N. assignis* Hartman, 1950, *N. brachycephala* Moore, 1903, *N. caeca* (Fabricius, 1780), *N. californiensis* Hartman, 1938, *N. ciliata*, *N. longosetosa* Örsted, 1842, *N. neopolybranchia* Imajima and Takeda, 1987, *N. paradoxa* Malm, 1874, *N. pente* Rainer, 1984, *N. punctata* Hartman, 1938, *N. rickettsi* Hartman, 1938, *N. sachalinensis* Alalykina and Dnestrovskaya, 2015 and *N. schmitti* Hartman, 1938; one species belongs to *Aglaophamus*: *A. malmgreni* (Théel, 1879); and one to *Micronephthys*: *M. minuta* (Théel, 1879) (Buzhinskaja 2013, Alalykina and Dnestrovskaya 2015).

Herein, an illustrated key is provided to identify species known from the Sea of Okhotsk. This key is based mainly on external morphological characters. In brief species descriptions characters of the pharynx are also included, which are easily visible by dissection and highlighted by staining. This review facilitates the creation of a valid checklist of Nephtyidae species for this region.

Remarks on the key

Nephtyids are rather similar in their gross morphology and often difficult to distinguish. The main taxonomic characters are the position of the first branchiae, their shape and the number of branchiferous chaetigers, parapodial features (shape and size of acicular lobes, pre- and postacicular lobes, characters of chaetae) and pharynx structure.

The parapodia are biramous. Both noto- and neuropodia consist of acicular, pre- and postacicular lobes, and dorsal (notopodial) and ventral (neuropodial) cirri. The acicular lobes are supported by one acicula and may be conical, rounded or bilobed (Fig. 1). The branchiae (also called interramal cirri), are inserted below the dorsal cirri; they may be involute or recurved, slender and digitiform, or basally inflated and foliaceous. Foliaceous branchiae may be evenly flattened or with a thick tapering midrib and thin lateral wings (Fig. 2). A small spherical papilla may be present at the base of a branchia under the notopodial cirrus. The shape and proportions of these structures vary along the body, so they should be examined on the chaetigers that are recommended in the key.

The pharynx is a large eversible muscular proboscis, covered with soft papillae located in different areas that can be seen when everted (Fig. 3) and usually with one pair of small subterminal jaws located inside (visible with dissection). The anterior margin is surrounded by 18–20 bifid terminal papillae separated dorsally and ventrally

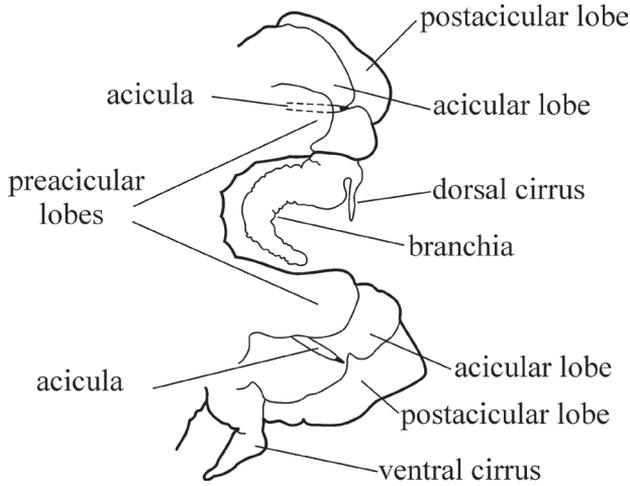


Figure 1. Explanation of main parapodial terminology used.

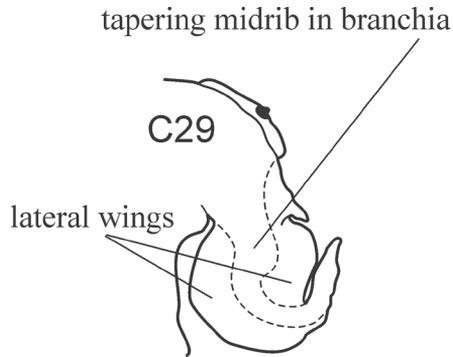


Figure 2. Shape of foliaceous branchia with midrib and wings.

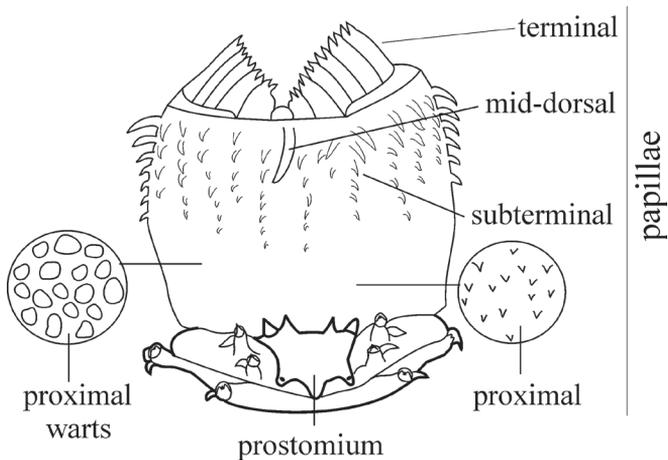


Figure 3. Explanation of main terminology of pharynx used.

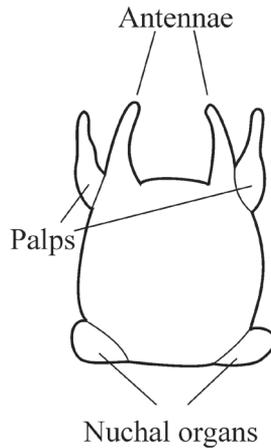


Figure 4. Explanation of prostomium terminology used.

by gaps; each gap may bear a single conical papilla. The subterminal region has 14 to 22 longitudinal rows of conical to digitiform papillae decreasing in size towards the base of the pharynx (absent in *Inermonephtys*). A single longer subterminal papilla may be present mid-dorsally and mid-ventrally. The proximal surface may be smooth or covered with small warts (flat outgrowths) or small papillae (conical or rounded) which slightly rise above the surface.

The prostomium is subquadrangular to subpentagonal (shape depends on whether the proboscis is everted or not). A pair of conical antennae is present in the anterior corners of the prostomium (absent in *Inermonephtys*). A pair of palps is inserted ventrolaterally (may be bifid in *Micronephtys*). A pair of nuchal organs is located dorsolaterally on the posterior margin of the prostomium (Fig. 4). Pigment spots on prostomium (if present) may fade. It is strongly recommended to examine several specimens, rather than a single individual for identification. Staining with methylene blue makes morphological characters more visible. The segment on which the branchiae begin should be checked on both sides of worm. Several undamaged parapodia from both sides of the worm should be examined.

The morphological details of the parapodia can usually be seen under the stereomicroscope without preparing slides. All parapodia are shown in anterior view. Pharynx dissection is not always necessary but may be useful to confirm identifications. It is important to mention that not all characters are developed in juveniles, and it is not always possible to identify fragmented animals without specialized training.

Each species of *Nephtys* is here provided with a brief description and distribution. All figures are original except for that of *N. brachycephala* (after Uschakov 1950) and *N. assignis* (after Hartman 1950). Abbreviations: AMNH – American Museum of Natural History, New York, USA; USNM – National Museum of Natural History, Washington, DC, USA; MCZ – Museum of Comparative Zoology of Harvard Uni-

versity, Cambridge, MA, USA; C – chaetiger. Abbreviations with numbers denote the chaetiger, i.e. C3 means the third chaetiger. All features used in the couplets are shown in the figures nearby.

No key is complete and perfect. The key given below should be used with caution and collated with descriptions of the species concerned. If you have any difficulties, do not hesitate to contact us by e-mail or by other means.

Taxonomic remarks

1. *Nephtys brachycephala* Moore, 1903 was originally described from Sagami Bay and recorded only a few times subsequently from the northern part of the Sea of Japan (Annenkova 1937, 1938), the Sea of Okhotsk (Uschakov 1950, 1955), the Bering Sea (Levenstein 1961), the Pacific coast of Japan (Imajima and Hartman 1964) and British Columbia (Berkeley 1966). It was questionably referred to *N. paradoxa* Malm, 1874 by Pettibone (1954). Recently, Ravara et al. (2010) also synonymized *N. brachycephala* sensu Uschakov with *N. paradoxa*, based on the literature, without examination of Uschakov's specimens.

Nephtys schmitti Hartman, 1938 from Alaska was also synonymized with *N. paradoxa* by Imajima and Takeda (1987) tentatively as they had not examined the type material. Hilbig (1997) examined the holotype of *N. schmitti* and specimens of *N. paradoxa* from Alaska and concluded that they represented two valid species. Later, Ravara et al. (2010) examined the Alaskan specimens of *N. schmitti* (including the holotype) and specimens of *N. paradoxa* from Europe (including the type locality) and found no significant differences between these specimens. However they considered *N. schmitti* to belong to a *N. paradoxa* species complex that seemed to have a worldwide distribution, and that the taxonomic status of this species complex should be carefully revised with examination of more specimens.

All three closely related species *N. brachycephala*, *N. schmitti* and *N. paradoxa*, have foliaceous branchiae and similar parapodial features. However, in contrast to *N. paradoxa*, the two other species (*N. brachycephala* and *N. schmitti*) have leaf-like branchiae with a thick tapering midrib that runs through its centre. Our examination of material from the Arctic, North Atlantic and north-western Pacific (497 specimens) has indicated that the foliaceous branchiae of *N. paradoxa* specimens lack the tapering midrib.

Furthermore, we examined the type material of both *N. brachycephala* (USNM 15722) and *N. schmitti* (USNM 20323) and found considerable differences between these species. *Nephtys schmitti* has foliaceous branchiae between chaetigers 12–35. From chaetiger 36 the foliaceous lobes suddenly disappear and the large cylindrical branchiae decrease gradually in size posteriorly, absent in the last 8–9 chaetigers. In *N. brachycephala*, the foliaceous branchiae start at chaetiger 15 and

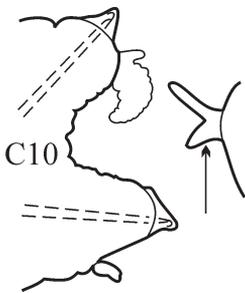
decrease gradually in size to chaetiger 50 and only the shortened midribs remain until chaetiger 55–58; branchiae are absent in posterior segments. We consider all these to be separate species.

2. *Nephtys discors* Ehlers, 1868 was originally described from Maine, USA and its distribution appears to be restricted to the north-western Atlantic. Specimens of *N. discors* from the west coast of Kamchatka (Sea of Okhotsk) (Imajima 1961) were examined and synonymized with *N. assignis* Hartman, 1950 by Banse (1972). We examined the type material of *N. discors* (MCZ IZ 700 and MCZ IZ 91707) and came to the same conclusion as Banse (1972). *Nephtys discors* sensu Imajima and Takeda (1987) from the east coast of Hokkaido (off the Notsuke Peninsula, on the southern edge of the Sea of Okhotsk, north-western Pacific) appeared to belong to the same species as the one from the west coast of Kamchatka, therefore was also considered as *N. assignis* (Ravara, 2010). Thus we excluded *N. discors* from our key and included *N. assignis*.

Nevertheless, both species remain valid. *Nephtys assignis* is a Pacific species with the initially minute branchiae increasing in size through segments 12–20; it has a proximally smooth pharynx and posterior parapodia with well-developed branchiae. *Nephtys discors* is a West Atlantic species with the branchiae best developed on the anterior third of the body and rudimentary in the posterior half; the pharynx is covered with proximal warts.

Key to nephtyid species from the Sea of Okhotsk

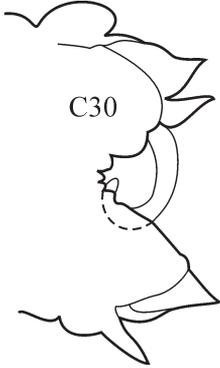
- 1 3–9 branchiferous chaetigers in worms longer than 3 mm; no more than 34 chaetigers. Up to 16 mm long (usually shorter)*Micronephtys minuta*



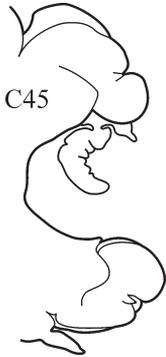
Small worms with body length up to 16 mm (Théel 1879), up to 34 chaetigers. Branchiae from C6–C9 to C10–C14 (Dnestrovskaya and Jirkov 2001) small, wrinkled, always shorter than notopodia. Palps bifid (arrow), upper branch twice as long as lower (visible in well preserved worms only). Parapodial preacicular and postacicular lobes rudimentary; acicular lobes conical. Pharynx with elongate mid-dorsal papilla; proximal region smooth. Arcto-boreal, shelf.

- Usually several tens of chaetigers with branchiae; up to 100 chaetigers or more and may be over 200 mm long in adults (in juveniles number of chaetigers may be low, but just before the pygidium there is a growing zone with numerous developing chaetigers)2

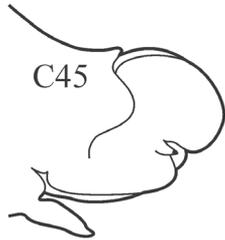
2(1) Branchiae of median parapodia curved inward.....*Aglaophamus malmgreni*



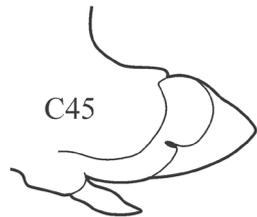
Body length up to 195 mm, up to 87 chaetigers. Branchiae from C9–C22 to C22–C47, always longer than notopodia. All preacicular and postacicular lobes well developed but always lower than acicular lobes. Neuropodial preacicular lobes in anteriormost chaetigers (before branchiae) bilobed with small lower and larger upper parts; in median branchiferous chaetigers rounded; and in posteriormost chaetigers rudimentary. Notopodial postacicular lobes bilobed with equal parts in anterior and median parapodia, and with small lower and larger upper parts in posterior chaetigers. Acicular lobes conical. Proximal region of pharynx smooth; elongate mid-dorsal and mid-ventral subterminal papillae absent. Arctoboreal, lower shelf, slope and deeper.



– Branchiae of median parapodia curved outward
.....*Nephtys*...**3**



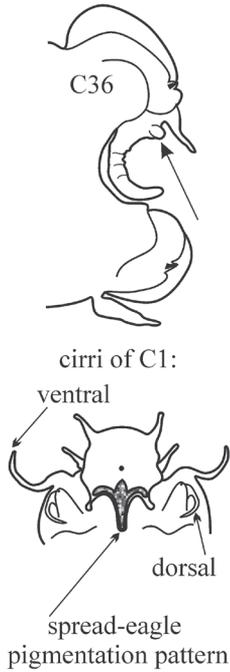
3(2) Neuropodial postacicular lobes of median chaetigers (after C30) almost equal or shorter than acicular lobes **4**



– Neuropodial postacicular lobes of median chaetigers (after C30) distinctly longer than acicular lobes **10**

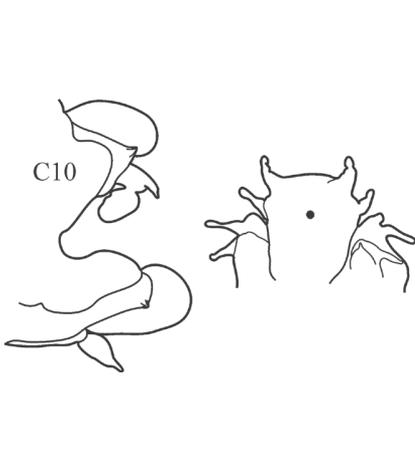
- 4(3) Branchiae from C3 or C4 5
- Branchiae from C5 or posteriorly..... 6

5(4) In median parapodia, acicular lobes bilobed; dorsal and ventral parapodial cirri of C1 (arrow) long; subsequent chaetigers with short dorsal and ventral cirri; in median and posterior chaetigers cirri long again*N. californiensis*



Large worms with body length up to 300 mm, up to 160 chaetigers (Hilbig 1997). Branchiae from C3 or C4 to posterior end of body, longer than notopodia in median region. Large worms with small spherical papilla at base of branchia under notopodial cirrus (arrow). Prostomium always with small dark spot in central part and sometimes with spread-eagle pigmentation pattern in posterior part (all fading during prolonged storage). Parapodial preacicular lobes low; dorsal part of each neuropodial preacicular lobe collar like, surrounding corresponding acicular lobe. Neuropodial postacicular lobes somewhat longer than notopodial postacicular lobes; after C30 both subequal in length or slightly longer than acicular lobes. Ventral cirri of median and posterior chaetigers slender and digitate, somewhat larger than corresponding dorsal cirri. Postacicular chaetae numerous, extremely long, soft and flexible. Proximal region of pharynx smooth; elongate mid-dorsal and mid-ventral subterminal papillae absent. Subtropical-boreal, intertidal to shelf.

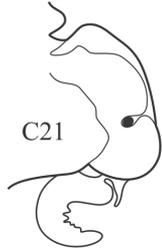
- Acicular lobes rounded-conical or conical throughout; dorsal and ventral parapodial cirri short throughout..... *N. neopolybranchia*



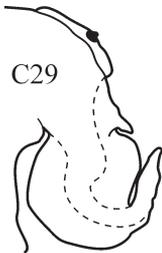
Small worms with body length up to 24 mm, up to 62 chaetigers. Branchiae small (always shorter than notopodia), from C3 to near posterior end. Prostomium with small dark spot or cross in central part (fading during prolonged storage). Parapodial preacicular lobes rudimentary. Anterior neuropodial postacicular lobes (before C12) distinctly longer than acicular lobes, posteriorly subequal in length, or slightly shorter than acicular lobes. Proximal region of pharynx with minute warts; elongate mid-dorsal and mid-ventral subterminal pharyngeal papillae absent. Boreal and subtropical, intertidal to upper shelf.



6(4) Branchiae initially small, shorter than dorsal cirri, gradually increasing in size; in median chaetigers more or less foliaceous7



– Branchiae of anterior chaetigers longer than dorsal cirri, cirriform throughout.....9



7(6) Foliaceous branchiae with a thick tapering midrib and thin lateral wings8

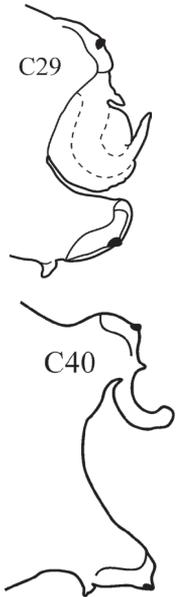
– Foliaceous branchiae without a tapering midrib and lateral wings, their thickness not varying from the centre to the edges.....*N. paradoxa*



small conical proximal papillae

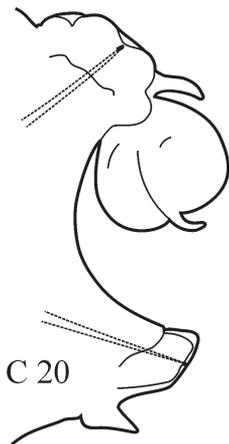
Body length up to 200 mm, up to 150 chaetigers (Rainer 1991). Branchiae from C7–C12, minute at first, gradually increasing in size to C25–C27, in median chaetigers often (but not always) more or less foliaceous, rounded fleshy, without tapering midrib or thin lateral wings. Parapodial preacicular lobes rudimentary. Anterior notopodial acicular lobes sometimes slightly bilobed, posteriorly always rounded-conical. Postacicular lobes of anterior and median parapodia subequal in length to or slightly longer than acicular lobes, posteriorly shorter than acicular lobes. Pharynx with short mid-dorsal subterminal papilla; in large worms proximal region of pharynx sometimes covered with small conical papillae. Arcto-boreal lower shelf.

- 8(7) Branchiae from C7 or C8; thin lateral wings of well-developed branchiae reaching to approx. half way along midrib or slightly higher, absent exactly from C36..... *N. schmitti*



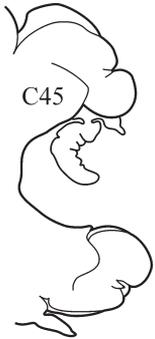
Body length up to 90 mm, approx. 100 chaetigers (Hilbig 1997). Branchiae minute at first, increasing in size gradually; well-developed branchiae with thick tapering midrib and thin lateral wings reaching half way along midrib from C10–C15 to C35. Exactly from C36 branchiae without lateral wings, long and digitiform, posteriorly decreasing in size gradually, absent from last 8–9 chaetigers. Parapodial preacicular lobes low throughout, poorly developed. Acicular lobes of anterior parapodia rounded (notopodial acicular lobes sometimes slightly bilobed), rounded-conical in median region and conical in posterior chaetigers. Anterior parapodial postacicular lobes (before C30) subequal in length, or slightly longer than acicular lobes, posteriorly shorter than acicular lobes. Both dorsal and ventral cirri of anterior and median chaetigers short, broadly conical, tapering to pointed tip, posteriorly decreasing in size to small and conical. Pharynx proximal region wrinkled, without papillae; elongate mid-dorsal subterminal papilla absent. Boreal slope and upper bathyal.

- Branchiae from C4 or C5; thin lateral wings of well-developed branchiae reach almost to the distal end of the midrib except for a slightly projecting tip..... *N. brachycephala*



Body length more than 64 mm, more than 60 chaetigers (Moore 1903). Branchiae minute at first, increasing in size gradually; well-developed branchiae (after C15) broadly foliaceous with thick tapering midrib and thin lateral wings reaching almost to distal end of midrib except for slightly projecting tip. Posteriorly branchiae decreasing in size very gradually: posterior to C41, branchiae rounded fleshy, without wings; from C51, only small cylindrical midrib present. Branchiae absent after C55–C58. Parapodial rami widely separated, noto- and neuropodia subequal in size. Pre- and postacicular lobes poorly developed, subequal in length to or shorter than acicular lobes. Acicular lobes of anterior parapodia rounded (in notopodia sometimes slightly bilobed), rounded-conical in median region and conical in posterior chaetigers. Elongate mid-dorsal subterminal papilla absent. Subtropical-boreal shelf.

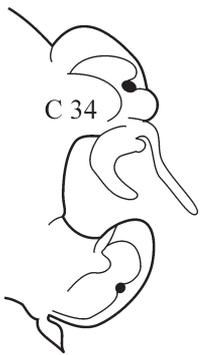
- 9(6) Branchiae from C5 or C6, they continue to C75–C85 as structures longer than dorsal cirri; dorsal cirri of median chaetigers short, broadly triangular...
..... *N. pente*



flat, distally rounded proximal papillae

Body length up to 140 mm, up to 90 chaetigers (Rainer 1991). Branchiae decreasing in size to minute knob (shorter than dorsal cirri) after C75–C85 and then completely absent. Parapodial preacicular lobes low throughout, poorly developed. In anterior and median chaetigers acicular lobes deeply bilobed, posteriorly indentation of acicular lobes becoming shallower, but may be visible up to last chaetigers. Postacicular lobes rounded, in anterior and median parapodia slightly longer or subequal in length to acicular lobes, in posterior chaetigers equal in length to or shorter than acicular lobes. Pharynx with long mid-dorsal subterminal papilla, proximal region in adults with flattened distally rounded papillae (conical in juveniles). Arcto-boreal upper shelf.

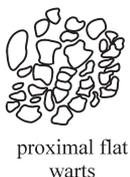
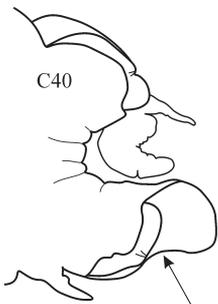
- Branchiae from C8–C12 (rarely from C7), they continue as structures longer than dorsal cirri to C45–C55; dorsal cirri of median chaetigers long and cirriform *N. ciliata*



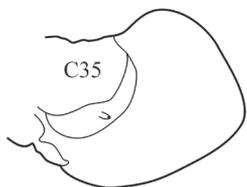
small conical proximal papillae

Body length up to 170 mm, up to 94 chaetigers. After C45–C55 branchiae decreasing in size to small knob (shorter than dorsal cirrus), and then completely absent. Notopodial preacicular lobes rudimentary, neuropodial preacicular lobes low, but distinct. Acicular lobes bilobed in anterior and median region, rounded in posterior chaetigers. Notopodial postacicular lobes shorter or subequal in length to acicular lobes, neuropodial postacicular lobes subequal in length to or slightly longer than acicular lobes. Pharynx with long mid-dorsal subterminal papilla, proximal region covered with small conical papillae. Arcto-boreal lower shelf.

10(3) Neuropodial postacicular lobes of median chaetigers with distinct indentation on the ventral side (arrow); branchiae from C3 to near posterior end (rarely from C4 – usually in small worms) *N. longosetosa*



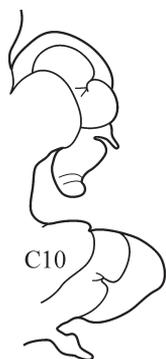
Body length up to 174 mm, up to 121 chaetigers. Parapodial preacicular lobes low and rounded, in large worms sometimes slightly bilobed in notopodia. Acicular lobes of anterior chaetigers (and in median chaetigers in large worms) bilobed. Neuropodial postacicular lobes of median and posterior chaetigers much longer than acicular and notopodial lobes, with rounded tips and distinct indentation on ventral side (around C40). Pharynx with long mid-dorsal sub-terminal papilla, proximal region smooth or covered with flat warts in large specimens. Boreal shelf.



– No indentation on ventral side of neuropodial postacicular lobes; branchiae from C4 or later ... **11**

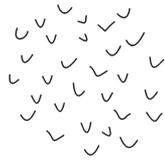
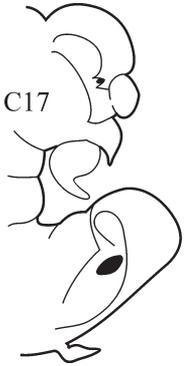


11(10) Interramal (internal) parts of acicular lobes enlarged (arrows), distinctly higher than dorsal and ventral (outer) parts of acicular lobes **12**



– Interramal parts of acicular lobes not enlarged, sub-equal in size and shape to dorsal and ventral (outer) lobes **13**

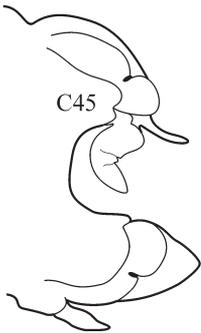
- 12(11) Branchiae from C6; rounded interramal parts of acicular lobes enlarged in anterior and median chaetigers *N. rickettsi*



small conical pharyngeal papillae

Body length up to 300 mm, up to 120 chaetigers (Hartman 1938), according to our data up to 127 chaetigers. Branchiae of median chaetigers basally thickened, fleshy with narrow tips, shorter and flattened towards tail; in last 15–17 chaetigers shorter than dorsal cirri. In large animals, dorsal cirri of first few (five or more) chaetigers subglobular, triangular-foliaceous towards tail; conical in all chaetigers of small worms. Parapodial preacicular lobes rudimentary. Neuropodial acicular lobes bilobed only in anterior chaetigers, notopodial acicular lobes also bilobed in median chaetigers, obliquely-oval towards tail. Postacicular lobes much longer than acicular lobes, rounded-foliaceous. Pharynx without mid-dorsal subterminal papilla; median part of pharynx with small conical papillae, proximal region smooth. Arcto-boreal, shelf.

- Branchiae from C4; rounded interramal parts of acicular lobes greatly enlarged up to posterior end *N. sachalinensis*



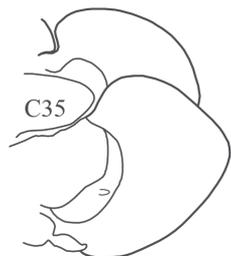
small rounded proximal papillae

Body length up to 107 mm, up to 112 chaetigers (Alalykina and Dnestrovskaya 2015). Branchiae to near posterior end. Dorsal cirri triangular-foliaceous in anterior chaetigers, elongate and subulate in median and posterior chaetigers. Parapodial preacicular lobes simple, low, rounded. Acicular lobes bilobed from C3–C4 to near posterior end. In median chaetigers notopodial postacicular lobes obliquely rounded, slightly longer or equal to acicular lobes. Neuropodial postacicular lobes elongated-triangular with obtuse tips, almost twice as long as acicular lobes. Pharynx without mid-dorsal subterminal pharyngeal papilla; proximal and median regions of pharynx with small rounded papillae. Boreal, upper sublittoral.

- 13(11) Branchiae from C7–C9; neuropodial postacicular lobes of median chaetigers distinctly longer than notopodial ***N. punctata***

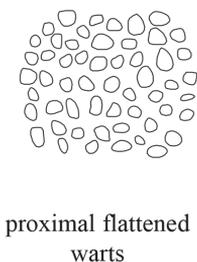
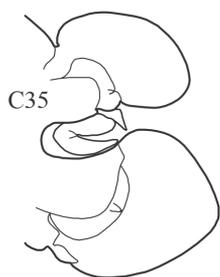


Body length up to 100 mm, up to 108 chaetigers (Hilbig 1997). Branchiae only slightly larger than dorsal cirri at first, best developed from around C20, continuing as large structures through median region, decreasing gradually in size in posterior chaetigers, absent from last 10 or so chaetigers. Notopodial preacicular lobes rounded, rudimentary, neuropodial preacicular lobes of median chaetigers with interramal (dorsal) outgrowth (arrow), not fused with postacicular lobes. Acicular lobes deeply bilobed in anteriormost chaetigers, only slightly bilobed in median region, distinctly conical in posterior chaetigers. Neuropodial postacicular lobes elongate with rounded tips in median parapodia, gradually decreasing after C50–C60; dorsal cirri elongate and subulate in median chaetigers. Pharynx with long mid-dorsal subterminal papilla, proximal region covered with minute rounded papillae. Subtropical-boreal, shelf to slope and upper bathyal.



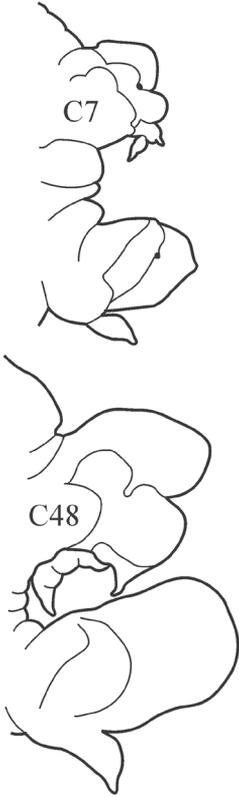
- Branchiae from C4–C6; neuropodial postacicular lobes of median chaetigers subequal in length to notopodial postacicular lobes or only slightly longer **14**

- 14(13) Branchiae from C4 (rarely from C5); in median chaetigers notopodial postacicular lobes obliquely oval, neuropodial postacicular lobes distinctly triangular with pointed (in juveniles) or rounded tips ***N. caeca***



Body length up to 250 mm, up to 150 chaetigers (Rainer 1991). Parapodial preacicular lobes poorly developed, rounded. Acicular lobe bilobed in anteriormost and median regions of large worms. Postacicular lobes extending well beyond acicular lobes; neuropodial postacicular lobes subequal in length to notopodial postacicular lobes or only slightly longer. Mid-dorsal subterminal papilla of pharynx similar in size to largest subterminal papillae or absent; proximal region covered with flattened warts. Arcto-boreal, upper shelf.

- Branchiae from C6; both noto- and neuropodial postacicular lobes wide, rounded.....*N. assignis*



Body length up to 200 mm, up to 145 chaetigers (Hilbig 1997). Branchiae at first, minute, short and thick, gradually increasing in size through C12–C20, in median chaetigers large, recurved and cirriform, posteriorly decreasing in size, absent from last few chaetigers. Parapodial preacicular lobes poorly developed, rounded. Notopodial acicular lobes of median chaetigers deeply incised, neuropodial acicular lobes obliquely rounded. Postacicular lobes of median chaetigers foliaceous, extending well beyond acicular lobes; neuropodial postacicular lobes slightly longer than notopodial postacicular lobes. Pharynx without mid-dorsal subterminal papilla, proximally smooth. Tropical-boreal, sublittoral to shelf.

List of Nephtyidae inhabiting the Sea of Okhotsk

- Aglaophamus* Kinberg, 1865
 - Aglaophamus malmgreni* (Théel, 1879)
- Micronephthys* Friedrich, 1939
 - Micronephthys minuta* (Théel, 1879)
- Nephtys* Cuvier, 1817
 - Nephtys assignis* Hartman, 1950
 - Nephtys brachycephala* Moore, 1903
 - Nephtys caeca* (Fabricius, 1780)
 - Nephtys californiensis* Hartman, 1938
 - Nephtys ciliata* (Müller, 1789)
 - Nephtys longosetosa* Örsted, 1842
 - Nephtys neopolybranchia* Imajima & Takeda, 1987
 - Nephtys paradoxa* Malm, 1874
 - Nephtys pente* Rainer, 1984

Nephtys punctata Hartman, 1938

Nephtys rickettsi Hartman, 1938

Nephtys sachalinensis Alalykina & Dnestrovskaya, 2015

Nephtys schmitti Hartman, 1938

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Morphological and molecular diversity of Lake Baikal candonid ostracods, with description of a new genus

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Abstract

Uncoupling between molecular and morphological evolution is common in many animal and plant lineages. This is especially frequent among groups living in ancient deep lakes, because these ecosystems promote rapid morphological diversification, and has already been demonstrated for Tanganyika cichlid fishes and Baikal amphipods. Ostracods are also very diverse in these ecosystems, with 107 candonid species described so far from Baikal, majority of them in the genera *Candona* Baird, 1845 and *Pseudocandona* Kaufmann, 1900. Here we study their morphological and molecular diversity based on four genes (two nuclear and two mitochondrial), 10 species from the lake, and 28 other species from around the world. The results of our phylogenetic analysis based on a concatenated data set, along with sequence diversity, support only two genetic lineages in the lake and indicate that a majority of the Baikal *Candona* and *Pseudocandona* species should be excluded from these genera. We describe a new genus, *Mazepovacandona* **gen. n.**, to include five Baikal species, all redescribed here. We also amend the diagnosis for the endemic genus *Baicalocandona* Mazepova, 1972 and redescribe two species. Our study confirms an exceptional morphological diversity of Lake Baikal candonids and shows that both Baikal lineages are closely related to *Candona*, but only distantly to *Pseudocandona*.

Keywords

Crustacea, Deep lakes, molecular phylogeny, taxonomy, CO1, 16S rRNA, 18S rRNA, 28S rRNA

Introduction

In the past decade the number of Candonidae genera and species has almost doubled, so that now the family contains about 500 Recent species in 39 genera and eight tribes (see Martens and Savatnalinton 2011; Karanovic 2012). This increase is mostly due to the study of previously poorly sampled regions, such as Australia (Karanovic 2007) and South America (Karanovic and Datry 2009; Higuera and Martens 2012, 2014). Almost each genus described from those regions is supported by numerous synapomorphic characters, with phylogenetically resolved position within the family Candonidae. This has been supported by a cladistic analysis of the family based on morphological characters (Karanovic 2007). In this analysis, Candonini is the only tribe which seems not to be monophyletic. It comprises the greatest number of genera (12), most of which are Holarctic and described more than 100 years ago (Meisch 2000).

There were several attempts to revise some of the most speciose and taxonomically problematic Candonini genera, such as *Candona* Baird, 1845, *Fabaeformiscandona* Krstić, 1972, *Pseudocandona* Kaufmann, 1900, and *Typhlocypris* Vejdovský, 1882 (see Meisch 1996; Karanovic 2005, 2006, 2013; Namiotko et al. 2014). However, the results are only partial because the current diagnosis of both *Candona* and *Pseudocandona* exclude almost all Baikal Lake representatives of these two genera.

A majority of 104 Baikal candonids were described in two main publications: Bronstein (1947) and Mazepova (1990). There are three genera in the lake: *Candona* Baird, 1845 (with 48 species and 5 subspecies), *Pseudocandona* Kaufmann, 1900 (27 species and 3 subspecies), and *Baicalocandona* Mazepova, 1976 (11 species and 10 subspecies). Only *Baicalocandona* is endemic. The original descriptions, although missing some important taxonomic information, revealed a great morphological diversity and indicated that Baikal candonids need to be revised and probably subdivided into several genera (Karanovic 2007, 2012; Danielopol et al. 2011). Only two species, *Pseudocandona gajewskajae* Bronstein, 1947 and *P. ceratina* Mazepova, 1982 were studied after their original descriptions (Martens et al. 1992a, b). The authors provided more morphological details of the two species and concluded that their position within *Pseudocandona* is dubious. Similarly, Baikal amphipods are also extremely morphologically diverse, but recent studies showed that a morphologically diverse family Acanthogammaridae is monophyletic, while morphologically conservative Micruropodidae is paraphyletic (Macdonald III et al. 2005). In general, morphological and molecular evolution have been uncoupled not only in ancient lakes (Martens 1994), but also in other ecosystems and across all life kingdoms (Pisani et al. 2007; Renaud et al. 2007; Sotiaux et al. 2009; Poisot et al. 2011; Dávalos et al. 2012).

Lake Baikal is a place of exceptional biodiversity. Over 2500 species have been recorded so far, more than half of them endemic to the lake (Timoshkin 2001). Crustaceans are especially diverse, with amphipods having nearly 300 species (Takhteev 2000). Ostracods are the second most diverse crustacean group with 90% species endemic to the lake (Martens 1994). Besides candonids, Lake Baikal is a biodiversity hot spot for another unrelated ostracod group, Cytheroidea, with almost all species

assigned to a single genus, *Cytherissa* Sars, 1925 (47 species and 10 subspecies). Schön and Martens (2012) compared molecular evolution and phylogeny of cytheroid lineages from Lake Baikal and Lake Tanganyika based on two gene markers, *COI* and ITS. While the latter marker failed to resolve phylogenetic relationships in either of the lakes, *COI* did so in Lake Tanganyika, but not in Baikal. The phylogenetic tree of Lake Baikal cytheroids is awash with multifurcations and the authors conclude that the morphological revision of the Baikal cytheroids is necessary.

In order to recover phylogenetic position of the Lake Baikal candonids within the family we used 10 species from the lake and another 28 from around the world, targeting type species of the genera *Candona*, *Pseudocandona* and *Fabaeformiscandona*, since the majority of the Baikal species currently belong to the former two genera, and all three genera are also currently polyphyletic (Karanovic 2007; Danielopol et al. 2011). Two nuclear (18S, 28S), and two mitochondrial (16S and *COI*) regions were amplified and a phylogenetic tree based on concatenated data set of three genes (two nuclear and 16S) was reconstructed. At the moment, description of all Baikal candonids is not up to the modern standards of ostracod taxonomy and species need to be redescribed. Redescriptions are also necessary in order to provide enough morphological data which can be accurately compared with the level of molecular divergence.

Material and methods

Collecting and taxonomy

Samples were taken from 11–15 m depths by SCUBA diving from the shore of Lake Baikal. Three bottom types were sampled: rock, mud, and sand. Ostracods were sorted alive on the spot and immediately fixed in 97% ethyl alcohol. Dissection and identification was done with the aid of Zeiss Axiostar-plus light microscope and Leica DM 2500 compound microscope, equipped with N-Plan objectives, respectively. Scanning Electron Microscope (SEM) photographs were taken with a Hitachi S-4700 at Eulji University (Seoul). Photographs of Zenker organ and hemipenis were taken with Olympus C-5050 digital camera mounted on Olympus PX51 compound microscope.

Collected ostracods were identified with the aid of Mazepova (1990). The terminology for A1, Md, Mxl, L5 and L6 follows Broodbakker and Danielopol (1982), and for L7 Meisch (1996). Here, the view of Meisch (2007) regarding the terminology and homology of the most posterior appendage on the ostracod body (“furca”) is accepted.

DNA extraction and amplification

In the first step of the DNA extraction specimens were kept for 2–3 hours in distilled water. LaboPass Tissue Mini extraction kit (Cosmo Genetech Co., LTD, Korea) was used in all further steps of extraction, following the manufacturer's protocol. Frag-

ments of *COI* were amplified using universal Folmer primers (Folmer et al. 1994). Fragments of 28S were amplified using the primer pairs dd/ff, ee/mm, vv/xx from Hillis and Dixon (1991), of the 18S with primers from Yamaguchi (2003), and fragments of 16S were amplified with primers from Palumbi et al. (1996), all using a TaKaRa PCR Thermal Cycler Dice. For all amplifications PCR reactions were carried out in 25 µl volumes, containing: 5 µl of DNA template, 2.5 µl of 10× ExTaq Buffer, 0.25 µl of TaKaRa Ex Taq (5 units/ µl), 2 µl of dNDTP Mixture (2.5 mM each), 1 µl each primer, and 13.25 µl distilled H₂O. The PCR protocol for *COI* amplification consisted of initial denaturation for 5 minutes at 94°C, 40 cycles of denaturation for 1 minute at 94°C, annealing for 2 minutes at 46°C, extension for 3 minutes at 72°C, and final extension at 72°C for 10 minutes. Protocol for 28S consisted of initial denaturation for 5 minutes at 94°C, 40 cycles of denaturation for 35s at 95°C, annealing for 1 minute at 50°C, extension for 1 minute at 72°C, and final extension at 72°C for 5 minutes. PCR settings for the amplification of 18S followed Yamaguchi (2003) for each corresponding primer pair. Settings for 16S consisted of initial denaturation at 94°C for 5 minutes, 35 cycles of denaturation for 30s at 94°C, annealing for 30s at 48°C, extension for 1 minute at 72°C, and final extension at 72°C for 10 minutes. The PCR products were electrophoresed on 1% agarose gels; if DNA was present the products were purified for sequencing reactions using the LaboPass PCR Purification Kit, following the guidelines provided with the kit. DNA was sequenced on an ABI automatic capillary sequencer (Macrogen, Seoul, South Korea) using the same set of primers always in both directions.

Molecular data analysis

All sequences were visualized using Finch TV version 1.4.0 (<http://www.geospiza.com/Products/finchtv.shtml>). BLAST (Altschul et al. 1990) analysis of GenBank database were used to check that the obtained sequences were ostracod in origin and not contaminants. Each sequence was checked for the quality of signal and sites with possible low resolution, and corrected by comparing forward and reverse strands. Sequences were aligned in MEGA 7 (Kumar et al. 2016) with ClustalW (Thompson et al. 1994) with extension penalty changed from default settings (6) to 1 for 28S dataset in order to allow alignment of homologous regions that were separated by expansion segments present in some taxa but not others. All alignments were manually checked and corrected where necessary. The 28S alignments were also checked with Gblock (Castresana 2000) and ambiguous blocks were removed. We performed analyses of the concatenated dataset including 18S, 28S, and 16S fragments. Datasets for some species were composed of sequences acquired from different specimens in order to avoid missing data, and for our outgroup we combined 16S from two different, but closely related, species. All specimens of one species came from the same locality and their identity was confirmed by close morphological examination. Missing data were coded "?". Recent simulations and empirical analyses suggested that missing data in

Bayesian phylogenetics are not themselves problematic, and that incomplete taxa can be accurately placed as long as the overall numbers of characters are large (Wiens 2003; Wiens and Moen 2008). Sequence differences were calculated in MEGA 7 using uncorrected p-distance method. For the best fit evolutionary model program jModelTest 2.1.6 (Darriba et al. 2012; Guindon and Gascuel 2003) was used with the Akaike information criterion (Hurvich and Tsai 1989). Bayesian inference reconstruction in MrBayes v3.2.6 (Huelsenbeck and Ronquist 2001; Ronquist and Huelsenbeck 2003; Ronquist et al. 2012) was performed with the best fit model and priors for the base and state frequencies calculated by jModelTest. Data were partitioned into five blocks corresponding to gene regions, each with its fixed priors. The 28S data set was analyzed as three independent fragments: d/f; e/m, and v/x, corresponding to the primer sets used for their amplification. All analyses ran with four chains simultaneously for two million generations in two independent runs, sampling trees every 200 generations. Of the four chains three were heated and one was cold, the temperature value ("Temp" command in MrBayes) was 0.1 (default option). The results were summarized and trees from each MrBayes run were combined with the default 25% burn-in. A >50% posterior probability consensus tree was constructed from the remaining trees. For the choice of the outgroup we relied on the phylogeny published in Hiruta et al. (2016). Since the relationships within Cypridoidea was not clearly resolved and Candonidae appears as a sister taxon to all other Cypridoidea, we decided on a representative of Cyclopyrididae, which used to be in the same family with Candoninae. Sequence GenBank accession numbers are listed in Supplement 1. Software FigTree v1.4.3 was used for tree visualizations.

Results

Taxonomy

Genus *Mazepovacandona* gen. n.

<http://zoobank.org/3CEDBD01-E93F-499C-991A-984D6B089700>

Type species. *Mazepovacandona directa* (Bronstein, 1947), comb. n.

Other species. *M. godlewski* (Mazepova, 1984), comb.n., *M. navitarum* (Mazepova, 1976), comb. n., *M. orbiculata* (Mazepova, 1990), comb. n., *M. spicata* (Mazepova, 1982), comb. n.

Diagnosis. Shell shape variable, but surface generally smooth or poorly ornamented. A1 7- or 6-segmented. Male A2 with t-setae transformed into sensory setae, z-setae transformed into claws. Female A2 G2-claw considerably shorter than G1 or G3. Exopod of A2 consisting of small plate and three setae of which one is long. Male prehensile palps asymmetrical and both with hook-like fingers. L6 with basal seta and with one seta on each endopodal segment, except on last segment, which carries two setae and one claw. L7 with only d1- and dp-setae on basal segment, e- and f-setae

missing, g-seta long; terminal segment with short h1-seta and h2- and h3-setae equally long; penultimate segment divided or incompletely divided. UR with both claws and setae present. Zenker organ with variable number of spine whorls, varying from 3+2 to 5+2; anterior part (cap) hemispherical, lattice-like structure well-developed. Hemipenis with small a-lobe not projecting laterally; M-peace terminally rounded (ball-like); ejaculatory process (bursa copulatrix) terminally pointed.

Etymology. The genus is named after late Dr. Galina Mazepova as an acknowledgment of her outstanding contribution to the study of Lake Baikal ostracod fauna.

Remarks. *Mazepovacandona* currently contains five morphologically diverse species. The carapace shape (from triangular to banana shaped) is only one example of this diversity. The number of segments on the antennule and the way male z-setae on the second antenna are developed is also variable, however all females have G2-claw on the second antenna shorter than the rest of the claws. The number of setae on the second segment of the Md-palp is also variable and it can be either three or four. Prehensile palps are dissimilar among species, although all have clearly pronounced hooked-like fingers on both left and right palp. The basal seta (d1) on the walking leg is shorter in all five species than in two *Baicalocandona* species redescribed here. The length of this seta relative to the d2-seta (always absent in Candonidae) is an important taxonomic character in some Cyprididae, such as Cyprinotinae (see the key in Karanovic 2012) and Eucypridinae (see Martens 1989). The d1-seta is often absent in Candonidae, and the importance of its length for the taxonomy of the family has never been studied. In all *Mazepovacandona* the penultimate segment of the cleaning leg is at least partially subdivided, but this tends to be a variable character, for example in *Candona*, *Fabaeformiscandona* (see Meisch 2000), and a few genera from Australia (see Karanovic 2007). The hemipenis morphology in *Mazepovacandona* is characterized by a rounded distal end of the M-peace. The morphology of this part is an important taxonomic character in *Candona* (see Petkovski 1960). Also, the ejaculatory process (*bursa copulatrix*) is pointed in all species of the new genus, but the morphology of this part has not been studied for its taxonomic importance. The hemipenis of the two examined species (*M. directa* and *M. orbiculata*) was in an erected state and because of that the position of the a-lobe and its shape were not easy to observe. It is interesting to note that all examined males of *M. directa* had their hemipenis erected. The hemipenis illustrations of these two species in Mazepova (1990) also show an erected copulatory organ. The Zenker organ has a balloon-like anterior end, a characteristic which has been noted in *Pseudocandona inaequivalvis baikalensis* Bronstein, 1947, some *Undulacandona* species (see Smith 2011; Karanovic and Cho 2017), and in the families Cyclocyprididae and Paracyprididae (see Danielopol 1982). The morphology and development of the Zenker organ has been studied recently (see Yamada and Matzke-Karasz 2012; Yamada et al. 2014). The phylogenetic importance of its morphology is recognized on the higher taxonomic levels (Danielopol 1978; Matzke-Karasz 1997), but not well understood at the generic or even family level. Many of the Candonidae genera have the number of whorls of spines as a part of their diagnosis. In the new genus, the number ranges from five to seven, and they all have well-developed spines, which is a sign of the sexual ma-

turity (Yamada et al. 2014). Interestingly, Kesling (1957) reported a variability of the whorl numbers in one *Candona* species, where some individuals have seven and others eight whorls. The latter number is very unusual in the family Candonidae, where the number of whorls never exceeds seven.

