ZooKeys 1102: 1–42 (2022)
doi: 10.3897/zookeys.1102.84953
https://zookeys.pensoft.net

RESEARCH ARTICLE

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Revision of Taiwanese and Ryukyuan species of *Pristepyris* Kieffer, 1905, with description of a new species (Hymenoptera, Bethylidae)

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Academic editor: F. J. Peris Felipo | Received 6 April 2022 | Accepted 21 April 2022 | Published 19 May 2022

http://zoobank.org/2398E5CC-9413-4AE5-976B-DEF9F138A814

Citation: Liao H, Terayama M, Eguchi K (2022) Revision of Taiwanese and Ryukyuan species of *Pristepyris* Kieffer, 1905, with description of a new species (Hymenoptera, Bethylidae). ZooKeys 1102: 1–42. https://doi.org/10.3897/zookeys.1102.84953

Abstract

The pristocerine genus *Pristepyris* comprises 38 valid species recorded worldwide, except in the Australian Region. Of them, three species, namely *P. mieae* (Terayama, 1995), *P. tainanensis* (Terayama, 1995) and *P. takasago* (Terayama, 1996), have been recorded from Taiwan and three species, i.e. *P. ishigakiensis* (Yasumatsu, 1955), *P. minutus* (Yasumatsu, 1955) and *P. ryukyuensis* (Terayama, 1999), from the Ryukyus in Japan. In the present study, the species-level classification of both Taiwanese and Ryukyuan species of *Pristepyris* was revised using newly-collected specimens by the external and male genital morphological as well as molecular phylogenetic analysis. Overall, six species of *Pristepyris* were recorded from Taiwan and the Ryukyus. Among these, five were previously recorded for the region and were revised here: *P. ishigakiensis*, *P. mieae*, *P. ryukyuensis*, *P. tainanensis* and *P. zhejiangensis*. Additionally, a new species, *P. seqalu* **sp. nov.**, is herein described and illustrated. Furthermore, the species *P. minutus* is transferred to *Eleganesia* and *P. takasago* is synonymized under *P. minutus*. Due to the new combination of *Pristepyris minutus*, a key to Taiwanese and Ryukyuan species of the genus *Eleganesia*, based on male morphology, is provided in Appendix 1. We confirmed for the first time the correspondence between the male and female species of *P. zhejiangensis* by molecular data. High compatibility in species delimitation patterns, suggested by the morphological and molecular phylogenetic approaches, highlighted the significance of the former approach for accurately classifying aged voucher specimens of Pristocerinae in public collections.

Keywords
Flat wasp, Japan, male genitalia, molecular phylogeny, morphology, Pristocerinae, Taiwan

Introduction

Bethylidae, also known as flat wasps, are a cosmopolitan family belonging to the Chrysidoidea; they involve approximately 2,900 valid named species (excluding fossil species) that are assigned to 96 genera of nine subfamilies in the current classification (Azevedo et al. 2018; Colombo et al. 2020). Flat wasps are parasitoids, which are potential natural enemies of lepidopteran (Noctuidae, Tortricidae) and coleopteran (Cerambycidae, Curculionidae) pests in farmlands, orchards and timber plantations (Azevedo et al. 2018).

Recently, Alencar et al. (2018) and Azevedo et al. (2018) significantly revised the classification of the subfamily Pristocerinae, by combining conventional morphological examination and molecular phylogenetic analysis. The revised classification is the best working hypothesis for further taxonomic and other related studies in specific geographic regions (Liao et al. 2019, 2021).

As a part of our long-term project to revise and update the species and higher classifications of East and Southeast Asian Bethylidae, we focused on the genus *Pristepyris* (Kieffer 1905; sensu Alencar et al. 2018). This genus consists of 38 validly-named species recorded from the Ethiopian (one species), Nearctic (19 species), Neotropic (three species), Oriental (ten species) and Palaearctic (four species) Regions (Azevedo et al. 2018). Of them, three species, namely *P. mieae*, *P. tainanensis* and *P. takasago*, are recorded from Taiwan and three species, namely *P. ishigakiensis*, *P. minutus* and *P. ryukyuensis*, from the Ryukyu Islands in Japan (Azevedo et al. 2018). In the present study, the species-level classification of Taiwanese and the Ryukyuan species of *Pristepyris* has been revised using an integrative approach of morphological examination and molecular phylogenetic analyses using newly-collected specimens.

Materials and methods

Sampling sites

Pristepyris specimens were collected by sweeping undergrowth along trails in the woody habitats in the following localities: Taipei and New Taipei City (northern Taiwan, Oct 2017, May 2018, Oct 2019); Nantou County (central Taiwan, Mar 2019); Hualian County (eastern Taiwan, Oct 2019); Pingtung County (southern Taiwan, May and Oct 2017); Yakushima, Okinawa Hontou, Irabu–jima, Ishigaki–jima and Iriomote–jima Islands (Aug 2017, Jul 201, Sep 2021); and Tokyo (Apr 2016, Aug 2020) (Fig. 1). Collected specimens were preserved in 99% ethanol.

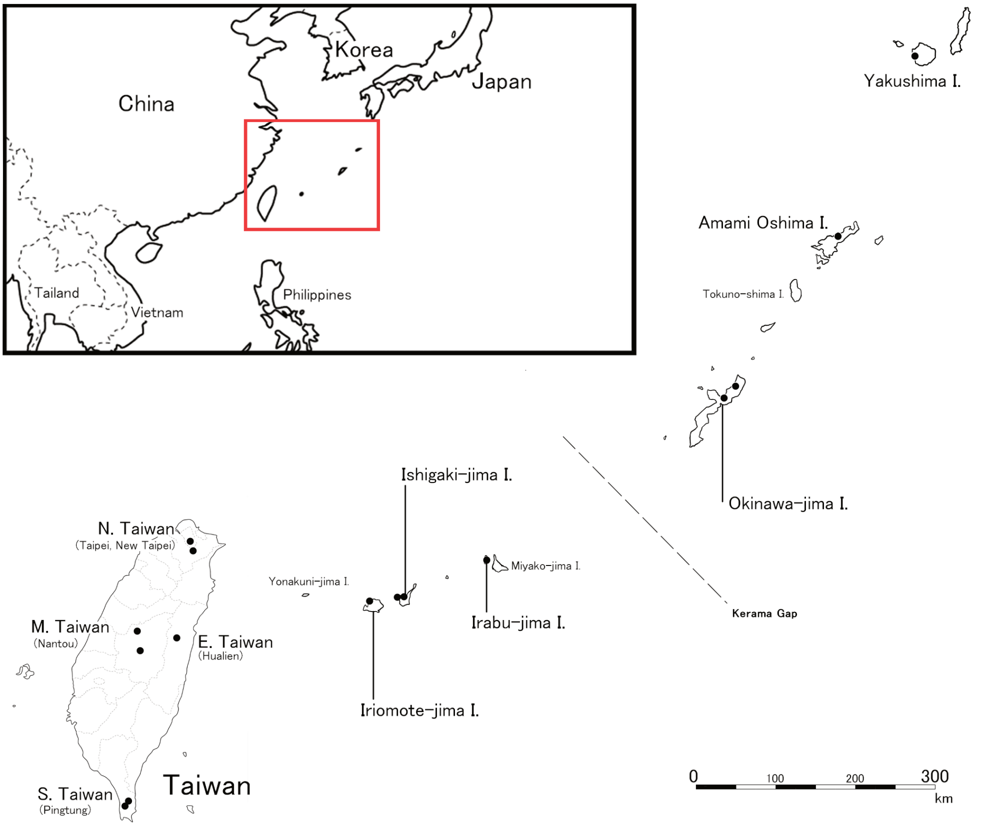

Figure 1. Sampling sites (dots) of *Pristepyris* and *E. minuta* comb. nov. in the present study. From northern Ryukyu to southern Taiwan, including Tokyo City, Japan

Specimen depository

Specimens examined in the current study are (or will be) deposited in the following institutions:

HUS	Hokkaido University, Sapporo (Laboratory of Systematic Entomology) (Masahiro Ohara);
NMNS	National Museum of Natural Science, Taichung City, Taiwan (Jingfu Tsai);
NIAES–NARO	Institute for Agro-Environmental Sciences–National Agriculture and Food Research Organization, Tsukuba, Japan (Junsuke Yamasako);
NSMT	National Museum of Nature and Science, Tokyo, Japan (Tsukuba Research Departments, Tsukuba, Japan) (Tatsuya Ide);
SCAU	South China Agricultural University, China;
TARI	Taiwan Agricultural Research Institute, Taichung (Chifeng Lee).

Morphology-based examination and identification

Following the definition of the genus *Pristepyris* proposed by Alencar et al. (2016) and Azevedo et al. (2018), 76 *Pristepyris* specimens (73 males and three females) were recogniszed in the current study. They were then sorted into morphospecies, based on external and male genital morphology and identified at the species level by referring to the original descriptions or by examining the type materials (or high-resolution images of the type materials provided by NARO) of the following named congeners recorded from Taiwan, the Ryukyus and their adjacent areas (mainland Japan and China).

P. ishigakiensis (Yasumatsu, 1955), Japan, original description
P. japonicus (Yasumatsu, 1955), Japan, original description. Additional non-type material examined. Two males (JT160420_01, JT200820_03); Minami-osawa, Hachiouji City, Tokyo Pref., Japan, 35°37'11"N, 139°23'03"E, 154 m alt. HauChuan Liao leg. (sweeping); 20/IV/2016, 20/VIII/2020.
P. mieae (Terayama, 1995), Taiwan, holotype (female, NARO), examined.
P. minutus (Yasumatsu, 1955), Japan, holotype (male, KUF), examined.
P. rugulosus (Terayama et al. 2002), China, holotype (male, SCAU), examined.
P. ryukyuensis (Terayama, 1999), Japan, holotype (male, NARO), examined.
P. sinensis (Terayama et al. 2002), China, holotype (male, SCAU), examined.
P. tainanensis (Terayama, 1995), Taiwan, paratype (male, NARO), examined.
P. takasago (Terayama, 1995), Taiwan, holotype (male, NARO), examined.
P. zhejiangensis (Terayama et al. 2002), China, holotype (male, SCAU), examined.

Imaging, measurements, indices and terminology

Morphological examination, imaging, line-drawing and measurement were performed as in Liao et al. (2021): **HL**, head length, from the anterior margin of the clypeus to the posterior margin of the head in dorsal view; **HW**, maximum width of head including compound eyes; **EL**, compound eye length in dorsal view; **POL**, minimum distance between median margins of posterior ocelli; **WOT**, maximum distance between lateral margins of posterior ocelli; **AOL**, minimum distance between antero-inner margin of posterior ocellus and posterolateral margin of anterior ocellus; **OOL**, minimum distance between anterolateral margin of posterior ocellus and posteromedian margin of compound eye; **DAO**, transverse diameter of anterior ocellus; **LM**, length of mesosoma, measured from the anteriormost flange of the pronotum to the posteriormost of the metapectal-propodeal complex; **LMT**, length of metasoma, measured from the posteriormost of the metapectal-propodeal complex to the apex of the gaster (excluding the sting); **LPD,** length of the dorsal pronotal area, measured in lateral view from the junction between the pronotal flange and dorsal pronotal area to the posteriormost point of the dorsal pronotal area; **WPD,** maximum width of the dorsal pronotal area; **LP**, length of the metapectal-propodeal complex, measured from the junction of the transverse anterior carina and median carina to the posteriormost of the metapectal-propodeal complex; **WP**, width of the metapectal-propodeal complex,

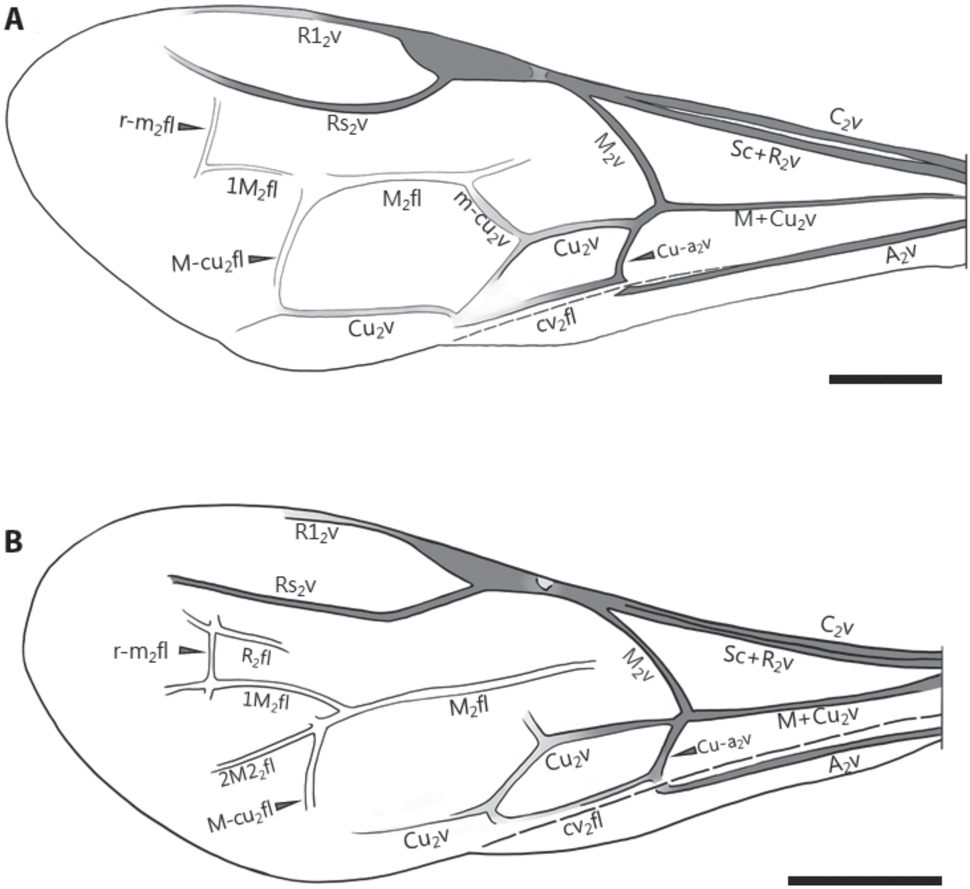

Figure 2. Forewing venation **A** *Pristepyris*, drawing was made based on *P. ishigakiensis* (JI170808_38). **B** *Eleganesia*, drawing was made, based on *E. minuta* comb. nov. (JO190717_13). Scale bars: 0.5 mm.

measured along the transverse line passing the anteriormost points of the propodeal spiracles; **TL**, total body length. Sensilla placodea (antennal plate organs) were taken by a JSM-6510 scanning electron microscope. The morphological terminology follows predominantly Lanes et al. (2020). Fig. 2 depicts the abbreviations of forewing veins.

DNA sequencing

A total of 39 specimens of the ingroup morphospecies, including *P. ishigakiensis*, *P. japonicus*, *P. minutus* and *P. zhejiangensis*, were studied for their molecular phylogenetic analyses, together with 67 specimens of 45 outgroup morphospecies of the subfamilies Pristocerinae (12 genera), Epyrinae (one genus) and Scleroderminae (one genus) (Table 1). DNA was extracted from the second and third right legs of each specimen using the Chelex-TE-ProK protocol (Satria et al. 2015) with an incubation time of 24 hours. Nuclear 28S ribosomal RNA (rDNA) was amplified and sequenced using the primer D2B (GTCGGGTTGCTTGAGAGTGC) and D3Ar (TCCGTGTTTCAAGACGGGTC) (Fisher and Smith 2008). Mitochondrial cytochrome oxidase subunit 1 (COI) genes were amplified and sequenced using the primer LCO1490 (GGTCAACAAATCATAAAGATATTGG) and HCO2198 (ATGTGCGTTCRAAATGTCGATGTTCA) (Folmer et al. 1994). Polymerase chain reaction (PCR) amplification, cycle sequencing reactions, sequencing using ABI PRISM 3130xl (Applied Biosystems) and sequence assembly using ChromasPro 1.7.6 (Technelysium Pty Ltd., Tewantin QLD, Australia) were conducted by following Satria et al. (2015). COI was aligned by ClustalW (Thompson et al. 1994) built-in MEGA X (Kumar et al. 2018) and 28S sequencing done using Multiple Sequence Alignment Software, MAFFT version 7 (Katoh et al. 2019, https://mafft.cbrc.jp/alignment/software/).

Table 1. Data of specimens used for molecular phylogenetic analysis. The data of the morphospecies name labelled "IA" were taken by Alencar et al. (2018). AU = Australia, BR = Brazil, JP = Japan, KY = Kenya, MA = Madagascar, NI = Nigeria, PNG = Papua New Guinea, TH = Thailand, TW = Taiwan.

Specimen no.	Country	Morphospecies	Sex	Coordinates	Accession number	
					28S	COI
Pristepyris						
JI170808_30	JP	*P. ishigakiensis*	M	24°26'N, 124°05'E	LC705070	LC704953
JI170808_33	JP	*P. ishigakiensis*	M	24°26'N, 124°05'E	LC705067	LC704954
JI170808_34	JP	*P. ishigakiensis*	M	24°26'N, 124°05'E	LC705068	LC704955
JI170808_36	JP	*P. ishigakiensis*	M	24°26'N, 124°05'E	LC705069	LC704956
TP171019_10	TW	*P. ishigakiensis*	M	24°04'N, 120°46'E	LC705075	LC704961
TH171007_37	TW	*P. ishigakiensis*	M	23°49'N, 121°33'E	LC705071	LC704957
TH171007_40	TW	*P. ishigakiensis*	M	23°49'N, 121°33'E	LC705072	LC704958
TH171007_41	TW	*P. ishigakiensis*	M	23°49'N, 121°33'E	LC705073	LC704959
TH171007_42	TW	*P. ishigakiensis*	M	23°49'N, 121°33'E	LC705074	LC704960
JT200820_03	JP	*P. japonicus*	M	26°34'N, 128°00'E	LC705077	LC704963
TP170606_13	TW	*P. seqalu* sp. nov.	M	22°08'N, 120°48'E	LC705062	LC704964
TP170606_26	TW	*P. seqalu* sp. nov.	M	22°08'N, 120°48'E	LC705063	LC704949
TN170427_01	TW	*P. zhejiangenisis*	F		LC705084	LC704971
TNT171019_04	TW	*P. zhejiangenisis*	M	24°51'N, 121°33'E	LC706441	LC704972
TNT180504_01	TW	*P. zhejiangenisis*	M	24°51'N, 121°33'E	LC491436	LC490571
TN190315_24	TW	*P. zhejiangenisis*	M	23°51'N, 120°56'E	LC704973	LC704973
JM190717_31	JP	*P. zhejiangenisis*	M	24°49'N, 125°13'E	LC705070	LC704966
JM190717_32	JP	*P. zhejiangenisis*	M	24°49'N, 125°13'E	LC705067	LC704967
JM190717_37	JP	*P. zhejiangenisis*	M	24°49'N, 125°13'E	LC705082	LC704969
JM190717_38	JP	*P. zhejiangenisis*	M	24°49'N, 125°13'E	LC705083	LC704970
JIR190717_47	JP	*P. zhejiangenisis*	M	24°23'N, 123°48'E	LC705078	LC704965
	TH	*P.* sp. 2 (IA)	M		MG760740	MG760791
	TH	*P.* sp. 3 (IA)	M		MG760739	MG760790
Acrenesia						
	BR	*A.* sp. 10 (IA)	M		MG760753	MG760804
	BR	*A.* sp. 11 (IA)	M		MG760754	MG760805

Specimen no.	**Country**	**Morphospecies**	**Sex**	**Coordinates**	**Accession number**	
					28S	**COI**
	BR	*A.* sp. 12 (IA)	M		MG760755	MG760806
	BR	*A.* sp. 13 (IA)	M		MG760756	MG760807
	BR	*A.* sp. 14 (IA)	M		MG760757	MG760808
Apenesia						
JO180202_01	JP	*A. makiharai*	F		LC598842	LC598798
JK171031_03	JP	*A. makiharai*	F		LC705058	LC704945
JK171031_04	JP	*A. makiharai*	F		LC705059	LC704946
	BR	*A. perlonga* (IA)	M		MG760761	MG760812
	PNG	*A.* sp. 1 (IA)	M		MG760759	MG760810
	PNG	*A.* sp. 2 (IA)	M		MG760760	MG760811
Austranesia						
	AU	*A.* sp. 16 (IA)	M		MG760750	MG760801
	AU	*A.* sp. 17 (IA)	M		MG760751	MG760802
	AU	*A.* sp. 18 (IA)	M		MG760752	MG760803
Cleistepyris						
	BR	*C.* sp. 1 (IA)	M		MG760774	MG760830
	BR	*C.* sp. 2 (IA)	M		MG760776	MG760832
	BR	*C.* sp. 3 (IA)	M		MG760780	MG760836
Dissomphalus						
TP170606_28	TW	*D. wusheanus*	M	22°08'N, 120°48'E	LC704947	LC704947
TP170606_30	TW	*D. wusheanus*	M	22°08'N, 120°48'E	LC704950	LC704950
	NI	*D.* sp. 2 (IA)	M		MG760768	MG760821
	NI	*D.* sp. 3 (IA)	M		MG760769	MG760822
Dracunesia						
	BR	*D.* sp. 19 (IA)	M		MG760747	MG760798
	BR	*D.* sp. 21 (IA)	M		MG760748	MG760799
	BR	*D.* sp. 22 (IA)	M		MG760749	MG760800
Eleganesia						
TN160725_25	TW	*E. chitouensis*	M	24°05'N, 121°01'E	LC598843	LC598799
TP170606_25	TW	*E. chitouensis*	M	22°07'N, 120°47'E	LC598846	LC598800
TN181022_01	TW	*E. meifuiae*	M	24°05'N, 121°10'E	LC598862	LC598807
JO170808_05	JP	*E. minuta* comb. nov	M	26°34'N, 128°00'E	LC705098	LC704986
JA170808_13	JP	*E. minuta* comb. nov	M	28°16'N, 129°19'E	LC705092	LC704980
JI170808_28	JP	*E. minuta* comb. nov	M	24°26'N, 124°05'E	LC705093	LC704981
JI170808_35	JP	*E. minuta* comb. nov	M	24°26'N, 124°05'E	LC705099	LC704987
TNT180629_11	TW	*E. minuta* comb. nov	M	24°54'N, 121°30'E	LC705103	LC704991
TNT180706_01	TW	*E. minuta* comb. nov	M	24°53'N, 121°34'E	LC705104	LC704992
TNT180706_06	TW	*E. minuta* comb. nov	M	24°53'N, 121°34'E	LC705105	LC704993
TNT180706_07	TW	*E. minuta* comb. nov	M	24°53'N, 121°34'E	LC705106	LC704994
TNT180706_08	TW	*E. minuta* comb. nov	M	24°53'N, 121°34'E	LC705107	LC704995
TN181022_47	TW	*E. minuta* comb. nov	M	23°51'N, 120°56'E	LC705102	LC704990
JO190717_15	JP	*E. minuta* comb. nov	M	26°45'N, 128°12'E	LC705100	LC704988
JIR190717_49	JP	*E. minuta* comb. nov	M	24°23'N, 123°48'E	LC704985	LC704985
JIR190717_54	JP	*E. minuta* comb. nov	M	24°23'N, 123°48'E	LC705094	LC704982
JT200820_05	JP	*E. minuta* comb. nov	M	26°34'N, 128°00'E	LC705101	LC704989
JK210921_05	JP	*E. minuta* comb. nov	M	30°18'N, 130°25'E	LC705095	LC704983
JK210921_07	JP	*E. minuta* comb. nov	M	30°18'N, 130°25'E	LC705096	LC704984

Specimen no.	Country	Morphospecies	Sex	Coordinates	Accession number	
					28S	COI
TN190315_26	TW	*E. takasago*	M	23°52'N, 120°55'E	LC598834	LC598874
TP170606_C2	TW	*E. takasago*	F	22°07'N, 120°48'E	LC598838	LC598876
TT191007_09	TW	*E. takasago*	M	25°05'N, 121°32'E	LC598839	LC598877
JT200820_02	TW	*E. elegans*	M	35°37'N, 139°23'E	LC598803	LC598857
JM190717_46	JP	*E. kijimuna*	M	24°55'N, 125°18'E	LC598819	LC598848
JO170808_04	JP	*E. kijimuna*	M	26°34'N, 128°00'E	LC598820	LC598849
TP170606_14	TW	*E. paiwan*	M	22°07'N, 120°48'E	LC598818	LC598859
Epynesia						
JO190717_22	JP	*E. bishamon*	M	26°45'N, 128°12'E	LC598841	LC598879
TN170110_27	TW	*E. bishamon*	M		LC704952	LC704952
TD200628_01	TW	*E. bishamon*	F		LC704951	LC704951
Pristocera						
TH191007_25	Taiwan	*P. formosana*	M	23°56'N, 121°31'E	LC705061	LC704948
TNT171019_01	Taiwan	*P. formosana*	M	24°51'N, 121°33'E	LC705087	LC704975
TP171019_08	TW	*P. formosana*	M	22°07'N, 120°45'E	LC490570	LC490572
	KY	*P.* sp. 1 (IA)	M		MG760741	MG760792
	UAE	*P.* sp. 2 (IA)	M		MG760772	MG760825
	TH	*P.* sp. 3 (IA)	M		MG760770	MG760823
	KY	*P.* sp. 4 (IA)	M		MG760742	MG760793
Propristocera						
JO170808_01	JP	*P. okinawensis*	M	26°34'N, 128°00'E	LC479553	LC480272
TN160725_9-2	TW	*P. okinawensis*	M	24°05'N, 121°02'E	LC479556	LC480275
TP170606_18	TW	*P. okinawensis*	M	22°07'N, 121°02'E	LC479561	LC480280
JI170808_19	JP	*P. seediq*	M	24°26'N, 124°05'E	LC479571	LC480290
TNT180706_02	TW	*P. seediq*	M	24°52'N, 121°34'E	LC479579	LC480298
TN160725_01	TW	*P. seediq*	M	24°05'N, 121°02'E	LC479576	LC480295
TP170606_32	TW	*P. seediq*	M	22°07'N, 120°47'E	LC479582	LC480301
JA170808_14	JP	*P. pingtungensis*	M	28°16'N, 129°19'E	LC479543	LC480262
JI170808_17	JP	*P. pingtungensis*	M	24°26'N, 124°05'E	LC479544	LC480263
TH191007_38	TW	*P. pingtungensis*	M	24°01'N, 121°32'E	LC705088	LC704976
TN160725_7-2	TW	*P. pingtungensis*	M	24°05'N, 121°02'E	LC479546	LC480265
TP171019_15	TW	*P. pingtungensis*	M	22°07'N, 120°45'E	LC479552	LC480271
Protisobrachium						
	MA	*P.* sp. 2	M		MG760767	MG760820
Pseudisobrachium						
JI170808_27	JP	*P. ryukyunum*	M	24°26'N, 124°06'E	LC705091	LC704977
TN170110_22	TW	*P. ryukyunum*	M	24°02'N, 121°10'E	LC705090	LC704978
TT191007_01	TW	*P. ryukyunum*	M	25°05'N, 121°36'E	LC705089	LC704979
	BR	*P.* sp. 1 (IA)	M		MG760787	MG760843
	BR	*P.* sp. 2 (IA)	F		MG760788	MG760844
	USA	*P.* sp. 3 (IA)	M		MG760789	MG760845
Trichiscus						
	KY	*T.* sp. 1 (IA)	M		MG760764	MG760817
	KY	*T.* sp. 2 (IA)	M		MG760765	MG760818
Holepyris						
JT200820_11	JP	*H. benten*	M	26°34'N, 128°00'E	LC705108	LC704996
Sclerodermus						
JK171103_01	JP	*Sclerodermus* sp.	F		LC705109	LC704997

Molecular phylogenetic analyses and calculation of genetic distances

Maximum Likelihood (ML) analysis was performed for the concatenated dataset of the COI and 28S datasets (hereafter referred to as the COI + 28S dataset) using IQ tree; ultrafast bootstrap (UFB; Minh et al. 2013) and SH-aLRT (Guindon et al. 2010). Prior to the ML analysis, the model TIM3 + F + G4 was selected for the 28S dataset (472-bp) and TPM2 + F + I + G4 for the COI dataset (602-bp) using ModelFinder and were run using partition analysis in iqtree-2.1.1 (Minh et al. 2020; http://www.iqtree.org/) under the Bayesian Information Criterion (BIC). Furthermore, support values were determined from 1,000 re-samplings.

