

The genus *Aphidura* (Hemiptera, Aphididae) in the collection of the Muséum national d'Histoire naturelle of Paris, with six new species

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Abstract

Specimens were studied of 65 samples of the genus *Aphidura* (Aphididae, Aphidinae, Macrosiphini) from the collection of the Muséum national d'Histoire naturelle (Paris). The possible synonymies of three pairs of species are discussed. New aphid host plant relationships are reported for *A. bozhkoeae*, *A. delmasi*, *A. ornata*, *A. pannonica* and *A. picta*; this last species is recorded for first time from Afghanistan. The record of *A. pujoli* from Pakistan is refuted. The fundatrices, oviparous females and males of *A. delmasi* are described. Six new species are established: *A. gallica* **sp. n.** and *A. amphorosiphon* **sp. n.** from specimens caught on species of *Silene* (Caryophyllaceae) from France and Iran, respectively, *A. pakistanensis* **sp. n.**, *A. graeca* **sp. n.** and *A. urmiensis* **sp. n.** from specimens caught on species of *Dianthus*, *Gypsophila* and *Spergula* (Caryophyllaceae) from Pakistan, Greece and Iran, respectively, and *A. iranensis* **sp. n.** from specimens caught on *Prunus* sp. from Iran. Modifications are made to the keys by Blackman and Eastop to aphids living on *Dianthus*, *Gypsophila*, *Silene*, *Spergula* and *Prinsepia* and *Prunus* (Rosaceae). An identification key to apterous viviparous females of species of *Aphidura* is also provided.

Keywords

New taxa, descriptions, synonymies, key of species, host plants, distributions

Introduction

In the early 1980s G. Remaudière and D. Hille Ris Lambers studied some samples of *Aphidura* (Hemiptera, Aphididae, Aphidinae, Macrosiphini) belonging to the Remaudière collection, which was at that time at the *Institut Pasteur* in Paris, but later moved to the *Muséum national d'Histoire naturelle*. They made preliminary works to describe several new species of this genus, but the work was interrupted and a manuscript draft was never prepared due to the illness and death in April 1984 of Hille Ris Lambers. Some of the slides studied by Hille Ris Lambers were sent with the rest of his collection to the British Museum (Natural History), currently the Natural History Museum, in London. Some years later Remaudière did establish one new species in this genus (Remaudière 1989) but this was from specimens that had not been part of his studies with Hille Ris Lambers.

All those samples, together with the rest of the specimens of *Aphidura* of the above-mentioned collection, have now been studied, and the results are presented in this paper.

The genus *Aphidura* was morphologically well defined by Hille Ris Lambers (1956), and the type species, *A. ornata* Hille Ris Lambers, is also well defined, so no doubt exists about the correct taxonomic position of the species included within it. Apterous viviparous aphids can be identified as *Aphidura*, in addition to the characteristics of the tribe Macrosiphini, by the presence of a pair of mesosternal mammiform processes (in Hille Ris Lambers's words: «*Distinct, conspicuously pigmented or pale, rough mammiform processi present on anterior part of mesosternum in apterae and larvae*»), together with a triangular or tongue-shaped cauda and reniform spiracular apertures centred in the respective sclerites.

Similar mesosternal processes are also present in several species of *Brachycaudus* van der Goot, 1913, mainly belonging to subgenus *Acaudus* van der Goot, 1913, and in the sole species of *Zinia*, *Z. veronicae* Shaposhnikov, 1950. These species of *Brachycaudus* have a helmet-shaped cauda and wide, rounded spiracular apertures, and *Z. veronicae* has a rounded cauda, reniform spiracular apertures that are placed in the posterior half of the spiracular sclerites and, in addition the dorsal cuticle is densely spinulose (Hille Ris Lambers 1956, Shaposhnikov 1950, Andreev 2004).

Aphidura currently includes 16 to 18 species and 1 subspecies (Blackman and Eastop 2006, Kadyrbekov 2013): *A. acanthophylli* Remaudière, 1989, *A. alata* Kadyrbekov, 2013, *A. bozhkoae* (Narzikulov, 1958) (type species of *Cerasomyzus* Narzikulov, 1958, which was established as subgenus of *Myzus* Passerini), *A. delmasi* Remaudière and Leclant, 1965, *A. gypsophilae* Mamontova-Solukha, 1963, *A. massagetica* Kadyrbekov, 2013, *A. melandrii* Kadyrbekov, 2013, *A. mordvilkoii* Shaposhnikov, 1984 (with its possible synonym *A. prinsepieae* Pashchenko, 1988), *A. naimanica* Kadyrbekov, 2013, *A. nomadica* Kadyrbekov, 2013, *A. ornata* Hille Ris Lambers, 1956, *A. ornatella* Narzikulov & Winkler, 1960 (with its possible synonym *A. bharatia* David, Sekhon & Bindra, 1970), *A. pannonica* Szelegiewicz, 1967 (with subspecies *A. pannonica cretacea* Mamontova-Solukha, 1968), *A. picta* Hille Ris Lambers, 1956 (with its possible

synonym *A. mingens* Pintera, 1970), *A. pujoli* (Gómez-Menor Ortega, 1950) and *A. togaica* Kadyrbekov, 2013.

Two species of *Aphidura* live on Rosaceae species and other species live on Caryophyllaceae species, mainly belonging to genus *Silene*. *A. pujoli* is monoecious holocyclic on Caryophyllaceae; it is possible that the life cycle of other species of *Aphidura* is also monoecious holocyclic, though it is also possible that some species host-alternate between species of Rosaceae and Caryophyllaceae (Blackman and Eastop 2006, Holman 2009, Kadyrbekov 2013).

The genus exhibits a Mediterranean-Pontian-Turanian distribution with extensions to neighbouring areas and exceptionally – *A. mordvilkoii* – to the Russian Far East. The current known distribution of each species is shown in the species identification key at the end of this paper, *A. picta* being the species with the widest distribution (Blackman and Eastop 2006, Holman 2009, Nieto Nafria et al. 2012, Kadyrbekov 2013).

Material and methods

Aphidura specimens of the aphid collection of the *Muséum national d'Histoire naturelle de Paris*, mounted in microscopic slides, belonging to 65 samples (Table 1) have been studied.

Aphids were identified, or their previous identifications were checked, by reference to the original descriptions (Hille Ris Lambers 1956, Gómez-Menor Ortega 1950, Narzikulov 1958, Narzikulov and Winkler 1960, Mamontova-Solukha 1963, Remaudière and Leclant 1965, Szelegiewicz 1967, Mamontova-Sholukha 1968, David et al. 1970, Pintera 1970, Shaposhnikov 1984, Pashchenko 1988, Remaudière 1989, Kadyrbekov 2013) and other informative works (Eastop and Blackman 2005, Blackman and Eastop 1994, 2006).

Morphological measurements were made according to Nieto Nafria and Mier Durante (1998). In the descriptions and keys, measurements are lengths except when indi-

Table 1. Studied samples.

<i>Aphidura</i> species	Country	Locality	Date	Coll.	Sample
Host plant					
<i>A. acanthophylli</i>					
<i>Acanthophyllum</i> sp.	Iran	Sharh-e Babak [NW 50 km] (Kerman)	4-IX-1972	R.	i3749
<i>A. amphorosiphon</i> sp. n.					
<i>Dianthus</i> sp.	Iran	without locality	sans date	D.	i1440
<i>Silene</i> sp.	Iran	Kuh-e Dinar (Kohgiluyed and Boyer-Ahmad)	14-IX-1955	R.	i1118a
Caryophyllaceae	Iran	Chalus [N 40 km Amol road] (Mazenderan)	3-V-1963	R.	i2417
<i>A. bozhkoeae</i>					
<i>Prunus spinosa</i>	Iran	Karadj (Alborz)	8-V-1955	R.	i196
<i>Prunus ?prostrata</i>	Iran	Bojnurd [E 10 km] (North Khorasan)	21-V-1966	R.	i2961

<i>Aphidura</i> species Host plant	Country	Locality	Date	Coll.	Sample
<i>Prunus ?prostrata</i>	Iran	Kuh-e Choret [90 km. Bojnurd] (North Khorasan)	25-V-1966	R.	i3028
<i>Prunus</i> sp.	Iran	?	?	?	i4347
	Iran	Shiraz (Fars)	?-V-1974	C.	i4092
<i>A. delmasi</i>					
<i>Silene italica</i>	France	Gémenos (Bouches-du-Rhône)	13-VI-1967	R.	6455
<i>Silene italica</i>	France	Lantosque (Alpes-Maritimes)	24-X-1968	R.	7591
<i>Silene italica</i>	France	Saint-Guilhem-le-Désert (Hérault)	17-IV-1966	R.	5751
<i>Silene italica</i>	France	Saint-Guilhem-le-Désert (Hérault)	21-VII-1966	L.	5752
<i>Silene italica</i>	France	Saint-Guilhem-le-Désert (Hérault)	30-IX-1966	L.	5753
<i>Silene italica</i>	France	Pont du Gard (Gard)	19-III-1969	R.&L.	7728
<i>Silene italica</i>	France	Utelle (Alpes-Maritimes)	11-V-1969	R.&L.	7876
<i>Silene italia</i>	France	Utelle (Alpes-Maritimes)	13-VI-1988	R.	15798
<i>Silene ?viscosa</i>	France	Finistret (Pyrénées Orientales)	9-VI-1983	R.	14459
<i>Silene</i> sp.	Greece	Lagadie [East] (Akadia)	3-VII-1964	R.	03087
<i>Silene</i> sp.	France	Lantosque (Alpes-Maritimes)	28-II-1970	R.	9258
<i>Silene</i> sp.	France	La-Garde-Freinet (Var)	26-III-1970	R.	9357
<i>Silene</i> sp.	France	Saint-Jean la-Rivière (Alpes-Maritimes)	16-IX-1969	R.	8690
vagrant	France	Utelle (Alpes-Maritimes)	7-XI-1989	R.	16079 b
<i>A. gallica</i> sp. n.					
<i>Silene gallica</i>	France	Banyuls-sur-Mer (Pyrénées-Orientales)	11-VII-1957	R.	4241
<i>Silene paradoxo</i>	France	Défilé de l'Inzecca (Haute-Corse)	4-VI-1979	L.	17925
<i>A. graeca</i> sp. n.					
<i>Gypsophila</i> sp.	Greece	Veria [to Kastania] (Imanthia)	18-VI-1964	R.	03026
<i>A. gypsophilae</i>					
<i>Gypsophila paniculata</i>	Slovakia	Chotín (Nitra)	25-VI-1984	H.	015379
<i>A. iranensis</i> sp. n.					
<i>Prunus</i> sp.	Iran	Khoy [N 30 km] (West Azerbaijan)	7-VIII-1955	R.	i982
<i>A. mordvilkoii</i>					
<i>Princepia sinensis</i>	Russia	? (Prymorsky Krai)	20-VI-1967	Sh.	016559
<i>Princepia sinensis</i>	Russia	? (Prymorsky Krai)	5-VI-1980	Pa.	014789
<i>A. ornata</i>					
<i>Silene inaperta</i>	France	Ste Catherine de Vars (Hautes- Alpes)	1-VII-1990	R.&M.V.	16454
<i>Silene italica</i>	France	Avène (Hérault)	1-V-1967	L.	18054
<i>Silene nutans</i>	Switzerland	Cassarate (Ticino)	25-V-1950	H.R.L.	02946
<i>Silene nutans</i>	Switzerland	Cassarate (Ticino)	25-V-1950	H.R.L.	016758
<i>Silene saxifraga</i>	France	La-Roche-de-Rame [S] (Hautes-Alpes)	22-VI-1969	R.&L.	8010
<i>A. ornatella</i>					
<i>Silene</i> sp.	Pakistan	Matiltan (Khyber Pakhtunkhwa)	14-VIII-1991	N-E.	014109
trap	Pakistan	Kalam Khyber Pakhtunkhwa	?-?-1987	N-E.	
trap	Pakistan	Matiltan (Khyber Pakhtunkhwa)	23-VII-1987	N-E.	

<i>Aphidura</i> species Host plant	Country	Locality	Date	Coll.	Sample
trap	Pakistan	Matiltan (Khyber Pakhtunkhwa)	30-VII-1987	N-E.	
<i>A. pakistanensis</i> sp. n.					
<i>Dianthus</i> sp.-	Pakistan	Kalam (Khyber Pakhtunkhwa)	17-VIII-1981	N-E.	014072
<i>A. pannonica</i>					
<i>Gypsophila paniculata</i>	Hungary	Ágasegyháza (Bács-Kiskun)	10-VI-1968	Sz.	014156
<i>Silene otites</i>	Hungary	Budapest [Sas-hegy] (Pest)	21-VI-1964	Sz.	014156
<i>Silene otites</i>	Slovakia	Chotín (Nitra)	25-VI-1984	H.	015380
<i>Silene otites</i>	Slovakia	Somotor (Košice)	27-VI-1962	Pi.	010615
<i>A. picta</i>					
<i>Dianthus barbatus</i>	Pakistan	Quetta (Baluchistan)	14-V-1991	N-E.	013878
<i>Dianthus crinutus</i>	Pakistan	Skardu (Gilgit-Baltistan)	2-VII-1991	N-E.	013965
<i>Dianthus ?barbatus</i>	Iran	Isfahan (Isfahan)	25-IV-1978	R.	i4222
<i>Dianthus</i> sp.	Afghanistan	Kabul (Kabul)	26-VI-1972		04565
<i>Dianthus</i> sp.	Iran	Karadj (Alborz)	?-XI-1948	D.	i81a
<i>Dianthus</i> sp. [cult.]	Turkey	Ankara (Ankara)	8-X-1950	T.	011930
<i>Silene conoida</i>	Iran	Laleeh zar (Kerman)	26-VI-1955	R.	i648
<i>Silene fruticosa</i>	Italy	Castelmola (Messina)	9-VI-1979	B.	012841
<i>Silene glauca</i>	Spain	Callosa de Ensiarrá (Alicante)	29-V-985	G.F.	012841
<i>Silene italica</i>	France	Col Turini (Alpes-Maritimes)	15-X-1969	R.	8672
<i>Silene italica</i>	France	Lantosque (Alpes-Maritimes)	24-X-1968	R.	7592
<i>Silene</i> sp.	Iran	Karadj (Alborz)	19-V-1955	R.	i282c
<i>A. pujoli</i>					
<i>Dianthus caryophyllus</i>	France	Defilé de l'Inzecca (Haute-Corse)	4-VI-1970	L.	18055
<i>Dianthus caryophyllus</i>	France	Defilé de l'Inzecca (Haute-Corse)	4-VI-1970	L.	18056
<i>Dianthus caryophyllus</i>	Italy	Ercolano [previously Resina] (Napoli)	17-VIII-1936	Ro.	02947
<i>Dianthus</i> sp.	Spain	Arenas de Cibrales (Asturias)	7-VI-1981	R.&N.N.	012841
<i>Dianthus</i> sp.	France	?	?	?	5670
trap	France	Montpellier (Hérault)	16-VII-1996	?	17749
trap	France	Valence (Charente)	1-VII-1996	?	17755
<i>A. urmiensis</i> sp. n.					
<i>Spergularia marina</i>	Iran	Charimboulaki, Lac Urmia (West Azerbaijan)	9-VIII-955	R.	i1004
<i>Spergularia marina</i>	Iran	Shahi island, Lac Urmia (East Azerbaijan)	5-VIII-1955	R.	i962

NOTES:

In the "Locality" column, supplementary information and upper administrative unit (such as county, department, province, regional unit, etc.) are respectively given in square brackets and in parentheses. In the "Coll" column the names of collectors have been abbreviated as follows: B., Barbagallo (S.); C., Chodjaï (M.); D., Davatchi (A.); G.F., González Funes (M.P.); H.R.L., Hille Ris Lambers (D.); H., Holman (J.); L., Leclant (F.); M.V. Muñoz Viveros (A.L.); N.N., Nieto Nafría (J.M.); N-E, Naumann-Etienne (K.); Pa., Pashchenko (N.S.); P., Pintera (A.); R., Remaudière (G.); Ro., Roberti (D.) Sh., Shaposhnikov (G.C.); Sz., Szelegiewicz (H.); and T., Tuatay (N.).

The numbers in the "Sample" column are the numbers of the Remaudière samples.

cated otherwise as width or diameter. A Leica DC digital 96 camera with IM 1000 version 1.10 software was used for the photomicrographs, which have been taken and mounted by L. M. Fernández Blanco.

In the modifications to the identification keys by Blackman and Eastop (1994, 2006) that are included in the discussion of each species, the terms that they use (for example ‘hair’ instead of ‘seta’ and ‘clavate’ instead of ‘swollen’) have been retained so that they can be easily understood and used by those accustomed to them.

Results and discussion

Generic characters

Apterous viviparous aphids can be identified as *Aphidura* by the presence of a pair of mesosternal mammariform processes, as mentioned above, and also by the following characters: (1) frons w-shaped with rugose or scabrous lateral tubercles not much higher than the broad median tubercle; (2) cephalic dorsum not ornamented or with spinules, which may be more-or-less scattered or in groups; (3) clypeus and mandibular and maxillar lamina more-or-less pigmented like cephalic dorsum and rostrum; (4) antennae not longer than body length; (5) secondary sensoria absent; (6) antennal segment I and II scabrous or rugose, segment III with scattered scales, and IV–VI more-or-less imbricated; (7) rostrum extending backward beyond middle coxae or reaching hind coxae; (8) ultimate rostral segment triangular with straight margins, usually darker than the previous segments; (9) legs with coxae and trochanters pale, femora entirely pale or with a darker distal part; tibiae pale in general with a distal portion smoky, exceptionally entirely pale, and tarsi brown; (10) first segment of tarsi with 2–4 setae; (11) abdominal spiracular apertures reniform, placed in the middle of small spiracular sclerites; (12) intersegmental sclerites well defined and usually pigmented, and embodied in the segmental sclerites if these are present; (13) thorax and abdomen often with a dorsal pattern of sclerotisation that is very variable between species, and can also vary within them (see below terminological usage); (14) siphunculi usually with a distinct preapical incision and flange, but variable in shape (see below for details and terminological usage); (15) cauda triangular to tongue-shaped; (16) spinules present, more-or-less conspicuously and densely, on mesosternal mammariform processes, postsiphuncular sclerites, spiracular sclerites 7, and abdominal terga 7 and 8; (17) antennal and dorsal setae short or very short, with blunt, frayed or (rarely) incassated apex; (18) dorsal setae not placed on tubercles, except sometimes in *A. acanthophylli*; (19) ventral setae longer than respective dorsal and pointed; and (20) setae on dorsal faces of femora and on proximal parts of tibiae with blunt or frayed apex, other setae on legs pointed.

The alate viviparous females have no mesosternal mammariform processes, and differ from apterae by having: (a) longer and more pigmented antennae, (b) round, double-rimmed secondary sensoria scattered along the ventral face of antennal segment III, and rarely on segment IV, (c) pigmentation of legs more extensive and darker; (d) dor-

sal abdomen often with more sclerotisation than in apterae, but again this varies greatly both between and within species; (e) spinules also present in the marginal sclerites.

Regarding the thoracic and abdominal dorsal sclerotisation, the term “spinopleural patch” is utilized here for a continuous sclerotisation of spinal and marginal areas of two or more segments (Figs 2B, D, 4A, 6A), and the term “discal plate” is utilized for the continuous and extensive sclerotisation of spinal, pleural and marginal areas of three or more segments (Figs 1A, C, 2A, C).

The siphunculi of *Aphidura* species are variable in shape: (a) cylindrical, subcylindrical (delicately tapering to the apex) or conspicuously tapering from base to apex, straight or curved outward (Figs 1D, 2A, 4B, 6A); (b) slightly swollen —«*cylindrical with very tapering apex, below their middle very little attenuated, so that they might be considered as very slightly clavate*» (Hille Ris Lambers 1956)—, having the maximal width of the distal half less than 1.2 times the minimal width of the stem (Figs 2D, 3A, 5B, 6A); (c) markedly swollen, with large base, cylindrical stem and a conspicuously swollen distal portion, the width of which is conspicuously greater (at least 1.2 times) than the minimal stem width (Figs 1A, 4D, 5C, 6B).

Synonymies in *Aphidura*

Possible synonymies of three pairs of *Aphidura* species are discussed: *A. bharatia* and *A. ornatella*, *A. mingens* and *A. picta*, and finally *A. prinsepieae* and *A. mordvilkoii*.

Eastop and Blackman (2005) established that *A. bharatia* is a synonym of the older name *A. ornatella*. Both species are considered valid by Kadyrbekov (2013) because he found differences between aphids identified as *bharatia* and others identified as *ornatella*, although he does not refer to Eastop and Blackman’s paper. In our opinion these differences could be enough to keep the validity of both species, but they can also be an expression of intraspecific variability, which would present a cline North to South; Kadyrbekov himself shows differences between *ornatella* populations from Kazakhstan and Tajikistan.

Characters of studied apterous and alate vivipara (Figs 1A, B; Table 2 for six alatae from Pakistan; only one alate of this species was previously known [Kadyrbekov 2013]), overlap characters mentioned by Kadyrbekov for southern (from India and Pakistan) and northern (from Kazakhstan and Tajikistan) populations. In conclusion, we consider it is preferable to keep the synonymy.

The species pair *Aphidura mingens* and *A. picta* provides a similar situation: they are considered synonymous names by Eastop and Blackman (2005) and valid names by Kadyrbekov (2013), who found differences in the siphunculi shape (slightly swollen in *picta* specimens and subcylindrical, more or less tapering and curved outwards in *mingens* specimens) and in several quantitative characters. The original description of *A. picta* is quite unsatisfactory because it is based on one specimen «*untypical of the species as a whole*» (Eastop and Blackman, op. cit), which «*might be a fundatrix of that species [A. ornatella]*» (Hille Ris Lambers 1956), and the species is so variable in sclerotisation, pigmentation, siphuncular shape and setal length (Fig. 1C).

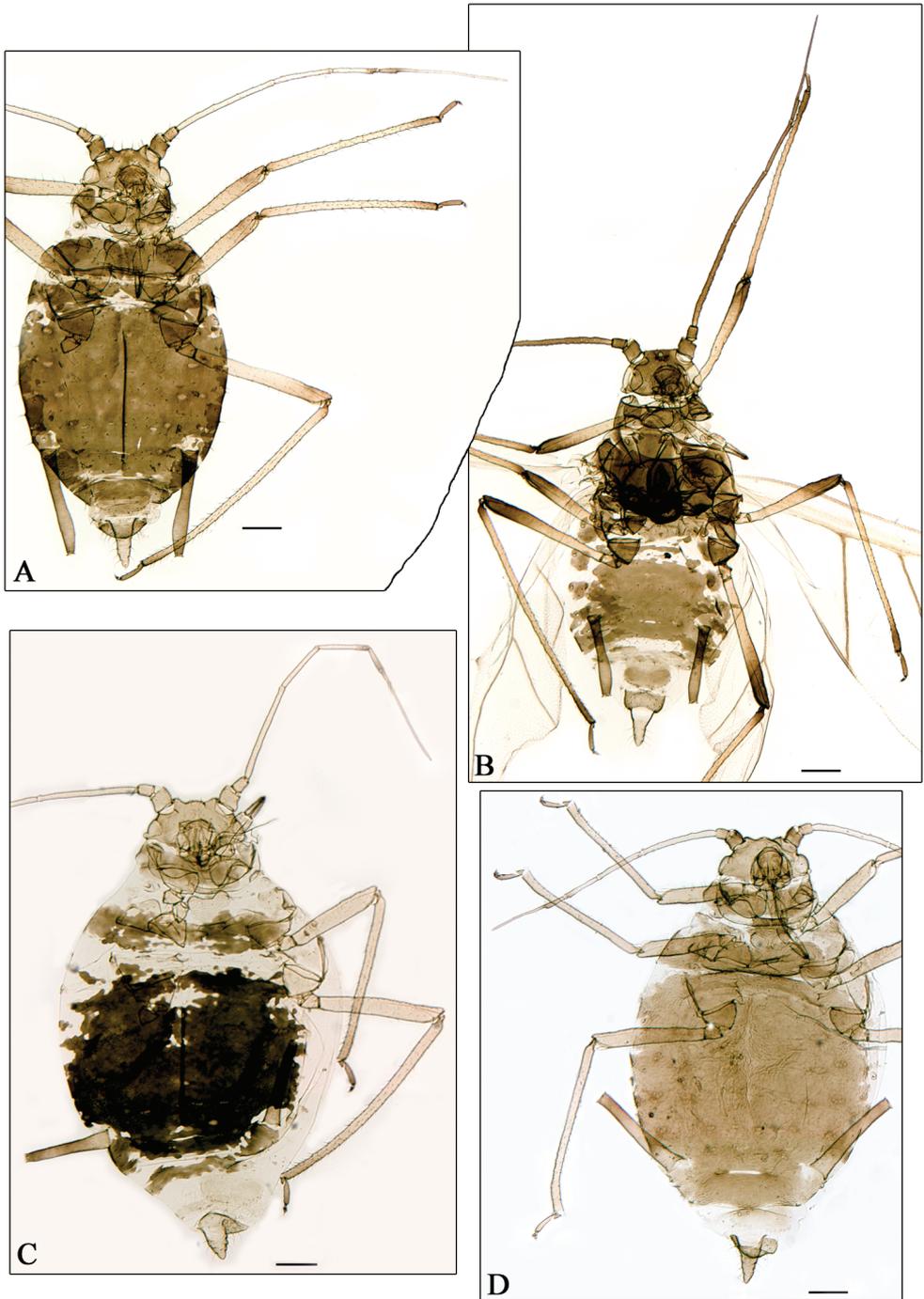


Figure 1. **A–B** *Aphidura ornatella* **C** *A. picta* **D** *A. mordvilkoii* **A, C–D** apterous viviparous female **B** alate viviparous female. Scale bars 0.2 mm.

Table 2. Metric and meristic features of *Aphidura ornatella*, and *A. delmasi*; n, number of measured specimens.

	<i>A. ornatella</i>	<i>A. delmasi</i>	<i>A. delmasi</i>	<i>A. delmasi</i>
	Al. viv. femal.	Fundatrices	Ovip. femal.	Males
	n = 6	n = 4	n = 4	n = 4
Body [mm]	1.637–2.100	1.700–2.200	1.625–1.775	1.175–1.425
Antenna [mm]	1.565–2.060	1.115–1.500	1.660–1.825	1.555–1.725
Antenna / Body [times]	0.96–1.11	0.65–0.68	1.01–1.12	1.20–1.44
Ant. segm. III [mm]	0.40–0.58	0.28	0.44	0.40–0.41
Ant. segm. IV [mm]	0.24–0.36	0.16–0.24	0.29–0.37	0.27–0.33
Ant. segm. V [mm]	0.21–0.29	0.15–0.23	0.25–0.26	0.21–0.25
Ant. segm. VI base [mm]	0.11–0.13	0.11–0.13	0.12–0.13	0.11–0.12
Ant. segm. VI processus terminalis [mm]	0.50–0.67	0.24–0.29	0.44–0.48	0.40–0.50
Ant. segm. VI processus terminalis/ Ant. segm. III [times]	1.09–1.24	0.62–0.93	1.1–1.20	1.00–1.22
Ant. segm. VI processus terminalis/ base [times]	4.62–5.36	1.96–2.48	3.62–4.04	3.48–4.30
Secondary sensoria, Ant. segm. III [number]	21–28	0	0	0
Ultimate rostral segm. [mm]	0.12–0.15	0.13–0.15	0.15–0.17	0.14
Ultimate rostral segm. / its basal width [times]	2.09–3.00	2.00–2.25	2.50–2.82	2.00–2.80
Ultimate rostral segm. / Ant. segm. VI base [times]	1.08–1.16	1.12–1.29	1.15–1.35	1.17–1.33
Hind tarsus, 2nd segm. [mm]	0.11–0.14	0.09–0.10	0.01–0.11	0.08–0.09
Hind tarsus, 2nd segm. / Ultimate rostral segm. [times]	0.93–1.04	0.67–0.70	0.65–0.71	0.57–0.67
Abdominal Marginal papillae [number]	0	0	0	0
Siphunculus [mm]	0.38–0.42	0.23–0.31	0.29–0.32	24–0.26
Siphunculus / Body [times]	0.19–0.23	0.13–0.15	0.17–0.20	0.17–0.21
Siphunculus / Ant. segm. III [times]	0.68–0.95	0.71–0.83	0.72–0.80	0.59–0.66
Siphunculus / its basal width [times]	5.07–6.25	3.22–4.43	4.41–4.75	4.00–4.64
Siphuncular widths, maximal / basal [times]	0.80–1.25	0.72–0.86	0.83–0.92	0.80–0.91
Siphuncular widths, maximal / minimal [times]	1.47–2.33	1	1	1
Cauda [mm]	0.13–0.19	0.15–0.22	0.18–0.19	0.10–0.15
Cauda / Siphunculus [times]	0.34–0.51	0.67–0.74	0.58–0.63	0.37–0.60
Cauda / its basal width [times]	1.05–1.41	1.20–1.43	1.29–1.42	0.68–1.33
Setae on ...				
... Frons [μ m]	21–28	35–50	45–55	35–45
... Frons / b. d. Ant. segm. III [times]	1.1–1.8	1.6–2.5	2.0–2.8	1.8–2.3
... Ant. segm. III [μ m]	12–20	17–23	22–25	17–23
... Ant. segm. III / b. d. Ant. segm. III [times]	0.7–1.1	0.9–1.0	1.0–1.3	0.9–1.3
... Ultimate rostral segm. [number]	14–17	5–8	8–12	9–12
... Abdominal segm. 8 [μ m]	25–35	35–45	45–50	38–40
... Abdominal segm. 8 / b. d. Ant. segm. III [times]	1.3–2.0	1.6–2.3	2.0–2.4	2.0–2.1
... Abdominal segm. 8 [number]	4–5	4–7	4–5	3–6
... Genital plate, discal [number]	2–4	2–8	7–10	–
... Genital plate, marginal [number]	10–16	12–13	17–21	–
... Cauda [number]	6–8	6–8	8–10	69

NOTE. Used abbreviations: Al., Alate; Ant., Antennal; b. d., basal diameter; femal., females; Ovip., Oviparous; segm., segment; viv., viviparous.

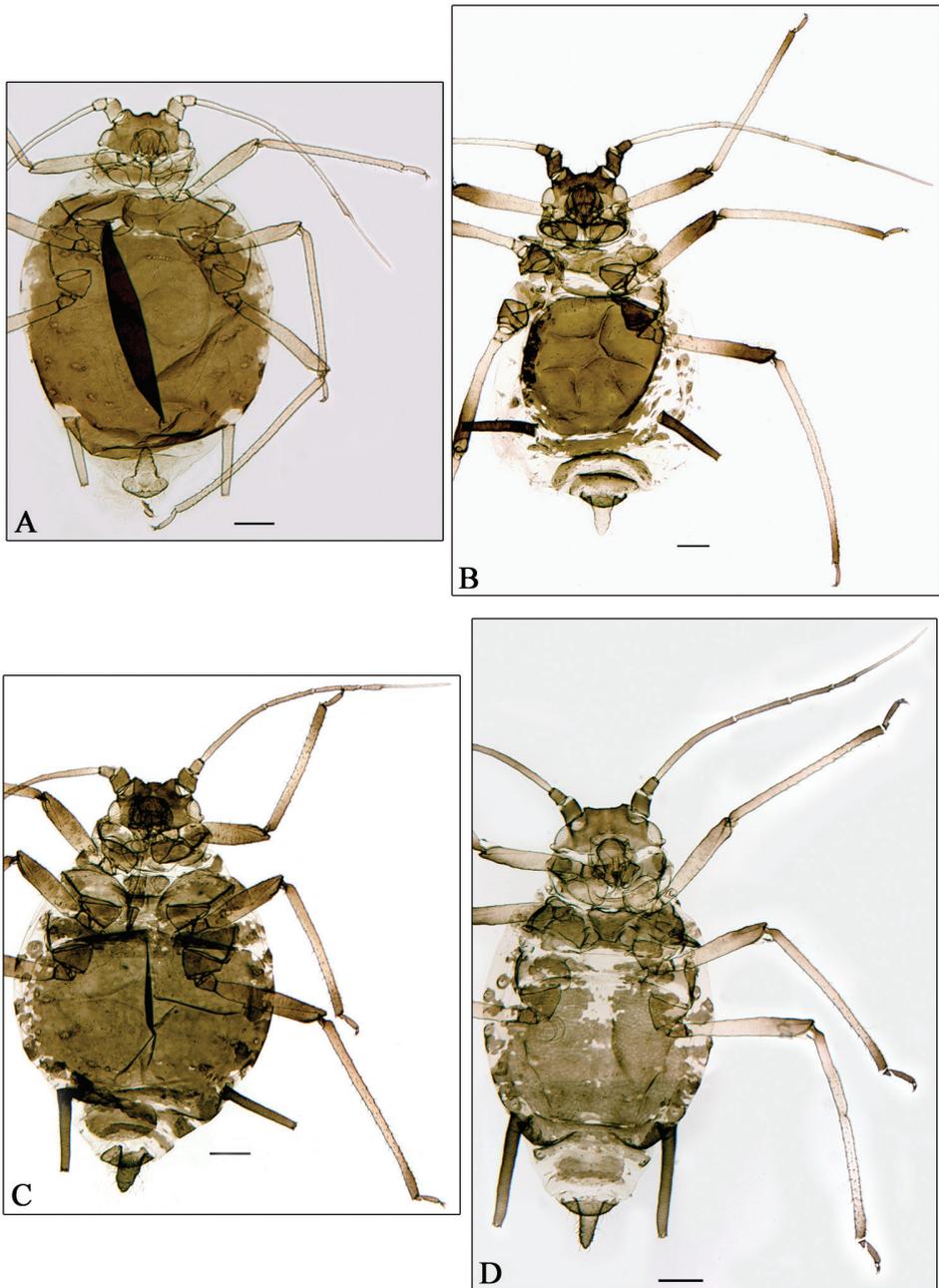


Figure 2. **A** *Aphidura bozkhoae*. **B** *A. delmasi*. **C** *A. ornata*. **D** *A. pannonica*. **A–D** apterous viviparous female. Scale bars 0.2 mm.

In our opinion the synonymy can stand, because V. F. Eastop studied a wide number of specimens from diverse provenances (host plants, localities and dates), including types (R. L. Blackman, pers. com.), and also because of our observations, or at least it should be

maintained in the sense that there is only one variable species involved. Nevertheless the valid name for this species could be *A. mingens* if the holotype of *A. picta* could be shown to be a fundatrix of *A. ornata*, in which case *A. picta* would be a synonym of that species.

Blackman and Eastop (2006) showed that *Aphidura mordvilkoii* and *A. prinsepieae* could be synonyms. Kadyrbekov (2013) established the synonymy. We have found differences between specimens identified as *prinsepieae* by Patshchenko and other ones identified as *mordvilkoii* by Shaposhnikov (Fig. 1D), similar to those shown by Kadyrbekov (2013). All of them can be considered to be a consequence of intraspecific variability. In conclusion, the established synonymy can be kept.

New host plant and country records

Collection data for the following first records are shown in Table 1.

Aphidura bozhkoeae (Fig. 2A) is recorded for the first time on *Prunus spinosa* and on *P. prostrata*; it was previously recorded from several other species habitually placed in *Prunus*, although some of them can be classified in *Cerasus* or in *Aflatunia*.

Aphidura delmasi (Fig. 2B) is recorded for the first time on *Silene viscosa*; it has previously been recorded on other species of *Silene*.

Aphidura ornata (Fig. 2C) is recorded for the first time on *Silene inaperta*, *S. nutans* and *S. saxifraga*; it has been recorded previously on four other species of *Silene*.

Aphidura pannonica (Fig. 2D) is recorded for the first time on *Gypsophila paniculata*; this aphid has been previously recorded from several species of *Silene*.

Aphidura picta (Fig. 1C) is recorded for the first time (i) on *Silene glauca* and (ii) from Afghanistan. This aphid has been recorded on several species of *Silene*, and also of *Dianthus*; and it was known from Iran, Tajikistan and Pakistan, and other Asiatic and European countries.

***Aphidura pujoli*, amendment of distribution**

The identification made by G. Remaudière, of four apterous viviparous females belonging to his sample 014072 from Pakistan, as *A. pujoli* is not correct; in fact these specimens belong to a new species, *A. pakistanensis*. In consequence the record of *A. pujoli* from Pakistan by Naumann-Etienne and Remaudière (1976) is incorrect, and *A. pujoli* (Fig. 3A) remains restricted to Europe, having been recorded from Portugal, Spain, France (including Corsica), Switzerland, Italy (including Sicily), and Ukraine.

***Aphidura delmasi*, new morphs**

Collecting data in Table 1: fundatrix, sample 7876; oviparous females and males, sample 7591.