Despite the morphological diversity of *Mazepovacandona*, this genus seems to be most closely related to *Candona* and *Fabaeformiscandona*. For example, prehensile palps of *M. directa* (elongated) are very similar to *candida*-group of *Candona*, while female genital lobe bears similarity to the *neglecta*-group. There is also similarity with *Fabaeformiscandona*, especially because several of its species have rounded distal part of the M-peace. The *breuli*-group of the latter genus is particularly similar to *Mazepovacandona* in sense that the M-peace is not so strongly sclerified and that most species have an UR with a long posterior seta. However, most of the species currently belonging to this group have a completely fused penultimate segment of the cleaning leg.

***Mazepovacandona directa* (Bronstein, 1947)**

Figs 1–3, 14D, 15D

Candona directa sp. n. – Bronstein (1947): p.12, fig. 121

Candona directa Bronstein – Mazepova (1990): p. 73, fig. 20B

Material examined. Two males and one female dissected and mounted on glass slides (shell of one male and one female on one SEM stub), 25 undissected specimens in 95% alcohol, 1 specimen used for the DNA extraction, all collected from 12–15 m depth by SCUBA diving off Listvyanka, 51°51'51.3"N, 104°50'37.8"E, 12 September 2015, collectors: Igor Khanaev and Ivan Nebesnykh.

Short redescription. Almost no sexual dimorphism in shell shape in lateral view (Fig. 1A–D). Both LV and RV subrectangular, dorsal margin straight and strongly inclined towards anterior end. Posterior end straight, anterior end rounded. RV with small recess antero-dorsally, ventral margin very slightly concave. Surface only centrally ornamented with shallow pits. Surface cuticular pores of two types: with simple lip and with semi operculum (Fig. 1E, F). Length around 1 mm.

A1 7-segmented with posterior setae transformed into claws (Fig. 3A). Male A2 with subdivided penultimate segment and t2- and t3-setae transformed into sexual bristles; z1- and z2-setae transformed into claws, as well asz3-seta; G1- and G3-claws reduced and short, G2-claw long (Fig. 2B). Female A2 (Fig. 3D) with all three z-seta untransformed; G2 claw short, and only slightly exceeding distal margin of terminal segment. Md-palp (Fig. 2C) with 3+2 setae on inner side, gamma seta not plumose. Mxl-palp (Fig. 2D) with rectangular terminal segment. Prehensile palps (Fig. 2G, H) with long bodies and short, curved fingers. L6 (Fig. 2G) with basal seta reaching far beyond distal margin of basal segment. L7 (Fig. 3A) clearly 5-segmented; basal segment with d1- and dp-seta; no e- or f-setae, g-seta long; terminal segment with setae h2- and h3- long and h1-seta shorter, but also considerably long. UR in both

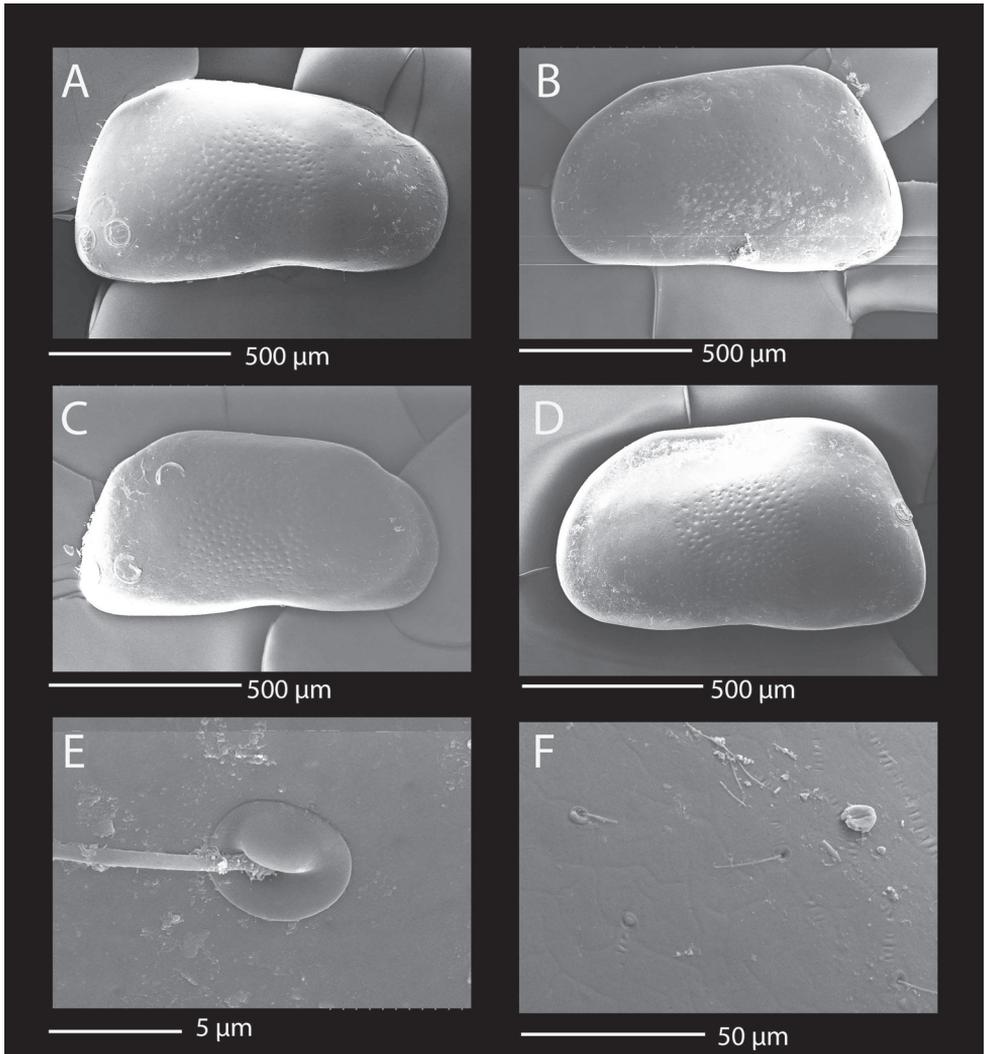


Figure 1. SEM photographs of *Mazepovacandona directa* (Bronstein, 1947). **A, B, E, F** male **C, D** female: **A** RV, lateral view **B** LV, lateral view **C** RV, lateral view **D** LV, lateral view **E** detail of a sensilla **F** detail of the shell surface.

sexes (Figs 2H, 3C) very similar and robust, with long posterior seta and strong claws. Hemipenis always (?) in semi-erectile mode (Fig. 3B, 14D); a-lobe relatively small but its shape hard to accurately perceive due to its folded position; M-peace rounded distally, ejaculatory tube with pointed distal end. Female genital field (Fig. 3E) with enlarged, semi-triangular lobe. Zenker organ with 5+2 whorls of spines (Fig. 15D); anterior cap hemispherical, with strongly sclerified margin, lattice very elaborately developed and on side adjoined by longer spines. Eyes present, white.

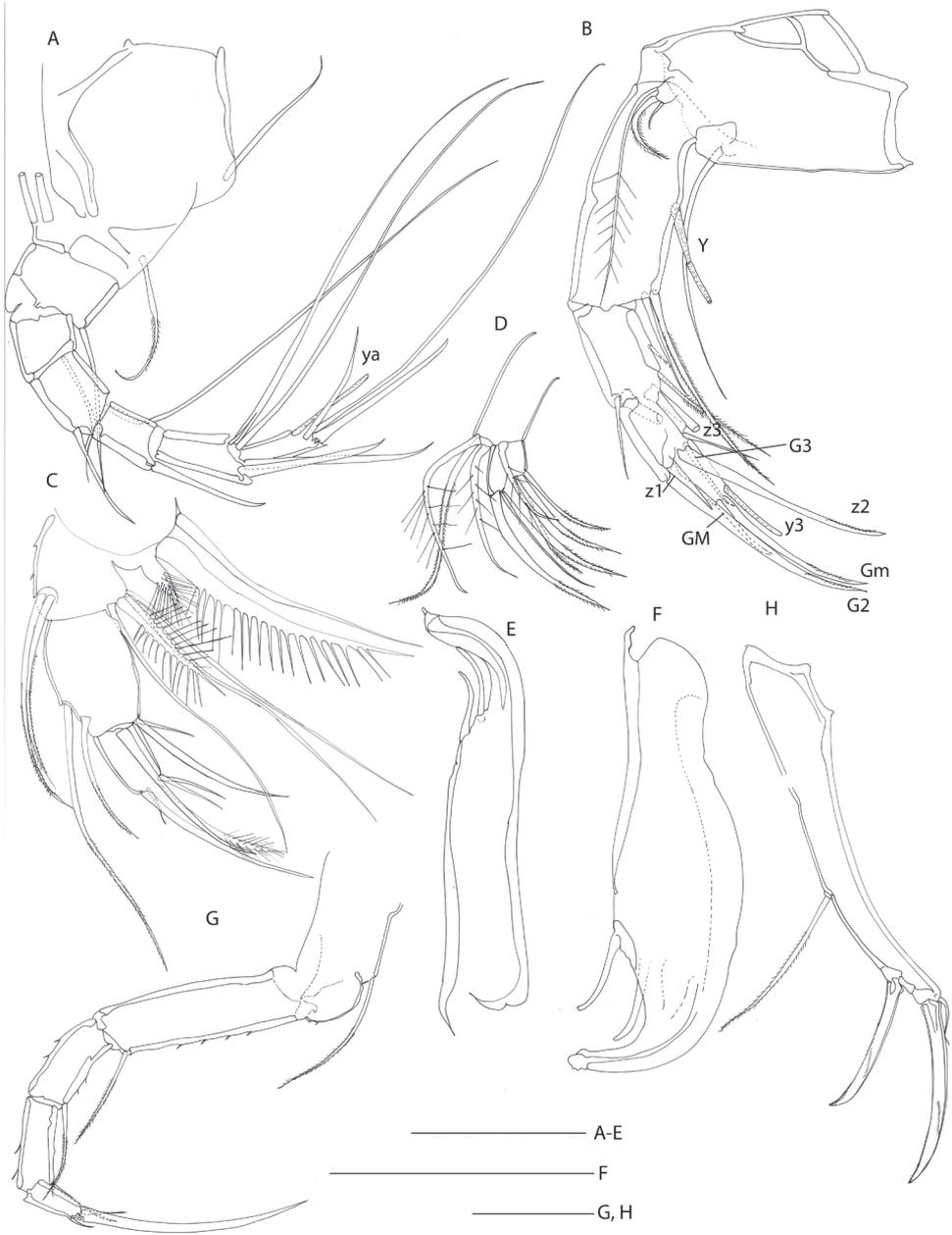


Figure 2. Line drawings of *Mazepovacandona directa* (Bronstein, 1947). Male. **A** A1 **B** A2 **C** Md-palp **D** Mxl-palp **E, F** prehensile palps **G** L6 **H** UR. Scales = 0.1 mm.

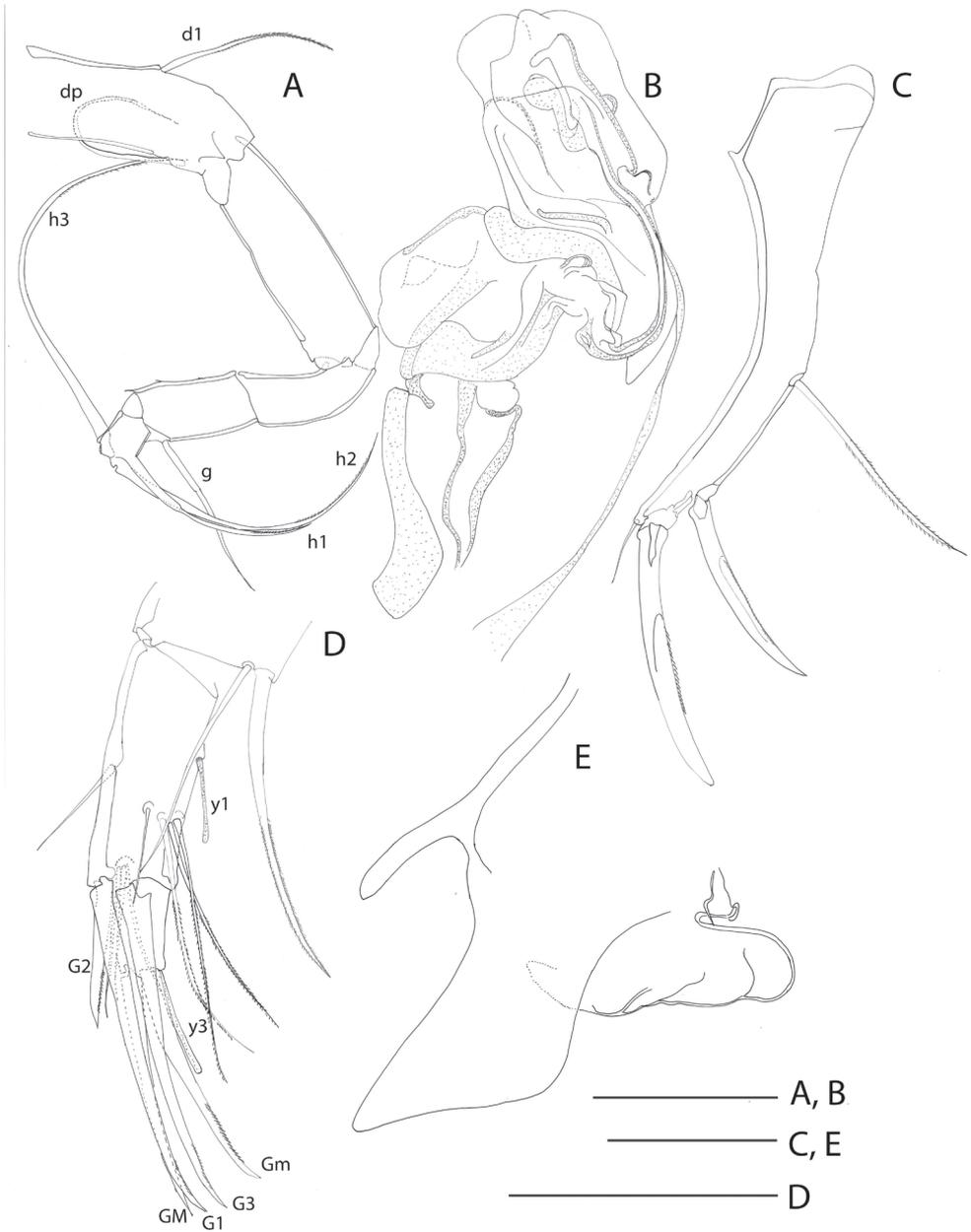


Figure 3. Line drawings of *Mazepovacandona directa* (Bronstein, 1947). **A, B** male **C–E** female **A** L7 **B** hemipenis **C** UR **D** A2 **E** genital segment. scales = 0.1 mm.

***Mazepovacandona godlewski* (Mazepova, 1984)**

Figs 4, 5

Candona godlewski sp. n. – Mazepova (1984): p. 38, fig. 12 (1–10)*Candona godlewski* Mazepova – Mazepova (1990): p. 43, fig. 4, 5B.

Material examined. One females dissected and mounted on glass slides (shell on the SEM stub), 2 undissected specimens in 95% alcohol, 2 specimens used for the DNA extraction), all collected from 12–15 m depth by SCUBA diving off Listvyanka, 51°51'51.3"N, 104°50'37.8"E, 12 September 2015, collectors: Igor Khanaev and Ivan Nebesnykh.

Short redescription. Both LV and RV banana shaped (Fig. 4A, B) with dorsal margin rounded, strongly arched and narrow ends, posterior end narrower than the anterior one. Valve margins framed with narrow fringe. Surface smooth, with few shallow pits only centrally (Fig. 4C). Surface cuticular pores simple, without lip (Fig. 4D). Length around 1 mm.

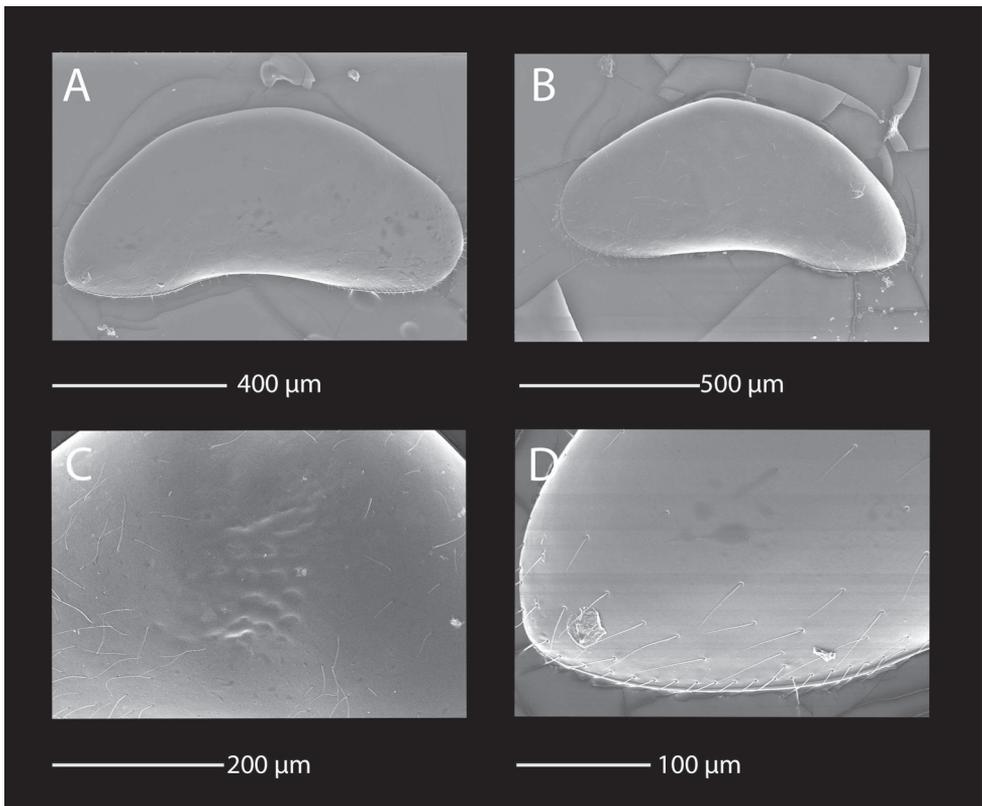


Figure 4. SEM photographs of *Mazepovacandona godlewski* (Mazepova, 1984). Female. **A** RV, lateral view **B** LV, lateral view **C** details of the fine surface ornamentation **D** details of the posterior end of the RV.

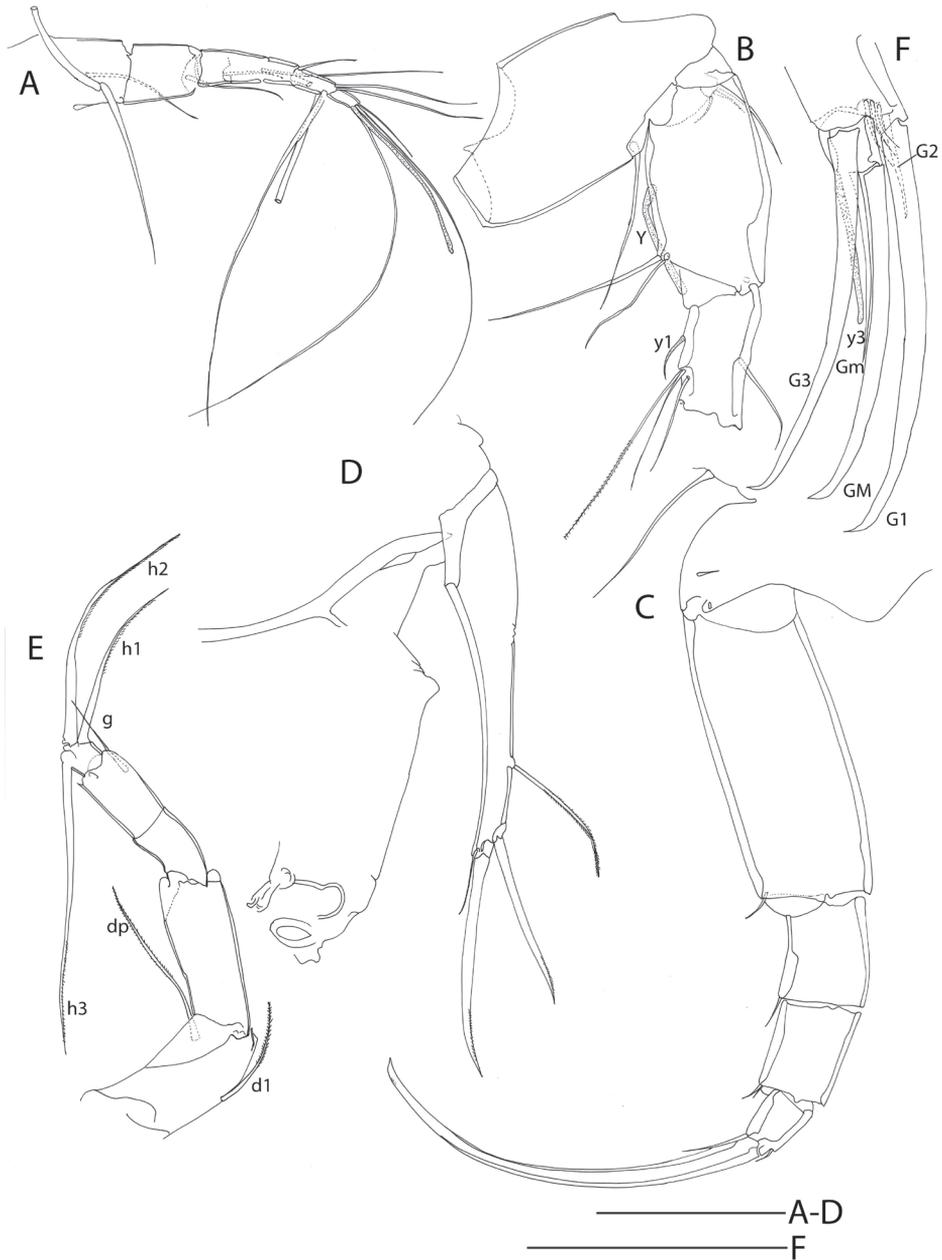


Figure 5. Line drawings of *Mazepovacandona godlewski* (Mazepova, 1984). Female. **A** A1 **B** First three segments of A2 **C** L6 **D** UR **E** L7 **F** penultimate and terminal segments of A2. Scales = 0.1 mm.

A1 7-segmented, with segments 3 and 4 partly fused (Fig. 5A), posterior setae thin. Male A2 with subdivided penultimate segment and t- and t3-setae transformed into sexual bristles. Female A2 (Fig. 5B, F) with all three z-seta untransformed; G2 claw

short, and only slightly exceeding margin of the terminal segment. Md-palp with 4+2 setae on the inner side, gamma seta not plumose. L6 (Fig. 5C) with basal seta reaching beyond basal segment. L7 (Fig. 5E) clearly 5-segmented; basal segment with d1- and dp-seta; no e-or f-setae, g-seta long; terminal segment with setae h2- and h3- long and h1-seta shorter, but also considerably long. UR (Fig. 5D) with long posterior seta, genital field with small semi-triangular lobe. Eyes large and dark.

Females not collected.

***Mazepovacandona navitarum* (Mazepova, 1976)**

Figs 6, 7, 14C, 15C

Baicalocandona navitarum sp. n. – Mazepova (1976): p. 72, fig. 9

Baicalocandona navitarum Mazepova – Mazepova (1990): p. 292, fig. 125, 126B

Material examined. One male soft body used for DNA extraction and after that dissected and mounted on a glass slide (shell of one SEM stub), collected from 12–15 m depth by SCUBA diving off Listvyanka, 51°51'51.3"N, 104°50'37.8"E, 12 September 2015, collectors: Igor Khanaev and Ivan Nebesnykh.

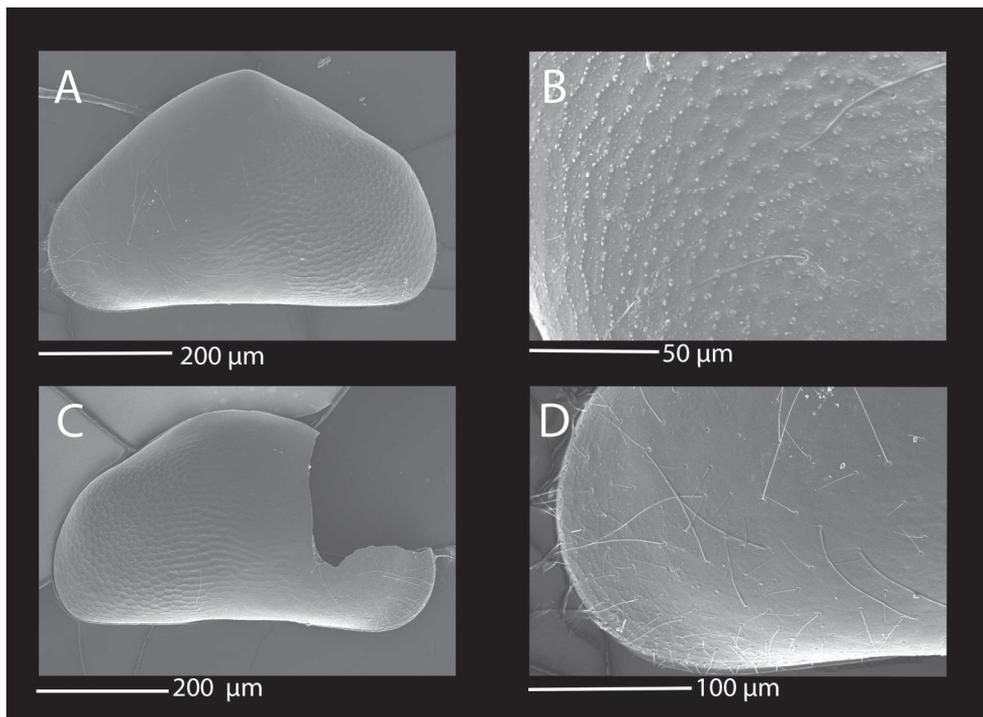


Figure 6. SEM photographs of *Mazepovacandona navitarum* (Mazepova, 1976). Male. **A** LV, lateral view **B** details of the surface ornamentation **C** RV, lateral view **D** details of the anterior end LV.

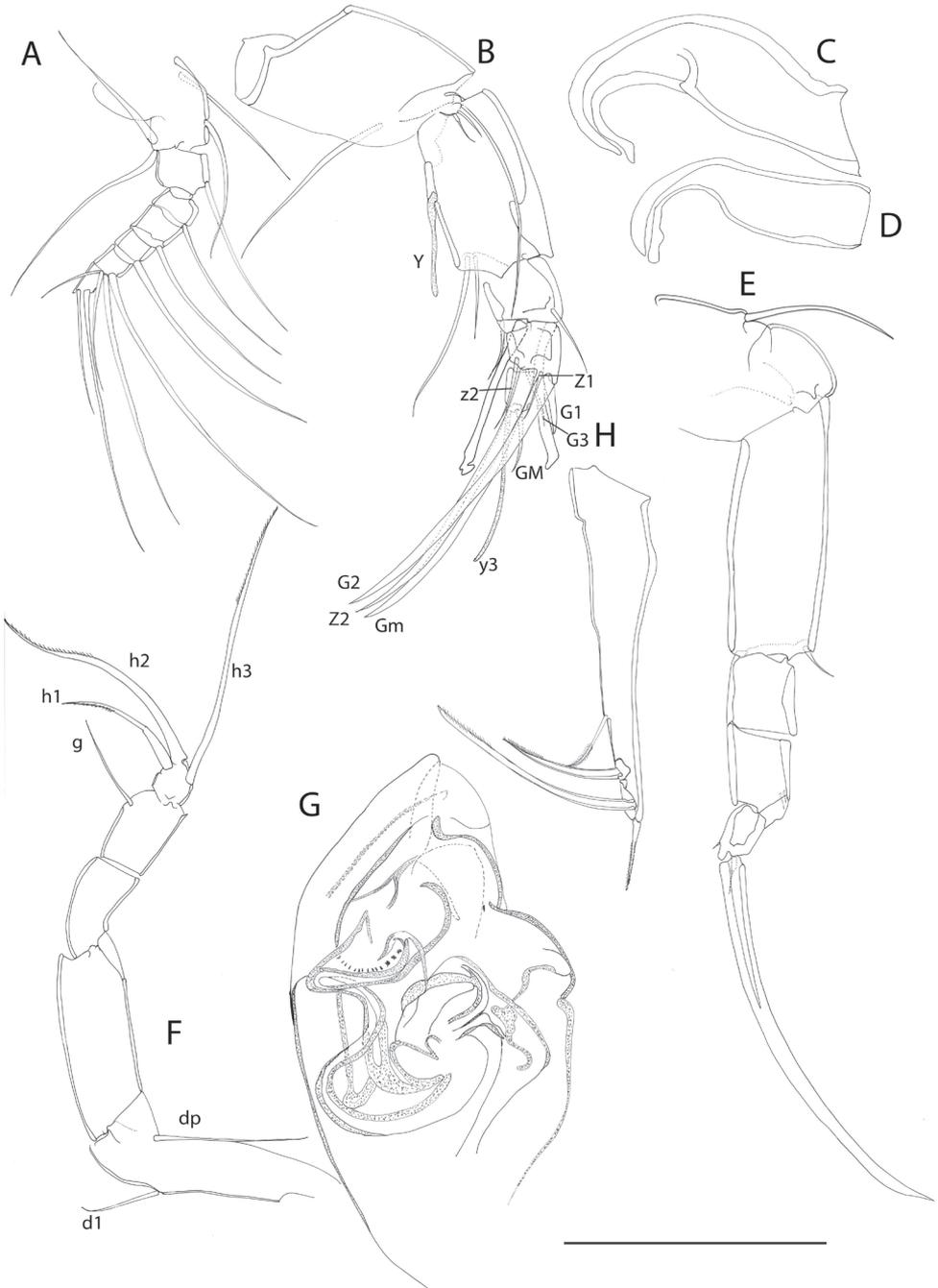


Figure 7. Line drawings *Mazepovacandona navitarum* (Mazepova, 1976). Male. **A** A1 **B** A2 **C, D** prehensile palps **E** L6 **F** L7 **G** hemipenis **H** UR. Scale = 0.1 mm.

Short redescription. Valves asymmetrical: LV subtriangular with pointed dorsal margin, RV with rounded dorsal margin (Fig. 6A, C). Posterior end much narrower than anterior end. Surface with shallow pits and reticulation only on the anterior part of the shell. Surface cuticular pores of only one type, with small lip (Fig. 6B, D). Size about 0.6 mm.

A1 7-segmented. Male A2 with subdivided penultimate segment and t2- and t3-setae transformed into sexual bristles; z2-setae transformed into claw, z1- and z3-setae untransformed; G1- and G3-claws reduced and short, G2-claw long (Fig. 7B). Prehensile palps (Fig. 7C, D) with almost equally long bodies and fingers, fingers hook-shape. L6 (Fig. 7E) with basal seta reaching far beyond distal margin of basal segment. L7 (Fig. 7F) clearly 5-segmented; basal segment with d1- and dp-setae; no e- or f-setae, g-seta long; terminal segment with setae h2- and h3- long and h1-seta shorter. UR (Fig. 7H) with all setae and claws; posterior seta not particularly long, and posterior claw almost half as long as anterior one. Hemipenis (Figs 7B, 14C) with a-lobe relatively triangular and not projecting; M-peace rounded distally, ejaculatory tube with pointed distal end. Zenker organ (Fig. 15C) with 3+2 whorls of spines; anterior cap hemispherical, with strongly sclerified margin.

Females not collected.

Mazepovacandona orbiculata (Mazepova, 1990)

Figs 8, 9, 14E, 15E

Candona orbiculata sp. n. – Mazepova (1990): p. 95, fig. 30

Material examined. One male soft body used for DNA extraction and after that dissected and mounted on one glass slide (shell on SEM stub), three juveniles kept in 95% alcohol, all collected from 12–15 m depth by SCUBA diving off Listvyanka, 51°51'51.3"N, 104°50'37.8"E, 12 September 2015, collectors: Igor Khanaev and Ivan Nebesnykh.

Short redescription. Valves reniform in lateral view, with almost evenly rounded dorsal margin (Fig. 8A, B). Anterior and posterior margins broadly rounded, posterior wider than anterior. Ventral margin almost straight, with bulging around mouth region. Surface smooth and covered with pores, all equipped with semi operculum (Fig. 8C, D). Length around 0.6 mm.

A1 lost during DNA extraction. Male A2 with subdivided penultimate segment and t2- and t3-setae transformed into sexual bristles; z1-seta transformed into claw, z2-setae not observed, z3-seta untransformed; G1- and G3-claws reduced and short, G2-claw long (Fig. 9A). Prehensile palps (Fig. 9B, C) with body and fingers equally long, fingers curved, hook-like. L6 (Fig. 9D) with basal seta reaching far beyond basal segment. L7 (Fig. 9E) not clearly 5-segmented, penultimate segment partially subdivided; basal segment with d1- and dp-setae; no e- or f-setae, g-seta long; terminal segment with setae h2- and h3- long and h1-seta shorter, but also considerably long. UR (Fig. 9G) robust, with long posterior seta and strong claws. Hemipenis always (?)

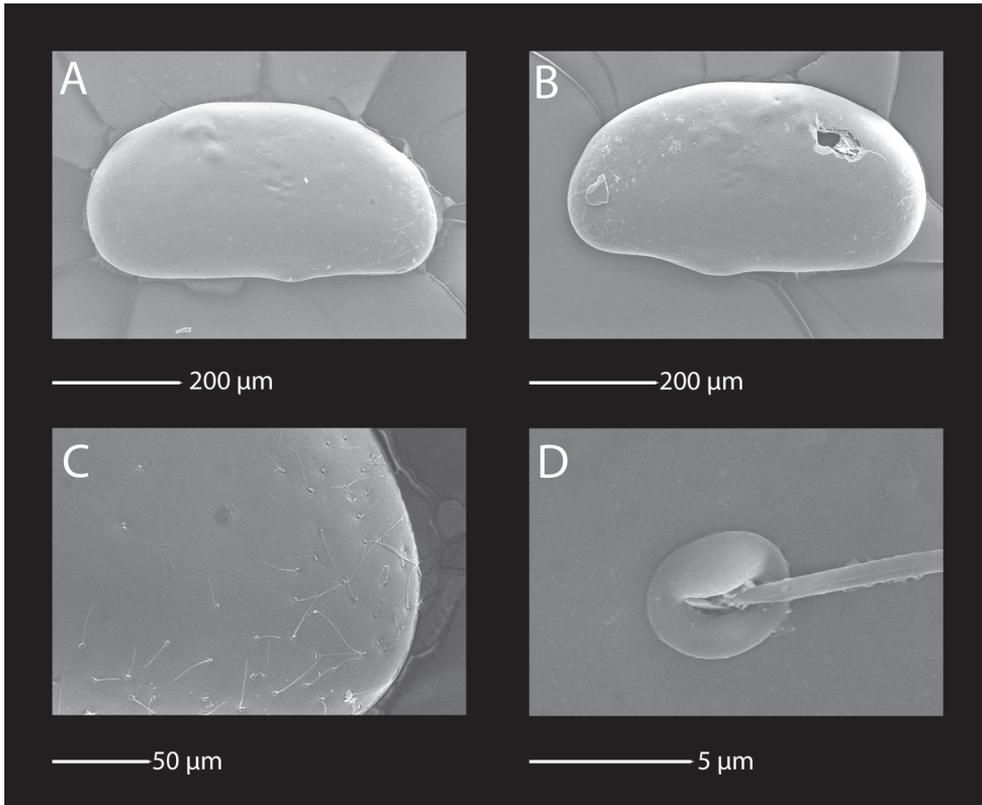


Figure 8. SEM photographs of *Mazepovacandona orbiculata* (Mazepova, 1990). Male. **A** RV, lateral view **B** LV, lateral view **C** details of the anterior end RV **D** detail of the surface sensilla.

in semi-erectile mode (Fig. 9F, 14E); a-lobe relatively small but its shape hard to accurately perceive due to its folded position; M-piece rounded distally, ejaculatory tube with pointed distal end. Zenker organ (Fig. 15E) with 4+2 whorls of spines; anterior cap hemispherical, with strongly sclerified margin, lattice elaborate, on anterior side adjoined by longer spines. Eyes large and dark.

***Mazepovacandona spicata* (Mazepova, 1982)**

Figs 10, 11, 14F, 15F

Candona spicata sp. n. – Mazepova (1982): p. 125, fig. 9A–N

Candona spicata Mazepova – Mazepova (1990): p. 99, fig. 32, 33B

Material examined. One male soft body used for DNA extraction and after that dissected and mounted on one glass slide (shell of one SEM stub), one juvenile kept in 95% alcohol, all collected from 12–15 m depth by SCUBA diving off Listvyanka,

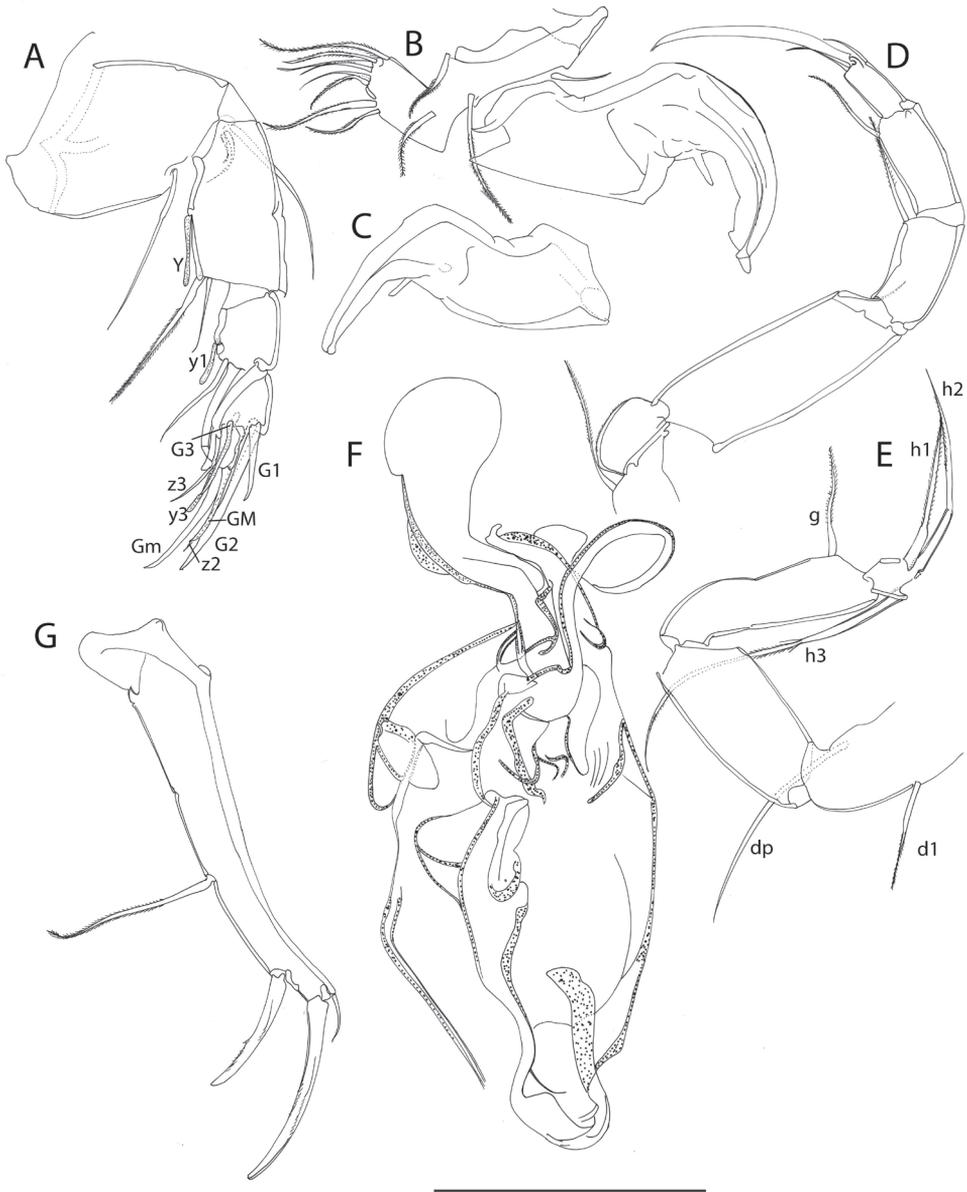


Figure 9. Line drawings *Mazepovacandona orbiculata* (Mazepova, 1990). Male. **A** A2 **B, C** prehensile palps **D** L6 **E** L7 **F** hemipenis **G** UR. Scale = 0.1 mm.

51°51'51.3"N, 104°50'37.8"E, 12 September 2015, collectors: Igor Khanaev and Ivan Nebesnykh.

Short redescription. Valves elongated in lateral view, with almost straight dorsal margin (Fig. 10A, B). Anterior end broadly rounded, posterior margin narrow and

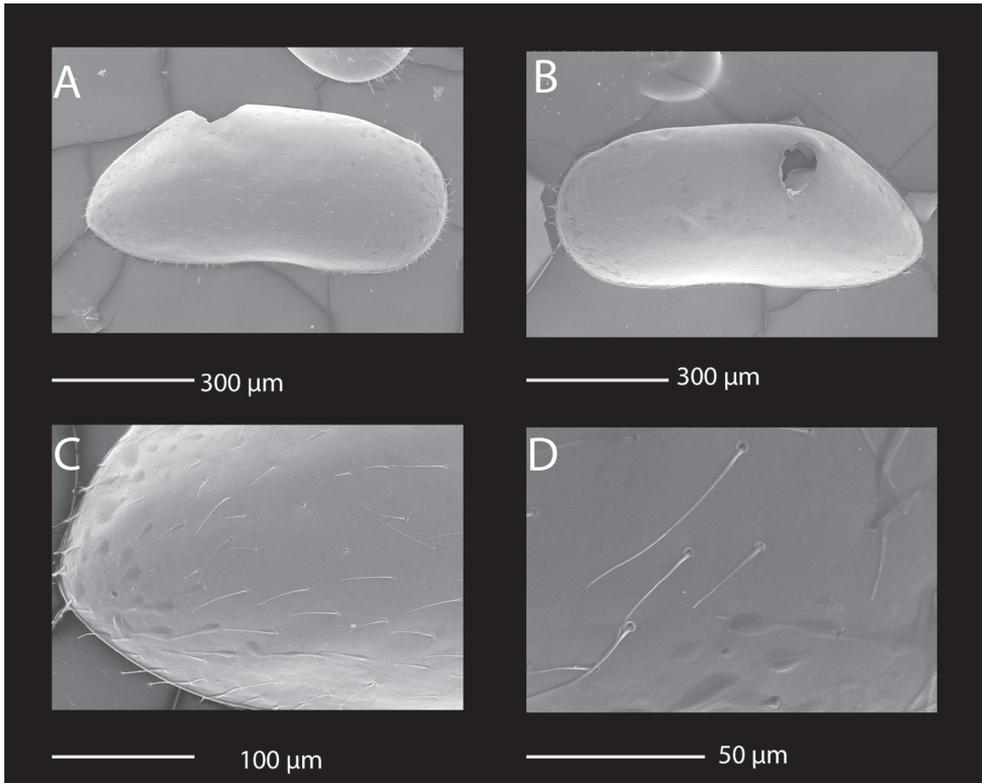


Figure 10. SEM photographs of *Mazepovacandona spicata* (Mazepova, 1982). Male. **A** RV, lateral view **B** LV, lateral view **C** details of the posterior end RV **D** details of the shell surface.

inclined. Valve margins framed with narrow fringe (Fig. 10C). Ventral margin concave around middle. Surface smooth and covered with pores, all equipped with lip (Fig. 10D). Length around 0.8 mm.

A1 7-segmented, some posterior setae transformed into claws (Fig. 11A). Male A2 with subdivided penultimate segment and t2- and t3-setae transformed into sexual bristles; z1- and z2-setae transformed into claws, z3-seta untransformed; G1- and G3-claws reduced and short, G2-claw long (Fig. 11B). Md-palp (Fig. 11D) with 3+2 setae in bunch, gamma-seta pappose. Prehensile palps (Fig. 11E, F) with especially long, thin, and curved fingers. L6 (Fig. 11H) with basal seta reaching far beyond basal segment. L7 (Fig. 11G) clearly 5-segmented, penultimate segment only partly subdivided; basal segment with d1- and dp-setae; no e- or f-setae, g-seta long; terminal segment with setae h2- and h3- long and h1-seta shorter. UR (Fig. 11I) with curved anterior margin and short posterior seta. Hemipenis (Fig. 11J, 15F) with rounded and not projecting a-lobe; M-peace rounded distally, ejaculatory tube with pointed distal end. Zenker organ (Fig. 15F) with 5+2 whorls of spines; anterior cap hemispherical, with strongly sclerified margin, lattice elaborate, on anterior side adjoined by longer spines. Eyes large and dark.

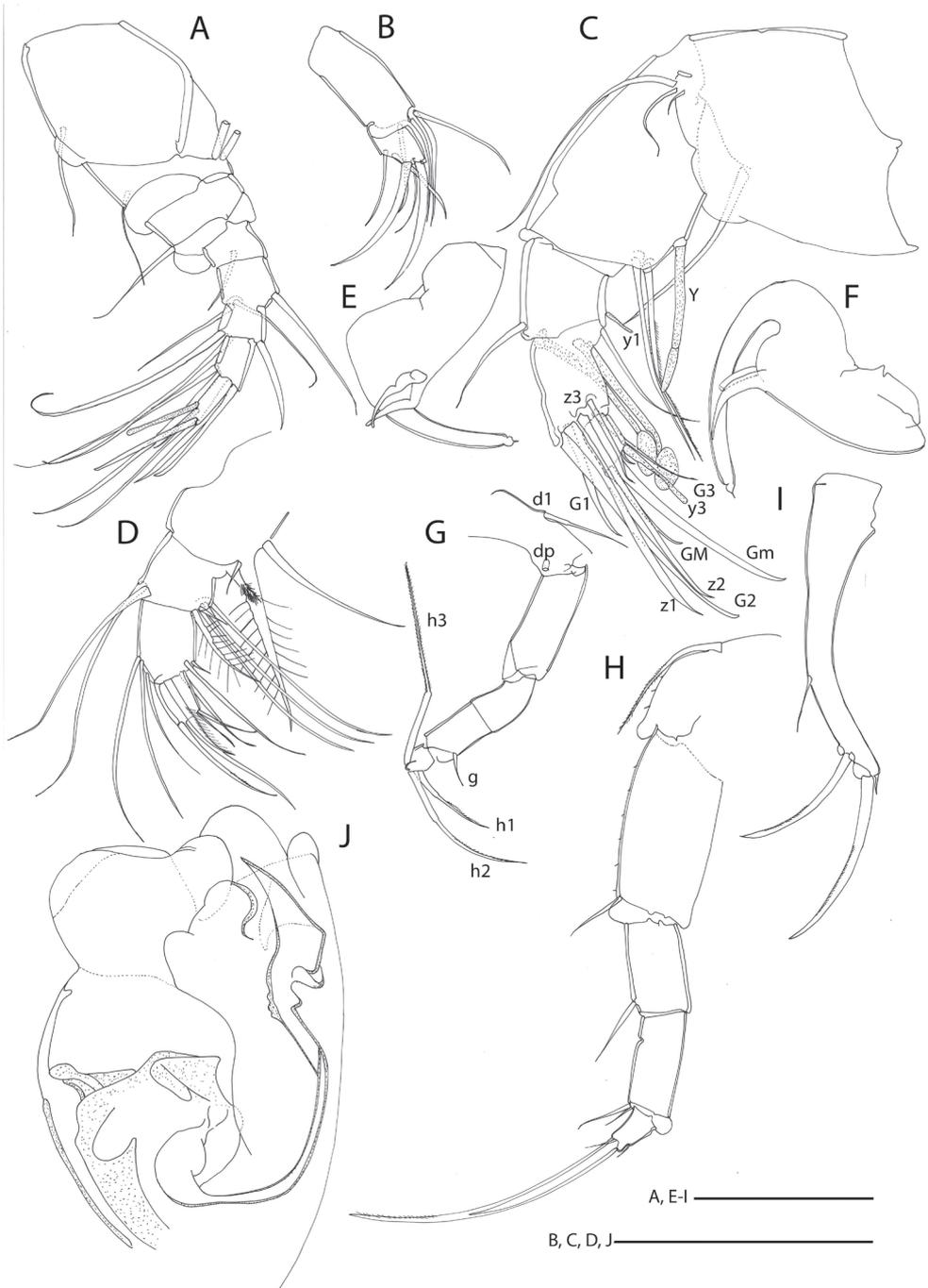


Figure 11. Line drawings of *Mazepovacandona spicata* (Mazepova, 1982). **A** A1 **B** Mxl-palp **C** A2 **D** Md-palp **E, F** prehensile palps **G** L7 **H** L6 **I** UR **J** hemipenis. Scales = 0.1 mm.