Bayesian Inference (BI) analyses were performed for the COI + 28S dataset using ExaBayes version 1.4 (Aberer et al. 2014) under the default substitution model GTR+G for 10,000,000 generations. The trees were sampled for every 500 generations, tuning parameters every 100 generations and the first 25% of the trees were discarded as burn-in. Tracer version 1.7.1 (Rambaut et al. 2018; http://tree.bio.ed.ac.uk/software/tracer/) was used for checking steady states of all parameter values of the runs. The posterior probability densities were similar between the runs and the effective sample size of parameter values was > 200. A final BI tree was generated using TreeAnnotator 1.8.4 (Drummond et al. 2012). The ML trees were displayed using Figtree 1.4.3 (http://tree.bio.ed.ac.uk/software/figtree/) and edited using FireAlpaca 5.5.1.

Pairwise p-distances and Kimura two-parameter (K2P) distances were calculated for the 28S and COI datasets using MEGA7 (Tamura et al. 2013).

Results

Morphospecies recognition based on the male

A total of 73 male specimens of *Pristepyris* were assigned into four named species and a novel species, i.e. *P. ishigakiensis*, *P. japonicus*, *P. minutus*, *P. zhejiangensis* and *P. seqalu* sp. nov. The details of the morphological features are provided in the taxonomy section.

The type material (holotype only) of *Pristepyris ryukyuensis* lacks its metasoma. The morphological information of the male genitalia, which is indispensable for discriminating similar species, according to the general external morphology (Liao et al. 2019, 2021) was unavailable. Therefore, the present study could not provide any evidence to support or reject the discrimination between *P. ryukyuensis* and *P. tainanensis* and between *P. ryukyuensis* and *P. zhejiangensis*. Furthermore, no metasomal and genital morphologies have been described in the original description of *P. tainanesis*; hence, we did not have an opportunity to dissect and examine the male genitalia to determine the type material, so we tentatively treated *P. ryukyuensis* and *P. tainanensis* as different species. These obscurities in species discrimination will be solved when many specimens from the Ryukyus, Taiwan and the eastern coastal region of mainland China become available for integrative taxonomy in the future.

Pristepyris minutus was morphologically characterized by the following features of the male genitalia and was well distinguished from four other named species of *Pristepyris* recognized above and *Pristepyris rugicollis* (Kieffer, 1905); type species of *Pristepyris*, morphological information were obtained from Azevedo and Alencar (2009); gonostipes fused to harpe in dorsal portion in *P. minutus* and fully divided from harpe in the other four species and *P. rugicollis*; aedeagus with unrecognized apical lobe and with enlarged ventral and dorsal valves in *P. minutus* and distinctly elongated apical lobe in the other four species and *P. rugicollis*.

Summarising the results of the morphological examination, the five male-based species of *Pristepyris* were assigned into two groups: group A consisting of *P. ishigakiensis*, *P. japonicus*, *P. zhejiangensis*, *P. seqalu* sp. nov. and *P. rugicollis*; group B had *P. minutus* based on the male genital morphology.

Molecular phylogenetic analyses and DNA barcoding

Molecular phylogenetic analyses recovered 15 major clades (including a far distant lineage, i.e. *Pseudisobrachium*) with higher support values (UFB ≥ 95/SH-aLRT ≥ 80/pp ≥ 0.95) and longer basal branches, which were almost consistent with the boundaries of genera proposed previously (Alencar et al. 2018; Azevedo et al. 2018). However, *Pristepyris* (sensu Alencar et al. 2018) was recorded as a polyphyletic group comprising the following two phylogenetically far distant clades with high support values: Clade α (100/100/0.98) involving four male-based species of the group A; Clade β (100/100/1) consisting solely of *P. minutus* (group B) and exhibiting the sister relationship with the clade consisting of six Taiwanese and Ryukyuan *Eleganesia* with strong support values (98/93/1). Similarly, *Acrenesia* was also recorded as a polyphyletic group consisting of two phylogenetically far distant clades with strong support values (100/100/1 in the Clade γ and δ, respectively). However, because the Clade γ and δ of *Acrenesia* remain undetected from Taiwan and the Ryukyus, this issue will be resolved in a separate study in the future.

Fourteen of the 15 distinct clades within the subfamily Pristocerinae were further grouped into two higher clades: Clade I (72.8/92/1) consisting of *Dissomphalus*, *Protisobrachium*, *Trichicus*, *Pristepyris*, *Pristocera* and *Propristocera*; Clade II (88.3/91/0.96) consisting of *Apenesia*, "*Acrenesia*" (Clade γ, δ), *Epynesia*, *Cleistepyris*, *Eleganesia* (including *P. minutus*), *Austranesia* and *Dracunesia*. The position of *Pseudisobrachium* remained unclear due to suspected long-branch attraction from the phylogenetic trees.

Two female specimens were assigned by DNA barcoding into *P. zhejiangensis*. The maximum distance within each of the species was remarkably smaller than the minimum distance in all pairs of the species, i.e. the DNA barcode gap was distinct (Table 2). In the Clade α, the maximum intraspecific p-distances calculated, based on the 28S dataset, were 0.2% for *P. ishigakiensis*, 0% for *P. seqalu* sp. nov. and

Table 2. The minimal interspecific distances calculated, based on the 28S and COI sequence datasets. Upper diagonal shows the distance in K2P model and lower diagonal shows the distance in p distance (%). N, number of specimens; max p, maximum p distance within the species; max K2P, maximum distance in K2P model within the species.

Datasets and Species	1	2	3	4
28S				
1. *P. ishigakiensis*		0.006	0.054	0.011
(N = 9; max p = 0.2; max K2P = 0.002)				
2. *P. japonicus*	0.6		0.056	0.010
(N = 1)				
3. *P. seqalu* sp. nov.	5.1	5.2		0.047
(N = 2; max p = 0; max K2P = 0)				
4. *P. zhejiangensis*	1.1	0.9	4.5	
(N = 9; max p = 0; max K2P = 0)				
COI				
1. *P. ishigakiensis*		0.156	0.161	0.128
(N = 9; max p = 6.5; max K2P = 0.069)				
2. *P. japonicus*	13.7		0.155	0.132
(N = 1)				
3. *P. seqalu* sp. nov.	14.1	13.7		0.130
(N = 2; max p = 0; max K2P = 0)				
4. *P. zhejiangensis*	11.8	12.3	11.7	
(N = 9; max p = 8.4; max K2P = 0.092)				

0% for *P. zhejiangensis*; however, the minimal interspecific p-distances calculated, based on the 28S datasets, ranged from 0.6%–5.2%. The maximum intraspecific p-distances calculated, based on the COI dataset, were 6.5% for *P. ishigakiensis*, 0% for *P. seqalu* sp. nov. and 8.4% for *P. zhejiangensis*, whereas the minimal interspecific p-distances calculated, based on the COI dataset, ranged from 11.7% to 14.1%.

Discussion

Confirmation of the species boundaries in *Pristepyris*

Each of the four species of group A and the one species of group B were recovered as an independent lineage in the molecular phylogenetic analyses (Fig. 3). Both the 28S and COI datasets of group A showed distinct DNA barcode gaps in all pairs of the species. Therefore, five different species can be consistently recognized.

Group A (the Clade α nested in the Clade I) and *Pristepyris rugicollis* (the type species of the genus) exhibited significant similarity in the male genital morphology; therefore, it could reasonably be determined as *Pristepyris* sensu stricto. This implies that *Pristepyris minutus* (the Clade β nested in the Clade II) is independent

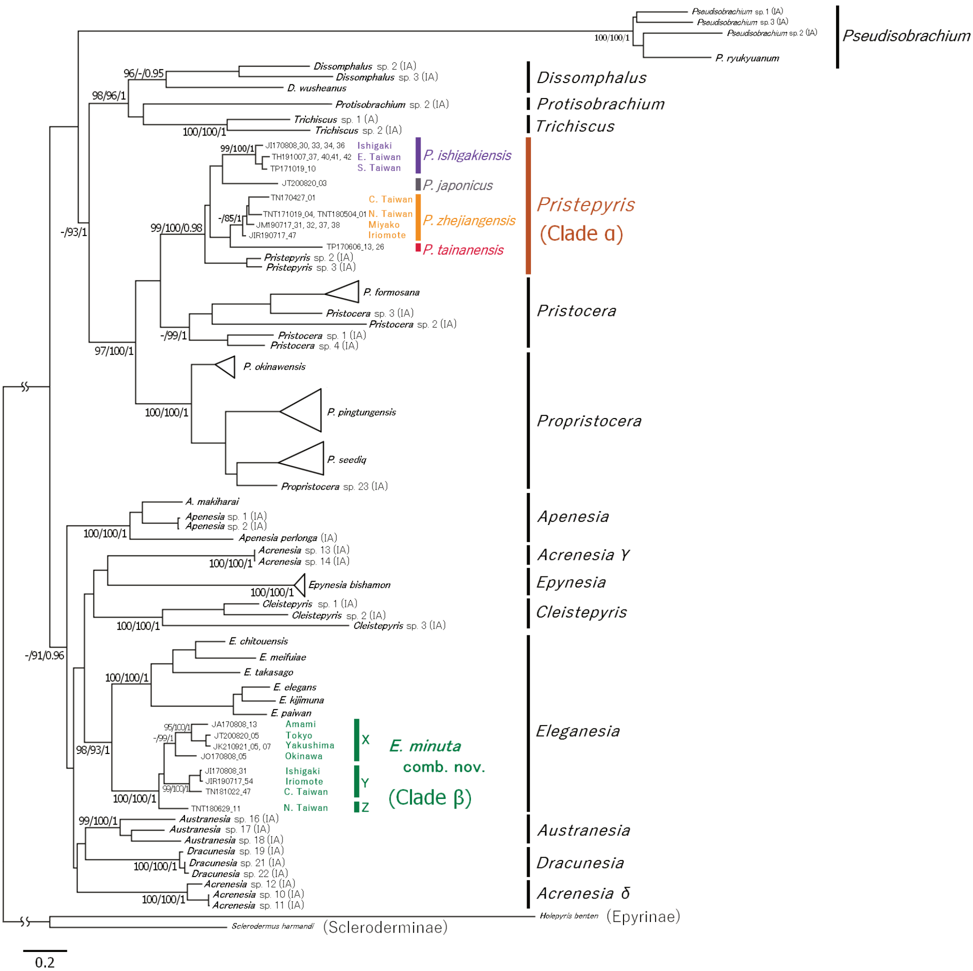

Figure 3. ML tree based on the 28S + COI dataset (1,075 bp in length). Ultrafast bootstrap (UFB), SH-aLRT and posterior probability (pp) values are given beside the nodes. The values were omitted when UFB < 95, SH-aLRT < 80 and pp < 0.90. Tips are labelled with specimen ID. **Tokyo,** Tokyo Metropolis; **Yakushima**, Yakushima Island; **Amami**, Amami-Oshima Island; **Okinawa**, Okinawa-Hontou Island; **Irabu**, Irabu–jima Island; **N. Taiwan**, Northern Taiwan; **C. Taiwan**, Central Taiwan; **E. Taiwan,** Eastern Taiwan; **S. Taiwan**, Southern Taiwan.

at the genus level from *Pristepyris*. Therefore, "*P. minutus*" is herein assigned to *Eleganesia* (new combination). The formal taxonomic treatment is shown in the taxonomy section.

Pristocerine genera can be assigned to two higher groups, based on the morphology of male genitalia. The complete articulation between gonostipes and harpe was observed in the group P: *Apenesia*, *Dissomphalus*, *Epynesia*, *Pristepyris* sensu stricto, *Pristocera* and *Propristocera* in our study similar to earlier studies (Alencar et al. 2018; Azevedo et al. 2018; Liao et al. 2019; Alencar and Azevedo 2020). Contrastingly, the incomplete articulation or complete fusion between gonostipes and harpe was observed in group Q: *Austranesia*, *Eleganesia* and *Epynesia* (Alencar et al. 2018; Liao et al. 2021). The division between P and Q groups seems to be supported by the antennal micromorphology of the female wasps (Fig. 19). Our examination of antennal structure with limited taxa revealed that the sensilla placodea are narrow on the antennae and long in *Pristepyris* sensu stricto and *Propristocera* of group P (Fig. 19C, D) and round in *Eleganesia* and *Apenesia* of group Q (Fig. 19A, B). Groups P and Q correspond to Clade I and II, respectively. Furthermore, *Caloapenesia*, *Calobrachium* and *Pseudisobrachium* show huge gonostipes and unique apically-divided harpe in the subfamily (Azevedo 2008; Gobbi and Azevedo 2010, 2014, 2016). *Pseudisobrachium* was recovered to be independent of both Clade I and II in phylogenetic trees. Therefore, it is likely that the phylogenetic and morphological examination with the further comprehensive taxon sampling will recognize multiple suprageneric taxa (tribes) within the subfamily Pristocerinae.

Geographic genetic divergence observed in *Eleganesia minuta* comb. nov.

Eleganesia minuta comb. nov. is widespread, but genetically subdivided into three COI lineages: X from the Kanto area of Japan to Okinawa Hontou Island; Y from Ishigaki–jima Island to Taiwan; and Z from Taiwan. The p-distance among the COI sublineages ranged between 11.1% and 14.6%. By referring to the molecular clock in COI of insects (Papadopoulou et al. 2010), which shows 3.36%–3.54% divergence per one million years, we can estimate that the COI sublineages have diverged for approximately three to four million years. Females of *E. minuta* comb. nov. are apterous; hence, they can be distributed only over long distances by phoretic copulation (Gordh 1990; Azevedo et al. 2016) or ocean currents that carry rotten logs in which fertile female wasps or parasitized hosts hide. This phenomenon can reduce female-mediated gene flow, thereby causing clear genetic divergence of the COI gene, which is inherited maternally.

Taxonomy of the Taiwanese and Ryukyuan species of *Pristepyris* and *Eleganesia*

Bethylidae Forster, 1856
Pristocerinae Mocsary, 1881
***Pristepyris* Kieffer, 1905**

***Pristepyris seqalu* sp. nov.**
http://zoobank.org/773D354A-5DF3-45A1-BCF6-3182C8D6A161
Figs 4, 5; Table 1

Male diagnosis. TL ≈ 5.9–6.0 mm. HL/HW × 100 = 98–105. Frons and vertex with shallow foveolae (ca. 0.03–0.05 mm in diameter), of which intervals are smooth and shining and narrower than diameter of foveolae. Anterior clypeal margin incurved medially. Mandible with five apical teeth. Transverse pronotal carina absent. Cervical pronotal area in lateral view round. LP/WP = 1.02–1.20. Metapostnotal median carina complete posteriorly, but fading in anterior half. Tergum II with weak longitudinal sulcus and weak longitudinal ridge, sternum II without longitudinal median carina. Hypopygium with incurved posterior margin. Apical lobe of aedeagus in lateral view short and lobate, weakly curved ventrad.

Female diagnosis. Unknown.

Male description. ***Color.*** Head black; body dark brown; mandible, antenna and legs brown or light brown; fore- and hind-wings subhyaline, with veins brown or light brown.

Head. Head capsule in full-face view evenly round posteriorly, without remarkable posterolateral corner; HL/HW × 100 = 98–105 (98 in holotype). Occipital carina present. Clypeus imbricate, roundly produced anteriad, with median longitudinal carina which not reach anterior clypeal margin; anterior clypeal margin incurved medially. Frons and vertex with deep foveolae (ca. 0.03–0.05 mm in diameter), of which intervals are smooth and shining and narrower than diameter of foveolae. Compound eye large and convex, with sparse thin and relatively short erect setae. POL:AOL = 12:7; OOL:WOT = 4:3; DAO = 0.12 mm. Mandible with five apical teeth; dorsal face faintly imbricate. Antennomere I (excluding basal neck and condylar bulb) 3× as long as maximum width; antennomere I:II:III = 17:3:12 in length; antennomere II 1.4× as long as maximum width, narrowed and bent in basal part; antennomere III–XI each 2.5–4.4× as long as maximum width; antennomere XII 5.2× as long as maximum width, elongate-cylindrical; antennomere XIII (terminal) 6.7× as long as maximum width, with pointed apex.

Mesosoma. Pronotum with pronotal flange extending anteriad beyond anterior margin of propleuron; cervical area in lateral view very steep. Dorsal area of pronotum subtrapezoidal, without distinct transverse pronotal carina (arrow in Fig. 4E), with incurved posterior margin, with deep foveolae, of which intervals are narrower than diameter of foveolae in anterior half, but wider in posterior half; LPD/WPD = 0.39–0.45 (0.39 in holotype). Mesoscutum smooth and shining in anterior 1/3; area along notauli and parapsidal signum foveolate; notaulus distinct in posterior 2/3 of mesoscutum, not reaching posterior margin; parapsidal signum distinct, almost reaching posterior margin of mesoscutum. Mesoscutellum smooth and shining, with sparse and deep foveolae. Mesoscuto-mesoscutellar suture deep and convex anteriad. Mesopleuron elongate; anterior, upper and lower fovea distinct; acropleural area (raised area surrounding anterior, upper and lower fovea) almost smooth and shining. Mesopleural pit absent. Mesodiscrimen concave, with weak median carina. Metasternum with metafurcal pit. Lateral surface of metapectal-propodeal complex obliquely and strongly rugose in marginal area and weakly rugose with intervals shining in central area. Metapectal-propodeal complex in dorsal view with LP/WP = 1.02–1.20 (1.11 in holotype), with lateral margins subparallel, but slightly convex; metapostnotal median carina distinct, almost complete posteriorly, but fading in anterior half; submedian rugae and sublateral margin distinct, but irregularly running; posterior transverse margin indistinct; dorsomedian face sparsely rugoso-scabrous, with intervals smooth and shining; dorsolateral face densely rugoso-scabrous; median portion of propodeal declivity transversely rugoso-scabrous.

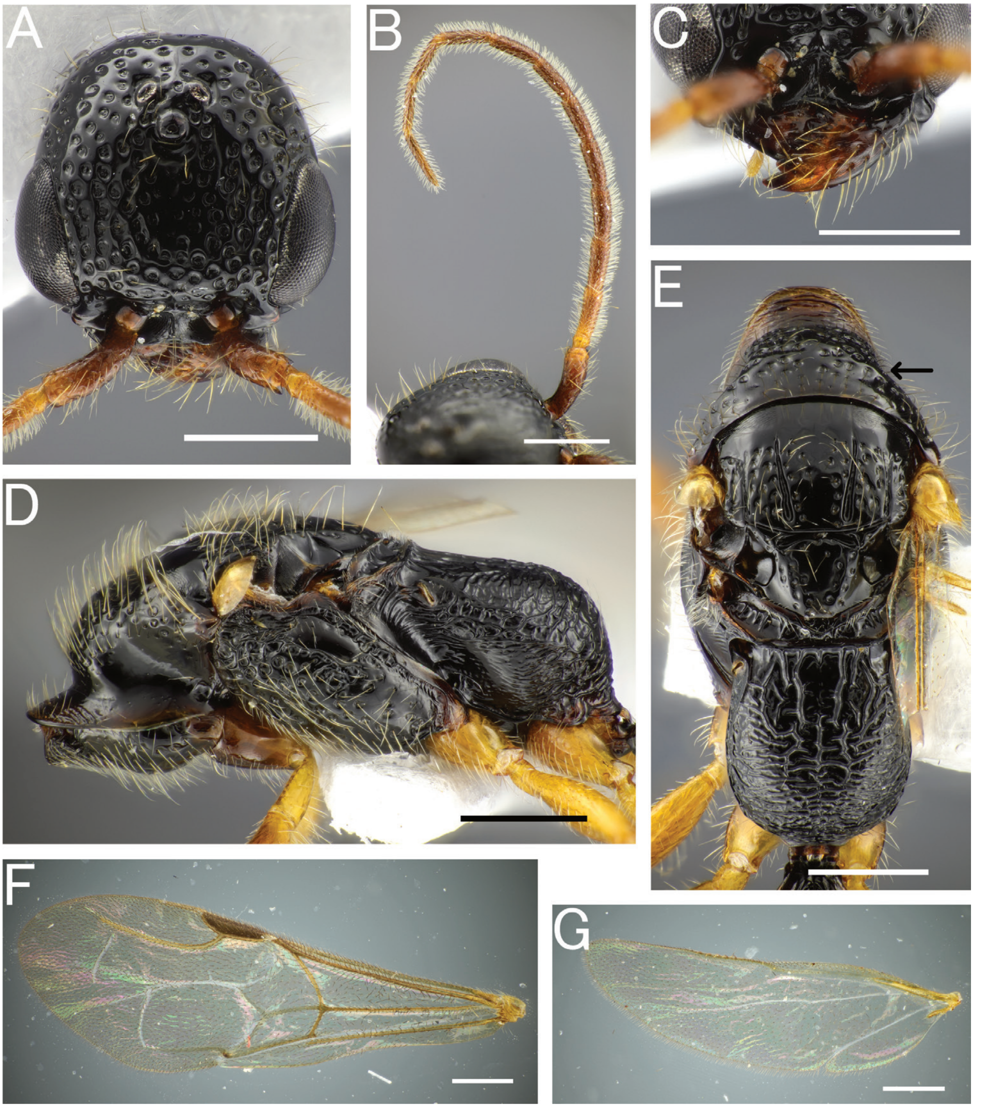

Figure 4. *Pristepyris seqalu* sp. nov., male, holotype (TP170606_26) **A** head in full-face view **B** antenna (left) **C** mandible **D** mesosoma in lateral view **E** mesosoma in dorsal view; arrow indicating transverse pronotal carina absent **F** fore-wing **G** hindwing. Scale bars: 0.5 mm.

Forewing with r-m$_2$ flexion line (arrows in Fig. 4F), without R$_2$ and 2M1$_2$ flexion line. Hindwing with five distal hamuli. Claws bifid, with thin and curved apical teeth.

Metasoma. Tergum II with weak longitudinal sulcus and weak longitudinal ridge; sternum II without longitudinal median carina. Hypopygium (subgenital plate) with spiculum much longer than S9ala; apical margin incurved medially; ventral face of apicomedian part with relatively dense setae. Gonostipes glabrous, unfused to harpe.

Harpe in ventral view elongate, slightly curved inward, with blunt apex, entirely covered with setae which increase in length toward apex; median basal portion with concavity which accommodates digitus and cuspis. Cuspis lobate and extending laterad, curled, with short, thick, conical setae near apex; subbasal part facing digitus with short and thin hairs. Digitus extending laterad, curled; lateral face with short, thick, conical setae at apex. Apical lobe of aedeagus in lateral view short and lobate, weakly curved ventrad.

Female description. Unknown.

Measurements. ***Holotype*:** HL 1.16 mm; HW 1.20 mm; EL 0.56 mm; WOT 0.28 mm; POL 0.12 mm; AOL 0.07 mm; OOL 0.40 mm; DAO 0.11 mm; LM 2.25 mm; LPD 0.47 mm; WPD 1.06 mm; LP 0.86 mm; WP 0.74 mm. Paratypes: HL 1.19–1.28 mm; HW 1.19–1.28 mm; EL 0.56–0.61 mm; WOT 0.30–0.32 mm; POL 0.14 mm; AOL 0.10 mm; OOL 0.40–0.42 mm; DAO 0.10 mm; LM 2.25–2.38 mm; LMT 2.68–2.73 mm; LPD 0.48–0.51 mm; WPD 1.10–1.16 mm; LP 0.85–1.00 mm; WP 0.80–0.87 mm; TL 5.9–6.0 mm.