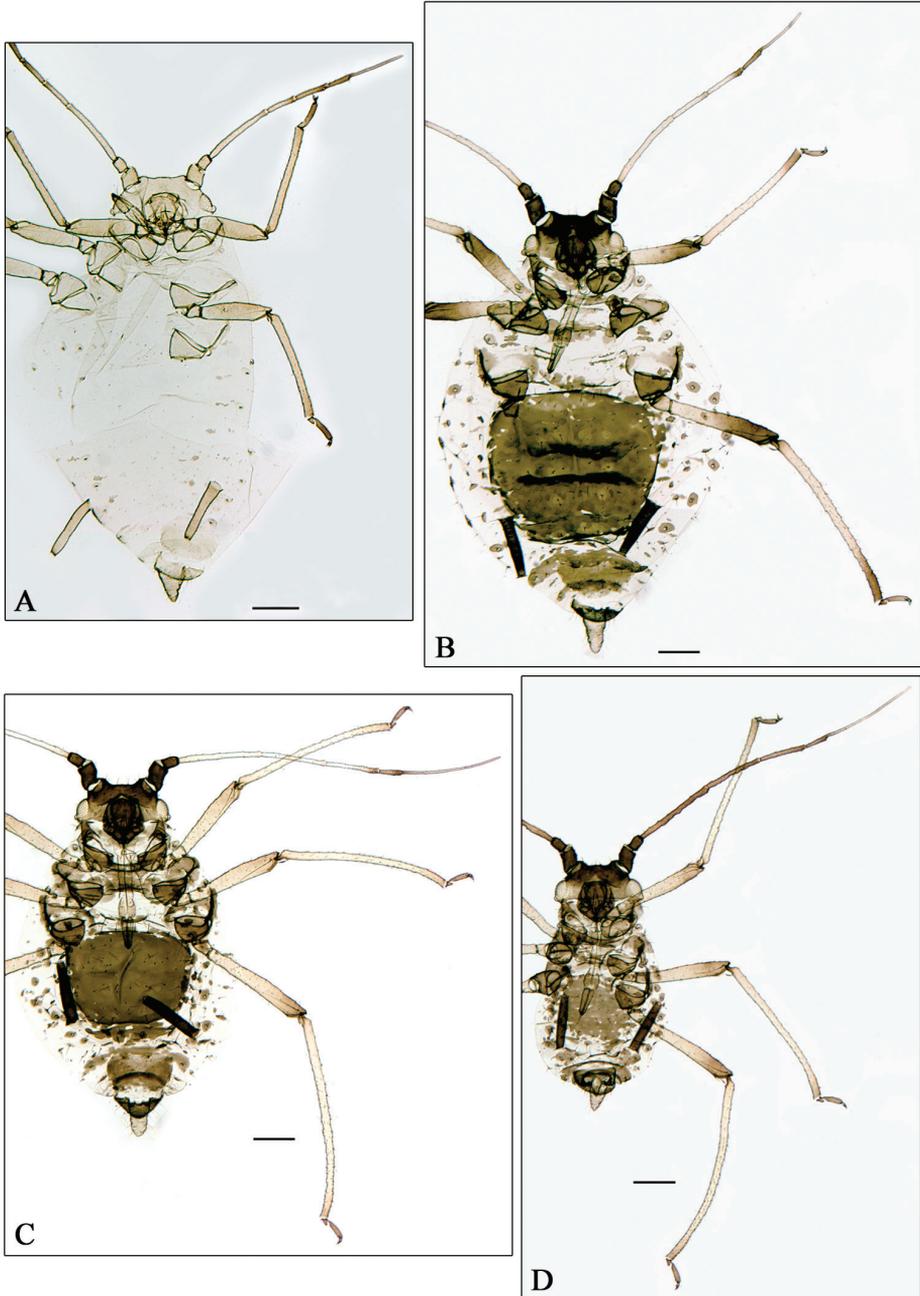


Figure 3. **A** *Aphidura pujoli*. **B–D** *A. delmasi* **B** fundatrix **C** oviparous female **D** male. Scale bars 0.2 mm.

Fundatrix. From 4 specimens (Fig. 3B). Very similar to the fundatrigenous aptera described by Remaudière and Leclant (1965) and illustrated in detail by Mme. M. Arnault (page 719, figures 1–8), with shorter antennae, legs and siphunculi, as

is normal in fundatrices, and without postsiphuncular sclerites. Metric and meristic features in Table 2.

Oviparous female. From 4 specimens (Fig. 3C). Very similar to the fundatrig-enous aptera, with paler antennae, yellowish legs (only tarsi are smoky). Hind tibiae not swollen, with 20–30 scent plates. Metric and meristic features in Table 2.

Male. From 4 specimens (Fig. 3D). Apterous. Also very similar to the fundatrig-enous aptera, but smaller, with paler legs (only tarsi are smoky) and longer antennae. Aedeagus and parameres brown. Metric and meristic features in Table 2.

New species

Six new species are established: *A. gallica* and *A. amphorosiphon*, which live on species of *Silene*, *A. pakistanensis*, *A. graeca* and *A. urmiensis*, which live on other caryophyllaceous plants (respectively species of *Dianthus*, *Gypsophila* and *Spergula*), and *A. iranensis*, which lives on *Prunus*.

Aphidura gallica sp. n.

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http://species-id.net/wiki/Aphidura_gallica

Apterous viviparous female (Figs 4A, B). Colour in life unknown. Head yellowish brown with rugosity near the eyes. Antennal segments I–IV as pale as cephalic dorsum, and V and VI darker. Dorsal pigmentation and sclerotisation very variable. In several specimens, holotype included prothorax with complete but pale band, metathorax with brown spinopleural transverse band and setiferous marginal sclerites, abdominal segments 1–6 with an extensive dark spinopleural patch, partially fragmented in midline and with an irregular lateral margin partly incorporating the marginal sclerites; abdominal segments 7 and 8 with bands paler than patch. In other specimens, dorsum mainly membranous, with pale brown to brown pleural sclerites on abdominal segments 1–6, which are irregular in shape and sometimes joined between segments, and several very small and pale marginal setiferous sclerites. Other specimens have an intermediate degree of sclerotisation and pigmentation. Mesosternal mammariform processes yellowish, thin and tall. Siphunculi cylindrical, dark, and densely covered with denticulate scales. Cauda triangular (sometimes with a slight constriction) with pointed apex, and not darker than legs. Anal and genital plates as pale as cauda. Metric and meristic features in Table 3.

Alate viviparous female (Fig. 4C). Head brown, as dark as thorax. Abdominal segments 1 and 2 with spinal sclerites; segments 4–5 with spinopleural patch, sometimes partially joined with the spinopleural bands on 3 and 6; segments 1–6 with marginal sclerites; segment 7 with a band paler than previously mentioned sclerites; segment 8 with pale setiferous sclerites, sometimes coalesced together. Metric and meristic features in Table 3.

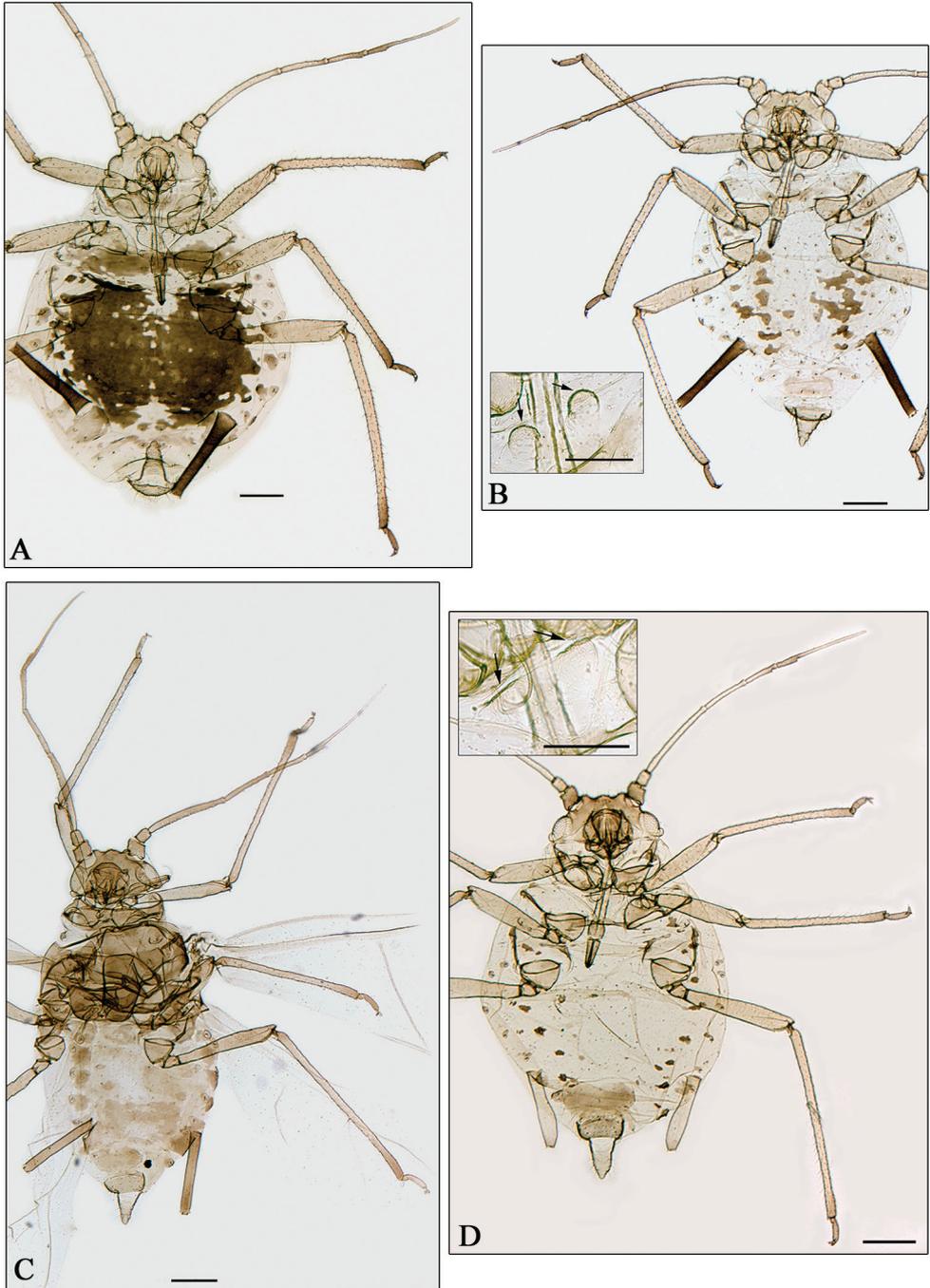


Figure 4. **A–C** *Aphidura gallica* sp. n. **D** *A. amphorosiphon* sp. n. **A–B, D** apterous viviparous female **C** alate viviparous female **A** pigmented form **B** unpigmented form **B, D** boxes mesosternum with mammariform processes. General scale bars 0.2 mm, boxes scale bar 0.01 mm.

Table 3. Metric and meristic features of *Aphidura gallica* sp. n. and *A. amphorosiphon* sp. n.; n, number of measured specimens.

	<i>A. gallica</i>	<i>A. gallica</i>	<i>A. amphoro-</i> <i>siphon</i>	<i>A. amphoro-</i> <i>siphon</i>	<i>A. amphoro-</i> <i>siphon</i>
	Apt. viv. femal.	Al. viv. femal.	Ap. viv. femal.	Al. viv. femal.	Male
	n = 30	n = 2	n = 12	n = 3	n = 1
Body [mm]	1.475–2.325	1.600–1.725	1.275–1.638	1.100–1.525	1.275
Antenna [mm]	1.070–1.735	1.343–1.343	0.978–1.170	1.265–1.615	1.340–1.380
Antenna / Body [times]	0.66–0.93	0.84–0.84	0.71–0.89	1.05–1.15	1.05–1.08
Ant. segm. III [mm]	0.32–0.49	0.23–0.36	0.26–0.35	0.35–0.40	0.38–0.38
Ant. segm. IV [mm]	0.16–0.36	0.12–0.22	0.14–0.20	0.20–0.28	0.22–0.23
Ant. segm. V [mm]	0.14–0.26	0.11–0.18	0.13–0.18	0.16–0.23	0.17–0.19
Ant. segm. VI base [mm]	0.08–0.13	0.10–0.10	0.09–0.11	0.10–0.13	0.10–0.11
Ant. segm. VI processus terminali [mm]	0.25–0.44	0.37–0.37	0.25–0.31	0.32–0.48	0.37–0.38
Ant. segm. VI processus terminalis/ Ant. segm. III [times]	0.66–0.99	1.04–1.04	0.77–1.07	0.85–1.22	1.00
Ant. segm. VI processus terminalis/ base [times]	2.88–4.08	3.89–3.89	2.57–3.08	3.37–4.04	3.57–3.70
Secondary sensoria, Ant. segm. III [number]	0	16–34	0	16–21	63–72
Secondary sensoria, Ant. segm. IV [number]	0	0	0	0	29–32
Secondary sensoria, Ant. segm. V [number]	0	0	0	0	11–15
Ultimate rostral segm. [mm]	0.11–0.15	0.10–0.13	0.12–0.14	0.10–0.13	0.10
Ultimate rostral segm. / its basal width [times]	2.00–3.00	2.00–2.60	2.18–2.80	2.88–2.88	2.67
Ultimate rostral segm. / Ant. segm. VI base [times]	1.10–1.87	1.37–1.37	1.12–1.42	0.96–1.05	0.95–1.00
Hind femur [mm]	0.39–0.60	0.39–0.50	0.35–0.46	0.38–0.45	0.42–0.43
Hind tibia [mm]	0.72–1.13	0.81–1.02	0.61–0.83	0.80–1.00	0.82–0.85
Hind tibia / Body [times]	0.43–0.59	0.51–0.59	0.45–.55	0.58–0.73	0.64–0.67
Hind tarsus, 2nd segm. [mm]	0.10–0.12	0.11–0.11	0.08–0.10	0.10–0.11	0.09–0.10
Hind tarsus, 2nd segm. / Ultimate rostral segm. [times]	0.70–0.95	0.81–1.05	0.67–0.83	0.83–0.95	0.90–0.95
Abdominal marginal papillae [number]	0	0	0	0	0
Siphunculus [mm]	0.35–0.50	0.35–0.42	0.27–0.33	0.25–0.30	0.24
Siphunculus / Body [times]	0.20–0.29	0.22–0.24	0.18–0.24	0.18–0.24	0.19
Siphunculus / Ant. segm. III [times]	0.87–1.24	0.99–1.84	0.90–1.04	0.65–0.77	0.64–0.65
Siphunculus / its basal width [times]	4.00–5.57	7.00–7.00	3.60–5.80	3.85–5.89	5.33
Siphuncular widths, maximal / basal [times]	0.50–0.86	0.80–0.80	0.83–1.20	0.81–1.11	1.33

	<i>A. gallica</i>	<i>A. gallica</i>	<i>A. amphoro-</i> <i>siphon</i>	<i>A. amphoro-</i> <i>siphon</i>	<i>A. amphoro-</i> <i>siphon</i>
	Apt. viv. femal.	Al. viv. femal.	Ap. viv. femal.	Al. viv. femal.	Male
	n = 30	n = 2	n = 12	n = 3	n = 1
Siphuncular widths, maximal / minimal [times]	1.00–1.00	1.00–1.00	1.25–1.79	1.47–2.00	2.18
Siphuncular minimal width / Hind tibia, diameter at middle [times]	1.05–1.57	1.33–1.69	1.00–1.57	1.00–.50	0.61
Cauda [mm]	0.15–0.24	0.15–0.19	0.14–0.19	0.09–0.15	0.09
Cauda / Siphunculus [times]	0.36–0.50	0.41–0.46	0.45–0.62	0.34–0.50	0.38
Cauda / its basal width [times]	1.07–1.32	1.12–1.36	1.10–1.46	0.86–1.45	0.78
Setae on ...					
... Frons [µm]	26–45	23–23	17–38	15–21	10
... Frons / b. d. Ant. segm. III [times]	1.2–2.3	1.6–1.6	1.0–1.9	0.8–1.2	0.5
... Vertex [µm]	23–35	18–18	10–23	15–20	13
... Vertex / b. d. Ant. segm. III [times]	1.00–1.75	1.3–1.3	0.6–1.3	0.8–1.1	0.7
... Ant. segm. III [µm]	13–25	15–20	7–13	7–10	5
... Ant. segm III / T. Ant. segm. III [times]	0.6–1.3	0.7–1.5	0.5–0.7	0.4–0.6	0.3
... Ultimate rostral segm. [number]	10–16	11–11	11–17	9–13	12
... Hind femur, dorsal [µm]	13–25	13–20	7–15	10–15	10
... Hind femur, ventral [µm]	23–45	25–28	20–30	17–23	15
... Hind tibia, dorsal, at middle [µm]	25–38	25–28	20–30	20–23	20
... Hind tibia, dorsal / Tibial diameter (at middle) [times]	0.5–1.0	0.8–0.9	0.6–1.0	0.8–0.9	0.6
... Hind tarsus, first segm. [number]	2–3	2–3	2–3	2–3	2–3
... Abdominal segm. 2–4 [µm]	13–23	16–20	7–13	10–13	7
... Abdominal segm. 2–4 / T. Ant. segm. III [times]	0.6–1.1	0.7–1.5	0.4–0.8	0.5–0.6	0.4
... Abdominal segm. 8 [µm]	23–38	23–28	22–33	18–25	23
... Abdominal segm. 8 / T. Ant. segm. III [times]	1.1–2.0	1.2–1.6	1.0–2.0	1.0–1.3	1.1
... Abdominal segm. 8 [number]	4–5	4–4	4–4	4–4	4
... Ventro-abdominal [µm]	25–50	28–33	20–35	25–33	23
... Genital plate, discal [number]	2–4	2–2	2–2	2–2	—
... Genital plate, marginal [number]	10–17	10–12	10–16	8–10	—
... Cauda [number]	6–9	8–8	6–7	6–6	6

NOTE. Used abbreviations: Al., Alate; Ant., Antennal; Apt., Apterous; b. d., basal diameter; femal., females; n, number of measured specimens; segm., segment; viv., viviparous.

Types. Holotype: Apterous viviparous female (specimen 2), on *Silene gallica*, Banyuls-sur-Mer (Pyrénées Orientales), France, 11-VII-1957, Remaudière *leg.* (sample 4241). Paratypes: 39 apterous and 9 alate viviparous females with the same data that the holotype; plus 49 apterous viviparae on *Silene paradoxa*, Défilé de l'Inzecca (Haute Corse), 4-VI-1970, F. Leclant *leg.* (sample 4660) [Remaudière sample 17925].

Etymology. The specific name of the new species, *gallica*, is an adjective that refers to the Galia, France in times of the Roman Empire, in feminine; it is also coincident with the specific name of the host plant of the holotype.

Discussion. See the discussion of the following new species.

***Aphidura amphorosiphon* sp. n.**

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http://species-id.net/wiki/Aphidura_amphorosiphon

Apterous viviparous female (Fig. 4D). Colour in life unknown. Head yellowish brown to brown. Antennal segments II-III or II-V pigmented like cephalic dorsum, and I and IV-VI or only VI darker than others. Mesosternal mammariform processes rounded, low and pale. Several specimens (holotype included) are pale in general with dark brown intersegmental sclerites, brown postsiphuncular and spiracular sclerites, pale brown setiferous sclerites on abdominal segments 6–8, sometimes coalescing together into transverse bands. The most pigmented specimen has a transverse spinopleural band on prothorax, fragmented bands on mesothorax and abdominal segments 1, 6 and 7, fragmented spinopleural patches on abdominal segments 2–5, and setiferous sclerites on metathorax and abdominal segments 1 and 8. Siphunculi markedly swollen, with stem nearly smooth, and pale or with a smoky apical portion. Cauda triangular, sometimes with a slight constriction near the base, and as pale as the greater part of siphunculi and legs. Genital and anal plates as pale as cauda. Metric and meristic features in Table 3.

Alate viviparous female (Fig. 5A). Head brown, as pigmented as pro- and pterothorax and darker than antennae, tarsi and distal portions of femora and tibiae. Abdominal segments 3–5 with a spinopleural patch, and 7–8 with transverse bands. Siphunculi as dark as pigmented parts of femora. Other qualitative features as in apterae. Metric and meristic features in Table 3.

Male. Winged. Qualitatively very similar to alate viviparous females; with dark parameres. Metric and meristic features in Table 3.

Types. Holotype: Apterous viviparous female (specimen 5), on *Silene* sp. Kuh-e Dinar (Kohgiluyed and Boyer-Ahmad), Iran, 14-IX-1955, Remaudière *leg.* (sample i1118a). Paratypes: 15 apterous, 2 viviparous females and 1 male with the same data that the holotype; plus 1 apterous viviparae and 2 alate viviparae on an unidentified species of Caryophyllaceae, Chalus [road to Amol] (Mazenderan), Iran, 3-V-1963, Remaudière *leg.* (sample i2417).

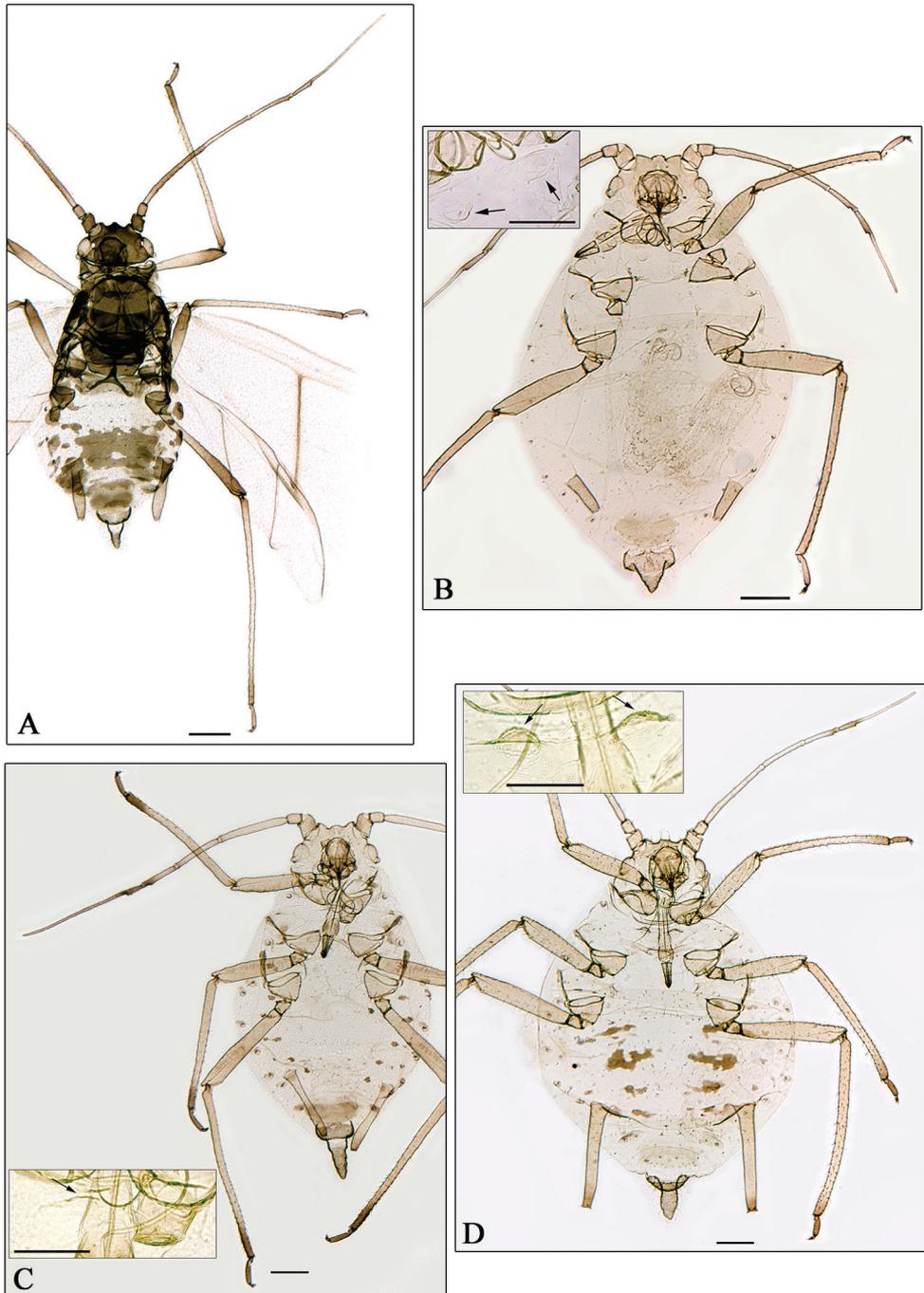


Figure 5. **A** *Aphidura amphorosiphon* sp. n. **B** *A. pakistanensis* sp. n. **C** *A. graeca* sp. n. **D** *A. urmiensis* sp. n. **A** alatae viviparous female **B–D** apterous viviparous female **B–D** boxes mesosternum with mammariform processes. General scale bars 0.2 mm, boxes scale bar 0.01 mm.

Etymology. The specific name is a neutral noun in apposition, formed for the Greek words “amphora” and “siphon”, which respectively mean flask and siphon, like in the genus *Amphorosiphon*.

Discussion. The distinctive features of *A. amphorosiphon* sp. n. and *A. gallica* sp. n. are summarized in the identification key to apterae of *Aphidura* in the general discussion, and in the following modification to the key to aphids on *Silene* (Blackman and Eastop 2006) for addition of *Aphidura amphorosiphon* and *A. gallica* (*Aphidura* spp. from Iran and from France respectively in that key), and also *A. massagetica* and *A. nomadica*, which have been recently described (Kadyrbekov 2013), with deletion of couplets 28 to 34, although several propositions have been partially or completely reutilised:

- 27 Anterior part of mesosternum without mammariform processes [rest of the proposition without modification] *Volutaphis schusteri*
- Anterior part of mesosternum with a pair of mammariform processes [rest of the proposition without modification] **35**
- 35 SIPH markedly clavate (distal maximum width habitually at least 1.2 times basal minimum)..... **36**
- SIPH cylindrical, subcylindrical, tapering from base to apex (sometimes outward curved), or slightly clavate (distal maximum width at most 1.2 times basal minimum width)..... **38**
- 36 Tergum with an extensive almost solid black shield extending over metanotum and ABD TERG 1–6, usually incorporating marginal sclerites.....
..... *Aphidura ornatella*
- Tergum pale or with variable sclerotisation, sometimes extensive but with large windows spinally and marginally, not forming a solid black shield ... **37**
- 37 ANT PT/BASE 2.55–3.1. RIV+V 1.2–1.5 times HT II. SIPH light with smoky apex. Cauda 1.1–1.5 times its basal width, with 6–7 hairs. Abdomen variably sclerotised and pigmented..... *Aphidura amphorosiphon*
- ANT PT/BASE 3.2–3.9. RIV+V 1–1.2 times HT II. SIPH uniformly pigmented. Cauda 1.1–1.2 times its basal width, with 7–11 hairs. ABD TERG 1–6 with a dark central patch and marginal sclerites *Aphidura nomadica*
- 38 SIPH pale or dusky, slightly clavate, 1.5–1.8 times cauda, which is short triangular. Tergum without sclerotisation, completely pale *Aphidura pujoli*
- SIPH brown to black at least in part, sometimes slightly clavate, 1.9–2.8 times cauda. Tergum with variable sclerotisation and pigmentation, rarely complete pale..... **39**
- 39 ABD TERG 2–3 with longest hairs 35–55 µm long, 1.5–2.0 times ANT BD III. ANT I long, 1.3–1.5 times its maximal width. Dorsal abdomen with a large central oval sclerite on ABD TERG (1)2–5 *Aphidura delmasi*
- ABD TERG 2–3 with longest hairs 4–25 µm long, 0.2–1.1 times ANT BD III. ANT I short, 1.1 times its maximal width at most. Dorsal abdomen with

- variable sclerotisation and pigmentation, but rarely with a central oval sclerite on ABD TERG 2–5 **40**
- 40 Tergum with an extensive almost solid black shield extending over metanotum and ABD TERG 1–6, usually incorporating marginal sclerites. Cauda dark broad triangular, longer than 2 times its basal width and usually shorter than 0.5 times SIPH, and with 10–16 hairs..... *Aphidura ornata*
- Tergum pale or with variable sclerotisation, sometimes extensive but with large windows spinally and marginally, not forming a solid black shield. Cauda variable in shape, proportions and colour..... **41**
- 41 Cauda tongue-shaped, 1.4–1.8 times its basal width..... **42**
- Cauda triangular, although sometimes with a slight constriction, 1.05–1.4 times its basal width..... **43**
- 42 ANT PT/BASE 4.0–5.7. Hairs on ANT III and ABD TERG 2–3 minute, maximally 4–7µm long, 0.15–0.3 times BD III. SIPH 2.2–2.8 times cauda...
..... *Aphidura pannonica*
- ANT PT/BASE 2.5–4.0. Hairs on ANT III and ABD TERG 2–3 maximally 8–22µm, 0.4–1.0 times BD III. SIPH 1.9–2.5 times cauda... *Aphidura picta*
- 43 RIV+V 0.9–1.0 times HT II, with 8–10 accessory hairs. Cauda 1.3–1.4 times its basal width. Hairs on ABD TERG 2–3 8–11 µm long, 0.3–0.5 times BD III..... *Aphidura massagetica*
- RIV+V 1.05–1.45 times HT II, with 10–16 accessory hairs. Cauda 1.05–1.35 times its basal width. Hairs on ABD TERG 2–3 13–23 µm long, 0.6–1 times BD III *Aphidura gallica*

***Aphidura pakistanensis* sp. n.**

urn:lsid:zoobank.org:act:D3B0B038-D4A8-41E8-803A-0D2CFE97A8CE

http://species-id.net/wiki/Aphidura_pakistanensis

Apterous viviparous female (Fig. 5B). Colour in life unknown. Antennae, rostrum, legs, siphunculi, genital plate and cauda yellowish. Frontal tubercles low. Mesosternal mammariform processes low, rough and pale, sometimes inconspicuous. Dorsum of thorax and abdomen without segmental sclerites; intersegmental and spiracular sclerites inconspicuous. The characteristic spinules on postsiphuncular area and tergum of abdominal segments 7 and 8 are dispersed and delicate. Siphunculi short, slightly swollen and densely covered with scales. Cauda short triangular, with broad basis. Metric and meristic features in Table 4.

Types. Holotype: Apterous viviparous female (specimen 1), on *Dianthus* sp. Kalam (Khyber Pakhtunkhwa), Pakistan, 1800 m, 17-VIII-1991, Naumann-Etienne leg. [Remaudière's sample 014072]. Paratypes: 3 apterous viviparous females with the same data that the holotype.

Etymology. The specific name of the new species is an adjective that refers to Pakistan, in feminine.

Table 4. Metric and meristic features of apterous viviparous females of *Aphidura pakistanensis* sp. n., *A. graeca* sp. n., *A. urmiensis* sp. n., and *A. iranensis* sp. n.; n, number of measured specimens.

	<i>A. pakistanensis</i>	<i>A. graeca</i>	<i>A. urmiensis</i>	<i>A. iranensis</i>
	n = 4	n = 1	n = 20	n = 6
Body [mm]	1.725–1.850	1.838	1.900–2.125	1.100–1.300
Antenna [mm]	1.053–1.655	1.670	1.333–1.755	1.005–1.210
Antenna / Body [times]	0.59–0.89	0.91	0.67–0.84	0.80–1.08
Ant. segm. III [mm]	0.32–0.49	0.37–0.40	0.39–0.52	0.30–0.43
Ant. segm. IV [mm]	0.15–0.26	0.26–0.26	0.21–0.34	0.16–0.20
Ant. segm. V [mm]	0.14–0.20	0.19–0.2	0.15–0.21	0.14–0.16
Ant. segm. VI base [mm]	0.11–0.14	0.14	0.09–0.12	0.08–0.10
Ant. segm. VI [mm]	0.22–0.31	0.56	0.30–0.44	0.31–0.35
Ant. segm. VI processus terminalis/ Ant. segm. III [times]	0.63–0.80	1.51	0.65–0.95	0.96–1.13
Ant. segm. VI processus terminalis/ base [times]	2.00–2.39	4.00	2.78–4.00	3.18–4.53
Ultimate rostral segm. [mm]	0.10–0.12	0.13	0.13–0.15	0.10–0.11
Ultimate rostral segm. / its basal width [times]	1.10–2.00	1.86	2.36–2.64	2.20–2.50
Ultimate rostral segm. / Ant. segm. VI base [times]	0.85–1.00	0.93	1.17–1.61	1.08–1.26
Hind femur [mm]	0.39–0.52	0.55–0.54	0.48–0.59	0.33–0.37
Hind tibia [mm]	0.73–0.95	0.92–0.92	0.86–1.05	0.63–0.70
Hind tibia / Body [times]	0.41–0.51	0.50–0.50	0.44–0.52	0.49–0.62
Hind tarsus, 2nd segm. [mm]	0.11–0.13	0.14–0.13	0.10–0.12	0.09–0.10
Hind tarsus, 2nd segm. / Ultimate rostral segm. [times]	1.05–1.20	1.04–1.00	0.69–0.81	0.84–0.95
Abdominal Marginal papillae [number]	0	0	0	(0)2–4
Siphunculus [mm]	0.17–0.20	0.39	0.47–0.58	0.26–0.31
Siphundulus / Body [times]	0.09–0.11	0.21	0.23–0.29	0.21–0.27
Siphunculus / Ant. segm. III [times]	0.41–0.56	1.04	1.11–1.36	0.79–1.02
Siphunculus / its basal width [times]	2.62–3.18	5.50	4.14–5.50	3.86–6.56
Siphuncular widths, maximal / basal [times]	0.69–0.82	0.79	0.44–0.67	0.61–0.89
Siphuncular widths, maximal / minimal [times]	1.00–1.06	1.38	1.00–1.00	1.06–1.13
Siphuncular minimal width / Hind tibia, diameter at middle [times]	1.42–1.50	0.94	1.24–1.65	1.25–1.89
Cauda [mm]	0.11–0.14	0.23	0.18–0.24	0.11–0.12
Cauda / Siphunculus [times]	0.55–0.82	0.60	0.33–0.45	0.37–0.40
Cauda / its basal width [times]	0.71–.00	1.80	1.20–1.60	0.92–1.05
Setae on ...				
... Frons [µm]	8–10	9	33–45	5–10
... Frons / b. d. Ant. segm. III [times]	0.38–0.44	0.39	1.40–2.12	0.25–0.67
... Vertex [µm]	8–10	8	25–40	8
... Vertex / b. d. Ant. segm. III [times]	0.38–0.57	0.3	1.1–1.9	0.4–0.5
... Ant. segm. III [µm]	8–10	10	14–21	5–8
... Ant. segm III / b. d. Ant. segm. III [times]	0.4–0.6	0.4	0.6–0.9	0.3–0.5
... Ultimate rostral segm. [number]	5–7	13	10–15	8–11
... Hind femur, dorsal [µm]	10–13	5	13–20	3–5
... Hind femur, ventral [µm]	13–18	13	25–40	8–10
... Hind tibia, dorsal, at middle [µm]	20–25	18	25–38	15–23

	<i>A. pakistanensis</i>	<i>A. graeca</i>	<i>A. urmiensis</i>	<i>A. iranensis</i>
	n = 4	n = 1	n = 20	n = 6
... Hind tibia, dorsal / Tibial diameter (at middle) [times]	0.7–0.8	0.41	0.6–0.9	0.6–0.9
... Hind tarsus, first segm. [number]	2–3	2–3	2–3	2–3
... Abdominal segm.s 2–4 [μ m]	10–10	3	15–23	4–8
... Abdominal segm.s 2–4 / b. d. Ant. segm. III [times]	0.4–0.6	0.11	0.7–1.1	0.2–0.4
... Abdominal segm. 8 [μ m]	20–25	10	23–38	8–15
... Abdominal segm. 8 / b. d. Ant. segm. III [times]	1.0–1.4	0.44	1.0–1.8	0.4–0.9
... Abdominal segm. 8 [number]	4–5	2	3–5	4
... Ventro-abdominal [μ m]	20–38	28	30–45	11–16
... Genital plate, discal [number]	2	2	2	2
... Genital plate, marginal [number]	10–14	13	9–18	7–10
... Cauda [number]	6–8	7	9–14	6–6

NOTE. Used abbreviations: Ant., Antennal; b. d., basal diameter; n, number of measured specimens; segm., segment.