Genus *Baicalocandona* Mazepova, 1976

Type species. *Baicalocandona biviva* Mazepova, 1976

Amended diagnosis. Shell shape (always) trapezoidal, surface ornamented in most species, at least in some parts. A1 7, 6 or 5-segmented. Male A2 with t-setae transformed into sensory setae, z-setae transformed into claws. Female A2 with G2-claw as long as G1 or G3. Exopod of A2 consisting of small plate and three setae of which one long. Male prehensile palps asymmetrical and both with hook-like fingers, but right palp with shorter, stockier and considerably less hook-like finger. L6 with basal seta and with one seta on each endopodal segment, except last, which carries two setae and one claw. L7 with only d1- and dp-seta on basal segment, e- and f-setae missing, g-seta long; terminal segment with short h1-seta and h2- and h3-setae equally long; penultimate segment fused without any notable subdivision. UR with both claws and setae present. Zenker organ with 4+2 whorls of spines. The anterior part (cap) more hemispherical and margin not sclerotized, lattice-like structure not well-developed; cap also with long radiating spine-like projections. Hemipenis with relatively large a-lobe not projecting laterally. M-peace terminally foot-like; ejaculatory process (bursa copulatrix) not terminally pointed, and with broad, rounded, finger-like extension; this process also with lateral thorn-like ornamented part.

Remarks. *Baicalocandona* at the moment includes 11 species and 11 subspecies. According to the diagnosis (Mazepova 1976, 1990), all species have a trapezoidal valve shape, males have sexual bristles on the second antenna, and the Zenker organ bears six whorls of spines. One species we redescribe below falls within this diagnosis, although it was originally described in *Candona*. We also noted some other morphological characters that improve the genus diagnosis, such as a very short finger on the right prehensile palp, a short basal seta (d1) on the walking leg, undivided penultimate segment of the cleaning leg, a foot-like shape of the M-peace of hemipenis, and ejaculatory process finger like and pronounced. Females also seem to have a long G2-claw on the second antenna, and Zenker organ has long spine-like projections on anterior end. Based on the redescription of two *Pseudocandona* species, *P. ceratina* and *P. gajewskaye*, only the absence of the male sexual bristles on the second antenna separates this genus from *Baicalocandona*. The number of A1 segments, as well as the number of setae on the second segment of the Md-palp seems to be variable. *Baicalocandona* is very similar to the European subterranean genus, *Schellencandona*, both in the shell shape and morphology of the hemipenis.

Baicalocandona rupestris dissona (Mazepova, 1990), **comb. n.**

Figs 12, 13, 14A, 15A

Candona rupestris dissona subsp. n. – Mazepova (1990): p. 152, fig. 56B, 57B.

Material examined. Soft parts of one male and one female used for DNA extraction, after that each dissected and mounted onto one glass slides, their shells kept on one

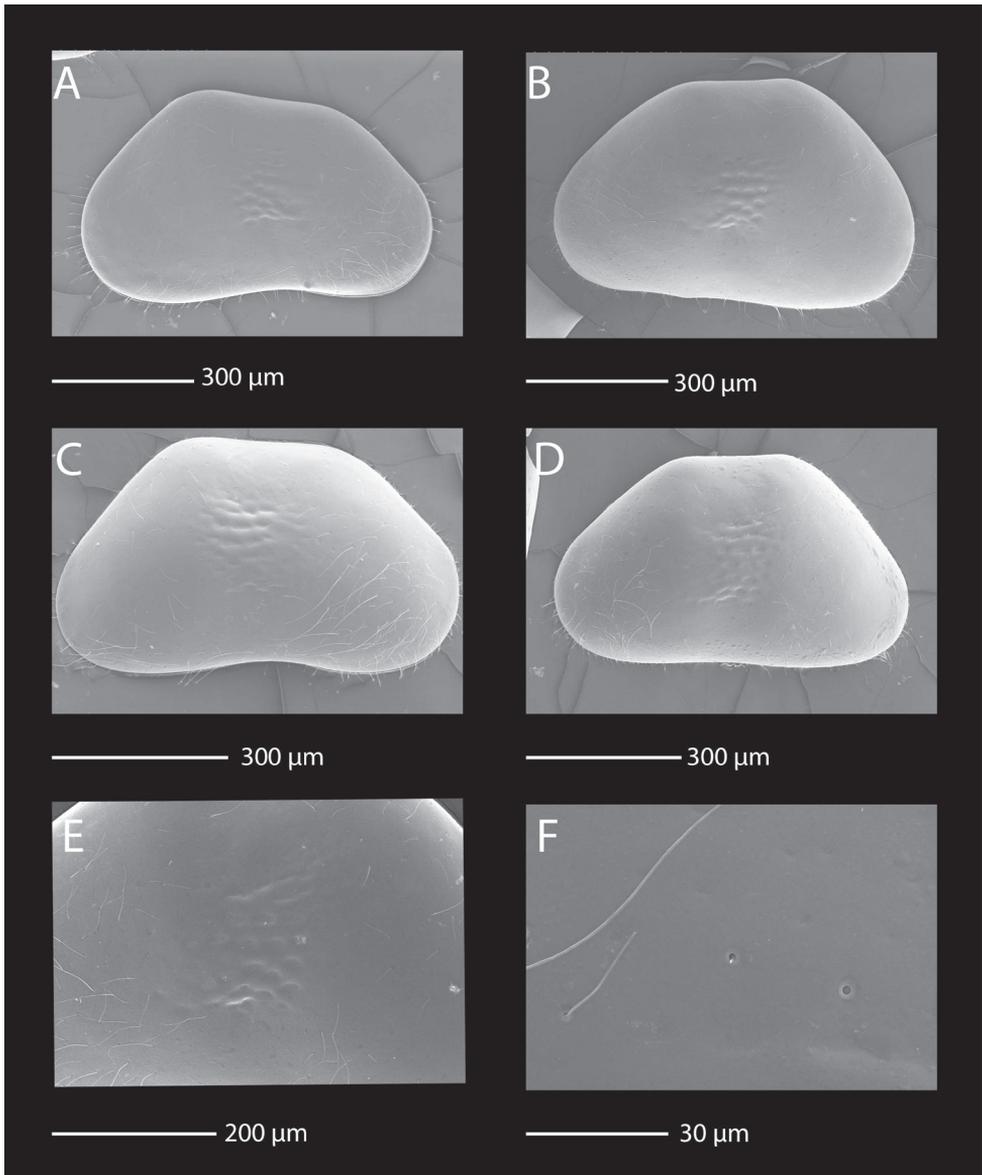


Figure 12. SEM photographs of *Baicalocandona rupestris disona* (Mazepova, 1990). **A, B, E, F** male **C, D** female **A** RV, lateral view **B** LV, lateral view **C** RV, lateral view **D** LV, lateral view **E** details of the fine surface ornamentation **F** details of shell surface pores and sensilla.

SEM stub each, 40 juveniles kept in 95% alcohol, all collected from 12–15 m depth by SCUBA diving off Listvyanka, 51°51'51.3"N, 104°50'37.8"E, 12 September 2015, collectors: Igor Khanaev and Ivan Nebesnykh.

Short redescription. Almost no sexual dimorphism in shell shape in lateral view (Fig. 12A–D). Both LV and RV trapezoidal, dorsal margin straight in middle and

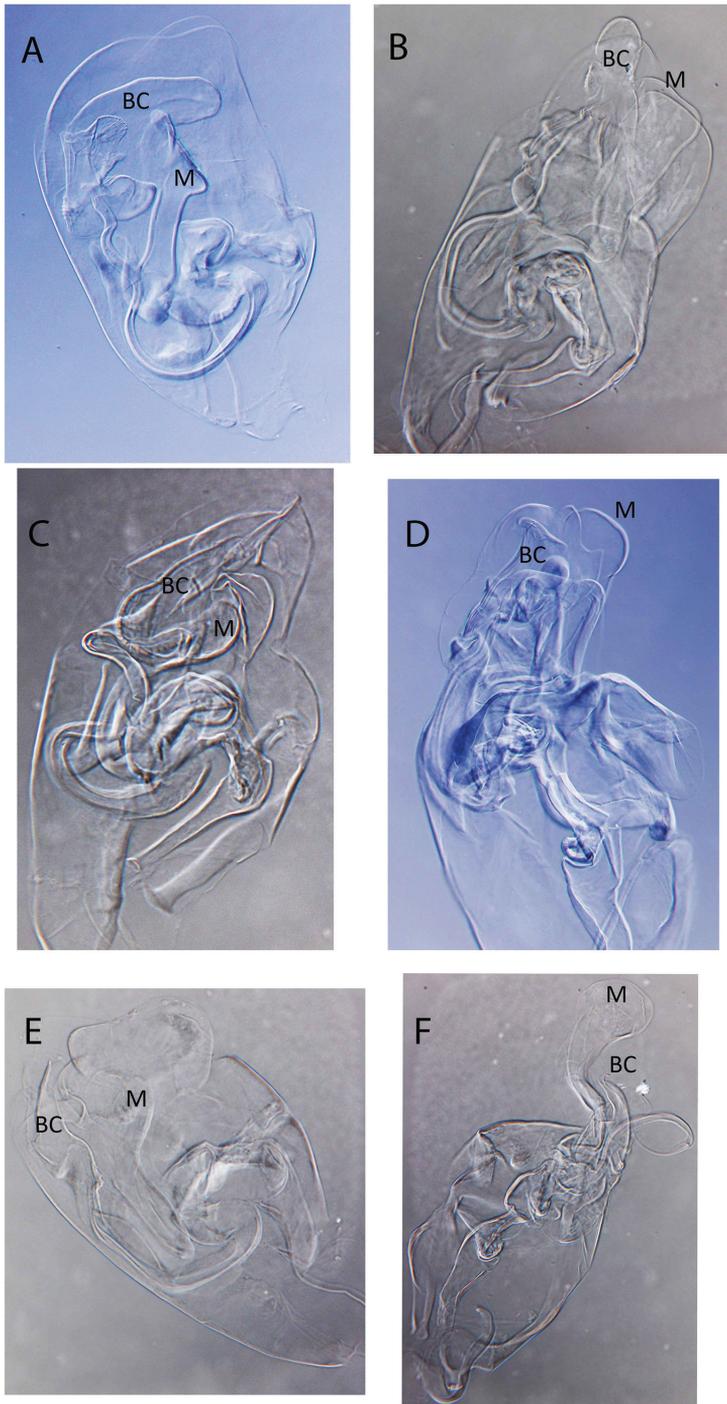


Figure 14. Light photographs of hemipenis. **A** *Baicalocandona rupestris disona* **B** *Baicalocandona* sp. **C** *Mazepovacandona navitarum* **D** *Mazepovacandona directa* **E** *Mazepovacandona orbiculata* **F** *Mazepovacandona spicata*. Not to scale.

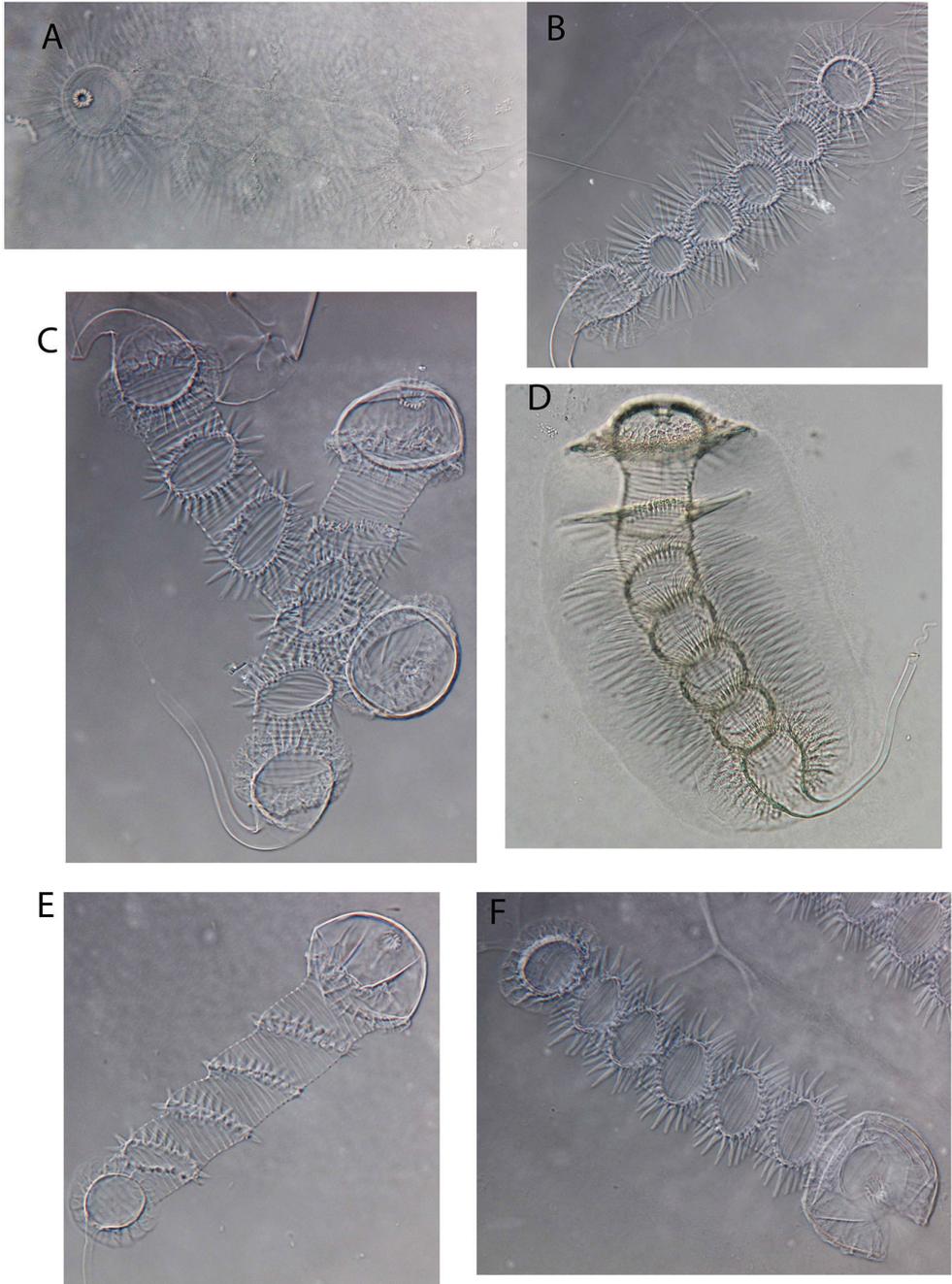


Figure 15. Light photographs of Zenker organ. **A** *Baicalocandona rupestris disona* **B** *Baicalocandona* sp. **C** *Mazepovacandona navitarum* **D** *Mazepovacandona directa* **E** *Mazepovacandona orbiculata* **F** *Mazepovacandona spicata*. Not to scale.

rounded/inclined towards anterior and posterior ends. Posterior and anterior ends narrower and anterior slightly wider than posterior end. Surface mostly smooth and ornamented with few shallow pits only centrally. Surface cuticular pores simple, without prominent lip. Surface sensory setae long (Fig. 12E, F). Length around 0.7 mm.

A1 7-segmented (Fig. 13A). Male A2 with subdivided penultimate segment and t2- and t3-setae transformed into sexual bristles; only z2-setae transformed into claws, z1, and z3-seta untransformed; G1- and G3-claws reduced and short, G2-claw long (Fig. 13B). Female A2 (Fig. 13M) with all three untransformed z-seta; G2 claw as long as all other claws. Md-palp (Fig. 13D) with 4+2 setae on inner side, gamma seta not plumose. Mxl-palp (Fig. 14C) with rectangular terminal segment. Prehensile palps (Fig. 13E, G) stocky, right one with very strong finger but not hook-like. L6 (Fig. 13H) with short basal seta. L7 (Fig. 13I) 4-segmented; basal segment with d1- and dp-setae; no e- or f-setae, g-seta long; terminal segment with setae h2- and h3- long and h1-seta shorter. UR in both sexes (Figs 13J, K) very similar, thin, and curved, with short posterior seta and thin, subequal claws. Hemipenis (Figs 13L, 14A) with large a-lobe but not laterally projecting, M-peace distally clearly foot-like, ejaculatory tube with large, finger-like distal end and with ornamented lateral plate. Female genital field (Fig. 13K) rounded. Zenker organ with 4+2 whorls of spines (Fig. 15A); anterior cap with thin margins and with long spine-like projections, and lattice not so well-pronounced. Eyes dark.

***Baicalocandona* sp.**

Figs 14B, 15B

Material examined. Soft parts of one male used for DNA extraction, after that dissected and mounted onto one glass slide, shell broken during dissection, collected from 12–15 m depth by SCUBA diving off Listvyanka, 51°51'51.3"N, 104°50'37.8"E, 12 September 2015, collectors: Igor Khanaev and Ivan Nebesnykh.

Short description. A1 6-segmented. Male A2 with subdivided penultimate segment and t2- and t3-setae transformed into sexual bristles; both z1- z2-setae transformed onto claws; G1- and G3-claws reduced and short, G2-claw long. Md-palp with 4+2 setae on the inner side, gamma seta not plumose. Prehensile palps stocky and right one with a very strong finger but not hook-like. Hemipenis (Fig. 14B); with large a-lobe but not laterally projecting, M-peace distally clearly foot-like, ejaculatory tube with large, finger-like distal end and with ornamented lateral plate. Zenker organ with 4+2 whorls of spines (Fig. 15B); anterior cap with thin margins and with long spine-like projections, and lattice not so well-pronounced.

Molecular analysis

BLAST analyses of the GenBank database revealed that the obtained sequences were ostracod in origin and not contaminants. No stop codons were detected in the *COI*

sequences. The *COI* alignment was 672 base pairs long, and included four species each with one sequence. The concatenated dataset was 3302 base pairs long, and it included 50 sequences belonging to 39 species. Of the individual alignments, 18S dataset was the longest (1042 positions) and also included 50 terminals. The alignment of 16S was the shortest (554 base pairs), and had only 21 species. After the exclusion of ambiguous blocks, 28S alignments varied from 660 base pairs (em fragment) to 455 base pairs (df fragment). The vx primer pair was the most successful in amplifying the region, while df fragment was very difficult to amplify and only 34 sequences were analyzed. The amplification by em primer pair was relatively successful, but this was the most difficult dataset to aligned due to the long expansion segments present in several species. Although initially this alignment was very long (1521 base pairs), after the Gblock analysis (Castresana 2000) it was truncated substantially.

GTR (Rodríguez et al. 1990) with unequal rates among sites, with gamma distribution and invariable site (GTR + G + I) for 18S, 16S, 28S (df and vx fragments), but without invariable sites for 28S em fragment, was chosen as the best fit evolutionary model.

The results of p-distance analysis are shown in Fig. 16, which illustrates overall, within, and between genera distances for each analyzed gene. Here we presented only distances relevant to the Baikal candonids and their closest relative, *Candona*. In the calculations, we reated sequences belonging to the two unidentified *Pseudocandona* species as *Baicalocandona* because they nest within *Baicalocandona* species on the phylogenetic tree (see below) and adding another genus name on the Figure 16 would introduce unnecessary confusion. All numerical data related to the p-distances are provided in the Supplements 2–7. The amplification of the *COI* region was not very successful, and we obtained a single sequence of *Baicalocandona* and three of the *Mazepovacandona* species. Nevertheless, it shows that the distances within *Mazepovacandona* are smaller than between it and *Baicalocandona*. The largest *COI* distance was between *B. rupestris* and *M. directa* (23%). Of the three 28S fragments, the em fragment was the most variable, exceeding even the variability of 16S. *Candona* and *Baicalocandona* diverged the most, with almost 20% differences. Divergence between *Candona* and *Mazepovacandona* was about 15%, and *Baicalocandona* and *Mazepovacandona* about 12%. *Candona* also had a very large within group variability of the em fragment (16%), which is very unusual and maybe because some of the sequences had extensive regions of nucleotide insertions (indels). The em fragment's variability is followed by fragment vx, where again *Candona* had the largest within group variability in comparison to the other two genera. The df fragment was very conservative, with maximum 4% differences found between *Candona* and *Mazepovacandona*. This fragment's variability was almost the same as the variability recorded for 18S. Of the three genera, *Baicalocandona* had the highest within group distance of 18S sequences, however only about 3%, while in the other two genera the distances were less than 2%. Between genera distances were almost identical, equaling 4%. *Candona* and *Baicalocandona* had the highest p-distance between their 16S sequences (18%). The distance between the latter genus and *Mazepovacandona* was around 14%. *Candona* and *Mazepovacandona* had only 10% differences between their 16S sequences. Except for the 16S, all other exam-

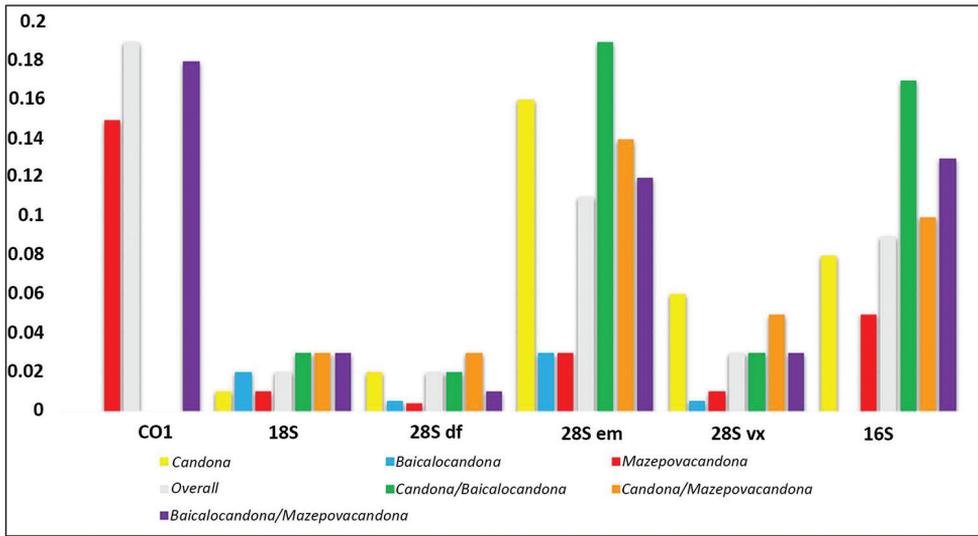


Figure 16. Pairwise p -distances for individual datasets.

ined sequence distances were smaller between the two Baikal genera than between any of them and *Candona*. On the other hand, distances were sometimes higher between *Candona* and *Baicalocandona* and sometimes between *Candona* and *Mazepovacandona*, depending on the marker.

After two million generation runs in MrBayes, the final standard deviation of split frequencies fell below 0.01 (it was around 0.003) and the potential scale reduction factor was ~ 1.0 for all parameters, suggesting that convergence had been reached. All resulting consensus trees were rooted with the outgroup, *Physocypria* sp. Fig. 17 illustrates the 50% consensus tree resulting from the analysis of the concatenated dataset. On this tree Candonidae is strongly supported as a monophyletic group. The Candonidae clade can be broadly divided into two subclades, both with high posterior probability values: one containing 15 sequences equating to nine species, and the other which incorporates 34 sequences belonging to 28 species. The former clade contained four Candonidae tribes, proposed by Karanovic (2007): Cryptocandonini, Candonopsini, Trapezicandonini, and Humphreyscandonini. Candonopsini was a sister taxon to Trapezicandonini, while Humphreyscandonini was the sister taxon to these two. These relationships received a relatively high posterior probability support, while the clade consisting of the two Cryptocandonini genera (*Cryptocandona* and *Undulacandona*) did not have high posterior probability.

The larger clade on the tree was composed of two tribes. All except *Cryptocandona smithi* Karanovic & Lee, 2012 belong to the largest Candonidae tribe, Candonini. Candonini can be broadly divided into three clades, all with maximum posterior probabilities. Ten Lake Baikal candonids did not form a monophyletic clade, but clustered with some non-Baikal species, in particular *Fabaeformiscandona kushiroensis*, *Candona candida*, *C. bimucronata*, and *C. neglecta*. *Fabaeformiscandona kushiroensis* is nested

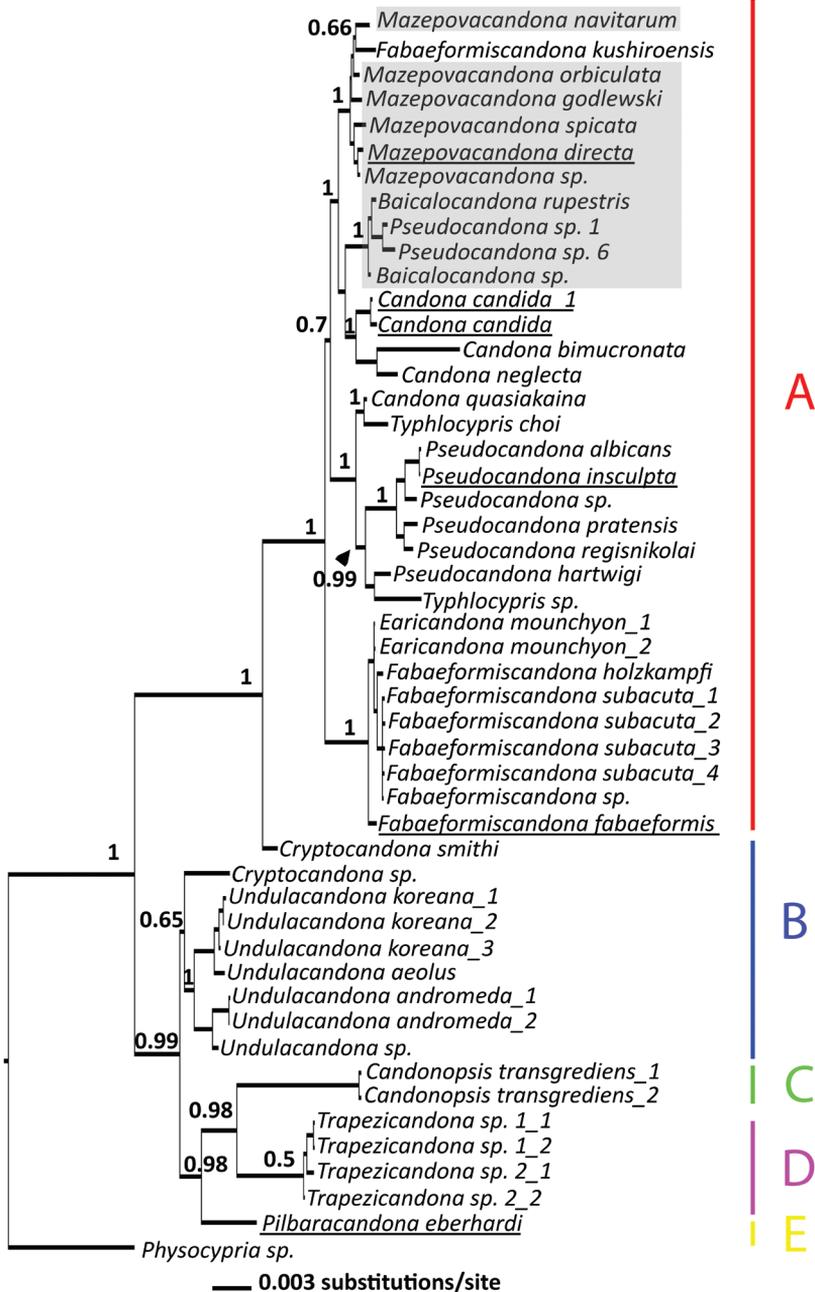


Figure 17. 50% majority rule consensus tree of the family Candonidae constructed from the concatenated dataset of two nuclear (18S & 28S) and one mitochondrial (16S) markers. Numbers on the branches represent Bayesian posterior probabilities. Underlined taxa represent type species. Grey shaded taxa are Lake Baikal species. Tree rooted with *Physocypria* sp. Tribes are labeled with letters: **A** Candonini **B** Cryptocandonini **C** Candonopsisini **D** Trapezicandonini **E** Humphreyscandonini.

within the *Mazepovacandona* clade. The clade composed of the second Baikal lineage and three *Candona* species received a very low support (below 0.5 posterior probability). A clade composed of nine species belonging to *Candona*, *Pseudocandona*, and *Typhlocypris* was sister to the previous, mostly composed of Baikal candonids, but this association did not have high posterior probability (0.7). The last group on the tree, consisting of *Earicandona* and *Fabaeformiscandona*, was strongly supported and was sister to the previous two clades.

Discussion

When defining Baikal genera, we were mostly lead by the results of the molecular phylogeny analysis, which indicated that the 10 Baikal species belong to only two lineages. However, the morphological diversity of Lake Baikal candonids is extraordinary, especially when compared with the candonid fauna from other parts of the world. In fact, when compared with the Holarctic candonid genera, each *Mazepovacandona* species redescribed in this paper has enough apomorphic characters (from the shell shape to the number of whorls on the Zenker organ) to be described in a separate genus. In addition, Mazepova's (1990) descriptions clearly show that each of the species redescribed here (but also many others) has one or more sister species in the lake. For example, *Candona humilis* Bronstein, 1939; *C. unguicaudata* Bronstein, 1930; *C. semilunaris dignitosa* Mazepova, 1990, and few other have a very similar carapace shape, hemipenis and prehensile palps to *M. directa*. Similarly, *C. muriformis* Mazepova, 1984; *C. unimodal* Mazepova, 1984; and *C. birsteini* Mazepova, 1990 have a lot of common morphological characters with *M. orbiculata*. On the other hand, representatives of *Baicalocandona* seem to be more morphologically uniform (starting with a trapezoidal shape of the shell) and this genus may even include a few Baikal *Pseudocandona* species. This large morphological and low molecular diversity of Lake Baikal Candonids is contributing to a long list of animal groups where morphological and molecular evolution have been uncoupled (Pisani et al. 2007; Renaud et al. 2007; Sotiaux et al. 2009; Poisot et al. 2011; Dávalos et al. 2012). It is interesting to note that Schön and Martens (2012) recovered several distinct clades in the Lake Baikal cytheroid ostracods based on the *COI* sequences. Although, at the moment they all belong to the same genus, the authors suggest a taxonomic revision and more detail morphological studies.

Based on our phylogenetic tree, none of the Baikal species included in this study could be assigned to either *Candona* or *Pseudocandona*, as demonstrated by the position of the type species of these two genera (underlined species on the tree). Nevertheless, they are morphologically and genetically more closely related to *Candona* than to any other Candonidae genera included in this analysis. *Candona* is a polyphyletic taxon, which is illustrated by the fact that most (if not all) of the *Candona* species endemic to Baikal Lake should be excluded from it, and by the position of *C. quasiakaina* Karanovic & Lee, 2012 nested within the true *Pseudocandona*/*Typhlocypris* clade on the tree. *Fabaeformiscandona* is also a polyphyletic genus, which was already speculated

many times (Karanovic 2006, 2007, 2013, etc.). The position of *Fabaeformiscandona kushiroensis* nested within the *Mazepovacandona* clade is an additional evidence. This Japanese species strongly differs from the typical *Fabaeformiscandona* species, and its affinity with *Mazepovacandona* can be seen in the morphology of the M-peace and ejaculatory tube of the hemipenis (see Hiruta and Hiruta 2015). There have been several attempts to revise *Candona* and *Fabaeformiscandona* which are the two largest Candonidae genera (Karanovic 2006), but there is still no consensus among the ostracodologists regarding the importance of many morphological characters (such as the shape of the shell, number of setae on the mandibular palp, morphology of the “gamma” seta on the same appendage, etc.). In the morphological cladistic analysis performed by Karanovic (2007) these characters were extremely homoplastic. Sexual characters (such as the morphology of the hemipenis) will probably prove to best reflect the generic groupings, and they should be built upon already existing morphological characterizations proposed by Petkovski (1960) and Danielopol (1969). The polyphyletic nature of *Typhlocypris* on the tree is partly a result of the nomenclature disagreements regarding the names *Typhlocypris* and *Pseudocandona* (Karanovic 2005; Namiotko et al. 2014). Morphological characters proposed by Namiotko et al. (2014) for *Typhlocypris* s. str. seem to warrant future better systematics of both genera. The polyphyletic nature of *Cryptocandona* has been suggested by Karanovic and Lee (2012) based on peculiar morphological characters of two species found in East Asia and one from Sweden. The present molecular analysis as well as the one performed by Karanovic and Cho (2017) confirms this. Systematic revision of *Candona*, *Cryptocandona*, *Fabaeformiscandona*, *Pseudocandona*, and *Typhlocypris* is beyond the scope of the present paper. The position of *F. kushiroensis* on the tree suggests that its ancestors originated in the lake. There are many similar examples in other Baikal groups. Sculpin fishes have a high diversity in Baikal and one closely related species in Lake Michigan (see Sherbakov 1999); endemic Baikal mollusks have a relative in Mongolian lakes (Papusheva et al. 1997); and an amphipod species found in Finnish streams has closest relatives in Baikal (Vainola et al. 1995). Karanovic and Abe (2010) and Karanovic et al. (2013) attributed to ancient lakes a role of biodiversity pumps for subterranean habitats in addition to their role as refugia, because their deep and dark benthic environments provide ideal conditions for the evolution of subterranean adaptations. Morphological affinity between *Baicalocandona* and *Schellencandona*, which is distributed in subterranean waters of Europe, is one example supporting this hypothesis.

Molecular diversity of gene markers commonly used for resolving higher phylogenetic relationships (18S and 28S) is relatively small between Baikal candonids and their closest relatives, in comparison to other ostracod lineages. For example, in the family Cyprididae, distances between 18S sequences vary from 2% (within genus) to 11% (between genera) (Kong et al. 2014); while in Polycopidae the same marker has approximately 3% intragenic and 10% intergeneric variability (Tanaka et al. 2014; Karanovic et al. 2016). The distances between *COI* sequences of the four Baikal candonids are within the range of those observed for other ostracods and crustaceans in general (Lefebure et al. 2006; Schön and Martens 2012; Schön et al. 2015, 2017).

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Supplementary material 1

Locality data and BenBank Accession Numbers

Authors: Ivana Karanovic, Tatiana Y. Sitnikova

Data type: molecular data

Explanation note: Species in bold are our sequences, regular font species were downloaded from the GenBank.

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Link: <https://doi.org/10.3897/zookeys.684.13249.suppl1>

Supplementary material 2

p-distances between 18S rRNA sequences

Authors: Ivana Karanovic, Tatiana Y. Sitnikova

Data type: statistical data

Explanation note: data were used for the Figure 16.

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Supplementary material 3

p-distances between 28S rRNA sequences, df region

Authors: Ivana Karanovic, Tatiana Y. Sitnikova

Data type: statistical data

Explanation note: data were used for the Figure 16.

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Supplementary material 4

p-distances between 28S rRNA sequences, em region

Authors: Ivana Karanovic, Tatiana Y. Sitnikova

Data type: statistical data

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Supplementary material 5

p-distances between 28S rRNA sequences, vx region

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Data type: statistical data

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Supplementary material 6

p-distances between 16S rRNA sequences

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Data type: statistical data

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Supplementary material 7

p-distances between *COI* sequences

Authors: Ivana Karanovic, Tatiana Y. Sitnikova

Data type: statistical data

Explanation note: data were used for the Figure 16.

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New species of Southeast Asian Dwarf Tarantula from Thailand: *Phlogiellus* Pocock, 1897 (Theraphosidae, Selenocosmiinae)

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Abstract

A new record of the tarantula genus *Phlogiellus* Pocock, 1897 from Thailand is described. Distributional data, natural history, morphological characters, and illustrations of male and female are provided. The Thai specimens belong to a new species, *Phlogiellus longipalpus* **sp. n.** The diagnosis of the new species and related species are discussed.

Keywords

Distribution, Mygalomorph, natural history, taxonomy

Introduction

Four genera of Theraphosidae are currently known from Thailand: *Cyriopagopus* Simon, 1887, *Ornithoctonus* Pocock, 1892, *Chilobrachys* Karsch, 1892 and *Phlogiellus* Pocock, 1897 (World Spider Catalog, 2017). *Phlogiellus*, the Asian dwarf tarantulas,

was erected for *Phlogiellus atriceps* Pocock, 1897. It is mainly distributed in Southeast Asia, peninsular Malaysia, Indonesia, the Philippines, Taiwan (Orchid Island), and some islands west of Wallace’s Line (West et al. 2012, Nunn et al. 2016, World Spider Catalog 2017). *Phlogiellus moniqueverdezae* Nunn et al., 2016 is the only *Phlogiellus* heretofore reported from Thailand (Nunn et al. 2016); here we report a second Thai species, *Phlogiellus longipalpus* sp. n. Collection sites for *P. moniqueverdezae* and *P. longipalpus* sp. n. are shown in Figure 1. According to West et al. (2012) *Phlogiellus* shares the following combination of characters: number of labial cuspules between 200–350, length of posterior lateral spinnerets nearly or equal to length of metatarsus IV, and deep fovea. However, Nunn et al. (2016) recanted the use of posterior lateral spinnerets length to length of metatarsus IV as the group synapomorphic character. Kishida (1920) proposed the genus *Yamia* for some species now placed in *Phlogiellus*, citing complete lack of a lyra on the prolateral face of the maxilla as a diagnostic character. By

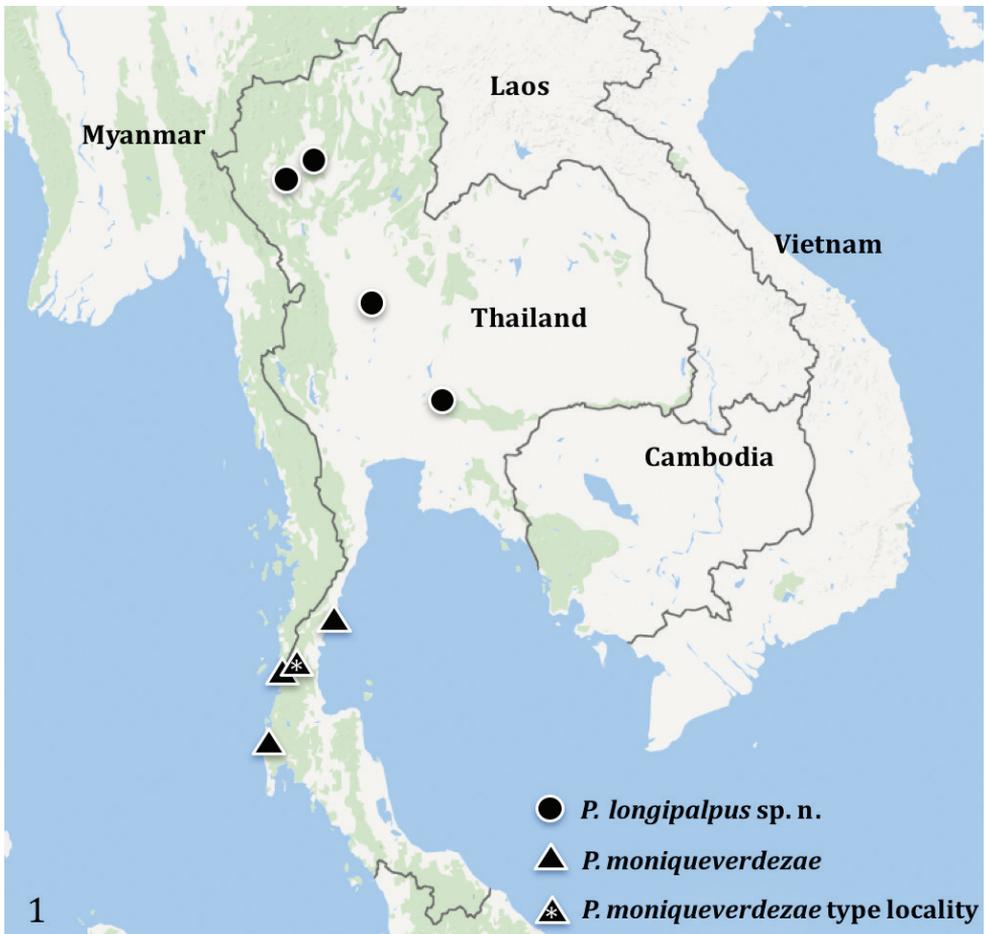


Figure 1. Distribution records of *Phlogiellus* in Thailand: *P. moniqueverdezae* Nunn et al., 2016 from Rangoon province, and *P. longipalpus* sp. n. (Kamphaengphet, Lamphun, Lampang and Saraburi provinces).

this criterion seven species of *Phlogiellus* would be included in *Yamia*: *P. aper* (Simon, 1891), *P. brevipes* (Thorell, 1897), *P. watasei* (Kishida, 1920), *P. mutus* (Giltay, 1935), *P. bundokalbo* (Barrion & Litsinger, 1995), *P. moniqueverdezae* Nunn et al., 2016 and *P. longipalpus* sp. n. Haupt and Schmidt (2004) and Zhu and Zhang (2008) also proposed the generic status of *Yamia* but without supporting phylogenetic analyses. A cladistic analysis of the subfamily Selenocosmiinae Simon, 1889 by West et al. (2012) using a morphological data set showed monophyly of [*Phlogiellus* + *Yamia*] and did not resolve relationships among *Phlogiellus* and the putative *Yamia* species. Raven (2005) considers *Yamia* a junior synonym of *Phlogiellus*, and suggests that the maxillary lyra may be lost secondarily in *Phlogiellus* as well as other selenocosmiine genera. Here, we document a second *Phlogiellus* from central and northern Thailand and describe it as a new species, *P. longipalpus* sp. n. Illustrations of the body and copulatory organs are provided, as well as information on natural history and remarks on morphological characters distinguishing this species from previously known species.

Materials and methods

Collections were carried out in Kamphaengphet, Lamphun, Lampang and Saraburi provinces, Thailand on 12 May 2014, 27 May 2014, 16 July 2015, and 8 Aug 2015, respectively. All tarantulas were collected and preserved in 95% ethanol. Specimens were transferred to the Center of Excellence in Entomology, Chulalongkorn University, Bangkok, for dissection and identification. All measurements were carried out using a Zeiss Stemi DV4 stereomicroscope equipped with an eyepiece micrometer. Diagnostic features were photographed using an Olympus Camedia c-4040zoom digital camera mounted to the phototube of an Olympus SZ60 stereoscope. Leg length and width measures were made on the left side of all specimens. Length of each leg segment was measured from the dorsal aspect, and leg width was measured at the basal end of the leg segment viewed from dorsal aspect. Tarsal measurements did not include claws. The relation factor (RF) was calculated as the ratio of the length of leg I to leg IV multiplied by 100 (von Wirth and Striffler 2005). Leg formula, the leg lengths in decreasing order, is also presented. Legs, pedipalps, stridulatory organs (cheliceral strikers and maxillae) were measured from the left side of all specimens. Color of morphological parts are as seen in alcohol-preserved specimens unless otherwise noted. The copulatory organs of females were dissected and cleared in 3M aqueous KOH solution. Specimens were identified by comparison of our measurements and images to those in Haupt & Schmidt (2004), Zhu and Zhang (2008), Schmidt (2010), West et al. (2012) and Nunn et al. (2016). All type and voucher specimens are deposited at the Chulalongkorn University Museum of Zoology (CUMZ), Bangkok, Thailand. The following abbreviations are used in the text:

AER anterior eye row;

ALE anterior lateral eyes;

AME anterior median eyes;

MOA median ocular area;

PER = posterior eye row; **PLE** = posterior lateral eyes; **PME** = posterior median eyes; **PLE** = posterior lateral eyes, **PLS** = posterior lateral spinnerets, **PME** = posterior median eyes, **PMS** = posterior median spinnerets, **Fem** = femur, **Pat** = patella, **Tib** = tibia, **Met** = metatarsus, **Tar** = tarsus.

All measures are given in millimeters (mm).

Other materials

P. moniqueverdezae Nunn et al., 2016: 1♂ (CUMZ-T3-NA2M) and 2♀ (CUMZ-T3-NA5FM, CUMZ-T3-NA3FM), (9°46'14.2"N 98°24'44.5"E) Koh Phayam, Ranong province, Thailand; 1♂ (CUMZ-T9-COM), (8°46'17.8"N 98°16'36.0"E), Takua Pa District, Phang-nga province, Thailand; 1♀ (CUMZ-T10-COFM), (8°46'17.8"N 98°16'36.0"E), Tha Sae District, Chumphon province, Thailand (Fig. 1).

Taxonomy

Phlogiellus longipalpus sp. n.

<http://zoobank.org/CF6F2F8D-15EB-48E1-BC32-7DAEA60C594D>

Type material. —**Thailand:** Holotype ♂, paratype 1♂, and paratype 3♀, Sai Thong Watthana district, Kamphaeng Phet province (16°17'45.6"N 99°52'49.8"E), 12th May 2014. Paratype: 1♂ and 2♀, Pa Sang district, Lamphun province (18°23'46.8"N 98°51'22.2"E), 27th May 2014; 1♀, Wiang Nuea district, Lampang province (18°18'09.6"N 98°30'36.6"E) 16th Jul 2015, and 1 ♀, Saraburi province, Muak Lek, (14°27'27.0"N 101°11'27.0"E), 8th Aug 2015. (CUMZ-(C1-NA1, C2-NA1, C4-NA2, C4-NA3, C4-NA4, C7-NA1, C8-CH2, B1-NA3, B1-NA1, B1-NA2): 3 ♂, 7♀).

Etymology. The specific name refers to the Latin *longus* ("long"), which describes both male pedipalp and female spermatheca, and *palpus* ("palm of the hand" or "feeler").

Diagnosis. *Phlogiellus longipalpus* sp. n. was included in the *Yamia* group of *Phlogiellus* based on the following morphological characters: male embolus with single retrolateral keel (Fig. 19), anterior eye row slightly procurved, ALE larger than PLE (Fig. 6), clypeus narrow or absent, third claw present on tarsus IV (Haupt & Schmidt 2004; Zhu & Tso 2005). *P. longipalpus* sp. n. differs from all other *Phlogiellus* species except *P. aper*, *P. brevipes*, *P. mutus*, *P. bundokalbo*, *P. watasei*, and *P. moniqueverdezae* in lacking a maxillary lyra (Fig. 7). *P. longipalpus* differs from the latter six species in possessing a long embolus that is more or less 3 times longer than palpal bulb length (Figs. 19, 21–23; Suppl. material 1, Figs. A1–A8) and in the shape of the female spermatheca, which is long with an apical bend (Figs. 20, 24; Suppl. material 1, Figs. B1–B8). It differs from *P. brevipes* in possessing 5 spines on the posterior metatarsi (only 2 known in *P. brevipes*). It differs from *P. aper* in possessing divided scopulae on tarsus IV (Fig. 18, 28) (Nunn et al., 2016).