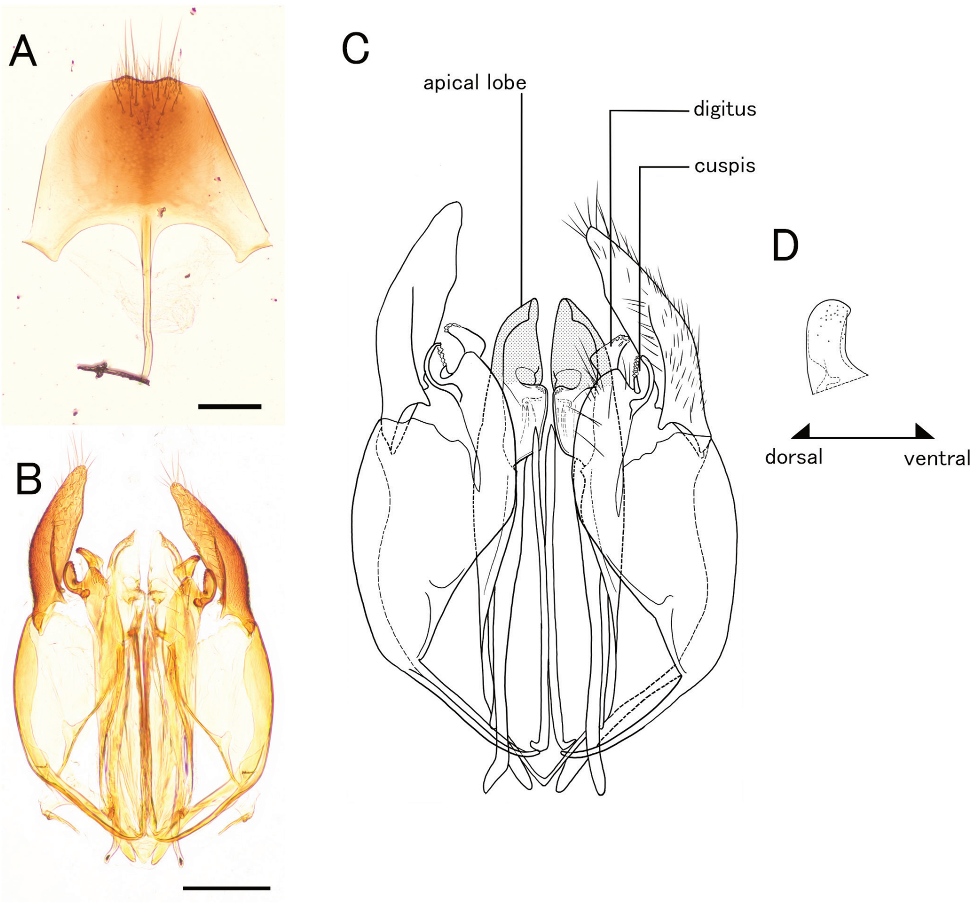

Figure 5. *Pristepyris seqalu* sp. nov., male genitalia, holotype (TP170606_26) **A** hypopygium **B, C** genitalia in ventral view **D** apical lobe in outer-lateral view. Scale bars: 0.2 mm.

Material examined. ***Holotype.*** Mt. Kaoshihfo, Pingtung Country, Taiwan, 22°07'53"N, 120°48'42"E, 483 m alt.; Yoto Komeda leg. (sweeping); 19/V/2017; NSMT. ***Paratypes.*** 2 males (TP170606_11, 13); same data as for holotype; TARI.

Etymology. This species is named after "seqalu", an aboriginal people who live primarily in Hengchen Township in Taiwan.

Taxonomic remarks. This species is most similar in general appearance to *P. rugulosus* (Terayama et al. 2002) among the named species known from East and Southeast Asia. According to Terayama et al. (2002), posterior transverse margin of metapectal-propodeal complex is distinct in *P. rugulosus*, but indistinct in *P. seqalu* sp. nov.; apical margin of hypopygium is incurved fully in *P. rugulosus*, but only incurved medially in *P. seqalu* sp. nov.; apical lobe of aedeagus in lateral view is relatively small and narrow in *P. rugulosus*, but relatively well-developed, broad and lobate in *P. seqalu* sp. nov.

Distribution and habitat. Southern Taiwan; evergreen broadleaf forest.

Pristepyris ishigakiensis (Yasumatsu, 1955)

Figs 6, 7; Table 1

Pristocera japonica ishigakiensis Yasumatsu, 1955: 245. Holotype (male, KUF), type loc.: Kainan, Ishigaki-jima, Ryukyu Is., Japan. *Acrepyris japonica ishigakiensis*: Terayama, 1996: 595 (genus transfer). *Acrepyris ishigakiensis*: Terayama, 1999: 103 (raised to species). *Pristepyris ishigakiensis*: Azevedo et al. 2018: 104 (genus transfer).

Male diagnosis. TL ≈ 6.3–8.0 mm. HL/HW × 100 = 95–100. Frons and vertex with deep foveolae (ca. 0.05–0.06 mm in diameter), of which intervals are smooth and shining and narrower than diameter of foveolae. Anterior clypeal margin nearly straight medially. Mandible with five apical teeth. Transverse pronotal carina present. Cervical pronotal area in lateral view forming an angulate corner. LP/WP = 1.10–1.16. Metapostnotal median carina incomplete posteriorly. Tergum II with longitudinal sulcus and ridge, sternum II with very weak longitudinal median carina or absent. Apical margin of hypopygium straight medially. Apical lobe of aedeagus in lateral view elongate and lobate, directed posteriad, weakly curved ventrad at apex.

Female diagnosis. Unknown.

Male redescription. Full description was given by Yasumatsu (1955) and Terayama (1999). Additional information as below.

Head. HL/HW×100 = 95–100 (98 in holotype). Frons and vertex with deep foveolae (ca. 0.05–0.06 mm in diameter), of which intervals are smooth and usually narrower than diameter of foveolae. Occipital carina present. Clypeus roundly produced anteriad; median clypeal carina moderately distinct, almost reaching anterior clypeal margin; anterior clypeal margin weakly incurved medially (Fig. 4C). Compound eye large and convex, with sparse thin erect setae. Mandible with five teeth.

Mesosoma. Dorsal area of pronotum smooth and shining, with deep foveolae; distinct transverse pronotal carinae present (arrow in Fig. 6F); cervical pronotal area in lateral view

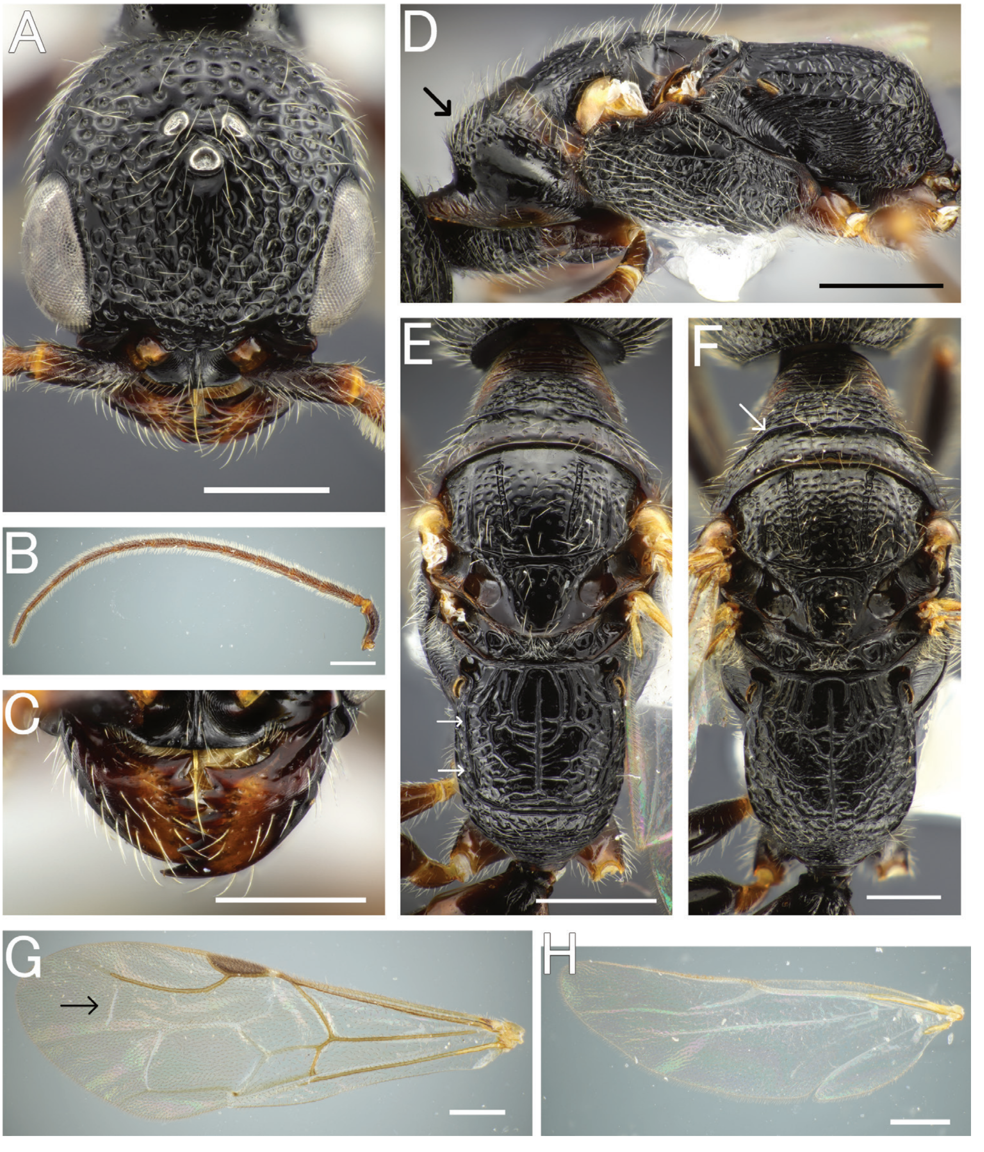

Figure 6. *Pristepyris ishigakiensis*, male, A–E, G, H, JI170808_34, F, TH190717_42 **A** head in full-face view **B** antenna (right) **C** mandible **D** mesosoma in lateral view; arrow indicating an angulate corner present on cervical pronotal area **E** mesosoma in dorsal view; arrows indicating posterior transverse margin extending to spiracle **F** mesosoma in dorsal view; arrow indicating transverse pronotal carina present **G** forewing **H** hindwing. Scale bars: 0.5 mm.

forming an angulate corner (arrow in Fig. 6D). Mesopleuron elongate; anterior, upper and lower fovea distinct; acropleural area smooth and shining, with sparse and small foveolae. Mesopleural pit absent. Mesodiscrimen concave, with weak median carina. Metasternum with metafurcal pit. Lateral face of metapectal-propodeal complex irregularly rugose

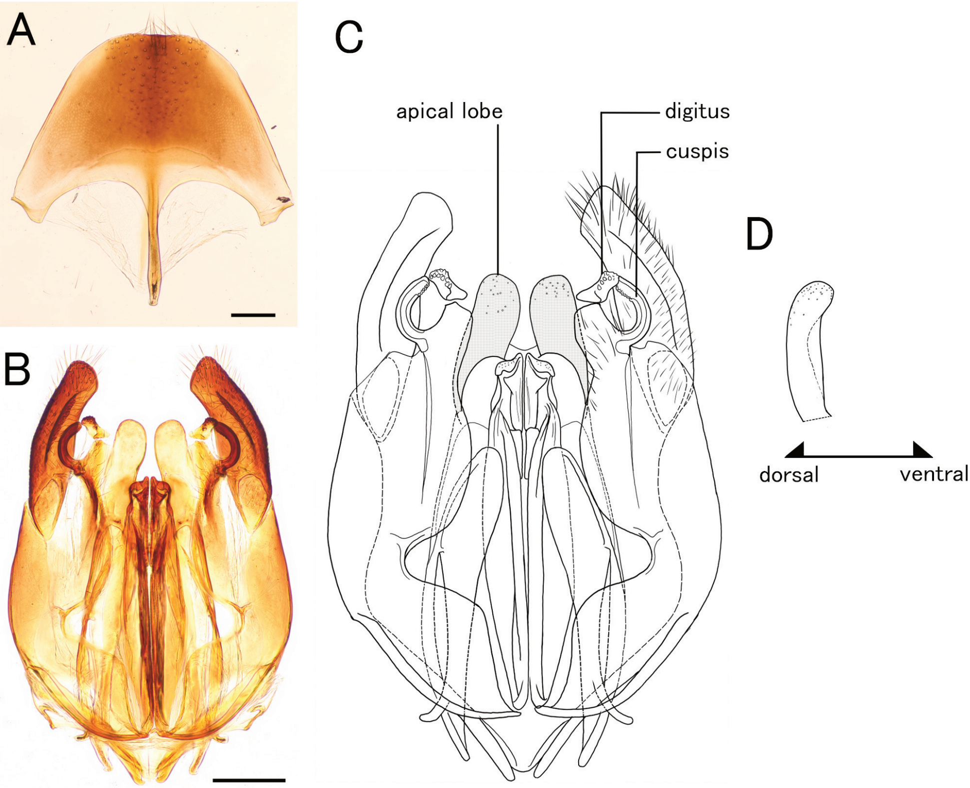

Figure 7. *Pristepyris ishigakiensis*, male genitalia, TH191007_40 **A** hypopygium **B, C** genitalia in ventral view **D** apical lobe in outer-lateral view. Scale bars: 0.2 mm.

entirely. Metapectal-propodeal complex in dorsal view with LP/WP = 1.10–1.16, with lateral margins subparallel and slightly convex; metapostnotal median carina distinct, but incomplete posteriorly; submedian rugae irregularly running and incomplete posteriorly; sublateral margin incomplete posteriorly; posterior transverse margin indistinct or distinctly extending to spiracle (Fig. 6E); dorsomedian and dorsolateral faces weakly rugoso-scabrous; median portion of propodeal declivity transversely rugoso-scabrous. Forewing with r-m_2 flexion line (arrows in Fig. 6G), without R_2 and $2M1_2$ flexion line. Hindwing with five distal hamuli. Tarsal claws bifid, with thin and curved apical teeth.

Metasoma. Tergum II with longitudinal sulcus and ridge; sternum II with very weak longitudinal median carina or absent. Hypopygium (subgenital plate) with spiculum much longer than S9ala; apical margin straight medially; ventral face of apicomedian part with relatively dense setae. Gonostipes glabrous, unfused to harpe. Harpe in ventral view elongated, slightly curved inward, with blunt apex, entirely covered with setae which increase in length toward apex; median basal portion with concavity which accommodates digitus and cuspis. Cuspis lobate and extending laterad, curled, with short, thick, conical setae near apex; subbasal part facing digitus with short and thin hairs. Digitus extending laterad, curled; lateral face with short, thick, conical setae at apex. Apical lobe of aedeagus in lateral view elongate and lobate, directed posteriad, weakly curved ventrad at apex.

Female description. Unknown.

Material examined. Japan: Ishigaki–jima. 3 males (JI170808_30, 33, 34); Mt. Omoto, 24°26'31"N, 124°05'56"E, 93 m alt.; Hauchuan Liao leg. (sweeping); 12/VIII/2017. 1 male (JI170808_36); Mt. Yarabu, 24°26'22"N, 124°05'32"E, 154 m alt.; Hauchuan Liao leg. (sweeping); 13/VIII/2017. **Taiwan: N. Taiwan.** 1 male (TT91007_06); Dagoushi Park, Taipei City, 25°05'20"N, 121°35'38"E, 81 m alt.; Hauchuan Liao leg. (sweeping); 9/X/2019. **E. Taiwan.** 5 males (TH191007_27, 37, 40, 41, 42); TsoTsang Trail, Hualien County, 24°00'53"N, 121°34'18"E, 266 m alt.; Hauchuan Liao leg. (sweeping); 24/X/2019. **S. Taiwan.** 1 male (TP171019_10); Baoli Experimental Forest, Pingtung County, 24°04'15"N, 120°45'51"E, 79 m alt.; Hauchuan Liao leg. (sweeping); 22/X/2017.

Taxonomic remarks. In our collection, a specimen from Ishigaki–jima Island has the posterior transverse margin of metapectal-propodeal complex that is distinct and extends to spiracle distinctly (Fig. 6E) and the other specimens have the margin that is indistinct as in the original description (Fig. 6F). However, there are no remarkable differences between the two forms in male genital morphology and in both the 28S and COI sequences. This fact suggests the conspecificity of the two forms (these are likely geographic variations of a single species).

Distribution and habitat. Southern Ryukyus (Terayama 2006), from the north to south of Taiwan (new to Taiwan); evergreen broadleaf forest.

Pristepyris mieae (Terayama, 1995)
Fig. 8

Acrepyris mieae Terayama, 1995: 142, figs 10. Holotype (female, NIAES), type loc.: Fenchifu Chiayi Hsien, Taiwan. *Pristepyris mieae*: Azevedo et al. 2018: 104 (genus transfer).

Male diagnosis. Unknown.

Female diagnosis. TL ≈ 6.3 mm. Frons and vertex with deep foveolae (ca. 0.03 mm in diameter), of which intervals are imbricate; intervals in vertex wider than diameter of foveolae; intervals in lateral and submedian part of frons narrower than diameter of foveolae; the area along mesal line without foveolae. Median portion of clypeus roundly and relatively strongly produced anteriad; apical clypeal margin deeply incurved medially. Compound eye less developed. Mandible with four teeth. Dorsal face of pronotum, mesoscutellum, mesopleuron and dorsal and lateral faces of metapectal-propodeal complex imbricate, with dense foveolae. Transverse pronotal carina absent.

Female redescription. Full description was given by Terayama (1995). Additional information as below.

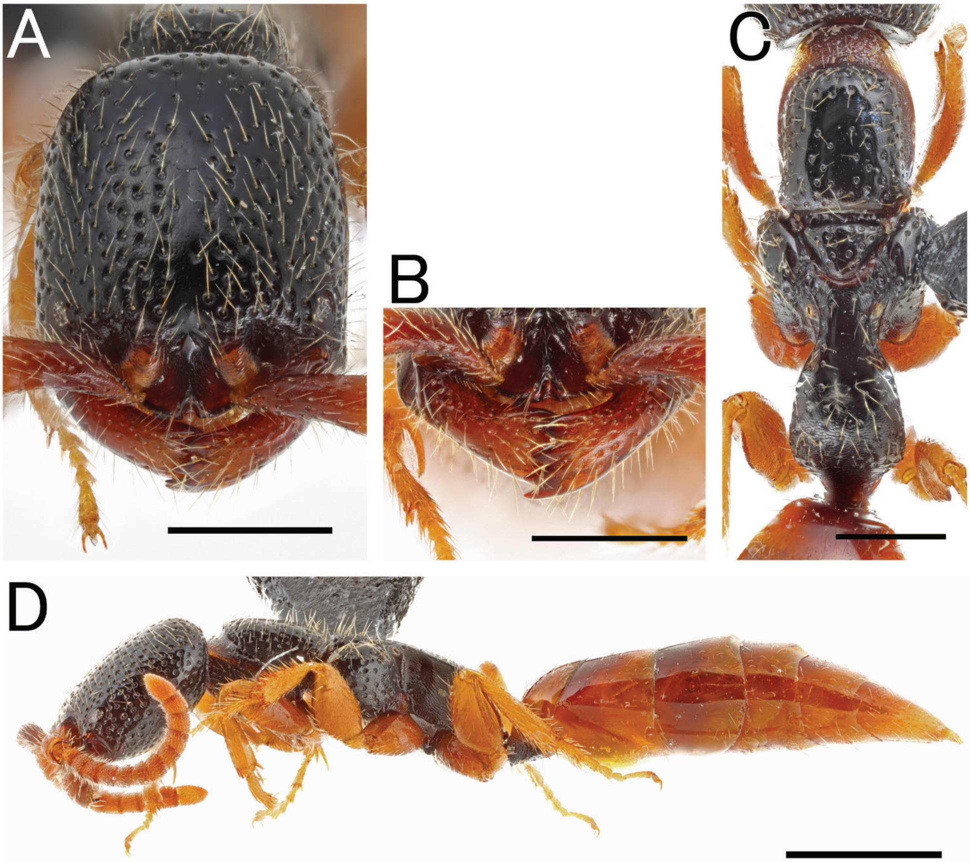

Figure 8. *Pristepyris mieae*, female, holotype **A** head in full-face view **B** mandible **C** mesosoma in dorsal view **D** mesosoma in lateral view. Scale bars: 0.5 mm.

Head. HL/HW × 100 = 131. Frons and vertex with deep foveolae (ca. 0.03 mm in diameter), of which intervals are imbricate; intervals in vertex wider than diameter of foveolae; intervals in lateral and submedian part of frons narrower than diameter of foveolae; the area along mesal line without foveolae. Occipital carina present. Median portion of clypeus roundly and relatively strongly produced anteriad; apical clypeal margin deeply incurved medially.

Mesosoma. Transverse pronotal carina absent. Dorsal area of pronotum imbricate with dense foveolae. Mesoscutum overlaid by posteromedian portion of pronotum. Mesoscutellum trapezoidal, 0.67× as long as maximum width, weakly imbricate with dense foveolae. Mesopleuron imbricate, with sparse foveolae; anterior, upper and lower fovea absent; mesopleural pit absent. Lateral face of metapectal-propodeal complex imbricate entirely. Metapectal-propodeal complex in dorsal view weakly constricted behind propodeal spiracles and then widened again posteriad, without any distinct carinae which subdivide dorsal face; LP/WP = 2.5; dorsomedian face weakly imbricate, with sparse foveolae; median portion of propodeal declivity weakly and transversely rugoso-scabrous, with sparse foveolae.

Taxonomic remarks. This species is morphologically most similar to the female of *P. zhejiangensis*. However, the female specimens of the genus *Pristepyris* have been rarely recorded and female-based species discrimination is hard to be conducted because of poor diagnostic characters in the females. We tentatively treated *P. mieae* as an independent species until additional specimens are available for molecular analyses.

Pristepyris ryukyuensis **(Terayama, 1999)**
Fig. 9

Acrepyris ryukyuensis Terayama, 1999: 702, figs 1, 2. Holotype (male, NIAES), type loc.: Shimoji, Miyako-jima, Okinawa, Japan. *Pristepyris ryukyuensis*: Azevedo et al. 2018: 104 (genus transfer).

Male diagnosis. HL/HW × 100 = 105. Frons and vertex with deep foveolae (ca. 0.05–0.06 mm in diameter), of which intervals are smooth and shining and narrower than diameter of foveolate. Anterior clypeal margin nearly straight medially. Mandible with five apical teeth. Transverse pronotal carina present. Cervical pronotal area in lateral view strongly and roundly produced. LP/WP = 1.09. Metapostnotal median carina incomplete posteriorly.

Female diagnosis. Unknown.

Male redescription. Full description was given by Terayama (1999). Additional information as below.

Head. HL/HW×100 = 105. Frons and vertex with deep foveolae (ca. 0.05–0.06 mm in diameter), of which intervals are smooth and shining and narrower than diameter of foveolate. Occipital carina present. Median portion of clypeus roundly produced anteriad; median clypeal carina moderately distinct, almost reaching anterior margin; anterior clypeal margin nearly straight medially. Compound eye large and convex, with sparse thin erect setae. Mandible with five teeth.

Mesosoma. Dorsal area of pronotum smooth and shining, with deep foveolae; distinct transverse carinae present (arrow in Fig. 9D); cervical pronotal area in lateral view strongly and roundly produced (arrow in Fig. 9C). Mesopleuron elongate; anterior, upper and lower fovea distinct; acropleural area smooth and shining. Mesopleural pit absent. Metapectal-propodeal complex in dorsal view with LP/WP = 1.09, with lateral margins subparallel and slightly convex; metapostnotal median carina distinct, but incomplete posteriorly; submedian rugae irregularly running; sublateral margin distinct, incomplete posteriorly; posterior transverse margin distinct; dorsomedian and dorsolateral faces weakly rugoso-scabrous; median portion of propodeal declivity weakly rugoso-scabrous.

Metasoma. Missing.

Female description. Unknown.

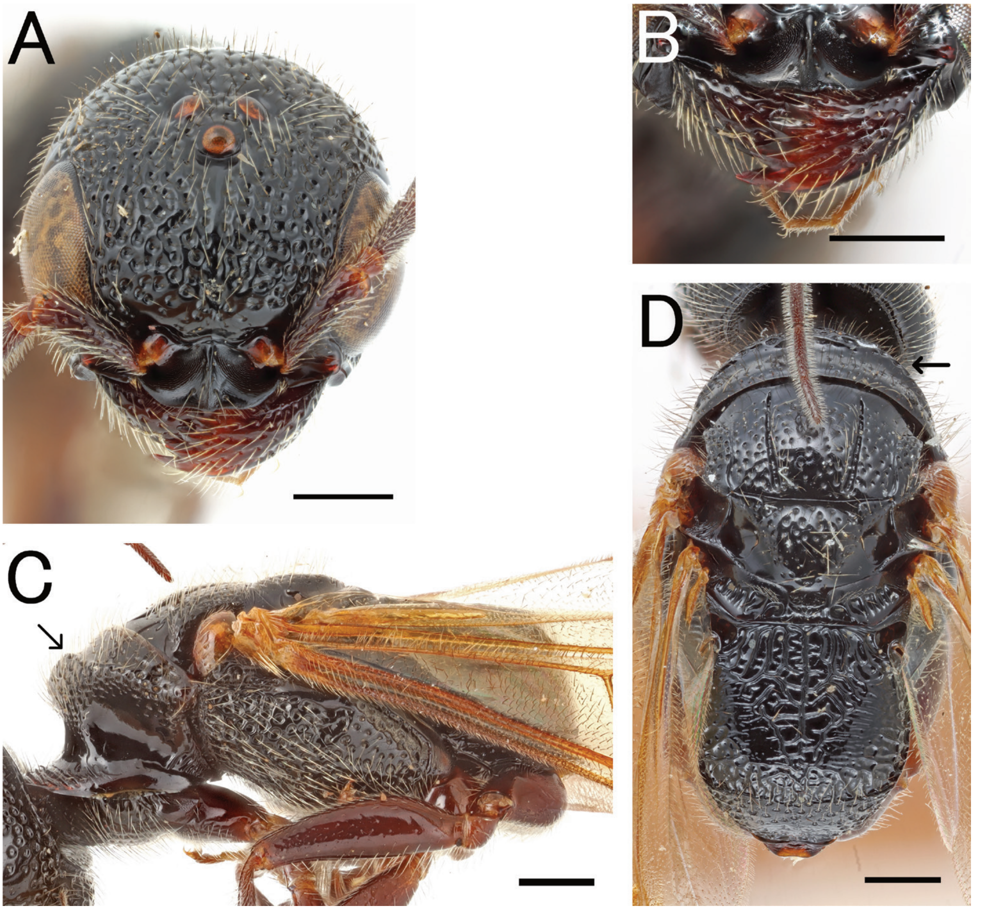

Figure 9. *Pristepyris ryukyuensis*, male, holotype **A** head in full-face view **B** mandible **C** mesosoma in lateral view; arrow indicating an angulate corner present on cervical pronotal area **D** mesosoma in dorsal view; arrow indicating transverse pronotal carina present. Scale bars: 0.5 mm.