Discussion. *Aphidura pakistanensis* sp. n. is the third species of the genus living on *Dianthus*. Its distinctive features are summarized in the identification key to apterae of *Aphidura* in the general discussion, and in the following modification to the key to aphids on *Dianthus* (Blackman and Eastop 2006) for addition of *A. pakistanensis*:

- 7 ABD TERG 1 and 7 without MTu. SIPH subcylindrical or slightly swollen). Anterior part of mesosternum with a pair of spinal mammariform processes... **7A**
- ABD TERG 1 and 7 with MTu. SIPH tapering from base to flange, with no trace of swelling. Anterior part of mesosternum without a pair of spinal mammariform processes **9**
- 7A Cauda as long as its basal width or shorter. SIPH not longer than 0.20 mm and 0.6 times ANT III. Mesosternal processes small and pale, sometimes inconspicuous. Abdomen without dorsal pigmentation ***Aphidura pakistanensis***
- Cauda longer than its basal width. SIPH longer than 0.26 mm and 0.60 times ANT III. Mesosternal processes pale or pigmented, always conspicuous. Abdomen pale or variably pigmented **8**
- 8 [without modification] ***Aphidura picta***
- [without modification] ***Aphidura pujoli***

***Aphidura graeca* sp. n.**

urn:lsid:zoobank.org:act:927C4017-2E8C-417E-BDDB-2A3262557025

http://species-id.net/wiki/Aphidura_graeca

Apterous viviparous female (Fig. 5C). Colour in life unknown. Head pale yellow. Antennal segment I–IV and proximal half of V as pale as cephalic dorsum, distal part of

V and VI yellow brown. Dorsum of thorax and abdomen membranous and pale, with yellowish brown spiracular and brown intersegmental sclerites. Mesosternal mammari-form processes low, rugose and pale. Siphunculi gently and asymmetrically swollen, rugose and more-or-less pigmented like tibiae. Cauda tongue-shaped with broad apex, pigmented like siphunculi. Anal and genital plates as pale as cauda. Metric and meristic features in Table 4.

Types. Holotype: Apterous viviparous female, on *Gypsophila* sp., Veria [road to Kastania] (Imanthia), Greece, 18-VI-1964, G. Remaudière leg. (sample 03026).

Etymology. The specific name of the new species is an adjective that means inhabitant of Greece, in feminine.

Discussion. *Aphidura graeca* sp. n. lives on *Gypsophila*, as does *A. gypsophilae*, and also *A. pannonica*, which has been above recorded on this plant-genus for first time. The distinctive features of *Aphidura graeca* are summarized in the identification key to apterae of *Aphidura* in the general discussion and in the following modification to the key to aphids on *Gypsophila* (Blackman and Eastop 2006), to include *A. graeca* and *A. pannonica*, and also *A. naimanica* and *A. togaica*, which have recently been described (Kadyrbekov 2013):

- 3 Anterior part of mesosternum with a pair of mammariiform processes, ornamented with spinules **3A**
- Anterior part of mesosternum without a pair of mammariiform processes ... **4**
- 3A SIPH markedly clavate..... **3B**
- SIPH not markedely clavate..... **3C**
- 3B ANT PT at least 1.40 times ANT III. Abdominal dorsum mostly membranous, and pale. SIPH pale..... *Aphidura graeca*
- ANT PT at most 1.20 times ANT III. Abdominal dorsum with pigmented patches and sclerites. SIPH pigmented..... *Aphidura naimanica*
- 3C Head, prothorax (with a complete or fragmented transversal band) and SIPH brown. Abdominal spinopleural patch variably developed and pigmented and sometimes fragmented or (often in small specimens) absent..... *Aphidura pannonica*
- Head, prothorax and SIPH (sometimes brownish apicad) pale. Abdomen variable sclerotised and pigmented..... **3C**
- 3D ANT PT/BASE 3.4-4.4. R IV+V at least 1.0 times HT II ... *Aphidura togaica*
- ANT PT/BASE 5.0-5.5. R IV+V shorter than HT II ... *Aphidura gypsophilae*

***Aphidura urmiensis* sp. n.**

urn:lsid:zoobank.org:act:41642023-E1EE-4E82-BD61-931EF3866450

http://species-id.net/wiki/Aphidura_urmiensis

Apterous viviparous female (Fig. 5D). Colour in life unknown. Head yellowish brown to brown. Clypeus bigger than those of the other species of *Aphidura*. Antennae

yellowish brown, with brown segment VI, distal 1/3 of V, and articulation between IV and V. Mesosternal mammariform processes well separated from one another, pale and round. Intersegmental sclerites small and dark brown; spiracular sclerites on segment 7 wider and darker than other abdominal spiracular sclerites; abdominal segments 3–6 with pleural and sometimes very small setiferous spinal sclerites, or with spinopleural sclerites; abdominal terga 7 and 8 pale. Siphunculi with narrow base, cylindrical (usually with slight outward curve) or slightly swollen, and as pale as tibiae. Cauda tongue-shaped, pale like genital and anal plate. Metric and meristic features in Table 4.

Types. Holotype: Apterous viviparous female (specimen 5), on *Spergula marina*, Shahi island, Lake Urmia (East Azerbaijan), Iran, 5-VIII-1955, Remaudière leg. (sample i962). Paratypes: 42 apterous with the same data that the holotype; plus 6 apterous viviparae on *S. marina*, Charimboulaki, Lake Urmia (West Azerbaijan), Iran, 9-VIII-1955, Remaudière leg. (sample i004a).

Etymology. The specific name, *urmiensis* is an adjective that refers to lake Urmia, in feminine, from the name of the Catholic Chaldean Archdiocese of Urmia.

Discussion. The distinctive features of *A. urmiensis* sp. n., which lives on *Spergula marina* are summarized in the identification key to apterae of *Aphidura* in the general discussion and in the following modification to key to aphids on *Spergula* and *Spergularia* (Blackman and Eastop 2006) for addition of *Aphidura urmiensis*:

- | | | |
|---|--|----------------------------------|
| 0 | Anterior part of mesosternum with a pair of spinal mammariform processes .. | <i>Aphidura urmiensis</i> |
| – | Anterior part of mesosternum without a pair of spinal mammariform processes .. | 1 |

***Aphidura iranensis* sp. n.**

urn:lsid:zoobank.org:act:B6A4D5D2-4826-4C5D-AF94-EFE0DCFF4A2C

http://species-id.net/wiki/Aphidura_iranensis

Apterous viviparous female (Fig. 6A). Colour in life unknown. Head brown. Vertex with spinules disposed in scattered groups. Prothorax and at least some of abdominal segment 2–4 with small marginal tubercles; abdominal segment 8 with 0–2, most frequently 1, small spinal tubercles. Mesosternal mammariform processes rounded and pale. Dorsal pigmentation and sclerotisation very variable. In several specimens (holotype included) prothorax with a complete band, mesothorax with a band with lateral windows, metathorax with two large spinopleural sclerites; abdominal segments 1–5 with several setiferous marginal sclerites, and a spinopleural patch, which has irregular edges and windows and may be coalesced with the metathoracic sclerites; abdominal segment 6 with small intersiphuncular and two postsiphuncular sclerites; segments 7 and 8 with brownish band; intersegmental sclerites are embodied in the above; spiracular sclerites inconspicuous. In less sclerotized and paler specimens the bands and patch

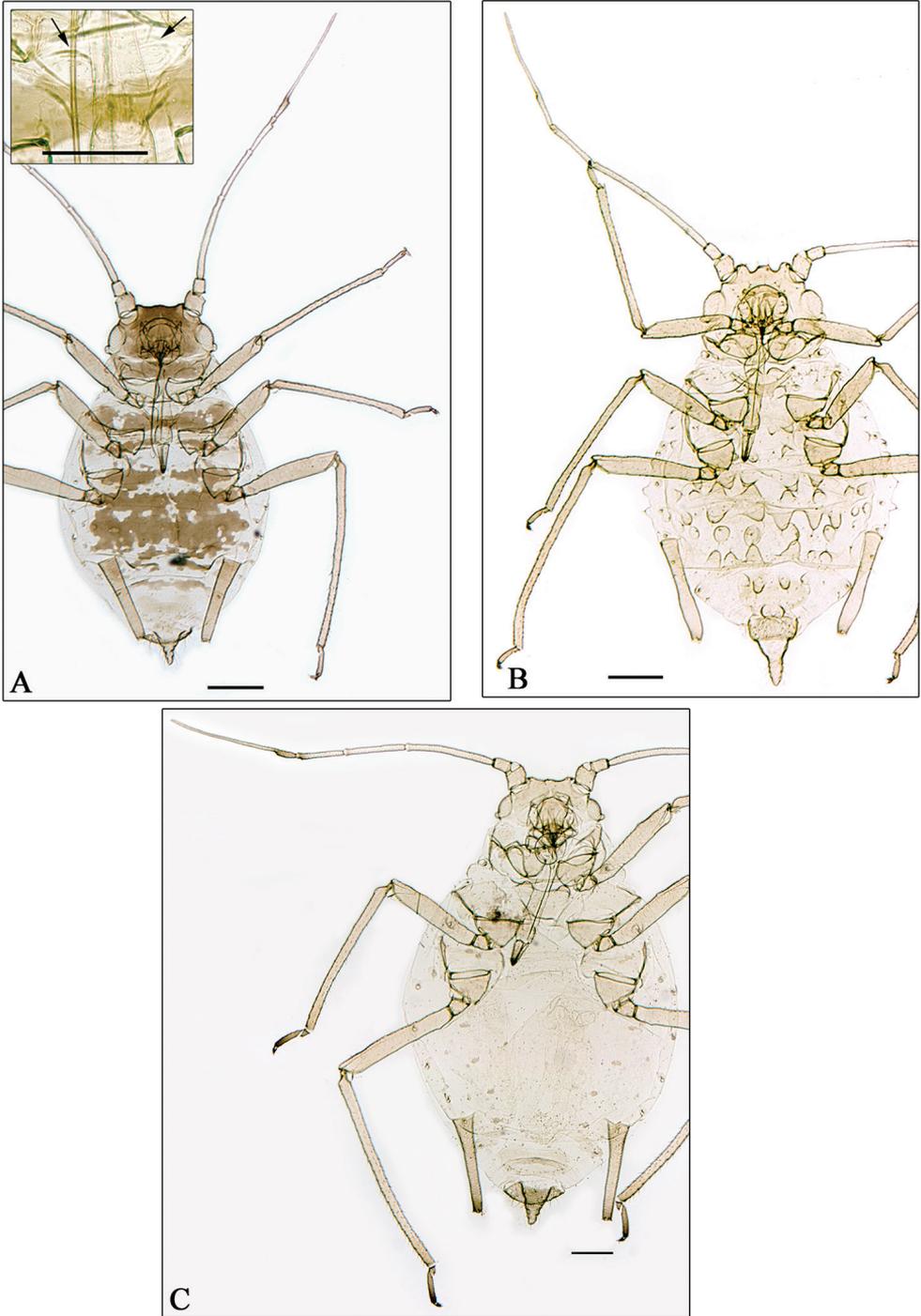


Figure 6. **A** *Aphidura iranensis* sp. n. **B** *A. acanthophylli* **C** *A. gypsophilae* **A–C** apterous viviparous female **A** box mesosternum with mammariform processes. General scale bars 0.2 mm, box scale bar 0.01 mm.

are broken. Siphunculi slightly swollen, ornamented with denticulate scales, and paler than cephalic dorsum and dorsal thoracic-abdominal sclerotized areas. Cauda thin triangular, paler than siphunculi. Genital plate pale; anal plate coloured like cauda. Metric and meristic features in Table 4.

Types. Holotype: Apterous viviparous female (specimen 1), on *Prunus* sp., Khoys [30 km North] (West Azerbaijan), Iran, 1700 m, 7-VIII-1955, G. Remaudière leg. (sample i982). Paratypes: 5 apterous viviparous females, with the same collecting data as holotype.

Etymology. The specific name of the new species, *iranensis*, is an adjective that refers to Iran, in feminine.

Discussion. *Aphidura iranensis* sp. n. is the second species of the genus living on species of *Prunus*. Its distinctive features are summarized in the identification key to apterae of *Aphidura* in the general discussion, and in the following modification to the key to aphids on *Prunus* (Blackman and Eastop 1994) for addition of *A. iranensis*:

- | | | |
|-----|--|----------------------------------|
| 7 | [without modification] | 8 |
| – | Head capsule with spiculose (sometimes delicate) or nodulose ornamentation | 30 |
| 32 | Anterior part of mesosternum with a pair of spinal mammariform processes, ornamented with spinules (Fig. 89B) | 32B |
| – | [without modification] | 33 |
| 32B | A continuous sclerotic and dark shield on (metanotum)ABD TERG 1-6(7), including marginal areas; and dorsum of other thoracic segments with sclerotic dark bands. ABD TERG 1-4 without marginal tubercles, and ABD TERG 8 without spinal tubercles..... | <i>Aphidura bozhkoeae</i> |
| – | A continuous dorsal sclerotic shield absent; dorsum of thoracic segments with sclerotic bands, and ABD TERG 1-5(7) with spinal and pleural sclerites or patches, which may be coalescing. ABD TERG 2-4 frequently with marginal tubercles, and ABD TERG 8 frequently with spinal tubercles | <i>Aphidura iranensis</i> |

General discussion

The features that distinguish the apterous viviparous females of the *Aphidura* species which share host plants have been described in the modifications to Blackman and Eastop's keys to aphids on different plant genera (Blackman and Eastop 1994, 2006) in the particular discussion of each new species.

The previously known and the new species together can be distinguished from each other using the following key to apterous viviparous females of species of *Aphidura*. In brackets are: (1) morphological characters that do not have correspondence in the other proposition of the disjunctive, but which are useful to confirm identification; (2) host plants, and distribution data; and (3) illustration reference. In the distribution of each species the countries are in geographical order from West to East, so that a quick general

assessment of the distribution of each species can be made. The key uses data of species recently described from the respective original descriptions (Kadyrbekov 2013); other data are from literature and personal observations. *A. melandrii* is accessible by two routes, because several specimens have slightly swollen siphunculi (maximal swollen width at least 1.2 times minimal stem width) and others have conspicuously swollen siphunculi.

Key to apterous viviparous females of *Aphidura* species of the world

- 1 Siphunculi markedly swollen (maximal swollen width at least 1.2 times minimal stem width)..... **2**
- Siphunculi of different form (cylindrical, subcylindrical, tapering or slightly swollen, see above “generic characters” section)..... **9**
- 2 Most of dorsal setae placed on conical tubercles. [Dorsum without segmental pigmented sclerotisation. On *Acanthophyllum* sp.; Iran. Fig. 6B] ***A. acanthophylli***
- Dorsal setae not placed on tubercles..... **3**
- 3 Mesosternal processes and cauda pale..... **4**
- Mesosternal processes and cauda more or less pigmented, light brown to brown **6**
- 4 Siphunculi dark brown, 2.3–2.7 times cauda which has 7–11 setae. Abdominal dorsum with spino-pleural patch, postsiphuncular sclerites pigmented and marginal sclerites. [Ultimate rostral segment 1.0–1.2 times second segment of hind tarsi. Cauda 1.1–1.2 times its basal width. On *Silene suffrutescens* and *S. sp.*; Kazakhstan. Kadyrbekov (2013): fig. 8] ***A. nomadica***
- Siphunculi pale, sometimes with smoky apex, 1.6–2.2 times cauda, which has 6–7 setae. If a spino-pleural patch present then ultimate rostral segment is 1.2–1.5 times second segment of hind tarsi **5**
- 5 Antennal segment VI processus terminalis at least 1.4 times antennal segment III and approximately 4 times antennal segment VI base. Longest dorsal setae on abdominal segment 2–4 approximately 3 µm. Cauda tongue-shaped. Dorsum pale with dark intersegmental sclerites. [On *Gypsophila* sp.; Grece. Fig. 5C] ***A. graeca* sp. n.**
- Antennal segment VI processus terminalis at most 1.1 times antennal segment III and at most 3.1 times antennal segment VI base. Longest dorsal setae on abdominal segment 2–4 are 7–13 µm. Cauda triangular, sometimes slight constricted. Dorsum with variable sclerotisation and pigmentation, sometimes mostly pale. [On *Silene* sp., and an unidentified caryophyllaceous species; Iran. Fig. 5D] ***A. amphorosiphon* sp. n.**
- 6 Abdominal (or thoracic-abdominal) discal plate present, sometimes divided in transversal bands..... **7**
- Abdominal discal plate absent; a broken an irregularly edged spinopleural patch usually present, sometimes with bridges to marginal sclerites..... **8**

- 7 Mesosternal processes wide and low. Longest dorsal setae on abdominal segment 2–4 are 10–11 µm. Discal plate sometimes divided in transversal bands. Siphunculus 1.6–2.0 times cauda, which has 7–11 setae. [On *Melandrium album*; Kazakhstan. Kadyrbekov (2013): fig. 6] **A. melandrii**
- Mesosternal processes more or less narrow and tall. Longest dorsal setae on abdominal segment 2–4 are 10–55 µm. Discal plate always complete. Siphunculus 1.6–2.6 times cauda, which has 5–8 setae. [On *Saponaria* sp., *Silene commutata*, *Si. kuschakewiczii*, *Si. lithophila*, *Si. vulgaris*, *Si. wallichiana*, *Si. wolgensis* and *Si.* sp.; Kazakhstan, Pakistan, Tajikistan, and India. Fig. 1A] **A. ornatella**
- 8 Siphunculus 1.7–2.7 times cauda. Longest frontal setae 22–28 µm and 1.0–1.4 times basal diameter of antennal segment III. [On *Gypsophila altissima* and *G. paniculata*; Kazakhstan. Kadyrbekov (2013): fig. 4]..... **A. naimanica**
- Siphunculus 1.5–1.7 times cauda. Longest frontal setae 35–40 µm and 1.6–1.8 times basal diameter of antennal segment III. [On *Cerastium cerastoides*; Kazakhstan. Kadyrbekov (2013): fig. 5] **A. alatavica**
- 9 First segment of tarsi with 4 or less habitually with 3 setae. [Head and prothoracic transversal band as dark as thoracic-abdominal discal plate. Siphunculi cylindrical and straight. On Rosaceae species] **10**
- First segment of tarsi habitually with 3 setae, sometimes with 2; very infrequently with 4 **11**
- 10 Antennal segment VI processus terminalis 2.2–2.7 times antennal segment VI base. Ultimate rostral segment with 2–5 accessory setae. Marginal tubercles usually present on abdominal segments 2–4. [On *Prinsepia sinensis*; Russia (Far Est, Primorsky Krai). Fig. 1D]..... **A. mordvilkoi**
- Antennal segment VI processus terminalis 3.8–4.2 times antennal segment VI base. Ultimate rostral segment with 8–10 accessory setae. Abdominal marginal tubercles always absent. [On *Prunus erythrocarpa*, *P. fruticosa*, *P. incana*, *P. spinosa*, *P. tianschanica*, *P. triloba*, *P. ulmifolia*, *P. verrucosa* and *Prunus* sp.; Georgia, Kazakhstan, Iran, Uzbekistan, Tajikistan, and Kyrgyzstan. Fig. 2A] **A. bozhkoae**
- 11 Siphunculus slightly swollen with a maximal width close to 1.2 times minimal stem width and 1.6–2.0 times cauda, which is 1.5–1.8 times its basal width and has 7–11 setae; both as dark as head dorsum and thoracic and abdominal sclerotisation (a discal plate can be present). Longest dorsal setae on abdominal segment 2–4 are 10–11 µm and approximately 0.5 times basal diameter of antennal segment III. [On *Melandrium album*; Kazakhstan. Kadyrbekov (2013): fig. 6]..... **A. melandrii**
- Characters not in above combination..... **12**
- 12 Siphunculus at most 1.95 times cauda (which is short triangular), pale or uniformly dusky and slight swollen. Dorsum of head and mesosternal processes pale. Segmental thoracic and abdominal sclerotisation and pigmentation absent..... **13**

- Siphunculus at least 1.90 times cauda, both diversely shaped and coloured. Dorsum of head and mesosternal processes pale or pigmented. Thoracic and abdominal segmental sclerotisation and pigmentation rare completely absent..... **14**
- 13 Siphunculus at least 0.26 mm, 0.6–0.95 times antennal segment III, and 1.7–1.95 times cauda, which is longer than its basal width. Mesosternal processes conspicuous. [On *Dianthus carthusianorum*, *D. caryophyllus*, *D. commutatus*, *D. monspessulanus*, *D. rupicola*, *D. sp.* and *Silene borysthenica*, Portugal, Spain, France, Switzerland, Italy and Ukraine. Fig. 3A] ***A. pujoli***
- Siphunculus shorter than 0.20 mm, 0.41–0.56 times antennal segment III, and 1.7–1.9 times cauda, which is not longer than its basal width. Mesosternal processes sometimes inconspicuous. [On *Dianthus sp.*; Pakistan. Fig. 5B] ***A. pakistanensis sp. n.***
- 14 Antennal segment I at least 1.25 times its maximal width. Longest dorsal setae on abdominal segments 2–4 are 35–55 µm and 1.5–2.0 times basal diameter of antennal segment III. [Discal plate oval and dark. Siphunculi weakly ornamented, smooth distad. On *Silene italica*, *S. nutans*, perhaps *S. viscosa*, and *S. sp.*; France, Italy, Greece. Fig. 2B]..... ***A. delmasi***
- Antennal segment I at most 1.1 times its maximal width. Longest dorsal setae on abdominal segments 2–4 at most 25 µm and 1.2 times basal diameter of antennal segment III..... **15**
- 15 Abdomen usually with spinopleural patch and separate marginal sclerites; if a discal plate is present then it has irregular margins and frequently there are windows in spinal areas of the thoracic, if integrated, and anterior abdominal segments. Dorsal patch or plate smooth and reticulated. Siphunculi dark brown to black, subcylindrical and usually straight, 1.8–2.0 times cauda, which is broad triangular and has 10–16 setae. Ultimate rostral segment with 6–10 accessory setae. [On *Silene inaperta*, *S. italica*, *S. nutans*, *S. saxifraga*, *S. otites*, *S. vulgaris*, *S. wolgensis* and *S. sp.*; France, Switzerland, Italy, Hungary, Romania, Ukraine and Russia. Fig. 2C]..... ***A. ornata***
- Characters not in above combination..... **16**
- 16 Longest setae on abdominal segments 2–4 (dorsum) and antennal segment III 3–8 µm and 0.15–0.50 times basal diameter of antennal segment III **17**
- Longest setae on abdominal segments 2–4 (dorsum) and antennal segment III 8–25 µm and 0.15–0.50 times basal diameter of antennal segment III; if they are 8 µm long then marginal abdominal tubercles present or ultimate rostral segment shorter than second segment of hind tarsi..... **18**
- 17 Siphunculi dark brown, head dorsum, mesosternal processes and cauda brown to dark brown. Ultimate rostral segment 1.15–1.25 times second segment of hind tarsi. Cauda 1.4–1.8 times its basal width. [On *Gypsophila paniculata*, *Silene borysthenica*, *S. moldavica*, *S. otites*, *S. wolgensis* and *S. sp.*; Slovakia, Hungary, Greece, Ukraine, and Moldova. Fig. 2D]..... ***A. pannonica***

- Siphunculi (with smoked apex, head dorsum, mesosternal processes and cauda pale. Ultimate rostral segment as long as second segment of hind tarsi. Cauda 1.0–1.1 times its basal width. [On *Gypsophila perfoliata*; Kazakhstan. Kadyrbekov (2013): fig. 1].....***A. togaica***
- 18 Marginal tubercles on abdominal segments 2–4 and usually at least 1 spinal tubercle on abdominal segment VIII. [Cauda triangular 0.92–1.05 times its basal width. On *Prunus*. Iran. Fig. 6A]***A. iranensis* sp. n.**
- Marginal and spinal abdominal tubercles absent **19**
- 19 Siphunculi pale, usually as pale as most part of tibiae..... **20**
- Siphunculi pigmented, usually darker than most part of tibiae..... **21**
- 20 Antennal segment VI processus terminalis 5.0–5.5 times antennal segment VI base. Cauda triangular or tongue-shaped with slight proximal constriction. Ultimate rostral segment shorter than second segment of hind tarsi. [On *Gypsophila arenaria*, *G. paniculata*, *G. perfoliata*, *G. sp.*; Slovakia, Hungary, Ukraine, Kazakhstan, Russia (Western Siberia). Fig. 6C].....***A. gypsophilae***
- Antennal segment VI processus terminalis 2.8–4.0 times antennal segment VI base. Cauda tongue-shaped. Ultimate rostral segment 1.23–1.45 times second segment of hind tarsi. [Clypeus swollen both forward and laterally. On *Spergularia marina*; Iran. Fig. 5D]***A. urmiensis* sp. n.**
- 21 Cauda tongue-shaped, 1.40–1.80 times its basal width. Mesosternal processes more or less pigmented, usually darker than tibiae. [Thoracic and abdominal sclerotisation variable, usually a spinopleural abdominal patch with irregular edges and windows in several segments, including the posterior ones. Siphunculi pigmented, but usually pale than abdominal sclerotised dorsum. On *Dianthus barbatus*, *D. caryophyllus*, *D. crinitus*, *D. sp.*, *Silene conoidea*, *S. fruticosa*, *S. italica*, *S. otites*, *S. paradoxa*, *S. thymifolia*, *S. vulgaris*, and *S. sp.*. Spain, France, Italy, Slovenia, Hungary, Greece, Bulgaria, Turkey, Israel, Iran, Afghanistan, Pakistan, Tajikistan, and Russia (Asiatic part). Fig. 1C].....***A. picta***
- Cauda triangular, although sometimes with a slight proximal constriction, 1.05–1.40 times its basal width. Siphunculi and mesosternal processes as pale as tibiae..... **22**
- 22 Ultimate rostral segment 0.90–1.00 times second segment of hind tarsus, with 8–10 accessory setae. Cauda approximately 1.30–1.40 times its basal width. Longest dorsal setae on abdominal segment 2–3 are 8–11 μm and 0.3–0.5 basal diameter of antennal segment III. [On *Silene lithophila*; Kazakhstan. Kadyrbekov (2013): fig. 2]***A. massagetica***
- Ultimate rostral segment 1.05–1.45 times second segment of hind tarsus, with 10–16 accessory setae. Cauda approximately 1.05–1.35 times its basal width. Longest dorsal setae on abdominal segment 2–3 are 13–23 μm and 0.6–1.0 basal diameter of antennal segment III. [On *Silene gallica* and *S. paradoxa*; France. Figs 4A, B].....***A. gallica* sp. n.**

A. pujoli (from Blackman and Eastop op. cit.) and *A. delmasi* (this paper) are monoecious holocyclic, and *A. amphorosiphon* is very possibly holocyclic (this paper). The life cycle of the other species of the genus is unknown. It is possible that three types of life cycle currently exist in this genus, as in *Brachycaudus* van der Goot, 1913: (i) monoecious (and probably holocyclic) on a rosaceous species (e.g. *A. bozhkoeae* on *Prunus* spp. and *A. mordvilkoii* on *Prinsepia sinensis*), (ii) monoecious on a Caryophyllaceae species (and also probably holocyclic, e.g. *A. delmasi* and *A. pujoli*), and (iii) dioecious cycle with rosaceous species as primary host, and Caryophyllaceae species as secondary host.

For us the more probable hypothesis is that all current species of *Aphidura* are monoecious, but that their common ancestor was dioecious, as in various other genera of Macrosiphini, and later the *Aphidura* branch diversified into two monoecious lineages, one Rosaceae-feeding and the other Caryophyllaceae-feeding. This is analogous to the South American species of *Pentamyzus* Hille Ris Lambers, 1966 which are all monoecious holocyclic, with several species living on *Acaena* (Rosaceae) and others on *Alopecurus*, *Hordeum* or *Poa* (Poaceae) (Nieto Nafria et al. 2002).

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Nuurcala obesa sp. n. (Blattida, Caloblattinidae) from the Lower Cretaceous Yixian Formation in Liaoning Province, China

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Abstract

Nuurcala obesa sp. n., in the cockroach family Caloblattinidae, is described from the Lower Cretaceous Yixian Formation (Liaoning Province, China) based on a combination of differential characters of fore- and hind wing venation, colouration and body structures. Systematically, *Nuurcala* (Vršanský, 2003), known from the Cretaceous sediments of Bon Tsagaan and Khurilt, Mongolia, is closely related to other genera of Caloblattinidae known from the Jurassic and Cretaceous localities in other parts of Asia.

Keywords

Fossil cockroach, new species, Huangbanjigou, wing venation, colouration

Introduction

Caloblattinidae, a large extinct family of cockroaches, was erected by Vršanský and An-sorge, it consists of over 50 genera comprising nearly 200 described species distributed in Argentina, Australia, Brazil, Burma, China, England, France, Germany, Greenland, Japan, Kazakhstan, Kirgizstan, Mongolia, Russia, Spain, Switzerland, and South Af-rica during Middle Triassic to Late Cretaceous (Vršanský 2000, 2008b). Up to now,

the Caloblattinidae is presently under review and a number of taxa (both genera and species) are still waiting reassessment (Vršanský 2007), most of them were transferred from the taxonomical “waste basket” of the family Mesoblattinidae (Vršanský 2000). Caloblattinids probably originated from Phylloblattidae in the Early Triassic, representing part of the cockroach lineage leading from the older ancestors toward living cockroach taxa (Vršanský et al. 2002, 2003b). This family is distinguished by its large body, fairly long ovipositors in females, and both wings with dark colouration and veins multiple-branched (Vršanský 2000). Amber specimens of caloblattinids are extraordinary rare probably due to their large size resulting in lower probability of amber inclusion (Vršanský 2009).

Caloblattinidae was the dominant family from Upper Jurassic in Karatau, South Kazakhstan (Vishniakova 1968, 1973). The Raphidiomimidae originated from the Caloblattinidae (which is presumed to be paraphyletic family with respect to Raphidiomimidae, Liberiblattinidae and some other extinct families) (Vršanský 2003a). Both Caloblattinidae and Raphidiomimidae share strong synapomorphies such as wide abdominal segments, long palps, elongated wings with apparent intercalaries, diagonal fold in the forewing, hind wing with many reticulations in CuA-CuP space, R with R1 and RS abundantly branched, M weakly branched, CuA secondarily branched (Liang et al. 2009). We have collected about 1500 fossil cockroaches in sediments of the Early Cretaceous of Yixian Formation, most of them belong to Blattulidae (Wang et al. 2007a, b). However, so far, only 2 species of Caloblattinidae have been described: *Rhipidoblattina laternoforma* (Lin, 1978), *Euryblattula beibiaoensis* (Wang, 1987). This indicates in the Early Cretaceous, Caloblattinidae were not dominant in the Yixian Formation.

The strata of the Yixian Formation represent mainly lacustrine sediments intercalated with volcanoclastics, which contains a large number of Jehol Biota fossils, such as well-preserved dinosaurs, primitive birds, early mammals, fishes, ostracods, plants and abundant insects (Sun et al. 1998, Hou et al. 1999, Ding et al. 2001, Ren et al. 2010). Palaeobotanical data, including spores, pollen and plants described, indicate warm and moist climate (Ding et al. 2001). Zhang et al. (2004) and Xing et al. (2005) respectively base on isotope data and abundant statistical analysis of fossils data, coming to the consistent opinion that the age of Yixian Formation is determined as Early Cretaceous. And this opinion has been accepted widely (Swisher et al. 1999, Lu 2000, Zhou et al. 2003, Franz et al. 2007). Here we consider the age of Yixian Formation as the Early Cretaceous (about 125 Ma).

Material and methods

The four specimens were collected from the Yixian Formation, Huangbanjigou, Chaomidian Village, Beipiao City, Liaoning Province, China. All type specimens are deposited in the fossil insect collection of the Key Laboratory of Insect Evolution & Environmental Changes, Capital Normal University, Beijing, China. They were examined with a Leica MZ 12.5 dissecting microscope and illustrated with the aid of a drawing

tube attached to the microscope. Line drawings were made with Photoshop CS 3.0 graphic software. Photographs of fossils were taken by a MZ12.5 dissecting microscope (Leica, Wetzlar, Germany), either dry or with alcohol.

The venation nomenclature used in this paper is based on the interpretation of Comstock and Needham (1898), followed also by Vishniakova (1964) and Vršanský (1997 and later). Abbreviations used: RFW- Right forewing; LFW- Left forewing; HW- Hind wing; Sc- Subcosta; R- Radius; Rs- Radius Sector; M- Media; Cu-Cubitus (A- anterior, P- posterior); A- Anal veins; Ant- Antenna. PIN – Paleontological Institute, Russian Academy of Sciences, Moscow, Russia. CNU – Capital Normal University, Beijing. PCMAS – Paleontological Center of Mongolian Academy of Sciences.

Systematic palaeontology

Order Blattida Latreille, 1810 (= Blattaria Latreille, 1810; = Blattodea Brunner von Wattenwyl, 1882)

Superfamily Caloblattinoidea Vršanský & Ansorge, 2000

Family Caloblattinidae Vršanský & Ansorge, 2000

Genus *Nuurcala* Vršanský, 2003

<http://species-id.net/wiki/Nuurcala>

Type species. *Nuurcala popovi* Vršanský, 2003

Composition.

Nuurcala popovi Vršanský, 2003. Bon Tsagaan Nuur, Bed 87/8, Mongolia; Barremian or Aptian, Early Cretaceous.

Nuurcala srneci Vršanský, 2008. Khurilt, Bed 210/24, Mongolia, Barremian or Aptian, Early Cretaceous.

Nuurcala sp. (collected by expedition of PIN led by M.B. Mostovski and P. Vršanský) Baissa, Transbaikalian Russia, ?Valanginian, Early Cretaceous.

Nuurcala sp. (collected by D. Davaadorj, deposited in the PCMAS, undescribed) Erdenyi Ula, Mongolia, Early Cretaceous.

Stratigraphic and paleogeographic range of the genus. ?uppermost Jurassic; Lower - Upper Cretaceous; Asia.

***Nuurcala obesa* Wang & Ren, sp. n.**

urn:lsid:zoobank.org:act:1009795B-D0EA-41D4-A356-B3FEA7515871

http://species-id.net/wiki/Nuurcala_obesa

Figs 1–4

Differential diagnosis. Differs from *N. popovi* and *N. srneci* in having relatively small head, and antennal sockets conspicuous at sides, antennae long and thick; forewing

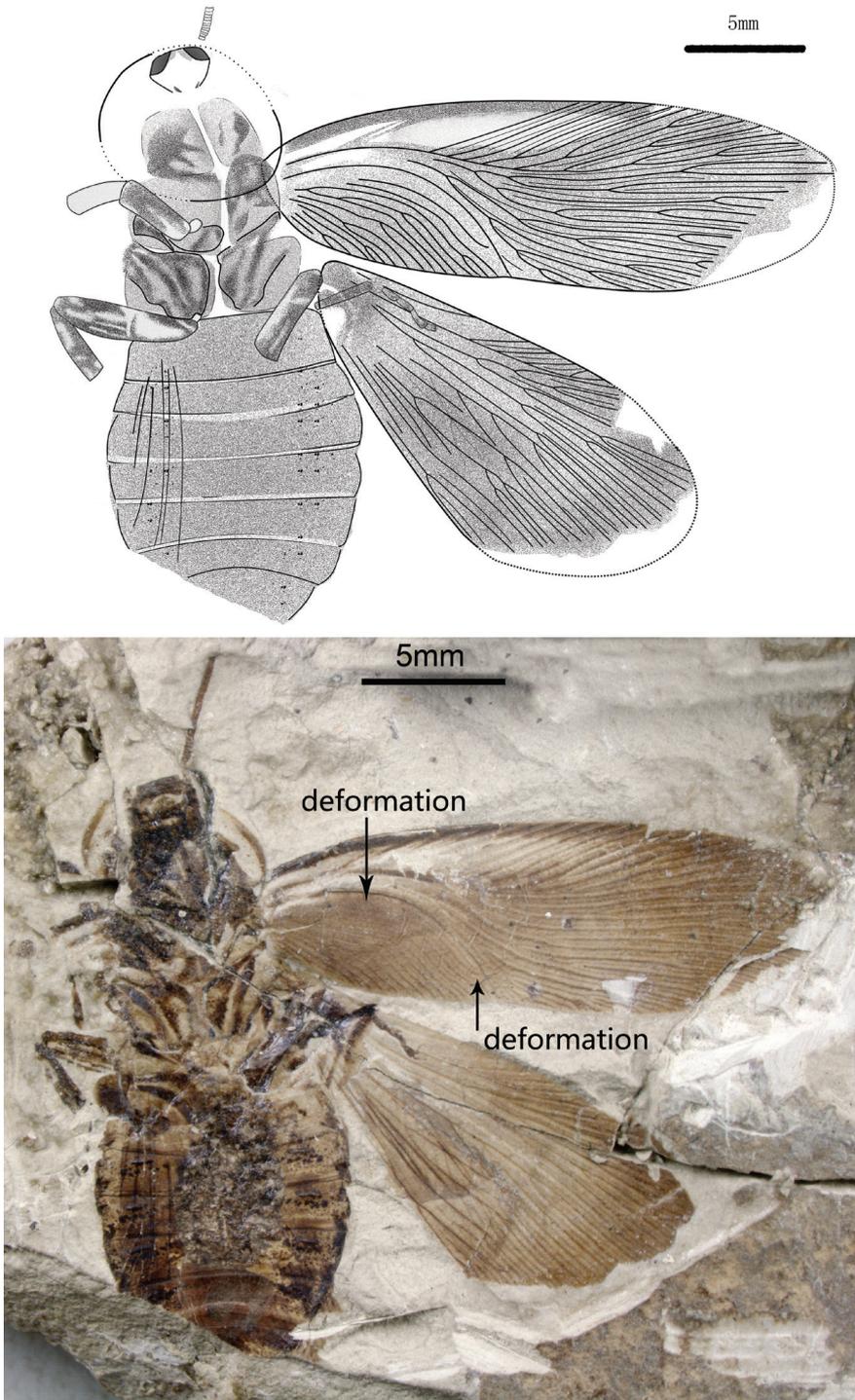


Figure 1. *Nuurcala obesa*, sp. n. Holotype, CNU-BLA-NN-2012055 **A** Line drawing **B** photograph. Scale bars = 5 mm.