Figures 2–3. *Phlogiellus longipalpus* sp. n. **2** paratype ♂, CUMZ-C3-NA2 **3** paratype ♀, CUMZ-C4-NA4.

Description – Male. Holotype ♂ CUMZ-C2-NA1: Color (in life, Fig. 2): dark brown, carapace black. Total length (including chelicerae) 20.88; cephalothorax 8.38 long, 6.63 wide, 2.0 high (caput); fovea 1.52 wide, procurved, deep; cephalothorax black, with cover of short, whitish brown hairs dorsally, golden yellow to yellowish brown hairs on lateral margins (Fig. 4). Clypeus 0.24; ocular tubercle 0.96 long, 1.47

wide. Anterior eyes with long hairs in front of AME and mid-posterior PME area. Anterior eye row slightly procurved and posterior row slightly recurved; eyes whitish, ALE oval in shape and larger than the round AME (Fig. 6); eye lengths/widths: AME 0.30/0.28; ALE 0.39/0.27; PLE 0.24/0.18; PME 0.21/0.12; eye interdistances: AME–AME 0.21; AME–ALE 0.12; AME–PME 0.11; ALE–ALE 0.77; ALE–PME 0.21; PME–PME 0.69; PME–PLE 0.06; PLE–PLE 0.96; and ALE–PLE 0.20. Chelicerae dark, with row of 9 promarginal teeth with rows of orange-red setae (Fig. 9), a series of strikers (>60), in > 4 horizontal rows (unordered). Strongest/longest strikers on lowest rows. Each striker is needle-form (Fig. 8), lacking filiform ends. Maxillae reddish brown, 2.95 long, 1.55 wide with 115 cuspules, covered with orange-red setae on pro-lateral surface; maxillary lyra absent (Fig. 7). Labium blackish-brown on the basal half, reddish brown elsewhere; 0.93 long, 1.50 wide, with 202 cuspules (Fig. 13). Sternum dark-brown, covered with 2 types of hairs: strong dark and soft white (Fig. 10); 4.45 long, 3.65 wide with 3 pairs of ovoid sigillae present near lateral margins opposite coxa I, II and III. Sigilla: anterior pair obscured close to sternal margin; median pair 0.27 long, 0.15 wide 0.33 from sternal margin; posterior pair 0.42 long, 0.18 wide 0.60 from sternal margin. Abdomen 9.88 long, 6.13 wide, brownish yellow and hirsute dorsally, dark gray and thickly hirsute laterally and ventrally (Fig. 12). Legs: Pat, Tib, Met and Tar dark brown, prolateral and retrolateral surface of femora dark, thickly covered with long and short grayish white hairs (Fig. 16), coxae and trochanter dark brown dorsally, lighter brown ventrally. Met IV with 5 distal spines. Length of legs, palpal segments and RF shown in Table 1.

Scopulae on metatarsi and tarsi I through IV may be undivided, divided longitudinally by several rows of long, straight spiniform setae or absent. Fig. 28 illustrates diagrammatically the state of the scopulae on metatarsi and tarsi of legs I–IV for *P. longipalpus* and other *Phlogiellus* species. In addition, we noted whether the extension of the scopulae was complete (running nearly the full length of the tarsus or metatarsus) or reduced in length (e.g., extension $\frac{3}{4}$ the length of the leg segment). Scopula extension on Met I, complete; Met II, complete; Met III, complete; Met IV, $\frac{3}{4}$ and denser at distal end than proximal end. Scopula extension on Tar I, complete; Tar II, complete; Tar III, complete; Tar IV, complete but denser at the distal end, and with a small, nearly hairless oval (“bald spot”) at the proximal end. Tar II, III and IV with dense tufts of scopular hair at distal end (Fig. 15). Male tibia I spur absent. Spines: Met I and II: absent; Met III: 8 spines, Met IV: 6. Tar I–III with 2 claws, Tar IV with third claw (Fig. 14); claws covered by dense hair, dorsally with 2 rows of club-shaped setae. Spinnerets white-yellow, covered with dark longer and thinner hairs; PMS 1.16 long, 0.36 wide; PLS 4.92 long basal to apical (2.02, + 1.34, + 1.56), wide (0.64 + 0.72 + 0.41) (Fig. 12). Pedipalps dark gray reddish brown, covered with longer and thinner hairs on tibia; tibia swollen, cymbium with two lobes of light brown shaggy scopulae, bulb and embolus 3.09 long dark reddish brown (Fig. 19), palpal bulb ellipsoid and partly concave, 0.91 long, 0.51 wide; embolus extremely long, thin, curved like a partly twisted horn with sharp tip, with single retrolateral keel (Figs 21–23).

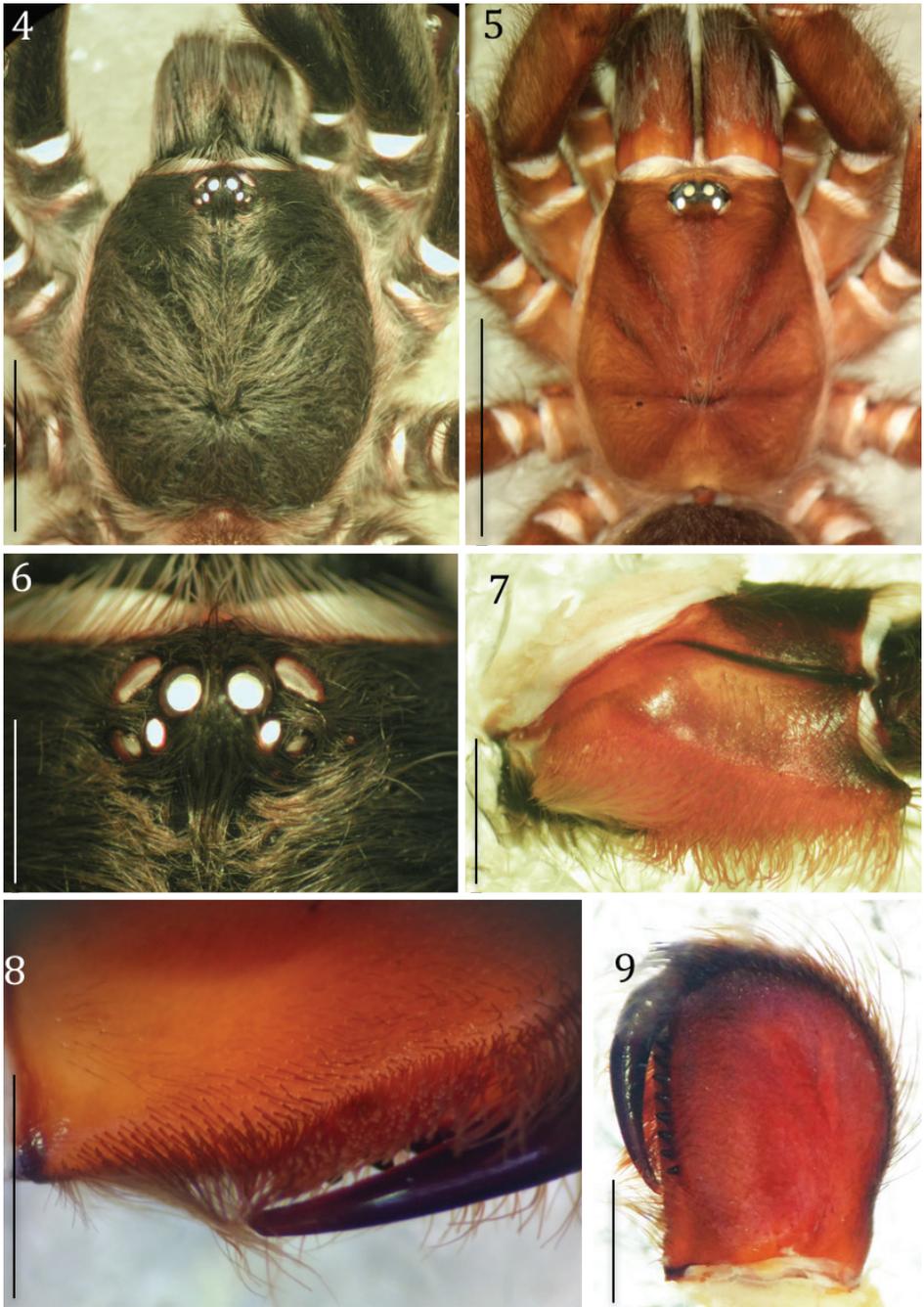
Table 1. Legs and palp measurements (in mm) of holotype CUMZ-C2-NA1 ♂ *Phlogiellus longipalpus* sp. n. Relation Factor (RF) = 99.27.

	I	II	III	IV	Palp
Fem	6.60	5.76	4.92	5.94	4.08
Pat	3.48	2.55	2.94	3.20	2.88
Tib	5.12	4.15	3.18	4.14	4.24
Met	3.48	3.75	3.36	4.98	-
Tar	1.83	1.83	1.83	2.40	1.51
Total	20.51	18.04	16.23	20.66	12.71

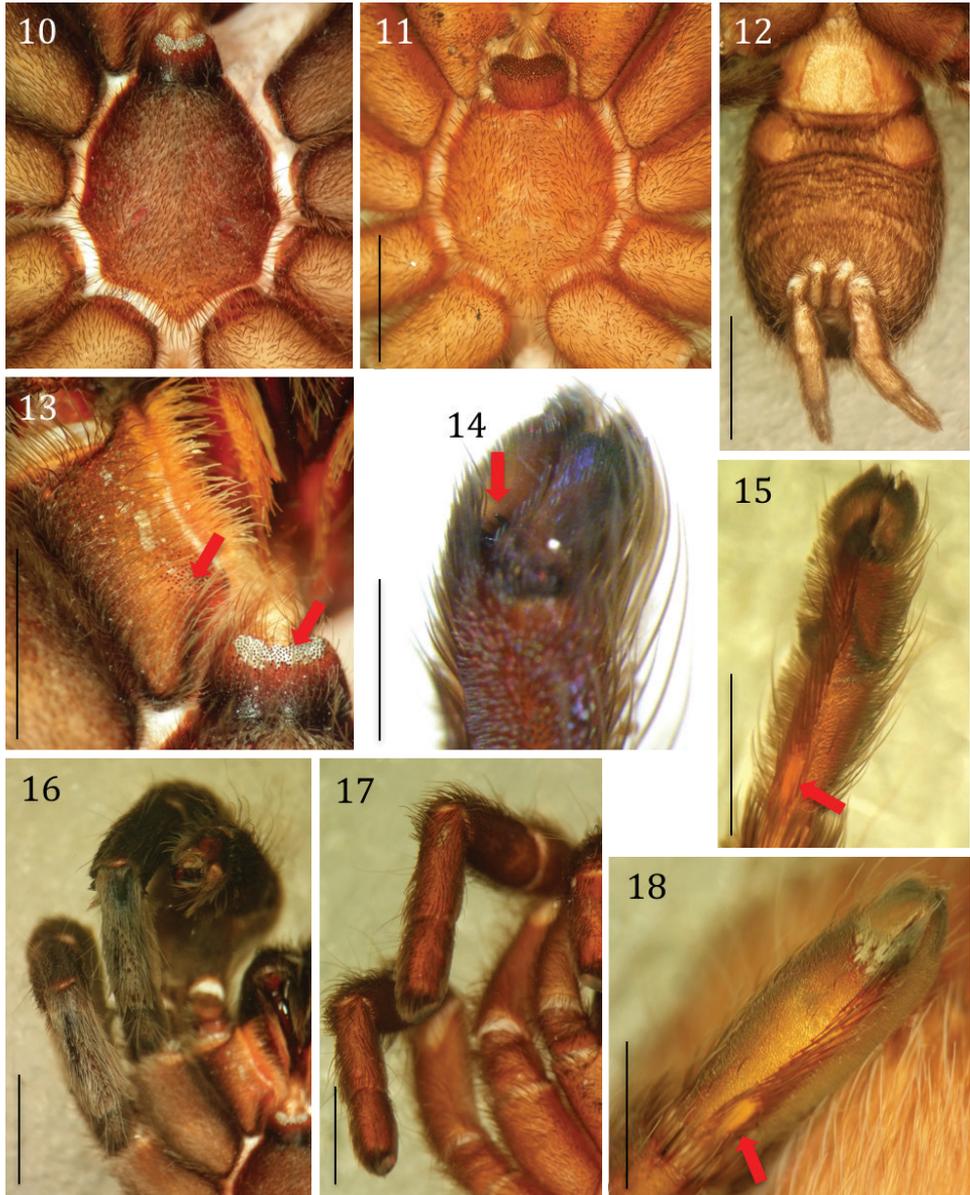
Variation – Male (range (mean ± standard deviation)): Total length (including chelicerae) 13.7–21.00 (18.52±4.18); cephalothorax 6.60–8.33 (7.19±0.98) long, 2.88–6.63 (4.74±1.88) wide, 2.00–2.88 (2.51±0.46) high (caput); fovea 1.00–1.52 (1.28±0.26) wide; clypeus 0.18–0.24 (0.21±0.04) narrow or absent; ocular tubercle 0.90–1.02 (0.96±0.06) long, 1.10–1.47 (1.34±0.21) wide. Eye length/width: AME, 0.20–0.30 (0.26±0.05)/0.20–0.28 (0.25±0.04); ALE, 0.30–0.39 (0.35±0.05)/0.21–0.30 (0.26±0.05); PLE, 0.24–0.30 (0.26±0.03)/0.15–0.20 (0.18±0.03); PME, 0.15–0.21 (0.19±0.03)/0.10–0.12 (0.11±0.01). Inter-eye distances: AME–AME, 0.10–0.21 (0.16±0.06); AME–ALE, 0.10–0.12 (0.11±0.01); AME–PME, 0.10–0.12 (0.11±0.01); ALE–ALE, 0.77–0.84 (0.80±0.04); ALE–PME, 0.20–0.24 (0.22±0.02); PME–PME, 0.50–0.72 (0.64±0.12); PME–PLE, 0.06–0.10 (0.07±0.02); PLE–PLE, 0.80–0.99 (0.92±0.10); and ALE–PLE, 0.10–0.20 (0.14±0.05). Maxillae 1.70–2.95 (2.46±0.67) long, 1.2–1.56 (1.44±0.21) wide. Labium 0.90–1.14 (0.99±0.13) long, 1.20–1.74 (1.48±0.27) wide. Sternum 3.20–4.45 (3.93±0.65) long, 2.40–3.78 (3.28±0.77) wide. Abdomen 6.32–9.88 (8.32±1.82) long, 3.52–6.35 (5.33±1.57) wide. Length of legs and palpal segments shown in Table 2. Spinnerets: PMS 0.80–1.23 (1.06±0.23)

Table 2. Legs and palp measurements of ♂ *Phlogiellus longipalpus* sp. n. (n= 3) (range, mean ± standard deviation).

	I	II	III	IV	Palp
Fem	4.60–7.36 (6.19±1.43)	4.00–6.40 (5.39±1.24)	3.30–4.92 (4.34±0.90)	4.20–6.88 (5.67±1.36)	2.50–4.47 (3.68±1.04)
Pat	3.20–4.32 (3.67±0.58)	2.55–3.76 (2.97±0.68)	2.3–3.06 (2.77±0.41)	2.60–3.60 (3.13±0.50)	2.10–2.88 (2.58±0.42)
Tib	4.00–5.58 (4.90±0.81)	3.30–4.56 (4.00±0.64)	2.30–3.18 (2.87±0.49)	2.80–5.52 (4.15±1.36)	3.10–4.24 (3.81±0.62)
Met	3.00–4.38 (3.62±0.70)	2.80–4.14 (3.56±0.69)	2.50–3.84 (3.23±0.68)	3.90–5.76 (4.88±0.93)	–
Tar	1.70–2.58 (2.04±0.48)	1.80–2.34 (1.99±0.30)	1.83–2.40 (2.08±0.29)	2.30–2.68 (2.46±0.20)	1.30–1.51 (1.42±0.11)
Total	16.50–24.22 (20.41±3.86)	14.50–21.20 (17.91±3.35)	12.40–17.22 (15.28±2.55)	15.80–24.44 (20.30±4.33)	9.00–12.75 (11.49±2.15)



Figures 4–9. *Phlogiellus longipalpus* sp. n. **4, 6, 7** holotype ♂, CUMZ-C2-NA1: **4** carapace, dorsal view **5** carapace, dorsal view, paratype ♀, CUMZ-C4-NA4 **6** eyes, dorsal view **7** left maxilla, prolateral view. **8, 9** paratype ♂, CUMZ-C4-NA4: **8** chelicerae striker, retrolateral view **9** right chelicerae prolateral view. Scale bars: 4 mm (**4–5**); 1 mm (**6–9**).



Figures 10–18. *Phlogiellus longipalpus* sp. n. **10, 12, 13, 15–16** holotype ♂, CUMZ-C2-NA1: **11–17** paratype ♀, CUMZ-C4-NA4: **14–15** paratype ♂, CUMZ-C4-NA3 **10** sternum, labium and coxae, ventral view **11** sternum, labium, and coxae, ventral view **12** abdomen and spinneret, ventral view **13** labium and maxilla, arrows indicate cusps **14** left tarsus IV, ventral view, arrow indicates third claw **15** right tarsus IV, ventral view, arrow indicates “bald spot” **16** right legs I and II, dorsal view **17** right legs I and II, dorsal view **18** paratype ♀, CUMZ-C1-NA1, left tarsus IV, ventral view, arrow indicates “bald spot”. Scale bars: 2 mm (**10–11**); 3 mm (**12**); 2 mm (**13, 16–18**); 0.5 mm (**14**); 1 mm (**15**).

long, 0.30–0.39 (0.35±0.05) wide; PLS 3.40–4.92 (4.15±0.76) long basal to apical (1.30–2.02 (1.65±0.36), + 0.90–1.34 (1.08±0.23), + 1.20–1.56 (1.43±0.20)), wide (0.39–0.64 (0.55±0.14) + 0.51–0.72 (0.59±0.11) + 0.39–0.42 (0.40±0.02)).

Description – Female. Paratype ♀ CUMZ-C4-NA4: Color (in life, Fig. 3): dark brown, carapace brown. Total length (including chelicerae) 17.51; cephalothorax 6.56 long, 4.25 wide 2.12 high (caput); fovea 0.87 wide, procurved, deep; cephalothorax brown, covered with short whitish brown hairs dorsally, golden yellow to yellowish brown hairs on lateral margins (Fig. 5); clypeus 0.15 high; ocular tubercle 0.72 long, 1.14 wide. Anterior eyes with long hairs in front of AME and mid-posterior PME area; anterior eye row slightly procurved and posterior row slightly recurved. Eyes whitish, ALEs oval in shape, larger than the round AMEs. Eye length/width: AME, 0.30/0.15; ALE, 0.21/0.22; PLE, 0.27/0.15; PME, 0.20/0.13; Inter-eye distances: AME–AME, 0.14; AME–ALE, 0.11; AME–PME, 0.09; ALE–ALE, 0.57; ALE–PME, 0.16; PME–PME, 0.48; PME–PLE, 0.05; PLE–PLE, 0.66; and ALE–PLE, 0.11. Chelicerae dark orange with row of 10 promarginal teeth, cheliceral face with stridulatory ridges and rows of orange-red setae, a series of strikers (>60), in > 4 horizontal rows (unordered). Strongest/longest strikers on lowest rows. Each striker needleform, lacking filiform ends (Fig. 8). Maxillae reddish brown, 2.34 long, 1.24 wide with 152 cuspules, prolateral surface of maxilla covered with orange-red setae, and maxillary, and maxillae lyra absent. Labium reddish brown, 0.88 long, 1.28 wide with 271 cuspules. Sternum brownish, covered with 2 types of hair: strong dark and soft white (Fig. 11); sternum 2.9 long, 2.64 wide, with 3 pairs ovoid sigillae present near lateral margins opposite coxa I, II and III. Sigillae: anterior pair obscured close to sternal margin; median pair 0.24 long, 0.15 wide, 0.12 from sternal margin; posterior pair 0.30 long, 0.17 wide, 0.39 from sternal margin. Abdomen 9.50 long, 6.20 wide, gray-yellow and hirsute dorsally, brownish gray and thickly hirsute laterally and ventrally. Legs brownish, thickly covered with grayish white short and long hairs (Fig. 17), coxae and trochantera brown. Met IV with 5 distal spines. Length of legs, palpal segments shown in Table 3. Leg formula (length) IV, I, II, III.

Scopulae: Met I, II, III, undivided; Met IV, divided. Tar I, II, undivided; Tar III, IV, divided by several rows of long spines (Fig. 18). Met I, II, III, complete; Met IV, extension $\frac{3}{4}$, denser at distal end than at proximal end. Scopula extension on Tar I, II, III, IV complete; Tar IV scopula denser at the distal end and with a small, nearly hairless oval

Table 3. Legs and palp measurements (in millimeters) of paratype CUMZ-C4-NA4 ♀ *Phlogiellus longipalpus* sp. n. from Thailand. RF = 97.54.

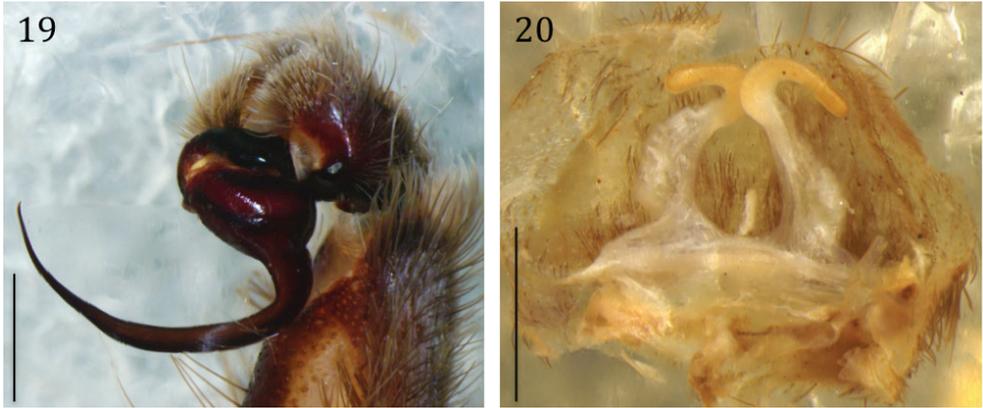
	I	II	III	IV	Palp
Fem	4.48	3.35	2.95	4.15	2.65
Pat	2.40	2.10	2.15	2.20	2.10
Tib	2.75	2.10	1.75	2.80	1.90
Met	1.90	1.45	1.50	2.82	-
Tar	1.55	1.20	1.15	1.44	1.65
Total	13.08	10.20	9.50	13.41	8.30

(“bald spot”) at the proximal end (see Fig. 18). Hairs of distal scopula on Tar II, III and IV more evenly distributed than in the male, not forming tufts of hair (compare Figs. 15, 18). Spines: Met I and II, absent; Met III, 7 spines; Met IV, 6 spines. Tar I–III with 2 claws, Tar IV with third claw, 2 dorsal rows of club-shaped setae. Spinnerets white-yellow, covered with long, thin dark hairs; PMS 0.87 long, 0.48 wide; PLS 3.48 length of segments (from basal to apical) ($1.38 + 0.87 + 1.23$), width of segments (basal to apical) $0.63 + 0.54 + 0.45$. Genitalia: epigastric fold 1.86. Spermathecae (Figs. 20, 24): paired, each 0.3 mm wide at base and the pair fused at the base, 1.05 (left) and 1.11 (right) mm long, 0.42 (left) – 0.54 (right) wide, and apically bent; sclerotization heaviest apically, gradually decreasing basally.

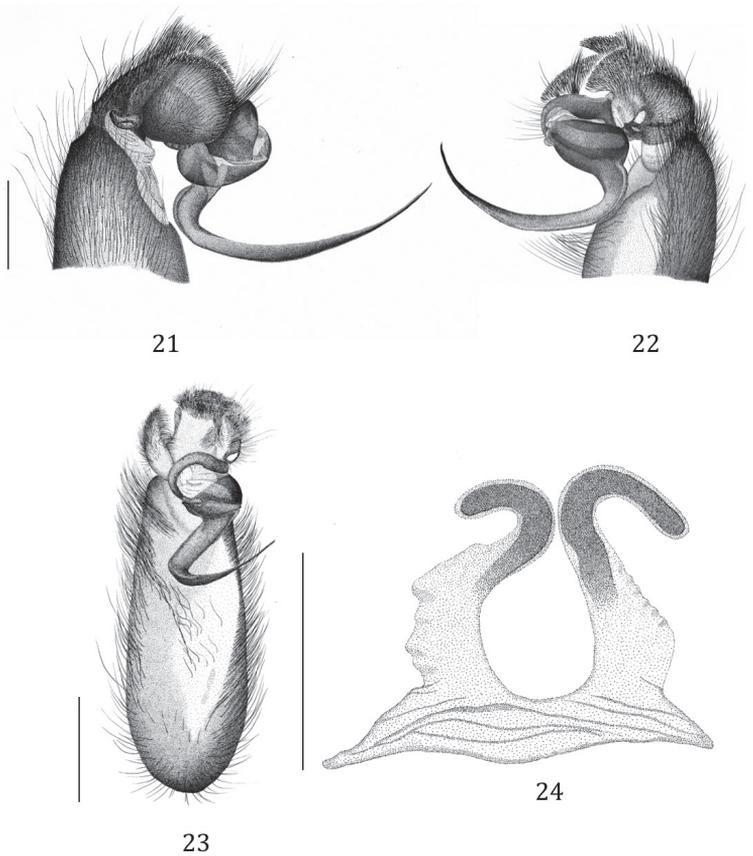
Variation – Female (N = 7; range (mean \pm standard deviation)): Total length (including chelicerae) 14.30–26.75 (20.31 ± 4.72); cephalothorax 6.56–10.70 (8.80 ± 1.54) long, 4.25–8.20 (6.27 ± 1.41) wide, 2.12–4.16 (3.05 ± 0.69) high (caput); fovea 0.87–1.68 (1.29 ± 0.28) wide; clypeus 0.15–0.30 (0.21 ± 0.05) or absent; ocular tubercle 0.70–1.14 (0.91 ± 0.20) long, 1.00–1.80 (1.44 ± 0.30) wide. Eye length/width: AME 0.20–0.40 (0.28 ± 0.07)/0.15–0.40 (0.26 ± 0.08); ALE 0.21–0.50 (0.36 ± 0.10)/0.20–0.45 (0.28 ± 0.08); PLE 0.27–0.45 (0.33 ± 0.05)/0.15–0.20 (0.19 ± 0.02); PME 0.20–0.40 (0.28 ± 0.07)/0.13–0.20 (0.18 ± 0.03). Inter-eye distances: AME–AME 0.14–0.50 (0.33 ± 0.14); AME–ALE 0.10–0.50 (0.22 ± 0.15); AME–PME 0.09–0.50 (0.23 ± 0.16); ALE–ALE 0.57–1.70 (0.98 ± 0.38); ALE–PME 0.16–0.40 (0.28 ± 0.11); PME–PME 0.48–1.80 (0.88 ± 0.44); PME–PLE 0.05–0.30 (0.14 ± 0.09); PLE–PLE 0.66–1.90 (1.09 ± 0.39); and ALE–PLE 0.11–0.50 (0.28 ± 0.16). Maxillae 2.30–3.35 (2.73 ± 0.41) long, 1.20–2.20 (1.66 ± 0.39) wide. Labium 0.88–1.40 (1.06 ± 0.20) long, 1.28–1.96 (1.50 ± 0.27) wide. Sternum 2.90–4.82 (3.93 ± 0.85) long, 2.64–4.32 (3.50 ± 0.73) wide. Abdomen 7.38–15.62 (10.96 ± 2.99) long, 4.80–8.80 (6.74 ± 1.67) wide. Length of legs and palpal segments shown in Table 4. Spinnerets: PMS 0.80–1.40 (1.04 ± 0.26) long, 0.40–0.60 (0.53 ± 0.07) wide; PLS 3.48–5.13 (4.09 ± 0.55) long from base to apex, basal segment 1.20–2.10 (1.53 ± 0.29), median segment 0.87–1.59 (1.17 ± 0.24), apical segment 0.90–1.89 (1.40 ± 0.35) long; width of basal segment 0.63–1.05 (0.82 ± 0.17), median segment 0.54–0.99 (0.75 ± 0.16) and apical segment 0.45–0.75 (0.58 ± 0.12).

Table 4. Legs and palp measurements [range (mean \pm standard deviation)] of ♀ *Phlogiellus longipalpus* sp. n. (n=7).

	I	II	III	IV	Palp
Fem	3.20–6.90 (3.63 ± 1.34)	3.20–5.90 (4.51 ± 1.08)	2.90–5.36 (3.96 ± 1.08)	3.80–7.00 (5.35 ± 1.25)	2.50–4.64 (3.63 ± 0.94)
Pat	2.30–4.64 (3.63 ± 0.97)	2.10–4.30 (3.01 ± 0.86)	1.80–3.50 (2.65 ± 0.66)	2.20–4.20 (3.12 ± 0.77)	1.80–3.20 (2.51 ± 0.56)
Tib	2.70–4.90 (3.76 ± 0.86)	2.10–3.70 (2.90 ± 0.58)	1.75–3.90 (2.64 ± 0.81)	2.80–4.80 (3.95 ± 0.81)	1.90–3.20 (2.60 ± 0.60)
Met	1.80–3.76 (2.64 ± 0.80)	1.45–3.70 (2.55 ± 0.79)	1.50–3.45 (2.59 ± 0.71)	2.70–5.60 (4.11 ± 1.15)	–
Tar	1.55–3.40 (2.33 ± 0.64)	1.20–3.33 (2.13 ± 0.74)	1.15–3.20 (2.24 ± 0.65)	1.44–3.50 (2.59 ± 0.65)	1.65–3.30 (2.56 ± 0.61)
Total	12.00–23.10 (17.60 ± 4.35)	10.20–20.90 (15.12 ± 3.89)	9.50–18.20 (14.09 ± 3.61)	13.41–25.10 (19.13 ± 4.49)	8.30–14.20 (11.30 ± 2.58)



Figures 19, 20. *Phlogiellus longipalpus* sp. n. **19** holotype ♂, CUMZ-C2-NA1, left pedipalps, retrolateral view **20** paratype ♀, CUMZ-C4-NA4, spermathecae, dorsal view. Scale bars: 1 mm.



Figures 21–24. *Phlogiellus longipalpus* sp. n. **21** holotype ♂, CUMZ-C2-NA1, left pedipalp, prolatateral view **22** same, retrolateral view **23** same, ventral view **24** CUMZ-C4-NA4, spermathecae, dorsal view. Scale bars 1 mm (**21–24**).

Distribution and natural history. Specimens were collected near villages in Lampang, Lamphun and Kampanget provinces at approximately 200–500 meters in elevation. The habitat was disturbed by human activity and organic agriculture, including cultivation of mango, coconut, and bamboo (Fig. 25). Some specimens were collected from houses in the rainy season and others in shaded forest habitats; they appear to choose moist habitats. Some nests were built in colonies of termites or ants, which are used as prey (Figs 26–27). The nest consists of a shallow (1–2 cm deep) subterranean system of silken retreat tubes under stones or logs. One part of their web appeared to be used for accumulated prey scraps. Specimens from Saraburi province were collected in forest under rock and timber.

Remarks. Nunn et al. (2016) recently revised *Phlogiellus* and gave very strong support for two synapomorphies of *Phlogiellus*: number of labial cuspules between 160–320, fewer than other selenocosmiine genera and very deep fovea. However, R. Raven (pers. comm.) pointed out that in Nunn et al. (2016), *P. pelidnus* Nunn et al., 2016 was described and shown to have more than 320 labial cuspules. This inconsistency of using the number of labial cuspules as a valid synapomorphic characters of *Phlogiellus* remains to be investigated. For our study, *P. longipalpus* sp. n. is placed in *Phlogiellus* as it has deep fovea, while the labial cuspule numbers are between 202–317



Figures 25–27. *Phlogiellus longipalpus* sp. n. Kamphaengphet province, Sai Thong Watthana. **25** locality where specimens are collected **26** habitat under log **27** subterranean system of silk tube retreats with litter.

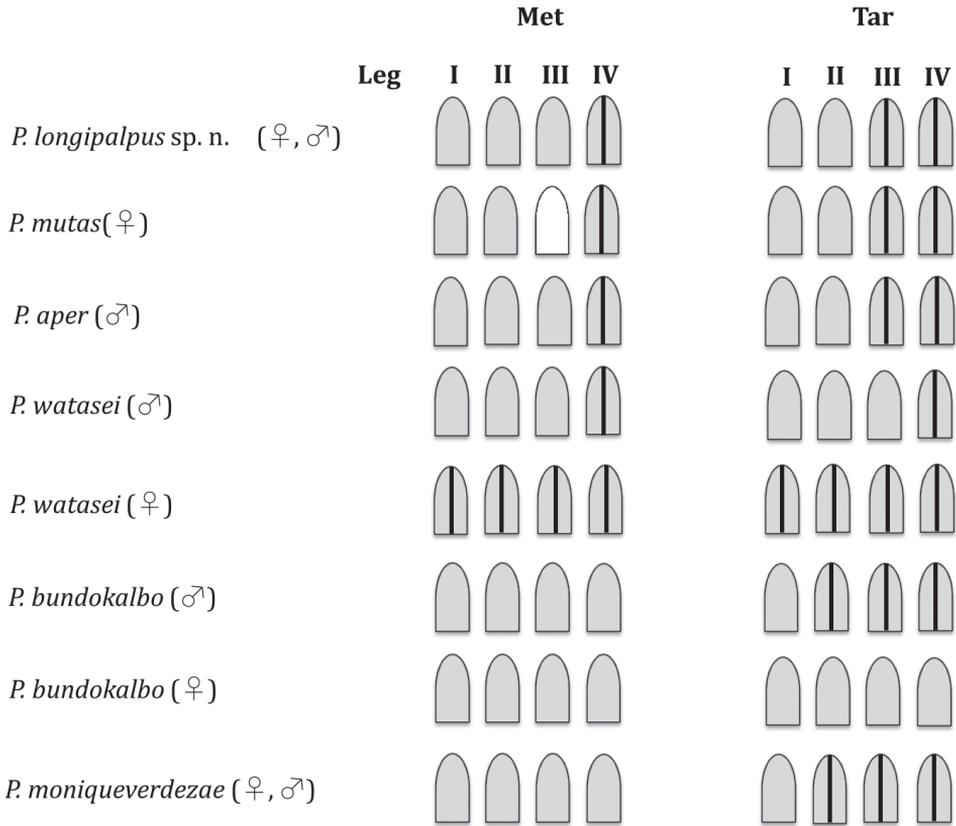


Figure 28. Metatarsal and tarsal scopae of legs I–IV of *Phlogiellus* lacking of maxillary lyra (*P. longipalpus* sp. n., *P. mutas*, *P. aper*, *P. watasei*, *P. bundokalbo*, and *P. moniqueverdezae*), indicating whether scopulae are entire, divided by rows of bristles or absent (grey – undivided, grey with black vertical line – divided, white – absent).

(average 281±42). *Phlogiellus longipalpus* sp. n. differs from *P. pelidnus*, *P. baeri* (Simon, 1877), *P. subinermis* (Giltay, 1934), *P. atriceps* Pocock 1897, *P. inermis* (Ausserer, 1871), *P. insulanus* (Hirst, 1909), *P. johnreylazoi* Nunn et al., 2016, *P. xinping* (Zhu and Zhang, 2008), *P. bogadeki* Nunn et al., 2016, *P. orophilus* (Thorell, 1897), and *P. obscurus* (Hirst, 1909) in lacking a maxillary lyra, a character it shares with *P. aper* (Simon, 1891), *P. brevipes* (Thorell, 1897), *P. watasei* (Kishida, 1920), *P. mutus* (Giltay, 1935), *P. bundokalbo* (Barrion and Litsinger, 1995), and *P. moniqueverdezae* Nunn et al., 2016. *P. longipalpus* sp. n. differs from other *Phlogiellus* species that lack a maxillary lyra by possession of a long embolus that is more or less 3 times longer than palpal bulb length (Suppl. material 1, Figs. A1–A8) and long, uniquely shaped female receptacle (Suppl. material 1, Figs. B1–B8). In addition, the pattern of tarsal scopula division illustrated in Fig. 28 can be used to distinguish mature specimens of *P. longipalpus* sp. n., *P. mutas*, *P. aper*, *P. watasei*, *P. bundokalbo*, and *P. moniqueverdezae*. This character cannot be used to diagnose *P. brevipes* (material not examined) or the female of *P. aper* (no specimens have been described) (Raven 2005, Guadanucci 2005, Nunn et al. 2016).

Distribution. Thailand (Central and Northern).

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Supplementary material I

Supplemental figures

Authors: Narin Chomphuphuang, Deborah Smith, Sitthipong Wongvilas, Varat Sivayyapram, Chaowalit Songsangchote, Natapot Warrit

Data type: Species figures

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Notes on the *Stenus cirrus* group of Zhejiang, East China, with descriptions of two new species (Coleoptera, Staphylinidae)

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Abstract

Two new *Stenus* species of the *cirrus* group collected from Zhejiang Province, East China, are described, *S. wuyanlingus* Liu, Tang & Luo, **sp. n.**, *S. yuyimingi* Liu, Tang & Luo, **sp. n.** and a new distributional locality for *S. ovalis* Tang, Li & Zhao, 2005 was discovered. The diagnostic characters of the new species are illustrated, and a key to species of the group from Zhejiang Province is provided.

Keywords

China, Coleoptera, new species, Staphylinidae, *Stenus cirrus* group, Zhejiang

Introduction

The *Stenus cirrus* group is a large group with 73 species worldwide. Among them, 56 species are known from China (Tang et al. 2008; Puthz 2009; Yu et al. 2014; Liu and Tang 2017) and seven species are known from Zhejiang: *S. cirrus* Benick, L., 1940, *S. guangxiensis* Rougemont, 1984, *S. ovalis* Tang, Li & Zhao, 2005, *S. zhulilongi* Tang & Puthz, 2008, *S. lijinweni* Tang & Puthz, 2008, *S. jinlongshanus* Tang & Puthz, 2008

and *S. shenshanjiai* Tang & Puthz, 2008. The members of the group are characterized by the oval paraglossae and the presence of long and suberect setae on abdomen. Recently, two new species of the *Stenus cirrus* group from Zhejiang Province were found in our collections and they will be described in this paper.

Material and methods

The specimens examined in this paper were mainly collected at various locations in Zhejiang, East China by sifting leaf litter in broad leaf forests. Specimens were killed with ethyl acetate and dried. For examination of the male and female genitalia, the apical three abdominal segments were detached from the body after softening in hot water. The aedeagi, together with other dissected parts, were mounted in Euparal (Chroma Gesellschaft Schmidt, Koengen, Germany) on plastic slides. Photos of sexual characters were taken with a Canon G9 camera attached to an Olympus CX31 microscope; habitus photos were taken with a Canon macro photo lens MP-E 65 mm attached to a Canon EOS7D camera and stacked with Zerene Stacker.

The type specimens treated in this study are deposited in the following public and private collections:

SHNU Department of Biology, Shanghai Normal University, P. R. China

cPut Private collection V. Puthz, Schlitz, Germany

The measurements of proportions are abbreviated as follows:

- BL** body length, measured from the anterior margin of the clypeus to the posterior margin of abdominal tergite X
- FL** forebody length, measured from the anterior margin of the clypeus to the apicolateral angle of elytra
- HW** width of head including eyes
- PW** width of pronotum
- EW** width of elytra
- PL** length of pronotum
- EL** length of elytra, measured from humeral angle
- SL** length of elytral suture

Taxonomy

Stenus wuyanlingus Liu, Tang & Luo, sp. n.

<http://zoobank.org/0F0F88C6-8EA2-4316-B391-B24D295BCF1A>

Figs 1, 2, 7–13

Type material. CHINA: Zhejiang: Holotype: ♂, glued on a card with labels as follows: “China: Zhejiang Prov. Taishun County, Wuyanling, 27°42’N, 119°41’E, alt.



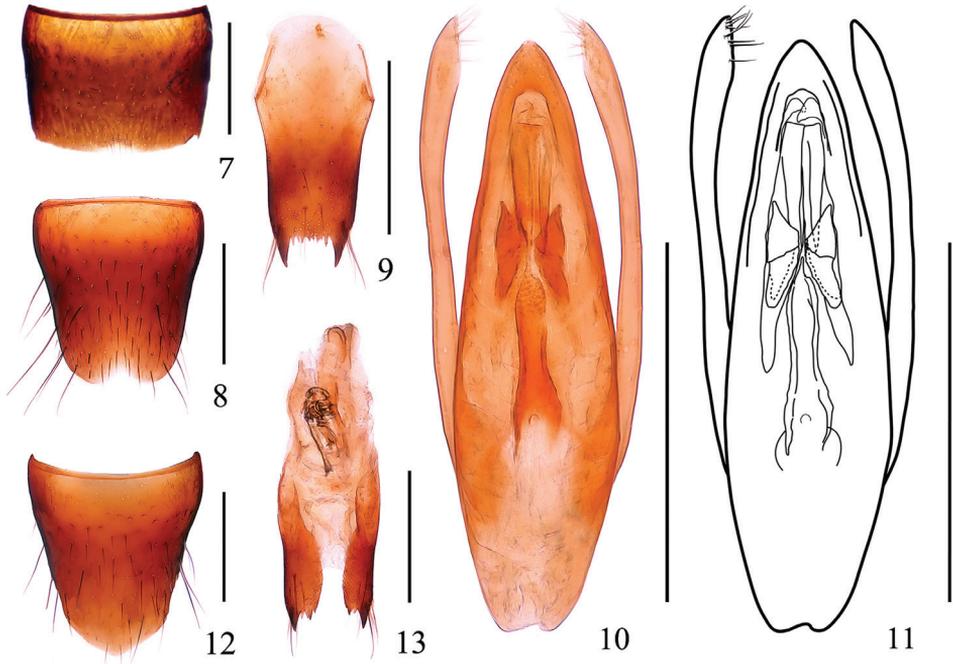
Figures 1–6. Habitus. **1, 2** *Stenus wuyanlingus* sp. n. **3, 4** *Stenus yuyimingi* sp. n. **5, 6** *Stenus ovalis*. Scale bars: 1 mm.

1550 m. 6.V.2012, ZHU Jian-Qing leg”. “Holotype / *Stenus wuyanlingus* / Liu & Tang” [red handwritten label] (SHNU). **Paratypes:** 6♂♂5♀♀, same data as for the holotype. (1♂1♀ in cPut, remainder in SHNU).

Description. Brachypterous. Head black, pronotum and abdomen blackish brown, elytra light brown with median portion more or less lighter. Antennae, maxillary palpi and legs yellowish brown except antennal club infuscate. Labrum reddish brown.

BL: 2.7–3.1 mm, FL: 1.4–1.6 mm. HW: 0.63–0.71 mm, PL: 0.45–0.49 mm, PW: 0.43–0.51 mm, EL: 0.44–0.52 mm, EW: 0.48–0.61 mm, SL: 0.32–0.40 mm.

Head 1.21–1.30 times as wide as elytra; interocular area with two deep longitudinal furrows, median portion convex, slightly extending a little beneath the level of inner eye margins, with a impunctate line along midline; punctures round, larger and sparser in median portion than those near inner margins of eyes, diameter of large punctures about as wide as apical cross section of antennal segment II; interstices between punctures distinctly reticulated, varied from narrower than half the diameter of punctures to a little narrower than diameter of punctures except those along



Figures 7–13. *Stenus wuyanlingus*. **7** male sternite VII **8** male sternite VIII **9** male sternite IX **10, 11** aedeagus **12** female sternite VIII **13** valvifers and spermatheca. Scale bars: 0.25 mm.

the midline of convex median portion, which may be slightly wider than diameter of punctures. Paraglossae oval.

Pronotum 0.94–1.04 times as long as wide; disk uneven, with distinct median longitudinal furrow almost throughout; punctures confluent, varied in size, mostly smaller than large punctures of head; interstices reticulated, narrower than diameter of punctures except those in median area, which may be much wider than diameter of punctures.

Elytra 0.81–0.95 times as long as wide; disk with shallow sutural impression and humeral impression; punctures confluent, slightly larger than those on pronotum in average; interstices rarely reticulated, narrower than half the diameter of punctures.

Legs with tarsomeres IV strongly bilobed.

Abdomen cylindrical; paratergites very narrow with few punctures, present only in segment III, tergites and sternites totally fused in segment IV–VI, posterior margin of tergite VII with indistinct palisade fringe; punctation round to elliptic, gradually becoming smaller and sparser posteriad; interstices smooth, mostly wider than diameter of punctures except those on basal impressions of tergites III–V, which may be distinctly narrower than half the diameter of punctures.

Male. Sternite VII (Fig. 7) with inconspicuous emargination at middle of posterior margin; sternite VIII (Fig. 8) with shallow emargination at middle of posterior margin;

sternite IX (Fig. 9) with long apicolateral projections, posterior margin serrate. Aedeagus (Figs. 10–11) widest at basal third and tapering towards the apex; median longitudinal bands each with ventral band very long, straight, narrowed apically; lateral longitudinal bands short; expulsion clasps each with anterior plate distinctly separated from the posterior plate, rounded apically, posterior plate pointed posteriorly; copulatory tube moderately long, rather stout, with basal chamber submembranous, main tube distinctly divided into basal tube and apical tube, the basal tube gently constricted near the middle, apical tube very thin; parameres longer than median lobe, each with 8–11 setae on apico-internal margins.

Female. Sternite VIII (Fig. 12) with posterior margin weakly pointed at middle; spermatheca (Fig. 13) strongly sclerotized, spermathecal duct with multiple bends.

Distribution. China (Zhejiang).

Remarks. The new species can be easily recognized among Chinese members of the group by the smaller size and reticulations of head and pronotum. It can be distinguished from other species by its sparser punctation along in median area of head and pronotum, and the lighter color of elytra.

Etymology. The specific name is derived from the type locality of this species.