Taxonomic remarks. This species is most similar to *Pristepyris zhejiangensis.* The two species share two remarkable features: mandible is five-toothed; cervical pronotal area in lateral view is strongly and roundly produced (arrow in Fig. 9C). However, the type material (holotype only) of *P. ryukyuensis* lacks the mesosoma and no metasomal and genital morphology is given in the original description. Therefore, it is impossible to conclude whether the two morphospecies are conspecific or not. *Pristepyris ryukyuensis* is tentatively treated as an independent species of which the identity will be discussed, based on the further intensive sampling in the whole of the potential distributional range (the Ryukyus, Taiwan and the eastern coastal region of mainland China). Furthermore, the *P. ryukyuensis*-like and *P. zhejiangensis*-like specimens newly obtained from the Ryukyus and Taiwan were treated as *P. zhejiangensis*, based on the reliable male genital morphology.

***Pristepyris tainanensis* (Terayama, 1995)**
Fig. 10

Acrepyris tainanensis Terayama, 1995: 143, figs 11–14. Holotype (male, HUS), type loc.: Raisha, Taiwan; paratype (male, HUS), type loc.: Kanshirei; paratype (male, NIAES), type loc.: Kuanzuling, Tainan Hsien. *Pristepyris tainanensis*: Azevedo et al. 2018: 104 (genus transfer).

Male diagnosis. TL ≈ 8.6 mm. HL/HW × 100 = 103. Frons and vertex with shallow foveolae (ca. 0.05–0.06 mm in diameter), of which intervals are smooth and shining and narrower than diameter of foveolae. Anterior clypeal margin nearly straight medially. Mandible with five apical teeth. Transverse pronotal carina present. Cervical pronotal area in lateral view forming an angulate corner. LP/WP = 0.96. Metapostnotal median carina not complete posteriorly.

Female diagnosis. Unknown.

Male redescription. Full description was given by Terayama (1995). Additional information as below.

Head. Frons and vertex with deep foveolae (ca. 0.05–0.06 mm in diameter), of which intervals are smooth and shining; intervals in vertex and frons usually narrower than diameter of foveolae. Occipital carina present. Median portion of clypeus roundly produced anteriad; median clypeal carina moderately distinct, almost reaching anterior margin; anterior clypeal margin truncate, nearly straight medially. Compound eye large and convex. Mandible with five teeth.

Mesosoma. Dorsal area of pronotum smooth and shining, with deep foveolae; distinct transverse carina(e) present (arrow in Fig. 10D); cervical pronotal area in lateral view forming an angulate corner (arrow in Fig. 10C). Mesopleuron elongate; anterior, upper and lower fovea distinct; acropleural area smooth and shining. Mesopleural pit absent. Lateral face of metapectal-propodeal complex irregularly rugose. Metapectal-propodeal complex in dorsal view with LP/WP = 0.96, with lateral margins subparallel and slightly convex; metapostnotal median carina distinct, but incomplete posteriorly; submedian rugae irregularly running and incomplete posteriorly; sublateral margin incomplete posteriorly; posterior transverse margin weak; dorsomedian and dorsolateral faces weakly rugoso-scabrous; median portion of propodeal declivity transversely rugoso-scabrous.

Female description. Unknown.

Taxonomic remarks. This species is most similar to *Pristepyris ishigakiensis.* The two species share two remarkable features: mandible is five-toothed; cervical pronotal area in lateral view forming an angulate corner (arrow in Figs 6D, 10C). However, no metasomal and genital morphology is given in the original description of *P. tainanesis* and the present authors had no opportunity to dissect and examine the male genitalia of the type material. Therefore, it is impossible to conclude whether the two morphospecies are conspecific or not and *P. tainanensis* is tentatively treated as an independent species. The identity will be discussed when the "topotypes" of *P. tainanesis* become available in the future.

Distribution and habitat. Southern Taiwan.

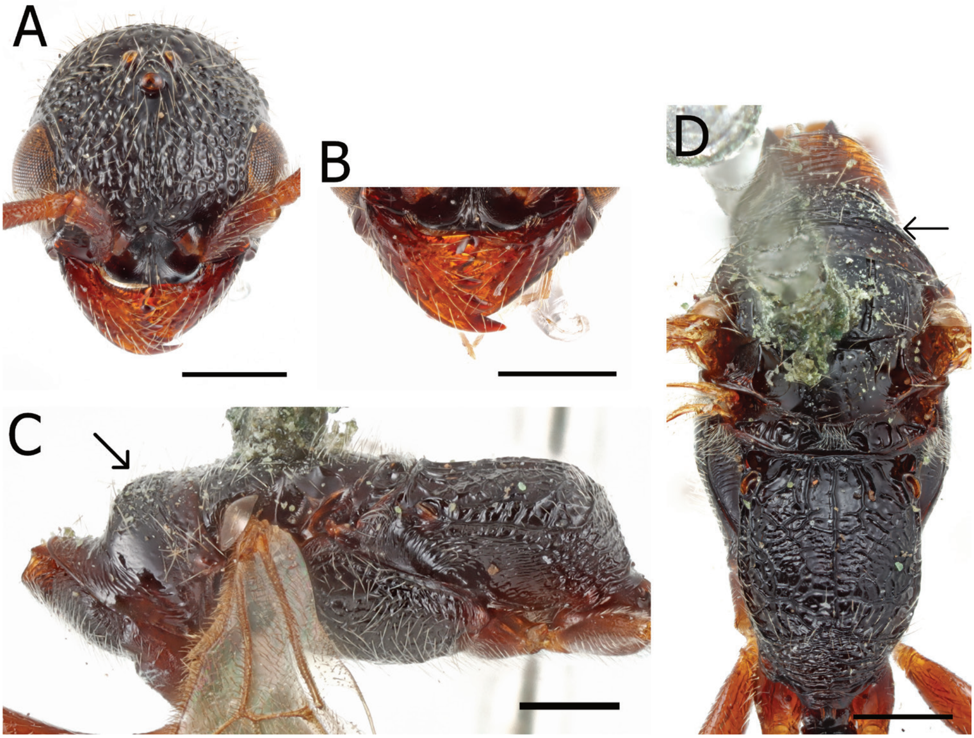

Figure 10. *Pristepyris tainanensis*, male, paratype **A** head in full-face view **B** mandible **C** mesosoma in lateral view (mirror-reversed); arrow indicating an angulate corner present on cervical pronotal area **D** mesosoma in dorsal view; arrow indicating transverse pronotal carinae present. Scale bars: 0.5 mm.

Pristepyris zhejiangensis **(Terayama, Xu & He, 2002)**
Figs 11–13; Table 1

Acrepyris zhejiangensis Terayama et al. 2002: 83, figs 9–16. Holotype, type loc.: Deqing, Zhejiang, China. *Pristepyris zhejiangensis*: Azevedo et al. 2018: 104 (genus transfer).

Male diagnosis. TL ≈ 6.1–9.3 mm. HL/HW × 100 = 88–103. Frons and vertex with deep foveolae (ca. 0.05–0.06 mm in diameter), of which intervals are smooth and shining and narrower than diameter of foveolate. Anterior clypeal margin nearly straight medially. Mandible with five apical teeth. Transverse pronotal carina present. Cervical pronotal area in lateral view round. LP/WP = 0.97–1.04. Metapostnotal median carina incomplete posteriorly. Tergum II with longitudinal sulcus and ridge, sternum II with longitudinal median carina. Apical margin of hypopygium straight medially. Apical lobe of aedeagus in lateral view elongate and spatulate, with broadened and rounded apex, in ventral view somewhat winding.

Female diagnosis. TL ≈ 6.5 mm. HL/HW×100 = 118–126. Frons and vertex with deep foveolae (ca. 0.03–0.04 mm in diameter), of which intervals are imbricate; intervals in vertex wider than diameter of foveolae; intervals in lateral and submedian part of frons as narrow as or narrower than diameter of foveolae; the area along mesal line without foveolae. Median portion of clypeus roundly and relatively strongly produced anteriad; apical clypeal margin deeply incurved medially. Compound eye less developed. Mandible with four teeth. Transverse pronotal carina absent. Dorsal face of pronotum, mesoscutellum, mesopleuron and dorsal and lateral faces of metapectal-propodeal complex imbricate. Mesosoma excluding dorsal and lateral faces of metapectal-propodeal complex with dense foveolae. Tarsal claws with thin and curved

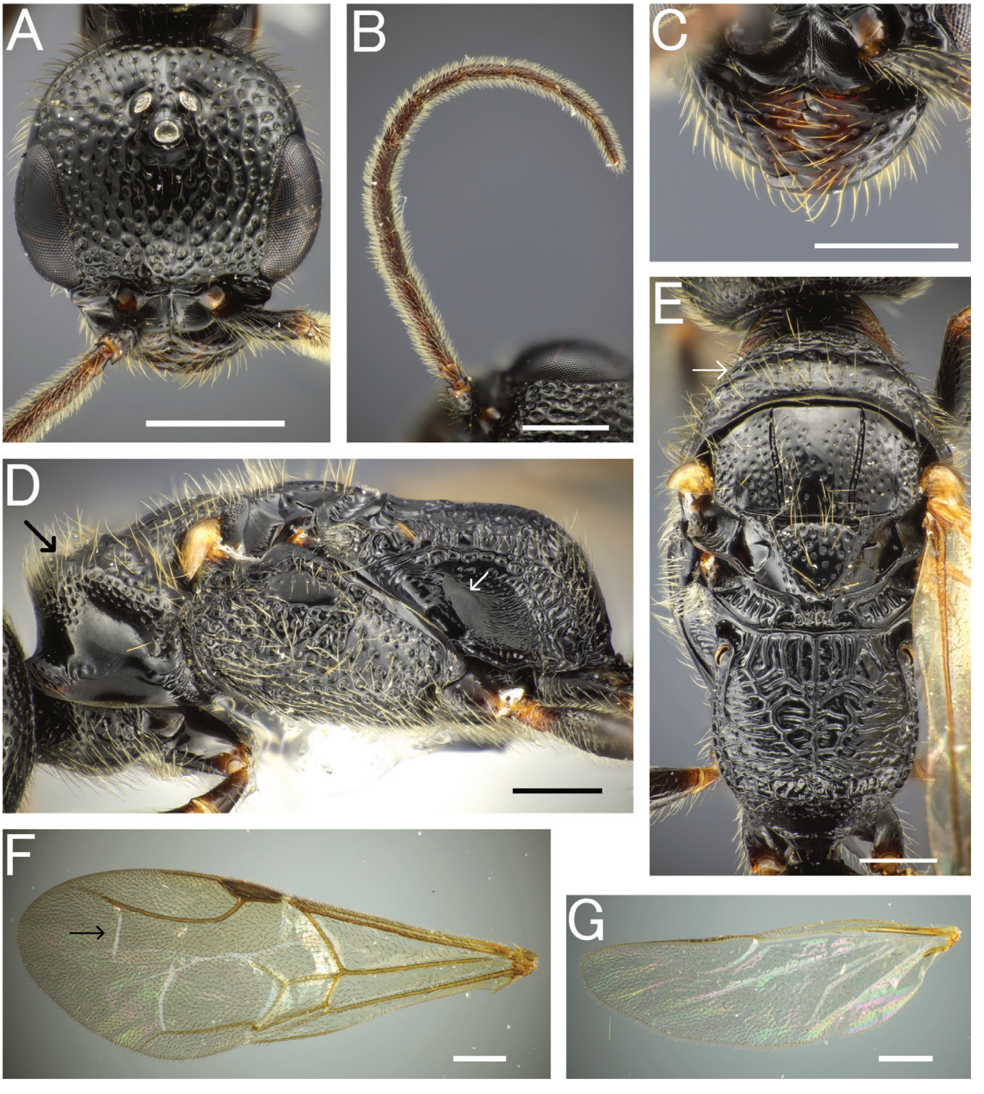

Figure 11. *Pristepyris zhejiangensis*, male **A–C, F, G** TNT180504_01 **D, E** JM190717_33 **A** head in full-face view **B** antenna (left) **C** mandible **D** mesosoma in lateral view; arrow indicating an angulate corner present on cervical pronotal area **E** mesosoma in dorsal view; arrow indicating transverse pronotal carina present **F** forewing **G** hindwing. Scale bars: 0.5 mm.

tooth. Tergum II with weak longitudinal ridge, without longitudinal sulcus. Sternum II without longitudinal median carina.

Male redescription. Full description was given by Terayama et al. (2002). Additional information as below.

Head. HL/HW×100 = 88–103 (88 in holotype). Frons and vertex with deep foveolae (ca. 0.05–0.06 mm in diameter), of which intervals are smooth and shining and narrower than diameter of foveolate. Occipital carina present. Median portion of clypeus roundly produced anteriad; median clypeal carina moderately distinct, almost reaching anterior margin; anterior clypeal margin nearly straight medially. Compound eye large and convex, with sparse thin erect setae. Mandible with five teeth.

Mesosoma. Dorsal area of pronotum smooth and shining, with deep foveolae, with distinct transverse pronotal carinae (arrow in Fig. 8E). Cervical pronotal area in lateral view round. Mesopleuron elongate; anterior, upper and lower fovea distinct; acropleural area smooth and shining. Mesopleural pit absent. Mesodiscrimen concave, with weak median carina. Metasternum with metafurcal pit. Lateral face of

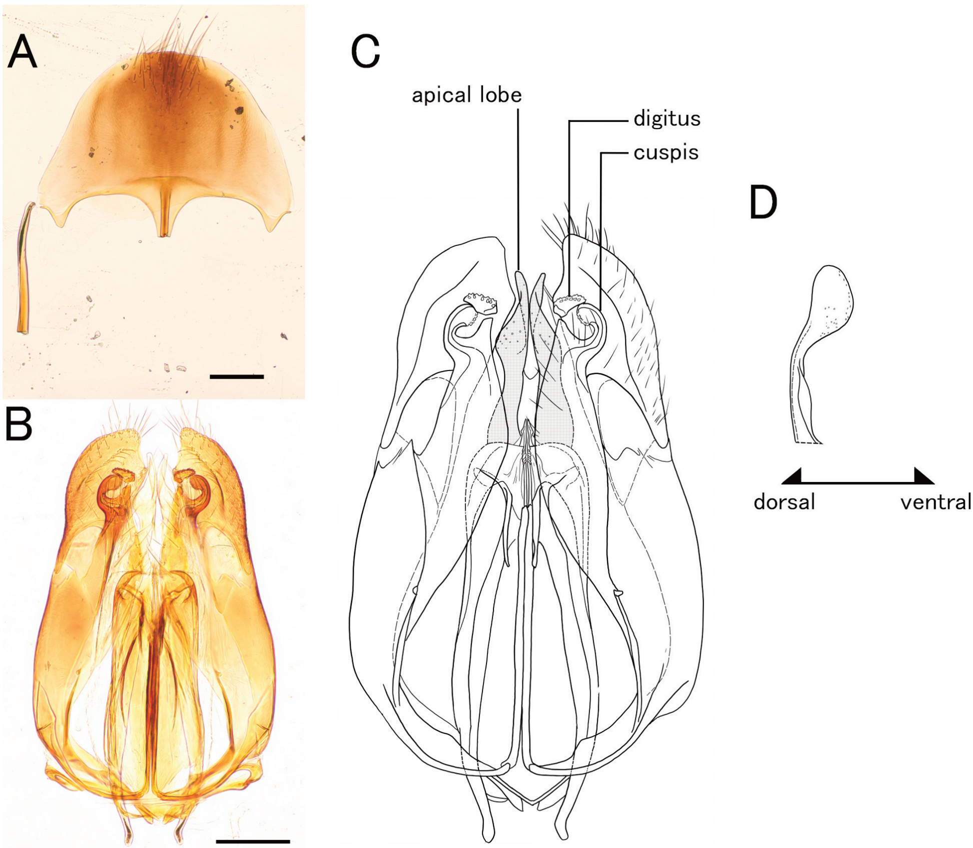

Figure 12. *Pristepyris zhejiangensis*, male genitalia, TNT180504_01 **A** hypopygium **B, C** genitalia in ventral view **D** apical lobe in outer-lateral view. Scale bars: 0.2 mm.

metapectal-propodeal complex smooth and shining anteriorly, irregularly rugose on posterior half of central area. Metapectal-propodeal complex in dorsal view with LP/WP = 0.97–1.04, with lateral margins subparallel and slightly convex; metapostnotal median carina distinct, but incomplete posteriorly; submedian rugae irregularly running; sublateral margin distinct, incomplete posteriorly; posterior transverse margin distinct; dorsomedian and dorsolateral faces weakly rugoso-scabrous; median portion of propodeal declivity transversely rugoso-scabrous. Forewing with r-m_2 flexion line (arrows in Fig. 8F), without R_2 and $2M1_2$ flexion line. Hindwing with five distal hamuli. Tarsal claws bifid, with thin and curved apical teeth.

Metasoma. Tergum II with longitudinal sulcus and ridge; sternum II with longitudinal median carina. Hypopygium with spiculum much longer than S9ala (spiculum broken in Fig. 9A); apical margin straight medially; ventral face of apicomedian part with relatively dense setae. Gonostipes glabrous, unfused to harpe. Harpe in ventral view widely elongated, slightly curved inward, with blunt apex, entirely covered with setae which increase in length toward apex; median basal portion with concavity which accommodates digitus and cuspis. Cuspis lobate and extending laterad, curled, with short, thick, conical setae at apex; subbasal part facing digitus with short and thin setea. Digitus extending laterad, curled; lateral face with short, thick, conical setae near apex. Apical lobe of aedeagus in lateral view elongate and spatulate, with broadened and rounded apex, in ventral view somewhat winding.

Female description. Female of this species was newly-recognised by molecular phylogenetic analyses in the present study.

Color. Body mostly dark brown; mandible, antenna, anterior flange of pronotum and legs brown or light brown.

Head. Head capsule with posterior margin slightly incurved, with posterolateral corner round; HL/HW × 100 = 118–126. Occipital carina present. Frons and vertex with deep foveolae (ca. 0.03–0.04 mm in diameter), of which intervals are imbricate; intervals in vertex wider than diameter of foveolae; intervals in lateral and submedian part of frons as narrow as or narrower than diameter of foveolae; the area along mesal line without foveolae. Median portion of clypeus roundly and relatively strongly produced anteriad, imbricate; median longitudinal carina not reaching anterior clypeal margin; anterior clypeal margin deeply incurved medially. Compound eye less developed. Mandible with four teeth; basalmost tooth relatively shorter than other ones. Antennomere I (excluding basal condylar bulb) 2.7× as long as maximum width; antennomere I:II:III = 5:1:1 in length; antennomere II 0.9× as long as maximum width, narrowed and bent in basal part; antennomere III–XII each 0.76–0.85× as long as maximum width, elongate-cylindrical; antennomere XIII (terminal) 1.3× as long as maximum width, with round apex. Tarsal claws with thin and curved tooth.

Mesosoma. Pronotum with anterior flange extending anteriad beyond anterior margin of propleuron; transverse pronotal carina absent; cervical pronotal area in lateral view round, with a steep anterior face; dorsal area subtrapezoidal, with almost straight posterior margin, with deep foveolae of which intervals are wider than

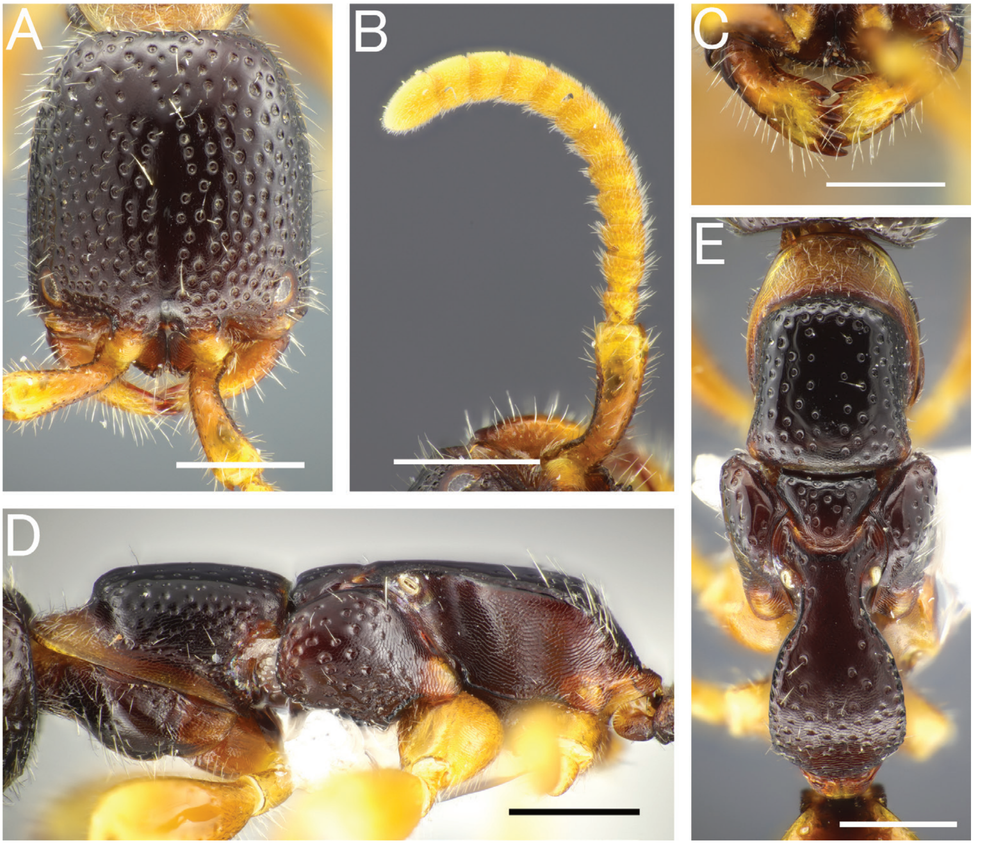

Figure 13. *Pristepyris zhejiangensis*, female, TN170427_01 **A** head in full-face view **B** antenna (left) **C** mandible **D** mesosoma in lateral view **E** mesosoma in dorsal view. Scale bars: 0.5 mm.

diameter of foveolae and weakly imbricate; LPD/WPD = 1.00–1.07. Mesoscutum overlain by posteromedian portion of pronotum. Mesoscutellum trapezoidal, 0.63–0.64× as long as maximum width, weakly imbricate, with sparse and deep foveolae. Mesopleuron largely imbricate excluding smooth anterodorsal part, with sparse and deep foveolae; anterior, upper and lower fovea absent; mesopleural pit absent. Mesodiscrimen with weak median carina. Metasternum with metafurcal pit. Lateral face of metapectal-propodeal complex imbricates entirely. Metapectal-propodeal complex in dorsal view weakly constricted behind propodeal spiracles and then widened again posteriad, without any distinct carinae which subdivide dorsal face; LP/WP = 2.28–2.42; dorsomedian face weakly imbricate; median portion of propodeal declivity weakly and transversely rugoso-scabrous, with sparse foveolae.

Metasoma. Tergum II with weak longitudinal ridge, without longitudinal sulcus; sternum II without longitudinal median carina.

Material examined. Japan: Irabu–jima. 15 males (JM190717_31–45); Makiyama Park, 24°48'57"N, 125°13'00"E, 93 m alt.; HauChuan Liao leg. (sweeping); 23/VII/2019. 1 female (JM190717_28); Makiyama Park, 24°48'57"N, 125°13'00"E, 93 m alt.; HauChuan Liao leg. (sweeping); 23/VII/2019. **Iriomote–jima** 1 male (JIR190717_47); Tropical Biosphere Research Center, 24°23'48"N, 123°48'11"E, 33 m alt. HauChuan Liao leg. (sweeping). **Taiwan: N. Taiwan.** 2 males (TNT171019_04, TNT180504_01); Mt. Dadao Wurai, New Taipei City, 24°51'09"N, 121°33'27"E, 548 m alt.; Hauchuan Liao leg. (sweeping); 26/X/2017, 4/V/2018. **C. Taiwan.** 1 male (TN190315_24); Sungpolun Trail, Nantou County, 23°52'06"N, 120°55'44"E, 789 m alt.; HauChuan Liao leg. (sweeping); 20/III/2019. 1 female (TN170427_01); Huisun Experimental Forest, Nantou County. Po-Cheng Hsu leg.; 27/IV/2017.