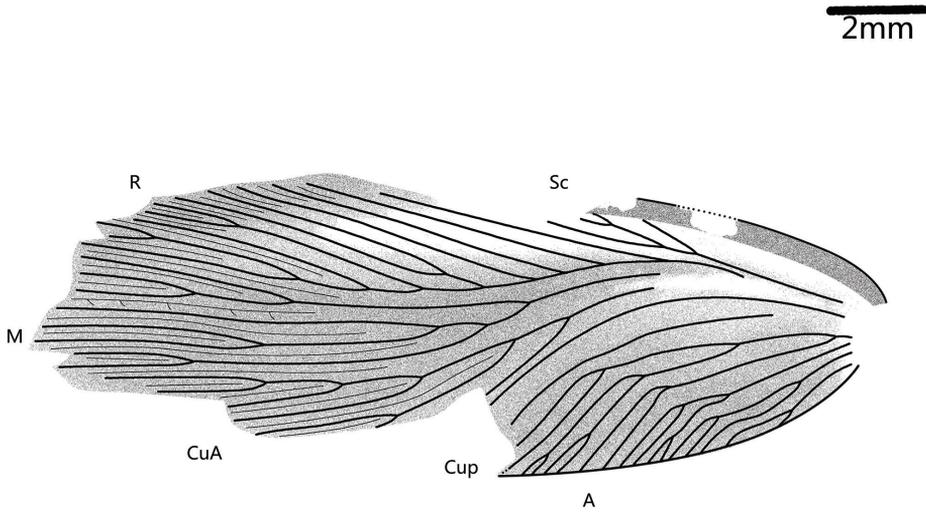


Figure 2. *Nuurcala obesa*, sp. n. Paratype, CNU-BLA-NN-2012056 **A** Line drawing **B** photograph. Scale bars = 2 mm.

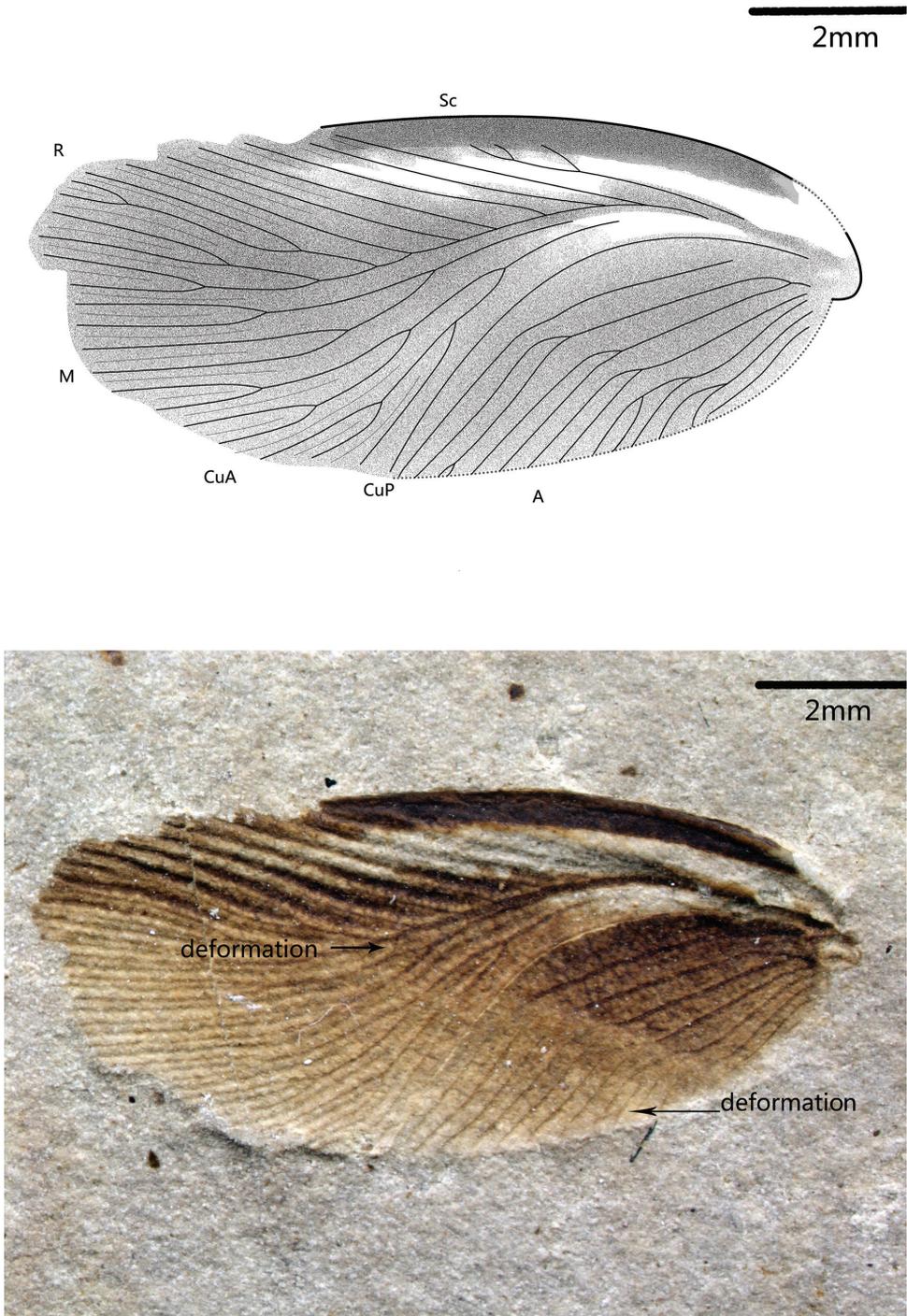


Figure 3. *Nuurcala obesa*, sp. n. Paratype, CNU-BLA-NN-2012057 **A** Line drawing **B** photograph. Scale bars = 2 mm.



Figure 4. *Nuurcala obesa*, sp. n. Paratype, CNU-BLA-NN-2012058; photograph. Scale bar = 2 mm.

with dark colouration except for R area, a dark maculae present at the edge of Sc area; hindwing with dark colouration; Legs with dark colouration, femora thick, tarsus with five segments and a claw (Fig. 1).

Description. Holotype (Fig.1): body medium to large size, length about 23.8 mm as preserved, total estimated length is 25.2 mm, and width 9.9 mm; Abdomen with 6–7 visible segments. head small, length 1.8 mm, and width 2.5 mm, antennal sockets conspicuous at sides. Pronotum, shield-like, vaulted, transversal, simple symmetrical zonal colouration at the margin, length 6.2 mm, width 6.9 mm. Forewings: length 22 mm, width 6 mm; one dark maculae present at the edge of Sc area, dark colouration with pale area in R; 55 veins at margin; intercalaries thick, all over wing surface; Sc 3 branches, shorter than clavus; R sigmoidal 15 branches, with undifferentiated Rs, reaching the anterior wing margin; M slightly curved with 9 branches, most posterior branches of M reaching wing apex; CuA slightly curved to posterior wing margin and 10 branches; CuP curved and simple; clavus long, more than a third of the wing's length; A with tertiary branches. Hind wing (17 mm long as preserved vs. 22 mm long for forewing) with branched Sc; both R1 and RS about 9 veins; M 4 branches; Cu (\pm 9) with additional blind branches that may reticulate, fan-like pleating present visible on forewing. Legs with dark colouration, femora thick, about 2 times as long as tibia, tarsus with five segments and a claw, spines obscure.

Paratypes (Figs 2–4): only forewing preserved, length range about 11.5–19 mm, width range about 5.2–5.7 mm; 42–48 veins at margin; Sc 3–5 branches, R sigmoidal 12–15 branches, M slightly curved and 4–9 branches, CuA 7–10 branches.

Materials. Holotype, partially preserved specimen with both fore- and hind wings and a body, CNU-BLA-NN-2012055 (Fig. 1). Paratypes (three isolated forewings): CNU-BLA-NN-2012056 (Fig. 2), CNU-BLA-NN-2011057 (Fig. 3), CNU-BLA-NN-2011058 (Fig. 4).

Type locality and horizon. Yixian Formation; Early Cretaceous; Huangbanjigou, Chaomidian Village, near Beipiao City, Liaoning Province, China.

Etymology. The specific name is derived from the Latin word “obesus”, (meaning “fat”), refer to the relatively large abdomen.

Discussion

We consider the present taxon belonging to the genus *Nuurcala* based on the following features: Body medium to large size, both wings have dark markings, and forewing with characteristic colouration pattern. The four specimens vary in size significantly (wing length from 11.5 to 22 mm), and the size range of this species supports that Caloblattinidae are highly variable in size (Vršanský 2000), which is different from the Blattulidae (Wang et al. 2007a, b).

N. obesa sp. n. is similar to *N. popovi* Vršanský, 2003 in the following aspects: head hypognathous, pronotum transverse ovoid, and forewing with distinct cubital space, rather wide, but differs from *N. popovi* Vršanský, 2003 by forewings with subparallel margins and characteristic markings (dark markings with pale area in R), Sc branched, R rich, M branched, Cu veins ending prior to the apex of the wing, A branched, CuA almost straight, and then curved to posterior wing margin, anal area wide.

N. obesa sp. n. differs from *N. srneci* Vršanský, 2008 by the latter having much bigger head and the veins less numerous than *N. obesa*. The new species differs from *Nuurcala* sp. (PCMAS) from Erdenyi Ula, Mongolia in having a bigger pronotum (in contrast to 5.8/6.2 mm; forewing length 21 mm).

The number of forewing veins in *N. obesa* sp. n. is differs from those of previously reported *N. popovi* and *N. srneci*. For comparison, the data are listed in Table 1. The total number of forewing veins of *N. obesa* (42–55 veins) is higher than that of *N. srneci* (about 44 veins), but much less than that of *N. popovi* (54–83 veins). The number of forewing M veins of *N. obesa* (4–9 veins) is lower than those in *N. popovi* (8–17 veins) and *N. srneci* (6–11). The differences of venation further justify the erection of *Nuurcala obesa* sp. n.

There are some taxa placed in other genera which show affinities to the *Nuurcala*. *N. obesa* sp. n. differs from *Rhipidoblattina hebeiensis* Hong, 1980 from the Middle Jurassic Jiulongshan Formation (Hong 1980) by the dark maculae at the edge of Sc area, different dark colouration position at forewing, and more A veins for the new species. The new species is closely similar to *Samaroblatta nitida* Lin, 1986, which

Table 1. Variability of number of veins in forewings for three species of *Nuurcala*.

Species	Number of veins in forewings					
	Sc	R	M	Cu	A	Total
<i>N. obesa</i>	1–3	12–15	4–9	8–10	14–19	42–55
<i>N. popovi</i>	3–5	16–25	8–17	12–17	15–21	54–83
<i>N. srneci</i>	±3	13–16	6–11	8–14	5–7	±44

has the same forewing type and the intercalaries, but differs in venation character and the dark maculae (Lin 1986). The veins of new species have more branches than *Samaroblatta rhypha* Lin, 1986 and *Summatiblatta colorata* Lin, 1986. The new species differs from *Soliblatta lampra* Lin, 1986 by the shape of forewing, the latter with a lance shaped forewing (Lin 1986). The new species differs from *Shartegoblattina colorata* Vršanský, 2005 from the Sharin-Gol in Mongolia by the characters as follows: the new species just has one dark maculae present at the edge of Sc area, but *S. colorata* Vršanský, 2005 with colouration dark along the fore margin, more pale in the distal part than the new species. The new species differs obviously from *Solemnia alexandri* Vršanský, 2008 from the Houtiyn-Hotgor Locality in Mongolia due to the latter forewings extremely elongated.

Yixian Formation is characterized by a high proportion of coloured species (Wang et al. 2007a, b, Wei et al. 2013). Dry habitats are rather characterized by monochromatic and pale cockroach individuals (Vršanský et al. 2009, Wei and Ren in press). The new taxon supports the notion that Yixian Formation was humid and moist.

The family Caloblattinidae, starting with its first occurrence in the Middle Triassic, was important in almost all known ecosystems and dominated from the earliest Jurassic up to the latest Early Cretaceous (Vršanský 2008b). It is enigmatic that the family Caloblattinidae was rare in the Yixian Formation. Only 4 species have been described so far (Ren et al. 1995, Hong 1983, and this study). This is in contrast to the fact that in nearly all Jurassic and Cretaceous localities, this family is dominant or co-dominant (Vršanský et al. 2002). The Cretaceous is the most dynamic period in the history of the order. The transition between the Jurassic and Cretaceous is characterised by the change in the dominant families, and by appearance of extant families in the fossil record. Caloblattinidae have been replaced by Blattellidae, Mesoblattinidae and, to a lesser extent, by Blattulidae as the dominant families (Vršanský et al. 2002). In the Yixian formation, Blattulidae were dominant, and their taxonomic analysis supports the Jurassic/Lower Cretaceous age (Wang et al. 2007a, b). During Upper Jurassic/Lower Cretaceous transition, Caloblattinidae are known mostly from the rich assemblages in Karatau, South Kazakhstan (Vishniakova 1968, 1973), and the less rich one in Argentina, Australia, Brazil, Burma, China, England, France, Germany, Greenland, Japan, Kazakhstan, Kirgizstan, Mongolia, Russia, Spain, Switzerland, and South Africa. Comparing climates of Yixian Formation and other regions, the warm and moist climate of Yixian Formation might have been more suitable for Blattulidae.

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Oribatid mites (Acari, Oribatida) from riverine environments of some islands in Oceania

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Abstract

A checklist of identified oribatid mite taxa from riverine freshwater environments from six islands in Polynesia (New Caledonia, Tahiti, Moorea, Rurutu, Tubuai, Raiatea) is presented; 18 species, 16 genera and eight families were recorded. *Trhypochthoniellus longisetus* (Berlese, 1904) and *Trimalaconothrus albulus* Hammer, 1972 prevailed on distribution. *Fortuynia smiti* **sp. n.** (Fortuyniidae) is described from New Caledonia. The new species is morphologically most similar to *Fortuynia marina* Hammen, 1960 from New Guinea, but it differs from the latter by the longer notogastral setae *dm*, *lm*, *c*₂, *p*₁, epimeral setae *3b* and adanal setae *ad*₁ and the presence of prodorsal lateral ridges.

Keywords

Oribatida, riverine environment, checklist, new species, *Fortuynia*, Oceania

Introduction

At present, the fauna of oribatid mites (Acari: Oribatida) of the Oceania islands (Australian region) is studied insufficiently (for example: Jacot 1924, 1934; Sellnick 1959; Hammer 1971, 1972, 1973; Mahunka 1982; Balogh and Balogh 1986; Schabetsberger et al. 2009).

Our research is based on total oribatid mite material, which was collected by Nathalie Mary and Harry Smit from rivers of six islands of the Pacific region: New Caledonia (Melanesia), Tahiti, Moorea, Rurutu, Tubuai, Raiatea (all Polynesia). The primary purpose of this paper is to present a checklist of identified taxa.

In the course of taxonomic identification we found a new species, belonging to the genus *Fortuynia* Hammen, 1960 (Ameronothroidea, Fortuyniidae). The secondary purpose of the paper is to describe and illustrate this species under the name *Fortuynia smiti* sp. n. The genus *Fortuynia* is proposed by Hammen (1960) with *Fortuynia marina* Hammen, 1960 as type species. Currently, it comprises 10 species and two subspecies, which collectively are distributed in the Pantropical and Subtropical regions (sensu Subías 2004, updated 2013). The generic characters of *Fortuynia* were presented by Hammen (1960) and also summarized by Balogh and Balogh (1992) and Bayartogtokh et al. (2009). The identification keys to species of the genus have been presented earlier by Luxton (1986), Marshall and Pugh (2002) and Bayartogtokh et al. (2009).

Materials and methods

The oribatid mite material was collected by Harry Smit and Nathalie Mary from several Pacific Islands. Smit's oribatid mite material: all samples are water samples, made with a dip net. Mary's oribatid mite material: all samples were taken with a surber net when sampled the benthos of the rivers and streams.

List of localities

Melanesia: New Caledonia

01: Marais de la Rivière Blanche, Parc de la Rivière Bleue, 26.IX.2000, collected by H. Smit.

02: Koné Rivière, 10 km east of Koné, 01.X.2000, collected by H. Smit.

Polynesia – Society Islands: Tahiti

03: Papeenu River, 25.VI. 2007, collected by N. Mary.

04: Vahiria River, 26.VI. 2007, collected by N. Mary.

05: Vaitepiha River, 27.VI. 2007, collected by N. Mary.

Polynesia – Society Islands: Moorea

06 Opunohu River, 24.VI. 2007, collected by N. Mary.

07: Vaihana River, 07.VII. 2007, collected by N. Mary.

08: Vaipapa River, 08.VII. 2007, collected by N. Mary.

09: Paopao River, 09.VII. 2007, collected by N. Mary.

Polynesia – Austral Islands: Rurutu

10: Vairee River, 30.VI. 2007, collected by N. Mary.

11: Te Vaavai River, 01.VII. 2007, collected by N. Mary.

12: Vaipapa River, 01.VII. 2007, collected by N. Mary.

13: Peva Iti River, 02.VII. 2007, collected by N. Mary.

Polynesia – Austral Islands: Tubuai

14: Vaitoaha River, 04.VII. 2007, collected by N. Mary.

15: Matarahu River, 04.VII. 2007, collected by N. Mary.

16: Hautara River, 05.VII. 2007, collected by N. Mary.

17: Taahuai River, 05.VII. 2007, collected by N. Mary.

18: Vaiapu River, 05.VII. 2007, collected by N. Mary.

Polynesia – Society Islands: Raiatea

19: Vaiatarau River, 11.VII. 2007, collected by N. Mary.

20: Apoomau River, 11.VII. 2007, collected by N. Mary.

21: Vaimariri River, 12.VII. 2007, collected by N. Mary.

All specimens were studied in lactic acid, mounted in temporary cavity slides for the duration of the study, and then stored in 70% alcohol in vials. Body measurements are presented in micrometers. The body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the ventral plate. Notogastral width refers to the maximum width in dorsal aspect. Lengths of body setae were measured in lateral aspect. Formula for leg setation are given in parentheses according to the sequence trochanter–femur–genu–tibia–tarsus (femulus included). Formula for leg solenidia are given in square brackets according to the sequence genu–tibia–tarsus. Terminology used in this paper mostly follows that summarized by Hammen (1960), Norton and Behan-Pelletier (2009).

Faunistic aspect

We recorded 18 species belonging to 16 genera and eight families. *Ceratozetes hamobatooides* Hammer, 1967 is a new record for Oceania (previously known from New Zealand), all other taxa were recorded in Oceania previously. *Trhypochthoniellus longisetus* (Berlese, 1904) and *Trimalaconothrus albulus* Hammer, 1972 prevailed on distribution (found in 19 localities on six and five islands, respectively). Also, *Hydrozetes lemnae* (Coggi, 1897) is registered from 11 localities (on five islands), *Schelorbates praeincisus* (Berlese, 1910) in six localities (on three islands). The majority of species (13 from 18) were found in 1–3 localities (Table 1). Comparing a previous investigation of oribatid

mites in freshwater on Pacific islands (Schabetsberger et al. 2009) three species found in lentic waters of Pacific islands are common with records of the present study (*Hydrozetes lemnae* – Fiji, *Nasozetes stunkardi* Sengbusch, 1957 – Fiji, *Trhypochthoniellus longisetus* – Samoa).

Description of new species

Fortuynia smiti Ermilov, Tolstikov, Mary & Schatz, sp. n.

urn:lsid:zoobank.org:act:7400FB31-6262-4525-A1A5-AD92C8696501

http://species-id.net/wiki/Fortuynia_smiti

Figs 1–13

Diagnosis. Body size 564–614 × 381–431. Body surface microfoveolate. Lamellar lines, internal and lateral ridges developed. Rostral setae weakly thickened, with short cilia; lamellar setae thin, slightly barbed. Interlamellar and exobothridial setae minute. Sensilli short, clavate, smooth. Notogaster with 14 pairs of setae and one pair of setal alveoli (c_3). Length of setae c_1 , $da > c_2$, dm , la , $lm > p_1 > lp$, $h_3 > dp$, h_1 , $h_2 > p_1$, p_2 . Adanal setae ad_1 longer than other adanal setae.

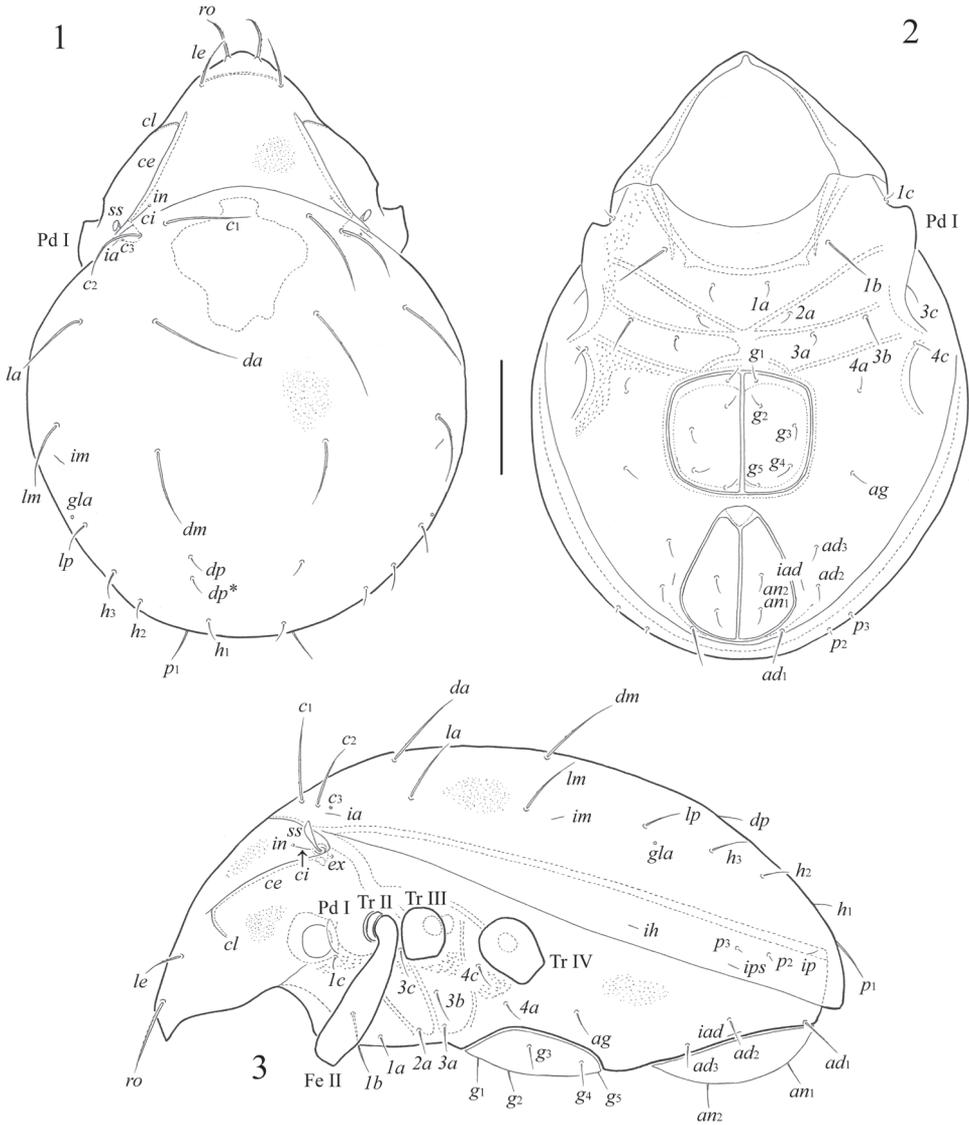
Description. Male. Measurements. Body length 581 (holotype, male), 564–614 (six paratypes, all males); body width 398 (holotype), 381–431 (six paratypes, all males).

Integument. Body color brown to yellow-brownish. Body surface microfoveolate (clearly visible under high magnification, ×1000). Lateral podosomal regions with tuberculate cerotegument (diameter of tubercles up to 6).

Prodorsum. Rostrum rounded. Lamellar lines (ce) strong, equal to half of prodorsum. Internal ridges (ci) present, very thin, reaching insertions of interlamellar setae. Anterior part of lamellar lines with short lateral ridges (cl), which are located perpendicularly to them. Rostral setae (ro , 69–82) setiform, weakly thickened, with short cilia, set on small tubercles. Lamellar setae (le , 41–45) setiform, thin, slightly barbed. Interlamellar (in) and exobothridial (ex) setae minute (1), poorly visible. Sensilli (ss , 32–36) curved backwards, with short stalk and longer clavate, smooth head.

Notogaster. Lenticulus present, with amorphic borders. Notogastral region with 14 pairs of setiform, smooth notogastral setae and one pair of setal alveoli (c_3). Setae c_1 , da (90–102) longer than c_2 , dm , la , lm (69–82), p_1 (30–36), lp , h_3 (28–32), dp , h_1 , h_2 (20–24); p_1 , p_2 shortest (4–6). Lyrifissures ia , im , ip , ih and ips and opisthonotal gland openings (gla) distinct, located typically for the genus.

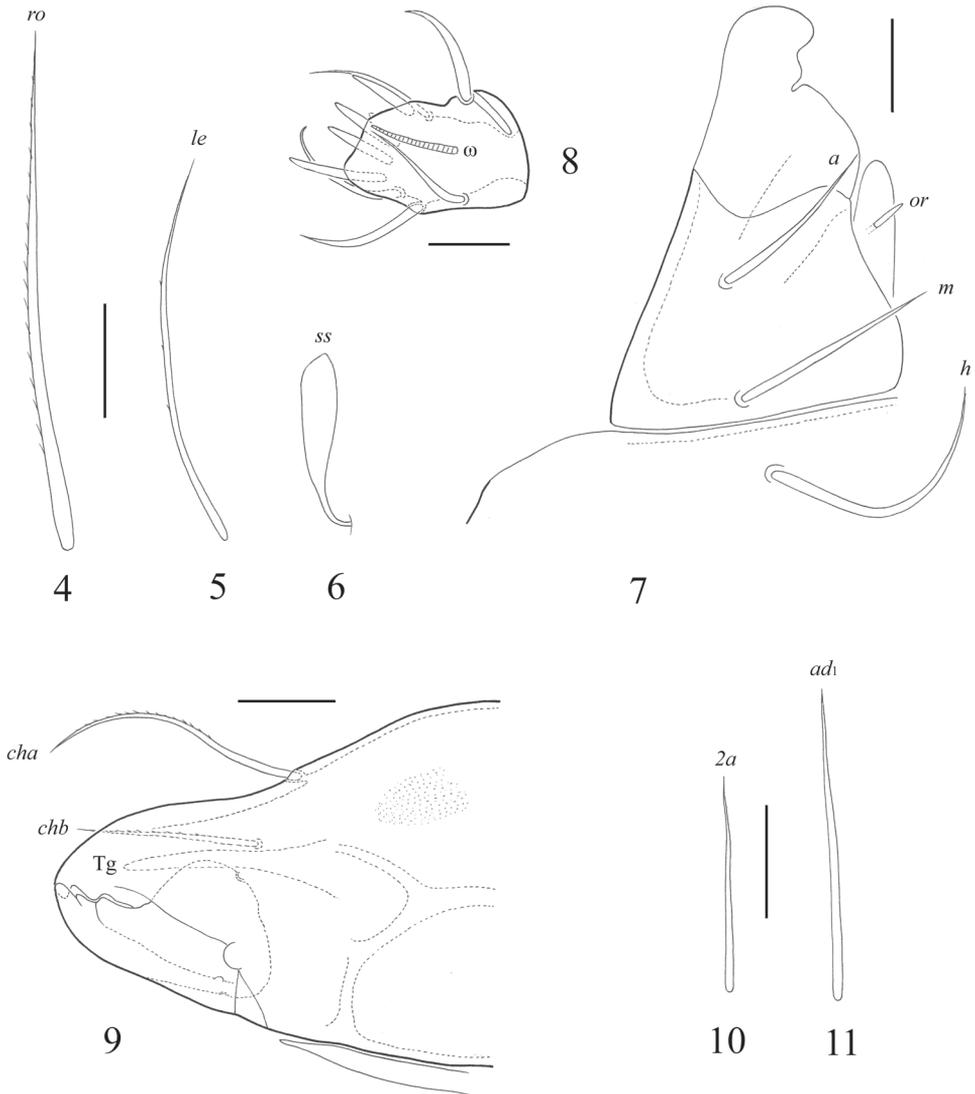
Gnathosoma. Subcapitulum longer than wide (118–205 × 143–151). Subcapitular setae setiform, smooth; h (82–86) longer than a and m (both 53–57). Lips only with one spiniform seta (or , 10–12). Palps (123–131) with setation 0–2–1–3–9(+ω). All setae smooth. Solenidion weakly thickened, blunt-ended, pressed to surface of tarsus, not attached with eupathidium. Chelicerae (188–205) with two barbed setae; cha (69–73) longer than chb (45–49). Trägårdh's organ (Tg) long, conical.



Figures 1–3. *Fortuynia smiti* sp. n., adult: **1** dorsal view **2** ventral view (gnathosoma and legs not illustrated) **3** lateral view (gnathosoma and legs except femur II and trochanters II–IV not illustrated). Scale bar 100 μ m.

Epimeral and lateral podosomal regions. Apodemes 1, 2, 3 and sejugal well developed. Apodemes 2 and sejugal fused medially. Epimeral setal formula 3–1–3–2; setae setiform, smooth. Setae *1b* (49–61) longer than *3b* (41–49), *1a*, *2a*, *3a*, *3c*, *4a*, *4c* (24–36); *1c* shortest (16–20). Pedotecta I (Pd I) of medium size, concave.

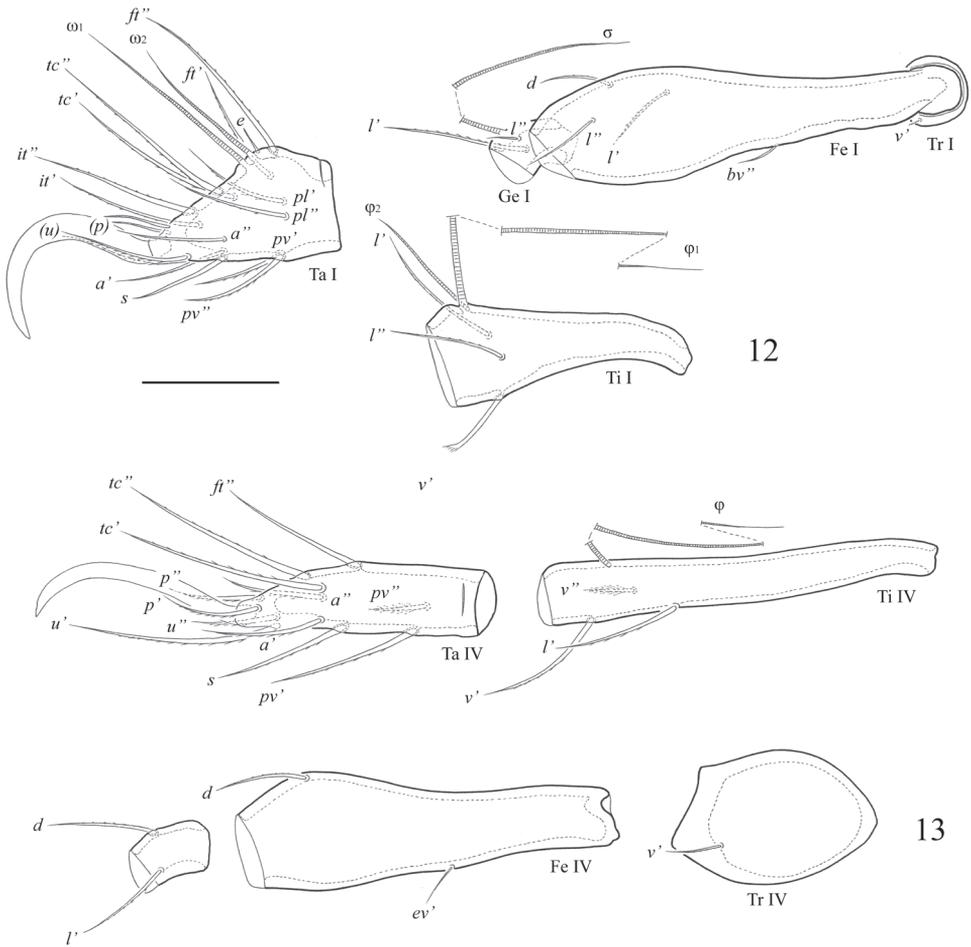
Anogenital region. Anogenital setae setiform, thin, smooth. Five pairs of genital (g_1 – g_5), one pair of aggenital (*ag*), two pairs of anal (an_1 , an_2) and the anterior two pairs



Figures 4–11. *Fortuynia smiti* sp. n., adult: **4** rostral seta **5** lamellar seta **6** sensillus **7** subcapitulum, right half of anterior part, ventro-lateral view **8** palptarsus **9** chelicera, anterior part **10** epimeral seta **2a** **11** adanal setae ad_1 . Scale bar (4–7, 9–11) 20 μm , (8) 10 μm .

of adanal (ad_2 , ad_3) setae similar in length (28–32); only the first pair of adanal setae ad_1 longer (41–53). Lyrifissures iad located in paraanal position.

Legs. Claw of each leg large, smooth. Porose areas developed typically for the genus (Bayartogtokh et al. (2009). Formulae of leg setation and solenidia: I (1–4–2–3–18) [1–2–2], II (1–4–2–3–15) [1–1–2], III (2–3–1–3–15) [1–1–0], IV (1–2–2–3–12) [0–1–0]; homology of setae and solenidia indicated in Table 2. Setae setiform, well or



Figures 12–13. *Fortuynia smiti* sp. n., adult: **12** segments of leg I, left, antiaxial view **13** segments of leg IV, right, antiaxial view. Scale bar 50 μ m.

slightly barbed except smooth *p* on tarsi I, II and *s*. Famulus (*e*) short, straight, weakly blunt-ended. All solenidia long setiform, pointed.

Material examined. Holotype (male) and six paratypes (all males): Locality 02.

Type deposition. The holotype (in alcohol) is deposited in the collection of the Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia; two paratypes (in alcohol) are deposited in the collection of the Siberian Zoological Museum, Novosibirsk, Russia; four paratypes (in alcohol) are deposited in the collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

Etymology. The species is named after our colleague, the renowned acarologist, Dr. Harry Smit (Netherlands Centre for Biodiversity Naturalis, Leiden, The Netherlands), who has collected the specimens of *Fortuynia smiti* sp. n.

Table 2. Leg setation and solenidia of adult *Fortuynia smiti* sp. n.

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	v'	$d, (l), bv''$	$(l), \sigma$	$(l), v', \varphi_1, \varphi_2$	$(ft), (tc), (it), (p), (u), (a), s, (pv), (pl), e, \omega_1, \omega_2$
II	v'	$d, (l), bv''$	$(l), \sigma$	$(l), v', \varphi$	$(ft), (tc), (it), (p), (u), (a), s, (pv), \omega_1, \omega_2$
III	l', v'	d, l', ev'	l', σ	$l', (v), \varphi$	$(ft), (tc), (it), (p), (u), (a), s, (pv)$
IV	v'	d, ev'	d, l'	$l', (v), \varphi$	$ft'', (tc), (p), (u), (a), s, (pv)$

Roman letters refer to normal setae (e to famulus), Greek letters to solenidia. Single prime (') marks setae on anterior and double prime (") setae on posterior side of the given leg segment. Parentheses refer to a pseudosymmetrical pair of setae.