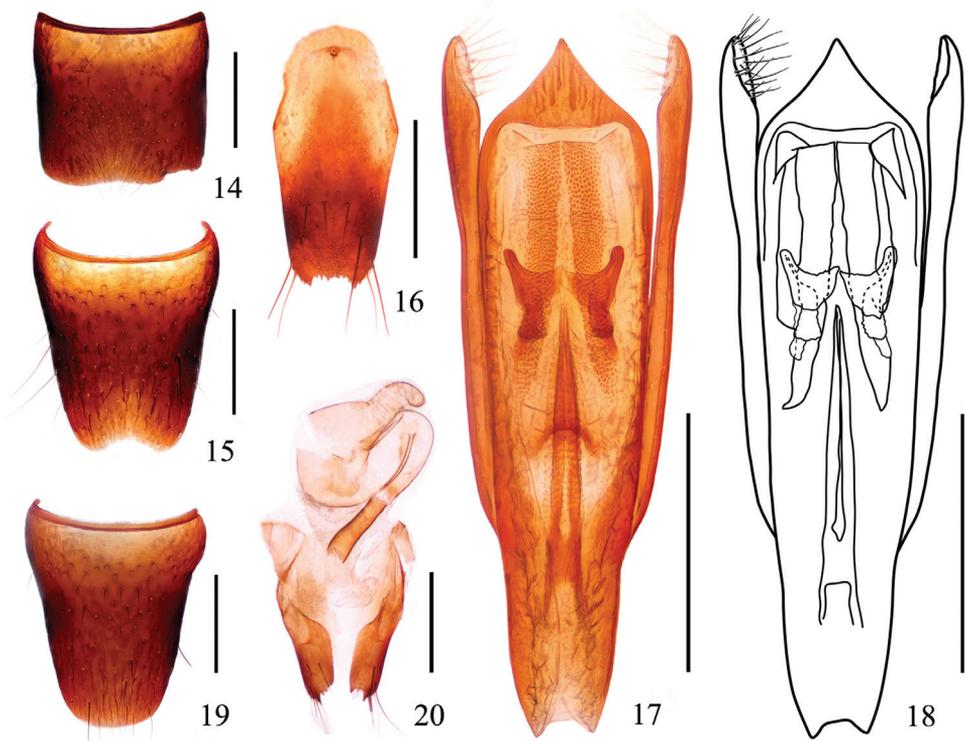
***Stenus yuyimingi* Liu, Tang & Luo, sp. n.**

<http://zoobank.org/40B0916F-3286-4CBA-A7C8-3909E9C019C2>

Figs 3, 4, 14–20

Type material. CHINA: Zhejiang: Holotype: ♂, glued on a card with labels as follows: “China: S. Zhejiang, Lishui City, Longquan Fengyangshan N.R., forest nr. Xiaobian Vil., 27°55’58”N, 119°10’57”E, mixed leaf litter, sifted, 690–780 m, 9.X.2013, Z. Peng, Y.-M. Yu, Z.-W. Yin leg”. “Holotype / *Stenus yuyimingi* / Liu & Tang” [red handwritten label] (SHNU). Paratypes: 1♂, same data as for the holotype, but Mihougu, 27°55’0.18”N, 119°11’52.91”E, near stream, 1116 m, 03.V.2016, Jiang, Liu & Zhou leg (SHNU); 1♂, same data as for the holotype, but Datianping, 27°54’33”-55’18”N, 119°10’20”-17”E, mixed litter, moss, sifted, 1170–1300 m. 7.X.2013, Feng, Peng, Yu, Yin leg. (cPut); 1♂, same data as for the holotype, but Jitou Vil., 27°55’58”N, 119°12’44”E, fern, silvergrass, fir, sifted, ca, 1050 m, 9.X.2013, Z Peng, Y.-M. Yu, Z.-W. Yin leg. (SHNU); 1♂1♀, same data as for the holotype, but Datian-Ping 27°54’36”N, 119°10’20”E, bush leaf, moss, ferns, sifted & beating, 1320 m. 27.IV.2014, Peng, Song, Yan, Yin & Yu leg. (SHNU); 1♀, same data as for the holotype (SHNU); 1♀, same data as for the holotype, but Luao Vil., 27°55’00”N, 119°11’53”E, moss, fern, bamboo, bush, sifted, 1130 m, 4.X.2013, Z Peng, Y.-M. Yu, Z.-W. Yin leg. (SHNU).

Description. Brachypterous. Head black, pronotum and elytra brown, each elytron with median portion inconspicuously lighter, abdomen dark brown. Antennae, maxillary palpi and legs yellowish brown except antennal club infusate. Labrum reddish brown.



Figures 14–20. *Stenus yuyimingi*. **14** male sternite VII **15** male sternite VIII **16** male sternite IX **17**, **18** aedeagus **19** female sternite VIII **20** valvifers and spermatheca. Scale bars: 0.25 mm.

BL: 3.6–4.4 mm, FL: 1.8–2.1 mm. HW: 0.77–0.86 mm, PL: 0.61–0.69 mm, PW: 0.56–0.66 mm, EL: 0.70–0.78 mm, EW: 0.70–0.85 mm, SL: 0.52–0.59 mm.

Head 1.02–1.09 times as wide as elytra; interocular area with two deep longitudinal furrows, median portion convex, extending to the level of inner eye margins; punctures round, distinctly larger and sparser in median portion than those near inner margins of eyes, diameter of large punctures slightly wider than apical cross section of antennal segment II; interstices smooth, narrower than half the diameter of punctures except those along the midline of the median portion, which may be as wide as the diameter of punctures. Paraglossae oval.

Pronotum 0.98–1.10 times as long as wide; disk relatively even with median longitudinal furrow very short and indistinct; punctures mostly round and slightly confluent, similar size to those of head; interstices smooth, mostly narrower than diameter of punctures except in median area, which may be triple as wide as diameter of punctures.

Elytra 0.93–1.00 times as long as wide; disk relatively even; punctures slightly and longitudinally confluent, of similar size to those of pronotum; interstices smooth, distinctly narrower than diameter of punctures.

Legs with tarsomeres IV strongly bilobed.

Abdomen cylindrical; paratergites very narrow and almost impunctate, present only in segment III, tergites and sternites totally fused in segments IV–VI, posterior margin of tergite VII with indistinct palisade fringe; punctures round, gradually becoming smaller and sparser posteriorly; interstices smooth, mostly wider than diameter of punctures except those on basal impressions of tergites III–V, which may be distinctly narrower than half the diameter of punctures.

Male. Sternite VII (Fig. 14) with inconspicuous emargination at middle of posterior margin; sternite VIII (Fig. 15) with shallow emargination at middle of posterior margin; sternite IX (Fig. 16) with short apicolateral projections, posterior margin serrate. Aedeagus (Figs. 17–18) apical sclerotized area triangular with a sharp projection at apex; median longitudinal bands each with ventral band very long, straight, narrowed apically; lateral longitudinal bands short; expulsion clasps each with anterior plate distinctly separated from the posterior plate, rounded apically; copulatory tube very long, rather slender, with basal chamber submembranous and main tube, the main tube gradually shrink, pointed apically; parameres as long as median lobe, each with about 19–22 setae on apico-internal margins.

Female. Sternite VIII (Fig. 19) entire; spermatheca (Fig. 20) strongly sclerotized, swollen in the middle of spermathecal duct.

Distribution. China (Zhejiang).

Remarks. The new species can be easily distinguished from the Chinese members of the group by the coloration and sexual characters.

Etymology. This species is named in honor of Mr. Yi-Ming Yu who collected some specimens of the new species.

***Stenus ovalis* Tang, Li & Zhao, 2005**

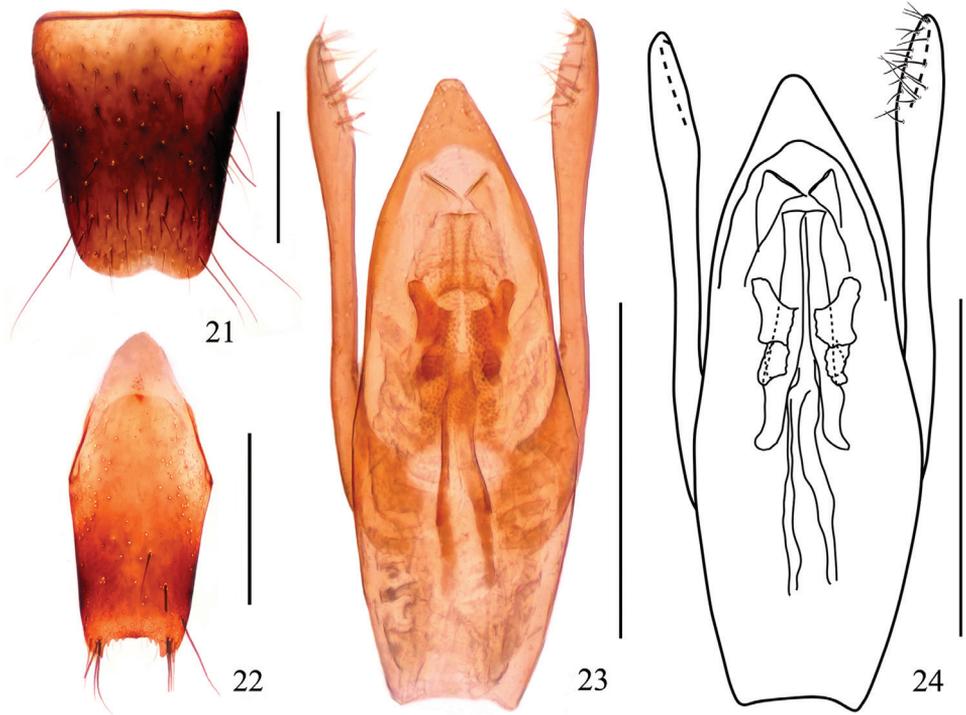
Figs 5, 6, 21–24

Stenus ovalis Tang, Li & Zhao, 2005: 613.

Material examined. CHINA: Zhejiang: 1♂, Longquan City, Fengyangshan N.R., Mihougu, 27°55'0.18"N, 119°11'52.91"E, near stream, 1116 m. 03.V.2016, Jiang, Liu & Zhou leg. (SHNU).

Measurements. BL: 4.2 mm, FL: 1.9 mm. HW: 0.77 mm, PL: 0.62 mm, PW: 0.56 mm, EL: 0.69 mm, EW: 0.67 mm, SL: 0.52 mm. Head 1.14 times as wide as elytra, pronotum 1.10 times as long as wide, elytra 1.03 times as long as wide.

Male. Sternite VIII (Fig. 21) with a shallow emargination at middle of posterior margin; sternite IX (Fig. 22) with short apicolateral projections, posterior margin serrate. Aedeagus (Figs. 23–24) apical sclerotized portion roundly projected at apex; median longitudinal bands each with ventral band long, narrowed apically; lateral longitudinal bands short; expulsion clasps each with anterior plate distinctly separated from the posterior plate, rounded apically; copulatory tube moderately long, rather stout, with basal chamber submembranous, main tube distinctly divided into basal tube and api-



Figures 21–24. *Stenus ovalis*. **21** male sternite VIII **22** male sternite IX **23, 24** aedeagus. Scale bars: 0.25 mm.

cal tube, the basal tube gently constricted near the middle, apical tube relatively thin; parameres longer median lobe, each with about 19 setae on apico-internal margins.

Distribution. China (Zhejiang).

Remarks. This is a new distributional locality of the species which is originally described from Wuyanling Nature Reserve of Zhejiang.

Key to species of the *Stenus cirrus* group of Zhejiang

- 1 Abdominal tergites III–VI with narrow to very narrow linear margination.... *S. cirrus* L. Benick, 1940
- Only abdominal tergite III with complete paratergites, tergites, and sternites totally fused in segments IV–VI..... 2
- 2 Small species, BL = 2.3–3.1 mm, head and pronotum with distinct reticulation..... 3
- Large species, BL = 3.5–5.0 mm, interstices of head and pronotum smooth... 4

- 3 Interstices in median portions of head and pronotum much wider than diameter of punctures. Habitus: Figs. 1, 2; sexual characters: Figs. 7–13.....
.....*S. wuyanlingi* sp. n.
- Interstices in median portions of head and pronotum much narrower than diameter of punctures. Habitus: Fig. 4 (in Tang et al. 2008); sexual characters: Figs. 20–24 (in Tang et al. 2008) *S. shenshanjiai* Tang, Zhao & Puthz, 2008
- 4 Elytra without orange spots. Habitus: Figs. 3, 4; sexual characters: Figs. 14–20
.....*S. yuyimingi* sp. n.
- Elytra with orange spots..... 5
- 5 Head distinctly wider than elytra 6
- Head distinctly narrower than elytra. Aedeagus: Fig. 3 (in Puthz, 1998). BL = 3.5–4.7 mm.....
.....*S. guangxiensis* Rougemont, 1984
- 6 Punctuation of pronotum and elytra dense but not crowded. Habitus: Fig. 3 (in Tang et al. 2005); sexual characters: Figs. 12–15 (in Tang et al. 2005). BL = 4.1–4.7 mm
.....*S. ovalis* Tang, Li & Zhao, 2005
- Punctuation of pronotum and elytra very dense, crowded. Species best identified by their sexual characters..... 7
- 7 Punctuation of elytra very densely crowded. Male: apical emargination 8th abdominal sternite very broad and shallow. Habitus: Fig. 1 (in Tang et al. 2008); sexual characters: Figs. 7–11 (in Tang et al. 2008). BL = 3.7–5.0 mm.....
.....*S. zhulilongi* Tang & Puthz, 2008
- Punctuation of elytra less dense, less crowded. Male: apical emargination of 8th abdominal sternite narrower, rounded..... 8
- 8 Elytral spot longer, extending towards shoulder. Habitus: Fig. 2 (in Tang et al. 2008); sexual characters: Figs. 12–15 (in Tang et al. 2008). BL = 3.8–5.0 mm.....
.....*S. lijnweni* Tang & Puthz, 2008
- Elytral spot shorter than half elytron length. Habitus: Fig. 3 (in Tang et al. 2008); sexual characters: Figs. 16–19 (in Tang et al. 2008). BL = 3.7–5.0 mm.....
.....*S. jiulongshanus* Tang & Puthz, 2008

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The Tabanidae of the Mitaraka expedition, with an updated check list of French Guiana (Diptera)

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Abstract

This paper documents the horse fly fauna collected in lowland rainforest in the southwesternmost part of French Guiana (Mitaraka). During this “Our Planet Revisited” survey nine tabanid species were recorded from French Guiana for the first time: *Chrysops ecuadorensis* Lutz, *C. incisus* Macquart, *Catachlorops amazonicus* Henriques & Gorayeb, *Chlorotabanus flagellatus* Krolow & Henriques, *Cryptoylus cauri* Stone, *Phaeotabanus phaeopterus* Fairchild, *Philipotabanus stigmaticalis* (Kröber), *Stypommisa captiroptera* (Kröber) and *Tabanus amapaensis* Fairchild. An updated check list of Tabanidae of French Guiana is presented, including 79 species and one unidentified *Chrysops*.

Keywords

Amazon basin, distribution, horse flies, list of species, Neotropics, new records

Introduction

The horse flies (Diptera, Tabanidae) have a worldwide distribution with almost 4,400 valid species (Pape et al. 2011). The Neotropical region has the highest species richness with approximately 1,205 species (Henriques et al. 2012), about 28% of the global tabanid fauna.

In French Guiana tabanid diversity has only poorly been studied. Except for species described by e.g., Fabricius and Macquart in the 18th and 19th centuries, only few species have been recorded from this part of South America and the Kröber catalogue (1934) only lists 22 species. Subsequent species lists were provided by Floch (1955) and Floch and Fauran (1955). Fairchild (1970) extended the list of French Guiana to 38 species by compiling data from the literature (including original descriptions), Floch's work, and by examining material from the Muséum National d'Histoire Naturelle (MNHN, Paris, France). In the second part of the same manuscript, through material received from A.S. Balachowsky, Fairchild described two new species and added eight new records, which further increased the number to 48 species. More recently Raymond et al. (1984) recorded another 15 species for the first time from French Guiana. Other significant inventories by Raymond (1986, 1987) investigating the efficiency of sampling methods also added new records and confirmed old ones. In contrast to the compiled number of species from the above-mentioned papers (63 spp.), in the most recent Neotropical catalogue merely 48 species were cited from French Guiana, with 35 restricted to French Guiana, and 13 with a wider Neotropical distribution (Coscarón and Papavero 2009).

In 2015, a biodiversity survey was conducted in the southwesternmost part of French Guiana (Pascal et al. 2015) that produced a substantial number of dipteran samples, including diverse Tabanidae (Pollet et al. 2015). The objective of the present paper is to document on the tabanid fauna encountered during the Mitaraka 2015 survey (French Guiana) and to present an updated check list of Tabanidae of French Guiana.

Methods

In 2015 the “Our Planet Revisited” or “La Planète revisitée” Guyane 2014–2015 expedition, also known as the “Mitaraka 2015 survey”, was conducted in French Guiana (Pollet et al. 2014, Pascal et al. 2015). This was the 5th edition of a large-scale biodiversity survey undertaken by the French Museum of Natural History in Paris and the NGO Pro-Natura international (both in France). Both organizations jointly run the “Our Planet Reviewed” programme which aims to rehabilitate taxonomical work that focuses on the largely neglected components of global biodiversity, i.e., invertebrates (both marine and terrestrial). Basic arthropod taxonomy and species discovery were at the heart of the survey, although forest ecology and biodiversity distribution modelling, nevertheless, were also part of the project. The expedition was conducted in the Mitaraka Mountains, a largely unknown and uninhabited area in the southwestern-

most corner of French Guiana, directly bordering Surinam and Brazil (Fig. 1). It is part of the Tumuc Humac mountain chain, extending east in Amapa region and west in southern Surinam. The area consists primarily of tropical lowland rain forest with scattered inselbergs, isolated hills that stand above the forest plains (Figs 2–5).

From 22 February to 11 March 2015, a team of 32 researchers explored the area, including 12 invertebrate experts. During a second period (11 – 27 March), a second equal-sized team took over and a third smaller team returned to the site from 12 to 20 August 2015. MP was the coordinator of the collected Diptera, and was also the only Diptera worker actively involved in this survey. Invertebrate sampling was carried out near the base camp, on the drop zone (an area near the base camp that had been clear-cut entirely to allow helicopters to land) and, in particular, along four trails of approximately 3.5 km that started from the base camp in four different directions (Fig. 6). During the first period (22 February to 11 March 2015) more than 21 different collecting methods were applied, with a total of 401 traps operational within a perimeter of 1 km². This array consisted primarily of pan traps (n = 280), Charax butterfly traps (n = 50), square Malaise traps (SLAM) (n = 32), Flight Intercept Traps (FIT, n = 13) and Butterfly banana traps (n = 12), but also a light trap (Figs 7–10). In the second and third periods, pan traps were no longer included. A total of 217 invertebrate samples (often pooled yields of different traps of the same type) were examined, including 93 sweepnet samples, and 27 and 62 samples collected by SLAM and coloured pan traps (24 blue, 22 yellow and 16 white traps), respectively. As MP mainly focused on Dolichopodidae during active collecting, sweep net samples only rarely contained tabanids. Relevant metadata on the samples (e.g., exact locality and geographic coordinates, date or time period, collection method, and collector(s)) are provided in Appendix 1.

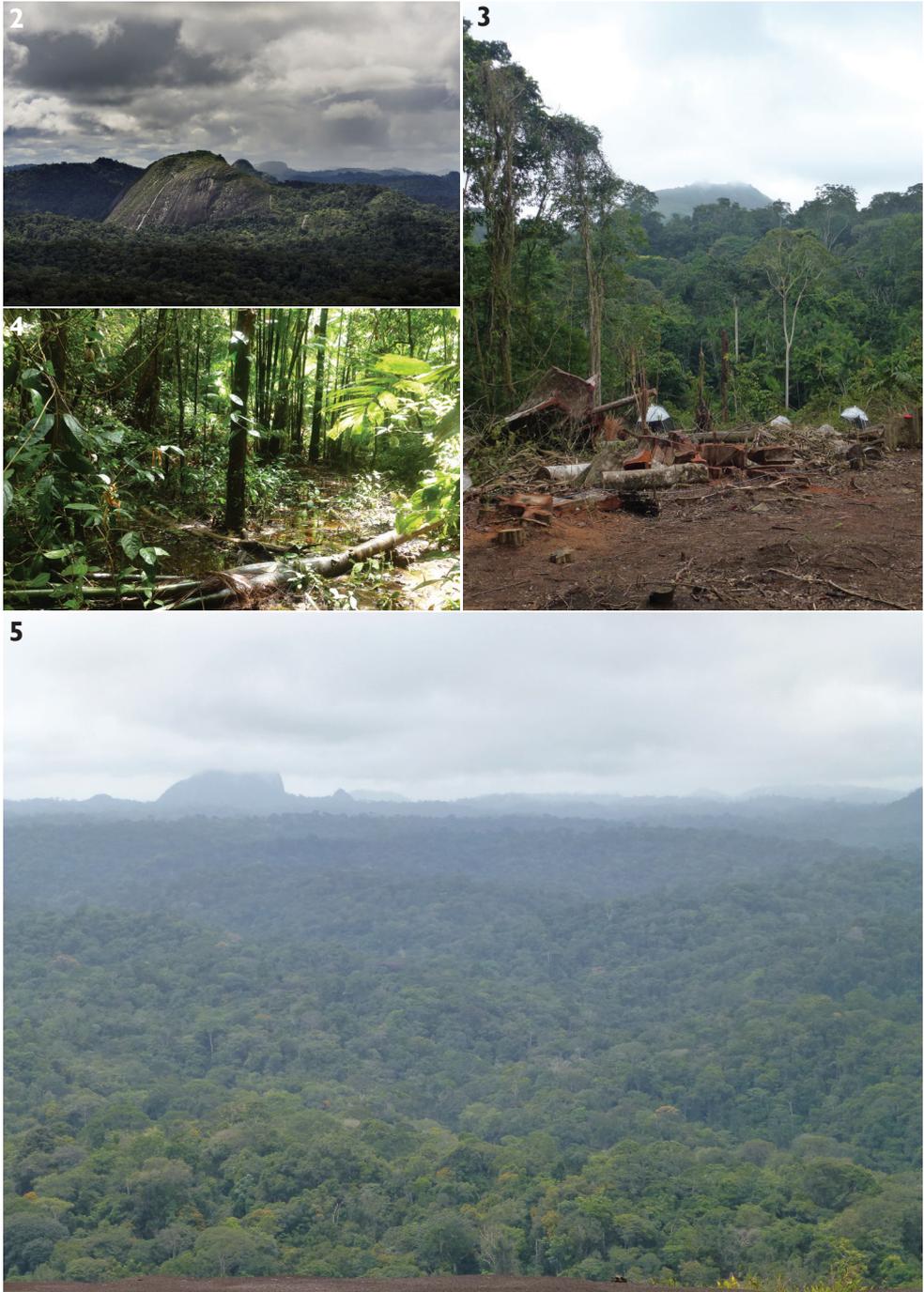
Non-pan trap samples were sorted to insect orders and families at the SEAG offices (<http://insectafgseag.myspecies.info/fr>), while pan trap samples were treated similarly at MP's home lab. Dipteran subsamples (mostly per family) were subsequently disseminated among experts worldwide, in the case of Tabanidae to TKK and ALH. The identification of the tabanid species was conducted by ALH and TKK using taxonomical reviews and identification keys (Barretto 1950, Fairchild and Philip 1960, Fairchild 1976, Wilkerson and Fairchild 1982, Fairchild 1983, 1984, 1985, Gorayeb and Fairchild 1985, Fairchild and Wilkerson 1986, Burger 1996, Henriques and Gorayeb 1999, Henriques 2006, Krolow and Henriques 2010, Turcatel et al. 2010, Krolow et al. 2015), original descriptions, and direct comparison to reliably identified species from the Invertebrates Collection of the Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil (INPA) and the Entomological Collection of the Universidade Federal do Tocantins, Porto Nacional, Brazil (CEUFT). All collected material was stored in 70% alcohol during the expedition, being dry mounted on pins only about 11 months later in the laboratory. Preservation in alcohol usually affects the recognition of diagnostic features, which often no longer allows identification to species level.

In order to build an updated check list, species distribution records were compiled from the following literature: Fairchild (1976, 1983, 1984), Henriques and Gorayeb (1993), Henriques and Rafael (1993), Fairchild and Burger (1994), Henriques (1997),



Figure 1. Map of French Guiana with indication of the investigated area (Mitaraka).

Coscarón and Papavero (2009), Krolow and Henriques (2010), Turcatel et al. (2010), Krolow et al. (2015), and Henriques (2016). Doubtful country records are indicated by “?”. Next to previously published records, all records from the Mitaraka 2015 survey are included in the check list. Each of these records is represented by the sample code and the number and gender of the collected specimens. Detailed information on the samples is given in Appendix 1. First records for French Guiana are explicitly indicated.



Figures 2–5. Investigated habitat types at Mitaraka **2** Inselberg Sommet-en-Cloche (photo Xavier Desmier) **3** drop zone (photo Marc Pollet) **4** river bed forest (photo Marc Pollet) **5** lowland rain forest of southern French Guiana (photo Marc Pollet).

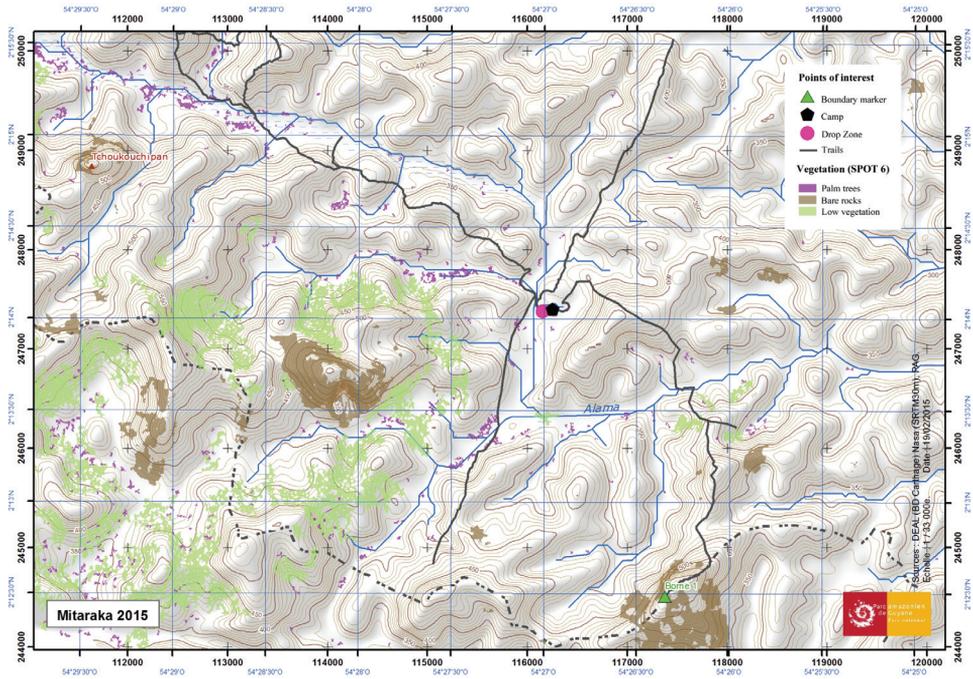


Figure 6. Mitaraka site map with four trails indicated (map by Maël Dewynter).

The specimens collected during the Mitaraka 2015 survey are deposited in the Muséum National d’Histoire Naturelle, Paris, France (MNHN), CEUFT, and INPA, according to an agreement between TKK and MNHN. Another acronym used in this paper is AMNH: American Museum of Natural History, New York, USA.

Results

A total number of 255 tabanids of 24 species was collected during the Mitaraka 2015 survey. The subfamily Tabaninae is clearly the best represented with 19 species, followed by Chrysopsinae with three species, and Pangoniinae with two species. Of the 24 species only one belonging to *Chrysops* cannot be identified at a specific level. Female specimens were dominant in the samples, accounting for 233 specimens. Nineteen of the 22 males were collected at the light trap. The 6 m long Malaise trap that was installed over a river proved to be most productive, and collected nearly 2/5 of the specimens (see Table 1). Also SLAM traps, light traps, and flight intercept traps yielded at least 10 different species. In sharp contrast to this, neither blue nor yellow or white pan traps produced one single tabanid. In palm forests and forests along rivers, only *Bolbodimyia brunneipennis* Stone, *Dichelacera marginata* Macquart and *Pityocera cervus* (Wiedemann) were encountered. Fifteen different species were encountered on or near the drop zone and 16 species in the Malaise trap over the river. *D. marginata* seems



Figures 7–10. Collecting techniques applied during Mitaraka survey **7** SLAM (photo Marc Pollet), **8** 6m long Malaise trap (MT) (photo Julien Touroult) **9** flight intercept trap (FIT), with Eddy Poirier (photo Julien Touroult) **10** light trap (LT), with Eddy Poirier (photo Marc Pollet).

Table 1. Overview of sampling methods that yielded Tabanidae during the Mitaraka 2015 survey.

Collecting methods*	MT(6m)	LT	SLAM	FIT	SW	PVP	PVB
Total number of examined samples	5	10	27	8	93	2	1
Tabanidae species (no. males + females)							
<i>Fidena auripes</i> (Ricardo)			2	3			
<i>Pityocera cervus</i> (Wiedemann)	4		9				
<i>Chrysops ecuadorensis</i> Lutz				1			
<i>Chrysops incisus</i> Macquart							1
<i>Chrysops</i> sp.			1	1			
<i>Bolbodimyia brunneipennis</i> Stone	4	1	8	1	1		
<i>Catachlorops amazonicus</i> Henriques & Gorayeb			1				
<i>Chlorotabanus flagellatus</i> Krolow & Henriques	1	2					
<i>Chlorotabanus inanis</i> (Fabricius)	3	5	1				
<i>Cryptoylus cauri</i> Stone	9	15	2				
<i>Diachlorus curvipes</i> (Fabricius)	2			5			
<i>Diachlorus fuscistigma</i> Lutz	2		1	1			
<i>Dichelacera damicornis</i> (Fabricius)	10	1	1			1	
<i>Dichelacera marginata</i> Macquart	34	1	18	1	3		
<i>Leucotabanus albovarius</i> (Walker)	1	6					
<i>Phaeotabanus phaeopterus</i> Fairchild	1						
<i>Philipotabanus stigmatalis</i> (Kröber)		1	1				
<i>Stypommisa captiroptera</i> (Kröber)		6	1	1			
<i>Stypommisa modica</i> (Hine)	1						
<i>Tabanus amapaensis</i> Fairchild			1				
<i>Tabanus antarcticus</i> Linnaeus	1						
<i>Tabanus discus</i> Wiedemann	1						
<i>Tabanus occidentalis</i> Linnaeus	22	5		29			
<i>Tabanus trivittatus</i> Fabricius	2	15	1	1		1	
Number species	16	11	14	10	2	2	1
Number specimens	98	58	48	44	4	2	1

* MT(6m): 6m long Malaise trap, LT: light trap, SLAM: square Malaise trap, FIT: flight intercept trap, SW: sweep net, PVP: pink polytrap automatic light trap, PVB: blue polytrap automatic light trap.

to prefer humid sites near open water as only one specimen was collected on the drop zone compared to 15 in wet forests and 34 along the river.

This investigation revealed ten species recorded for the first time from French Guiana (see check list). After also screening previous records in the literature, an updated check list of 80 species of Tabanidae is presented here.

List of species of Tabanidae from French Guiana

PANGONIINAE

SCIONINI

Fidena analis (Fabricius, 1805)

Records of French Guiana: see Fairchild and Burger (1994).

Distribution: Guyana, French Guiana, Brazil (Amazonas).

Fidena auripes (Ricardo, 1900)

Figure 11A

Records of French Guiana: see Fairchild (1970). **Examined material:** sample Mitaraka/219 (1♀ MNHNP); Mitaraka/224 (1♀ CEUFT; 1♀ INPA); Mitaraka/229 (1♀ CEUFT; 1♀ MNHNP).

Distribution: Guyana, Suriname, French Guiana, Brazil (Pará).

Fidena aurulenta Gorayeb, 1986

Records of French Guiana: see Fairchild and Burger (1994).

Distribution: French Guiana, Brazil (Pará).

Fidena mattogrossensis (Lutz, 1912)

Records of French Guiana: see Fairchild (1970), as *Fidena fulgifascies* Barretto, 1957.

Distribution: Guyana, Suriname, French Guiana, Brazil (Amazonas, Rondônia, Mato Grosso).

Fidena pseudoaurimaculata (Lutz, 1909)

Records of French Guiana: see Fairchild (1970) and Henriques (2016).

Distribution: Venezuela, Guyana, Suriname, French Guiana, Brazil (Amazonas to Amapá, and Mato Grosso).

Fidena schildi (Hine, 1925)

Records of French Guiana: see Fairchild (1970) and Henriques and Gorayeb (1993).

Distribution: Costa Rica to Colombia, French Guiana, Brazil (Roraima, Amazonas).

***Pityocera cervus* (Wiedemann, 1828)**

Figure 11B

Records of French Guiana: see Fairchild (1970), Henriques & Gorayeb (1993), Henriques (1997) and Krolow et al. (2015). **Examined material:** sample Mitaraka/150 (1♀ MNHNP); Mitaraka/186 (1♀ MNHNP); Mitaraka/189 (3♀ MNHNP); Mitaraka/199 (2♀ CEUFT); Mitaraka/202 (1♀ MNHNP); Mitaraka/207 (1♀ MNHNP); Mitaraka/208 (1♀ MNHNP); Mitaraka/213 (1♀ INPA); Mitaraka/229 (2♀ CEUFT).

Distribution: Colombia, Venezuela, Guyana, Suriname, Ecuador, French Guiana, Brazil (North), Peru, Bolivia.

CHRYSOPSINAE**CHRYSOPSINI*****Chrysops ecuadorensis* Lutz, 1909 – new to French Guiana**

Figure 11C

Examined material: sample Mitaraka/224 (1♀ CEUFT).

Updated Distribution: Ecuador, Peru (Madre de Dios), Guyana, French Guiana, Brazil (Pará).

***Chrysops formosus* Kröber, 1926**

Records of French Guiana: see Fairchild (1970).

Distribution: Trinidad, French Guiana, Brazil (Acre, Rondônia, Amazonas, Roraima, Pará, Amapá, Maranhão, Bahia).

***Chrysops incisus* Macquart, 1846 – new to French Guiana**

Figure 11D

Examined material: sample Mitaraka/227 (1♀ INPA).

Updated Distribution: Colombia, Guyana, Suriname, French Guiana, Brazil (Acre, Amazonas, Pará, Amapá, Maranhão), eastern Peru, Bolivia.

***Chrysops laetus* Fabricius, 1805**

Records of French Guiana: see Raymond et al. (1984).

Distribution: Colombia (Vaupés), Suriname, French Guiana, Brazil (Rondônia, Amazonas, Roraima, Pará, Amapá, Paraná, Rio Grande do Sul), ?Paraguay, ?Argentina (Misiones).

Chrysops tristis (Fabricius, 1798)

Records of French Guiana: see Fabricius (1798) and Fairchild (1970).

Distribution: Trinidad, Venezuela, Guyana, Suriname, French Guiana, ?Brazil.

Chrysops varians Wiedemann, 1828

Records of French Guiana: see Fairchild (1970).

Distribution: Panama, Trinidad, Colombia, Venezuela, Guyana, French Guiana, Ecuador, Peru, Brazil (Amapá to Rio Grande do Sul), Argentina (Misiones, Entre Ríos, Chaco), Paraguay.

Chrysops variegatus (De Geer, 1776)

Records of French Guiana: see Fairchild (1970).

Distribution: Southern Mexico to Argentina (Misiones), West Indies.

Chrysops venezuelensis Kröber, 1925

Records of French Guiana: see Raymond et al. (1984), as subspecies of *Chrysops variegatus*.

Distribution: Trinidad, Venezuela, Suriname, French Guiana, Brazil (Pará).

Chrysops weberi Bequaert, 1946

Records of French Guiana: see Fairchild (1970).

Distribution: eastern Colombia, Venezuela, Guyana, French Guiana, Peru, Brazil (Rondônia, Amazonas).

Chrysops sp.

Figure 11E

Examined material: sample Mitaraka/218 (1♀ CEUFT); Mitaraka/220 (1♀ MNHNP).

Comment: Two specimens of this morphotype were captured, but it was not possible to identify them with safety by the lack of recent taxonomic works of this genus.

RHINOMYZINI

Betrequia ocellata Oldroyd, 1970

Records of French Guiana: see Raymond et al. (1984).

Distribution: eastern Colombia, French Guiana, Brazil (Amazonas, Pará, Ceará).

TABANINAE

DIACHLORINI

Acanthocera gorayebi Henriques & Rafael, 1992

Records of French Guiana: see Henriques and Rafael (1999).

Distribution: Guyana, French Guiana, Peru, Brazil (Acre, Rondônia, Amazonas, Pará, Amapá, western Maranhão, Mato Grosso).

Acanthocera marginalis Walker, 1854

Records of French Guiana: see Fairchild (1970) and Henriques and Rafael (1993).

Distribution: Colombia, Guyana, Suriname, French Guiana, Trinidad, Ecuador (Napo, Morona Santiago), Peru (Loreto), Brazil (Acre, Roraima, Amazonas, Pará, Amapá, Mato Grosso).

Bolbodimyia brunneipennis Stone, 1954

Figure 11F

Records of French Guiana: according to Fairchild (1970), the specimen was erroneously identified by Surcouf (1921) as *Bolbodimyia bicolor* (Bigot) from the locality of Maroni. One female from Saint Laurent du Maroni is deposited at the AMNH (Henriques 2016). **Examined material:** sample Mitaraka/104 (1♀ MNHNP); Mitaraka/115 (1♂ CEUFT); Mitaraka/150 (2♀ MNHNP); Mitaraka/186 (2♀ CEUFT); Mitaraka/189 (2♀ MNHNP); Mitaraka/191 (1♀ MNHNP); Mitaraka/199 (1♀ MNHNP); Mitaraka/200 (1♀ MNHNP); Mitaraka/208 (1♀ MNHNP); Mitaraka/211 (1♀ MNHNP); Mitaraka/213 (1♀ INPA); Mitaraka/219 (1♀ CEUFT).

Distribution: Guyana, French Guiana, Brazil (Roraima, Pará, Amapá).

***Catachlorops amazonicus* Henriques & Gorayeb 1999 – new to French Guiana**

Figure 11G

Examined material: sample Mitaraka/229 (1♀ INPA).

Updated distribution: French Guiana, Brazil (Amapá and Amazonas), Peru.

***Catachlorops balachowskyi* Fairchild, 1970**

Records of French Guiana: see Fairchild (1970).

Distribution: French Guiana.

***Catachlorops halteratus* Kröber, 1931**

Records of French Guiana: see Fairchild (1970).

Distribution: Guyana, Suriname, French Guiana, Peru (Loreto), Brazil (Rondônia, Amazonas, Roraima, Pará, Maranhão, Mato Grosso).

***Catachlorops rubiginosus* (Summers, 1911)**

Records of French Guiana: see Raymond et al. (1984) as *Catachlorops rubiginosa*.

Distribution: Guyana, French Guiana, Peru, Brazil (Amazonas, Pará, Mato Grosso).

***Catachlorops rufescens* (Fabricius, 1805)**

Records of French Guiana: see Fairchild (1970).

Distribution: Guyana, French Guiana, Brazil (Rondônia, Amazonas, Roraima, Pará, Maranhão, Mato Grosso).

***Chlorotabanus flagellatus* Krolow & Henriques, 2009 – new to French Guiana**

Figure 11H

Examined material: sample Mitaraka/100 (1♀ MNHNP); Mitaraka/102 (1♂ CEUFT); Mitaraka/186 (1♀ CEUFT).

Updated distribution: French Guiana, Brazil (Amazonas, Pará).

***Chlorotabanus inanis* (Fabricius, 1787)**

Figure 11I

Records of French Guiana: see Fairchild (1970), Krolow and Henriques (2010) and Henriques (2016). **Examined material:** sample Mitaraka/008 (1♂ MNHNP); Mitaraka/029 (1♂ CEUFT); Mitaraka/100 (1♀ MNHNP); Mitaraka/102 (1♀ CEUFT); Mitaraka/115 (1♀ MNHNP); Mitaraka/186 (1♀ MNHNP); Mitaraka/188 (2♀ MNHNP); Mitaraka/229 (1♀ MNHNP).

Distribution: Southern Mexico to southern Brazil.

***Chlorotabanus leucochlorus* Fairchild, 1961**

Records of French Guiana: see Fairchild (1970) and Krolow and Henriques (2010).

Distribution: Colombia, Venezuela, eastern Peru, Guyana, Suriname, French Guiana, Brazil (Amapá, Amazonas, Pará, Maranhão, Rondônia).

***Chlorotabanus leuconotus* Krolow & Henriques, 2010**

Records of French Guiana: see Krolow and Henriques (2010).

Distribution: Colombia, Guyana, French Guiana, Brazil (Roraima, Amazonas, Pará, Maranhão, Rondônia); Peru (Madre de Dios).

***Chlorotabanus mexicanus* (Linnaeus, 1758)**

Records of French Guiana: see Fairchild (1970), Krolow and Henriques (2010) and Henriques (2016).

Distribution: Mexico, Belize, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Venezuela, Trinidad and Tobago, Suriname, French Guiana, Brazil (Pará), Ecuador.

***Cryptotylus cauri* Stone, 1944 – new to French Guiana**

Figure 11J

Examined material: sample Mitaraka/008 (1♀ MNHNP); Mitaraka/086 (1♀ CEUFT); Mitaraka/100 (9♀ MNHNP); Mitaraka/102 (1♀ CEUFT); Mitaraka/115 (3♀ CEUFT); Mitaraka/186 (2♀ MNHNP); Mitaraka/188 (1♀ MNHNP); Mitaraka/189 (4♀ MNHNP, 2♀ INPA); Mitaraka/229 (2♀ MNHNP).

Updated Distribution: Venezuela, Suriname, French Guiana.

Cryptotylus unicolor (Wiedemann, 1828)

Records of French Guiana: see Fairchild (1970).

Distribution: Panama to Brazil (as far as Mato Grosso), Paraguay, Argentina (Chaco).

Diachlorus bicinctus (Fabricius, 1805)

Records of French Guiana: see Raymond et al. (1984).

Distribution: Venezuela, Suriname, French Guiana, Trinidad, Peru, Bolivia, Brazil (Acre, Rondônia, Amazonas, Roraima, Pará, Amapá, Maranhão, Mato Grosso, Paraíba, Bahia).

Diachlorus curvipes (Fabricius, 1805)

Figure 11K

Records of French Guiana: see Fairchild (1970). **Examined material:** sample Mitaraka/186 (1♀ MNHNP); Mitaraka/189 (1♀ CEUFT); Mitaraka/219 (3♀ MNHNP); Mitaraka/220 (1♀ MNHNP); Mitaraka/224 (1♀ CEUFT).

Distribution: Costa Rica, Panama to Suriname, French Guiana, eastern Peru, Bolivia and Brazil (Roraima, Pará, Amapá, Rondônia, Maranhão, Paraíba, Mato Grosso, ?Minas Gerais), Trinidad.

Diachlorus fuscistigma Lutz, 1913

Figure 11L

Records of French Guiana: see Raymond et al. (1984). **Examined material:** sample Mitaraka/186 (1♀ MNHNP); Mitaraka/188 (1♀ CEUFT); Mitaraka/218 (1♀ MNHNP); Mitaraka/220 (1♀ MNHNP).

Distribution: Colombia, Suriname, French Guiana, Ecuador, Peru (Loreto), Brazil (Acre, Rondônia, Amazonas, Roraima, Pará, Amapá, Bahia), Bolivia.

Diachlorus scutellatus (Macquart, 1838)

Records of French Guiana: see Macquart (1838) and Fairchild (1970).

Distribution: Trinidad, Venezuela, Guyana, Suriname, French Guiana, Brazil (Amazonas, Pará).

***Dichelacera damicornis* (Fabricius, 1805)**

Figure 12A

Records of French Guiana: see Fairchild (1970) and Henriques and Gorayeb (1993). **Examined material:** sample Mitaraka/048 (1♀ MNHNP); Mitaraka/186 (5♀ MNHNP); Mitaraka/188 (3♀ MNHNP); Mitaraka/189 (3♀ CEUFT); Mitaraka/222 (1♀ CEUFT); Mitaraka/229 (1♀ MNHNP).

Distribution: ?Colombia, Venezuela to Brazil (Amazonas, Pará).

***Dichelacera marginata* Macquart, 1847**

Figure 12B

Records of French Guiana: see Macquart (1847), Fairchild (1970) and Henriques (2016). **Examined material:** sample Mitaraka/074 (2♀ MNHNP); Mitaraka/089 (1♀ MNHNP); Mitaraka/100 (1♀ MNHNP); Mitaraka/150 (10♀ CEUFT); Mitaraka/186 (17♀ MNHNP); Mitaraka/188 (6♀ MNHNP); Mitaraka/189 (10♀ MNHNP, 1♀ INPA); Mitaraka/191 (2♀ CEUFT); Mitaraka/192 (1♀ MNHNP); Mitaraka/195 (2♀ MNHNP); Mitaraka/207 (2♀ MNHNP); Mitaraka/229 (2♀ CEUFT).

Distribution: Nicaragua to northern Brazil and eastern Peru.

***Dichelacera t-nigrum* Fabricius, 1805**

Records of French Guiana: see Raymond et al. (1984).

Distribution: Venezuela and Guyana to Brazil (Pará).

***Lepiselaga crassipes* (Fabricius, 1805)**

Records of French Guiana: see Fairchild (1970).

Distribution: Mexico to northern Argentina (Formosa, Chaco, Salta, Tucumán, Santa Fé, Buenos Aires), Cuba, Jamaica, Hispaniola, Puerto Rico.

***Leucotabanus albovarius* (Walker, 1854)**

Figure 12C

Records of French Guiana: see Raymond et al. (1984). **Examined material:** sample Mitaraka/008 (1♀, 1♂ MNHNP); Mitaraka/100 (1♀, 1♂ MNHNP); Mitaraka/102 (1♀, 1♂ CEUFT); Mitaraka/189 (1♀ CEUFT).

Distribution: Guyana, Suriname, French Guiana, Ecuador (Napó, Orellana), Peru, Bolivia, Brazil (Acre, Rondônia, Amazonas, Roraima, Pará, Amapá).

***Leucotabanus exaestuans* (Linnaeus, 1758)**

Records of French Guiana: see Fairchild (1970).

Distribution: Mexico to Bolivia (Chapare) and Argentina (Salta, Chaco, Misiones), Trinidad.

***Leucotabanus janinae* Fairchild, 1970**

Records of French Guiana: see Fairchild (1970).

Distribution: Colombia, Suriname, French Guiana, Brazil (Amazonas, Pará, Amapá).

***Phaeotabanus cajennensis* (Fabricius, 1787)**

Records of French Guiana: see Fabricius (1787), Fairchild (1970).

Distribution: Trinidad to Colombia and French Guiana, Brazil (as far as São Paulo, Paraná) and Bolivia.

***Phaeotabanus fervens* (Linnaeus, 1758)**

Records of French Guiana: see Fairchild (1970).

Distribution: Trinidad and Venezuela to Argentina (Chaco).

***Phaeotabanus nigriflavus* (Kröber, 1930)**

Records of French Guiana: see Kröber (1930) and Fairchild (1970).

Distribution: Colombia, Venezuela, Guyana, Suriname, French Guiana, Trinidad, Ecuador, Peru, Brazil (Roraima, Amapá, Amazonas, Pará, Acre, Rondônia).

***Phaeotabanus phaeopterus* Fairchild, 1964 – new to French Guiana**

Figure 12D

Examined material: sample Mitaraka/188 (1♀ CEUFT).

Updated distribution: Panama (Darién), eastern Colombia, eastern Ecuador (Pichincha), French Guiana, Brazil (Roraima, Amazonas, Pará, Mato Grosso), eastern Peru.

***Philipotabanus stigmatalis* (Kröber, 1931) – new to French Guiana**

Figure 12E

Examined material: sample Mitaraka/002 (1♀ MNHNP); Mitaraka/191 (1♀ CEUFT).**Updated distribution:** Guyana, French Guiana, Brazil (Acre, Amazonas, Roraima, Pará, Amapá).***Stribasoma festivum* (Wiedemann, 1828)****Records of French Guiana:** see Fairchild (1970) and Turcatel et al. (2010).**Distribution:** French Guiana, Brazil (Acre, Amazonas, Pará, ?Mato Grosso), Argentina (Formosa).***Stypommisa captiroptera* (Kröber, 1930) – new to French Guiana**

Figure 12F

Examined material: sample Mitaraka/100 (1♀, 1♂ INPA); Mitaraka/102 (3♂ CEUFT); Mitaraka/115 (1♂ MNHNP); Mitaraka/219 (1♀ CEUFT); Mitaraka/229 (1♂ INPA).**Updated distribution:** Mexico to French Guiana, Brazil (Rondônia, Amazonas, Roraima, Pará), ?Paraguay.***Stypommisa glandicolor* (Lutz, 1912)****Records of French Guiana:** see Fairchild (1970) and Henriques (2016).**Distribution:** Costa Rica, Colombia, Suriname, French Guiana, Peru, Bolivia, Brazil (Acre, Rondônia, Amazonas, Pará, Amapá, Mato Grosso).***Stypommisa modica* (Hine, 1920)**

Figure 12G

Records of French Guiana: see Henriques and Gorayeb (1993). **Examined material:** sample Mitaraka/188 (1♀ CEUFT).**Distribution:** Guyana, French Guiana, Peru, Bolivia, Brazil (Acre, Rondônia, Amazonas, Pará).***Stypommisa tantula* (Hine, 1920)****Records of French Guiana:** see Raymond et al. (1984).

Distribution: Guyana, French Guiana.