Taxonomic remarks. This species is most similar in general appearance to *P. ryukyuensis* among the named species known from East and Southeast Asia (for details, see under Taxonomic remarks of "*P. ryukyuensis*").

Distribution and habitat. Eastern China (Zhejiang), southern Ryukyu, northern and central Taiwan (new to Taiwan); evergreen broadleaf forests.

Key to Taiwanese and Ryukyuan species of the genus *Pristepyris*, based on male morphology

As mentioned above, the present study was unable to provide any evidence which supports or rejects the discrimination between *P. ryukyuensis* and *P. tainanensis* and between *P. ryukyuensis* and *P. zhejiangensis*. *Pristepyris ishigakiensis* was also unable to be discriminated from *P. tainanensis* morphologically. Therefore, these morphological forms are treated as "*P. zhejiangensis* species complex" and "*P. ishigakiensis* species complex", respectively, in the following key and are likely *P. ryukyuensis* or *P. tainanensis*. Female-based species, *P. mieae*, of which the male is unknown, is also omitted from the following key.

1 Transverse pronotal carina absent; apical lobe of aedeagus in lateral view short and lobate (Fig. 5C) .... ***P. seqalu* sp. nov.**

– Distinct transverse pronotal carinae present; apical lobe of aedeagus in lateral view elongate and lobate (Fig. 7C) or elongate and spatulate (Fig. 12C) **2**

2 Cervical pronotal area in lateral view strongly and roundly produced (black arrow in Fig. 11D); apical lobe of aedeagus in ventral view winding (Fig. 12C), in lateral view elongate and spatulate (Fig. 12D) .... ***P. zhejiangensis* species complex**

– Cervical pronotal area in lateral view forming an angulate corner (arrow in Fig. 6D), but not strongly and roundly produced; apical lobe of aedeagus in ventral view straight, not winding (Fig. 7C), in lateral view elongate and lobate (Fig. 7D) .... ***P. ishigakiensis* species complex**

Eleganesia Alencar & Azevedo, 2018

Eleganesia minuta (Yasumatsu, 1955) comb. nov.

Figs 14–18; Table 1

Pristocera minuta Yasumatsu, 1955: 246. Holotype (male, KUF), type loc.: Sobosan, Prov. Bungo, Kyusyu, Japan. *Acrepyris minutus*: Terayama, 1996: 595 (genus transfer). *Pristepyris minutus*: Azevedo et al. 2018: 104 (genus transfer). Comb. nov.

Apenesia takasago Terayama, 1996: 143, figs 15–18. Holotype (male, NSMT), type loc.: Tokkasha, Nantou Hsien, Taiwan. *Pristepyris takasago*: Azevedo et al. 2018: 104 (genus transfer). Syn. nov.

Male diagnosis. TL ≈ 3.3–5.5 mm. HL/HW × 100 = 98–109. Frons and vertex almost smooth and shining or with shallow foveolae, of which intervals are smooth and shining and wider than diameter of foveolae. Anterior clypeal margin nearly straight. Mandible with four apical teeth. Transverse pronotal carina absent. Cervical pronotal area in lateral view gently rounded. LP/WP = 1.30–1.44. Metapostnotal median carina distinct, but incompletely reaching posterior transverse margin. Tergum II without longitudinal ridge and sulcus, sternum II with longitudinal median carina. Hypopygium with almost straight apical margin. Aedeagus with developed ventral and dorsal valves; apical lobe reduced.

Female diagnosis. TL = 3.7 mm. HL/HW × 100 = 139. Frons and vertex with foveolae (ca. 0.01 mm in diameter), of which intervals are imbricate; intervals in lateral part of frons as wide as or narrower than diameter of foveolae; intervals in vertex and median part of frons wider than diameter of foveolate. Median portion of clypeus roundly produced anteriad. Compound eye less developed. Mandible with four teeth. Transverse pronotal carina absent. Cervical pronotal area in lateral view gently rounded. Dorsal area of pronotum, mesoscutellum, mesopleuron and dorsomedian face of metapectal-propodeal complex imbricate. Dorsal area of pronotum, mesoscutellum, mesopleuron and dorsolateral face of metapectal-propodeal complex with spare foveolae. Tergum II without longitudinal ridge and sulcus.

Male description. Full description was given by Yasumatsu (1955) and Terayama (2006). Additional information as below.

Head. HL/HW × 100 = 98–109 (100 in holotype of *P. minuta*). Frons and vertex almost smooth and shining or with inconspicuous foveolae (ca. 0.01–0.02 mm in diameter, Fig. 15A) or shallow foveolae (ca. 0.02–0.04 mm, Fig. 15B), of which intervals are smooth and shining and wider than diameter of foveolae. Occipital carina present. Median portion of clypeus shortly produced anteriad; median clypeal carina moderately distinct, not reaching anterior margin; anterior clypeal margin nearly straight medially. Compound eye large and convex, with sparse thin erect setae. Mandible with four teeth.

Mesosoma. Pronotum without transverse pronotal carina; cervical pronotal area in lateral view round; dorsal area smooth and shining, or with sparse, inconspicuous or

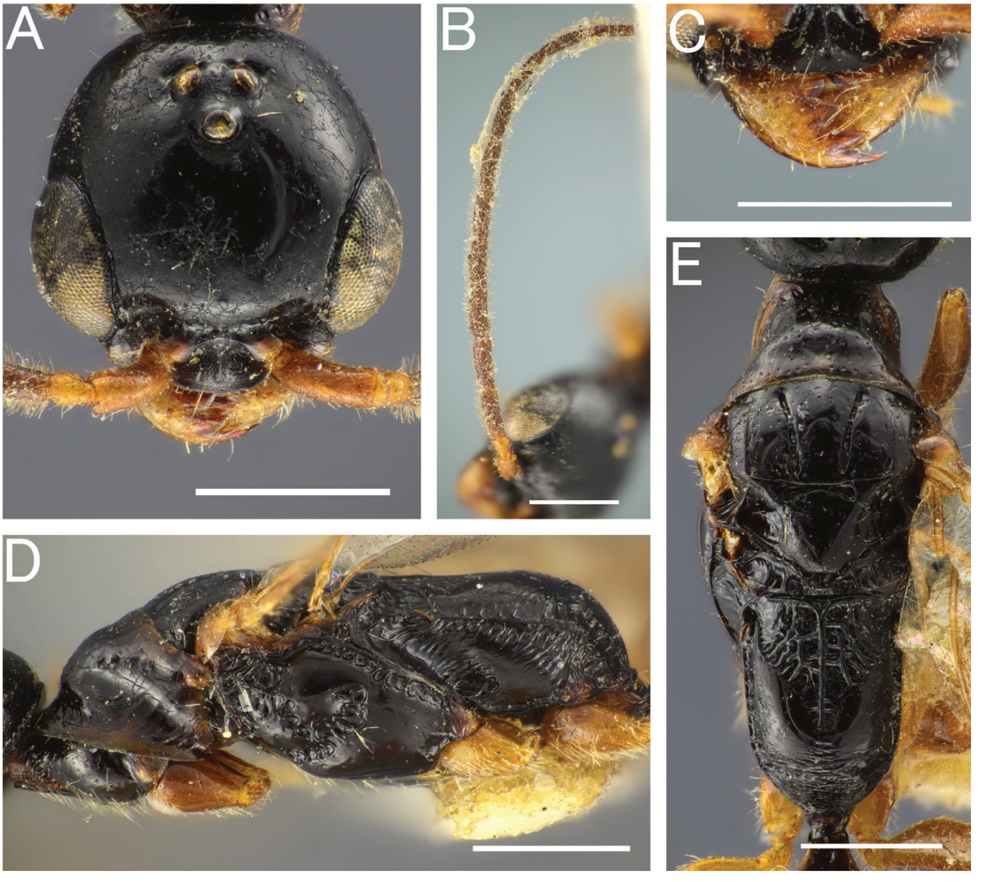

Figure 14. *Eleganesia minuta* comb. nov., male, holotype **A** head in full-face view **B** antenna (right) **C** mandible **D** mesosoma in lateral view **E** mesosoma in dorsal view **F** Forewing **G** hindwing. Scale bars: 0.5 mm.

shallow foveolae. Mesopleuron elongate; anterior, upper and lower fovea distinct; acropleural area smooth and shining, with inconspicuous foveolae; mesopleural pit absent. Mesodiscrimen concave, without median carina. Metasternum with metafurcal pit. Lateral face of metapectal-propodeal complex obliquely rugose in marginal area and irregularly rugose in central area. Metapectal-propodeal complex in dorsal view with lateral margins subparallel and slightly convex; LP/WP = 1.30–1.44 (1.30 in holotype of *P. minuta*); metapostnotal median carina distinct, but incompletely reaching posterior transverse margin; submedian rugae irregularly running; sublateral margin distinct, but short, incomplete posteriorly; posterior transverse margin distinct; dorsomedian face weakly rugoso-scabrous; dorsolateral face smooth and shining; median portion of propodeal declivity with transversely rugoso-scabrous. Forewing with long $R1_2v$ vein and R_2 flexion line, of which the latter is shorter than $1M_2$ flexion line (arrows in Fig. 15F), without $2M1_2$ flexion line. Hindwing with four distal hamuli. Tarsal claws bifid, with thin and curved apical teeth; basal one very short.

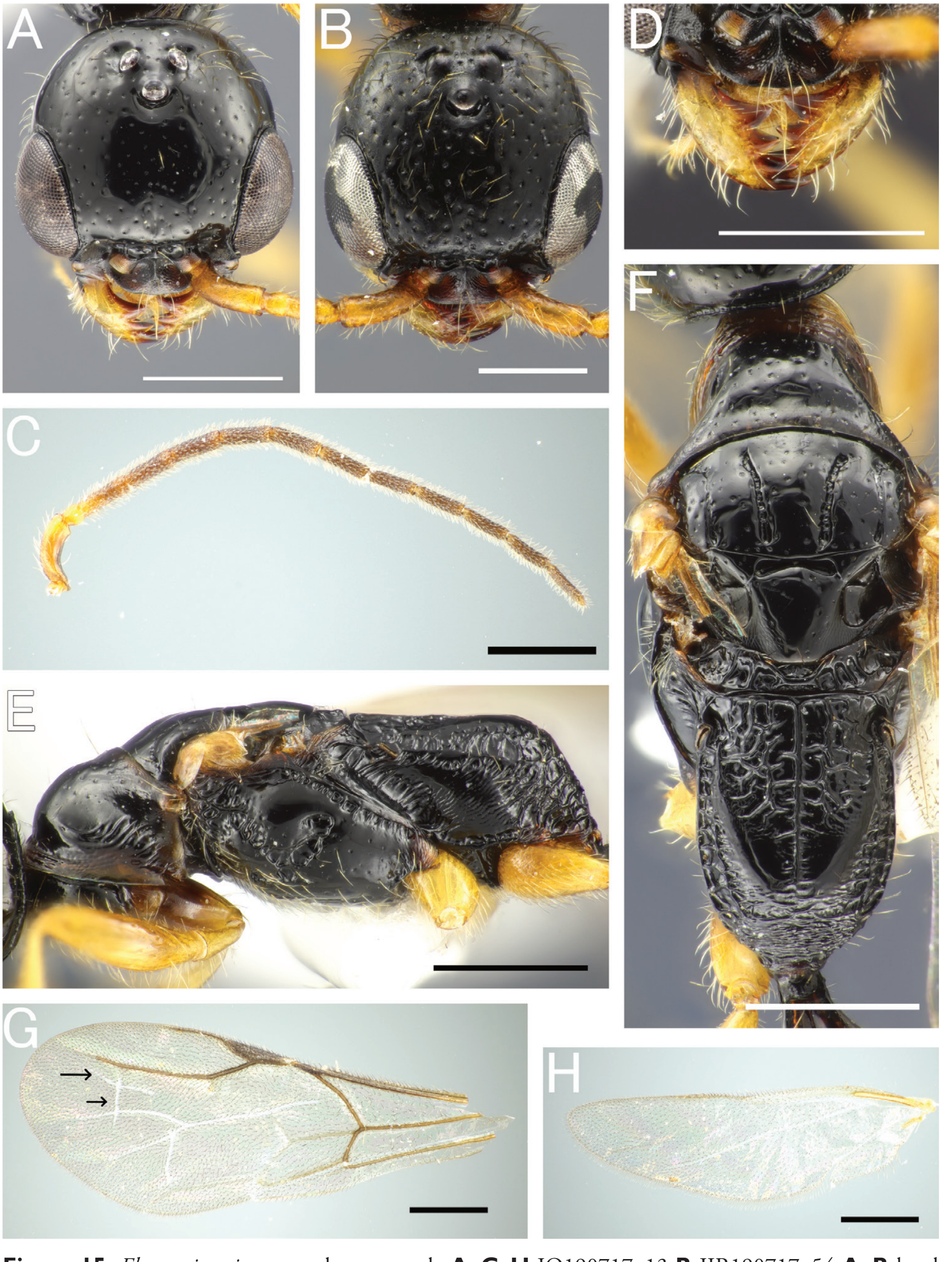

Figure 15. *Eleganesia minuta* comb. nov., male **A, C–H** JO190717_13 **B** JIR190717_54 **A, B** head in full-face view **C** antenna (left) **D** mandible **E** mesosoma in lateral view **F** mesosoma in dorsal view **G** forewing **H** hindwing. Scale bars: 0.5 mm.

Metasoma. Tergum II without longitudinal ridge and sulcus; sternum II with longitudinal median carina. Hypopygium with very long spiculum, with almost straight apical margin; apicomedian part thickened which is visible as a small triangular region;

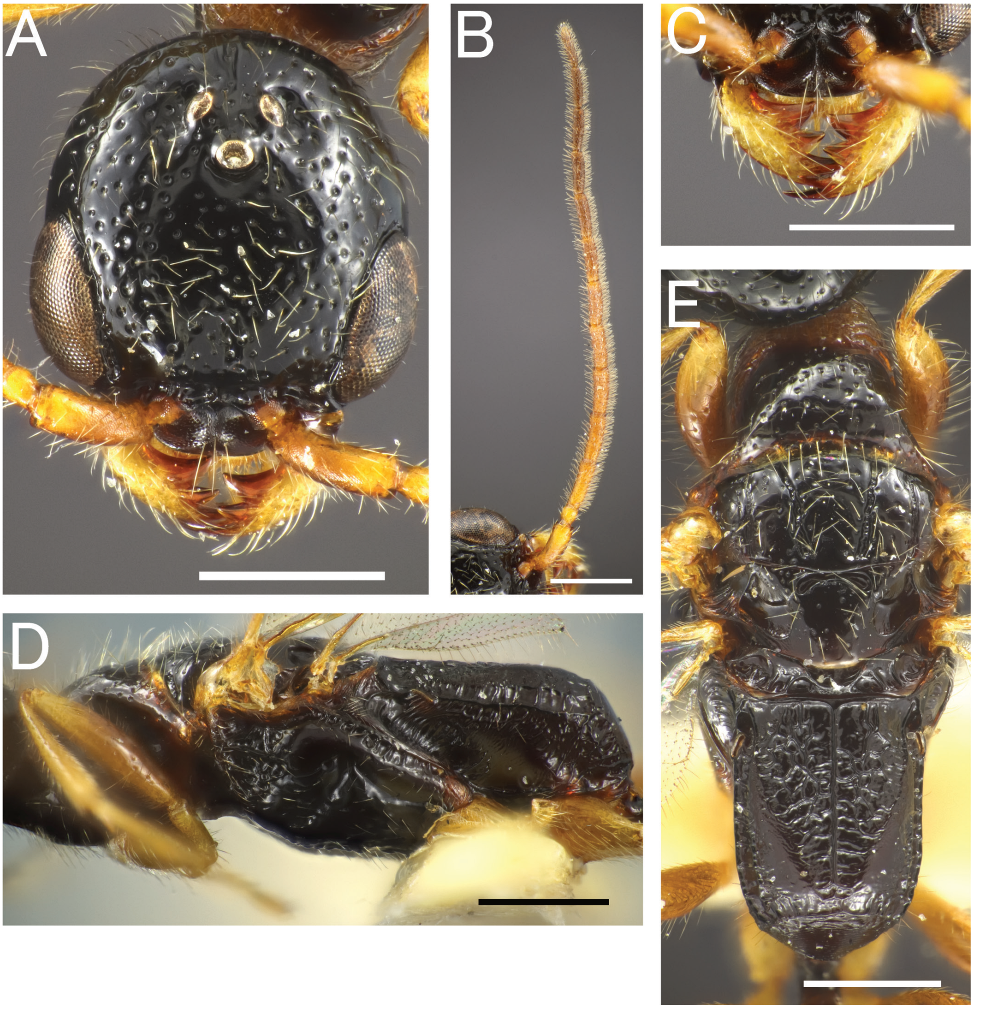

Figure 16. "*Pristepyris takasago*", male, holotype **A** head in full-face view **B** antenna (right) **C** mandible **D** mesosoma in lateral view **E** mesosoma in dorsal view **F** forewing **G** hindwing. Scale bars: 0.5 mm.

outer face of apicomedian part with relatively dense setae; membrane developed between spiculum and S9ala (Fig. 17A), without thickened margin. Gonostipes thin and glabrous, fused to harpe in dorsal portion. Harpe in ventral view elongate-spatulate, slightly curved inward, with blunt apex, entirely covered with setae which increase in length toward apex; median basal portion with concavity which accommodates digitus and cuspis. Subbasal part of volsella with seta-bearing area which is almost as long as cuspis. Cuspis elongate-lobate and straight, extending posteriad, with several long setae at the apex. Digitus extending laterad, curled. Aedeagus with reduced apical lobe; dorsal lobe large; ventral lobe elongated, with large lobate projection produced ventrally in posterior portion (arrow in Fig. 17D, F, H).

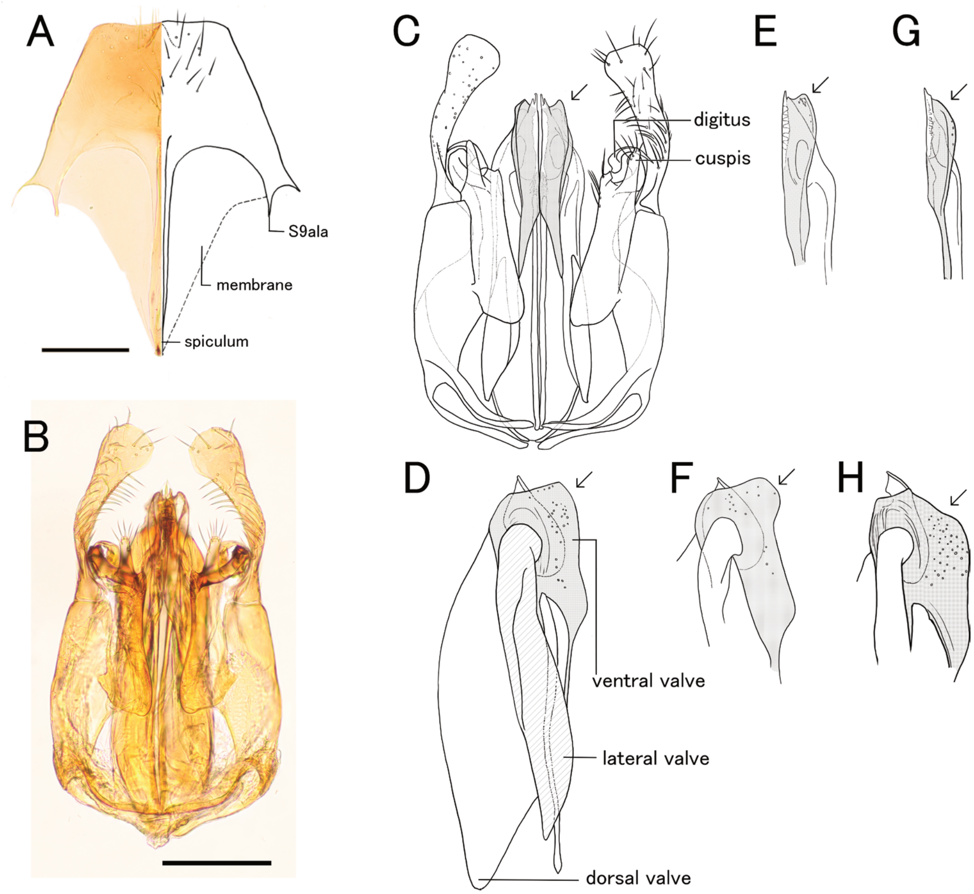

Figure 17. *Eleganesia minuta* comb. nov., male genitalia **A, C** (JO190717_13) from Okinawa-Hontou Island **B** (holotype) **D** (JA170808_13) from Amami-Oshima Island **E** (JI170808_31) **F** (JI170808_35) from Ishigaki–jima Island **G** (TNT180706_01) **H** (TNT180706_06) from Taiwan **A** hypopygium **B, C, E, G** genitalia (and aedeagus) in ventral view **D, F, H** aedeagus in outer-lateral view; arrows show morphological variation in ventral valve of aedeagus. Scale bars: 0.2 mm.

Female description. Female of this species was recognized for the first time by collecting a male and female pair in copulation.

Color. Body light brown; mandible, antenna and legs as same as or lighter than body.

Head. Head capsule with posterior margin very weakly incurved, with posterolateral corner round; HL/HW × 100 = 139. Occipital carina present. Frons and vertex foveolate (ca. 0.01 mm in diameter), with intervals imbricate; intervals in lateral part of frons as wide as or narrower than diameter of foveolae; intervals in vertex and median part of frons as wide as or wider than diameter of foveolae. Clypeus imbricate; median portion roundly produced anteriad; median longitudinal carina reaching anterior clypeal margin which is slightly incurved medially (Fig. 18C). Compound eye less developed. Mandible with four teeth. Antennomere I (excluding the basal condylar bulb) 3.1× as long as maximum width; antennomere I:II:III = 27:8:6 in length; antennomere II 0.9× as long as maximum width, narrowed and bent in basal part; antennomere III–XII each 0.72–0.78× as long as maximum width, elongate-cylindrical; antennomere XIII (terminal) 1.7× as long as maximum width, with round apex.

Mesosoma. Pronotum with anterior flange extending anteriad beyond anterior margin of propleuron; cervical pronotal area in lateral view gently round; dorsal area subtrapezoidal, with weakly incurved posterior margin, with inconspicuous foveolae of which intervals are imbricate and wider than diameter of foveolae; transverse pronotal carina absent; LPD/WPD = 1.36. Mesoscutum overlain by posteromedian portion of pronotum. Mesoscutellum trapezoidal, 0.72× as long as maximum width, weakly imbricate, with a few inconspicuous foveolae. Mesopleuron elongate and imbricate;

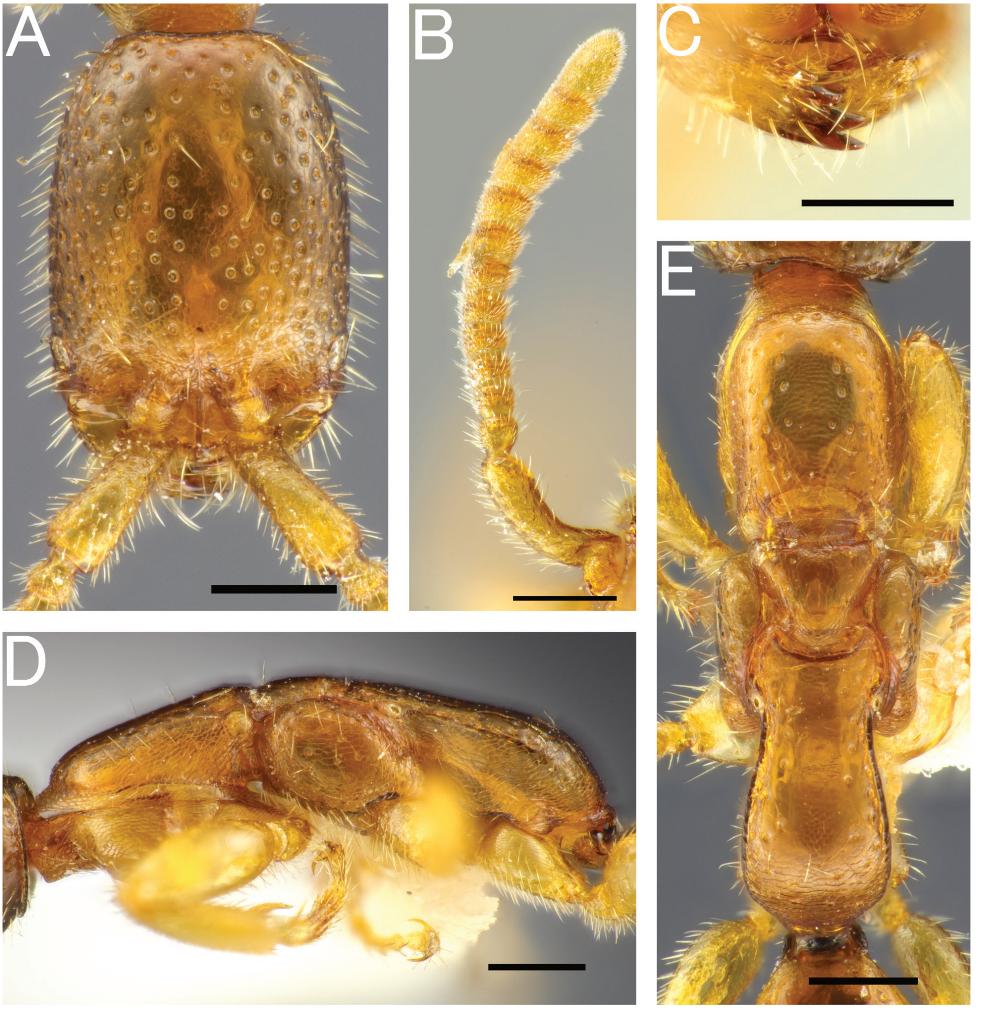

Figure 18. *Eleganesia minuta* comb. nov., female **A** head in full-face view **B** antenna (left) **C** mandible **D** mesosoma in lateral view **E** mesosoma in dorsal view. Scale bars: 0.2 mm.

anterior, upper and lower depressions absent; mesopleural pit absent. Lateral face of metapectal-propodeal complex imbricates entirely. Metapectal-propodeal complex in dorsal view weakly constricted behind propodeal spiracles and then widened again posteriad, without any distinct carinae which subdivide dorsal face; LP/WP = 2.16; dorsomedian face smooth and shining; median portion of propodeal declivity weakly transversely rugoso-scabrous.