Comparison. *Fortuynia smiti* sp. n. is most similar to *Fortuynia marina* Hammen, 1960 from New Guinea (Hammen 1960) in having following combination of morphological characters: body of medium size; presence of lamellar lines and internal ridges; presence of alveoli notogastral setae c_3 . However it differs from the latter by the long notogastral setae dm, lm, c_2, p_1 , epimeral setae $3b$ and adanal setae ad_1 (versus short in *F. marina*) and the presence of prodorsal lateral ridges (versus absent in *F. marina*).

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Echinophyllia tarae sp. n. (Cnidaria, Anthozoa, Scleractinia), a new reef coral species from the Gambier Islands, French Polynesia

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Abstract

A new shallow water scleractinian coral species, *Echinophyllia tarae* sp. n., is described from the Gambier Islands, French Polynesia. It is characterized by an encrusting corallum, a few large and highly variable corallites with protruding walls, and distinctive costosepta. This coral was observed in muddy environments where several colonies showed partial mortality and re-growth. The new species has morphological affinities with both *E. echinata* and with *Echinomorpha nishibirai*, from which it can be distinguished on the basis of the diameter and the protrusion of the largest corallite, the thickness of the septa, and the development of the size of the crown of paliform lobes.

Keywords

Lobophylliidae, *Echinophyllia echinata*, *Echinomorpha nishibirai*, Tara Oceans Expedition

Introduction

At present, *Echinophyllia* Klunzinger, 1879 is known to include eight extant zooxanthellate species (Veron and Pichon 1980, Veron 2000, 2002), namely *E. aspera* (Ellis & Solander, 1786), the type species, *E. echinata* (Saville-Kent, 1871), *E. orpheensis* Veron & Pichon, 1980, *E. echinoporoides* Veron & Pichon, 1980, *E. patula* (Hodgson & Ross, 1982), *E. costata* Fenner & Veron, 2000, *E. pectinata* Veron, 2000, and *E. taylorae* (Veron, 2000). The genus used to be part of the family Pectiniidae Vaughan & Wells, 1943 together with *Pectinia* Blainville, 1825, *Mycedium* Milne Edwards & Haime, 1851, and *Oxypora* Saville-Kent, 1871. Based on molecular results by Fukami et al. (2008), Dai and Horng (2009) moved *Echinophyllia* and *Oxypora* to the family Lobophylliidae Dai & Horng 2009, and Budd et al. (2012) placed the remainder of the Pectiniidae in the Merulinidae Verrill, 1866. To date, the most detailed and updated overview of morphologic characters of *Echinophyllia* including micro-morphology is provided by Budd et al. (2012). However, species level morpho-molecular investigations of species boundaries and phylogenetic relationships for *Echinophyllia* have not been performed, and so far the genus has never been formally revised.

Presently, *Echinophyllia* is known to occur in the Indo-Pacific, from the seas around Arabia (Sheppard and Sheppard 1991, Pichon et al. 2010, Riegl et al. 2012), the Indian Ocean (Obura 2012) and the western and central Pacific Ocean (Chevalier 1971, Veron and Pichon 1980, Best et al. 1989, Veron 2000, Hoeksema and van Ofwegen 2004) to French Polynesia in the east, including the Society, Tuamotu, Austral and Gambier Islands (Pichon 1985, Glynn et al. 2007).

The remote and relatively poorly studied Gambier Islands are found at the southeast end of the vast French Polynesian territory (Figure 1a, b). The actual islands were once all part of the same volcano, which in time has almost completely drowned (Brousse et al. 1974). Today, they are found in a lagoon approximately 35 km long (north to south) and 30 km wide (west to east) delimited by a continuous reef, which emerges at low tide in the north and is submerged in the south (Brousse et al. 1974, Chevalier et al. 1974) (Figure 1c). The current knowledge of reef-dwelling corals from the Gambier Archipelago is based on the studies carried out in the mid-seventies by Chevalier (1974), who published a preliminary list including 60 species of zooxanthellate and azooxanthellate scleractinians. Since then, no further studies were carried out on the coral fauna of the islands until the Tara Oceans scientific Expedition with MV Tara (Karsenti et al. 2011) allowed sampling of 24 sites between June and July 2011, which also resulted in an update on the local mushroom coral fauna (Hoeksema and Benzoni 2013).

With regard to *Echinophyllia* species, Chevalier (1974) only reported on the presence of *E. aspera*. According to him this species is typical of fringing reefs around the main islands in the large lagoon. During the recent Tara Oceans Expedition the presence of *Echinophyllia aspera* was actually not recorded. However, another *Echinophyllia* species, morphologically different from others already known, was commonly observed at the fringing reefs and lagoon pinnacles of the Gambier Islands. The species is here described as *Echinophyllia tarae* sp. n. and its similarities with its congeners as well as *Echinomorpha nishihirai* (Veron, 1990) are discussed.

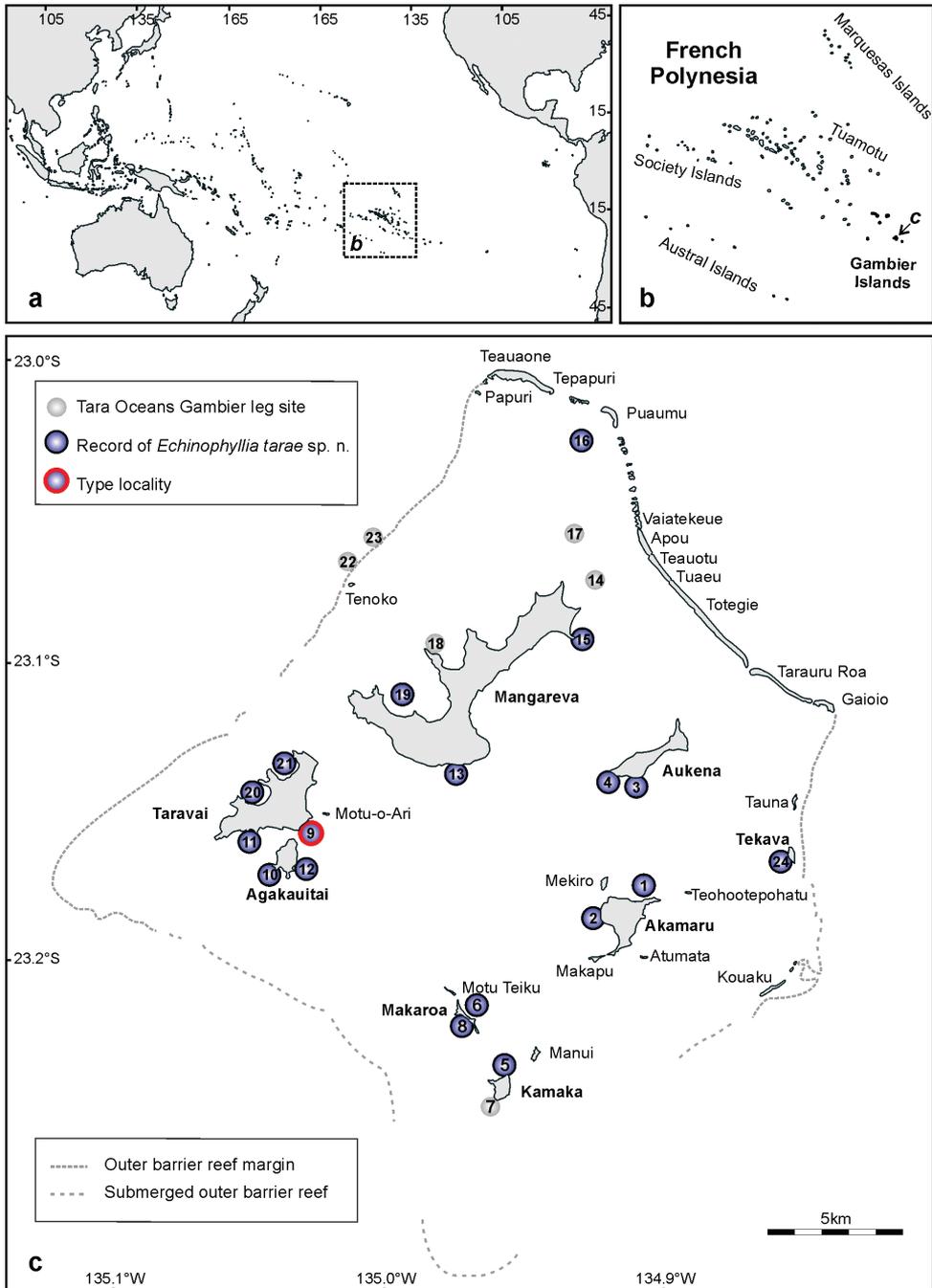


Figure 1. Map of **a** the Pacific Ocean, showing the position of French Polynesia **b** the island groups belonging to French Polynesia, and **c** the study area in the Gambier Archipelago showing the 24 sampling sites of the Tara Oceans leg and the sites where *Echinophyllia tarae* sp. n. was found. Stippled rectangle in **a** shows the position of the map shown in **b**. Arrow in **b** shows the position of the Gambier Archipelago shown in **c**.

Methods

A reference collection of Scleractinia was sampled in the Gambier, including coral skeletons and tissues fixed for DNA, after *in situ* photographs were taken. The collection contained five specimens of *Echinophyllia tarae* sp. n. Sampling took place during SCUBA diving at different sites around the islands of Taravai, Akamaru, and Makaroa (Figure 1). Digital images of living corals in the field were taken with a Canon G9 in an Ikelite underwater housing system. Coral specimens were collected, tagged, and for each specimen a fragment of 1 cm² was broken off the colony and preserved in CHAOS solution for further molecular analysis. The remaining corallum was placed for 48 hours in sodium hypochlorite to remove all soft parts, rinsed in freshwater and dried for microscopic studies. Images of coral skeletons were taken with a Canon G9 digital camera and through a Leica M80 microscope equipped with a Leica IC80HD camera. For high resolution and deep field close ups of three-dimensional details of corallites and septa, a series of images of the same subject at different focus intervals were taken (approximately 10) and the images were fused using the Helicon Focus 5.3 software (Kozub et al. 2000–2012).

A total of 24 sites was surveyed (Table 2). Each site position was recorded with a Garmin eTrex GPS. At each site all coral species encountered in a 1 hour SCUBA dive were recorded and data were included into a geo-referenced database. At least two images per specimen were taken underwater, one of the complete colony and one close-up. Digital images were then analyzed to verify underwater preliminary records and species presence records were used to produce a species per site matrix. Data on the occurrence of *E. tarae* sp. n. in the field in the different sites was extracted from this species per site database.

The holotype was deposited at Museum National d’Histoire Naturelle (MNHN) in Paris, the other four specimens are at the University of Milano-Bicocca (UNIMIB) coral facility together with the rest of the Tara Oceans Expedition collection (186 specimens), which will ultimately be housed at the MNHN once their study is completed. Specimens of other *Echinophyllia* species were examined at the Museum of Tropical Queensland (MTQ), Townsville, Australia, and at the Institut de Recherche pour le Développement (IRD), Nouméa, New Caledonia.

Systematic section

Order Scleractinia Bourne, 1905

Family Lobophylliidae Dai and Horng, 2009

Genus *Echinophyllia* Klunzinger, 1879

Type species (by monotypy). *Madrepora aspera* Ellis & Solander, 1786.

***Echinophyllia tarae* sp. n.**

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http://species-id.net/wiki/Echinophyllia_tarae

Figures 2–8, 9a, b, 10b, d

Material examined. Holotype: MNHN-IK.2012-8000 (Figures 2–4). Type Locality: Taravai Island, Gambier, French Polynesia (MV Tara, Tara Oceans Expedition, Site 9), 23°9.404'N; 135°1.769'E, 10 m, 30 June 2011, coll. F. Benzoni.

Corallum: The holotype is a knob-shaped, plocoid, encrusting colony attached to a fragment of a dead tabular *Acropora* coral (Figure 2). The specimen is 9.2 cm high, and 8.5 x 5 cm wide at the base in its original growth position.

Corallites: The 12 corallites are oval in shape and variable in size (Figure 2, 3), ranging from 3.3 cm in diameter (C1 in Figure 2, 3a) to 1.0 cm. Corallites are organically united (see terminology in Budd et al. 2012). The central position of C1 (the largest corallite) is less obvious in the holotypes due to its knob-shaped growth form. Corallites protrude up to 1 cm and are directed in different directions (Figure 2). Corallite wall is septothecal.

Costosepta: Variable in number depending on the size of the corallite (Figure 3a–d), exsert and thickened over the theca. The largest corallite contains 26 septa arranged in five orders (Figure 3a). Septa of the first three orders are thicker than the others. Septal teeth are elliptical in outline, large and high (> 0.6 mm) according to the parameters defined by Budd et al. (2012) (Figure 3a–d), and their tips are irregular bulbous. Tooth spacing is very high (> 2 mm). Septal side granulation is weak. Paliform lobes (see Benzoni et al. 2011 for a definition) thick and well developed, forming an obvious crown around the columella, which was also visible *in vivo*. Paliform lobes always present and of similar size at the proximal margin of the first two orders of septa (Figures 3a–d). In larger corallites, in which more than four orders are present, they can also form in front of the third order but then they are of smaller dimensions (Figure 3b). The costal parts of the costosepta are thick and unequal. They are strongly ornamented by triangular shaped teeth (Figure 3e, f), which bear fine granules on the tip (Figure 3f). Exothecal alveoli are present at the insertion of lower order costae (Figure 3e). Costae cover the whole surface of the coenosteum between corallites.

Columella: Well developed, deep in the fossa (Figure 3b) made by a mesh of twisted intermingled processes derived from the inner end of the higher order septa: the first two in smaller corallites (Figure 3a–d), and up to the fourth order in larger corallites (Figure 10b–d).

Colour: The living colony was mottled brown. Tips of septa and costae ornamentation varied from light beige to white.

Other material (Gambier, French Polynesia, Tara Oceans Expedition): UNIMIB TO-GA028, Akamaru Island (Site 2), 23°11.082'N; 134°54.331'E, 26 June 2011, coll. F. Benzoni; UNIMIB TO-GA071 Makaroa Island (Site 6), 23°12.960'N; 134°57.991'E, 28 June 2011, coll. F. Benzoni; UNIMIB TO-GA099

Table 1. Dimensions of the examined specimens of *Echinophyllia tarae* sp. n.. For each specimen the total number (n.) of corallites, the maximum and minimum diameter of the largest and smallest corallite in the colony, the number of septa, and of paliform lobes is listed. LC = largest corallite; SC smallest corallite.

Specimen code	n. of corallites	Diam. LC max-min: (cm)	Diam. SC max-min: (cm)	n. of septa LC	n. of paliform lobes LC
MNHN-IK.2012–8000	12	3.3 – 2.0	1.0 – 0.9	26	11
UNIMIB TO-GA028	4	3.1 – 2.4	1.1 – 0.9	39	14
UNIMIB TO-GA071	4	2.3 – 2.1	1.0 – 0.9	34	8
UNIMIB TO-GA084	4	3.2 – 2.4	1.9 – 1.8	29	11
UNIMIB TO-GA099	3	3.5 – 3.0	1.2 – 1.0	52	24

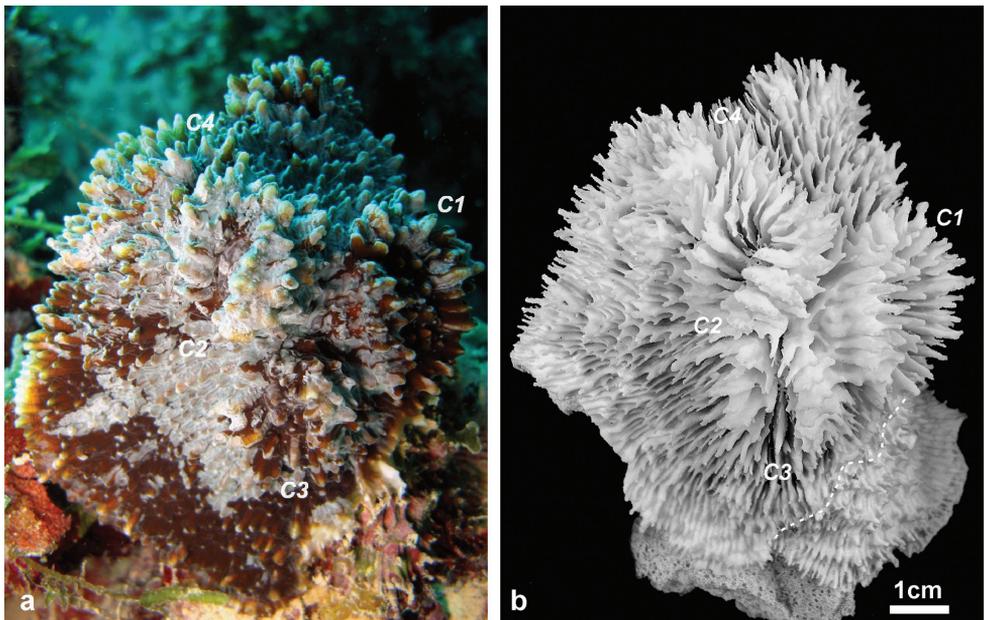


Figure 2. Holotype of *Echinophyllia tarae* sp. n. (MNHN-IK.2012–8000) **a** the colony *in situ* before collection, and **b** the corallum after removal of the animal tissues. C1 to 4 indicate the position of same corallite (C) in the two images. Numbers are assigned in decreasing order of corallite size, C1 being the largest. Stippled line on the specimen in **b** shows the boundary of living tissue at the time of collection.

Taravai Island (Site 11), 23°9.540'N; 135°3.055'E, 1 July 2011, coll. F. Benzoni; UNIMIB TO-GA186 Taravai Island (Site 9), 23°9.404'N; 135°1.769'E, 30 June 2011, coll. F. Benzoni.

Variation of skeletal structures: Colony size is relatively small (Figures 2–8), the largest colony is 20 cm wide (Figure 6f). Corallum generally encrusting, its plane following the surface of the underlying substrate (Figures 4b, d, e) but also knob-like (Figures 4a, c) with foliose margins where they become detached from the substrate. The number of corallites per colony is low, ranging from 1 to 15. A large, central primary corallite is always present (Figures 2, 6a, b). Secondary corallites

Table 2. Occurrence of *Echinophyllia tarae* sp. n. encountered during the Tara Oceans Expedition in the Gambier Islands. For each site the site code (as in Figure 1), island name and reef type, coordinates, sampling date, and recorded presence or absence of the species are listed.

Site	Island, reef type	Latitude	Longitude	Date	<i>E. tarae</i> sp. n.
1	Akamaru, fringing reef	23°10.61'S	134°54.37'W	26/06/11	recorded
2	Akamaru, fringing reef	23°11.08'S	134°55.33'W	26/06/11	recorded
3	Aukena, fringing reef	23°08.44'S	134°55.18'W	27/06/11	recorded
4	Aukena, fringing reef	23°08.56'S	134°54.74'W	27/06/11	recorded
5	Kamaka, fringing reef	23°14.19'S	134°57.47'W	28/06/11	recorded
6	Makaroa, fringing reef	23°12.96'S	134°57.99'W	28/06/11	recorded
7	Kamaka, fringing reef	23°14.98'S	134°57.80'W	29/06/11	not recorded
8	Makaroa, fringing reef	23°13.32'S	134°58.34'W	29/06/11	recorded
9	Taravai, fringing reef	23°09.40'S	135°01.77'W	30/06/11	recorded
10	Agakautai, fringing reef	23°10.17'S	135°02.52'W	30/06/11	recorded
11	Taravai, fringing reef	23°09.54'S	135°03.05'W	01/07/11	recorded
12	Agakautai, fringing reef	23°10.35'S	135°01.99'W	01/07/11	recorded
13	Mangareva, fringing reef	23°08.25'S	134°57.11'W	02/07/11	recorded
14	Mangareva/Totegie	23°04.78'S	134°54.99'W	04/07/11	not recorded
15	Mangareva, fringing reef	23°05.45'S	134°55.69'W	04/07/11	recorded
16	Lagoon pinnacles	23°01.55'S	134°55.69'W	05/07/11	recorded
17	Lagoon pinnacles	23°04.12'S	134°55.83'W	05/07/11	not recorded
18	Mangareva, fringing reef	23°05.57'S	134°59.16'W	07/07/11	not recorded
19	Mangareva, fringing reef	23°06.14'S	134°59.23'W	07/07/11	recorded
20	Taravai, fringing reef	23°08.72'S	135°03.09'W	08/07/11	recorded
21	Taravai, fringing reef	23°08.03'S	135°02.14'W	08/07/11	recorded
22	outer barrier north	23°04.21'S	135°00.85'W	09/07/11	not recorded
23	outer barrier north	23°03.79'S	135°00.49'W	09/07/11	not recorded
24	Tekava, fringing reef	23°10.13'S	134°51.51'W	10/07/11	recorded

are often inclined in various directions and show variable diameter sizes within the same colony (Figures 5a–e, Table 1). The largest corallite observed (specimen UNIMIB TO-GA099, Figure 4d) is 3.5 cm in diameter, the smallest, in the same specimen, 0.9 mm (Figure 5e). The numbers of septa, orders of septa, and paliform lobes vary between and within colonies. First order septa always thicker than the others and in some cases up to 4 mm thick (Figure 5f). Columella always present, large and oval in the largest corallite, less developed in smaller corallites. Costae typically thick, alternating in size (Figure 5c, d) and strongly dentate, although variably so between specimens.

Field characteristics and colouration: The colouration is showing much variation, ranging from dark brown (Figures 7a–c, e), to mottled brown (Figures 2a, 7f), beige (Figures 6e, f), and bright green (Figures 6c, 7d). The tissue on the tips of septal teeth and costal spines teeth can be lighter in colour (Figure 6c) or white (Figure 7c), possibly as a result of tissue being less thick above these structures. In very mottled colonies (Figure 7f) or with lighter colouration of the tissue over costoseptal teeth (Figure 7b)

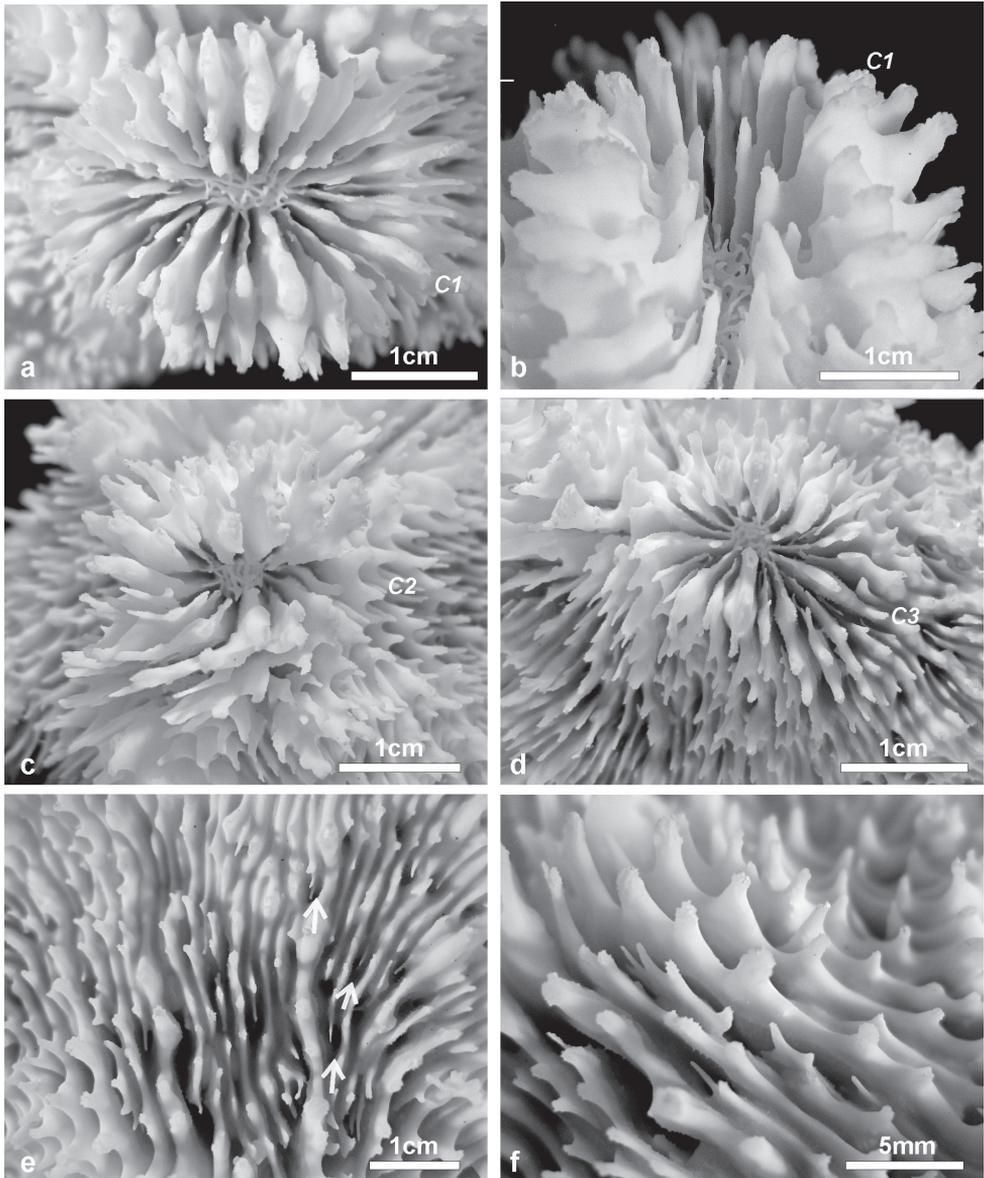


Figure 3. Details of corallites, septa, and costae in the holotype of *Echinophyllia tarae* sp. n. (MNHN-IK.2012–8000) **a** top view of the largest corallite in the colony, **b** lateral view of the same corallite shown in **a**, **c** top view of the second largest corallite, and **d** of the third **e** top and **f** side view of the costae. C1 to 3 indicate the corallites as shown in Figure 2. White arrows in **e** indicate the position of exothecal alveoli at the insertion of costae.

the size and shape of the corallites may be hard to detect. The crown of paliform lobes is always prominent (Figure 5) and often obvious, especially in the largest corallite (Figures 6, 7b).

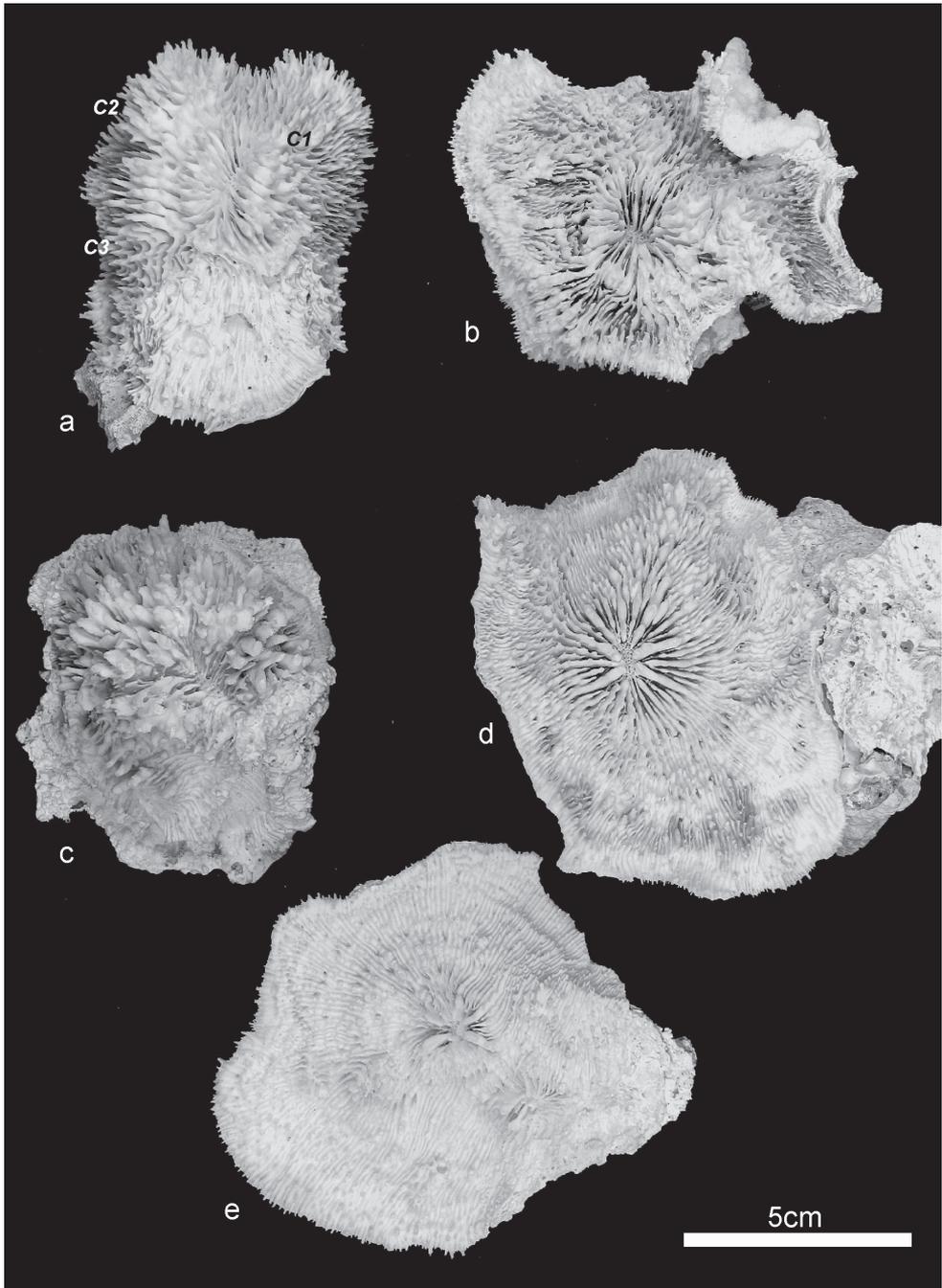


Figure 4. Specimens of *Echinophyllia tarae* sp. n. collected for this study **a** side view of the holotype (MNHN-IK.2012-8000) **b** specimen UNIMIB TO-GA028 **c** specimen UNIMIB TO-GA186 **d** specimen UNIMIB TO-GA099 **e** specimen UNIMIB TO-GA071. C1 to 3 indicate the holotype corallites as shown in Figures 1 and 2.

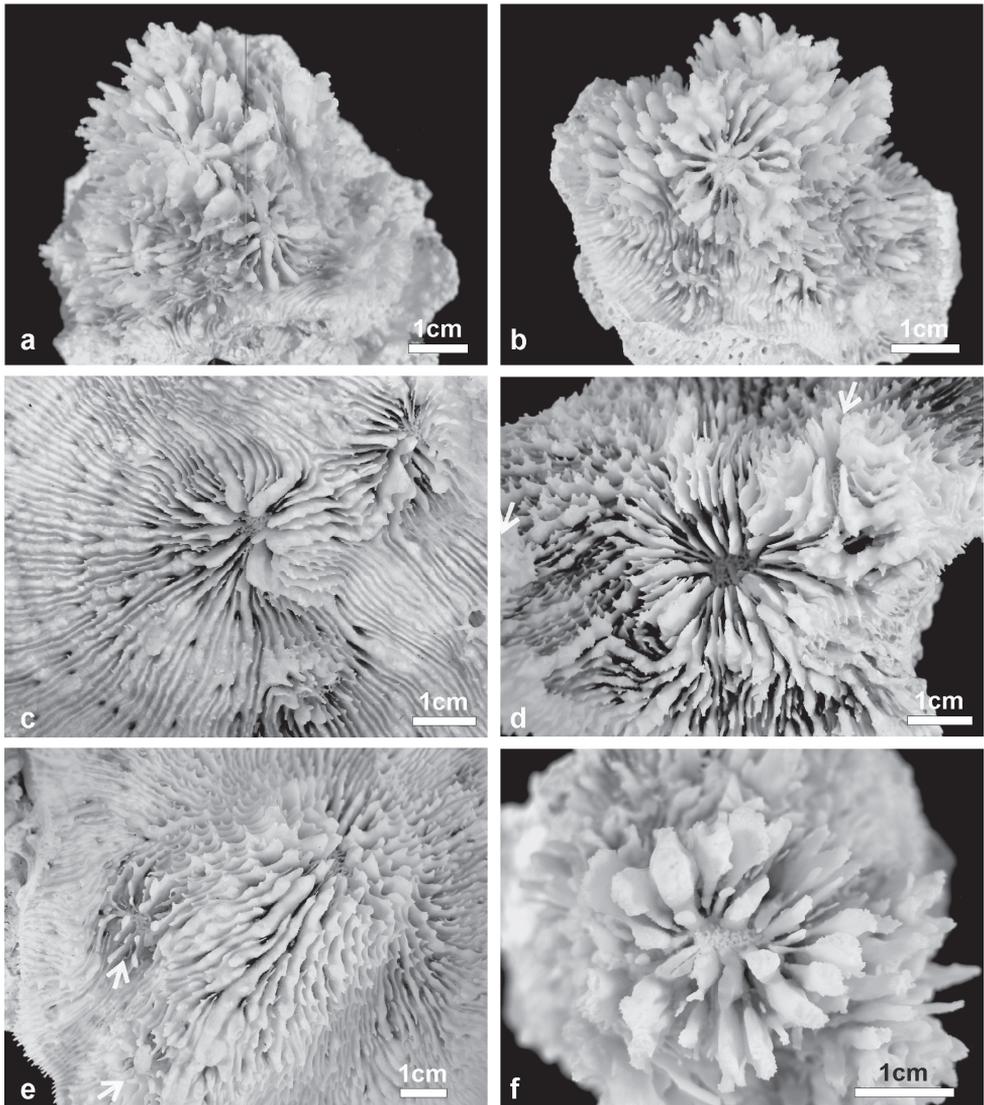


Figure 5. Variation in shape and size of the corallites of *Echinophyllia tarae* sp. n. **a** and **b** two lateral views of specimen UNIMIB TO-GA186 **c** specimen UNIMIB TO-GA071 **d** UNIMIB TO-GA028 **e** specimen UNIMIB TO-GA099 **f** close up-of a corallite of the same specimen as in **a** and **b**. White arrows in **e** indicate the position of secondary corallites.

Ecology: *Echinophyllia tarae* sp. n. inhabits protected reef habitats and was observed between 5 and 20 m depth. It commonly grows on dead coral fragments, usually parts of branching or tabular *Acropora* colonies, which are covered by crustose coralline algae and fleshy macroalgae (Figures 6–7). This species can grow on well-illuminated surfaces but also encrusts shaded underhangs. In well-lit conditions the appearance is

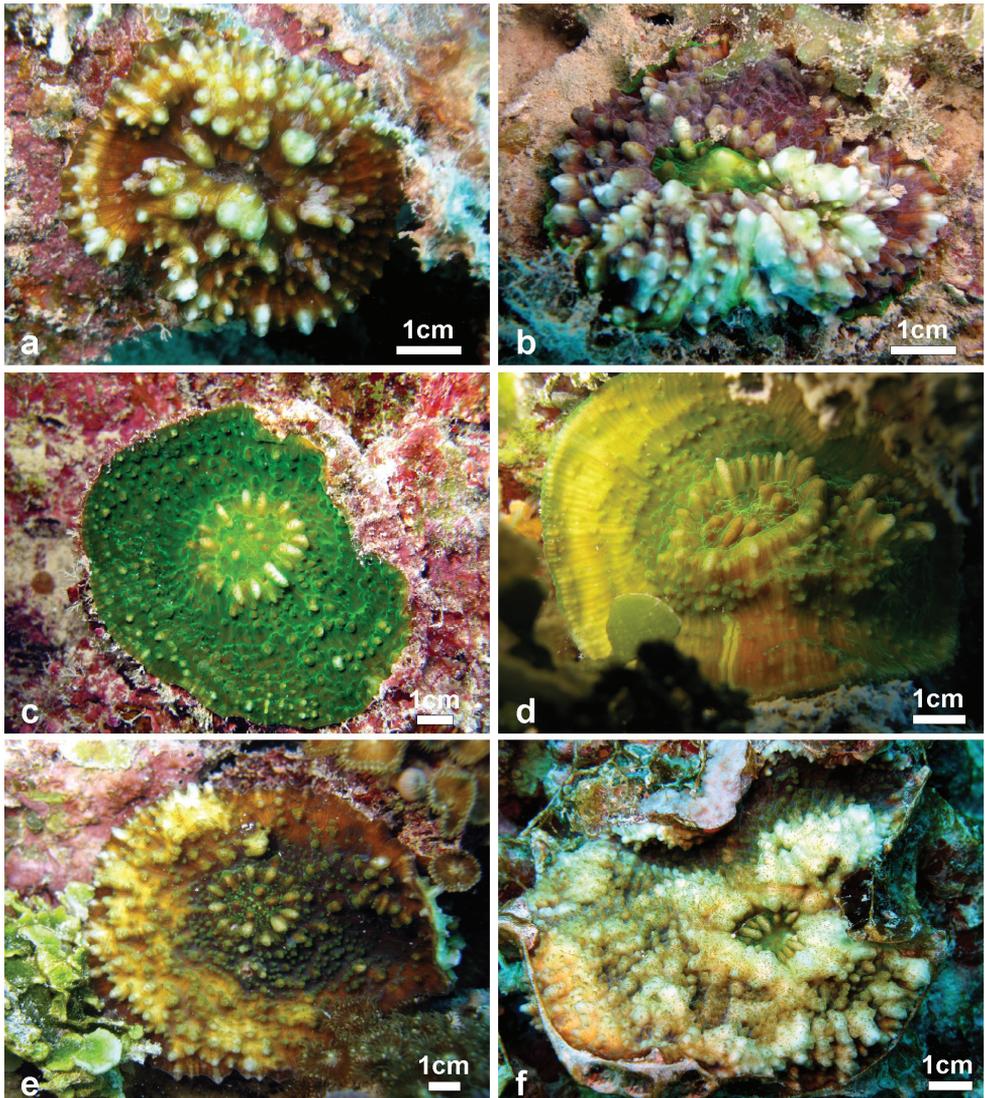


Figure 6. Variation of corallum shape, costosepta ornamentation, and colouration in smaller colonies of *Echinophyllia tarae* sp. n. observed *in situ* **a** young one polyp brown coloured specimen settled on crustose coralline algae, Mangareva Island (Site 15) **b** a dark brown two polyp colony with green oral discs, Taravai Island (Site 21) **c** one polyp bright green specimen with a large raised central corallite in which the crown of pali is clearly visible and spiky and well developed costae, Makarao Island (Site 6) **d** a light green colony with two raised polyps in central position, well developed crown of pali and costae ornamentation smoothening towards the colony periphery, northern lagoon pinnacles (Site 16) **e** brown colony with one raised polyps in central position and markedly teathed costae, Mangareva Island (Site 13) **f** *in situ* image of specimen UNIMIB TO-GA028 (Figures 4b, 5d) showing the irregularly shaped colony with a very rugged and almost inflated appearance, Akamaru Island (Site 2). Sites are indicated in Figure 1.