Remarks: this species was not recognized as *Stypommisa* by Fairchild and Wilkerson (1986), and neither transferred to another genus. For unclear reasons, it was omitted in the Fairchild and Burger catalog (1994), but listed as *Stypommisa* by Coscarón and Papavero (2009).

TABANINI

Phorcotabanus cinereus (Wiedemann, 1821)

Records of French Guiana: see Fairchild (1970), as *Stenotabanus* (*Phorcotabanus*) *cinereus*.

Distribution: Colombia (Meta), Ecuador, Peru, French Guiana, Brazil (Amapá, Amazonas, Pará, Acre, Ceará), Bolivia, Argentina (Chaco, Salta).

Poeciloderas quadripunctatus (Fabricius, 1805)

Records of French Guiana: see Raymond et al. (1984).

Distribution: Mexico to Argentina (Salta, Tucumán, Catamarca, Misiones, Entre Ríos, Buenos Aires).

Tabanus amapaensis Fairchild, 1961 – new to French Guiana

Figure 12H

Examined material: sample Mitaraka/229 (1♀ CEUFT).

Updated Distribution: Suriname, French Guiana, Brazil (Amazonas, Pará, Amapá).

Tabanus angustifrons Macquart, 1848

Records of French Guiana: see Macquart (1848), Fairchild (1984) and Raymond (1986).

Distribution: Colombia, Venezuela, French Guiana, Peru, Brazil (Rondônia, Amazonas, Roraima, Pará, Amapá, Mato Grosso).

Tabanus antarcticus Linnaeus, 1758

Figure 12I

Records of French Guiana: see Fairchild (1970). **Examined material:** sample Mitaraka/186 (1♀ CEUFT).

Distribution: Trinidad, Venezuela, Suriname to Peru and Brazil (Amazon basin, Bahia).

***Tabanus callosus* Macquart, 1848**

Records of French Guiana: see Fairchild (1970).

Distribution: Colombia (Vaupés, Amazonas), Peru (Madre de Dios, Putumayo), Guyana, French Guiana, Brazil (Rondônia, Amazonas, Roraima, Pará, Amapá, ?Bahia).

***Tabanus casteetus* Fairchild, 1984**

Records of French Guiana: see Fairchild (1984), as *Tabanus testaceus* Macquart.

Distribution: Venezuela, French Guiana, Ecuador, Brazil (Amazonas).

***Tabanus crassicornis* Wiedemann, 1821**

Records of French Guiana: see Fairchild (1984).

Distribution: Colombia, Venezuela, Suriname, French Guiana, Brazil (Acre, Rondônia, Amazonas, Roraima, Pará, Amapá, Mato Grosso).

***Tabanus discifer* Walker, 1850**

Records of French Guiana: see Raymond (1986).

Distribution: Venezuela, Trinidad, Suriname, French Guiana, Brazil (Pará, Amazonas), Ecuador, Peru (Loreto), Bolivia.

***Tabanus discus* Wiedemann, 1828**

Figure 12J

Records of French Guiana: see Fairchild (1970). **Examined material:** sample Mitaraka/186 (1♀ CEUFT).

Distribution: Trinidad, ?Venezuela, Guyana, Suriname, French Guiana, Ecuador (Napo), Brazil (Acre, Rondônia, Amazonas, Roraima, Pará, Amapá, Mato Grosso).

***Tabanus fortis* Fairchild, 1961**

Records of French Guiana: see Fairchild (1970, 1984).

Distribution: Guyana, Suriname, French Guiana, Peru, Brazil (Amazonas, Pará, Amapá).

Tabanus fumomarginatus Hine, 1920

Records of French Guiana: see Fairchild (1970).

Distribution: Suriname, French Guiana, Peru, Brazil (Amapá, Amazonas).

Tabanus guyanensis Macquart, 1846

Records of French Guiana: see Macquart (1846) and Fairchild (1970, 1984).

Distribution: Colombia, French Guiana, eastern Ecuador, eastern Peru, Brazil (Amapá, Amazonas, Pará, Rondônia, Mato Grosso), eastern Bolivia.

Tabanus importunus Wiedemann, 1828

Records of French Guiana: see Fairchild (1970).

Distribution: Panama, Guyana, French Guiana, Trinidad, Peru, Bolivia, to Brazil (Rio Grande do Sul), Paraguay.

Tabanus kwatta Fairchild, 1983

Records of French Guiana: see Fairchild (1983).

Distribution: Venezuela, Suriname, French Guiana, Brazil (Pará).

Tabanus nebulosus De Geer, 1776

Records of French Guiana: see Fairchild (1970).

Distribution: Belize, Trinidad, ?Barbados to Brazil (until Mato Grosso do sul), Argentina (Tucumán, Formosa, Corrientes, Santa Fé, Chaco).

Tabanus occidentalis Linnaeus, 1758

Figure 12K

Records of French Guiana: in Fairchild (1970), as *Tabanus dorsiger* var. *dorsovittatus* Macquart. **Examined material:** sample Mitaraka/100 (2♀, 2♂ CEUFT); Mitaraka/115 (1♀ MNHNP); Mitaraka/186 (8♀ MNHNP); Mitaraka/188 (8♀ CEUFT); Mitaraka/189 (5♀, 1♂ MNHNP); Mitaraka/197 (1♀ MNHNP); Mitaraka/198 (2♀ MNHNP); Mitaraka/219 (13♀ MNHNP); Mitaraka/220 (12♀ MNHNP); Mitaraka/224 (1♀ MNHNP).

Distribution: Mexico to Argentina (Entre Ríos, Buenos Aires), Trinidad.

***Tabanus olivaceiventris* Macquart, 1847**

Records of French Guiana: see Bigot (1892), as *Tabanus pulverulentus*, and Fairchild (1970, 1984).

Distribution: Panama to Brazil (Pará, Amapá), Trinidad.

***Tabanus pellucidus* Fabricius, 1805**

Records of French Guiana: see Fairchild (1970, 1984).

Distribution: Colombia, Venezuela, Guyana, Suriname, French Guiana, Ecuador (Napo, Orellana, Pastaza), e. Peru, Brazil (Roraima, Amazonas, Pará, Amapá).

***Tabanus piceiventris* Rondani, 1848**

Records of French Guiana: see Fairchild (1970).

Distribution: Trinidad, Colombia, Venezuela, Guyana, Suriname, French Guiana, Ecuador (Napo, Orellana), Peru, Brazil (Acre, Rondônia, Amazonas, Roraima, Pará, Amapá, Maranhão, Tocantins), Bolivia.

***Tabanus pungens* Wiedemann, 1828**

Records of French Guiana: Raymond et al. (1984) and Raymond (1986).

Distribution: U.S.A. (Texas), Neotropics (except West Indies and Chile), Trinidad.

***Tabanus rubripes* Macquart, 1838**

Records of French Guiana: see Fairchild (1970).

Distribution: Panama to Paraguay.

***Tabanus tristichus* Fairchild, 1976**

Records of French Guiana: see Raymond (1986).

Distribution: Suriname, French Guiana, Brazil (Amapá, Pará).

***Tabanus trivittatus* Fabricius, 1805**

Figure 12L

Records of French Guiana: see Fairchild (1970). **Examined material:** sample Mitaraka/002 (1♀ MNHNP); Mitaraka/186 (1♂ MNHNP); Mitaraka/100 (2♀, 1♂ CEUFT); Mitaraka/102 (1♂ MNHNP); Mitaraka/115 (7♀, 2♂ MNHNP); Mitaraka/169 (1♀ MNHNP); Mitaraka/189 (2♀ MNHNP); Mitaraka/197 (1♀ MNHNP); Mitaraka/222 (1♂ MNHNP).

Distribution: ?Costa Rica, ?Panama, Colombia, Guyana, Suriname, French Guiana, Brazil (Rondônia, Amazonas, Roraima, Pará, Amapá, Maranhão, Tocantins).

***Tabanus vittiger* ssp. *guatemalanus* Hine, 1906**

Records of French Guiana: see Fairchild (1970), as *Tabanus subsimilis guatemalanus* Hine.

Distribution: U.S.A. (Florida), Bahamas, West Indies (Cuba, Cayman Islands, Jamaica, Puerto Rico), southeastern Mexico to Suriname, French Guiana and northern Brazil.

***Tabanus wilkersoni* Fairchild, 1983**

Records of French Guiana: see Raymond (1986) and Henriques and Gorayeb (1993).

Distribution: e. Colombia, French Guiana, eastern Peru, Brazil (Amapá, Amazonas, Pará, Mato Grosso do Sul).

Record excluded from French Guiana

Tabanus unipunctatus (Bigot 1892) was cited from French Guiana by Fairchild (1970). However, in the Fairchild and Burger catalog (1994) the species distribution was corrected to: Mexico to western Colombia. Probably the 1970 Fairchild record refers to *T. fumomarginatus*.

Discussion

French Guiana is part of the Guiana shield in northern Amazonia, bordering with Suriname in the west and Brazil (Amapá State) in the east, between the Maroni and Oiapoque rivers (Guitet et al. 2013). The Amazon rainforest covers more than 90% of this French department, while savannas and mangroves are present only along the coast (Guitet et al. 2014).

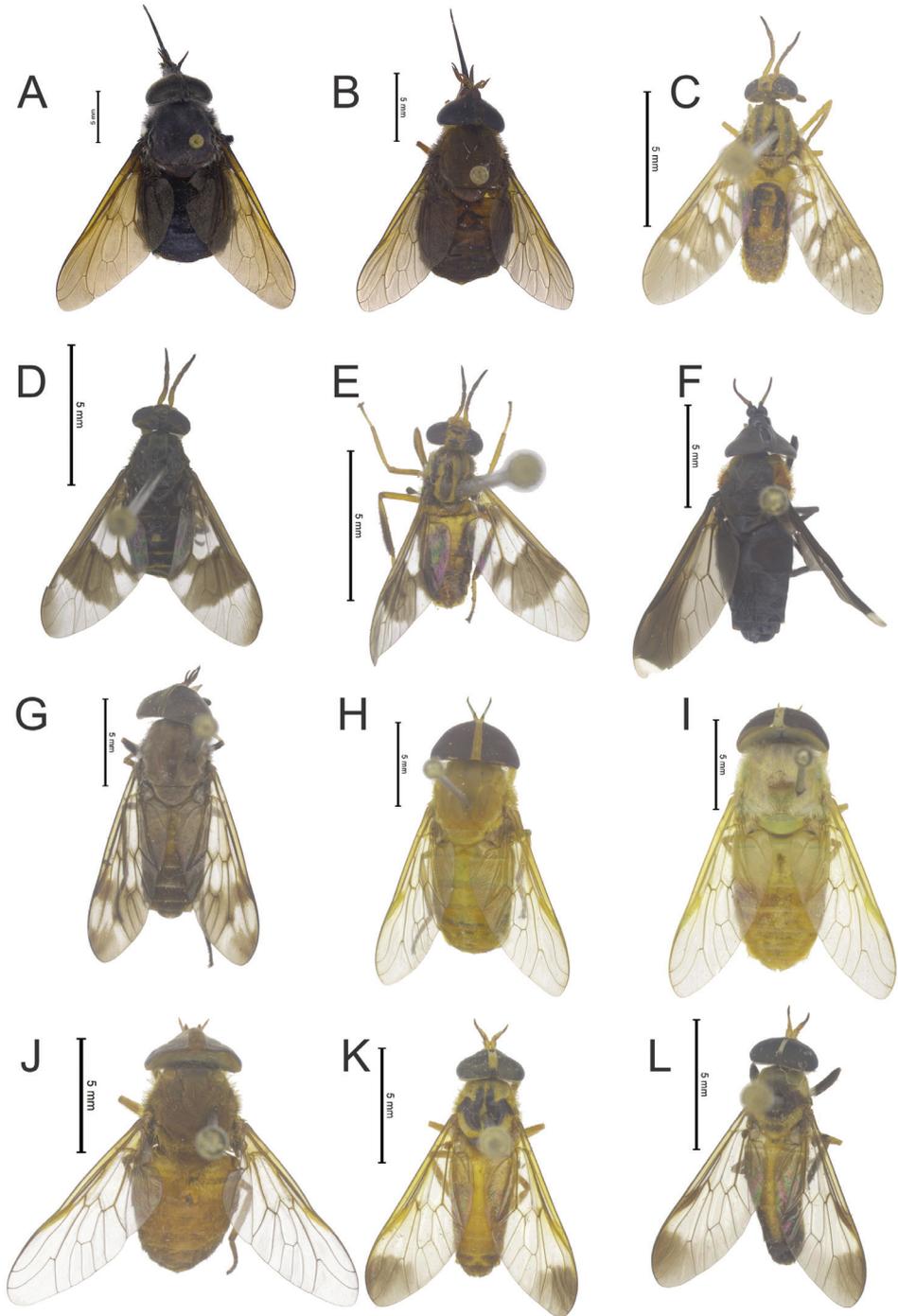


Figure 11. **A** *Fidena auripes* (Ricardo) **B** *Pityocera cervus* (Wiedemann) **C** *Chrysops ecuadorensis* Lutz **D** *Chrysops incisus* Macquart **E** *Chrysops* sp. **F** *Bolbodimyia brunneipennis* Stone **G** *Catachlorops amazonicus* Henriques & Gorayeb **H** *Chlorotabanus flagellatus* Krolow & Henriques **I** *Chlorotabanus inanis* (Fabricius) **J** *Cryptoylus cauri* Stone **K** *Diachlorus curvipes* (Fabricius) **L** *Diachlorus fuscistigma* Lutz. Photos by Augusto Henriques.

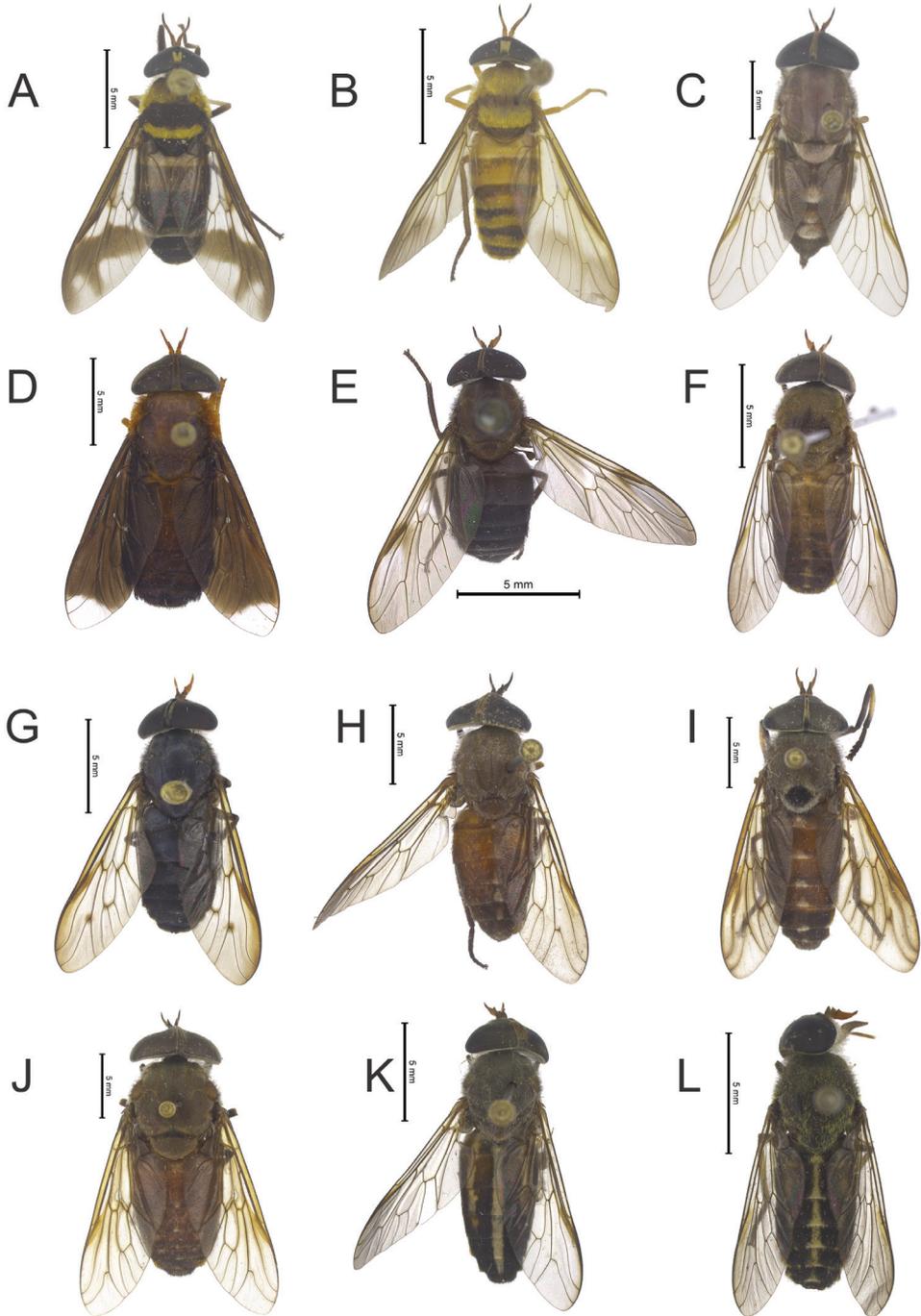


Figure 12. **A** *Dichelacera damicornis* (Fabricius) **B** *Dichelacera marginata* Macquart **C** *Leucotabanus albovarius* (Walker) **D** *Phaeotabanus phaeopterus* Fairchild **E** *Philipotabanus stigmatalis* (Kröber) **F** *Stypommisa captiroptera* (Kröber) **G** *Stypommisa modica* (Hine) **H** *Tabanus amapaensis* Fairchild **I** *Tabanus antarcticus* Linnaeus **J** *Tabanus discus* Wiedemann **K** *Tabanus occidentalis* Linnaeus **L** *Tabanus trivittatus* Fabricius. Photos by Augusto Henriques.

In their check list of insects of French Guiana, Brûlé and Touroult (2014) registered about 15,100 valid species names allocated in 20 orders and 322 families. According to the authors, Diptera is one of the poorest studied groups, with only 577 known species, including 6 endemic species, 50 species described from French Guiana, and 2 dubious records.

A high insect endemism in French Guiana is not very likely, because the country does not have strong geographical barriers with its neighbouring countries, Suriname and Brazil (Amapá) (Brûlé and Touroult 2014), and the same habitat types (or life zones) are present in each of these regions. This seems to be suggested by the observation that Suriname and Amapá share 49 and 42 species of Tabanidae (excluding the species with a large distribution) with French Guiana, respectively (Coscarón and Papavero 2009).

As expected, most species (76 sp.) observed in French Guiana belongs to the Amazonian tabanid fauna. Of its 80 species, 32 species have a large distribution in the Amazon basin, 30 species are shared by French Guiana with Suriname and/or Amapá state, and another 13 species with Guyana and/or Pará state. Three species have an even more extensive distribution range beyond French Guiana. Only one species might be endemic and another could not be identified, possibly a new species of *Chrysops*.

Currently, *Catachlorops balachowskyi* Fairchild seems endemic to French Guiana, while two other species, *Stypommisa tantula* (Hine) and *Fidena aurulenta* Gorayeb, are shared only with Guyana and Pará (Brazil), respectively.

The distribution records of Coscarón and Papavero (2009) were analysed, and it is estimated that approximately an additional 43 species have a high probability of occurring in French Guiana (Table 2). All estimated species have records from Suriname (11 spp.), Amapá (10 spp.), or both regions (2 spp.), or have a wide distribution in the Amazon region (20 spp.).

With respect to the collecting methods, although interception traps (including Malaise traps and SLAM) are a passive method and without attractive power, they are among the most effective methods for capturing female tabanids, because the females are strong and frequent flyers, travelling great distances daily looking for a blood meal. The six meters Malaise trap is extremely effective for Tabanidae, and on some occasions several hundreds of specimens have been collected during one day (Gressitt and Gressitt 1962). According to Brown (2005), the Malaise trap method is especially effective to collect Neotropical Diptera, and Tabanidae seems to be one of 22 most abundant families in Malaise trap samples.

While the females are satisfactorily collected by interception traps, the males are rarely found in these traps, mainly because they are nectarivores, and thus do not need to travel far in search of warm-blooded hosts. As a result, male tabanids are also poorly represented in collections and even often unknown. Their rarity in interception traps might also be related to the effect of flowering periods, their preference to fly in higher tree strata or by their flight in restricted areas waiting for females to mate (Krolow et al. 2010). In contrast, males are commonly attracted to light, and the use of luminous attractant for collecting horse flies usually attracts much more males than females,

Table 2. List of Tabanidae known from neighbouring regions and expected to occur in French Guiana.

N°	Species	Present occurrence
1	<i>Esenbeckia osornoi</i> Fairchild, 1942	Suriname, Amapá
2	<i>Fidena loricornis</i> Kröber, 1931	Amapá
3	<i>Fidena nigripennis</i> (Guérin-Méneville, 1832)	Suriname
4	<i>Chrysops calogaster</i> Schiner, 1868	Amapá
5	<i>Chrysops guttipennis</i> Kröber, 1929	Suriname
6	<i>Chrysops leucopilus</i> Wiedemann, 1828	Amazon
7	<i>Acanthocera bequaerti</i> Fairchild & Aitken, 1960	Suriname
8	<i>Acanthocera fairchildi</i> Henriques & Rafael, 1992	Amazon
9	<i>Acanthocera polistiformis</i> Fairchild, 1961	Amapá
10	<i>Catachlorops difficilis</i> (Kröber), 1931	Amazon
11	<i>Catachlorops fumipennis</i> Kröber, 1931	Amazon
12	<i>Catachlorops testaceus</i> (Macquart, 1846)	Guyana, Amapá
13	<i>Diachlorus nuneztovari</i> Fairchild & Ortiz, 1955	Amazon
14	<i>Diachlorus pechumani aitkeni</i> Fairchild, 1972	Surinam
15	<i>Diachlorus podagricus</i> (Fabricius), 1805	Amazon
16	<i>Diachlorus xynus</i> Fairchild, 1972	Suriname
17	<i>Dichelacera bifacies</i> Walker, 1848	Amapá
18	<i>Dichelacera cervicornis</i> (Fabricius), 1805	Suriname, Amapá
19	<i>Dichelacera varia</i> (Wiedemann, 1828)	Amapá
20	<i>Eutabanus pictus</i> Kröber, 1930	Amapá
21	<i>Leucotabanus pauculus</i> Fairchild, 1951	Amazon
22	<i>Phaeotabanus innotescens</i> (Walker, 1854)	Suriname
23	<i>Phaeotabanus prasiniventris</i> (Kröber, 1929)	Amapá
24	<i>Philipotabanus pictus</i> Gorayeb & Rafael, 1984	Amazon
25	<i>Selasoma tibiale</i> (Fabricius, 1805)	Amazon
26	<i>Stenotabanus cretatus</i> Fairchild, 1961	Amapá
27	<i>Stenotabanus geijskesi</i> Fairchild, 1953	Suriname
28	<i>Stibasoma currani</i> Philip, 1943	Amazon
29	<i>Stibasoma flaviventris</i> (Macquart, 1848)	Amazon
30	<i>Stibasoma fulvohirtum</i> (Wiedemann, 1828)	Amazon
31	<i>Stypommisa prunicolor</i> (Lutz, 1912)	Amazon
32	<i>Stypommisa venosa</i> (Bigot, 1892)	Amazon
33	<i>Tabanus amazonensis</i> (Barretto, 1949)	Amazon
34	<i>Tabanus cicur</i> Fairchild, 1942	Amazon
35	<i>Tabanus claripennis</i> (Bigot, 1892)	Neotropical
36	<i>Tabanus curtus</i> Hine, 1920	Suriname
37	<i>Tabanus glaucus</i> Wiedemann, 1819	Amazon
38	<i>Tabanus macquarti</i> Schiner, 1868	Suriname
39	<i>Tabanus sannio</i> Fairchild, 1956	Amazon
40	<i>Tabanus secundus</i> Walker, 1848	Suriname
41	<i>Tabanus sorbillans</i> Wiedemann, 1828	Amazon
42	<i>Tabanus unimacula</i> Kröber, 1934	Suriname
43	<i>Tabanus xuthopogon</i> Fairchild, 1984	Amapá

usually of species with crepuscular habits (Frost 1951, Anthony 1960, Philip 1982, Fairchild 1986, Henriques and Rafael 1999).

Taking into account the large number of interception trap types employed during the Mitaraka (with only one operational light trap), female specimens were dominant in the samples as expected, accounting for 233 specimens, mostly collected by interception trap types, such as the 6m long Malaise trap ($n = 98$), SLAMs ($n = 48$), and flight intercept traps ($n = 44$). On the other hand, 19 of the 22 males were collected at the light trap, although, curiously, the trap collected more females than males (39 females vs 19 males) (see Table 1).

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Appendix I

Table IA. See Legend of Table 1 for explanation of abbreviations for collecting methods.

Sample id	Sample cd	Label
13882	MITARAKA/002	(FR-GU) Guyane Française, Mitaraka, MIT-DZ, 02°14'01.8"N, 54°27'01.0"W, 306 m, drop zone, 23.ii.2015, LT, leg. Julien Touroult (FR-GU/Mitaraka/2015) - sample code: MITARAKA/002 (sorted by Marc Pollet, 2015)
13888	MITARAKA/008	(FR-GU) Guyane Française, Mitaraka, MIT-DZ, 02°14'01.8"N, 54°27'01.0"W, 306 m, drop zone, 25.ii.2015, LT, leg. Marc Pollet (FR-GU/Mitaraka/2015) - sample code: MITARAKA/008 (sorted by Marc Pollet, 2015)
13909	MITARAKA/029	(FR-GU) Guyane Française, Mitaraka, MIT-DZ, 02°14'01.8"N, 54°27'01.0"W, 306 m, drop zone, 28.ii.2015, LT, leg. Marc Pollet (FR-GU/Mitaraka/2015) - sample code: MITARAKA/029 (sorted by Marc Pollet, 2015)
13928	MITARAKA/048	(FR-GU) Guyane Française, Mitaraka, MIT-DZ, 02°14'01.8"N, 54°27'01.0"W, 306 m, drop zone, 2.iii.2015, LT, leg. Jean-Hervé Yvinec (FR-GU/Mitaraka/2015) - sample code: MITARAKA/048 (sorted by Marc Pollet, 2015)
13954	MITARAKA/074	(FR-GU) Guyane Française, Mitaraka, MIT-A-RBF1, 02°14'11.4"N, 54°27'07.0"W, 306 m, on vegetation along muddy trail and in swamp, 6.iii.2015, SW, leg. Marc Pollet (FR-GU/Mitaraka/2015) - sample code: MITARAKA/074 (sorted by Marc Pollet, 2015)
13966	MITARAKA/086	(FR-GU) Guyane Française, Mitaraka, MIT-DZ, 02°14'01.8"N, 54°27'01.0"W, 306 m, drop zone, 7.iii.2015, LT, leg. Marc Pollet (FR-GU/Mitaraka/2015) - sample code: MITARAKA/086 (sorted by Marc Pollet, 2015)
13969	MITARAKA/089	(FR-GU) Guyane Française, Mitaraka, MIT-C-RBF2, 02°14'03.4"N, 54°26'53.0"W, 299 m, on leaf litter, muddy spots and vegetation along muddy trail, 8.iii.2015, SW, leg. Marc Pollet (FR-GU/Mitaraka/2015) - sample code: MITARAKA/089 (sorted by Marc Pollet, 2015)
13980	MITARAKA/100	(FR-GU) Guyane Française, Mitaraka, MIT-DZ, 02°14'01.8"N, 54°27'01.0"W, 306 m, drop zone, 9.iii.2015, LT, leg. Marc Pollet (FR-GU/Mitaraka/2015) - sample code: MITARAKA/100 (sorted by Marc Pollet, 2015)
13982	MITARAKA/102	(FR-GU) Guyane Française, Mitaraka, MIT-DZ, 02°14'01.8"N, 54°27'01.0"W, 306 m, drop zone, 9.iii.2015, LT, leg. Marc Pollet (FR-GU/Mitaraka/2015) - sample code: MITARAKA/102 (sorted by Marc Pollet, 2015)
13984	MITARAKA/104	(FR-GU) Guyane Française, Mitaraka, MIT-C-RBF2, 02°14'03.4"N, 54°26'53.0"W, 299 m, on vegetation along muddy trail and in swamp, 10.iii.2015, SW, leg. Marc Pollet (FR-GU/Mitaraka/2015) - sample code: MITARAKA/104 (sorted by Marc Pollet, 2015)
13995	MITARAKA/115	(FR-GU) Guyane Française, Mitaraka, MIT-DZ, 02°14'01.8"N, 54°27'01.0"W, 306 m, drop zone, 24.ii.2015-10.iii.2015, LT, leg. Julien Touroult (FR-GU/Mitaraka/2015) - sample code: MITARAKA/115 (sorted by Marc Pollet, 2015)
14030	MITARAKA/150	(FR-GU) Guyane Française, Mitaraka, MIT-A-RBF2, 02°14'12.5"N, 54°27'08.1"W, 287 m, tropical wet forest (bas fond), 27.ii.2015-10.iii.2015, SLAM, leg. Marc Pollet (FR-GU/Mitaraka/2015) - sample code: MITARAKA/150 (sorted by Marc Pollet, 2015)
14049	MITARAKA/169	(FR-GU) Guyane Française, Mitaraka, MIT-DZ1, 02°14'01.4"N, 54°27'00.2"W, 304 m, tropical moist forest (plateau-slope), 1.iii.2015-8.iii.2015, SLAM, leg. Marc Pollet (FR-GU/Mitaraka/2015) - sample code: MITARAKA/169 (sorted by Marc Pollet, 2015)
14064	MITARAKA/186	(FR-GU) Guyane Française, Mitaraka, nr MIT-A-RBF1, river, 1.iii.2015-7.iii.2015, MT(6m), leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/186 (sorted by Marc Pollet, 2015)
14065	MITARAKA/188	(FR-GU) Guyane Française, Mitaraka, nr MIT-A-RBF1, river, 1.iii.2015, MT(6m), leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/188 (sorted by Marc Pollet, 2015)

Sample id	Sample cd	Label
14066	MITARAKA/189	(FR-GU) Guyane Française, Mitaraka, nr MIT-A-RBF1, river, 25.iii.2015, MT(6m), leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/189 (sorted by Marc Pollet, 2015)
14068	MITARAKA/191	(FR-GU) Guyane Française, Mitaraka, different sites nr base camp and along trails, tropical most forest (different sites), 14.iii.2015, SLAM, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/191 (sorted by Marc Pollet, 2015)
14069	MITARAKA/192	(FR-GU) Guyane Française, Mitaraka, different sites nr base camp and along trails, tropical most forest (different sites), 10.iii.2015-14.iii.2015, FIT, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/192 (sorted by Marc Pollet, 2015)
14072	MITARAKA/195	(FR-GU) Guyane Française, Mitaraka, different sites nr base camp and along trails, tropical most forest (different sites), 1.iii.2015-6.iii.2015, SLAM, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/195 (sorted by Marc Pollet, 2015)
14074	MITARAKA/197	(FR-GU) Guyane Française, Mitaraka, different sites nr base camp and along trails, tropical most forest (different sites), 20.iii.2015-25.iii.2015, FIT, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/197 (sorted by Marc Pollet, 2015)
14075	MITARAKA/198	(FR-GU) Guyane Française, Mitaraka, MIT-DZ, 02°14'01.8"N, 54°27'01.0"W, 306 m, tropical most forest (different sites) nr DZ, 6.iii.2015-10.iii.2015, FIT, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/198 (sorted by Marc Pollet, 2015)
14076	MITARAKA/199	(FR-GU) Guyane Française, Mitaraka, MIT-A-RBF2, 02°14'12.5"N, 54°27'08.1"W, 287 m, tropical wet forest (bas fond), 14.iii.2015-20.iii.2015, SLAM, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/199 (sorted by Marc Pollet, 2015)
14077	MITARAKA/200	(FR-GU) Guyane Française, Mitaraka, MIT-C-RBF2, 02°14'03.4"N, 54°26'53.0"W, 299 m, tropical wet forest (bas fond), 14.iii.2015-20.iii.2015, SLAM, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/200 (sorted by Marc Pollet, 2015)
14079	MITARAKA/202	(FR-GU) Guyane Française, Mitaraka, MIT-A-RBF2, 02°14'12.5"N, 54°27'08.1"W, 287 m, tropical wet forest (bas fond), 10.iii.2015-14.iii.2015, SLAM, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/202 (sorted by Marc Pollet, 2015)
14084	MITARAKA/207	(FR-GU) Guyane Française, Mitaraka, MIT-A-RBF2, 02°14'12.5"N, 54°27'08.1"W, 287 m, tropical wet forest (bas fond), 20.iii.2015-25.iii.2015, SLAM, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/207 (sorted by Marc Pollet, 2015)
14085	MITARAKA/208	(FR-GU) Guyane Française, Mitaraka, MIT-C-RBF2, 02°14'03.4"N, 54°26'53.0"W, 299 m, tropical wet forest (bas fond), 20.iii.2015-25.iii.2015, SLAM, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/208 (sorted by Marc Pollet, 2015)
14088	MITARAKA/211	(FR-GU) Guyane Française, Mitaraka, MIT-C-RBF2, 02°14'03.4"N, 54°26'53.0"W, 299 m, tropical wet forest (bas fond), 20.iii.2015-25.iii.2015, SLAM, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/211 (sorted by Marc Pollet, 2015)
14090	MITARAKA/213	(FR-GU) Guyane Française, Mitaraka, MIT-C-RBF2, 02°14'03.4"N, 54°26'53.0"W, 299 m, tropical wet forest (bas fond), 10.iii.2015-14.iii.2015, SLAM, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/213 (sorted by Marc Pollet, 2015)

Sample id	Sample cd	Label
14094	MITARAKA/218	(FR-GU) Guyane Française, Mitaraka, MIT-DZ, 02°14'01.8"N, 54°27'01.0"W, 306 m, tropical moist forest (plateau-slope - cleared), 1.iii.2015, SLAM, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/218 (sorted by Marc Pollet, 2015)
14095	MITARAKA/219	(FR-GU) Guyane Française, Mitaraka, MIT-DZ, 02°14'01.8"N, 54°27'01.0"W, 306 m, tropical moist forest (plateau-slope - cleared), 1.iii.2015, FIT, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/219 (sorted by Marc Pollet, 2015)
14096	MITARAKA/220	(FR-GU) Guyane Française, Mitaraka, MIT-DZ, 02°14'01.8"N, 54°27'01.0"W, 306 m, tropical moist forest (plateau-slope - cleared), 6.iii.2015, FIT, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/220 (sorted by Marc Pollet, 2015)
14098	MITARAKA/222	(FR-GU) Guyane Française, Mitaraka, different sites nr base camp and along trails, tropical moist forest (different sites), 10.iii.2015, PVP, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/222 (sorted by Marc Pollet, 2015)
14100	MITARAKA/224	(FR-GU) Guyane Française, Mitaraka, different sites nr base camp and along trails, tropical moist forest (different sites "sous bois"), 7.iii.2015, FIT, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/224 (sorted by Marc Pollet, 2015)
14103	MITARAKA/227	(FR-GU) Guyane Française, Mitaraka, different sites nr base camp and along trails, tropical moist forest (different sites), 3.iii.2015, PVB, leg. Julien Touroult & Eddy Poirier (FR-GU/Mitaraka/2015) - sample code: MITARAKA/227 (sorted by Marc Pollet, 2015)
14304	MITARAKA/229	(FR-GU) Guyane Française, Mitaraka, different sites nr base camp and along trails, open / partially opened areas around base camp and drop zone, and in savane roche 2, 12.viii.2015-20.viii.2015, SLAM, leg. Pierre-Henri Dalens (FR-GU/Mitaraka/2015) - sample code: MITARAKA/229 (sorted by Marc Pollet, 2015)

Three new species and one new subspecies of *Depressariinae* (Lepidoptera) from Europe

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Abstract

The species *Depressaria albarracinella* Corley, **sp. n.**, *Agonopterix carduncelli* Corley, **sp. n.** and *Agonopterix pseudoferulae* Buchner & Junnilainen, **sp. n.** and the subspecies *Depressaria saharae* Gastón & Vives ssp. *tabelli* Buchner, **ssp. n.** are described.

Depressaria albarracinella was first found in Spain in 1969 and recognised as apparently new but the specimens in NHMUK have remained undescribed. Additional Spanish material has been located in ZMUC and other collections and three specimens have been found from Greece.

Agonopterix carduncelli. A single male of an unidentified *Agonopterix* of the *pallorella* group was found in Algarve, Portugal in 2010. A search for larvae in March 2011 was successful and one male and one female were reared from *Carthamus caeruleus*. Additional specimens of the new species have been located in collections from Spain, Greece and Morocco.

Agonopterix pseudoferulae. A specimen from Greece with the name *Agonopterix ferulae* (Zeller, 1847) found in the Klimesch collection in ZSM had forewing markings which suggested that it might be a different species. Further specimens from Italy and Greece have been examined, among them two reared from *Elaeoselinum asclepium* (Apiaceae). Both genitalia and barcode show that this is an undescribed species.

Depressaria saharae Gastón & Vives, 2017 was described very recently (Gastón and Vives 2017) from northern Spain with a brief description, and figures of two males and male genitalia. Here the new species is redescribed, and additional data on distribution and relationships of the new species added. The opportunity is also taken to show that Canary Islands specimens with the same male genitalia should be treated as a new subspecies *D. saharae* ssp. *tabelli* Buchner, **ssp. n.**

Keywords

Lepidoptera, Gelechioidea, Depressariidae, *Depressaria*, *Agonopterix*, Italy, Greece, Morocco, Portugal, Spain, Canary Islands, new species, DNA barcoding

Introduction

Preparatory work for a proposed volume on Depressariinae in the series *Microlepidoptera of Europe* has revealed a number of taxonomically challenging species groups in the genera *Agonopterix* Hübner [1825] and *Depressaria* Haworth, 1811. This was not unexpected but there are more such groups than we had initially expected. However, in addition to the problem groups, some undescribed species have also been discovered which can be described without the necessity to resolve complex taxonomic issues. Two such species are described here in *Agonopterix* and one species and one subspecies in *Depressaria*.

Material and methods

Material has been examined from NHMUK, NHMV, TLME, ZMUC, ZSM and additionally specimens from many private collectors including those of the authors have been checked, here only listed if the material was of particular importance for this paper: Michael Dale (England), Gabriele Fiumi (Italy), Knud Larsen (Denmark), Toni Mayr (Austria), Willibald Schmitz (Germany), Peter Sonderegger (Switzerland), Lubomír Srnka (Slovakia), Jan Šumpich (Czech Republic) and Joachim Viehmann (Germany). Apart from one exception given in the description, each species includes both reared and light-trapped specimens.

Morphological examination and photographic documentation. Genitalia preparations followed standard techniques (Robinson 1976). Male preparations were stained with mercurochrome and females with chlorazol. The placement of holotypes is given under each species. Photographic documentation: Apart from two exceptions given in the descriptions, photos of specimens in total view were taken with Canon EOS 5D Mark III and Canon lens EF 100mm 2.8 L IS USM at 1:1., specimens were illuminated with two diffused flashes, using a third flash for setting the background whiteness. Detailed photos of specimens were taken with a Canon lens MP-E 65 at 2:1, using ring flash. Genitalia photos were taken with microscope (Wild Heerbrugg) using a 10x objective and a 2.5x ocular. Photos were edited using the software Helicon Focus 4.80 and Adobe Photoshop 6.0. For creating the black and white photos, based on the used stain, the G alpha channel of the RGB originals was used in males and the Y alpha channel of the CMYK originals in females. Genitalia examination and photos by P. Buchner, if not specified.

DNA-Barcoding. The full length lepidopteran DNA barcode sequence is a 658 basepair long segment of the 5' terminus of the mitochondrial COI gene (cytochrome c oxidase 1). DNA samples (dried leg) were prepared according to the accepted standards

and were processed at the Canadian Centre for DNA Barcoding (CCDB, Biodiversity Institute of Ontario, University of Guelph) to obtain DNA barcodes using the standard high-throughput protocol described in deWaard et al. (2008). Detailed specimen data are listed under Genetic data of species description. Sequences were submitted to GenBank: accession numbers are listed in an Appendix. Further details including complete voucher data and images can be accessed in the public dataset DS-DEEUR330 (http://www.boldsystems.org/index.php/Public_SearchTerms?query=DS-DEEUR330, [dx.doi.org/10.5883/DS-DEEUR330](https://doi.org/10.5883/DS-DEEUR330)) in the Barcode of Life Data Systems (BOLD; Ratnasingham and Hebert 2007). Neighbour-joining trees of DNA barcode data were constructed using Mega 5 (Tamura et al. 2011) under the Kimura 2 parameter model for nucleotide substitutions. Additionally, the evolutionary history was inferred by using the Maximum Likelihood method based on the Tamura-Nei model. Evolutionary analyses were conducted in MEGA7. This result is shown in radiation graphic, because in this view the evolutionary aspect is visualized better than in traditional tree.

Abbreviations

DEEUR	“Depressariinae of Europe”, prefix for number of a photo or slide made by P. Buchner
MNHN	Muséum National d’Histoire Naturelle, Paris, France
NHMUK	(formerly BMNH) Natural History Museum (British Museum, Natural History), London, United Kingdom
NHMV	Naturhistorisches Museum, Vienna, Austria
NMPC	National Museum, Prague, Czech Republic
TLMF	Tiroler Landesmuseum Ferdinandeum, Innsbruck, Austria
ZMUC	Zoological Museum, University of Copenhagen, Denmark
ZMUH	Zoology Museum, University of Helsinki, Finland
ZSM	Zoologische Staatssammlung München, Germany

Description of new species

Depressaria albarracinella Corley, sp. n.

<http://zoobank.org/69805CE8-47FC-43FA-BE58-06F6DB16C946>

Type locality. Spain, Granada, Sierra Nevada, Collado del Lobo, north side, 2300 m.

Holotype. ♂ Sierra Nevada, Collado del Lobo, North Side, 2300 m, 14.vii.1969 | Hispania mer. K. Sattler & D.J. Carter. BM 1970-26 | HOLOTYPE *Depressaria albarracinella* Corley, teste M. Corley, 2004 | B.M. ♂ Genitalia slide No. 30716 | Corley prep. 1915m.

Paratypes. Spain: ♀ Sierra Nevada, Collado del Lobo, North Side, 2300 m, 14.vii.1969, Hisp. mer. K. Sattler & D.J. Carter. BM 1970-26, *Depressaria albarracinella* Corley, det. M. Corley, 2004; ♂ Prov. Granada, Sierra Nevada, Puerto de la Ragua, 1000m,

1.vii.1969 K. Sattler & D.J. Carter. NHMUK prep. 18856 (NHMUK); ♀ Andalusia, Sierra Nevada, Camina de Veleta, 2300 m, 23.x.1983, leg. E. Traugott-Olsen (ZMUC); 6 ♂♂, 2 ♀♀, Spain, Almería, Sierra de los Filabres, Alto del Calar del Gallinero, 1900–2022m, 17.–18.vi.2007, J. Šumpich leg. et det. (NMPC); 2 ♀♀, Spain, Almería, Sierra de los Filabres, route Purchena – Senés, 1600m, 16.vi.2007, J. Šumpich leg. et det. (NMPC); ♂ Castellón, Banderetta Pass, 800 m, 17.vii.1992, leg. M. Fibiger (ZMUC); ♂ Teruel, Albarracin, Val de Vecar, 1250 m, 17–18.vii.1981, leg. M. Fibiger (ZMUC) (Corley gen. prep. 1711); ♀ Teruel, Albarracin, Val de Vecar, 15.vii.1992. M. Fibiger (ZMUC) (Corley gen. prep. 1717); ♂ Teruel, Albarracin, 1150 m, 3.v.2002, leg. K. Černý, det. P. Buchner; ♀ Zaragoza, Bujareloz, 6 km, ♀, 300m 29.v.2015, leg. J. Viehmann, det P. Buchner; ♂ Huesca, Candanos, 10 km S, 30.v.2015, leg. J. Viehmann, det P. Buchner.

Other material examined. Greece: ♂ Central Greece, Parnassos Mountains, 1 km NE Arachova, 1070 m, 9.vi.2013, leg. P. Skou (ZMUC), det. P. Buchner; 2♂♂ Lesbos, Molivos, 6.vi.1994 (gen.prep. DEEUR 5398) and 7.vi.1994, leg. J.P. Baungard (ZMUC), det. P. Buchner

Diagnosis. Externally *D. albarracinella* differs from other species of the *veneficella* group in the very weak or obsolete dark forewing markings and the absence of a dark spot at base of dorsum, but it is more reliably separated from other species in the group by various characters involving different proportions of one part of the male genitalia relative to another. This is best set out in a key.

The key below includes only the European species. *D. pentheri* Rebel, 1904 is omitted due to insufficient knowledge of this taxon. The North African *D. deverrella* Chrétien, 1915, has sometimes been listed as present in France, but we can find no evidence for this.

Key to males of European species of *Depressaria veneficella* group (see comparison in Fig. 1)

- | | | |
|---|--|--|
| 1 | Saccus very short, not exceeding one quarter of valva length | 2 |
| – | Saccus clearly longer than one quarter of valva | 3 |
| 2 | Aedeagus shorter than valva; valva nearly parallel-sided in distal two-fifths, slender, blunt | <i>gallicella</i> Chrétien, 1908 |
| – | Aedeagus about as long as valva, valva tapering to a sharp tip | <i>cervicella</i> Herrich-Schäffer, 1854 |
| 3 | Cornutus short, shorter than one-third of aedeagus | <i>veneficella</i> Zeller, 1847 |
| – | Cornutus longer than one-third of aedeagus | 4 |
| 4 | Saccus less than half as long as valva | <i>albarracinella</i> Corley, sp. n. |
| – | Saccus longer, more than half as long as valva | 5 |
| 5 | Distal part of valva, beyond median bulge, slender, length to width ratio of this part 3:1 or more | <i>eryngiella</i> Millière, 1881 |
| – | Distal part of valva, beyond median bulge, rapidly tapering from wide base, length to width ratio of this part 2:1 or less | <i>discipunctella</i> Herrich-Schäffer, 1854 |

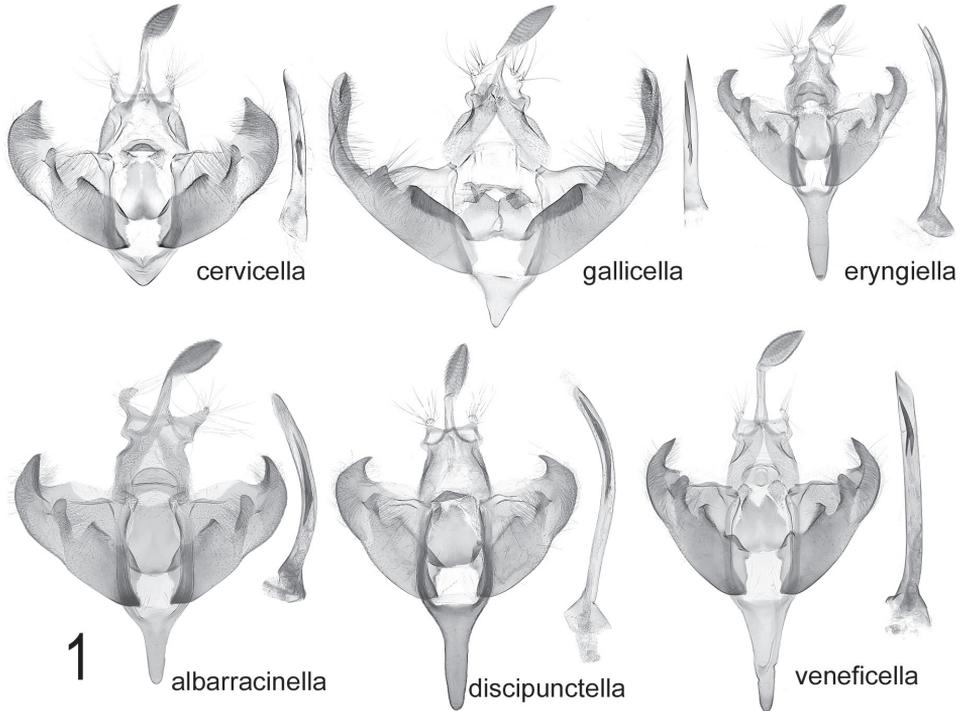


Figure 1. Comparison of male genitalia of European *D. veneficella* group species. *D. cervicella* (Austria, Mödling) *D. gallicella* (Switzerland, Saillon) *D. eryngiella* (Turkey, Malaty, Murhak Dagħ) *D. albarracinella* sp. n. (Greece, Arachova) *D. discipunctella* (Macedonia, Petrina) *D. veneficella* (Italy, Sicily).