Metasoma. Tergum II without longitudinal ridge and sulcus.

Material examined. Japan: Tokyo. 4 males (JT200820_01, 05–07); Minami-osawa, 35°37'11"N, 139°12'03"E, 154 m alt. HauChuan Liao leg. (sweeping); 20/VIII/2020. 1 female, Miyake-jima; Kentaro Tsujii leg.; 25/VIII–22/IX/2012. **Yakushima.** 2 males (JK210921_05, 07); Ohko-no-taki, 30°17'48"N, 130°24'51"E, 16 m alt. HauChuan Liao leg. (sweeping); 22/IX/2021. **Okinawa-Hontou.** 1 male (JO170808_05); Mt. Nago, 26°35'58"N, 128°01'09"E, 181 m alt. HauChuan Liao leg. (sweeping); 10/VIII/2017. 2 males (JO190717_13, 15); Kunigami Vil., 26°44'41"N, 128°13'10"E, 316 m alt. HauChuan Liao leg. (sweeping); 19/VII/2019. **Amami-Oshima.** 1 male (JA170808_13); Mt. Yuwan, 28°16'13"N, 129°19'26"E, 44 m alt. HauChuan Liao leg. (sweeping); 16/VIII/2017. **Ishigaki–jima.** 3 males (JI170808_28, 31, 35), Mt.

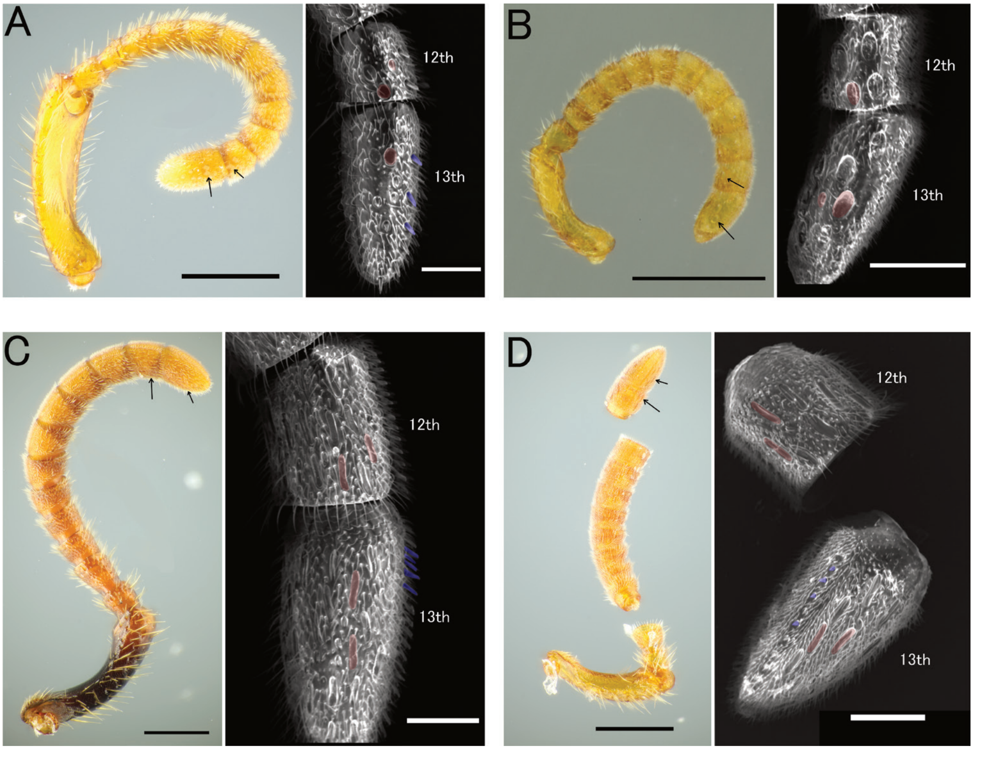

Figure 19. Sensilla placodea (red) and sensilla basiconica (blue) in female wasps, with SEM image. **A** *Apenesia makiharai*, JO180206_01 **B** *Eleganesia takasago*, TP170606_C2 **C** *Pristepyris zhejiangensis*, JM090717_28 **D** *Propristocera* sp. Scale bars: 0.25 mm in light microscope images; 50 µm in SEM images.

Omoto, 24°26'31"N, 124°05'56"E, 93 m alt. HauChuan Liao leg. (sweeping); 12–13/ VIII/2017. **Iriomote–jima.** 2 males (JIR190717_49, 54), Tropical Biosphere Research Center, 24°23'48"N, 123°48'11"E, 33 m alt. HauChuan Liao leg. (sweeping); 27–28/ VII/2019. **Taiwan: N. Taiwan.** 3 males (TNT180629_03, 04, 09), Mt. ShiZaiTou, New Taipei City, 24°54'14"N, 121°29'46"E, 778 m alt. HauChuan Liao leg. (sweeping); 29/VI/2018. 5 males (TNT180706_01, 04, 06–08), Mt. Ta Tung, New Taipei City, 24°52'53"N, 121°34'07"E, 602 m alt. HauChuan Liao leg. (sweeping); 6/ VII/2018. **C. Taiwan.** 2 males (TN181022_40, 47); Sun Moon Lake, Nantou County, 23°50'57"N, 120°56'16"E, 92 m alt. HauChuan Liao leg. (sweeping); 23/X/2018.

Taxonomic remarks. Due to the new combination of "*Pristepyris minutus*" to the genus *Elganesia*, the "Key to Taiwanese and Ryukyuan species of the genus *Eleganesia*, based on male morphology" given in Liao et al. (2021) is updated and given as Appendix 1.

The holotype of "*Pristepyris takasago*" was unable to be discriminated morphologically from *E. minuta* (including the holotype). Therefore, the former is herein synonymised under the latter.

In the present phylogenetic tree (Fig. 3), *E. minuta* was subdivided into three (or four) lineages, i.e. Lineage "X" from the Kanto area of Japan to Okinawa-Hontou; "Y" from Ishigaki–jima to Taiwan and "Z" from Taiwan. The lineages also showed differences in the shape of the lobate extension of the ventral valve of aedeagus (Lineage X as in Fig. 17C, D; Y as Fig. 17E, F; Z as Fig. 17G, H). However, there was no remarkable difference among them in external morphology and hypopygium (excluding weak variation in head sculpture as seen in Figs 14A, 15A, B, 16A) and also no differences in the 28S sequence (Table 2). As the lineages were parapatric or allopatric in the area of Taiwan and the Ryukyus, in the present study, the Lineage X, Y and Z are conspecific and treated as *E. minuta*. However, it is also possible that further taxon sampling and integrative taxonomy may reveal several cryptic species within *E. minuta* and determine one of them as "*E. takasago*" (see also "Discussion").

Distribution and habitat. Hokkaido to Ryukyus in Japan (Terayama 2006), northern South Korea (Lim et al. 2011), northern and central Taiwan; evergreen broadleaf forest.

Acknowledgements

We sincerely thank Dr. Su Yong-Chao (Kaohsiung Medical Univ.), Dr. Lin Chung-Chi (National Changhua University of Education) and Dr. Toshiharu Mita (Kyushu Univ.) for their kind help during our field surveys; Dr. C. F. Lee (TARI), Dr. J. F. Tsai (NMNS), Dr. S. Yoshimatsu and Dr. J. Yamasako (NARO) for kindly allowing us to examine their collections and taking high-quality photographs of type specimens; and Dr. Shimpei F. Hiruta (NSMT) for kindly giving us valuable suggestions on our phylogenetic analyses. We acknowledge receiving valuable information and advice concerning ABS-Nagoya Protocol from the ABS Support Team for Academia (National Institute of Genetics) and the ABS Advisory Team of TMU (Tokyo Metropolitan University), under the National BioResource Project under the Ministry of Education, Culture, Sports, Science and Technology (MEXT). This research is funded by the following foundations and societies: Asahi Glass Foundation [Leader: Katsuyuki Eguchi; FY2017-FY2020]; Tokyo Metropolitan University Fund for TMU Strategic Research [Leader: Prof. Noriaki Murakami; FY2020-FY2022]; and Tokyo Human Resources Fund for City Diplomacy.

References

Aberer AJ, Kobert K, Stamatakis A (2014) ExaBayes: Massively Parallel Bayesian Tree Inference for the Whole-Genome Era. Molecular Biology and Evolution 31(10): 2553–2556. https://doi.org/10.1093/molbev/msu236

Alencar IDCC, Azevedo CO (2020) Revision of the world *Apenesia* Westwood (Hymenoptera, Bethylidae). Zootaxa 4724(1): 1–72. https://doi.org/10.11646/zootaxa.4724.1.1

Alencar IDCC, Colombo WD, Azevedo CO (2016) *Pristocera masii*: rediscovery of the holotype and its transfer to *Acrepyris* (Hymenoptera: Bethylidae). Acta Entomologica Musei Nationalis Pragae 56: 795–803.

Alencar IDCC, Waichert C, Azevedo CO (2018) Opening Pandora's box of Pristocerinae: Molecular and morphological phylogenies of *Apenesia* (Hymenoptera, Bethylidae) reveal several hidden genera. Systematic Entomology 43(3): 481–509. https://doi.org/10.1111/syen.12295

Azevedo CO (2008) Characterization of the types of the Neotropical *Pseudisobrachium* (Hymenoptera: Bethylidae), with a key to species. Revista Brasileira de Zoologia 25(4): 737–801. https://doi.org/10.1590/S0101-81752008000400020

Azevedo CO, Alencar IDCC (2009) Rediscovery of *Pristepyris* Kieffer (Hymenoptera, Bethylidae), a new synonym of *Acrepyris* Kieffer. Zootaxa 2287(1): 45–54. https://doi.org/10.11646/zootaxa.2287.1.2

Azevedo CO, Colombo WD, Alencar IDCC, Brito CD, Waichert C (2016) Couples in phoretic copulation, a tool for male-female association in highly dimorphic insects of the wasp genus *Dissomphalus* Ashmead (Hymenoptera: Bethylidae). Zoologia 33(6): 1–7. https://doi.org/10.1590/s1984-4689zool-20160076

Azevedo CO, Alencar IDCC, Ramos MS, Barbosa DN, Colombo WD, Vargas RJM, Lim J (2018) Global guide of the flat wasps (Hymenoptera, Bethylidae). Zootaxa 4889(1): 1–294. https://doi.org/10.11646/zootaxa.4489.1.1

Colombo WD, Perkovsky EE, Azevedo CO (2020) Phylogenetic overview of flat wasps (Hymenoptera, Bethylidae) reveals Elektroepyrinae, a new fossil subfamily. Palaeoentomology 3(3): 269–283. https://doi.org/10.11646/palaeoentomology.3.3.8

Drummond AJ, Suchard MA, Xie D, Rambaut A (2012) Bayesian phylogenetics with BEAUti and the BEAST 1.7. Molecular Biology and Evolution 29(8): 1969–1973. https://doi.org/10.1093/molbev/mss075

Fisher BL, Smith AM (2008) A revision of Malagasy species of *Anochetus* Mayr and *Odontomachus* Latreille (Hymenoptera: Formicidae). PLoS ONE 3(5): e1787. https://doi.org/10.1371/journal.pone.0001787

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 294–299.

Gobbi FT, Azevedo CO (2010) Taxonomy of *Pseudisobrachium* (Hymenoptera, Bethylidae) from the Brazilian Atlantic Rain Forest. Revista Brasileira de Entomologia 54: 173–224. https://doi.org/10.1590/S0085-56262010000200003

Gobbi FT, Azevedo CO (2014) Revision of *Caloapenesia* (Hymenoptera, Bethylidae), with description of sixteen new species. Zootaxa 3860(6): 501–535. https://doi.org/10.11646/zootaxa.3860.6.1

Gobbi FT, Azevedo CO (2016) Revision of *Calobrachium* Gobbi & Azevedo, gen. nov. (Hymenoptera, Bethylidae), with description of seven new Oriental species. Zootaxa 4803: 221–238. https://doi.org/10.11646/zootaxa.4083.2.3

Gordh G (1990) *Apenesia evansi* sp. n. (Hymenoptera: Bethylidae) from Australia with comments on phoretic copulation in bethylids. Journal of the Australian Entomological Society 29(3): 167–170. https://doi.org/10.1111/j.1440-6055.1990.tb00341.x

Guindon S, Dufayard JF, Lefort V, Anisimova M, Hordijk W, Gascuel O (2010) New algorithms and methods to estimate maximum-likelihood phylogenies: Assessing the performance of PhyML 3.0. Systematic Biology 59(3): 307–321. https://doi.org/10.1093/sysbio/syq010

Katoh K, Rozewicki J, Yamada KD (2019) MAFFT online service: Multiple sequence alignment, interactive sequence choice and visualization. Briefings in Bioinformatics 20(4): 1160–1166. https://doi.org/10.1093/bib/bbx108

Kieffer JJ (1905) Description de nouveaux Proctotrypides exotiques avec une planche et une figure dans le texte. Annales de la Société Scientifique de Bruxelles 29: 95–142.

Kumar S, Stecher G, Li M, Knyaz C, Tamura K (2018) MEGA X: Molecular evolutionary genetics analysis across computing platforms. Molecular Biology and Evolution 35(6): 1547–1549. https://doi.org/10.1093/molbev/msy096

Lanes GO, Kawada R, Azevedo CO, Brothers DJ (2020) Revisited morphology applied for Systematics of flat wasps (Hymenoptera, Bethylidae). Zootaxa 4752(1): 1–127. https://doi.org/10.11646/zootaxa.4752.1.1

Liao H, Terayama M, Eguchi K (2019) Revision of Taiwanese and Ryukyuan species of *Propristocera* (Hymenoptera: Bethylidae), with description of a new species. Zootaxa 4668(4): 451–474. https://doi.org/10.11646/zootaxa.4668.4.1

Liao H, Terayama M, Eguchi K (2021) Revision of Taiwanese and Ryukyuan species of *Eleganesia* Alencar & Azevedo, 2018 (Hymenoptera, Bethylidae). Zoologischer Anzeiger 294: 62–79. https://doi.org/10.1016/j.jcz.2021.07.010

Lim J, Terayama M, Koh S, Lee J, Lee S (2011) A taxonomic review of the subfamily Pristocerinae (Hymenoptera: Chrysidoidea: Bethylidae) from Korea with descriptions of two new species. Journal of Natural History 45(7–8): 435–460. https://doi.org/10.1080/00222933.2010.534191

Minh BQ, Nguyen MAT, Haeseler AV (2013) Ultrafast approximation for phylogenetic bootstrap. Molecular Biology and Evolution 30(5): 1188–1195. https://doi.org/10.1093/molbev/mst024

Minh BQ, Schmidt HA, Chernomor O, Schrempf D, Woodhams MD, Haeseler AV, Lanfear R (2020) IQ-TREE 2: New models and efficient methods for phylogenetic inference in the genomic era. Molecular Biology and Evolution 37(5): 1530–1534. https://doi.org/10.1093/molbev/msaa015

Papadopoulou A, Anastasiou I, Vogler AP (2010) Revisiting the insect mitochondrial molecular clock: The mid-aegean trench calibration. Molecular Biology and Evolution 27(7): 1659–1672. https://doi.org/10.1093/molbev/msq051

Rambaut A, Drummond AJ, Xie D, Baele G, Suchard MA (2018) Posterior Summarization in Bayesian Phylogenetics Using Tracer 1.7. Systematic Biology 67(5): 901–904. https://doi.org/10.1093/sysbio/syy032

Satria R, Kurushima H, Herwina H, Yamane S, Eguchi K (2015) The trap-jaw ant genus *Odontomachus* Latreille form Sumatra, with a new species description. Zootaxa 4048: 1–36. https://doi.org/10.11646/zootaxa.4048.1.1

Tamura K, Stecher G, Peterson D, Filipski A, Kumar S (2013) MEGA6: Molecular Evolutionary Genetics Analysis version 6.0. Molecular Biology and Evolution 30(12): 2725–2729. https://doi.org/10.1093/molbev/mst197

Terayama M (1995) Taiwanese species of the genus Pristocera (Hymenoptera, Chrysidoidea, Berthylidae). Japanese Journal of Entomology 1: 139–145.

Terayama M (1996) The phylogeny of the bethylid wasp subfamily Pristocerinae (Hymenoptera, Bethylidae). Japanese Journal of Entomology 64: 587–601.

Terayama M (1999) Description of new species of the family Bethylidae from the Ryukyus, and taxonomic notes on the Japanese species of the *Sclerodermus*. In: Yamane S, Ikudome S, Terayama M (Eds) Identification Guide to the Aculeata of the Nansei Islands. Hokkaido University Press: Sapporo, Japan, 701–725.

Terayama M (2006) The Insects of Japan (Hymenoptera), Vol. 1. Touka Shobo Co, Fukuoka, Japan, 319 pp.

Terayama M, Xu ZF, He JH (2002) Three new species of the genus *Acrepyris* Kieffer, 1905 (Hymenoptera, Bethylidae) from China. Japanese Journal of Systematic Entomology 8: 81–86.

Thompson JD, Higgins DG, Gibson TJ (1994) CLUSTAL W: Improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. Nucleic Acids Research 22(22): 4673–4680. https://doi.org/10.1093/nar/22.22.4673

Yasumatsu K (1955) Taxonomic notes on three wireworm parasites of the genus *Pristocera* from the Far East (Hymenoptera: Bethyloidea). Journal of the Faculty of Agriculture, Kyushu University 10(3): 233–249. https://doi.org/10.5109/22656

Appendix 1

Updated key to Taiwanese and Ryukyuan species of the genus *Eleganesia*, based on male morphology

The following key is partly modified from Liao et al. (2021) in order to involve *E. minuta* comb. nov.

1 Mandible with 4 teeth **2**

– Mandible with 5 teeth 7

2 Dorsolateral face of metapectal-propodeal complex smooth and shining, inner membrane of hypopygium without anterior margin .... ***E. minuta* (Yasumatsu, 1955) comb. nov.**

– Dorsolateral face of metapectal-propodeal complex rugose, inner membrane of hypopygium with anterior margin **3**

3 Dorsal face of head and dorsal pronotal area with foveolae of which interspaces are imbricate .... ***E. liukueiensis* (Terayama, 1996)**

– Dorsal face of head and dorsal of pronotum with foveolae of which interspaces are smooth **4**

4 Antennomere III to XII short, 2.0× as long as wide .... ***E. takasago* (Terayama, 1996)**

– Antennomere III to XII long, more than 2.5× as long as wide **5**

5 Head long, HL/HW = 121. Compound eye with relatively long erect setae .... ***E. paiwan* Liao et al., 2021**

– Head relatively round, HL/HW less than 115. Compound eye with short erect setae **6**

6 Thickened region of apicomedian part of hypopygium trapezoidal. Ventral valve of aedeagus in lateral view with posteroventral projection quadrate .... ***E. elegans* (Terayama, 1999)**

– Thickened region of apicomedian part of hypopygium triangular. Ventral valve of aedeagus in lateral view with posteroventral projection narrowly produced .... ***E. kijimuna* Liao et al., 2021**

7 Antennomere III to XII 2.0–2.4× as long as wide. Frons and vertex with dense and shallow foveolae of which intervals are imbricate. LP/WP = 1.46–1.60. Apical margin of hypopygium broadly and evenly concave .... ***E. meifuiae* (Terayama, 1996)**

– Antennomere III to XII 3.0× as long as wide. Frons and vertex with dense and deep foveolae of which intervals are smooth and shining. LP/WP = 1.30–1.45. Apical margin of hypopygium with a median angular projection .... ***E. chitouensis* (Terayama, 1996)**

ZooKeys 1102: 43–58 (2022)
doi: 10.3897/zookeys.1102.83198
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Notomastus bermejoi, a new species of Capitellidae (Annelida, Polychaeta) from the Gulf of California, with morphological remarks on species with hooks in thoracic chaetigers

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Academic editor: Christopher Glasby | Received 7 March 2022 | Accepted 21 April 2022 | Published 19 May 2022

http://zoobank.org/5EC09C6D-2413-4608-AFE5-7582B496FBF0

Citation: Hernández-Alcántara P, Garcia-Garza ME, Solis-Weiss V (2022) *Notomastus bermejoi*, a new species of Capitellidae (Annelida, Polychaeta) from the Gulf of California, with morphological remarks on species with hooks in thoracic chaetigers. ZooKeys 1102: 43–58. https://doi.org/10.3897/zookeys.1102.83198

Abstract

Notomastus bermejoi **sp. nov.** from the Gulf of California shelf is described, illustrated, and compared with its congeners bearing hooded hooks in thoracic chaetigers. This new species is characterized by the presence of a prostomial palpode, only notopodia in the first chaetiger, hooded hooks in neuropodia of chaetiger 11, and its distinct methyl green staining pattern consisting of: chaetigers 1–4 slightly stained, chaetigers 5–10 with green bands encircling the segments, and a darker, solid, green band encircling the body in chaetigers 11–12. It is mainly distributed in the central Gulf of California in fine sand bottoms (62–96%) at 32–106.4 m depth, tolerating a wide range of temperature (13.2–17.59 °C), dissolved oxygen (0.8–4.93 ml/L), and organic carbon (3.0–7.2%). The type material and original descriptions of *Notomastus* species with hooks in thoracic chaetigers were examined; an identification key and tables with morphological distinctive characteristics, methyl green staining patterns, and geographic distribution of these close species are provided.

Keywords

Mexican Pacific, new species, Polychaeta, staining patterns, taxonomy

Introduction

Capitellids are burrowing worms, usually elongate and thread-like. They are among the most frequently recorded polychaetes in marine soft bottoms, living at a wide bathymetric range from intertidal to deep sea and may even be the dominant organisms in infaunal communities, especially in organically enriched sediments (Blake 2000). The family Capitellidae Grube, 1862 is one of the oldest recognized polychaete families and currently is composed of approximately 200 valid species belonging to 43 genera (Magalhães and Bailey-Brock 2012; Silva and Amaral 2019). Although they can be easily recognized at the family level, their accurate identification, even at the generic level, is difficult since very few distinctive morphological characters are visible (Magalhães and Blake 2019). So, definitions at the generic and species level have always been controversial, as they are mainly based on the number and structure of the thoracic chaetigers and the distribution of different types of chaetae along the body. However, as demonstrated recently (Magalhães and Blake 2019), those characters, far from being stable, can change with age and sexual maturity and, thus, 21 genera are monotypic and most of them are represented by a single type specimen, frequently incomplete.

The genus *Notomastus* M. Sars, 1851 is characterized by a thorax with 12 segments: the peristomium and 11 chaetigers; the first thoracic chaetiger is uni- or biramous and the last may have capillary chaetae, hooded hooks, or a mixture of both; in the abdominal chaetigers, hooded hooks are present, while branchiae can be present or absent (García-Garza and de León-González 2015). Ten of the 44 valid species, including *Notomastus bermejoi* sp. nov., were originally described from the Gulf of California: *N. abyssalis* Fauchald, 1972, *N. angelicae* Hernández-Alcántara and Solís-Weiss, 1998, *N. cinctus* Fauchald, 1972, *N. fauchaldi* García-Garza and de León-González, 2015, *N. landini* García-Garza and de León-González, 2015, *N. lobulatus* García-Garza and de León-González, 2015, *N. mazatlanensis* García-Garza, de León-González and Tovar-Hernández, 2019, *N. precocis* Hartman, 1960, and *N. sonorae* Kudenov, 1975.

Predictably, in *Notomastus*, the taxonomic problems detected in other capitellid genera also occur, with several species that do not entirely fit the genus definition, e.g., *N. exsertilis* Saint-Joseph, 1906 has only 10 thoracic chaetigers and bears capillary chaetae in the first two abdominal segments, or *N. hedlandica* where capillary chaetae in the first abdominal segment are present (Hartmann-Schröder 1979), making us think that they probably belong to other genera (García-Garza et al. 2019).

This confusing situation usually leads to misidentifications. This is the case of *Notomastus americanus* Day, 1973, which was originally described from off Beaufort, North Carolina, and then reported from the Gulf of California by Hernández-Alcántara and Solís-Weiss (1993, 1998, 1999), due to the presence of hooded hooks in neuropodia of chaetiger 11. However, *N. americanus* was later synonymized with *Notomastus hemipodus* Hartman, 1945 by García-Garza et al. (2012), based on their revision of the type material. Then, recently, the careful taxonomic examination of the specimens catalogued as *N. americanus* deposited in the Colección Nacional de

Anélidos Poliquetos, Instituto de Ciencias del Mar y Limnología (ICML)Universidad Nacional Autónoma de México (UNAM), Mexico City, revealed significant differences, not only with the type material of *N. americanus* (= *N. hemipodus*) but also with close species. That is why the aim of this study is to describe a new species of *Notomastus* from those misidentified organisms. To corroborate the status of the new species, we also reviewed the type material and original descriptions of *Notomastus* species with hooded hooks in thoracic chaetigers deposited in the National Museum of Natural History, Smithsonian Institution and Natural History Museum of Los Angeles County. An identification key and tables with morphological distinctive characteristics and methyl green staining patterns to support the future identification of these capitellids are provided.