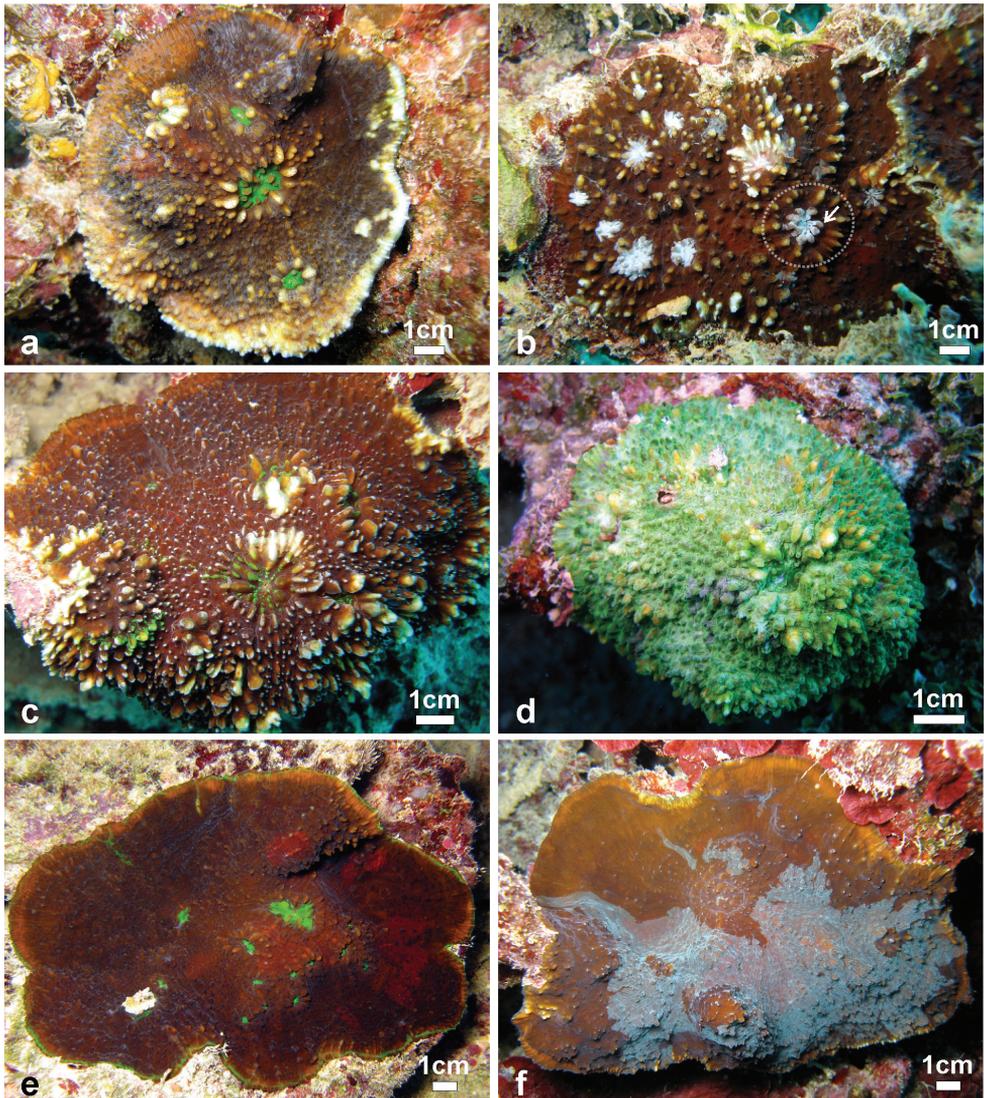


Figure 7. Variation of shape, spikiness of septa and costae, and colouration of large colonies *Echinophyllia tarae* sp. n. observed *in situ* **a** brown encrusting colony with free margins, bright green oral discs and raised corallites, Akamaru Island (Site 2) **b** brown encrusting colony with white oral discs, raised corallites (larger one in the stippled circle), and very spiky costae, Taravai Island (Site 9 – type locality), the prominent crown of paliform lobes of the largest corallite is indicated by the white arrow **c** brown knob shaped colony with bright green oral discs and raised corallites, note the white colouration of the tips of costae teeth, Taravai Island (Site 9 – type locality) **d** a bright green knob shaped colony, Taravai Island (Site 9 – type locality) **e** brown encrusting colony with bright green oral discs and relatively low-lying corallites, note the uniform colouration of the costae, Taravai Island (Site 9 – type locality) **f** mottled brown encrusting colony with free margins and relatively low-lying corallites, note the uniform colouration of the costae, Taravai Island (Site 9 – type locality). Sites are indicated in Figure 1.

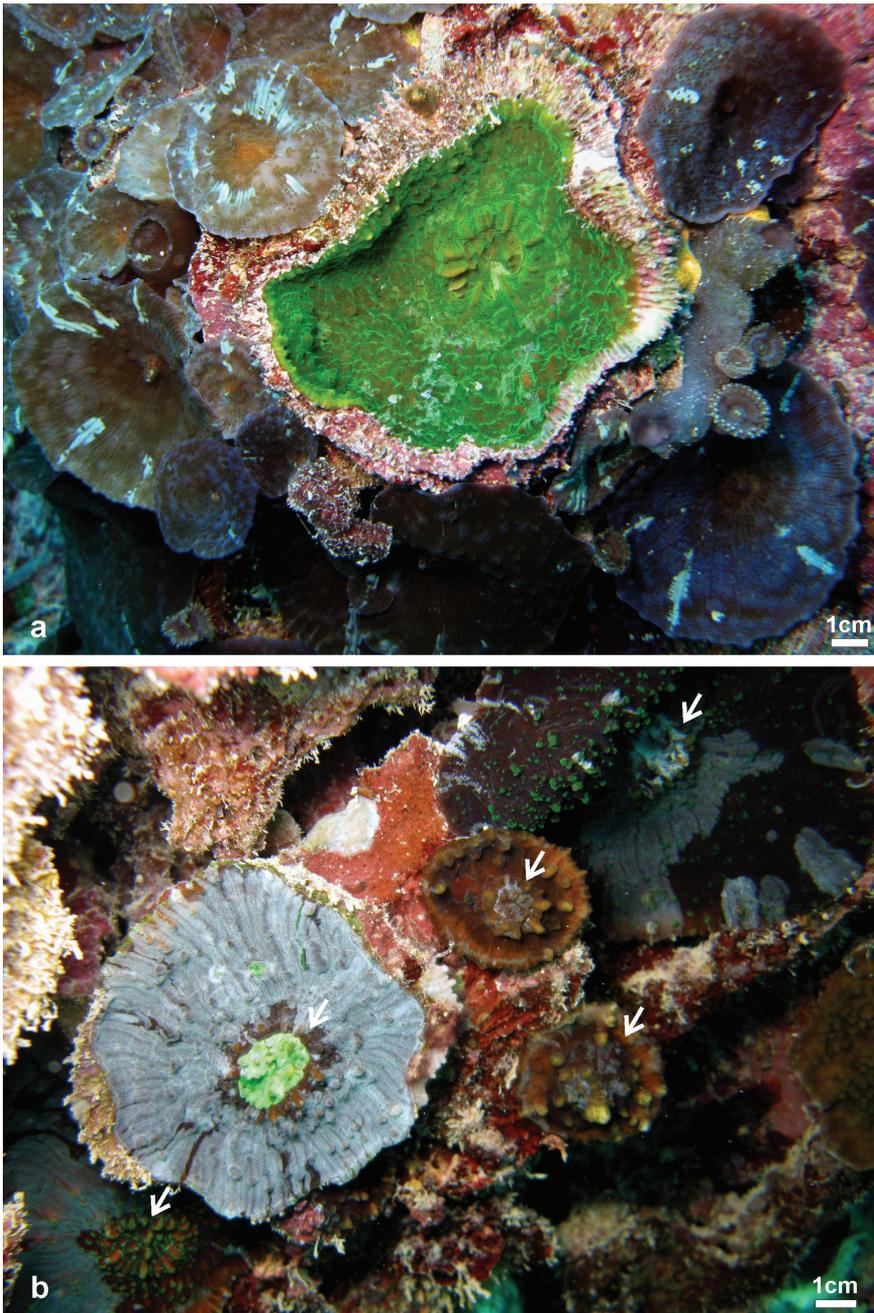


Figure 8. Frequently observed patterns of partial death and re-growth of *Echinophyllia tarae* sp. n. in the field **a** concave colony with a large central corallite showing a peripheral rim of skeleton encrusted by pink coralline algae and surrounded by zoanthids and corallimorpharians, Mangareva Island (Site 19) **b** a similar situation as in **a** but with re-growth occurring over previously dead colonies, note the variation of colouration in adjacent corals, Taravai Island (Site 11). White arrows in **b** indicate the position of larger central corallites. Sites are indicated in Figure 1.

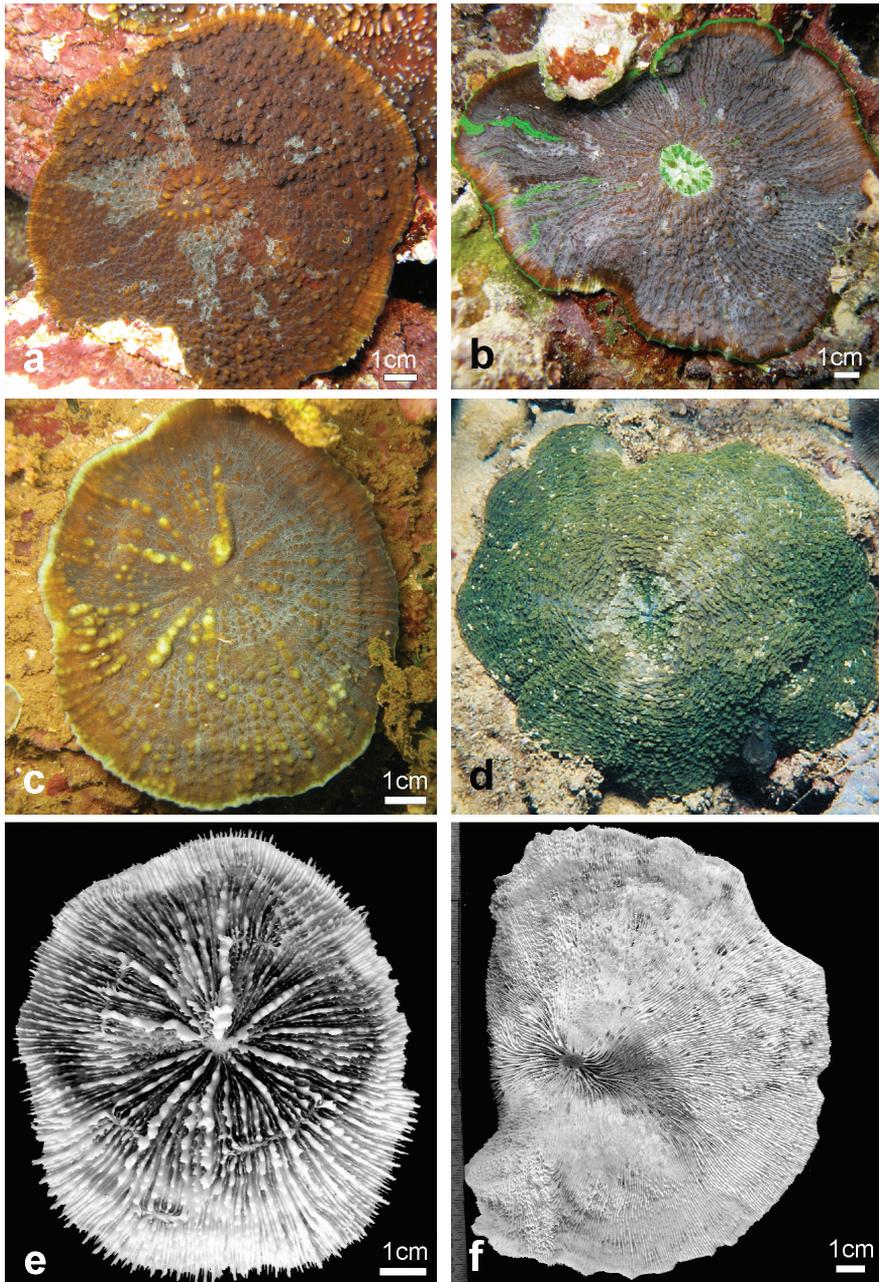


Figure 9. Comparison of *in situ* morphology between specimens of *Echinophyllia tarae* sp. n., *E. echinata*, and *Echinomorpha nishibirai* and corallum morphology of the latter two **a** *E. tarae* sp. n. resembling *E. echinata*, Agakaitai Island (Site 10) **b** another colony of the new species resembling *E. nishibirai*, Taravai Island (Site 11) **c** *E. echinata* from Cap Bocage, New Caledonia (IRD HS 3171) **d** *E. nishibirai*, Ryukyu Islands, Japan, picture by K. Yanagiya **e** same specimen as in **c**, **f** holotype of *E. nishibirai* (MTQ G 32483), Okinawa Island, Japan. Images **c** and **e** from the IRD LagPlon database (http://lagplon.ird.ncf/consultv2_5/rechSimple.faces). Sites are indicated in Figure 1.

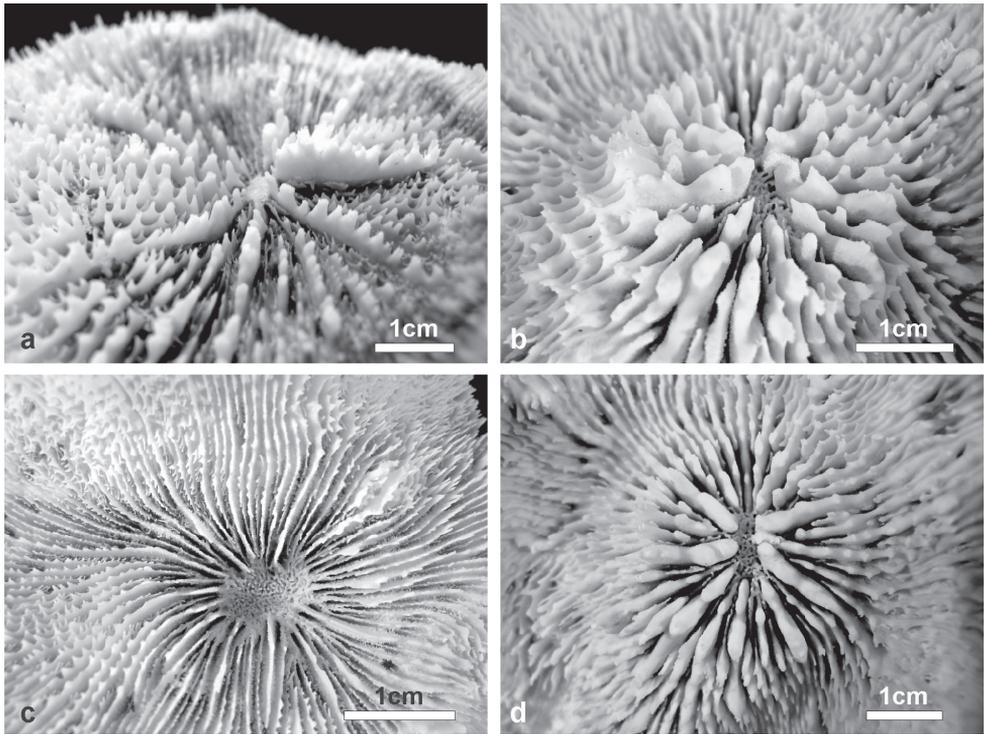


Figure 10. Comparison of central corallite morphology between **a** *Echinophyllia echinata* **b** and **d** *E. tarae* sp. n., and **c** *Echinomorpha nishihirai*: **a** side view of the central corallite of the same *E. echinata* specimen as in Figure 8c (IRD HS 3171) **b** side view of the central protocorallite of *E. tarae* sp. n. (UN-IMIB TO-GA099), **c** top view of the central corallite of *E. nishihirai* holotype (MTQ G 32483) **d** top view of the same corallite as in **b**.

typically corrugated (Figures 6a–b, e–f, 7a–d). However, in some cases a certain degree of inflation of the soft tissues was observed (Figures 6a–b, f), although this generally depends on the very developed ornamentation of the underlying costosepta, which is most obvious when a live colony (Figure 6f) is compared with the clean skeleton (Figures 4b, 5d). In poorly lit conditions the overall appearance is smoother and the colouration more uniform (e.g. Figures 6d, 7e–f) although the oral discs remain generally brightly coloured and different from the rest of the tissues. Re-growth of partially dead colonies, especially at the margins, is common (Figure 8). Such patterns of partial death and recovery could result from competition with other benthic invertebrates, like soft-bodied corallimorpharians and zoanths which can co-occur with this species (Figure 8a). The observed patterns of partial death may also be caused by deposition of sediment on the living corals. In fact, *Echinophyllia tarae* sp. n. is most commonly found at sheltered sites characterized by calm water conditions and muddy sediment which could be stirred up and deposit on benthic organisms suffocating them (Ertfemeijer et al. 2012). The dead parts of the corallum are generally encrusted by coralline algae over which the coral can re-grow or re-settle (Figure 8b).

Occurrence: This species was commonly encountered on the fringing reefs off Mangareva, Aukena, Tekava, Akamaru, Kamaka, Makaroa, Agakauitai, and Taravai islands as well as at the base of the lagoon pinnacles found in the lagoon north of Mangareva Island (Figure 1, Table 2). Its distribution outside the Gambier archipelago is unknown although it could also occur in the Austral Islands (see Discussion section). No record is known from other localities.

Affinities: In its encrusting growth form, and in the presence of a central larger and protruding corallite this species is similar to *Echinophyllia echinata* and *Echinomorpha nishibirai* (see Discussion). Ongoing molecular analyses will reveal the phylogenetic relationships of this species with its congeners.

Etymology. This species is named after MV Tara, which allowed the exploration of coral reefs in Gambier. Moreover, the name “tara” in the Polynesian language may refer to a spiny, pointed object, which applies well to the new species typically featuring pointed skeletal structures. In the same language, Tara is also the name of a sea goddess.

Discussion

The study of the *Echinophyllia tarae* sp. n. material and the *in situ* observations indicated a remarkable phenotypic variation within and between specimens regarding calice size, shape, and inclination, and the number of septa and paliform lobes in the corallite. Thus, *E. tarae* sp. n. is distinct from the other *Echinophyllia* species by the presence of a larger central corallite with a raised wall, thicker primary costosepta, and a very pronounced crown of paliform lobes. In addition, *E. tarae* sp. n. forms relatively small colonies with few corallites.

The type species of *Echinophyllia*, *E. aspera*, has overall smaller and more evenly sized corallites than *E. tarae* sp. n. Although a central corallite can be recognized in small colonies of *E. aspera* (Veron and Pichon 1980), this is smaller than in the new species and does not have its very thickened septa and pronounced crown of paliform lobes. Although the few secondary corallites in *E. tarae* sp. n. may be smaller than the central one and comparable in size to those in *E. aspera* (Figures 5b–c, e), in the latter species the septa are equally thin, while in the former the first cycle septa are markedly thicker. Moreover, *E. aspera* can form much larger colonies than *E. tarae* sp. n. (see Veron and Pichon 1980, figures 516, 520). *Echinophyllia rugosa* Chevalier, 1975, from New Caledonia, has smaller corallites than *E. aspera* and less numerous septa (Chevalier 1975). *E. rugosa* was synonymized with *E. aspera* by Veron and Pichon (1980), and has smaller corallites than *E. tarae* sp. n.

Among the remainder of the *Echinophyllia* species, *E. echinoporoides* and *E. costata*, have smaller and more numerous corallites with less prominent costosepta ornamentation and a more poorly developed crown of paliform lobes, whereas a central larger corallite is not distinguishable (Veron and Pichon 1980, Veron 2000, 2002). Although a central corallite may be present in *E. pectinata* and in some colonies of *E. patula* (Veron 2000), in these species corallites are also smaller than in *E. tarae* sp. n..

Moreover, in *E. pectinata*, costae are equal and typically smooth (Veron 2002), corallites of *E. patula* are typically flush with the colony surface (Hodgson and Ross 1982), and a crown of paliform lobes is absent in both species.

Echinophyllia orpheensis has larger corallites than any of the aforementioned *Echinophyllia* species. A larger central corallite can be observed in some specimens like in one of the paratypes (Veron and Pichon 1980: Figure 525), and it forms a well-developed crown of paliform lobes and exert septa. However, when compared to *E. tarae* sp. n., the corallites of *E. orpheensis* are still smaller and more uniform in average diameter. Furthermore, in *E. orpheensis*, corallites are often raised and more exert than in the new species. They also point more irregularly in various directions and have fewer septa with smaller dentations than in *E. tarae* sp. n..

Live specimens of *E. tarae* sp. n. can bear strong resemblance with *Echinophyllia echinata* (confront Figure 9a and Figure 9c) and *Echinomorpha nishihirai* (confront Figure 9b and Figure 9d). However, the skeletal morphology (Figures 9e-f, 10) helps to distinguish the new species from these two. *Echinophyllia echinata* forms thin flat to vase shaped colonies, with a conspicuous central corallite and widely spaced radials (Veron and Pichon 1980). The holotype of this species (Saville-Kent, 1871) was most likely a juvenile, as also remarked by Veron and Pichon (1980). The original illustration shows the obvious larger central corallite and the thick costae continuing until the corallum margin, like in specimen IRD HS 3171 from New Caledonia (Figures 9c, e). Specimens of *E. echinata* illustrated by Veron and Pichon (1980) were examined at the MTQ, but none of these bears close morphologic similarity with *E. tarae* sp. n.. In fact, the corallum growth form in *E. echinata* and the presence of a larger central corallite may indeed remind of *E. tarae* sp. n. However, the usual pattern of corallite arrangement around the central one in *E. echinata* typically deriving from a circumoral budding (Figure 9e) is not observed in *E. tarae* sp. n., in which peripheral budding is observed (Figures 6b, d). Furthermore, the central corallite in *E. echinata* (Figure 10a) does not have the pronouncedly raised wall typical of *E. tarae* sp. n. (Figure 10b). Septa in *E. echinata* are thinner, septal teeth are smaller and more regularly spaced, and are devoid of the typical crown of well developed paliform lobes of *E. tarae* sp. n..

Echinomorpha nishihirai initially described by Veron (1990) in *Echinophyllia* and later moved to a new monotypic genus, is similar to *E. tarae* sp. n. in having a prominent central corallite, widely spaced peripheral corallites of smaller size, and by forming small encrusting colonies with a few corallites. Some of the colonies of *E. tarae* sp. n. observed *in situ* bear resemblance with *in vivo* images of *E. nishihirai* (Figures 9b, d). Despite this similarity, the skeletons of the two taxa are remarkably different. The holotype of *E. nishihirai* (MTQ G 32483) was examined (Figures 9f, 10c). Although the central corallite of the largest collected specimen of *E. tarae* sp. n. collected is similar in size to that of *E. nishihirai*, the latter lacks the typical raised rim of the former and its septa are more numerous, thinner and with finer dentations (Figure 10c). In another specimen of *E. nishihirai* (MTQ G 70283) the central corallite is actually more protruding from the colony surface than in the holotype, with which it shares thinner and more numerous septa reaching the columella and a denser and more acute

ornamentation. Furthermore, the typical and obvious crown of paliform lobes of *E. tarae* sp. n. is not present in *E. nishibirai*.

In his report on the diversity and distribution of scleractinian corals of the Gambier Islands Chevalier (1974) indicated the presence of *Echinophyllia aspera* typically found on fringing reefs. Unfortunately, his publication did not include illustrations of the coral species listed by him. The author was a remarkably thorough scientist and his unpublished field notes (*cabiers de terrain*) are an example of a naturalist's dedication and passion. He wrote these down in a series of notebooks in which he numbered pages and he registered painstakingly all details of reef profile, species distribution, specimens identification, colour and more. The complete series of notebooks is deposited at the MNHN in Paris and I could examine them during a visit in 2012. Field notes of 1969 (from page 1637 to 1707) include notes of Chevalier's fieldwork in the Gambier and served as reference for his 1974 publication. The author collected several specimens of *Echinophyllia* sp. at different sites in the lagoon which he later identified as *E. aspera* (Chevalier, 1974). At Agakauitai Island, he sampled specimen GAM78b which he identifies as "*Echinophyllia encroutant mais peut être espèce différente, couleur vert foncé*" [encrusting *Echinophyllia* but possibly a new species, colour dark green]. Unfortunately, despite much effort, the Gambier collection of Chevalier could not be located in the Scleractinia collection of the MNHN in Paris. Hence I was unable to verify if the possibly new species found by Chevalier is indeed the same as the one presently described, or if any of the specimens he collected belong to *E. tarae* sp. n.

In their compilation of zooxanthellate scleractinian coral species at 19 localities in the Eastern, South-eastern, and Central Pacific Ocean Glynn et al. (2007) reported *Echinophyllia aspera* from the Society, Tuamotu, and Austral Islands in French Polynesia and *E. echinata* from the Austral mostly based on data from Chevalier (1982) and later additions reworked by Pichon (1985). Again, in absence of a reference collection it is impossible to verify if *E. tarae* sp. n. has been misidentified with these species and, hence, if its distribution is actually wider than presently reported.

Conclusion

Echinophyllia tarae sp. n. is described from the Gambier Islands, French Polynesia. The species is characterized by a high intraspecific variation of several morphological traits. It also shows typical features that distinguish it from the other *Echinophyllia* species and from *Echinomorpha nishibirai*, such as the dimensions and the protrusion of the largest corallite (centrally located in flat colonies), the thickness of the septa, and the development of the crown of paliform lobes. Although the new species is common in the Gambier Islands, its occurrence elsewhere is unknown. The sampling of coral tissue from the type specimens of *E. tarae* sp. n. will allow molecular analyses in order to examine its phylogenetic relationships with its congeners and other species in the Lobophylliidae.

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Two new species of the bamboo-feeding leafhopper genus *Abrus* Dai & Zhang (Hemiptera, Cicadellidae, Deltocephalinae) from China

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Abstract

Two new species of the bamboo-feeding genus *Abrus* Dai & Zhang, 2002, *A. xishuiensis* **sp. n.** and *A. langshanensis* **sp. n.**, are described and illustrated from Guizhou and Hunan, South China. A checklist and a key to 13 known species are given.

Keywords

Bamboo leafhopper, Cicadomorpha, distribution, Homoptera, taxonomy

Introduction

The bamboo-feeding leafhopper genus *Abrus* was established by Dai and Zhang (2002) with six species from Hunan, Guangxi, Fujian, Guangdong and Gansu of China (type species: *Abrus hengshanensis* Dai & Zhang, 2002). To date, 11 species are recognized in the genus (Dai and Zhang 2002; Li and Wang 2006; Dai and Zhang 2008; Li et al.

2011) from southern China. Of them, *A. brevis* Dai & Zhang, *A. coneus* Dai & Zhang and *A. leigongshanensis* Li & Wang, were recorded feeding on bamboo (Li et al. 2011).

During on-going studies on species biodiversity of the bamboo-feeding leafhoppers in China, some specimens belonging to undescribed species of the genus *Abrus* were found. The purpose of this paper is to describe two new species and to provide an identification key to the known species of *Abrus*.

Material and methods

In the present paper, terminology follows Li et al. (2011). Dry specimens were used for the description and illustration. External morphology was observed under a stereoscopic microscope and characters were measured with an ocular micrometer. Measurements are given in millimeters; body length is measured from the apex of the head to the apex of the forewing in repose. The genital segments of the examined specimens were macerated in 10% KOH, washed in water and transferred to glycerine. Illustrations of the specimens were made with a Leica MZ 12.5 stereomicroscope. Photographs of the types were taken with a Leica D-lux 3 digital camera. The digital images were then imported into Adobe Photoshop 8.0 for labeling and plate composition. The type specimens and material examined are deposited in the Institute of Entomology, Guizhou University, Guiyang, China (IEGU).

Taxonomy

Abrus Dai & Zhang, 2002

<http://species-id.net/wiki/Abrus>

Abrus Dai & Zhang, 2002: 304; Dai and Zhang 2008: 38; Li et al. 2011: 16.

Type species. *Abrus hengshanensis* Dai & Zhang, 2002, by original designation.

Diagnosis. For the diagnosis and relationships of *Abrus* see Dai and Zhang (2008: 38) and Zahniser (2007–present).

Distribution. China (Gansu, Hunan, Fujian, Guizhou, Guangxi and Guangdong).

World checklist of species of *Abrus* Dai & Zhang

Abrus bifurcatus: Dai and Zhang 2002; China (Guangdong).

Abrus biprocessus: Li et al. 2011, Li and Wang 2006; China (Guizhou).

Abrus breviolus: Dai and Zhang 2008; China (Zhejiang).

Abrus brevis: Dai and Zhang 2002; China (Guangxi).

Abrus concavelus: Li and Wang 2006; China (Fujian).

- Abrus coneus*: Dai and Zhang 2002; China (Gansu, Guizhou and Hubei).
Abrus graciaeadeagus: Li et al. 2011; China (Guangxi).
Abrus hengshanensis: Dai and Zhang 2002; China (Hunan).
Abrus huangi: Dai and Zhang 2002; China (Guangxi).
Abrus leigongshanensis: Li and Wang 2006; China (Guizhou).
Abrus langshanensis sp. n.; China (Hunan).
Abrus wuyiensis: Dai and Zhang 2002; China (Fujian, Sichuan and Zhejiang).
Abrus xishuiensis sp. n.; China (Guizhou).

Key to species of the genus *Abrus* (male)

(Modified from Dai and Zhang 2008)

- 1 Basal projection of aedeagal shaft shorter than half length of shaft, reduced or absent (Fig. 23)..... **2**
 – Basal projection of aedeagal shaft equal to or longer than half length of shaft (Fig. 11)..... **3**
 2 Subgenital plate short, with posterior margin truncate..... *A. breviolus*
 – Subgenital plate moderately long, with posterior margin rounded (Fig. 19)..
 *A. langshanensis* sp. n.
 3 Aedeagal shaft about half length of basal projection, apical appendages extended posterad *A. brevis*
 – Aedeagal shaft as long as or longer than basal projection, apical appendages extended basolaterad (Figs 11, 12) **4**
 4 Pygofer with one long process at each posterodorsal margin *A. wuyiensis*
 – Pygofer without processes at posterodorsal margin (Fig. 6) **5**
 5 Pygofer with one pair of processes at each posteroventral margin .. *A. biprocessus*
 – Pygofer with one process or without processes at each posteroventral margin ... **6**
 6 Apical appendages of aedeagus branched at apex (Figs 11, 12) **7**
 – Apical appendages of aedeagus not branched at apex **10**
 7 Apical appendages of aedeagus with small process at base **8**
 – Apical appendages of aedeagus without process at base (Figs 11, 12)
 *A. xishuiensis* sp. n.
 8 Pygofer with long process at posteroventral corner; basal projection of aedeagus short, about half length of shaft *A. coneus*
 – Pygofer without long process at posteroventral corner, basal projection of aedeagus as long as shaft **9**
 9 Basal projection of aedeagus with pair of triangular appendages laterally at midlength, aedeagal shaft without ventral flange at apex *A. bifurcatus*
 – Basal projection of aedeagus without appendage laterally at midlength, aedeagal shaft with ventral triangular flange at apex..... *A. concavelus*
 10 Pygofer without process at ventral margin..... **11**

- Pygofer with process at ventral margin..... **12**
- 11 Apical appendages of aedeagus directed dorsally, basal projection of aedeagus without lateral appendages in ventral view *A. leigongshanensis*
- Apical appendages of aedeagus directed lateroventrally, basal projection of aedeagus with lateral appendages in ventral view..... *A. graciaedeagus*
- 12 Pygofer with process at caudoventral margin; basal projection of aedeagus dentate along ventral margin and with lateral appendages directed ventrally .
..... *A. huangi*
- Pygofer with digitate process in the middle of ventral margin; basal projection of aedeagus with a long process subapically and lateral appendages directed dorsally..... *A. hengshanensis*

***Abrus xishuiensis* sp. n.**

urn:lsid:zoobank.org:act:236C1818-2ED6-4197-953E-F64BE108CEF1

http://species-id.net/wiki/Abrus_xishuiensis

Figs 1–12

Type material. Holotype: ♂, **China:** Guizhou, Xishui, Changqiangou (106°12'N, 28°19'E), 700m, on bamboo, 29 Sep. 2000, X.-S. Chen; paratypes: 3 ♂♂, 3 ♀♀, same data as holotype.

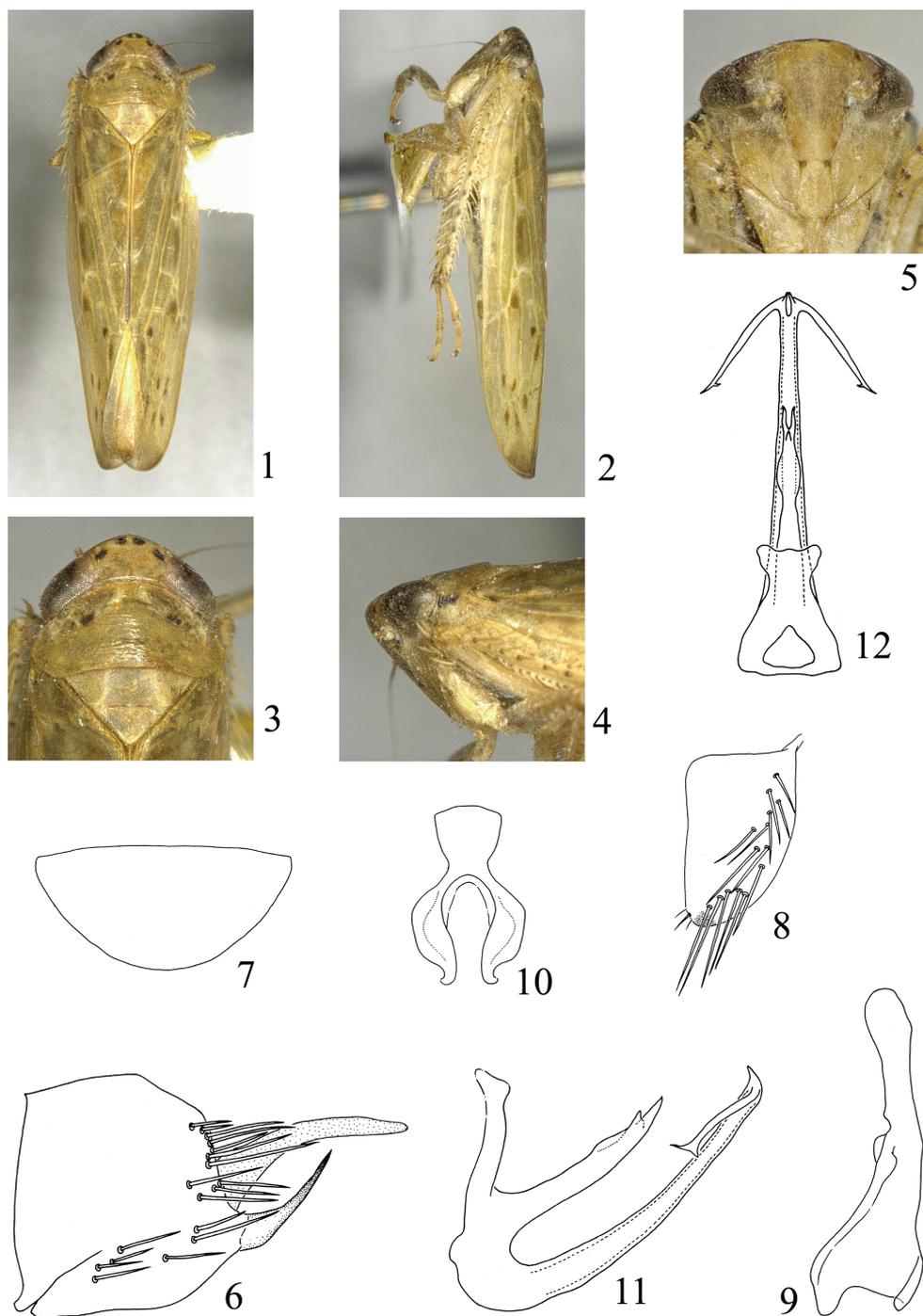
Etymology. The species is named after the type locality, Xishui, Guizhou Province in China.