Key to females of European species of *Depressaria veneficella* group

- 1 Ductus bursae expanded at anterior end then twisted and finally constricted at entrance to corpus bursae..... 2
- Ductus bursae simple without constriction at entrance to corpus bursae..... 4
- 2 Ostium close to posterior margin of sternite VIII..... 3
- Ostium opening on margin of sternite VIII *eryngiella* **Millière, 1881**
- 3 Sternite VIII anteriorly with a pair of sclerotized cusps, on either side of antrum *veneficella* **Zeller, 1847**
- Sternite VIII without such cusps..... *discipunctella* **Herrich-Schäffer, 1854**
- 4 Anterior margin of sternite VIII with deep sinus; ostium close to posterior margin *albarracinella* **Corley, sp. n.**
- Anterior margin of sternite VIII straight or slightly convex 5
- 5 Signum minute; ductus bursae of uniform width.. *gallicella* **Chrétien, 1908**
- Signum small, but wider than narrowest part of ductus bursae close to antrum; ductus bursae with swelling in middle..... *cervicella* **Herrich-Schäffer, 1854**

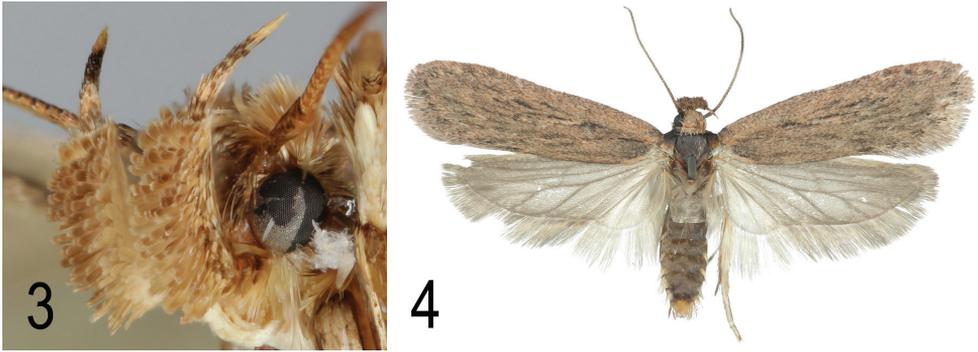


Figure 2. *Depressaria albarracinella* sp. n. Holotype male, Spain, Granada, Sierra Nevada, Collado del Lobo, North Side, 2300 m, 14.vii.1969, leg. K. Sattler & D.J. Carter (NHMUK) (photo D. Lees).

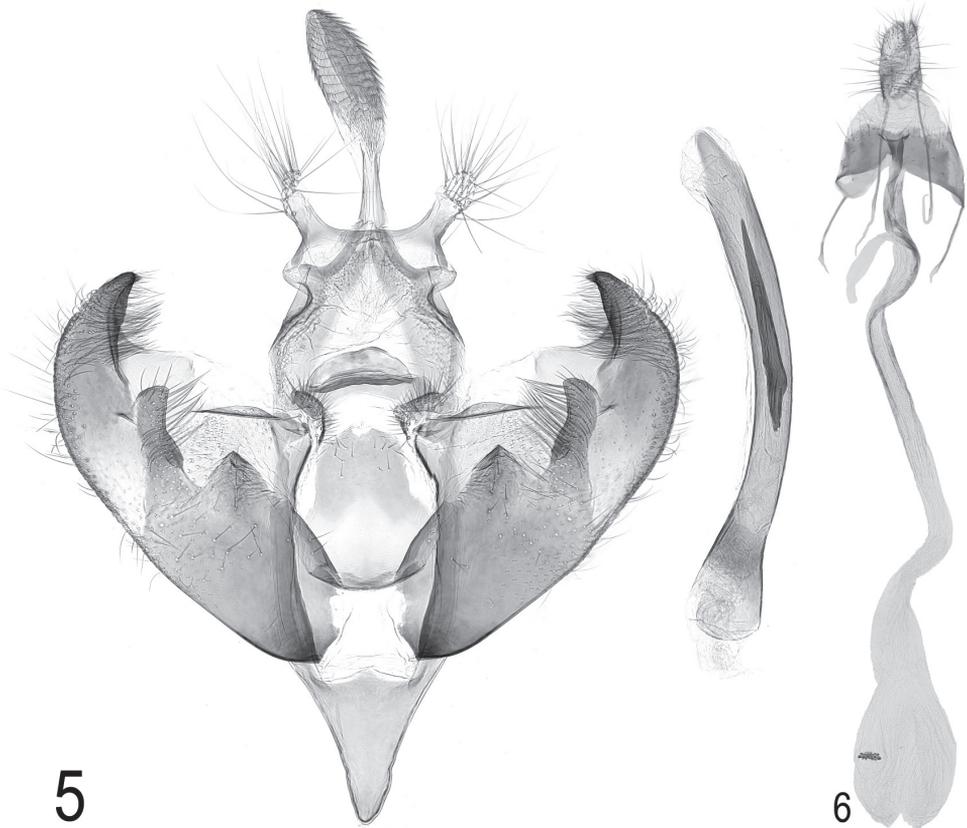
Description. Adult (Figs 2–4). Wingspan 23–26 mm. Head cinnamom-brown on neck and crown; face light brownish buff. Labial palp with segment 3 two-thirds length of segment 2, segment 2 buff with tufted scales on ventral side cinnamon; segment 3 cinnamon with dark grey ring beyond middle, tip cinnamom-buff. Antenna light grey-brown, narrowly ringed dark brown. Thorax light brownish buff, rarely darker. Forewing light brown, often with slight cinnamon tinge, often very weakly marked but sometimes with more or less faint grey-brown interrupted streaks in cell, in fold, beyond cell, between veins to costa and between veins to termen; occasionally a faint brown spot is present at base of dorsum; equally indistinct grey-brown spots between vein-ends at termen; cilia light brown, without obvious cilia line. Hindwing light grey, slightly darker posteriorly, with narrow grey-brown line around terminal and dorsal margins; cilia light grey-brown at apex to almost white at dorsal base, with a fine darker cilia line. Abdomen light grey-brown.

Variation: The forewing markings vary from almost completely obsolete to present but faint compared with most other *Depressaria* species. The specimen from Huesca, Spain (Fig. 4) is the most strongly marked that we have seen. Sometimes a faint V-shaped pale fascia is visible beyond end of cell.

Male genitalia (Fig. 5). Gnathos elongate; socii elongate, parallel-sided, divergent; valva almost as long as aedeagus, apex incurved, sacculus with two lobes, the inner broadly triangular, the second longer and narrower, slightly incurved; anellus broadly pyriform, distal margin slightly emarginated; saccus triangular, of similar length to anellus; aedeagus slender with slightly expanded base, cornutus about two-fifths length of aedeagus.



Figures 3–4. *Depressaria albarracinella* sp. n. Head. Paratype. Spain, Granada, Sierra Nevada, Camina de Veleta, 2300 m, 22.x.1987, leg. E. Traugott-Olsen (ZMUC) **4** *Depressaria albarracinella* sp. n. Paratype. Spain, Huesca, Candasnos, 30.v.2015, leg. J. Viehmann.



Figures 5–6. *Depressaria albarracinella* sp. n. Male genitalia. Paratype. Spain, Castellón, Banderetta Pass, 800 m, 17.vii.1992, leg. M. Fibiger, slide DEEUR 0762 (ZMUC) **6** *Depressaria albarracinella* sp. n. Female genitalia. Paratype. Spain, Granada, Camina de Veleta, 2300m, 22.x.1987, leg. E. Traugott-Olsen, slide DEEUR 0772 (ZMUC).

Female genitalia (Fig. 6). Anterior margin of sternite VIII with median sinus, ostium close to posterior margin; ductus bursae long, without swellings or ornamentation; signum small, wider than long, not as wide as ductus bursae in most of its length.

Molecular data. Data of barcoded specimens. TLMF Lep 19062 (658 bp.[1n], ♀, Spain, Aragon, Albarracin, 40°25'N; 1°27'W, 3.v.2003, leg. et coll. K. Cerny, gen. prep. DEEUR 1786); TLMF Lep 19150 (658 bp.[0n], ♂, Spain, Huesca, Candanos, 41°30'N; 0°40'E, 30.v.2015, leg. J. Viehmann, coll. W. Schmitz, gen. prep. DEEUR 3903); TLMF Lep 17687 (658 bp.[0n], ♂, Greece, Parnassos Mountains, 1 km NW Arachova, 1070 m, 38°29'N; 22°35'E, 9.vi.2013, leg. P. Skou, coll. ZMUC, gen. prep. DEEUR 2326).

Neighbour-joining analysis (Fig. 7) shows *Depressaria eryngiella* as the nearest neighbour with 2.45% p-distance. Intraspecific variability, based on present knowledge, 0% within the Spanish population and 1.08% between Spanish and Greek populations.

For Maximum Likelihood analysis, see Fig. 70.

Etymology. The species name is an adjective derived from Albarracin in Spain, an area where two of the paratypes were taken.

Distribution. Spain: Mountain areas of Eastern Spain from Sierra Nevada and Sierra de Los Filabres northwards, in the provinces of Granada, Almería, Castellón, Teruel, Zaragoza and Huesca. **Greece:** Parnassos Mountains in Central Greece, Lesbos.

Bionomics. Larva and food-plant unknown, but the latter is likely to belong to Apiaceae. Adult moths have been taken in May, June, July and October. It is probable that overwintering takes place in the adult stage, but less clear when the larvae would be feeding.

Remarks. The genus *Depressaria* Haworth, 1811 includes around 125 species (Wikipedia 2016) with the greatest number in the Palearctic region. The majority of

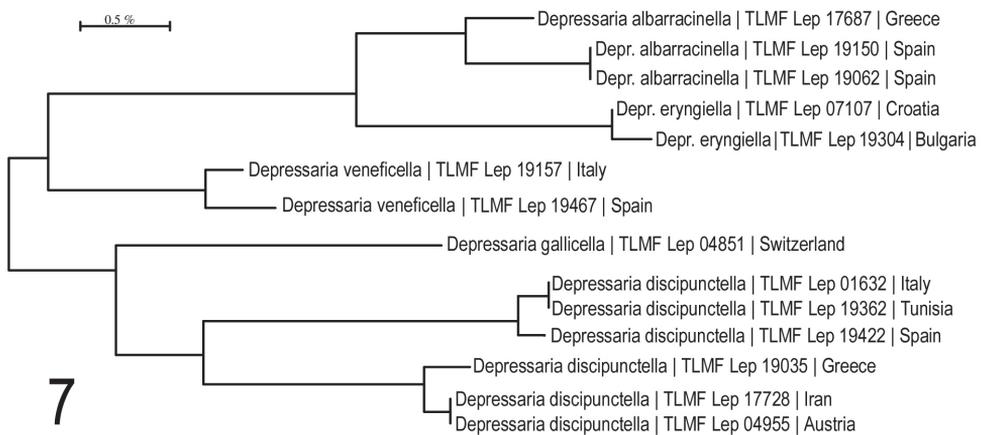


Figure 7. Neighbour-joining tree of *Depressaria albarracinella* sp. n. and related species. Associated BOLD BINs: *D. albarracinella*: BOLD:ACX8130; *D. eryngiella*: BOLD:ACF7124; *D. veneficella*: BOLD:ADC7254; *D. gallicella*: BOLD:ABA1484; *D. discipunctella*: BOLD:AAO4681 (upper cluster) & BOLD:ABA1412 (lower cluster).

the species are rather similar externally, but for the most part, the male genitalia give clear differences between species. Indeed there is such diversity in genital morphology within the genus that it is difficult to characterise the genus using genitalia characters. Within this great diversity there are some clearly defined groups, with a number of species sharing a suite of genitalia characters. One such group is the *veneficella* group (Hannemann, 1953), currently with 13 species described from the Palaearctic region extending from western Europe and North Africa through the Middle East to central Asia, with the most eastern records from north-east China, Mongolia and the Altai region of Siberia. Lvovsky (1996) when describing *D. erzurumella* Lvovsky, 1996 from Turkey, provided a key based on male genitalia to 11 species, omitting *D. pentheri* Rebel, 1904, which was known only from the female. Subsequently he described *D. kailai* Lvovsky, 2009 (Lvovsky 2009). The new species, *D. albarracinella*, belongs to this group.

The *veneficella* group is characterised by rather long wings, forewings brown with pattern usually consisting of blackish streaks between the veins, but the pattern very reduced in some species. Male genitalia have elongate gnathos (nearly globose only in *altaica* Zeller, 1854 and *kailai*), valvae incurved at apex, costal margin sometimes with median bulge, sacculus widely crossing the valva with two (rarely three) processes on the posterior edge, the outer reaching close to the costal margin of valva or exceeding it, saccus often elongate, aedeagus slender, long with a single cornutus. Female genitalia with long ductus bursae. Species identification most often rests on the male genitalia, where the shape of the incurved apex of the valva, the length of the saccus and the relative proportions of the various parts provide diagnostic characters, in particular the length of the cornutus relative to the aedeagus and the length of the aedeagus relative to the length of the valva. Those species with known food-plants all feed on Apiaceae.

The presence of an undescribed species of this group in Spain was recognised by Klaus Sattler after he and David Carter collected several specimens in Sierra Nevada in 1969. These have remained unnamed in NHMUK since that date. Further specimens were later collected in the same area and elsewhere in Spain, most of these deposited in ZMUC. It was these that first came to the notice of M. Corley in 2004. Recently the species has been found in additional localities in Spain and in Greece. It is described here as *D. albarracinella* Corley sp. n.

The specimens from Greece have not been included in the type series. Although there is no reason to doubt the identification, the p-distance of over 1% between the barcodes of Spanish and Greek specimens suggests that caution is not out of place.

***Agonopterix carduncelli* Corley, sp. n.**

<http://zoobank.org/F0BDBC85-90F3-41B9-8CE1-8DECC95F9CF8>

Type locality. Portugal, Algarve, Boliqueime, 70 m, 37°8'N; 8°1'W.

Holotype. ♂, Portugal, Algarve, Boliqueime, 24.xi.2011, M.J. Dale | *Agonopterix carduncelli* Corley Holotype | slide MD01355, DEEUR photo 0758 *A. carduncelli* | DNA barcode id. TLMF Lep 07015. Specimen to be deposited in NHMUK.

Paratypes. Portugal: 1 ♂, Algarve, Boliqueime, 20.xi.2010, M.J. Dale, gen. prep. DEEUR 0757, in coll. M.J. Dale; 1 ♂, Algarve, Mexilhoeira Grande, Cruzinha, 15.v.2011 ex l. iii.2011, *Carthamus (Carduncellus) caeruleus*, leg. M.F.V. Corley, DEEUR 0777, in coll. M. Corley; 1 ♀, same data but emerged 23.v.2011, gen. prep. DEEUR 0776, in coll. M. Corley; **Spain:** 1 ♂, Cuenca, Izotely, 30.ix.2008, leg. L. Srnka, gen. prep. DEEUR 2183, det. P. Buchner; **Greece:** 1 ♀, Messalongi Galatas, 5.v.2007, W. Schmitz, DEEUR 4404, det. P. Buchner; **Morocco:** 1 ♂, 1 ♀, High Atlas, Ifrane, 30.vi.1972, leg. F. Hahn, gen. prep. DEEUR 1983 (♂) bzw DEEUR 1980 (♀), det. P. Buchner; 1 ♂ same locality, 2.vii.1972, G. Friedel (ZSM), gen. prep. DEEUR 1677, det. P. Buchner.

Diagnosis. The characteristic shape of segment 2 of the labial palp and the absence of a posterior crest on the thorax are features shared with a few other species mostly with similar coloration. *A. straminella* (Staudinger, 1870) is most similar with black dot at base of dorsum and black terminal dots together with paler hindwing, but lacks cell dots. Forms of *A. carduncelli* sp. n. without evident cell dots require genitalia examination to distinguish them from *A. straminella*. Other related species have better developed cell dots. In the male genitalia, *A. carduncelli* sp. n. is recognisable by the longer curved cuiller and broader valva in comparison with related species. The female is unique among European *Agonopterix* in the absence of a signum.

Description. Adult (Figs 8–9). Wingspan 19.5–21 mm. Head dull ochreous-buff, face creamy buff. Labial palp segment 2 with only the distal half rough-scaled and furrowed, pale buff with scattered light brown scales, segment 3 pale buff or ochreous-buff. Antenna with scape dull ochreous-brown, proximal part of flagellum ochreous-buff, ringed grey-brown, distally grey-brown. Thorax dull ochreous-buff often with darker median line, without posterior crest. Forewing pale ochreous-buff with faint pinkish tinge when fresh, with a variable amount of scattered light brown and blackish scales, particularly along veins towards termen and sometimes also in cell and between dorsum and fold; a black or brown dot at base of dorsum, a small dot in cell at two-fifths and usually another at end of cell; terminal spots dark grey-brown; a faint grey-brown stripe stretching through subdorsal area ending in a wider patch below end of cell; cilia pale ochreous-buff with weak cilia line. Hindwing light grey, darker in outer half; cilia light greyish ochreous with indistinct cilia lines. Legs pale ochreous-buff, foreleg blackish on upper side of tibia and part of tarsus. Abdomen light greyish buff.

Variation: Some specimens have many more scattered dark scales than others. The subdorsal spot can be distinct or dull pale brown; the cell dots may be obsolete, or if developed may still be indistinct due to the abundance of scattered scales; the development of the subdorsal streak is variable.

Male genitalia. (Fig. 12). Similar to related species, but gnathos almost exceeding socii by its own length, valva broader and smooth-sided, slightly curved, tapered to rounded apex; cuiller curving outwards at middle, parallel-sided, round and slightly wrinkled at apex, crossing four-fifths width of valva, longer than in related species due to broader valva. Fig. 13 shows male genitalia of the other six *pallorella* group species for comparison.



8



9

Figures 8–9. 8 *Agonopterix carduncelli* sp. n. Holotype male. Portugal, Algarve, Boliqueime, 24.xi.2011, leg. M.J. Dale 9 *Agonopterix carduncelli* sp. n. Paratype. Portugal, Algarve, Mexilhoeira Grande, Cruzinha, 15.v.2011, e.l. on *Carthamus* (*Carduncellus*) *caeruleus*, leg. M.F.V. Corley.

Female genitalia. (Fig. 14). Anterior margin of sternite VIII nearly straight, not bulging, ostium just beyond middle of plate; ductus bursae smooth, gradually expanding to corpus bursae; signum absent.

Description of larva. Head dark brown; prothoracic plate, thoracic legs and anal plate shining black; body deep purplish brown; pinacula black. Full grown larva a little exceeding 20 mm.



Figures 10–11. **10** *Agonopterix carduncelli* sp. n. Head. Portugal, Algarve, Boliqeime, 20.xi.2010, leg. M.J. Dale **11** *Agonopterix carduncelli* sp. n. Head. Mexilhoeira Grande, Cruzinha, 23.v.2011, e.l. on *Carthamus* (*Carduncellus*) *caeruleus*, leg. M.F.V. Corley.



Figure 12. *Agonopterix carduncelli* sp. n. Male genitalia. Holotype. Portugal, Algarve, Boliqeime, 24.xi.2011, leg. M.J. Dale, slide MD01355 (gen. prep. and photo M. J. Dale).

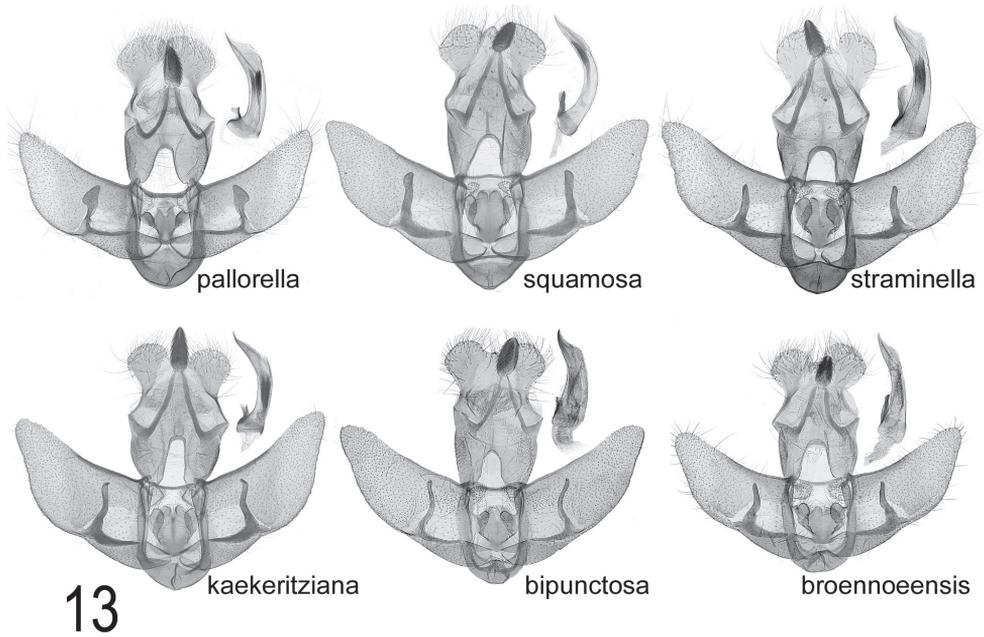


Figure 13. Comparison of male genitalia of European *A. pallorella* group species, excluding *A. carduncelli* sp. n. *A. pallorella* (Tunisia, Ksar); *A. squamosa* (Turkey, Amasia); *A. straminella* (Tunisia, Jebel Chambi); *A. kaekeritziana* (Austria, Schwarzau); *A. bipunctosa* (Sweden, Ronneby); *A. broennoeensis* (Russia, Kola, Apatity).



Figure 14. *Agonopterix carduncelli* sp. n. Female genitalia. Paratype. Morocco, Ifrane, 30.vi.1972, gen. prep. DEEUR 1980, leg. & coll. F. Hahn.

Molecular data. Data of barcoded specimens. TLMF Lep 06978 (658 bp.[0n], ♂, Portugal, Mexilhoeira Grande, Cruzinha, 37°10'N; 8°37'W, leg. larva iii.2011 from *Carthamus (Carduncellus) caeruleus*, e.p. 23.v.2011, leg., cult. and coll. M. Corley P9827); TLMF Lep 06994 (620 bp.[0n], ♀, Portugal, Mexilhoeira Grande, Cruzinha, 37°10'N; 8°37'W, leg. larva iii.2011 from *Carthamus (Carduncellus) caeruleus*, e.p. 15.v.2011, leg., cult. and coll. M. Corley P9824, gen. prep. DEEUR 0776); TLMF Lep 07015 (658 bp.[0n], ♂, Holotype, Portugal, Algarve, Loulé, Boliqueime, 70 m, 37°8'N; 8°1'W, 24.xi.2011, gen. prep. MD01355, leg. and coll. M.J. Dale); TLMF Lep 07017 (658 bp.[0n], ♂, Portugal, Algarve, Boliqueime, 37°7'N; 8°9'W, 20.xi.2010, leg. and coll. M.J. Dale, gen. prep. DEEUR 0757).

Neighbour-joining analysis shows *Agonopterix multiplicella* (Erschoff, 1877) (BOLD:AAF7196, TLMF Lep 19102) as the nearest neighbour with 1.83% p-distance and *A. straminella* (BOLD:ABZ7581) as the second nearest neighbour with 2% p-distance. Intraspecific variability, based on present knowledge, 0.16% within the Portuguese population. So far, genetic data are available only from Portuguese specimens.

Differences in DNA barcodes arise over time through chance mutations. Such stochastic events sometimes lead to fairly unrelated species appearing as nearest neighbours. This is evidently the case with *A. carduncelli* sp. n. and *A. multiplicella*. The latter species has none of the characters of the *pallorella* group.

Etymology. The species name, a noun in genitive case, is derived from the larval food-plant *Carthamus [=Carduncellus] caeruleus* (Asteraceae).

Distribution. Currently known only from Portugal, Spain, Greece and Morocco, but potentially more widespread around the Mediterranean with its food-plant.

Bionomics. The larva feeds in the tips of shoots of *Carthamus caeruleus* (L.) C. Presl in late March before the flowers develop. Larvae from Algarve collected on 17 March 2011 emerged in captivity in May. Small larvae were collected on 25 March 2017 (Portugal, Beira Litoral, Ansião, M. Corley and J. Nunes) and reared on by J. Nunes. Two reached the final instar (Figs 15–16) but succumbed to parasitoids.

Remarks. *Agonopterix* Hübner, 1825 with around 245 species (Wikipedia 2017) mainly in the Holarctic region is the largest genus in Depressariidae. Unlike *Depressaria*,



Figure 15–16. *Agonopterix carduncelli* sp. n. Small larvae were collected on 25 March 2017 (Portugal, Beira Litoral, Ansião, M. Corley and J. Nunes) and reared on by J. Nunes. Two reached the final instar (Figs 15–16) but succumbed to parasitoids.

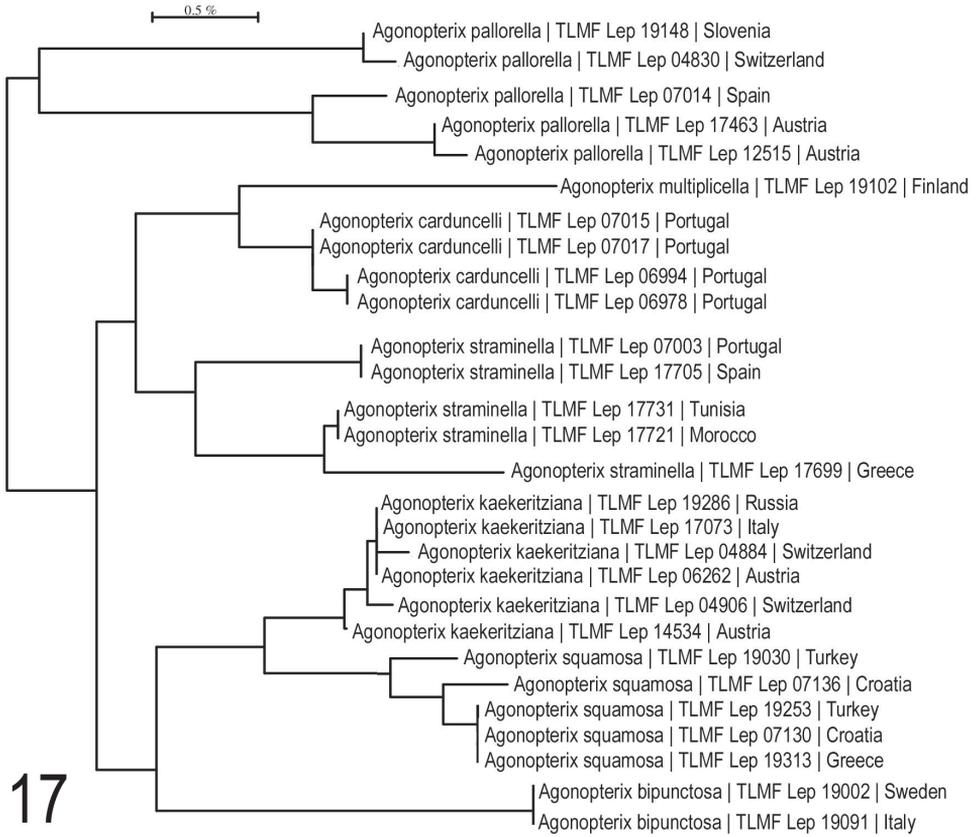


Figure 17. Neighbour-joining tree of species of *pallorella*-group and *A. multiplicella*. Associated BOLD BINs: *A. pallorella*: BOLD:ABA0382 (upper cluster); BOLD:ABU5790 (lower cluster); *A. multiplicella*: BOLD:AAF7196; *A. carduncelli*: BOLD:ABZ7583; *A. straminella*: BOLD:ABZ7581 (upper cluster) BOLD:ACX7863 (lower cluster); *A. kaekeritziana*: BOLD:AAF7198; *A. squamosa*: BOLD:ACF7120; *A. bipunctosa*: BOLD:ABA0011.

male genitalia are rather similar throughout the genus. Easily defined groups within the genus are less obvious than in *Depressaria*, but there are some such groups. One of these is the *pallorella* group which includes several closely related species all feeding on Asteraceae tribe Cynareae and sharing similar pale ochreous coloration, forewings without defined basal patch, oblique pair of dots reduced to one or absent, labial palp characteristic with appressed scales on underside of segment 2 in proximal half, distal half with forward projecting scales making a triangular tuft, thorax without posterior crest. The species of this group are *A. pallorella* (Zeller, 1839), *A. kaekeritziana* (Linnaeus, 1767), *A. bipunctosa* (Curtis, 1850), *A. broennoeensis* Strand, 1920, *A. straminella* (Staudinger, 1870) and *A. squamosa* (Mann, 1864). A few other described taxa are synonyms of the above mentioned species. However one species has been previously overlooked and is described here as *A. carduncelli* sp. n.

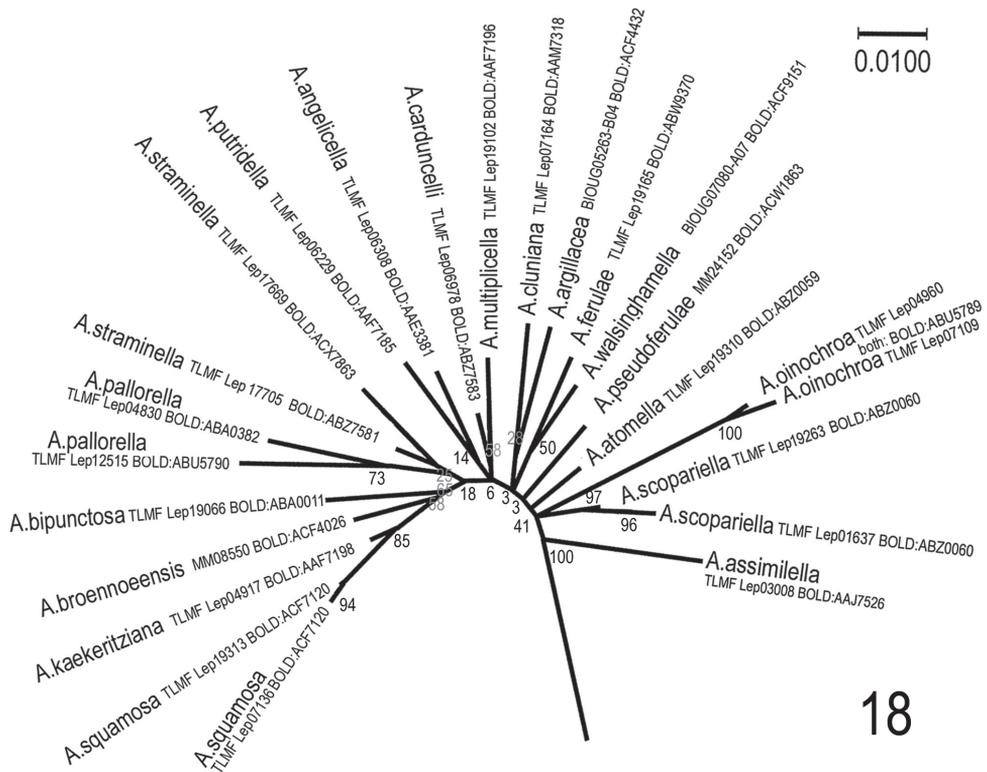


Figure 18. Maximum Likelihood analysis of selected species of the genus *Agonopterix*: *A. pallorella*-group, *A. multiplicella* and species near *A. pseudoferulae*. In addition to the selection used for the neighbour-joining tree, the following *Agonopterix* species were included: *A. angelicella* (Hübner, [1813]) (TLMF Lep 06308, BOLD:AAE3381); *A. argillacea* (Walsingham, 1881) (BIOUG05263-B04, BOLD:ACF4423); *A. assimilella* (Treitschke, 1832) (TLMF Lep 03008, BOLD:AAJ7526); *A. walsinghamella* (Busck, 1902) (BIOUG07080-A07, BOLD:ACF9151). The evolutionary history was inferred by using the Maximum Likelihood method based on the Tamura-Nei model. The tree with the highest log likelihood (-4818.52) is shown. Initial trees for the heuristic search were obtained automatically by applying Neighbor-Join and BioNJ algorithms to a matrix of pairwise distances estimated using the Maximum Composite Likelihood (MCL) approach, and then selecting the topology with superior log likelihood value. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. The proportion of sites where at least 1 unambiguous base is present in at least 1 sequence for each descendent clade is shown next to each internal node in the tree. The analysis involved 54 nucleotide sequences from selected species of *Agonopterix* and *Depressaria*. Only the *Agonopterix* part of the tree is shown here. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 657 positions in the final dataset. Evolutionary analyses were conducted in MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets (Kumar, Stecher and Tamura 2015). The result is shown in radiation graphic, because in this view the evolutionary aspect is visualized better than in rectangular tree.

The existence of an *Agonopterix* feeding on *Carthamnus* in Algarve, Portugal was suspected from the late 1990s when empty spinings were found by M. Corley on the plant in late April. After Michael Dale found an adult of an undescribed species in 2010, a visit to Algarve in March 2011 by M. Corley targeting larvae on this plant was successful, resulting in two reared adults (see paratypes).

Two reared specimens (which survived the deterioration of their larval food-plant after M. Corley returned to England), show a grey-brown tinge in place of scattered dark scales and lack the row of terminal dots, but these features are shared by some of the Moroccan specimens.

Corley (2002) mentions a specimen without signum from Setúbal, Portugal in MNHN which was considered to be a possible aberration of *A. mendesi* Corley, 2002. As the signum is not known to be absent in any other *Agonopterix* species, it is extremely probable that this specimen belongs to *A. carduncelli* sp. n.

***Agonopterix pseudoferulae* Buchner & Junnilainen, sp. n.**

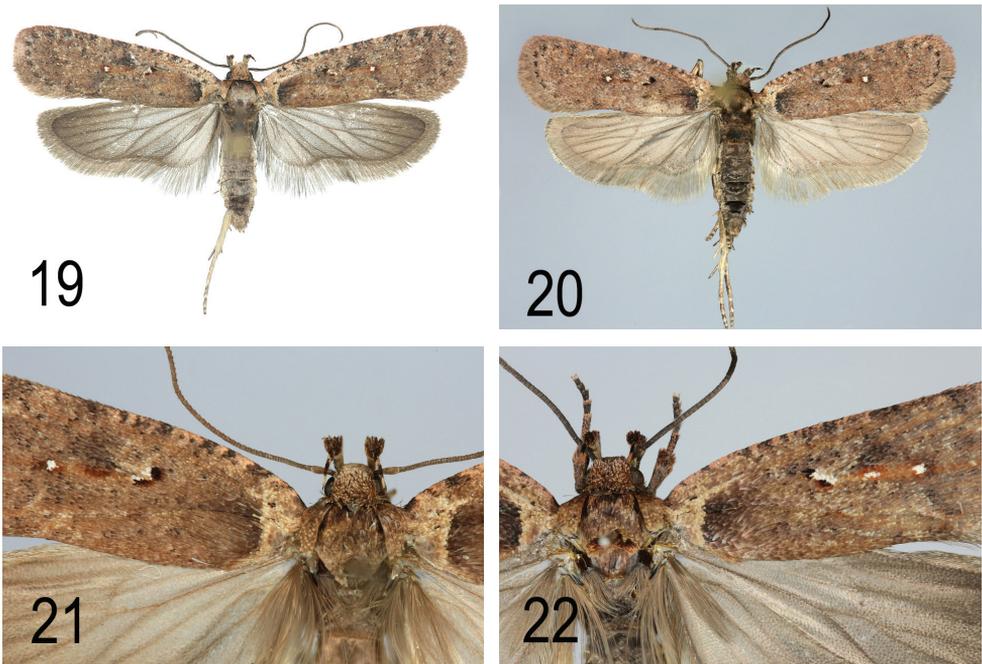
<http://zoobank.org/8C70763C-9C9E-47CB-ABE7-F20B9271976C>

Type locality. Italy, Sardinia, Laconi, 39°51'N; 9°3'E.

Holotype. ♂, Italy, Sardinia, Laconi, 16.vi.2009, leg. J. Junnilainen, DNA barcode id. BC TLMF Lep 19306, gen. prep. DEEUR 4462, in coll. J. Junnilainen.

Paratypes. 1 ♀, same data as holotype, DNA barcode id. MM24152, leg. & coll. J. Junnilainen; 2 ♂♂, 3 ♀♀, same data as holotype, leg. & coll. J. Junnilainen; 1 ♂, 1 ♀, same data as holotype, leg. J. Junnilainen, in coll. ZMUH; 1 ♂, 1 ♀, same data as holotype, leg. J. Junnilainen, in coll. NHMUK; 1 ♂, 1 ♀, same data as holotype, leg. J. Junnilainen, in coll. M. Corley; 1 ♀, Greece, Peloponnese, Chelmos, 2100 m, 10.vii.1963, leg. J. Klimesch, coll. ZSM; 1 ♀, Italy, Puglia, 21.vii.1955, leg. S. Zangheri, in coll. ZSM; 1 ♂, Italy, Puglia, "FG" Gargano sopra Vieste, 400 m, 5.ix.2008, coll. G. Fiumi; 1 ♂, Italy, Sicilia, Madonie, Piano Battaglia, 18.x.1990, gen. prep. DEEUR 1928, in coll. TLMF; 1 ♀, Italy, Latium, Mt Terminillo, 17.vii.2010, DNA barcode id. TLMF Lep 19067, gen. prep. DEEUR 1737, leg. & coll. T. Mayr; 1 ♂, 1 ♀, Italy, Puglia, Gargano, leg. larva 4.iv.2016 from *Elaeoselinum asclepium*, e.p. end of April 2016, leg., cult. & coll. P. Sonderegger.

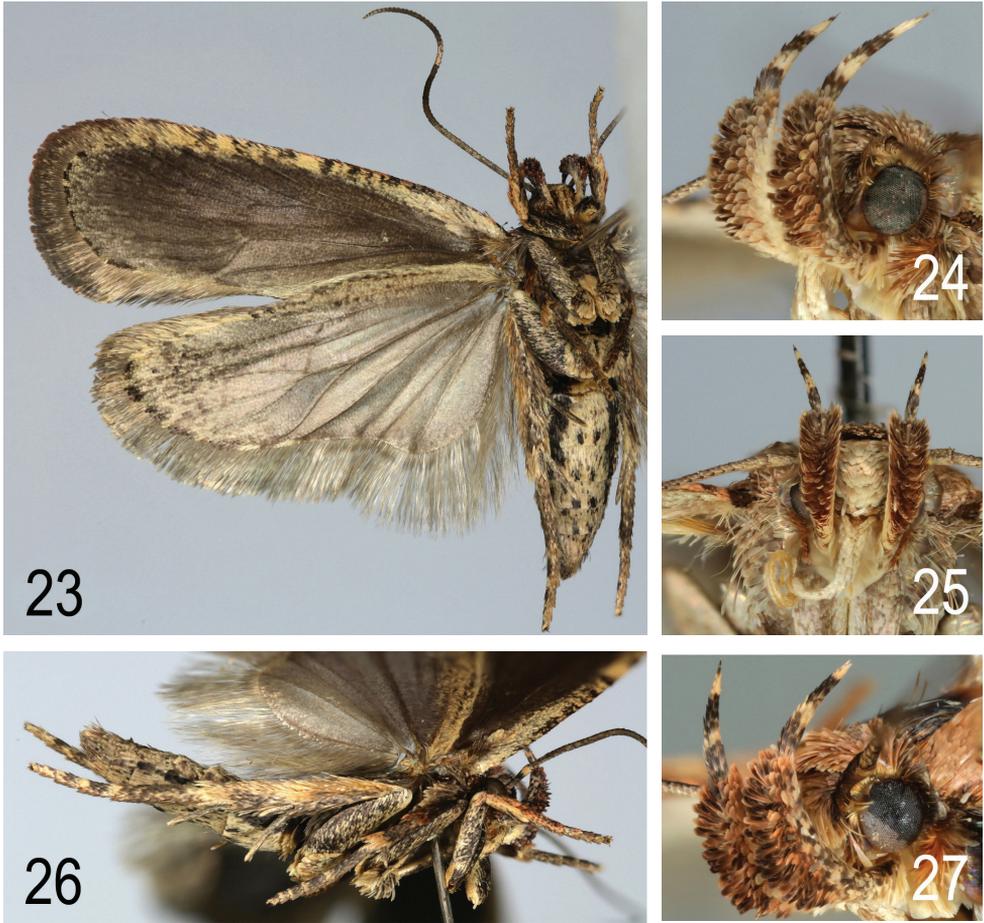
Diagnosis. *A. pseudoferulae* sp. n. (Figs 19–27) was confused with *A. ferulae* (Figs 28–29) by Klimesch. At first glance, they do look similar, but a closer look shows two constant differences: the brick-red line between the proximal pair of dots and the distal dot and the diffuse dark spot which touches this line on costal side in *A. pseudoferulae* sp. n., which are both absent in *A. ferulae* (if diffuse dark spots are present, they are found in other areas). *A. atomella* (Denis & Schiffermüller, 1775) (Fig. 33) and *A. scopariella* (Heinemann, 1870) (Fig. 32), the two species closest to *A. pseudoferulae* sp. n. in DNA barcode, do not have the reddish elements in central forewing pattern. *A. oinochroa* (Turati, 1879) (Fig. 31) has reddish elements here, but they surround the dots and do not form a line. A forewing pattern similar to *A. pseudoferulae* sp. n. is found



Figures 19–22. 19 *A. pseudoferulae* sp. n. Holotype (Italy, Sardinia, Laconi), general view 20 *A. pseudoferulae* sp. n. Paratype. (Italy, Sardinia, Laconi), general view 21 *A. pseudoferulae* sp. n. Paratype. (Greece, Peloponnese), head, thorax and forewing base 22 *A. pseudoferulae* sp. n. Paratype. (Italy, Puglia, Gargano, e.l. *Elaeoselinum asclepium*), head, thorax and forewing base.

only in *A. cluniana* Huemer & Lvovsky, 2000 (Fig. 30), but here differences are found in outline of forewing and shape of interneural dots at outer margin: apex rounded, outer margin convex, interneural dots round and diffuse in *A. pseudoferulae* sp. n., apex pointed, outer margin straight to concave, interneural dots narrow lines in *A. cluniana*.

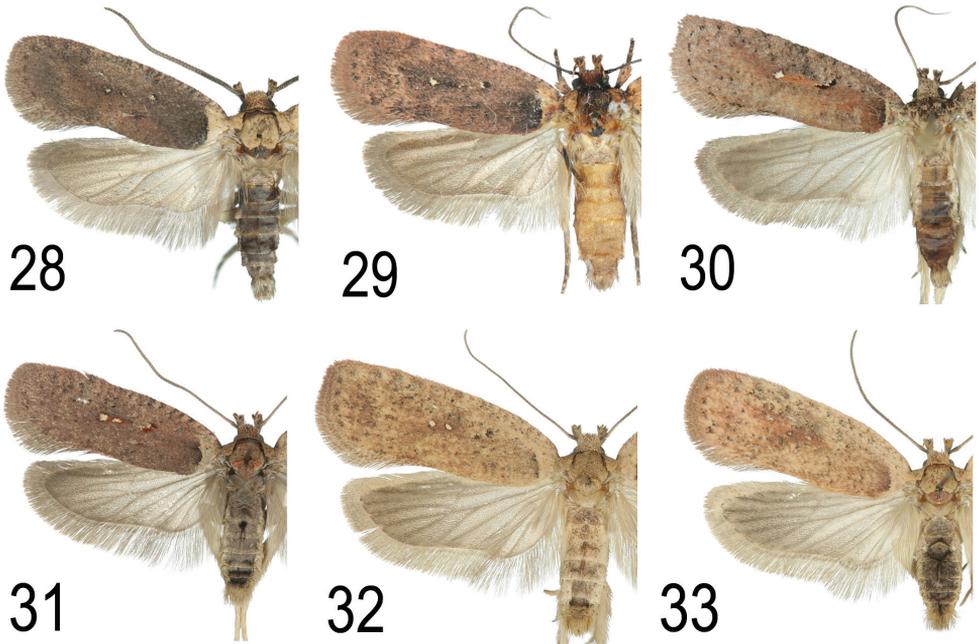
Description. Adult: Wingspan 19–21 mm. Scales of head brown, tips markedly paler. Labial palp segment 2 inner side pale, outer and ventral sides medium greyish brown or rusty brown scales mixed with blackish scales; third segment bicoloured, blackish at base, shortly above middle and at extreme tip, pale between the dark areas. Antenna dark brown. Thorax with posterior crest, rather dark brown, tegulae similar. Forewing predominantly dark reddish brown, whitish and black scales interspersed in low (but variable) numbers, basal field markedly paler, gradually passing into a pale stripe which runs along costa especially in proximal half and is interrupted by irregular dark patches. The centre of the forewing has the typical basic pattern of *Agonopterix* (two oblique dots at about one-third, one or two dots along veins at about one-half and a diffuse black spot between the two pairs of dots but closer to the costa) but with very distinct details: the two black, oblique dots partly bordered with reddish (brick-red to ochreous) scales which may connect the two dots on their proximal margin, distal margin pale to white, the third dot at about one-half with clear white centre and sur-



Figures 23–27. 23 *A. pseudoferulae* sp. n. Paratype. (Italy, Gargano, e.l. *Elaeoselinum asclepium*), ventral view 24–25 *A. pseudoferulae* sp. n. Paratype (Greece, Peloponnese), palps (24 lateral view 25 frontal view) 26 *A. pseudoferulae* sp. n. Paratype (Italy, Gargano, e.l. *Elaeoselinum asclepium*), lateral view 27 *A. pseudoferulae* sp. n. Paratype (Italy, Mt Terminillo), palps, lateral view.

rounded by a few dark scales, a brick-red to ochreous line connects the oblique dots with the distal dot and exceeds it a little; the diffuse blackish spot touches the brick-red line between the dots on the costal side. Cilia concolorous with wings. Under side of forewing dark grey except costa which is predominantly yellowish with interspersed groups of dark scales. Hindwing rather dark greyish brown, moderately translucent at base, cilia concolorous with wings, base and tips darker than in between. Legs covered with a mix of dark grey and pale scales, tibia yellowish to rusty brown on outer side, especially on fore- and hindlegs. Abdomen greyish, with broad dark line laterally and two rows of indistinct dark spots on ventral side.

No gender-specific differences could be found.