Materials and methods

The material examined was collected in the continental shelf of the Gulf of California, Mexican Pacific (20°30'–31°38'N, 105°42'–114°50'W), as part of the oceanographic expedition "Cortes 2" (Fig. 1; Table 1) on board the R/V *El Puma* of the Universidad Nacional Autónoma de México (**UNAM**). The samples were collected with a Smith-McIntyre grab (0.1 m^2) and sieved through a 0.5 mm mesh. The specimens were fixed in 10% formalin in seawater and later preserved in 70% ethanol. Additionally, at each station, depth, temperature, and salinity were measured with a Niels Brown CTD, and the dissolved oxygen determined by the Winkler method (Strickland and Parsons 1972). The organic matter content was evaluated by the Walkley and Black (1934) acid digestion method and the sediment texture was determined following the method of wet sieving (Folk 1980).

The specimens were examined under dissecting and compound light microscopes, both with an integrated camera for photography. Detailed examination of the chaetal types, distribution, and morphology were supported with scanning electron microscope images: specimens were dehydrated via a graded ethanol series, critical-point dried with liquid CO_2, coated with gold, and examined in a JEOL JSM6360LV microscope at the Instituto de Ciencias del Mar y Limnología (**ICML**), UNAM. The methyl green staining pattern was examined by immersing the specimens for 2 min in a saturated solution of methyl green in 70% ethanol, then washing them in ethanol 70% to remove the excess methyl green (Warren et al. 1994).

All identified specimens and the type material of the new species were deposited in the Colección Nacional de Anélidos Poliquetos of the ICML, UNAM (CNAP-ICML: DFE.IN.061.0598). Paratypes were deposited in the Natural History Museum of Los Angeles County (**LACM-AHF Poly**).

The type material of *Notomastus* species with hooded hooks in thoracic chaetigers deposited in the National Museum of Natural History, Smithsonian Institution (**USNM**) and in the Natural History Museum of Los Angeles County were also examined to compare their morphological characteristics with those found in the new capitellid.

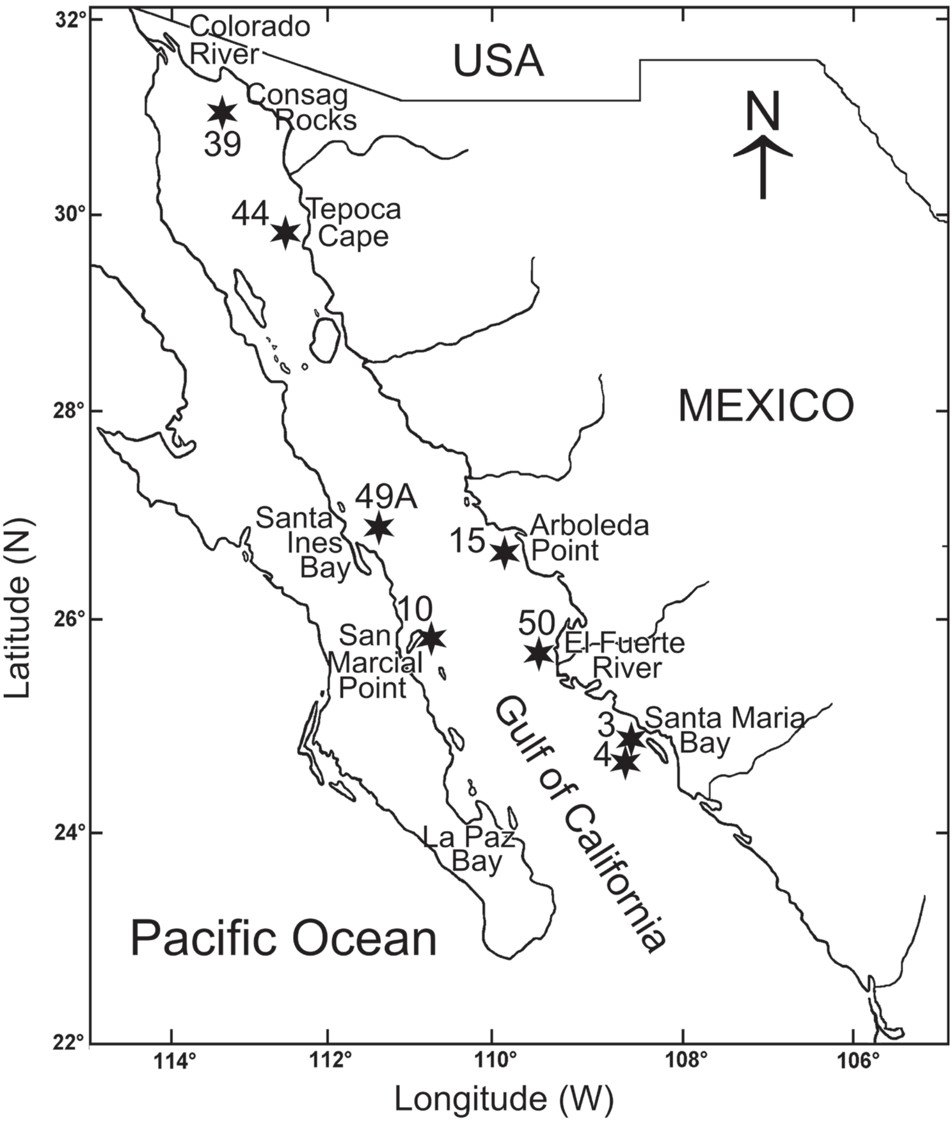

Figure 1. Gulf of California showing the sampling stations where *Notomastus bermejoi* sp. nov. was collected.

Table 1. Location and environmental conditions of the sampling stations where *Notomastus bermejoi* sp. nov. was collected.

Station	GPS Coordinates	Depth (m)	Salinity (psu)	Temperature (°C)	Dissolved oxygen (ml/lt)	Organic matter (%)	Sand (%)
39	30°59.4'N, 114°04.1'W	106.4	35.16	13.2	1.73	3.0	82
44	30°02.4'N, 112°55.4'W	104.1	35.26	14.2	2.40	7.2	74
15	26°51.1'N, 110°06.5'W	49.8	35.22	14.1	1.04	4.6	88
50	25°46.8'N, 109°35.4'W	97.0	34.99	13.2	1.47	5.7	62
3	25°02.4'N, 108°31.7'W	32.0	35.04	14.0	1.02	5.7	96
4	24°56.9'N, 108°41.8'W	79.0	35.00	13.2	0.80	3.0	77
49A	26°59.6'N, 111°50.4'W	100.0	35.10	13.2	1.34	3.6	96
10	25°58.6'N, 111°06.9'W	39.0	35.51	17.5	4.93	4.1	87

Results

Taxonomy

Family Capitellidae Grube, 1862

Genus *Notomastus* M. Sars, 1851

Type species. *Notomastus latericeus* M. Sars, 1851: 199–200.

Diagnosis. The genus *Notomastus* has a conical prostomium, palpode present or absent; eyespots present in multiple spots or absent. Peristomium clearly distinct from prostomium. First chaetiger uniramous or biramous. Eleven thoracic chaetigers. Chaetigers 1–11 with only capillaries or last 1–3 thoracic chaetigers with notopodial capillaries and neuropodial hooks. Abdominal segments with only hooded hooks. Branchiae present or lacking. Genital pores present or absent. Lateral organs present on thorax and abdomen. Pygidium unadorned but unknown for many species (Magalhães and Blake 2019).

Notomastus bermejoi sp. nov.

http://zoobank.org/8BDAB03F-3774-4BF4-80E6-514FF76B5E96
Figs 2A–J, 3A–F

Notomastus americanus—Hernández-Alcántara and Solís-Weiss 1993: 1034, 1998: 710–711, 1999: 27.

not Notomastus americanus—Day 1973: 100, fig. 131n (= *N. hemipodus* Hartman, 1945 fide García-Garza et al. 2012).

Material examined. Type locality. Mexico • Gulf of California, Tepoca Cape; 30°02.4'N, 112°55.4'W; 104.1 m. ***Holotype*:** from type locality; 17 Mar. 1985; P. Hernández-Alcántara leg.; fine sand sediment; CNAP-POH-17-002. ***Paratypes*:** Mexico • 2 specs.; Gulf of California; same collection data as for holotype; CNAP-POP-005 • 2 specs.; El Fuerte River, Sta. 50; 25°46.8'N, 109°35.4'W; 87 m; 20 Mar. 1985; same collector as for preceding; fine sand sediment; CNAP-POP-006 • 1 spec.; San Marcial Point, Sta. 10; 25°58.6'N, 111°06.9'W; 39 m; 11 Mar. 1985; same collector as for preceding; fine sand sediment; CNAP-POP-17-007 • 1 spec.: Arboleda Point, Sta. 15; 26°51.1'N, 110°06.5'W; 49.8 m; 12 Mar. 1985; same collector as for preceding; fine sand sediment; coated with gold for SEM studies; CNAP-POP-17-008 • 4 specs.; North Consag Rocks, Sta. 39; 30°59.4'N, 114°04.1'W; 106.4 m; 16 Mar. 1985; same collector as for preceding; fine sand sediment; LACM-AHF Poly 12858.

Additional material. Mexico • 1 spec.; Gulf of California, El Fuerte River, Sta. 50; 25°46.8'N, 109°35.4'W; 87 m; 20 Mar. 1985; same collector as for preceding; CNAP-PO-036/GCA-CS-2006 • 1 spec.; San Marcial Point, Sta. 10; 25°58.6'N, 111°06.9'W); 39 m; 11 Mar. 1985; same collector as for preceding; CNAP-PO-036/GCA-CS-2007 • 3 specs.; Arboleda Point, Sta. 15; 26°51.1'N, 110°06.5'W; 49.8 m; 12 Mar. 1985; same collector as for preceding; CNAP-PO-036/GCA-CS-2008 • 1 spec.;

Santa Maria Bay, Sta. 3; 25°02.4'N, 108°31.7'W; 32 m; 19 Mar. 1985; same collector as for preceding; CNAP-PO-036/GCA-CS-2009 • 6 specs.; North Consag Rocks, Sta. 39; 30°59.4'N, 114°04.1'W; 196.4 m; 16 Mar. 1985; same collector as for preceding; CNAP-PO-036/GCA-CS-2010 • 2 specs.; Santa Maria Bay, Sta. 4; 24°56.9'N, 108°41.8'W; 79 m; 10 Mar. 1985; same collector as for preceding; CNAP-PO-036/GCA-CS-2011 • 1 spec.; Santa Ines Bay, Sta. 49A; 26°59.6'N, 111°50.4'W; 100 m; 19 Mar. 1985; same collector as for preceding; CNAP-PO-036/GCA-CS-2012.

Comparative type material examined. *Notomastus americanus* Day, 1973. ***Holotype*:** USA • 1 spec.; North Carolina, Beaufort; 4 Jun. 1965; USNM 43118. ***Paratypes*:** USA • 14 specs.; same collection data as for holotype; USNM 43119.

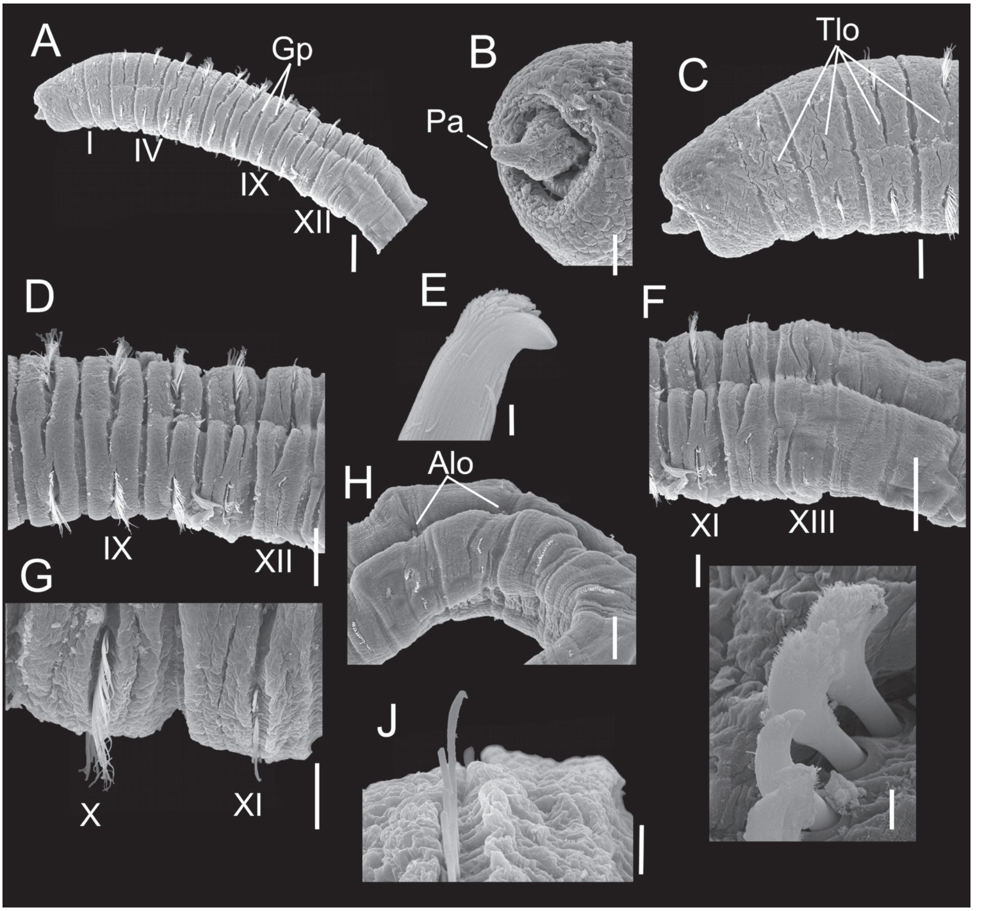

Figure 2. *Notomastus bermejoi* sp. nov., paratype (CNAP-POP-17-008) **A** thoracic region, lateral view **B** prostomium, frontal view **C** prostomium and chaetigers 1–4, lateral view **D** chaetigers 8–12, lateral view **E** hooded hook chaetiger 11 **F** chaetigers 11–14, lateral view **G** neuropodia 10–11 **H** abdominal chaetigers (18–21) **I** abdominal hooded hooks **J** neuropodia 11, hooded hooks. Abbreviations: Alo = abdominal lateral organs; Gp = genital pores; Pa = palpode; Tlo = thoracic lateral organs. Scale bars: 500 µm (**A**); 100 µm (**B, G**); 200 µm (**C, D, F, H**); 2 µm (**E**); 5 µm (**I**); 20 µm (**J**).

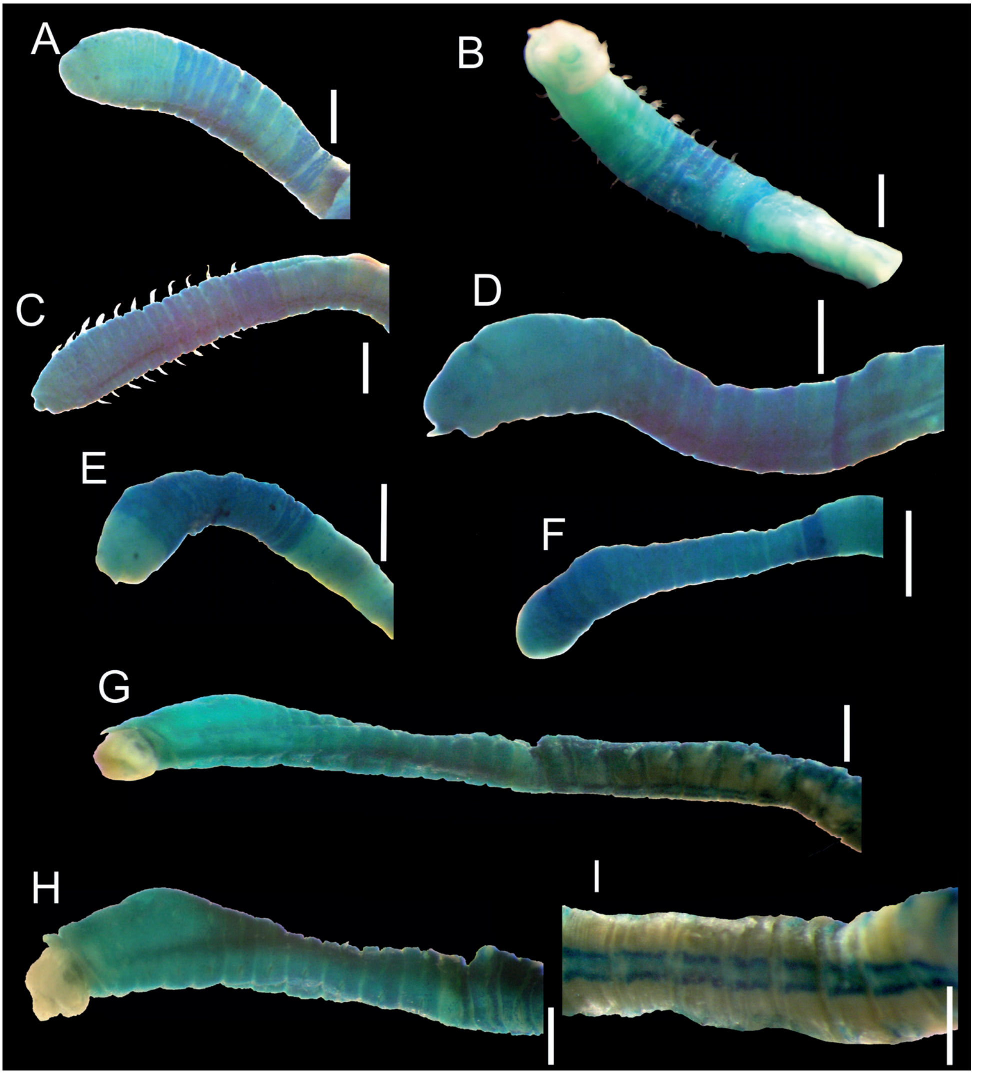

Figure 3. Methyl green staining patterns. *Notomastus bermejoi* sp. nov. **A** holotype (CNAP-POH-17-002) **B–E** paratypes (CNAP-POP-005 to 008) **F** additional material (CNAP-PO-036/GCA-CS-2006) **G–I** *Notomastus americanus* Day, 1973 (= *N. hemipodus* Hartman, 1945), holotype (USNM43118) **A** thoracic region, lateral view **B** thoracic and anterior abdominal regions, ventral view **C–F** thoracic and anterior abdominal regions, lateral view **G** thoracic and anterior abdominal regions, lateral view **H** anterior region, lateral view **I** abdominal region, ventral view. Scale bars: 0.5 mm (**A–F**); 1 mm (**G–I**).

Notomastus angelicae—Hernández-Alcántara and Solís-Weiss, 1998. ***Holotype*:** Mexico • 1 spec.; Gulf of California, El Fuerte River; 25°39.8'N, 109°28.5'W; 28.6 m; 20 Mar. 1985; USNM 180697. ***Paratypes*:** Mexico • 5 spec.; same collection data as for holotype; LACM-AHF-POLY-1902 • 5 specs.; same collection data as for holotype; USNM 180698.

Notomastus daueri Ewing, 1982. ***Holotype*:** USA • 1 spec.; Louisiana, Northern Gulf of Mexico; 28°56'N, 90°04'W; 27.7 m; 16 Apr. 1980; USNM 71442. ***Paratype*:** USA • 1 spec.; same locality as for holotype; 21 Aug. 1980; USNM 71443.

Notomastus precocis Hartman, 1960. ***Holotype*:** USA • 1 spec.; Santa Catalina Basin, California, Sta. 2848; 33°18.0'N, 118°42.0'W; 1305 m; 23 Jun. 1954; LACM-AHF POLY 0416.

Notomastus teres Hartman, 1965. ***Holotype*:** Bermuda • 1 spec.; Bermuda, Sta. 2; 32°16.5'N, 64°36.3'W; 1700 m; 18 Apr. 1960; LACM AHF 0418. ***Paratypes*:** Bermuda • 1 spec.; same collection data as for holotype; LACM AHF 0418 • 1 spec.; same collection data as for holotype; USNM 57105.

Etymology. The species is named after the Bermejo Sea, as the Gulf of California was originally known, and where this new capitellid was collected.

Diagnosis. Prostomium conical with anterior palpode. Peristomium and first six chaetigers with tessellated epithelium. Thorax with peristomium and 11 chaetigers; first chaetiger uniramous. Chaetiger 1–10 with only bilimbate capillaries, chaetiger 11 with notopodial bilimbate capillaries and neuropodial hooded hooks. Thoracic and abdominal chaetigers biannulate. Transition between thorax and abdomen marked by chaetal change. Methyl green staining pattern consisting of: chaetigers 1–4 slightly stained, chaetigers 5–10 with green bands encircling the segments, and a darker, solid, green band encircling the body in chaetigers 11 and 12. Abdominal chaetigers with hooded hooks in both rami. Notopodial and neuropodial abdominal hooded hooks of similar shape. Branchiae not observed. Pygidium unknown.

Description. Holotype incomplete, with 32 segments, 13.5 mm long, 0.8 mm wide. Paratypes incomplete, with 18–40 segments, 6.5–16.5 mm long, 0.7–0.8 mm wide. Colour in ethanol light brown. Prostomium conical, with anterior palpode (Fig. 2A, B). Proboscis with soft papillae basally, smooth surface distally. Peristomium and chaetigers 1–5 or 1–6 with tessellated epithelium (Fig. 2C), following thoracic segments smooth (Fig. 2A). Thorax with 12 segments, including peristomium and 11 biannulate chaetigers with deep intra- and intersegmental grooves (Fig. 2A, C, D). First chaetiger uniramous with only notopodial capillaries (Fig. 2C), chaetigers 2–10 with only bilimbate capillaries in both rami, around 8–26 per fascicle; chaetiger 11 with around 25 notopodial bilimbate capillaries; and neuropodia with 5–12 hooded hooks per fascicle (Fig. 2E–G, J). Hooded hooks with several rows of subapical teeth above main fang, basal row with 3–5 teeth, and apical one multidentate, smooth hood (Fig. 2E). Notopodia dorsolaterally inserted in first four thoracic chaetigers, then gradually located more dorsally (Fig. 2A). Neuropodia ventrolateral. Lateral organs present along body, positioned between noto- and neuropodia; thoracic lateral organs oval, close to notopodia (Fig. 2C); anterior abdominal lateral organs globular, exposed (Fig. 2H). Genital pores on last thoracic chaetigers, located on intersegmental areas of chaetigers 8/9, 9/10, 10/11, and 11/12 (Fig. 2A). Transition between thorax and abdomen marked by chaetal change and size of segments (Fig. 2D, G). Abdominal chaetigers with smooth epithelium and hooded hooks on both rami (Fig. 2F, H). Abdominal hooks of similar shape to thoracic hooks but shaft shorter (Fig. 2I). Notopodial lobes close together on anterior abdominal region, chaetal fascicles with 10–16 hooded hooks (Fig. 2H). Neuropodial lobes lateral, expanded up to dorsal region, ventrally separated (Fig. 2H); chaetal fascicles with around 20 hooded hooks. Notopodial and neuropodial abdominal hooded hooks of similar shape, shoulder developed and moderate hood (Fig. 2I); posterior shaft longer than anterior one. Branchiae not observed. Pygidium unknown.

Methyl green staining pattern. Holotype with prostomium, peristomium, and chaetigers 1–4 slightly stained; chaetigers 5–10 with green bands encircling the biannulate segments, separated by an unstained ring corresponding to the fringe between chaetigers; in chaetigers 11 or 12 a darker, solid, green band encircling body (Fig. 3A). In paratypes, chaetigers 11 and/or 12 have a darker, solid, green band encircling body (Fig. 3B–E). In the additional material some thin specimens stained green from chaetiger 2 or 3 and a darker green band only on chaetiger 11 (Fig. 3F). Abdominal region uniformly stained light green.

Remarks. So far, seven species of the genus *Notomastus* bearing hooded hooks on some thoracic parapodia had been accepted as valid species. They can be classified in two main groups: those species with the first chaetiger biramous and those having the first chaetiger uniramous (only notopodium present) (Table 2). In the first group we find *N. daueri*, *N. angelicae*, and *N. precocis* Hartman, 1960, from the northern Gulf of Mexico, Gulf of California, and California, respectively. The second group, with species having the first chaetiger uniramous, includes *N. teres*, *Notomastus* sp. A of Ewing, 1984a (a species still not formally named), *N. mossambicus* (Thomassin, 1970), *N. sunae* Lin, García-Garza, Lyu & Wang, 2020 and the new species *N. bermejoi* (Table 2).

Table 2. Comparison of *Notomastus* species with hooded hooks in thoracic chaetigers.

Species	Length	Palpode	Eyespots	Thoracic epithelium	First chaetiger	Thoracic segments	Neuropodia with hooks	Branchiae
N. angelicae Hernández-Alcántara and Solís-Weiss, 1998	15 mm (48 segments, incomplete)	Present	Present	1 to 4 areolated	Biramous	Biannulate	11	Not observed
N. daueri Ewing, 1982	65 mm (234 segments, complete)	Absent	Absent	1 to 4–5 faintly areolated	Biramous	Ventral biannulation	11	From chaetiger 60
N. mossambicus (Thomassin, 1970)	32 mm (105 segments, incomplete)	Absent	Present	1 to 3–4 hexagonal areolation	Uniramous	Uniannulate	11	Not observed
N. precocis Hartman, 1960	15.5 (around 50 segments, incomplete)	Present	Absent	Smooth	Biramous	Uniannulate	9 to 11	Posterior chaetigers
N. sunae Lin, García-Garza, Lyu & Wang, 2020	33.74 mm (over 100 chaetigers, complete)	Present	Present	1 to 4–5 slightly areolated	Uniramous	Biannulate	11	Not observed
N. teres Hartman, 1965	10.5 mm (35 segments, incomplete)	Absent	Absent	Smooth	Uniramous	Uniannulate	10 and 11	Not observed
Notomastus sp. A of Ewing, 1984a	4 mm (29 segments, incomplete)	Absent	Present (usually)	Smooth	Uniramous	Uniannulate	9 (mixed), 10 and 11	Not observed
Notomastus bermejoi **sp. nov.**	13.5 mm (34 segments, incomplete)	Present	Not observed	1 to 5–6 tessellated	Uniramous	Biannulate	11	Not observed

Initially, *N. bermejoi* sp. nov. can be clearly separated from these species, because in *N. teres* from Bermuda and New England, *Notomastus* sp. A from the northern Gulf of Mexico, and *N. mossambicus* from Madagascar the prostomium lacks an anterior palpode and their thoracic chaetigers are uniannulated. In addition, *N. teres* has hooded hooks on neuropodia of chaetigers 10 and 11, whereas in *Notomastus* sp. A, recognized as close to *N. teres* by Ewing (1984a), the hooded hooks are also present in neuropodia of chaetigers 10 and 11 but also, in neuropodia of chaetiger 9, capillaries and hooks are mixed (Table 2). *Notomastus mossambicus* has only hooded hooks in notopodia of chaetiger 11, but chaetigers 1–10 bear capillary chaetae of two types: one limbate and the other shorter, widely limbate, a character only observed in this species (Thomassin 1970; Çinar 2005).