Measurement. Body length including forewing male 9.02–9.25 mm (N = 4), female 9.35–9.90 mm (N = 3); forewing length male 7.62–8.10 mm (N = 4), female 8.00–8.40 mm (N = 6).

Coloration. Orange to yellowish brown (Figs 1–5). Crown with two pairs of similar blackish brown spots on anterior margin, along suture pale reddish orange. Eyes blackish brown, anterior angle pale reddish brown. Pronotum with pair blackish brown spots on anterior part, with short pale reddish orange stripe centrally. Scutellum with reddish orange marking centrally, transverse suture pale reddish orange. Inner and central antepical cells at apex, third and fourth apical cells at base each with a dark brown spot.

Head and thorax. Crown length 0.7× medial width between eyes. Pronotum length 1.93× medial length of crown. Scutellum length 0.93× medial length of pronotum. Forewing length 3.87× medial width at widest part.

Male genitalia. Pygofer (Fig. 6) trapeziform in shape, with macrosetae along posterior margin and midventrally; posterior margin truncate; posteroventral process broad at base, acute apically, slightly curved dorsad, directed posterodorsad; membranous process at inner apex, slightly curved ventrally, broad at base, acute apically, apex acute. Genital valve (Fig. 7) broad triangular, posterior margin rounded, basal width 2.02× median length. Subgenital plate (Fig. 8) broad and short; outer margin rounded; with many macrosetae on lateral region. Style (Fig. 9) long; broad at base;



Figures 1–12. *Abrus xishuiensis* sp. n. **1** Male habitus, dorsal view **2** Same, lateral view **3** Head and thorax, dorsal view **4** Same, lateral view **5** Face **6** Pygofer, lateral view **7** Valve **8** Subgenital plate **9** Style **10** Connective **11** Aedeagus, lateral view **12** Same, posteroventral view.

narrow at middle; apex slightly widening; apical margin rounded. Connective (Fig. 10) Y-shaped, shaft robust, arms well developed, shaft length $0.65\times$ length of arm. Aedeagus (Figs 11, 12) with developed basal projection dorsally, about $2/3$ length of aedeagal shaft; apex branched in dorsal view; dorsal margin with a stout tooth subapically, grooved at apical third; aedeagal shaft in profile (Fig. 11) slightly curved dorsad, slender, long, tapering apically; dorsal margin of apex with pair small processes, beak-like, directed dorsally; shaft with pair of lateral appendages subapically, each with apex branched. Phallosome apical on ventral surface.

Host plant. Bamboo (*Chimonobambusa angustifolia* C. D. Chu & C. S. Chao).

Distribution. Southwest China (Guizhou).

Remarks. This species resembles *A. biprocessus* Li, 2011 in appearance, but can be distinguished by body size ♂ 9.02–9.25 mm, ♀ 9.35–9.90 mm (♂ 8.1 mm, ♀ 8.2 mm in *biprocessus*); pygofer with one process at posteroventral corner (with two processes in *biprocessus*); basal projection of aedeagus with apical appendages stout and short (slender and long in *biprocessus*); subapical appendages of aedeagal shaft branched at apex, without a small branch basally (not branched at apex, with a small branch at basal third in *biprocessus*).

Abrus langshanensis sp. n.

urn:lsid:zoobank.org:act:EDFF6A6F-7337-4AAE-915F-FB2631FDE451

http://species-id.net/wiki/Abrus_langshanensis

Figs 13–27

Type material. Holotype: ♂, **China:** Hunan, Xinning, Langshan (110°49'E, 26°22'N), on bamboo, *Indocalamus* sp., 6 Oct. 2010, X.-S. Chen and L. Yang; paratypes 1 ♂, 1 ♀, data same as holotype; paratype 1 ♂, Hunan, Xinning, Langshan, on bamboo, *Indocalamus* sp., 2 Oct. 2011, X.-S. Chen and L. Yang.

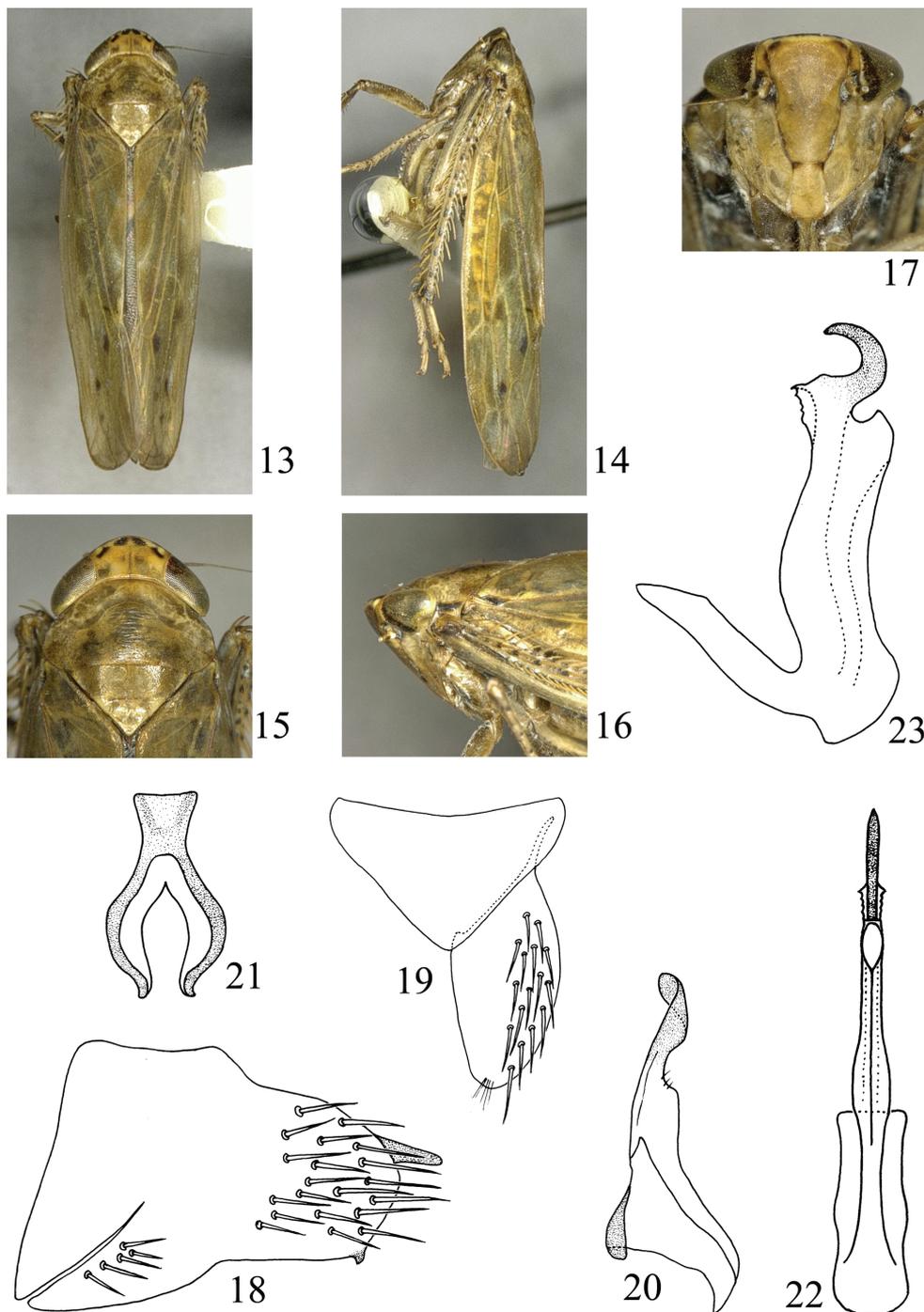
Etymology. This species is named after the type locality, Langshan, Xinning, Hunan Province in China.

Measurement. Body length including forewing male 9.10–9.60 mm (N = 3), female 9.55 mm (N = 1); forewing length male 7.70–8.10 mm (N = 3), female 7.85 mm (N = 1).

Coloration. General color pale yellowish orange (Figs 13–17). Crown with two pairs of similar blackish brown spots on anterior margin. Eyes blackish brown, ocelli pale yellowish white. Face pale yellowish white. Inner and central antepical cells at apex, third and fourth apical cells at base each with a dark brown spot.

Head and thorax. Crown medial length $0.58\times$ width between eyes. Pronotum length $2.03\times$ medial length of crown. Scutellum length $0.87\times$ medial length of pronotum. Forewing length $4.00\times$ medial width at widest part.

Male genitalia. Pygofer in lateral view (Fig. 18) narrower posteriorly; covered with macrosetae posteriorly, with several basoventrally dorsad of ventral margin; dorsal margin sinuate; ventral margin concave medially; with a small papillae posteriorly. Genital valve (Fig. 19) broad triangular; posterior margin slightly acute and rounded;



Figures 13–23. *Abrus langshanensis* sp. n. **13** Male habitus, dorsal view **14** Same, lateral view **15** Head and thorax, dorsal view **16** Same, lateral view **17** Face **18** Pygofer, lateral view **19** Valve and subgenital plate **20** Style **21** Connective **22** Aedeagus, posteroventral view **23** Same, lateral view.



Figures 24–29. *Abrus langshanensis* sp. n. and its host plant. **24, 25** Adult resting on leaf of bamboo **26, 27** Nymph resting on leaf of bamboo **28** View of the area where *A. langshanensis* were captured, in Langshan, Xinning, Hunan, with *Indocalamus* sp. **29** View of the plant. Photograph by X.-S. Chen.

basal width $1.95\times$ medial length. Subgenital plate (Fig. 19) broad and short; outer margin roundedly curved; with many macrosetae on lateral region. Style (Fig. 20) long; broad at base; narrowing apically; apex slightly recurved; apical margin acute and rounded. Connective (Fig. 21) Y-shaped; stem robust; arms well developed; length of stem $0.44\times$ that of arm. Aedeagus (Figs 22, 23) without basal projection dorsally; aedeagal shaft in lateral view (Fig. 23) almost S-shaped; apex produced into a robust hook-like process. Phallotreme apical on ventral surface.

Host plant. Bamboo (*Indocalamus* sp.).

Distribution. South China (Hunan).

Remarks. This new species is similar to *A. breviolus* Dai & Zhang, 2008 in aedeagus having reduced or small basal projection dorsally, but can be distinguished by posterior margin of male pygofer without process (with stout process dorsally in *breviolus*); apical margin of subgenital plate rounded (truncate in *breviolus*); aedeagal shaft with apex hook-like, without pair of subapical appendages (with pair of subapical appendages laterally in *breviolus*).

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Fossils from the Middle Jurassic of China shed light on morphology of Choristopsychidae (Insecta, Mecoptera)

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Abstract

Choristopsychidae, established by Martynov in 1937 with a single isolated forewing, is a little known extinct family in Mecoptera. Since then, no new members of this enigmatic family have been described. Based on 23 well-preserved specimens with complete body and wings from the Middle Jurassic of north-eastern China, we report one new genus and three new species of Choristopsychidae, two new species of the genus *Choristopsyche* Martynov, 1937: *C. perfecta* **sp. n.** and *C. asticta* **sp. n.**; one new species of *Paristopsyche* **gen. n.**: *P. angelineae* **sp. n.**; and re-describe *C. tenuinervis* Martynov, 1937. In addition, we emend the diagnoses of Choristopsychidae and *Choristopsyche*. Analyzing the forewing length/width ratios of representative species in Mecoptera, we confirm that choristopsychids have the lowest ratio of forewing length/width, meaning broadest forewings. These findings, the first fossil choristopsychids with well-preserved body structure and the first record of Choristopsychidae in China, shed light on the morphology of these taxa and broaden their distribution from Tajikistan to China, while increasing the diversity of Mesozoic Mecoptera in China.

Keywords

Mecoptera, Choristopsychidae, new genus, new species, Middle Jurassic, China

Introduction

Choristopsychidae is a rather obscure extinct family in the Order Mecoptera. The family, erected by Martynov in 1937 with an isolated forewing fossil, contains only one species up to date, *Choristopsyche tenuinervis*. Its locality is Shurab II Ditch 63(8), which is in a Pliensbachian terrestrial horizon in the Sulyukta Formation of Tajikistan (Lower Jurassic) (Martynov 1937, Aristov et al. 2009). The family is recognized by a combination of the following characters: forewing broad, ScP long with two long anterior branches; RP and MA with two branches each; MP with five branches; and CuA coalesced with MP basally, strongly bent at about its midpoint (Martynov 1937).

Recently, we collected 23 well-preserved fossils from the Daohugou Village, Ningcheng County, Inner Mongolia, China; Jiulongshan Formation, Middle Jurassic. Herein, based on their different morphological characters, we erect one new genus with one new species and two new species of *Choristopsyche* Martynov, 1937, and re-describe *C. tenuinervis* Martynov, 1937, while emending diagnoses of Choristopsychidae Martynov, 1937 and *Choristopsyche* Martynov, 1937.

There are abundant well-preserved fossil insects from Daohugou, including 19 reported orders so far (Ren et al. 2010b). The age of the Daohugou fossil-bearing beds is ca. 164–165 million years ago (Ma) (Bathonian-Callovian boundary interval, the late Middle Jurassic) (Chen et al. 2004).

Material and methods

This study is based on 23 fossil specimens housed in the fossil insect collection of the Key Laboratory of Insect Evolution & Environmental Changes, College of Life Sciences, Capital Normal University, Beijing, China (CNUB; Dong Ren, Curator).

Photographs of whole specimens were taken with a Nikon D100 digital camera coupled to a Nikkor 105 mm macro lens. The specimens were examined using a Leica MZ12.5 dissecting microscope, and illustrated with the aid of a drawing tube attached to the microscope. Line drawings were made with CoreDRAW X4 graphic software.

The wing venation nomenclature used in this paper is based on the interpretations and system proposed by Novokshonov (2002) with some revisions, Corresponding abbreviations are: ScP, posterior Subcosta; RA, anterior Radius; RP, posterior Radius; MA, anterior Media; MP, posterior Media; CuA, anterior Cubitus; CuP, posterior Cubitus; 1A, the first anal vein; 2A, the second anal vein (Fig. 1E). The length of the wing is measured by the straight-line distance from the wing base to apex, and the width of the wing, the straight-line distance from the wing anterior margin to posterior margin at its broadest point.

Systematic palaeontology

Order Mecoptera Packard, 1886

Family Choristopsychidae Martynov, 1937

<http://species-id.net/wiki/Choristopsychidae>

Emended diagnosis. Forewing broad oval or subtriangular, field between C and ScP comparatively broad; ScP well developed and forked twice, forming three long branches; RA unforked, one crossvein between ScP and RA and between RA and RP; RP and MA both with two branches; MP with five branches, and the MP₄₊₅ forking basal to the MP₂₊₃ forking; MP and CuA merged at the base; CuA strongly bent at its mid point; an oblique crossvein between CuA and CuP; a curved crossvein between the midpoint of CuA and MP₅; CuP, 1A and 2A almost parallel. Hind wing, similar in shape to the forewing but slightly smaller, ScP short, forked twice, the second bifurcation coalesces with RA for a short distance; RP and MA both with two branches; MP with five branches, the stem of MP₄₊₅ forked earlier than that of forewing, and with a crossvein to CuA; CuA almost straight. Head, oviform with big and oval compound eyes; antennae long and filiform; small chewing mouthpart. Thorax: prothorax smaller than mesothorax and metathorax. Legs: long and slender, all legs nearly of the same shape, but hind legs longer than fore legs and mid legs, and femora wider than tibia, and tibia longer than femora. Abdomen slender, tapering apically, about eleven segments and the female terminal segment with cercus.

Genus *Choristopsyche* Martynov, 1937

<http://species-id.net/wiki/Choristopsyche>

Type species. *Choristopsyche tenuinervis* Martynov, 1937 (Lower Jurassic of Tajikistan)

Emended diagnosis. Forewing, the separation of RP+MA from RA distal to the separation of MP from CuA.

Included species. Type species (*C. tenuinervis* Martynov, 1937), *C. perfecta* sp. n. and *C. asticta* sp. n.

Choristopsyche tenuinervis Martynov, 1937

http://species-id.net/wiki/Choristopsyche_tenuinervis

Figs 1, 2

Emended diagnosis. Forewing, RP+MA forking distal to MP forking.

Description of new material. CNU-MEC-NN2011075p/c (Fig. 1), a well preserved specimen with part and counterpart in dorsal view, with almost complete fore-

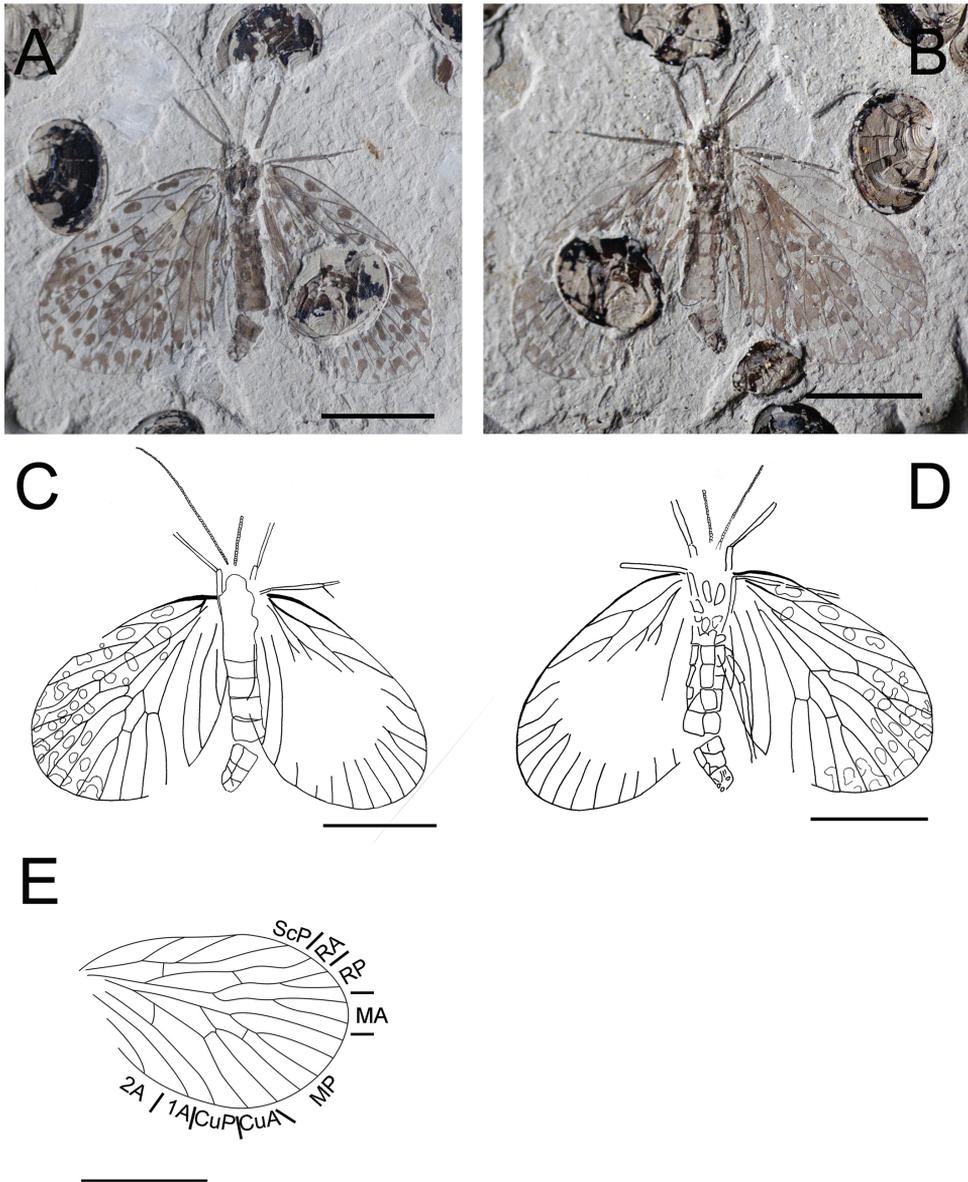


Figure 1. Photographs and line drawings of *Choristopsyche tenuinervis* Martynov, 1937 **A** Photograph of part, no. CNU-MEC-NN2011075p **B** Photograph of counterpart, no. CNU-MEC-NN2011075c **C** Line drawing of whole specimen of part, no. CNU-MEC-NN2011075p **D** Line drawing of whole specimen of counterpart, no. CNU-MEC-NN2011075c **E** Line drawing of forewing of part, no. CNU-MEC-NN2011075p. Scale bars represent 5 mm.

wings, but partially preserved hind wings and body, and forewings overlapping hind wings. The terminus of abdomen is missing, sex unknown. Wings: Left forewing, length 11.0 mm, width 6.7 mm, broadly oval, RP forking distal to MA forking; MP₂₊₃

forking basal to the forking of MA, and the stem of MP_3 about twice as long as the stem of MP_{2+3} ; with one crossvein between RA and RP, and between MP_{2+3} and MP_4 ; CuP, 1A, 2A single. Right forewing is similar to left forewing, but parts missing. Hind wings, smaller than forewings, overlapped by forewings, the venation visible but unclear. There are many spots on all four wings, symmetric between left and right wings.

In addition, there are nine new materials with analogous wing venation to that of specimen CNU-MEC-NN2011075p/c. They are listed as follows.

CNU-MEC-NN2011080 (Figs 2A, C), a well preserved specimen with clear wings, but parts of body, and the right forewing overlapping the right hind wing. Sex unknown. Wing: Right forewing, length 11.8 mm, width 6.7 mm, RP forking distal to the forking of MA; MP_{2+3} forking at about the same level as the forking of MA; the stem of MP_3 about twice as long as the stem of MP_{2+3} ; with one crossvein between MP_{2+3} and MP_4 ; CuP, 1A, 2A single. Left forewing is similar to right forewing, but the apex of the wing absent. Hind wings, length at about 10.1 mm, width 6.2 mm, similar to forewings but smaller. CNU-MEC-NN2009317 (Figs 2B, D), an almost complete specimen, female, with forewings overlapping hind wings, and nearly complete body, but legs absent in dorsal view. Wings: right forewing, length at about 9.5 mm, width 4.9 mm; RP forking distal to the forking of MA; MP_{2+3} forking at about the same level to the forking of MA; the stem of MP_3 as long as the stem of MP_{2+3} ; CuP, 1A, 2A single. Left forewing is similar to right forewing. Hind wings, similar to forewings, but smaller; CuA almost straight. CNU-MEC-NN2009414 (Figs 2E, F), an almost complete preserved specimen in lateral view, female, with complete body and forewings, and right forewing overlapped with body and parts of left forewing, and right hind wing overlapped with left hind wing. The mouthparts are missing, the maxillary palpus with five segments visible. Abdomen: tapering apically, with eleven segments, and a pair of cercus can be visible, female. Wings: Left forewing, length at about 10.1 mm, width 6.4 mm, broadly oval, RP forking basal to the forking of MA; MP_{2+3} forking significantly basal to the forking of MA; the stem of MP_3 about three times as long as the stem of MP_{2+3} ; with one crossvein between RA and RP, and between MA and MP_1 ; CuP, 1A, 2A single. Right forewing is similar to left forewing, but there are crossveins between ScP and RA, RA and RP, MA and MP_1 . Hind wing: similar to forewing but smaller, RA straight, with one crossvein to RP. CNU-MEC-NN2009318 (Fig. 2G), a partially preserved specimen in dorsal view, with parts of forewings, hind wings and body, but the filiform antennae and venation visible, and the forewings overlapping the hind wings. CNU-MEC-NN2011070 (Fig. 2H), an almost completely preserved specimen in ventral view, with almost complete body and four wings, and hind wings overlapped with forewings. CNU-MEC-NN2011071 (Fig. 2I), a partially preserved specimen in dorsal view, with parts of body and forewings, but left hind wing is missing, and right hind wing is obscure. CNU-MEC-NN2009383 (Fig. 2J), a partially preserved specimen with four outspread wings and parts of body. CNU-MEC-NN2011083 (Fig. 2K), a specimen in dorsal view, female, with almost complete body but some legs not visible due to coverage by wings, and forewings overlapping hind wings. CNU-MEC-NN2011085 (Fig. 2L), a comparatively complete specimen in lat-

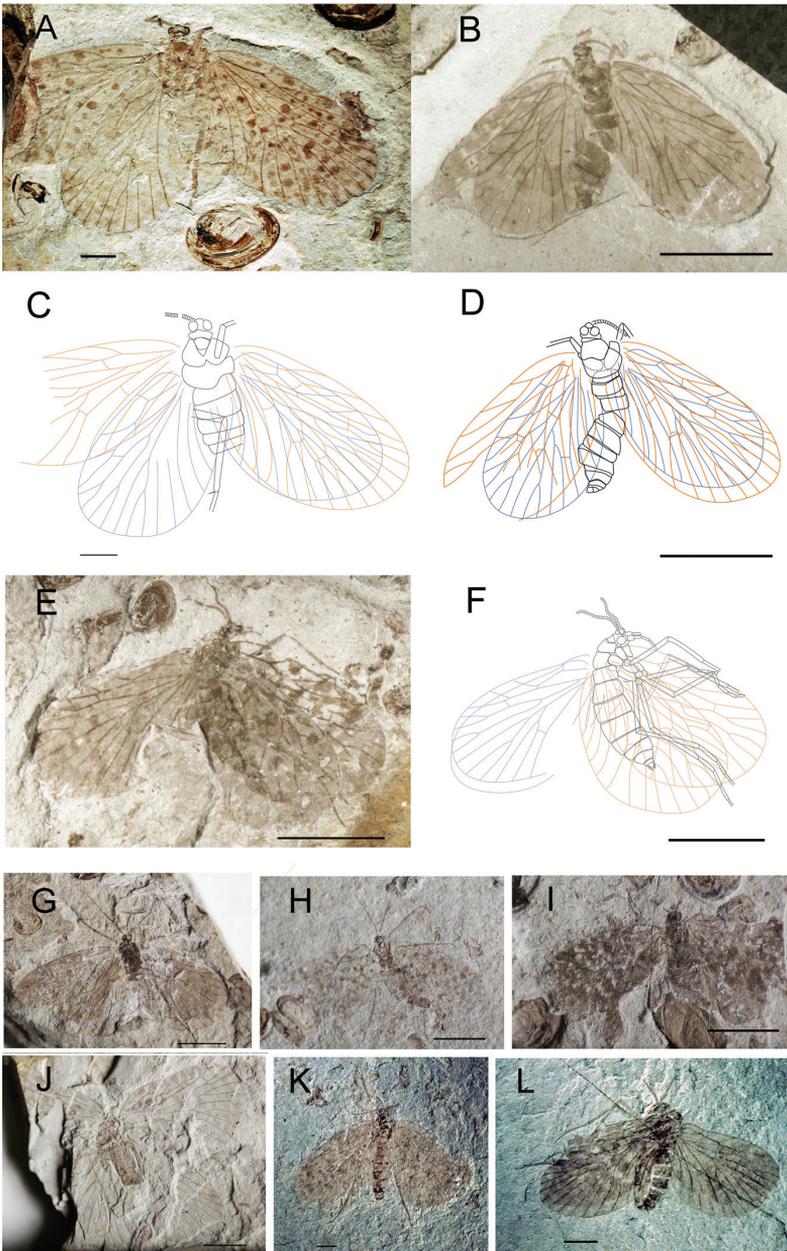


Figure 2. Photographs and line drawings of *Choristopsyche tenuinervis* Martynov, 1937 **A** Photograph of no. CNU-MEC-NN2011080 **B** Photograph of no. CNU-MEC-NN2009317 **C** Line drawing of no. CNU-MEC-NN2011080 **D** Line drawing of no. CNU-MEC-NN2009317 **E** Photograph of no. CNU-MEC-NN2009414 **F** Line drawing of no. CNU-MEC-NN2009414 **G** Photograph of no. CNU-MEC-NN2009318 **H** Photograph of no. CNU-MEC-NN2011070 **I** Photograph of no. CNU-MEC-NN2011071 **J** Photograph of no. CNU-MEC-NN2009383 **K** Photograph of no. CNU-MEC-NN2011083 **L** Photograph of no. CNU-MEC-NN2011085. Scale bars of **A**, **C**, **K**, **L** represent 2 mm. Scale bars of **B**, **D**, **E**, **F**, **G**, **H**, **I**, **J** represent 5 mm.

eral view, male, and forewings overlapping hind wings; chewing mouthparts visible; Abdomen almost completely-preserved, the posterior six segments can be seen clearly, and abdomen bent at six and seven segment, but the posterior segments faint below the left forewing, the scorpion-like terminal visible.

New material. CNU-MEC-NN2011075p/c, CNU-MEC-NN2011080, CNU-MEC-NN2009317, CNU-MEC-NN2009414, CNU-MEC-NN2009318, CNU-MEC-NN2011070, CNU-MEC-NN2011071, CNU-MEC-NN2009383, CNU-MEC-NN2011083, CNU-MEC-NN2011085, deposited in CNUB.

Type locality and horizon. Daohugou Village, Ningcheng County, Inner Mongolia, China, Jiulongshan Formation, Middle Jurassic (Bathonian–Callovian boundary interval, ca 164–165 Ma).

Remarks. These ten specimens exhibit differences in the characters of “RP forking vs. MA forking”, “MP₂₊₃ forking vs. MA forking” and “Length ratio of the stem of MP₃ and the stem of MP₂₊₃”, which are considered as intraspecific variations.

***Choristopsyche perfecta* sp. n.**

urn:lsid:zoobank.org:act:FA6A6E51-B3BD-459E-AED4-021539147BA3

http://species-id.net/wiki/Choristopsyche_perfecta

Fig. 3

Diagnosis. Forewing, RP+MA forking almost at the same level to MP forking.

Description. Holotype CNU-MEC-NN2011082 (Figs 3A, B), an almost complete preserved specimen, maybe male, with four outspread wings, but with partially preserved body. Head is partially preserved, only with one compound eye visible. Thorax: prothorax smaller than mesothorax and metathorax in ventral view. Legs: some parts of fore legs and left hind leg visible. Abdomen: tapering apically, with six segments visible, but the terminal visible, maybe male. Wings: Right forewing, length 22.2 mm, width at about 11.4 mm, RP forking distal to the forking of MA; MP₂₊₃ forking distal to the forking of MA; the stem of MP₃ about twice as long as the stem of MP₂₊₃; with one crossvein between CuP and 1A; CuP, 1A single. Left forewing is partially preserved, similar to right forewing. Hind wings, length 18.4 mm, width at about 10.3 mm, similar to forewings but smaller than forewings, and left hind wing partially preserved. There are many spots on all four wings, symmetric between left and right wings.

Paratypes: CNU-MEC-NN2009352 (Figs 3C, E), an almost complete preserved specimen, with clear wing venation and structure of body in side pressure, and forewings partially overlapped with hind wings, sex unknown. Wings: Left forewing, length 18.8 mm, width 10.0 mm, RP forking slightly distal to the forking of MA; MP₂₊₃ forking at about the same level to the forking of MA; the stem of MP₃ about twice as long as the stem of MP₂₊₃; with one crossvein between MP₁ and MA₄, MP₁ and MP₂, MP₂₊₃ and MP₄; CuP, 1A, 2A, 3A single, and one crossvein between CuP and 1A. Right forewing is similar to left forewing. Hind wing, similar to forewing, but

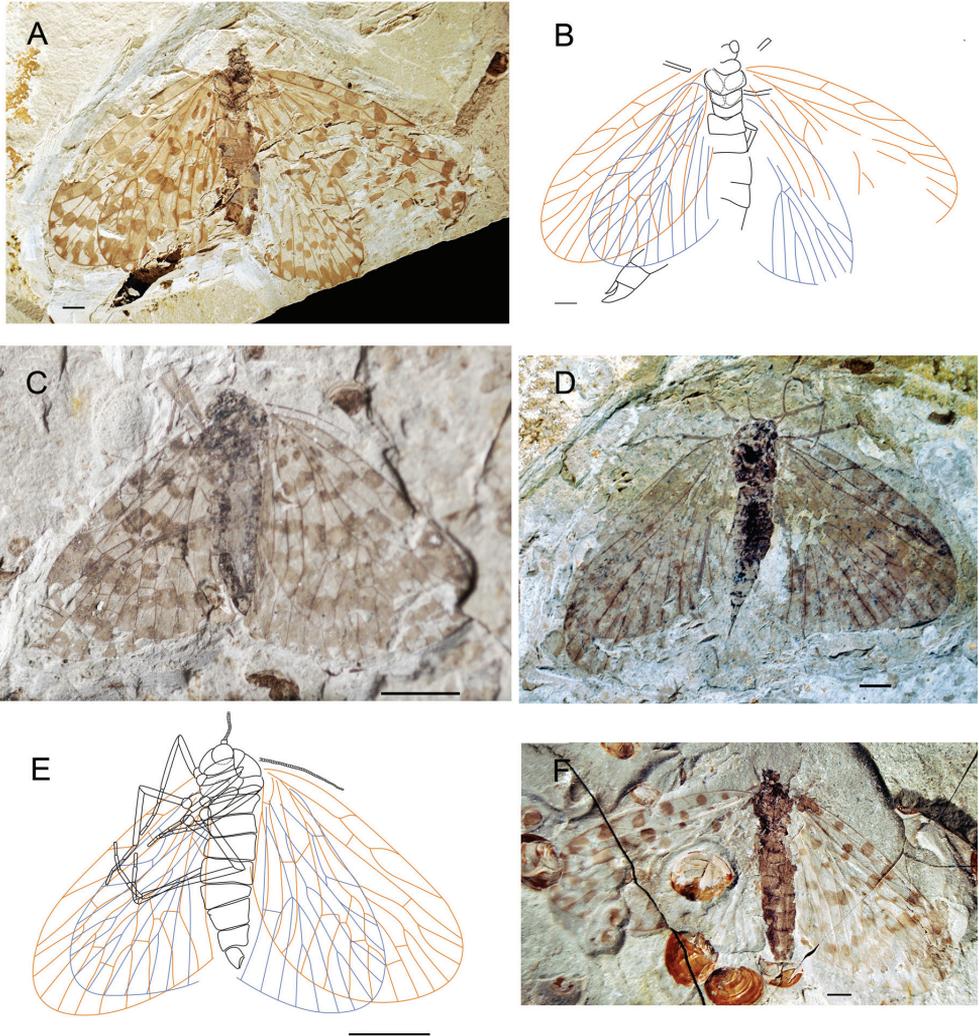


Figure 3. Photographs and line drawings of *Choristopsyche perfecta* sp. n. **A** Photograph of holotype, no. CNU-MEC-NN2011082 **B** Line drawing of holotype, no. CNU-MEC-NN2011082 **C** Photograph of paratype, no. CNU-MEC-NN2009352 **D** Photograph of paratype, no. CNU-MEC-NN2011079 **E** Line drawing of paratype, no. CNU-MEC-NN2009352 **F** Photograph of paratype, no. CNU-MEC-NN2011084. Scale bars of **A**, **B**, **D**, **F** represent 2 mm; scale bars of **C**, **E** represent 5 mm.

smaller. CNU-MEC-NN2011079 (Fig. 3D), female, a well-preserved specimen with complete body, and the terminal of abdomen visible, but the end of legs absent, and forewings overlapping hind wings, but parts of wings missing, RP forking distal to the forking of MA; Abdomen: tapering apically, with eleven visible segments, the tenth and eleventh segments smaller, and the eleventh segment with cerci visible. CNU-MEC-NN2011084 (Fig. 3F), a specimen with legs absent, and hind wings overlapped by forewings in dorsal view, sex unknown. Forewing, length 19.4 mm, width 10.0

mm, RP forking at the same level to the forking of MA; MP_{2+3} forking basal to the forking of MA; the stem of MP_3 about twice as long as the stem of MP_{2+3} .