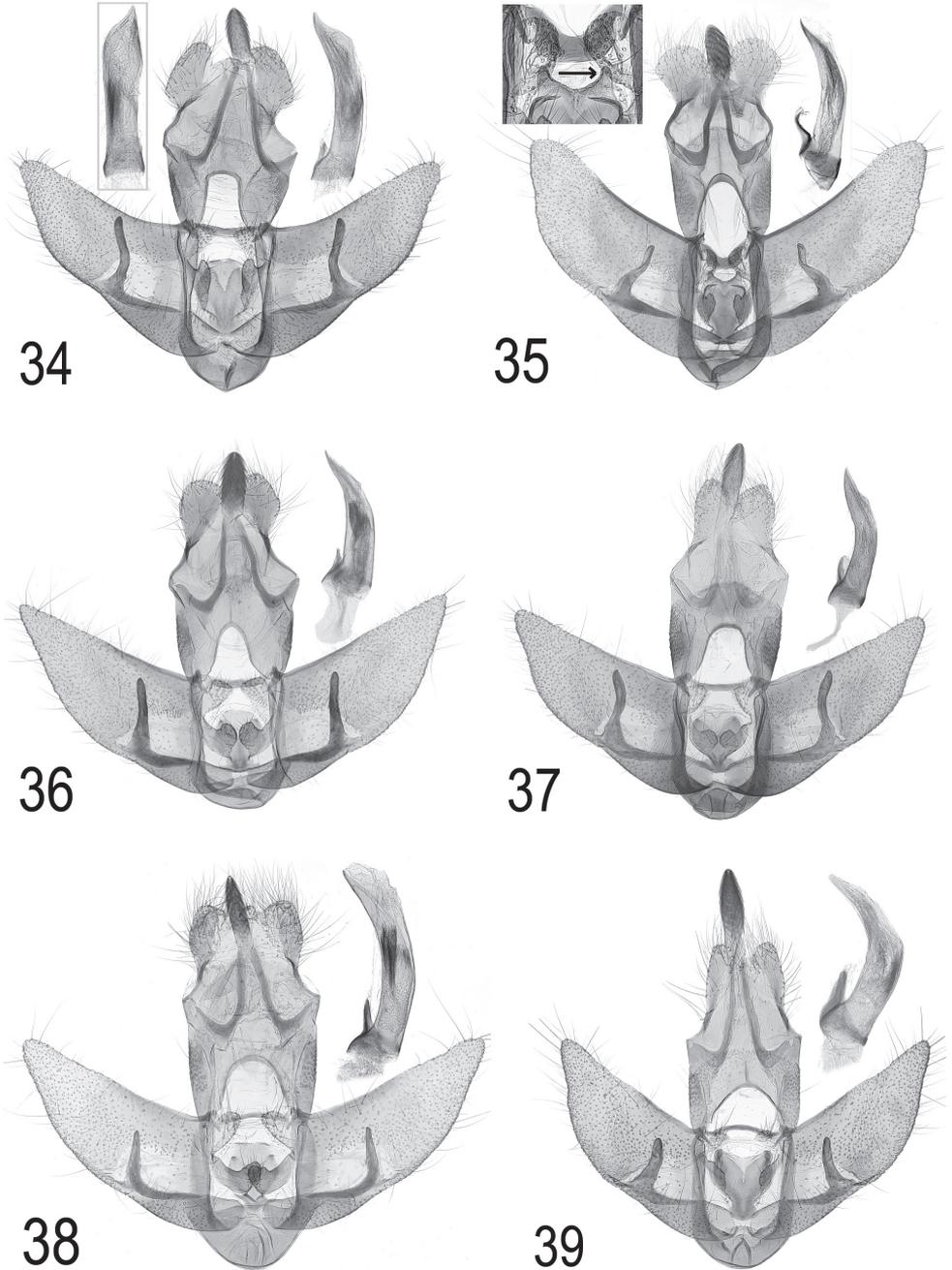


Figures 28–33. Comparison of wing patterns of several species similar to *A. pseudoferulae* sp. n. **28** *A. ferulae* (France, Var, e.l. *Ferula communis*) **29** *A. ferulae* (Italy, Sardinia, Gennargentu) **30** *A. cluniana* (Austria, Vorarlberg, Bangs) **31** *A. oinochroa* (Germany, Kaiserstuhl, e.l. *Genista tinctoria*) **32** *A. scopariella* (Italy, Lugano, e.l. *Laburnum*) **33** *A. atomella* (Austria, Lower Austria, Waschberg).

Variation: Little variation was found within the nine examined specimens. The number of interspersed white scales on forewing varies to some extent, and between the proximal pair of dots and the distal dot, an additional white dot may be developed or not. In one specimen the thorax (but not tegulae) is entirely black.

Male genitalia (Fig. 34): There is no single feature which separates male genitalia of *A. pseudoferulae* sp. n. from all other species of *Agonopterix*, therefore it is best to compare genitalia with each of the externally similar species individually.

A. ferulae (Fig. 35) belongs to the *alpigena/selini* species group, which is characterised by a two-horned process of the anellus toward transtilla (see arrow in insert of Fig. 35) in combination with transtilla significantly widened in the middle. In *A. pseudoferulae* sp. n. these features are not present. In *A. atomella* (Fig. 36), *A. oinochroa* (Fig. 37) and *A. scopariella* (Fig. 38) anellus lobes are large, nearly touching in *A. atomella* and *A. oinochroa*, overlapping in *A. scopariella* in standard preparation. In *A. pseudoferulae* sp. n. anellus lobes are narrow with a wide gap in between. In *A. cluniana* (Fig. 39) cuiller is rather short (about 70% of valva-width) and socii markedly narrow, gnathos far exceeding end of socii, in *A. pseudoferulae* sp. n. cuiller nearly reaching costa of valva (at least 90% of valva-width), socii and gnathos of average shape, compare Figs 34 and 39 (appearance of socii and gnathos may be influenced by preparation artifacts, so it is not helpful to point out a numerical ratio).



Figures 34–39. Comparison of male genitalia of *A. pseudoferulae* sp. n. with selected species. **34** *A. pseudoferulae* sp. n. Holotype, insert: aedeagus in ventral view **35** *A. ferulae* (Portugal, Trás-os-Montes), insert: anellus process and transtilla **36** *A. atomella* (Italy, Friuli, Redipuglia) **37** *A. oinochroa* (Spain, Leon, Vilafeliz de Babla) **38** *A. scopariella* (Croatia, Novi Vinodolsky) **39** *A. cluniana* (Austria, Vorarlberg, Bangs).

Female genitalia (Figs 40, 41a). Anterior margin of sternite VIII with a triangular process, which is separated from lateral parts of anterior margin by distinct steps (arrows 41a), ostium round, in the centre of sternite VIII, not reaching into the triangular process. Ductus seminalis with about 8 turns. Ductus bursae rather stout with structures common in genus *Agonopterix*, widening gradually in its course. Corpus bursae of average size (diameter approximately equalling width of sternite VIII in standard preparation, i.e. dorsoventrally flattened), signum narrow oval (4 times wider than long), rather large (maximum diameter about one half diameter of bursa).

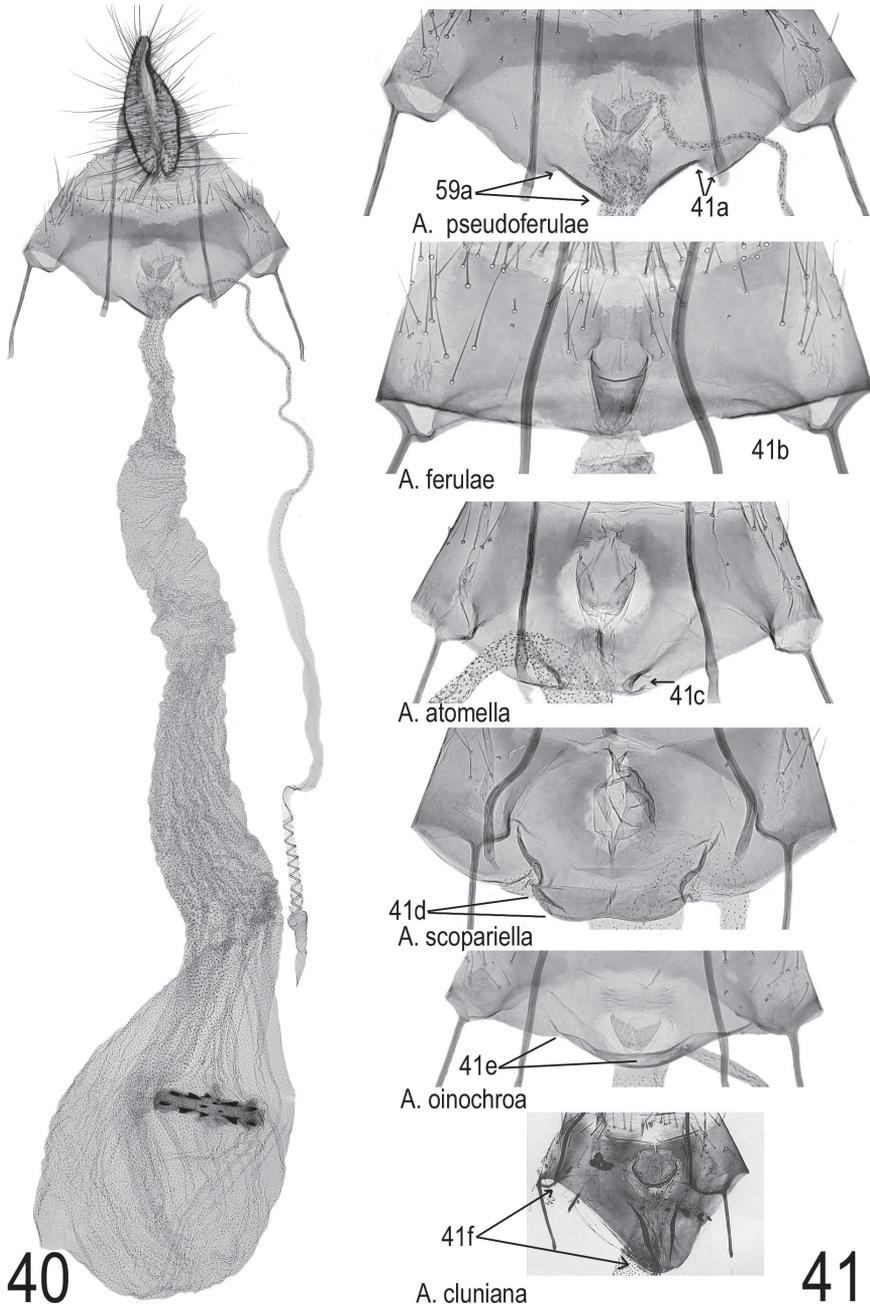
As in the males, all the species compared with *A. pseudoferulae* sp. n. also show distinct differences in female genitalia: *A. ferulae* (Fig. 41b) has a straight margin of sternite VIII without any fold. In *A. atomella*, oblique folds (arrow Fig. 41c) are developed at each side of centre of margin. In *A. scopariella* these folds are also present and between them, the anterior margin shows a somewhat rectangular extension (arrow Fig. 41d). In *A. oinochroa* it is slightly curved with a narrow transverse fold (arrow Fig. 41e), in *A. cluniana* it is extremely bulged (arrow Fig. 41f), which gives a character of the female genitalia of this species which is unique within *Agonopterix*.

Molecular data. Data of barcoded specimens: BC TLMF Lep 19306 (658 bp., holotype, ♂, Italy, Sardinia, Laconi, 39°51'N; 9°3'E, 16.vi.2009, leg. & coll. J. Junnilainen); MM24152 (658 bp., ♀, same locality as holotype, leg. & coll. J. Junnilainen); TLMF Lep 19067 (658 bp., ♀, Italy, Latium, Mt Terminillo, 1600m, 42°29'N; 13°0'E, 17.vii.2010, gen. prep. DEEUR 1737 P. Buchner, leg. & coll. T. Mayr).

Neighbour-joining analysis shows *Agonopterix atomella* ([Denis & Schiffermüller], 1775) (BOLD:ABZ0059) as the nearest neighbour at a minimum of 2.45% p-distance. So far there are only sequences from the Italian population available, where no intraspecific divergence had been found, but this may change when Greek specimens are sequenced.

For Maximum Likelihood analysis, see Fig. 18.

Related species: Searching for the most closely related species based on a neighbour-joining tree (Fig. 42), Maximum Likelihood analysis (Fig. 18) and genitalia patterns of both sexes has not achieved a satisfactory result in *A. pseudoferulae*. Compared with the nearest neighbour, there are some distinct differences: *A. atomella* is a Fabaceae-feeder, in male genitalia anellus lobes are very different. Looking further afield at the second nearest neighbour, *Agonopterix scopariella* (Heinemann, 1870) with a p-distance of 2.6% is also a Fabaceae-feeder, and the differences in genitalia are at least as marked as in *A. atomella*. On the other hand, the two Fabaceae-feeders *A. atomella* and *A. oinochroa* have very similar male genitalia, but a barcode distance of 4.08%. This suggests that every single parameter must be handled with care. Pronounced similarity may result from being closely related, but it does not prove it, because a single distinctive feature may develop independently in different groups. The only certainty from present evidence is that *A. pseudoferulae* is not a cryptic species.



Figures 40–41. Comparison of female genitalia of *A. pseudoferulae* sp. n. with selected species. **40** *A. pseudoferulae* sp. n., general view, paratype (Italy, Latium, Mt Terminillo) **41** ostium region of six selected species enlarged, arrows: see text under “female genitalia” **41a** *A. pseudoferulae* sp. n. (same specimen as Fig. 40) **41b** *A. ferulae* (Italy, Sardinia, Gennargentu) **41c** *A. atomella* (Austria, Lower Austria, Waschberg) **41d** *A. scopariella* (Portugal, Madeira, Faja da Nogueira) **41e** *A. oinochroa* (Serbia, Deliblato Sands) **41f** *A. cluniana* (Austria, Vorarlberg, photo from Huemer & Lvovsky, 2000).

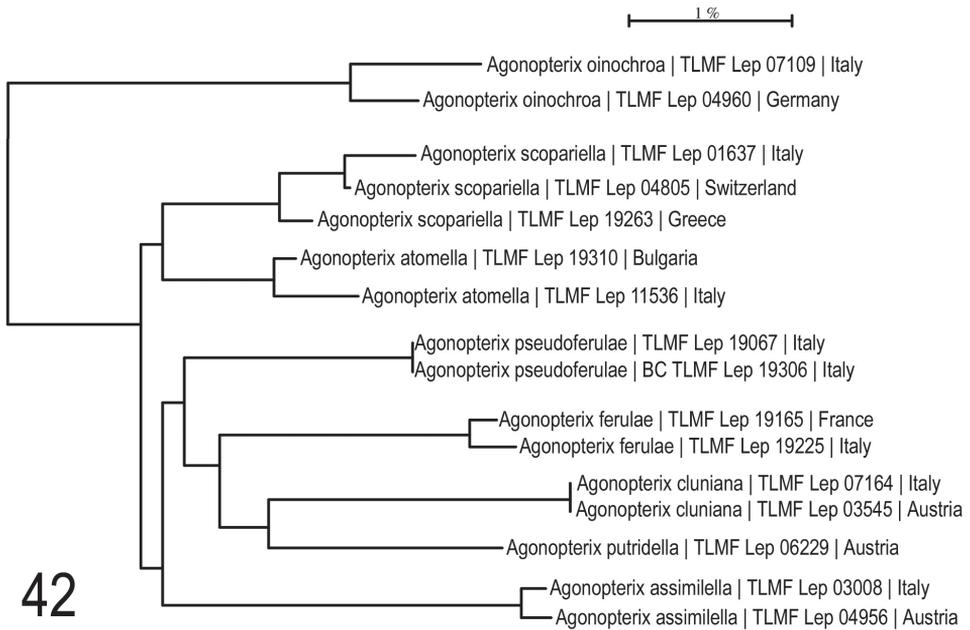


Figure 42. Neighbour-joining tree of *Agonopterix pseudoferulae* sp. n. and its closest clusters. Associated BOLD BINs: *A. oinochroa*: BOLD:ABU5789; *A. scopariella*: BOLD:ABZ0060; *A. atomella*: BOLD:ABZ0059; *A. pseudoferulae*: BOLD:ACW1863; *A. ferulae*: BOLD:ABW9370; *A. cluniana*: BOLD:AAM7318; *A. putridella*: BOLD:AAF7185; *A. assimilella*: BOLD:AAJ7526.

Etymology. The species name is a noun in genitive case. The first specimens of this new species were discovered in ZSM in the Klimesch collection under *A. ferulae*. This was decisive for the species name *pseudoferulae*, which means “the false *ferulae*”.

Distribution. So far known from Italy and Greece. In Italy it had been collected from Mt Terminillo (Latium), Gargano (Puglia), Madonie, Piano Battaglia (Sicily) and Laconi (Sardinia) and in Greece from Chelmos (Peloponnese).

Bionomics. Peter Sonderegger reared it from larvae collected on *Elaeoselinum asclepium* (L.) Bertol. (Apiaceae) from Gargano, Italy. Unfortunately he was not expecting anything of great interest, so no photo or larval description was obtained. Larvae were collected on 4 April, while the moth emerged in late April. Moths in good condition have been caught in June and July, and a worn specimen has been caught in October. It remains unclear in which stage the species survives winter.

Remarks. In ZSM under the name *Agonopterix ferulae* P. Buchner found a specimen collected by Josef Klimesch in Greece, which had a red mark in the discal cell which is not present in *A. ferulae*. Genitalia examination showed that it was distinct from *A. ferulae* and subsequently, when more recent specimens were found it was possible to obtain barcodes. Both genitalia and barcodes show this to be a new species not closely related to *A. ferulae*. It is described here as *A. pseudoferulae*.

***Depressaria saharae* Gaston & Vives ssp. *tabelli* Buchner, ssp. n.**

<http://zoobank.org/C90466AD-E3A7-4BF8-A452-ECFDD33E93EF>

Type locality. Spain, Canary Islands, Tenerife, Guimar.

Holotype. ♂, Spain, Canary Islands, Tenerife, Guimar, 6.iii. *Bupleurum aciphyllum* [*Bupleurum salicifolium* ssp. *aciphyllum*], ex. 16.iv.1907, Wlsm. 99748 | Walsingham Collection 1910-427 | B.M. ♂ Genitalia Slide No. 23304, NHMUK010305296, coll. NHMUK.

Paratypes. 1 ♀, Spain, Canary Islands, Tenerife, Guimar, La Ladera, 800 m, 23.iv.1998, GP DEEUR 2634, DNA-barcode id TLMF Lep 17692 (658 bp., BOLD:ADC8281), leg. & coll. K. Larsen.; 1 ♀, Tenerife, Los Gigantes, 100 m, 8-11.i.2008, GP DEEUR 2807, DNA-barcode id TLMF Lep 17711 (658 bp., BOLD:ADC8281), leg. & coll. K. Larsen.

Other material examined. *Depressaria saharae* ssp. *saharae*. 1 ♂, Spain, Granada, Sierra Nevada, 2430 m, 37°6.23'N; 3°23.84'W, 3.vii.2015, J. Tabell leg., GP ♂ 5480 J. Tabell, DEEUR 4024, DNA barcode id. TLMF Lep 19164 (658 bp., BOLD:ACF8051); 1 ♂, same collection data, without barcode; 2 ♂♂, Teruel, Albarracin, Val de Vecar, 1100 m, 3.x.2015, leg. J. Viehmann, coll. W. Schmitz; 1 ♂, Sr. de Albarracin, Sr. Alta, 1750m, 25.vi.2016, leg. J. Viehmann, coll. W. Schmitz; 3 ♂♂, Teruel, Albarracin. 6 km env. 1.x.2008, GP DEEUR 1000 & 1005, leg. & coll. L. Srnka, 1 of them (GP DEEUR 1000) with DNA barcode id. TLMF Lep 07068 (584 bp., BOLD:ACF8051)

Introductory note. It may be considered unusual to give a detailed description of the nominate subspecies before the description of a new subspecies, but in this case the original Spanish description is not detailed enough to serve as the basis for a comparison of the two subspecies. The original description is completely without information on genetic data and has little on relationships of the new species. It is therefore necessary to include such information on the nominate subspecies in this investigation.

Diagnosis. The wing pattern of both subspecies of *D. saharae* belongs to one of the basic patterns in the genus *Depressaria* which can also be found e.g. in *D. ultimella* Stainton, 1849 and *D. daucella* (Denis & Schiffermüller, 1775), with which this species was confused by Walsingham (published by him as *Depressaria apiella* (Hübner, 1796)). A situation which is often found in *Depressaria* is a combination of high intraspecific variability and near identical basic wing patterns used by several species, which makes it very difficult to determine specimens externally. When intraspecific variability is larger than the mean difference between the species, identification may become impossible. On the other hand, most species of *Depressaria* have distinctive genitalia in both sexes. This is the case in *D. saharae*, where diagnosis must be based on genitalia: see relevant paragraphs below.

Description. *Depressaria saharae* ssp. *saharae* specimens (only males) from mainland Spain (Figs 43–47): Wingspan 18–23 mm. Head greyish brown, tips of the scales markedly paler than the rest. Labial palp second segment with long, forward projecting scales which are dark grey with a narrow whitish distal margin, third segment medium



43

Figure 43. *Depressaria saharae* ssp. *saharae* Spain, Granada, Sierra Nevada, 3.vii.2015, J. Tabell leg, general view.



44



45



46



47

Figures 44–47. *Depressaria saharae* ssp. *saharae* same data as Fig. 43, but another specimen **44** lower side **45** head and thorax **46** labial palp, frontal view **47** labial palp, lateral view.

grey with flesh-coloured tinge, only at base with some blackish scales. Antenna with scape blackish, flagellum blackish on dorsal side and medium yellowish grey on ventral side. Thorax and tegulae medium greyish brown, thorax with 3 dark longitudinal streaks, one in the middle and one at each side. Forewing ground colour grey, with distinct blackish longitudinal streaks, especially in outer one-third; whitish scales are interspersed in low numbers over the whole surface, also forming an acute angled transverse line at about two-thirds, angle about 50°, and a longitudinal, somewhat interrupted line in the middle from about one-fifth to one-half; in older specimens the patterns formed by the whitish scales soon become invisible, but the longitudinal blackish streaks remain visible even in rather worn specimens; cilia dark grey, without distinct contrast from wings. Hindwing moderately translucent at base, becoming increasingly opaque toward distal part, medium greyish brown, veins darker; cilia concolorous with wings, basal one-third markedly darker than the rest in fresh specimens. Legs and abdomen without distinct patterns, covered with a mixture of light grey and blackish scales.

Depressaria saharae ssp. *tabelli* ssp. n. (Figs 48–52): Wingspan 22–24 mm. Head warm yellowish brown, tips of the scales only slightly paler than the rest. Labial palp second segment with long, forward projecting scales which are dark warm brown with a narrow whitish distal margin, third segment yellowish at the very tip, rest of distal half predominately black, basal half with varying proportions of blackish and pale scales. Antenna as in nominate ssp. Thorax and tegulae warm medium brown, thorax without black longitudinal streaks, only a slightly darker shadow may be visible. The most striking differences are colour and patterns of forewings: ground colour warm medium brown in costal half, becoming darker in dorsal half, but without sharp borderline between these areas, longitudinal streaks reduced, much less prominent than in nominate ssp., in central part of costal half almost completely absent; interspersed whitish scales and acute angled transverse line as in nominate ssp., cilia following the general tendency more warm brown, no remarkable difference in hindwings, legs and abdomen.

No gender-associated differences could be found in the specimens from Canary Islands.

For comparison, *D. bupleurella* (Fig. 54), *D. daucella* (Fig. 55) and two forms of *D. ultimella* (Figs 56–57) are shown.

Male genitalia. Male genitalia of *D. saharae* (Figs 58–59) are really similar only to those of *D. bupleurella* Heinemann, 1870. The most distinctive difference is the width of the excavation in the costa of valva: narrow (less than half of the basal diameter of the bulges at each side of the excavation) in *D. bupleurella* (Fig. 60), wide (about equaling the basal diameter of these bulges) in *D. saharae*. Apart from the species pair *D. bupleurella* / *saharae*, the genitalia of *D. radiella* (Goeze, 1789) show some similarity, but with differences in many details; see comparison in Figs 58–61.

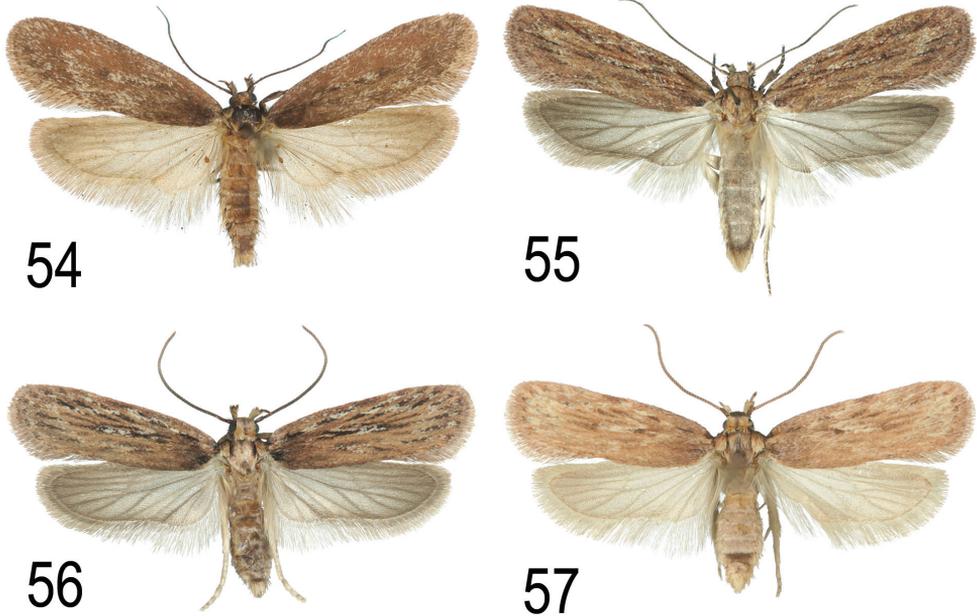
Female genitalia. Female genitalia (Figs 62–63 + 66) are also most similar to *D. bupleurella* (Figs 64 + 67) with nearly the same shape of ostium and an expansion in the middle of the long and narrow ductus bursae. The best feature to separate the species is the shape of the expansion: an asymmetrical swelling without longitudinal streaks



Figures 48–53. **48** *Depressaria saharae* ssp. *tabelli* ssp. n., holotype, Spain, Canary Islands, Guimar, e.l. *Bupleurum aciphyllum* 16.iv.1907 **49** *Depressaria saharae* ssp. *tabelli* ssp. n., Spain, Canary Islands, Guimar, 23.iv.1998, left forewing and palp **50–52** same specimen, details of head and palp **53** *Depressaria bupleurella*, Austria, Mannersdorf, 21. iii. 2016, leg. W. Stark.

in *D. saharae* ssp. *tabelli* but spindle-shaped with several longitudinal sclerotisations in *D. bupleurella*. *D. radiella* is also figured for comparison (Figs 65 + 68). Females of the nominate ssp. are unknown so far.

Molecular data. Data of barcoded specimens. TLMF Lep 19164 (658 bp., ♂, Spain, Granada, Sierra Nevada, 2430 m, 37°6.23'N; 3°23.84'W, 3.vii.2015, J. Tabell



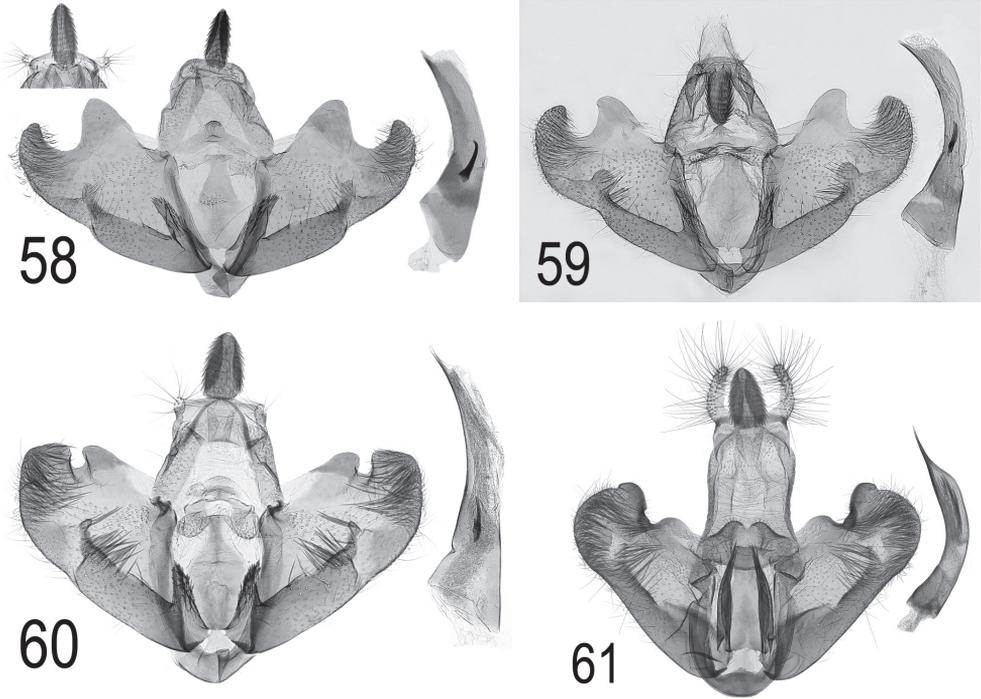
Figures 54–57. **54** *Depressaria bupleurella*, Germany, Pfalz, leg. Eppelsheim 1893, coll. NHMV **55** *Depressaria daucella*, Austria, Perchtoldsdorf, leg. P. Buchner 2012 **56** *Depressaria ultimella*, Sweden, Öland, e.l. *Cicuta virosa*, leg. R. Johansson 1990, coll. ZMUC **57** *Depressaria ultimella*, Belgium, Frameries, e.l. *Apium graveolens*, leg. A. Dufrane 1935, coll. ZSM.

leg., GP ♂ 5480 J. Tabell); TLMF Lep 07068 (584 bp., ♂, Spain, Teruel, Albarracin. 6 km env, 1.x.2008, 40°49.5'N; 3°2.22'W, leg. & coll. L. Srnka, gen. prep. DEEUR 1000); TLMF Lep 17692 (658 bp., ♀, Spain, Tenerife, Guimar, La Ladera, 800 m, 28°18'N; 16°25'W, 23.iv.1998, leg. & coll. K. Larsen, gen. prep. DEEUR 2634); TLMF Lep 17711 (658 bp., ♀, Spain, Tenerife, Los Gigantes, 100 m, 28°17'N; 16°51'W, 8-11.i.2008, leg. & coll. K. Larsen, gen. prep. DEEUR 2807).

Neighbour-joining analysis (Fig. 69) shows that *D. saharae* is a very isolated species with no obvious nearest neighbour. *Depressaria bupleurella* (BOLD:ABA1485; TLMF Lep 04843) shares a node in our NJ tree (Fig. 29), but at ~6.08-6.8% p-distance. Intraspecific variability, based on present knowledge, 0% within *D. saharae* ssp. *saharae*, 0% within *D. saharae* ssp. *tabelli* ssp.n and 2.01% between the two ssp.

Maximum Likelihood analysis (Fig. 70) shows in general the same situation. Following the conclusion of *D. bupleurella* as evolutionary neighbour based on genitalia patterns (see remarks below under Related species), this is not a surprise.

Related species. Based on male genitalia, *D. saharae* belongs to the *pastinacella* group (Hannemann, 1953), named after *D. pastinacella* (Duponchel, 1838), now valid as *D. radiella* (Goeze, 1783), which is characterised by the presence of a basal process of sacculus (clavus) and the absence or near absence of a distal process of sacculus (cuiller). Within this group, genitalia of both sexes clearly show *D. bupleurella* as closest species. Neighbour Joining tree and Maximum Likelihood analysis correspond with this



Figures 58–61. **58** *Depressaria saharae* ssp. *saharae*, preparation Jukka Tabell, slide 5480 J. Tabell; insert top left: *D. saharae* ssp. *saharae*, Spain, Teruel, 1.x.2008, with clearly visible socii, DEEUR 1000 **59** *D. saharae* ssp. *tabelli* ssp. n. holotype, Canary Islands, 16.iv.1907, coll. NHMUK, preparation Klaus Sattler, B.M. genitalia slide 23304 **60** *D. bupleurella*, Austria, Klosterneuburg, e.l. *Bupleurum*, 1922, coll. NHMV, slide MV18258 **61** *D. radiella*, Russia, Caucasus, leg. L. Srnka 2013, slide DEEUR 2174.

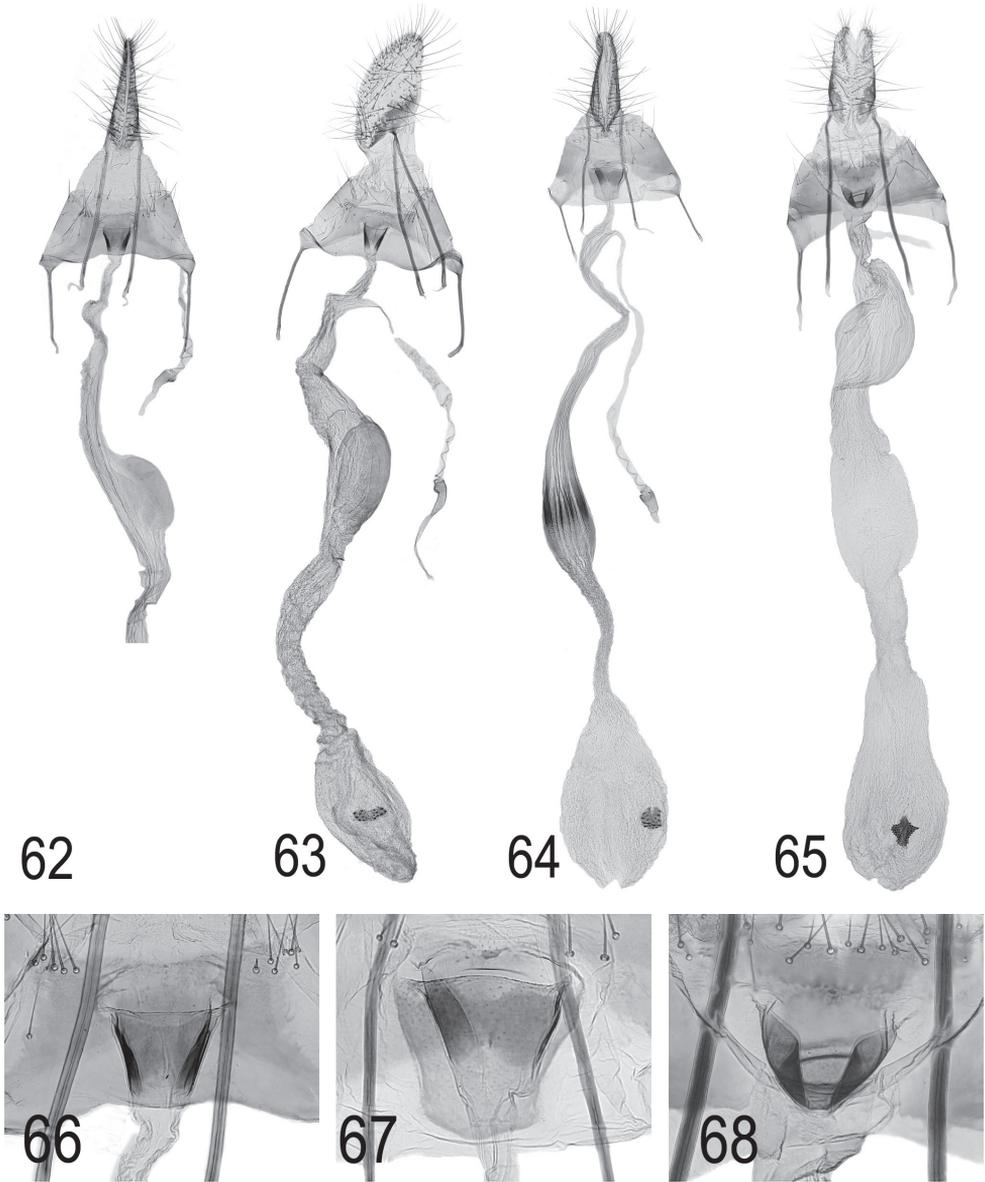
estimation. The close relatedness of *D. saharae* and *D. bupleurella* is also supported by biology with both species (so far only known from ssp. *tabelli*) feeding on *Bupleurum*.

Etymology. The subspecies name, a noun in the genitive case, honours Jukka Tabell, the Finnish lepidopterologist, who collected *D. saharae* - at this time still an undescribed species - in 2015 from the Spanish mainland, and sent specimens to Peter Buchner for study. They were essential to understanding this species and led to a search for females, which were found in collections from the Canary Islands and which are here treated as a separate subspecies.

Distribution. So far known only from Spain: Canary Islands (Tenerife).

Bionomics. Walsingham reared one moth from larvae collected on *Bupleurum aciphyllum* (*Bupleurum salicifolium* ssp. *aciphyllum* (Webb & Berthel.) Sunding & G. Kunkel) from Canary Islands, Tenerife, Guimar. This plant is an endemic species of Macaronesia. The food-plant of *D. saharae* ssp. *saharae* is unknown, but is likely to be another species of *Bupleurum*.

Remarks. The first encounter with male genitalia of *D. saharae* was a simple drawing in literature: Klimesch (1985) reports on a letter from Klaus Sattler regarding



Figures 62–68. **62 + 66** *Depressaria saharae* ssp. *tabelli* ssp. n. Spain, Canary Islands, Los Gigantes, 11.i.2008, slide DEEUR 2807 (**62** general view **66** ostium region enlarged) **63** *D. saharae* ssp. *tabelli* ssp. n. Spain, Canary Islands, Guimar, 23.iv.1998, slide DEEUR 2634 **64 + 27** *D. bupleurella*, Italy, coll. TLMF, slide DEEUR 1646 (**64** general view **67** ostium region enlarged) **65 + 68** *D. radiella*, Austria, leg. & coll. P. Buchner, slide DEEUR 0029 (**65** general view; **68** ostium region enlarged).

Walsingham's bred male from Tenerife which Walsingham had referred to *D. apiella*: "...According to Dr. Sattler, NHMUK London, this specimen belongs to a species near *D. bupleurella* or to a form of *D. bupleurella*. Dissection showed differences in

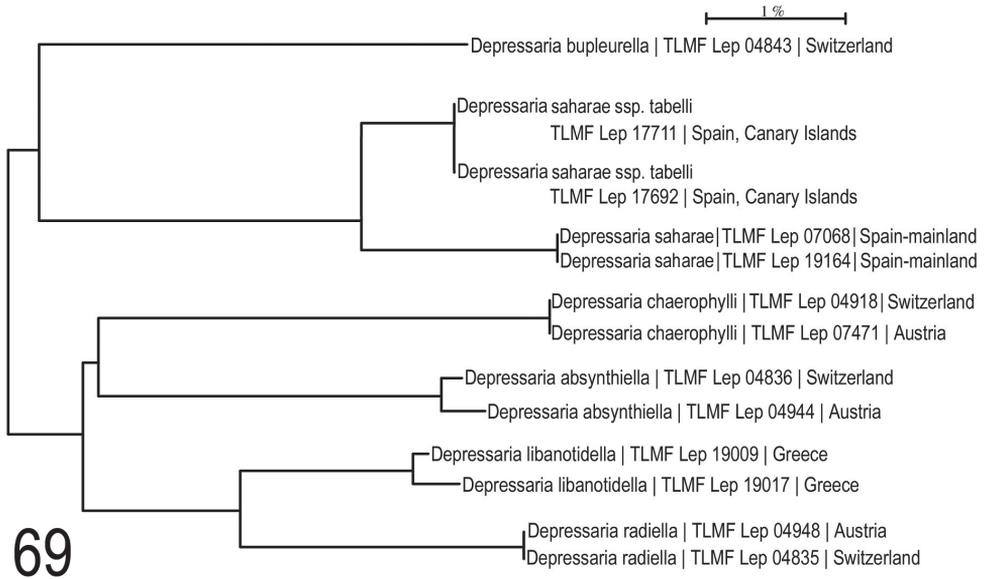


Figure 69. Neighbour-joining tree of *Depressaria saharae* and selected species. Associated BOLD BINs: *D. bupleurella*: BOLD:ABA1485; *D. saharae* ssp. *tabelli* ssp.n: BOLD:ADC8281; *D. saharae* ssp. *sahaeae*: BOLD:ACF8051; *D. chaerophylli*: BOLD:AAF8167; *D. absynthiella*: BOLD:ABA0596; *D. libanotidella*: BOLD:ACZ2964; *D. radiella*: BOLD:AAB6253.

costa of valva and in cuiller. It must be left to a later revision of this group to decide on the final status” [translated from German]. Some males from Teruel, dissected by P. Buchner, showed this distinctive genitalia feature also. DNA barcoding supported the view that it was not a form of *D. bupleurella*, but a distinct species. As at this stage females were unknown, it remained undescribed.

In the large collection of Knud Larson, two females from Tenerife were found, which were both in external appearance and in genitalia patterns close to *D. bupleurella*, but showed a 6.36% p-distance in DNA-barcode, while barcodes show a 2% difference compared to *D. saharae* from Teruel, separating into two reciprocally monophyletic clusters. This suggested they were at least closely related, but left open the question of conspecificity. A male reared by Walsingham from Tenerife in 1907 was the key to this so far unanswered question: it has genitalia like *D. saharae* from Teruel, but in external appearance is like the females from Tenerife. The lack of genitalic separation suggests that the Teruel and Tenerife specimens are conspecific, in spite of their different external appearance. The different external appearance of the Canary Island population, in combination with the corresponding external features of both sexes of the Canary Island population justify the treatment as two separate subspecies.

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Appendix

Table with details to Barcode Index Numbers (BIN), Sample ID, Process ID and GenBank Accession for 43 BIN-conform COI-5P sequences, used for the trees in this paper.

Species	Sample ID	Process ID	BIN	GenBank Accession
<i>Agonopterix atomella</i>	BC TLMF Lep 19310	DEEUR785-16	BOLD:ABZ0059	KY754269
<i>Agonopterix atomella</i>	TLMF Lep 11536	LEATE124-13	BOLD:ABZ0059	KY754251
<i>Agonopterix bipunctosa</i>	TLMF Lep 19002	DEEUR572-16	BOLD:ABA0011	KY754228
<i>Agonopterix bipunctosa</i>	TLMF Lep 19066	DEEUR636-16	BOLD:ABA0011	KY754239
<i>Agonopterix bipunctosa</i>	TLMF Lep 19091	DEEUR661-16	BOLD:ABA0011	KY754268
<i>Agonopterix carduncelli</i> sp. n.	TLMF Lep 06978	DEEUR299-12	BOLD:ABZ7583	KY754235
<i>Agonopterix carduncelli</i> sp. n.	TLMF Lep 06994	DEEUR315-12	BOLD:ABZ7583	KY754278
<i>Agonopterix carduncelli</i> sp. n.	TLMF Lep 07015	DEEUR336-12	BOLD:ABZ7583	KY754255
<i>Agonopterix carduncelli</i> sp. n.	TLMF Lep 07017	DEEUR338-12	BOLD:ABZ7583	KY754265
<i>Agonopterix cluniana</i>	TLMF Lep 07164	PHLAI960-14	BOLD:AAM731	KY754275
<i>Agonopterix ferulae</i>	TLMF Lep 19165	DEEUR735-16	BOLD:ABW9370	KY754264
<i>Agonopterix ferulae</i>	TLMF Lep 19225	DEEUR897-16	BOLD:ABW9370	KY754248
<i>Agonopterix kaekeritziana</i>	TLMF Lep 17073	ABOLB068-15	BOLD:AAF7198	KY754233
<i>Agonopterix kaekeritziana</i>	BC TLMF Lep 19286	DEEUR761-16	BOLD:AAF7198	KY754262
<i>Agonopterix kaekeritziana</i>	TLMF Lep 14534	LASTS082-14	BOLD:AAF7198	KY754242
<i>Agonopterix multiplicella</i>	TLMF Lep 19102	DEEUR672-16	BOLD:AAF7196	KY754241
<i>Agonopterix oinochroa</i>	TLMF Lep 07109	DEEUR430-13	BOLD:ABU5789	KY754250
<i>Agonopterix pallorella</i>	TLMF Lep 07014	DEEUR335-12	BOLD:ABU5790	KY754263
<i>Agonopterix pallorella</i>	TLMF Lep 19148	DEEUR718-16	BOLD:ABA0382	KY754236

Species	Sample ID	Process ID	BIN	GenBank Accession
<i>Agonopterix pallorella</i>	TLMF Lep 17463	LEATI078-15	BOLD:ABU5790	KY754259
<i>Agonopterix pseudoferulae</i> sp. n.	TLMF Lep 19067	DEEUR637-16	BOLD:ACW1863	KY754266
<i>Agonopterix pseudoferulae</i> sp. n.	BC TLMF Lep 19306	DEEUR781-16	BOLD:ACW1863	KY754244
<i>Agonopterix pseudoferulae</i> sp. n.	MM24152	LEFIJ2609-15	BOLD:ACW1863	KY754238
<i>Agonopterix putridella</i>	TLMF Lep 06229	DEEUR204-11	BOLD:AAF7185	KY754256
<i>Agonopterix scopariella</i>	TLMF Lep 19263	DEEUR864-16	BOLD:ABZ0060	KY754229
<i>Agonopterix squamosa</i>	TLMF Lep 19030	DEEUR600-16	BOLD:ACF7120	KY754254
<i>Agonopterix squamosa</i>	TLMF Lep 19146	DEEUR716-16	BOLD:ACF7120	KY754249
<i>Agonopterix squamosa</i>	BC TLMF Lep 19313	DEEUR788-16	BOLD:ACF7120	KY754246
<i>Agonopterix squamosa</i>	TLMF Lep 19253	DEEUR921-16	BOLD:ACF7120	KY754240
<i>Agonopterix straminella</i>	TLMF Lep 17699	DEEUR504-15	BOLD:ACX7863	KY754276
<i>Agonopterix straminella</i>	TLMF Lep 17705	DEEUR510-15	BOLD:ABZ7581	KY754230
<i>Agonopterix straminella</i>	TLMF Lep 17721	DEEUR526-15	BOLD:ACX7863	KY754257
<i>Agonopterix straminella</i>	TLMF Lep 17727	DEEUR532-15	BOLD:ACX7863	KY754243
<i>Agonopterix straminella</i>	TLMF Lep 17731	DEEUR536-15	BOLD:ACX7863	KY754237
<i>Depressaria albarracinella</i> sp. n.	TLMF Lep 17687	DEEUR492-15	BOLD:ACX8130	KY754260
<i>Depressaria albarracinella</i> sp. n.	TLMF Lep 19062	DEEUR632-16	BOLD:ACX8130	KY754274
<i>Depressaria albarracinella</i> sp. n.	TLMF Lep 19150	DEEUR720-16	BOLD:ACX8130	KY754261
<i>Depressaria discipunctella</i>	TLMF Lep 17728	DEEUR533-15	BOLD:ABA1412	KY754252
<i>Depressaria discipunctella</i>	TLMF Lep 19035	DEEUR605-16	BOLD:ABA1412	KY754267
<i>Depressaria discipunctella</i>	BC TLMF Lep 19311	DEEUR786-16	BOLD:AAO4681	KY754270
<i>Depressaria discipunctella</i>	BC TLMF Lep 19362	DEEUR837-16	BOLD:AAO4681	KY754247
<i>Depressaria discipunctella</i>	TLMF Lep 19422	DEEUR992-16	BOLD:AAO4681	KY754234
<i>Depressaria eryngiella</i>	TLMF Lep 07107	DEEUR428-13	BOLD:ACF7124	KY754271
<i>Depressaria eryngiella</i>	BC TLMF Lep 19304	DEEUR779-16	BOLD:ACF7124	KY754277
<i>Depressaria libanotidella</i>	TLMF Lep 19009	DEEUR579-16	BOLD:ACZ2964	KY754273
<i>Depressaria libanotidella</i>	TLMF Lep 19017	DEEUR587-16	BOLD:ACZ2964	KY754253
<i>Depressaria Depressaria saharanae</i>	TLMF Lep 07068	DEEUR389-13	BOLD:ACF8051	KY754279
<i>Depressaria saharanae</i> ssp. <i>tabelli</i> sp. n.	TLMF Lep 17692	DEEUR497-15	BOLD:ADC8281	KY754258
<i>Depressaria saharanae</i> ssp. <i>tabelli</i> sp. n.	TLMF Lep 17711	DEEUR516-15	BOLD:ADC8281	KY754245
<i>Depressaria saharanae</i>	TLMF Lep 19164	DEEUR734-16	BOLD:ACF8051	KY754232
<i>Depressaria veneficella</i>	TLMF Lep 19157	DEEUR727-16	BOLD:ADC7254	KY754231
<i>Depressaria veneficella</i>	TLMF Lep 19467	DEEUR1037-16	BOLD:ADC7254	KY754272