Material. Holotype CNU-MEC-NN2011082, Paratypes CNU-MEC-NN2009352, CNU-MEC-NN2011079, CNU-MEC-NN2011084, deposited in CNUB.

Type locality and horizon. Daohugou Village, Ningcheng County, Inner Mongolia, China, Jiulongshan Formation, Middle Jurassic (Bathonian–Callovian boundary interval, ca 164–165 Ma).

Etymology. The name is derived from the Latin word of *perfectus*, meaning “complete”.

Remarks. These four specimens exhibit differences in the character of “RP forking vs. MA forking”, “ MP_{2+3} forking vs. MA forking”, which is considered as intraspecific variations.

Choristopsyche asticta sp. n.

urn:lsid:zoobank.org:act:31DA887F-2987-4DAD-9520-5776FA0CD5CF

http://species-id.net/wiki/Choristopsyche_asticta

Fig. 4

Diagnosis. Forewing, RP+MA forking basal to MP forking.

Description. Holotype, CNU-MEC-NN2009394p/c (Figs 4A–D), an almost complete specimen, female, with well-preserved four outspread wings. Head: compound eyes are big and oval in ventral view, but mouthparts invisible and antenna partially preserved. Thorax: prothorax smaller than mesothorax and metathorax, visible in ventral view. Legs: all legs nearly the same shape and nearly completely preserved, long and slender in ventral view. Abdomen: slender and elongate, tapering apically, with eight visible segments. Wings: four wings are elongated and broad, with rounded apical margin. Forewings: Right forewing, length 20.7 mm, width 10.2 mm, almost triangular, dark color between C and RA; RP forking basal to the forking of MA; MP_{2+3} forking at about the same level to the forking of MA; the stem of MP_3 about twice as long as the stem of MP_{2+3} ; the stem of MA strongly bent posteriorly; and the stem of MP_{2+3} strongly bent at its basal one third part; with one crossvein between MA and MP_1 , MP_1 and MP_2 , and between MP_{2+3} and MP_4 ; and one oblique crossvein between the base of CuA and CuP, and at the point one oblique crossvein between CuP and 1A, CuP, 1A, 2A single. Left forewing is similar to right forewing. Hind wings: similar to forewing, but slightly smaller, length at about 16.8 mm, width at about 10.0 mm; Right hind wing, with one crossvein between RA and RP+MA. Left hind wing is similar to right hind wing. No spots on entire wings.

Paratypes: CNU-MEC-NN2011081 (Fig. 4E), female, a well-preserved specimen, with complete body and wings; Head, oval with two big compound eyes, filiform antenna and chewing mouthparts; Abdomen, slender and elongate in lateral view, tapering apically and complete preserved, length at about 13.4 mm; Wings, forewings overlapping some parts of hind wings, and with clear venation; Forewing, length 19.8 mm, width 8.4 mm, RP forking basal to the forking of MA; MP_{2+3} forking at the same level to the forking of MA; the stem of MP_3 about twice as long as the stem of MP_{2+3} . Hind

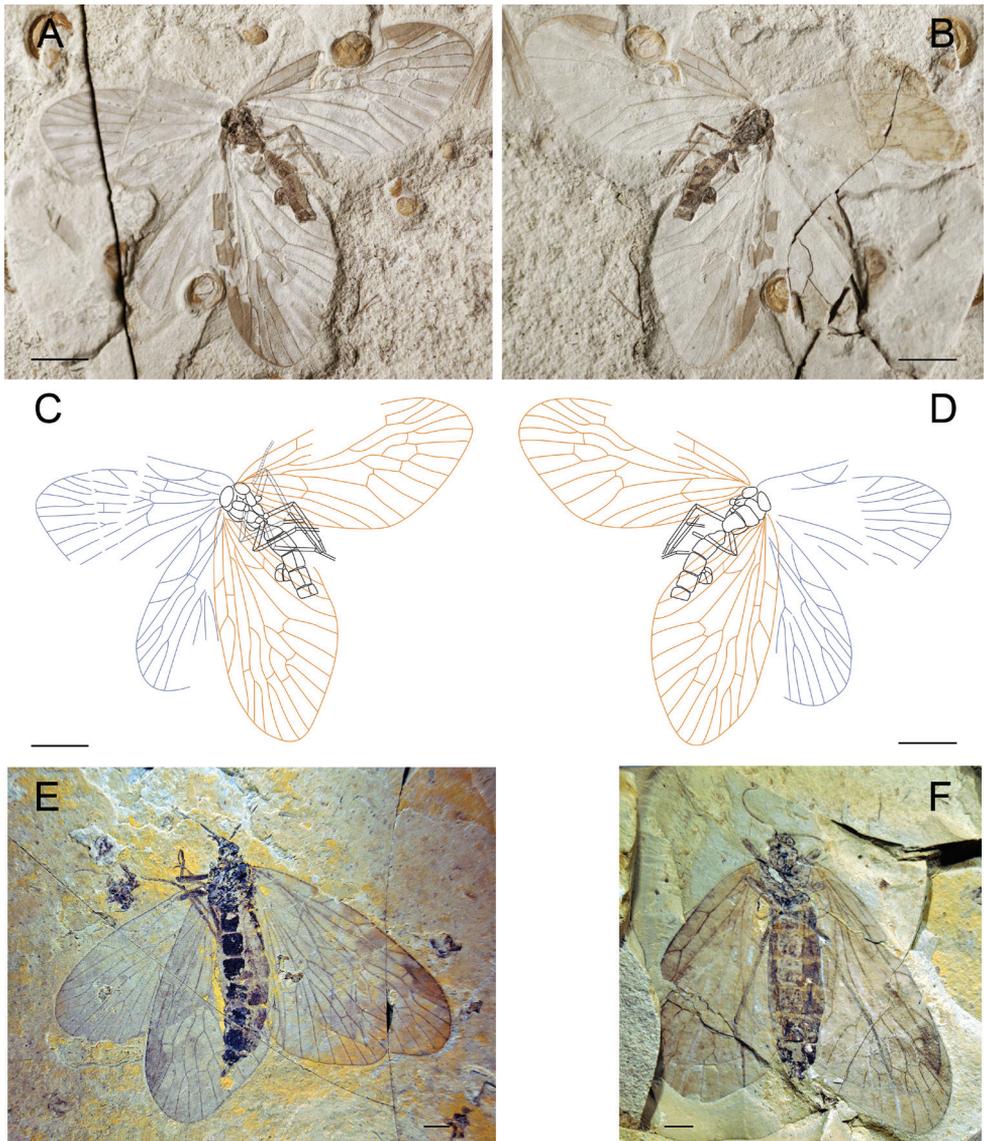


Figure 4. Photographs and line drawings of *Choristopsyche asticta* sp. n. **A** Photograph of part of holotype, no. CNU-MEC-NN2009394p **B** Photograph of counterpart of holotype, no. CNU-MEC-NN2009394c **C** Line drawing of part of holotype, no. CNU-MEC-NN2009394p **D** Line drawing of counterpart of holotype, no. CNU-MEC-NN2009394c **E** Photograph of paratype, no. CNU-MEC-NN2011081 **F** Photograph of paratype, no. CNU-MEC-NN2011086. Scale bars of **A–D** represent 5 mm. Scale bars of **E–F** represent 2 mm.

wing, length at about 16.6 mm, width 8.1 mm. CNU-MEC-NN2011086 (Fig. 4F), female, an fairly well-preserved specimen in dorsal view, forewings overlapping hind wings, with almost complete body; Forewing, length 20.8 mm, width at about 9.4

mm; RP forking basal to the forking of MA; MP₂₊₃ forking at the same level to the forking of MA; the stem of MP₃ about twice as long as the stem of MP₂₊₃. Hind wing, length 17.3 mm, width at about 9.0 mm.

Material. Holotype CNU-MEC-NN2009394p/c, Paratypes CNU-MEC-NN2011081, CNU-MEC-NN2011086, deposited in CNUB.

Type locality and horizon. Daohugou Village, Ningcheng County, Inner Mongolia, China, Jiulongshan Formation, Middle Jurassic (Bathonian–Callovian boundary interval, ca 164–165 Ma).

Etymology. The name is derived from the Latin word of *astictus*, meaning “no spots”.

***Paristopsyche* gen. n.**

urn:lsid:zoobank.org:act:B960BA0B-429E-4BCE-96D5-D59BDB7CC263

<http://species-id.net/wiki/Paristopsyche>

Type species. *Paristopsyche angelineae* sp. n..

Diagnosis. Forewing, the separation of RP+MA from RA at about the same level as the separation of MP from CuA.

Included species. Type species: *Paristopsyche angelineae* sp. n..

Etymology. The name is derived from the Greek word of *paris-*, meaning “equal”, and *psyche*, from the Greek, meaning “soul” or “mind”. The gender is feminine.

***Paristopsyche angelineae* sp. n.**

urn:lsid:zoobank.org:act:6C1AA33E-D1B1-4D52-9B7F-240CFA9FB1EB

http://species-id.net/wiki/Paristopsyche_angelineae

Figs 5, 6

Diagnosis. Forewing, RP+MA forking distal to MP forking.

Description. Holotype, CNU-MEC-NN2011076p/c (Figs 5A–D), a well preserved specimen in dorsal view, with outspread clear wings, but parts of body visible. Some segments of head, thorax, legs visible, but faint. Wings: Right forewing, length 8.4 mm, width 5.5 mm, broadly oval with clear venation, RP forking distal to MA forking; MP₂₊₃ forking at about the same level of the forking of MA; the stem of MP₃ about three times as long as the stem of MP₂₊₃; with one crossvein between MA and MP₁₊₂₊₃, and between MP₂₊₃ and MP₄. Left forewing is similar to right forewing, but the apex of the wing absent. Right hind wing, length at about 7.5 mm, width 4.6 mm, similar to forewing, but smaller, and overlapping with forewing partially. Left hind wing is similar to left hind wing, but partly folded as preserved. There are many spots on all four wings, symmetric between left and right wings.

Paratypes: CNU-MEC-NN2009319 (Fig. 5E), a partially preserved specimen with forewings and one hind wing, but body absent; forewing, length 9.0 mm, width 5.4 mm, RP forking distal to MA forking; MP₂₊₃ forking at about the same level of

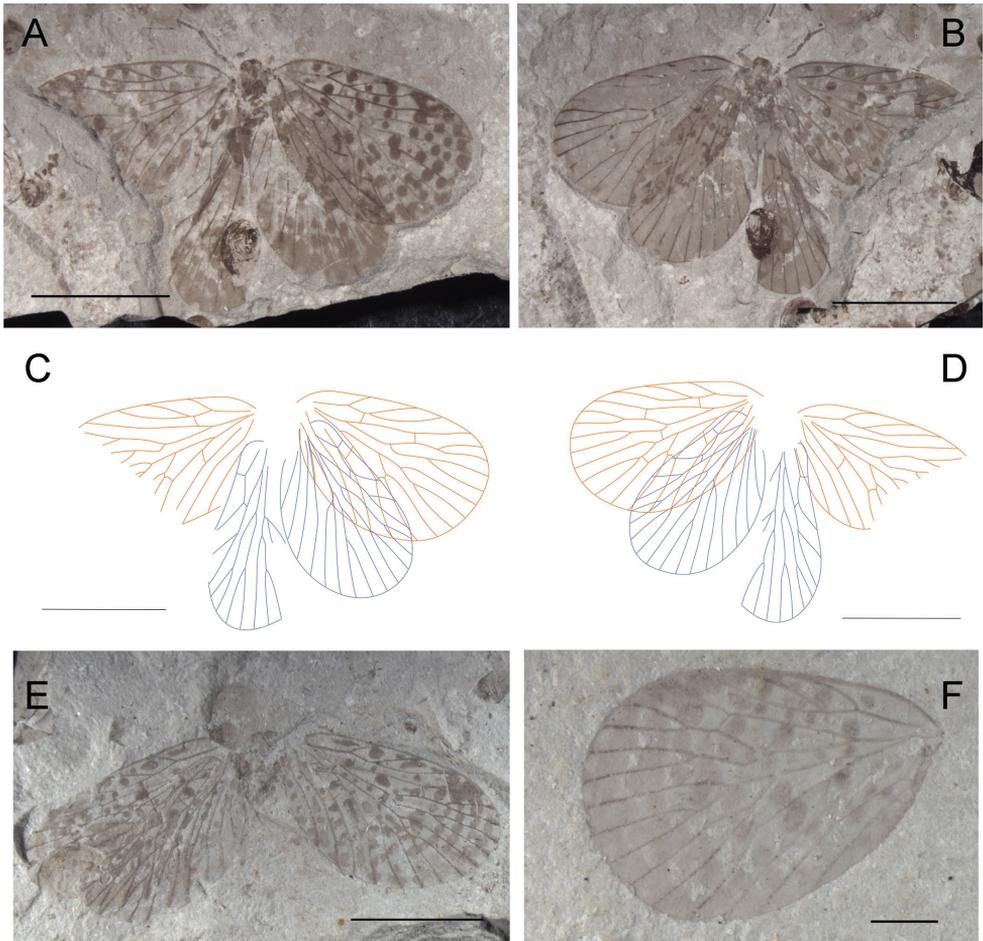


Figure 5. Photographs and line drawings of *Paristopsyche angelineae* gen. et sp. n. **A** Photograph of part of holotype, no. CNU-MEC-NN2011076p **B** Photograph of counterpart of holotype, no. CNU-MEC-NN2011076c **C** Line drawing of part of holotype, no. CNU-MEC-NN2011076p **D** Line drawing of counterpart of holotype, no. CNU-MEC-NN2011076c **E** Photograph of paratype, no. CNU-MEC-NN2009319 **F** Photograph of paratype, no. CNU-MEC-NN2011074. Scale bars of **A–E** represent 5 mm. Scale bar of **F** represents 1 mm.

the forking of MA; the stem of MP_3 about three times as long as the stem of MP_{2+3} . CNU-MEC-NN2011074 (Fig. 5F), a specimen with one complete and clear forewing, length 7.4 mm, width 5.2 mm, RP forking distal to MA forking; MP_{2+3} forking at about the same level of the forking of MA; the stem of MP_3 about three times as long as the stem of MP_{2+3} . CNU-MEC-NN2011069 (Figs 6A, B), a partially preserved specimen, with complete left wings and most of body except for the terminalia, but incomplete right wings in dorsal view. Wings: right forewing, length 11.2 mm, width 7.5 mm, broadly oval, field between C and RA wide; RP forking distal to MA forking; MP_{2+3} forking distal to the forking of MA; the stem of MP_3 about twice as long

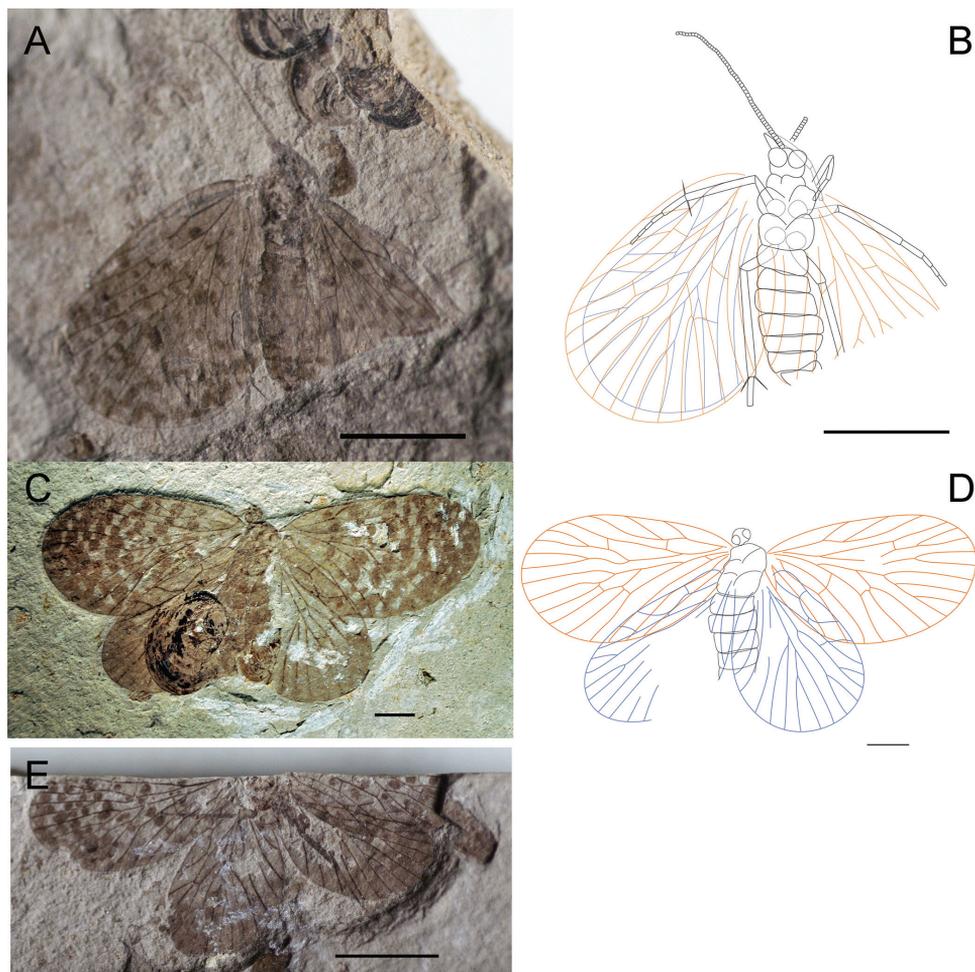


Figure 6. **A–B** Photographs and line drawings of paratypes of *Paristopsyche angelinae* sp. n. **A** Photograph of paratype, no. CNU-MEC-NN2011069 **B** Line drawing of paratype, no. CNU-MEC-NN2011069 **C** Photograph of paratype, no. CNU-MEC-NN2011078 **D** Line drawing of paratype, no. CNU-MEC-NN2011078 **E** Photograph of paratype, no. CNU-MEC-NN2011077. Scale bars of **A, B, E** represent 5 mm. Scale bars of **C–D** represent 2 mm.

as the stem of MP_{2+3} ; CuP, 1A, 2A, single. Right hind wing is similar to forewing, but slightly smaller. Left wings partially preserved. CNU-MEC-NN2011078 (Figs 6C, D), an almost preserved specimen in dorsal view, with outspread clear wings, but parts of body absent. Wings: Left forewing, length 10.7 mm, width 6.4 mm, RP forking at the same level of the forking of MA; MP_{2+3} forking basal to the forking of MA; the stem of MP_3 about four times as long as the stem of MP_{2+3} ; with one crossvein between MP_3 and MP_4 , and between 1A and 2A; CuP, 1A, 2A single. Right forewing, similar to left forewing, but individual asymmetry is shown by right wing having MP_3 with two branches, not the typical one branch in the left wing. Hind wings, length 8.2 mm,

width 6.2 mm, similar to forewings but smaller, and partially preserved. CNU-MEC-NN2011077 (Fig. 6E), a partially preserved specimen with complete hind wings but parts of forewings and body; Forewing, length at about 10.3 mm, RP forking at the same level of the forking of MA; MP_{2+3} forking basal to the forking of MA; the stem of MP_3 about three times as long as the stem of MP_{2+3} ; Hind wing, length at about 7.9 mm, width 5.0 mm.

Material. Holotype CNU-MEC-NN2011076p/c, Paratypes CNU-MEC-NN2011078, CNU-MEC-NN2011077, CNU-MEC-NN2011069, CNU-MEC-NN2009319, CNU-MEC-NN2011074, deposited in CNUB.

Type locality and horizon. Daohugou Village, Ningcheng County, Inner Mongolia, China, Jiulongshan Formation, Middle Jurassic (Bathonian–Callovian boundary interval, ca 164–165 Ma).

Etymology. The specific name is dedicated to Ms. Janet Angeline for her professionalism, dedication and accomplishments in her field and providing inspiration and support to CKS’s palaeontology studies.

Remarks. These six specimens exhibit differences in the characters of “RP forking vs. MA forking”, “ MP_{2+3} forking vs. MA forking” and “Length ratio of the stem of MP_3 and the stem of MP_{2+3} ”, which are considered as intraspecific variations.

Discussion

Willmann (1989) synonymized Choristopsychidae with Agetoparnopidae Carpenter, 1930 because of forewing venation. Novokshonov (2002) synonymized Choristopsychidae and Agetoparnopidae with Permochoristidae Tillyard, 1917 also because of wing venation of the forewing. Based on our new findings about the characters of Choristopsychidae and the reported family of Agetoparnopidae by Carpenter (1930) and Permochoristidae by Tillyard (1917), there are significant differences between Choristopsychidae, Agetoparnopidae and Permochoristidae. For example, the former has broad oval wings (vs. long and narrow), MA vein with 2 branches (vs. 3 branches), MP vein with 5 branches (vs. 6 branches), CuA strongly bent at its mid point (vs. CuA without bending) etc. Therefore, we consider that it is justifiable for Martynov in setting up the family of Choristopsychidae.

Based on studies of our specimens and the reported species of Choristopsychidae, we found the wing venation of this family is comparatively stable, that is, the numbers of branches of ScP, RP, MA, MP have almost no changes in these specimens. However we observed significant differences regarding the relative positions between bifurcation points of two different veins, especially the origination locations of the main veins. In the literature of Mecoptera taxonomy, these characters have been used as diagnostic characters for genera or species, such as in Orthophlebiidae, Aneuretopsychidae and so on (Hong and Zhang 2007, Qiao et al. 2012a, 2012b, Ren et al. 2011). Therefore, we contend the character of “the separation of RP+MA from RA distal, basal or at the same level to the separation of MP from CuA” is the generic diagnostic character for

Choristopsychidae; and the character of “the relative positions (basal or distal) between the forking of RP+MA and the forking of MP” is the specific diagnostic character. On the other hand, to avoid over classification of species, we also consider the characters of “RP forking vs. MA forking”, “MP₂₊₃ forking vs. MA forking” and “Length ratio of the stem of MP₃ and the stem of MP₂₊₃” are intraspecific variations.

Choristopsychids have relatively broad wings, either oval or subtriangular-shaped, with length/width ratio from 1.5 to 2.0, in contrast to long and narrow wings of most mecopterans. To compare relative forewing broadness for representative mecopterans, we summarize the data of forewing length, width and ratio of wing length/width in Table 1 and plot the ratio of wing length/width vs. wing length (in mm) in Fig. 7. The data and Fig. 7 indicate the family of Choristopsychidae has the lowest ratio, meaning broadest forewings among mecopterans. In addition, the data and Fig. 7 seem to show a general trend that for representative specimens of these families, the larger the body size, the narrower the forewings (comparatively higher ratio). The linear regression trend line is represented by $Y1 = 0.036 * X + 2.620$. For example, the family of Cimbrophlebiidae have large body size, with forewing length from 25 mm to 30 mm, and high ratio, with L/W ratio from 3.5 to 4.4 (Bruce 2009, Yang et al. 2012b). It is also noted that Panorpididae have unusually high ratio (more slender), with L/W ratio from 4 to 5, for their relatively small body size, with forewing length from 10 mm to 14 mm (Fu and Hua 2009, Zhou et al. 1993). If we exclude the data of Panorpididae, the linear regression trend line is $Y2 = 0.056 * X + 1.977$. The higher value of slope indicates clearer trend that the larger the body size, the narrower the forewings for all these families of Mecoptera excluding Panorpididae.

The oval-shape forewings for choristopsychids are rather unique for mecopterans. Broad subtriangular (*Choristopsyche asticta* sp. n.) forewings can be found in *Pseudopolycentopus* (e.g. *P. janeannae* Ren, Shih & Labandeira, 2010, *P. novokshonovi* Ren, Shih & Labandeira, 2010, and *Sinopolycentopus rasnitsyni* Shih, Yang, Ren & Labandeira, 2011) with length/width ratio 2.1, 2.2 and 2.5 respectively (Ren et al. 2010c, Shih et al. 2011), slightly narrower than that of *C. asticta* sp. n. with a subtriangular forewing and a ratio of 2.0.

Spots and bands of dark and light color are rather common for many mecopteran fossils from the Middle Jurassic of northeastern China. However, the patterns and many dark and light spots on all four wings, symmetric between left and right wings, are unique for choristopsychids (except for *C. asticta* sp. n. without dots). It is likely that these spots and patterns on forewings might have served potential functions of mimicry, disruptive camouflage, or mate identification. The symmetric pattern between the left and right wings suggests that these dots may have been genetically controlled for an individual. We do not use the spots and bands as a diagnostic character.

The paratype of *Paristopsyche angelinae* sp. n. (CNU-MEC-NN2011078) exhibits individual asymmetry by having vein MP₃ with two branches on the right wing, not the typical one branch on the left wing. Numerous cases of asymmetric variations within individual fossil insects have been reported from the Mesozoic of northeastern China. In the paratype of *Synapocossus sciaccchitanoae* Wang, Shih &

Table 1. Data of forewing length, width and length/width ratio of representatives of ten Families in Mecoptera.

Family	Genus	Species	No. of fossil	Length of forewing (mm)	Width of forewing (mm)	Ratio of length/width
Aneurtopsychidae Rasnitsyn & Kozlov, 1990	<i>Jeholopsyche</i> Ren, Shih & Labandeira, 2011	<i>J. liaoningensis</i> Ren, Shih & Labandeira, 2011	CNU-M- LB2005002	21.5	6	3.6
		<i>J. completa</i> Qiao, Shih & Ren, 2012	CNU-MEC- LB2011062	16.5	5.2	3.2
		<i>J. bella</i> Qiao, Shih & Ren, 2012	CNU-MEC- LB2011063	17	5.4	3.2
		<i>J. maxima</i> Qiao, Shih & Ren, 2012	CNU-MEC- LB2011064	31.7	8.5	3.7
Orthophlebiidae Handlirsch, 1906	<i>Orthophlebia</i> Westwood, 1845	<i>O. liaoningensis</i> Ren, 1997	LB95055	16	4.6	3.5
		<i>O. nervulosa</i> Qiao, Shih & Ren, 2012	CNU-MEC- NN2011060	27.5	6.0	4.6
Eomeropidae Cockerell, 1909	<i>Tsuchingothauma</i> Ren & Shih, 2005	<i>T. shihi</i> Ren & Shih, 2005	M-NN200401	28	10.5	2.7
	<i>Typhothauma</i> Ren & Shih, 2005	<i>T. yixianensis</i> Ren & Shih, 2005	M-LB200401	18	8	2.3
Pseudopolycentropodidae Handlirsch, 1925	<i>Pseudopolycentropus</i> Handlirsch, 1906	<i>P. janeanae</i> Ren, Shih & Labandeira, 2010	CNU-M- NN2005001	8	4	2
		<i>P. novokshonovi</i> Ren, Shih & Labandeira, 2010	CNU-M- NN2005002	8	3.9	2.1
	<i>Sinopolycentropus</i> Shih, Yang & Labandeira, 2011	<i>S. rasnitsyni</i> Shih, Yang & Labandeira, 2011	CNU-MEC- NN2010044	6.1	2.4	2.5
Cimbrophlebiidae Willmann, 1977	<i>Cimbrophlebia</i> Willmann, 1977	<i>C. flabelliformis</i> Bruce, 2009	UCCIPR L-18 F-763	28	7	4
		<i>C. leahyi</i> Bruce, 2009	TRUIPR L-018 F-1161	31	8	3.9
		<i>C. brooksi</i> Bruce, 2009	SR062005	31	7	4.4
		<i>C. westae</i> Bruce, 2009	SRUI099600	25	6	4.2
	<i>Perfecticimbrophlebia</i> Yang, Shih & Ren, 2012	<i>P. laetus</i> Yang, Shih & Ren, 2012	CNU-M- NN2010004	26.9	7.6	3.5
Nannochoristidae Tillyard, 1917	<i>Protochoristella</i> Sun, Ren & Shih, 2007	<i>P. polyneura</i> Sun, Ren & Shih, 2007	CNU-M- NN2006049	7.5	2	3.8
		<i>P. formosa</i> Sun, Ren & Shih, 2007	CNU-M- NN2006006	8	3	2.7
	<i>Itaplebia</i> Sukatsheva, 1985	<i>I. exquisita</i> Liu, Zhao & Ren, 2010	CNU-MEC- NN2009145	10.2	3.5	2.9
		<i>I. laeta</i> Liu, Zhao & Ren, 2010	CNU-MEC- NN2009311	8.2	2.6	3.2

Family	Genus	Species	No. of fossil	Length of forewing (mm)	Width of forewing (mm)	Ratio of length/width	
Mesopsychidae Tillyard, 1917	<i>Lichnomesopsyche</i> Ren, Labandeira & Shih, 2010	<i>L. gloriae</i> Ren, Labandeira & Shih, 2010	CNU-M- NN2005020	25	7	3.6	
		<i>L. daohugouensis</i> Ren, Labandeira & Shih, 2010	CNU-M- NN2005022	22	6.5	3.4	
	<i>Vitimopsyche</i> Novokshonov & Sukatasheva, 2001	<i>V. kozlovi</i> Ren, Labandeira & Shih, 2010	CNU-M- HP2005001	24	8	3	
Bittacidae Handlirsch, 1906	<i>Exilibittacus</i> Yang, Ren & Shih, 2012	<i>E. lii</i> Yang, Ren & Shih, 2012	CNU-M- NN2010001	7.5	2.2	3.4	
		<i>Preanabittacus</i> Novokshonov, 1993	<i>P. validus</i> Yang, Ren & Shih, 2012	CNU-MEC- NN2010005	18.7	5.6	3.3
		<i>Megabittacus</i> Ren, 1997	<i>M. spatiosus</i> Yang, Ren & Shih, 2012	CNU-MEC- NN2010003	41.0	11.5	3.6
		<i>Formosibittacus</i> Li, Ren & Shih, 2008	<i>F. macularis</i> Li, Ren & Shih, 2008	CNU-M- NN2007001	23	5	4.6
		<i>Jurahylobittacus</i> Li, Ren & Shih, 2008	<i>J. astictus</i> Li, Ren & Shih, 2008	CNU-M- NN2007002	12.6	3.0	4.2
Panorpidae Latreille, 1805	<i>Panorpa</i> Linnaeus, 1758	<i>P. kummingensis</i> Fu & Hua, 2009	28-08-1985	10.0-10.3	2.1-2.5	4.1-4.8	
		<i>P. kiautai</i> Zhou, Hu & Wu, 1993	1982-03-25	14.0	3.0	4.7	
		<i>P. choui</i> Zhou, Hu & Wu, 1993	1986-07-20	14.0	3.5	4	
		<i>Neopanorpa</i> Zhou, Hu & Wu, 1993	<i>N. obtrusa</i> Zhou, Hu & Wu, 1993	1987-06-20	11.0	2.2	5
		<i>N. moganshanensis</i> Zhou, Hu & Wu, 1993	1982-07-20	12.5	3	4.2	
		<i>N. tengchongensis</i> Zhou, Hu & Wu, 1993	1983-05-24	14	3	4.7	
		<i>N. menghaiensis</i> Zhou, Hu & Wu, 1993	1984-04-25	14.5	2.8	5.2	
		Choristopsychidae Martynov, 1937	<i>Choristopsyche</i> Martynov, 1937	<i>C. tenuinervis</i> Martynov, 1937		9.5	5
	CNU-MEC- NN2011080			11.8	6.7	1.8	
	CNU-MEC- NN2009317			9.5	4.9	1.9	
	CNU-MEC- NN2009414			10.1	6.4	1.6	
<i>C. perfecta</i> sp. n.	CNU-MEC- NN2009352			18.8	10.0	1.9	

Family	Genus	Species	No. of fossil	Length of forewing (mm)	Width of forewing (mm)	Ratio of length/width
			CNU-MEC-NN2011082	22.2	11.4	1.9
		<i>C. asticta</i> sp. n.	CNU-MEC-NN2009394	20.7	10.2	2.0
	<i>Paristopsyche</i> gen. n.	<i>P. angelinae</i> sp. n.	CNU-MEC-NN2011069	11.2	7.5	1.5
			CNU-MEC-NN2011078	10.7	6.4	1.7
			CNU-MEC-NN2011076	8.4	5.5	1.5

The ratio of forewing L/W

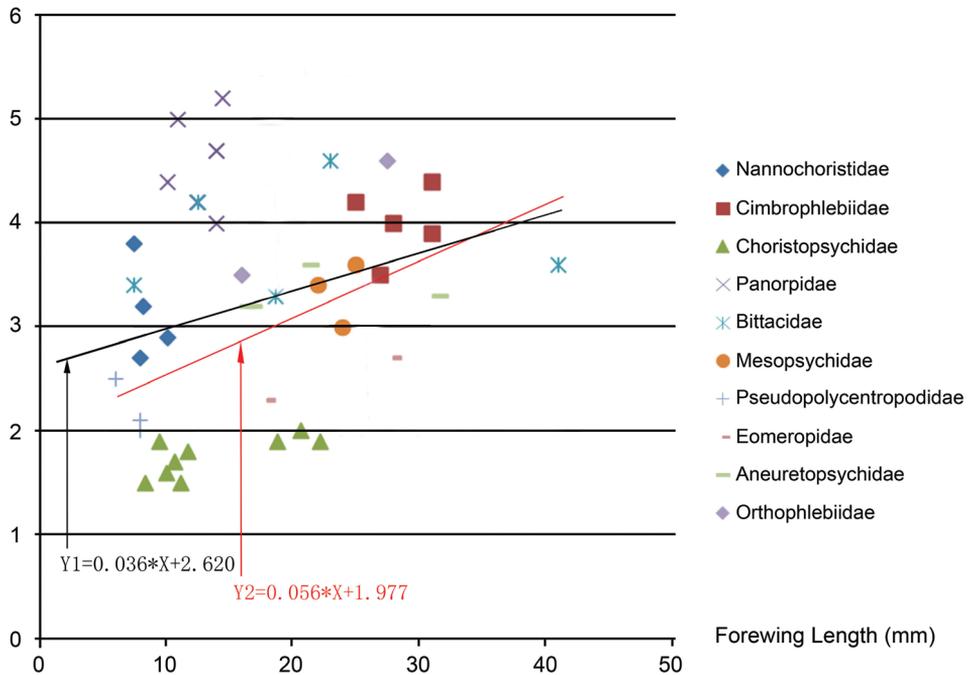


Figure 7. The ratio of forewing length (L)/width (W) vs. forewing length (in mm) of ten representative Families of Mecoptera. For all data points, the linear regression trend line is represented by $Y1 = 0.036 * X + 2.620$. Excluding the data of Panorpidae, the linear regression trend line is $Y2 = 0.056 * X + 1.977$.

Ren, 2012 from Daohugou, China, the left and right forewings of CNU-HEM-NN2007008p/c show some individual variation, i.e., 1 mm of coalescence within the left wing and only a point contact on the right wing (Wang et al. 2012). An odonatan species, belonging to Campterothlebiidae Handlirsch, 1920, has veins MA and MP fusing before the nodus in the left wing whereas the right wing has normal

venation (Zhang et al. 2008, Fig. 6). For Plecoptera, the variability of wing venation and the difference between the left and right wings of the same individual have been described in *Sinosharaperla zhaoi* Liu, Sinitshenkova & Ren, 2007 (Liu et al. 2007). *Exilibittacus lii* Yang, Ren & Shih, 2012 of Bittacidae (Mecoptera) has interesting asymmetric venational characters that RP+MA and MP of its left hind wing having only three branches and RP1+2 and MP3+MP4+CuA1+2 not forking, even though RP+MA and MP of its left and right forewings with typical four branches as those of most hangingflies (Yang et al. 2012a). Also the bittacid *Mongolbitacus daohugoensis* Petrulevičius, Huang and Ren, 2007 shows asymmetry in the anal veins of the forewings (Petrulevičius et al. 2007).

These new Chinese Choristopsychids, the first record in China, show many venational differences from the previously reported *Choristopsyche tenuinervis* Martynov, 1937. In addition, these new fossils with well preserved body structure and wings enhance our understanding of the morphological characters of this family, and provide a basis for future phylogenetic studies. Furthermore, these new species from China reveal that the early diversification of Choristopsychidae was well underway by the Middle Jurassic, while broadening the diversity of Mesozoic Mecoptera in China.

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