Notomastus bermejoi sp. nov. is close to *N. sunae* from southern China, since both species have an anterior palpode in the prostomium and the neuropodia of chaetiger 11 bear hooded hooks. However, in *N. sunae* the first 4 or 5 chaetigers are faintly areolated, and mainly display a unique stained pattern: thorax pigmented blue with different intensity and abdomen with a paired stripe of ventral stain, as those observed in *N. hemipodus*, but with a very dark blue colour on dorsum (Lin et al. 2020), which is clearly different from that observed in *N. bermejoi* sp. nov. (Table 3).

In contrast, Day (1973) described *N. americanus* from material collected in Beaufort, North Carolina, which also had a uniramous first chaetiger and hooded hooks in the neuropodia of chaetiger 11. However, earlier, Hartman (1945) had also described *N. hemipodus* from the same locality with only capillary chaetae in all thoracic chaetigers. The re-examination of the type material of both species, carried out by García-Garza et al. (2012), revealed similarities in their thoracic epithelial texture, a uniramous first chaetiger, an anterior palpode on the prostomium, and mainly the same methyl green staining pattern. Therefore, they reallocated *N. americanus* as a junior synonym of *N. hemipodus*.

Table 3. Methyl green staining pattern, depth and type locality of *Notomastus* species bearing hooded hooks in thoracic chaetigers.

Species	Methyl green staining pattern	Depth	Type locality
N. angelicae Hernández-Alcántara and Solís-Weiss, 1998	Chaetigers 1–2 medium green, 3–11 dark green	28.6 m	Sinaloa, Gulf of California
N. daueri Ewing, 1982	Chaetigers 3–6 medium green, 7–11 dark green	5.6–33.5 m	Louisiana, Northern Gulf of Mexico
N. mossambicus (Thomassin, 1970)	—	50–70 m	Madagascar
N. precocis Hartman, 1960	Chaetigers 1–8 dark green, 9–11 medium green with circle dark green bands	1305 m	Santa Catalina Basin, California
N. sunae Lin, García-Garza, Lyu & Wang, 2020	Thorax blue stained with different intensity; abdomen with a paired stripe of ventral stain, very dark blue colour on dorsum	Intertidal to 23 m	Xiamen Bay, Southern China
N. teres Hartman, 1965	Chaetigers 2–10 medium green with dark green bands, 11 dark green	500–4667 m	Bermuda; New England, USA
Notomastus sp. A of Ewing, 1984a	—	19–60 m	Off Texas, Northern Gulf of Mexico
Notomastus bermejoi **sp. nov.**	Chaetigers 1–4 slightly stained; chaetigers 5–10 with green bands encircling the segments, chaetigers 11–12 with a darker, solid, green band encircling body	32–106.4 m	Gulf of California

Thus, the characters of these capitellid species with hooks in thoracic neuropodia are clearly different from those observed in *N. bermejoi* sp. nov., in which an anterior palpode is present in the prostomium, the thoracic chaetigers are biannulate, a tessellated epithelium is present in the peristomium and in chaetigers 1 to 5–6, all thoracic capillaries are bilimbate, the hooded hooks are present on neuropodia of chaetiger 11 (only one specimen also had hooks in neuropodia 10), and its body pigmentation displayed a pattern not observed in other species: chaetigers 1–4 slightly stained, chaetigers 5–10 with green bands encircling the segments, and chaetigers 11–12 with a darker, solid, green band encircling body (Table 3).

Habitat. At depths of 32–106 m, in bottoms with 62–96% fine sand. Temperature: 13.2–17.5 °C; salinity: 34.99–35.51 psu; dissolved oxygen: 0.80–4.93 ml/L; organic carbon: 3.0–7.2% (Table 1).

Distribution. *Notomastus bermejoi* sp. nov. was collected in the eastern Gulf of California shelf, from Tepoca Cape to Santa Maria Bay, and in the western Gulf, it was found in Santa Ines Bay and San Marcial Point (Fig. 1).

Discussion

The specimens assigned to this new species were collected on the continental shelf of the Gulf of California and were originally identified as *N. americanus* due to the key character "presence of neuropodial hooded hooks on the last thoracic chaetiger" (Hernández-Alcántara and Solís-Weiss 1998). However, after a detailed revision of these specimens, their misidentification was suspected, since they displayed a clearly different methyl green staining pattern than observed in the type material of *N. americanus* (Table 3), confirming they are actually different species.

The examination of the methyl green pattern in the holotype of *N. americanus* (Fig. 3G–I) also showed that it corresponds to that found in *N. hemipodus* Hartman, 1945: chaetigers 1–6 with the same green intensity, a wide continuous longitudinal line on the ventral side from peristomium to chaetiger 6 (Fig. 3G, H) and the characteristic ventral abdominal region with a pair of longitudinal bands to the end of the body (Fig. 3I), even though *N. hemipodus* has only capillary chaetae in all thoracic chaetigers. The methyl green staining pattern of the holotype of *N. americanus* is illustrated here for the first time, which confirms the observations made by García-Garza et al. (2012) about the synonymy of both species. As García-Garza et al. (2012) had already indicated, the specimens of *N. americanus* examined by Day (1973), with hooks in neuropodia of chaetiger 11, can be considered juveniles. This was also mentioned by Ewing (1984a), when he examined specimens from the northern Gulf of Mexico, since in small specimens of *N. americanus* a mixture of capillaries and hooks in neuropodia of chaetiger 10 may also be present.

In the family Capitellidae, changes in chaetal structure during ontogeny represent a fundamental taxonomic problem, not only to identify the specimens to the genus level, but also to detect immature individuals. In *Notomastus*, as in several capitellid genera, during the chaetal development process, the hooks are gradually replaced by capillaries, so that even a mixture of hooks and capillaries can be found in neuropodia of middle and posterior thoracic segments (Ewing 1984b). However, from the 44 described species in this genus, including the new species described here, only eight have been reported with hooded hooks on some thoracic parapodia: *N. mossambicus*, *N. sunae*, *N. teres*, *N. daueri*, and *Notomastus* sp. A of Ewing (1984a), *N. precocis* Hartman, 1960, *N. angelicae*, and *N. bermejoi* sp. nov.

The first species described with hooded hooks in thoracic chaetigers was *N. precocis* by Hartman (1960), based on an incomplete specimen 15.5 mm long with nearly 50 segments, bearing a mixture of capillaries and hooded hooks in neuropodia of chaetigers 7 to 11, which was a distinctive character to separate it from close species. However, re-examination of its holotype showed that it could be an immature specimen of a known species, since the mixture of capillaries and hooks begins on chaetiger 7. When thoracic hooks in other species are present, it seems that the occurrence of hooks in neuropodia of chaetiger 11 is a stable character: *N. teres* described by Hartman (1965) from an incomplete specimen 10.5 mm long and 35 segments, showed that hooded hooks were present in neuropodia of chaetigers 10 and 11. Likewise, *N. mossambicus*, described from an incomplete individual 32 mm long and 105 segments, has hooded hooks in neuropodia of chaetiger 11. Ewing (1982) described *N. daueri* from a complete specimen, 65 mm long with 234 segments, also bearing hooks in neuropodia of chaetiger 11. Later, Ewing (1984a) described *Notomastus* sp A from an incomplete individual 4 mm long with 29 segments, with a mixture of capillaries and hooks in neuropodia of chaetiger 9, and only hooks in neuropodia of chaetigers 10 and 11. Hernández-Alcántara and Solís Weiss (1998) described *N. angelicae* from an incomplete specimen 15 mm long with 48 segments, bearing hooded hooks in neuropodia of chaetiger 11. It is important to emphasize that these authors examined 43 specimens, in which the occurrence of hooks on neuropodia of chaetiger 11 was constant, and only in one of them were capillaries and hooks in neuropodia 10 and 11 observed. Finally, in *N. bermejoi* sp. nov., where the holotype is an incomplete individual, 13.5 mm long with 32 segments, the hooded hooks are present in neuropodia of chaetiger 11 of all paratypes and additional material, except for one individual where mixed capillaries and hooks in neuropodia 10 were observed.

The occurrence of hooded hooks in thoracic neuropodia had already been discussed by Ewing (1982), who observed that immature specimens of *N. hemipodus*, *N. lobatus* (= *Rashgua lobatus* (Hartman, 1947)), and *N. daueri* bear only hooded hooks or a mixture of capillaries and hooks in as many as five posterior thoracic neuropodia and rarely in 1–2 notopodia. So, he suggested that the replacement of hooks by capillary chaetae in thoracic neuropodia in *Notomastus* follows this pattern: juveniles have only hooks in several neuropodia of the posterior half of the thorax; as the specimen grows, hooks are lost (shed, broken or resorbed?) and replaced by capillaries emerging from the superior region of the chaetal fascicle. This goes on until all hooks are replaced by capillaries and the process continues towards the posterior thoracic chaetigers until the adult stage is reached. In the same study, Ewing (1982) observed several variations in the chaetal arrangement of numerous juveniles of *N. daueri*: neuropodia of chaetigers 7–11 may have only capillaries, mixed chaetal fascicles, or only hooded hooks, but chaetigers 10 and 11 were rarely found with a combination of capillaries and hooks.

Therefore, and also in accordance with the observed characters in *N. bermejoi* sp. nov. and the previous observations provided regarding other species, we can establish that in the genus *Notomastus*, though variations in the chaetal arrangement are present in several thoracic neuropodia, the presence of exclusively hooded hooks in neuropodia of chaetiger 11 is constant, and it can thus be considered as a stable character to differentiate species.

Although other localities have not yet been well explored, until now, the *Notomastus* species bearing hooded hooks in thoracic chaetigers have almost entirely been recorded in the American seas. From the eight species described with this morphological characteristic, only *N. sunae* from southern China and *N. mossambicus* from Madagascar are reported from other regions. Three species were reported from the Gulf of Mexico or northwestern Atlantic, and in the Eastern Pacific, *N. precocis* was collected in the deep Santa Catalina Basin, California, while *N. angelicae* and *N. bermejoi* sp. nov. were recorded from the continental shelf of the Gulf of California.

Taxonomic key to species of *Notomastus* with hooded hooks in thoracic chaetigers

1	First chaetiger biramous	**2**
–	First chaetiger uniramous	**4**
2	Prostomium without anterior palpode; last thoracic neuropodia with a mixture of capillaries and hooks	***N. daueri* Ewing, 1982**
–	Prostomium with an anterior palpode	**3**
3	Last 2–3 thoracic neuropodia with a mixture of capillaries and hooks; thoracic epithelium smooth	***N. precocis* Hartman, 1960**
–	Only last thoracic neuropodia with hooks; epithelium clearly areolated in first 4 thoracic chaetigers	***N. angelicae* Hernández-Alcántara & Solís-Weiss, 1998**
4	Prostomium without an anterior palpode; thoracic chaetigers uniannulated	**5**
–	Prostomium bearing an anterior palpode; thoracic chaetigers biannulated	7
5	Thoracic epithelium smooth; with hooks in last 2 or 3 thoracic neuropodia	**6**
–	Thoracic epithelium areolated in first 3 or 4 chaetigers; with hooks only in neuropodia 11	***N. mossambicus* (Thomassin, 1970)**
6	Neuropodia of chaetigers 10 and 11 with hooded hooks and neuropodia 9 only with capillaries	***N. teres* Hartman, 1965**
–	Neuropodia of chaetigers 10 and 11 with hooded hooks and neuropodia 9 with mixed capillaries and hooks	***Notomastus* sp. A of Ewing, 1984a**
7	First 4 or 5 chaetigers faintly areolated; body pigmentation: thorax pigmented blue with different intensity, abdomen with a paired stripe of ventral stain	***N. sunae* Lin, García-Garza, Lyu & Wang, 2020**
–	First 5 or 6 chaetigers tessellated; body pigmentation: chaetigers 1–4 slightly stained, chaetigers 5–10 with green bands encircling the segments, chaetigers 11 and 12 with a darker, solid, green band encircling body	***N. bermejoi* sp. nov.**

Acknowledgements

The Instituto de Ciencias del Mar y Limnología of the Universidad Nacional Autónoma de México provided the financial support to carry out this study. Thanks are due to Michel Hendrickx, head of the institutional project "Cortes", for inviting us to participate in the oceanographic expeditions. Kristian Fauchald † (National Museum of Natural History, Smithsonian Institution) and Leslie H. Harris (Natural History Museum of Los Angeles County) are thanked for their support during our visits to the collections of the cited Museums. Yolanda Hornelas Orozco is also thanked for her assistance in SEM photography.

References

Blake JA (2000) Family Capitellidae Grube, 1862. In: Blake JA, Hilbig B, Scott PV (Eds) Taxonomic Atlas of the Benthic Fauna of the Santa Maria Basin and the Western Santa Barbara Channel, Volume 7, the Annelida Part 4, Polychaeta: Flabelligeridae to Sternaspidae. Santa Barbara Museum of Natural History, Santa Barbara, 47–96.

Çinar ME (2005) Polychaetes from the coast of Northern Cyprus (eastern Mediterranean Sea), with two new records for the Mediterranean Sea. Cahiers de Biologie Marine 46(2): 143–159.

Day JH (1973) New Polychaeta from Beaufort, with a key to all species recorded from North Carolina. NOAA Technical Report NMFS 375: 1–153. https://doi.org/10.5962/bhl.title.62852

Ewing RM (1982) A partial revision of the genus *Notomastus* (Polychaeta: Capitellidae) with a description of a new species from the Gulf of Mexico. Proceedings of the Biological Society of Washington 95(2): 232–237.

Ewing RM (1984a) Family Capitellidae Grube, 1862. In: Uebelacker JM, Johnson PG (Eds) Taxonomic Guide to the Polychaetes of the Northern Gulf of Mexico. Barry A Vittor and Associates, Mobile, 14.1–14.47. https://catalog.hathitrust.org/Record/002201750

Ewing RM (1984b) Generic revision of *Mastobranchus* and *Peresiella* (Polychaeta: Capitellidae) of descriptions of two new species from the Gulf of Mexico and Atlantic Ocean. Proceedings of the Biological Society of Washington 97: 792–800.

Fauchald K (1972) Benthic polychaetous annelids from deep water off western Mexico and adjacent areas in the Eastern Pacific Ocean. Allan Hancock Monographs in Marine Biology 7: 1–575.

Folk RL (1980) Petrology of sedimentary rocks. Hemphill Publishing, Austin, 184 pp. http://hdl.handle.net/2152/22930

García-Garza ME, de León-González JA (2015) The genus *Notomastus* (Polychaeta: Capitellidae) in the Gulf of California, Mexico, with the description of three new species. Proceedings of the Biological Society of Washington 128(2): 176–189. https://doi.org/10.2988/0006-324X-128.2.176

García-Garza ME, Harris LH, de León-González JA (2012) Redescription of *Notomastus hemipodus* Hartman, 1945 and *N. tenuis* Moore, 1909 (Polychaeta: Capitellidae). Proceedings of the Biological Society of Washington 125(1): 1–11. https://doi.org/10.2988/11-28.1

García-Garza ME, de León-González JA, Tovar-Hernández MA (2019) Catalogue of *Notomastus* M. Sars, 1851 (Annelida, Capitellidae) and the description of a new species from the Gulf of California. Zootaxa 4577(2): 249–273. https://doi.org/10.11646/zootaxa.4577.2.2

Grube AE (1862) Noch ein Wort über die Capitellen und ihre Stelle im Systeme der Anneliden. Archiv für Naturgeschichte 28(1): 1–378.

Hartman O (1945) The marine annelids of North Carolina. Duke University Marine Station Bulletin 2: 1–54.

Hartman O (1960) Systematic account of some marine invertebrate animals from the deep basins off Southern California. Allan Hancock Pacific Expedition 22: 69–215.

Hartman O (1965) Deep-water benthic polychaetous annelids off New England to Bermuda and other North Atlantic areas. Occasional Papers of the Allan Hancock Foundation 28: 1–384. http://digitallibrary.usc.edu/cdm/ref/collection/p15799coll82/id/20299

Hartmann-Schröder G (1979) Die Polychaeten der tropischen nordwestküste Australiens (zwischen Derby im Norden und Port Hedland im Süden). Teil 2. In: Hartmann-Schröder G, Hartmann G (Eds) Zur Kenntnis des Eulitorals der australischen Küsten unter besonder Berücksichtigung der Polychaeten und Ostracoden. Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut 76: 77–218. https://www.marinespecies.org/aphia.php?p=taxdetails&id=329997 [seen 2022-05-03]

Hernández-Alcántara P, Solís-Weiss V (1993) New record of sedentariate polychaetous annelids from the continental shelf of the Gulf of California. Bulletin of Marine Science 53: 1027–1041.

Hernández-Alcántara P, Solís-Weiss V (1998) Capitellids (Polychaeta: Capitellidae) from the continental shelf of the Gulf of California, with the description of a new species, *Notomastus angelicae.* Proceedings of the Biological Society of Washington 111: 708–719.

Hernández-Alcántara P, Solís-Weiss V (1999) Systematics and distribution of the polychaetes (Annelida: Polychaeta) from the sublittoral zone in the Gulf of California. Oceánides 13: 25–38.

Kudenov JD (1975) Sedentary polychaetes from the Gulf of California. Journal of Natural History 9(2): 205–231. https://doi.org/10.1080/00222937500770131

Lin JH, García-Garza ME, Lyu MX, Wang JJ (2020) A new species of *Notomastus* (Annelida, Capitellidae) from southern China, with remarks on its morphology and distribution. ZooKeys 946: 1–16. https://doi.org/10.3897/zookeys.946.50662

Magalhães WF, Bailey-Brock JH (2012) Capitellidae Grube, 1862 (Annelida: Polychaeta) from the Hawaiian Islands with description of two new species. Zootaxa 3581(1): 1–52. https://doi.org/10.11646/zootaxa.3581.1.1

Magalhães WF, Blake JA (2019) Capitellidae Grube, 1862. In: Westheide W, Purschke G, Böggemann M (Eds) Handbook of Zoology Online, a Natural History of the Phyla of the Animal Kingdom, Annelida: Polychaetes. De Gruyter, Boston/Berlin, 1–49. https//www.degruyter.com/view/zoology/bp_029147-6_76 [Accessed on 2019-05-21]

Saint-Joseph AA de (1906) Les annélides polychètes des côtes de France (Océan et côtes de Provence). Annales des Sciences Naturelles, Paris (series 9) 3: 145–258. https://biodiversitylibrary.org/page/34568749

Sars M (1851) Beretning om en i Sommeren 1849 foretagen zoologisk Reise i Lofoten og Finmarken. Nyt Magazin for Naturvidenskaberne 6: 121–211. [1850 date used in Hydrozoa, 1851 in Polychaeta and others]

Silva da CF, Amaral ACZ (2019) *Scyphoproctus* Gravier, 1904 (Annelida: Capitellidae): description of three new species and relocation of *Heteromastides* Augener, 1914 in *Scyphoproctus*. Zootaxa 4560: 95–120. https://doi.org/10.11646/zootaxa.4560.1.5

Strickland JDH, Parsons TR (1972) A practical handbook of seawater analysis. Fisheries Research Board of Canada. Bulletin 167: 1–310.

Thomassin BA (1970) Contribution à l'étude des polychètes de la région de Tuléar (S.W. de Madagascar) II. Quelques Aphroditidae des sables coralliens. Recueil des Travaux de la Station Marine d'Endoume (Supplement 10): 47–69.

Walkley A, Black IA (1934) An examination of the Degthareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science 27(1): 29–38. https://doi.org/10.1097/00010694-193401000-00003

Warren LM, Hutchings PA, Doyle S (1994) A revision of the genus *Mediomastus* Hartman, 1944 (Polychaeta: Capitellidae). Records of the Australian Museum 46(3): 227–256. https://doi.org/10.3853/j.0067-1975.46.1994.6

ZooKeys 1102: 59–82 (2022)
doi: 10.3897/zookeys.1102.76800
https://zookeys.pensoft.net

RESEARCH ARTICLE

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Five new species of *Synagelides* Strand, 1906 from China (Araneae, Salticidae)

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Academic editor: Dimitar Dimitrov | Received 20 October 2021 | Accepted 27 April 2022 | Published 19 May 2022

http://zoobank.org/BC653F50-304F-4559-9075-EDF212EB8102

Citation: Liu K-k, Zhao Z-Y, Xiao Y-h, Peng X-J (2022) Five new species of *Synagelides* Strand, 1906 from China (Araneae, Salticidae). ZooKeys 1102: 59–82. https://doi.org/10.3897/zookeys.1102.76800

Abstract

Five new species of salticids were collected from China: *Synagelides emangou* Liu, **sp. nov.** (♂, ♀) from Gansu province, and *S. jinding* Liu, **sp. nov.** (♂), *S. serratus* Liu, **sp. nov.** (♂, ♀), *S. shuqiang* Liu, **sp. nov.** (♂), and *S. triangulatus* Liu, **sp. nov.** (♀) from Jiangxi Province. All species are described and illustrated with photographs and SEM micrographs, and their distributions are also mapped.

Keywords

Ant-like, Gansu Province, Jiangxi Province, Jumping spider, taxonomy

Introduction

The family Salticidae, or jumping spiders, is the most diverse spider family worldwide. It consists of 6368 species in 659 genera (WSC 2021). Of these, 572 species in 123 genera have been reported from China. Of these 123 genera, *Phintella* Strand, 1906 (30 species) and *Synagelides* Strand, 1906 (30 species) have been reported as being the most diverse in China (Li and Lin 2021; WSC 2021). The spider species of the genus *Synagelides* Strand, 1906 are characterized by their ant-like bodies and conspicuously thickened femur I. They are usually found in a wide range of habitats such as grasslands and forests and living in bark, brush, leaf litter, humus, leaves, forest canopies, and under rocks. To date, there are 30 species (more than half of the total number of species) known from China, and eight species are known by only one sex (WSC 2021). Most of these *Synagelides* species are described from the southern provinces, and only two species were recorded from the northern provinces.

When examining spider specimens collected from Qinghai, Gansu, Hebei, Shanxi, and Jiangxi provinces, five new *Synagelides* species were identified, and they are described here: *Synagelides emangou* sp. nov., *S. jinding* sp. nov., *S. serratus* sp. nov., *S. shuqiang* sp. nov., and *S. triangulatus* sp. nov.

Materials and methods

Specimens were examined using a Zeiss Stereo Discovery V12 stereomicroscope with a Zeiss Axio Cam HRc. Both the male palps and female copulatory organs were dissected and examined in 80–85% ethanol. The vulvae were cleaned in pancreatin. All the specimens were photographed with an Olympus CX43 compound microscope with a KUY NICE CCD (Beijing Tiannuoxiang Scientific Instrument Co., Ltd, China). For SEM photographs, the specimens were dried under natural conditions, sprayed with gold with a small ion-sputtering apparatus ETD-2000 (Beijing Yilibotong Technology Development Co., Ltd, China), or used without coating, and photographed with a Zeiss EVO LS15 (Carl Zeiss AG, Germany) scanning electron microscope. Images were edited using the ImagineView software package and the Smart SEM User Interface.

All measurements were made by using a stereomicroscope with AxioVision SE64 Rel. 4.8.3 software and are given in millimeters. Leg measurements are given as the total length (femur, patella, tibia, metatarsus, tarsus). Specimens were put in separate bottles with a collection number and a serial number, such as 20200504-1, sp6. Holotype and paratype are labeled by red and yellow cards, respectively. All specimens are deposited in the Animal Specimen Museum, College of Life Science, Jinggangshan University (**ASM-JGSU**).

Terminology of male and female copulatory organs follows Liu et al. (2017), Kanesharatnam and Benjamin (2020), and Wang et al. (2020). The abbreviations used in the text and figures are:

Eyes

ALE anterior lateral eye;
AME anterior median eye;
PLE posterior lateral eye;
PME posterior median eye;
MOA median ocular area.

Legs

ti tibia;
pv proventral;
rv retroventral;
met metatarsus.

Male palp

DTA	dorso-prolateral tibial apophysis;	**RTA**	retrolateral tibial apophysis;
Em	embolus;	**SD**	sperm duct;
PCA	postero-prolateral cymbial apophysis;	**SS**	scale-like serrations;
RCA	postero-retrolateral cymbial apophysis;	**TA**	terminal apophysis;
		VFA	ventral femoral apophysis.

Epigyne

AR	atrial rim;	**FD**	fertilization duct;
At	atrium;	**GA**	glandular appendages;
CD	copulatory duct;	**MS**	median septum;
CO	copulatory opening;	**Spe**	spermatheca.
EH	epigynal hood;		

Taxonomy

Family Salticidae Blackwall, 1841
Tribe Agoriini Simon, 1901 (*sensu* Maddison 2015)
Genus *Synagelides* Strand, 1906

***Synagelides emangou* Liu, sp. nov.**
http://zoobank.org/CCBBBC83-FE2D-4FCD-9EF8-52CF934B8B17
Figs 1–3

Material examined. ***Holotype*** ♂, 33°57'23.50"N, 104°25'25.56"E, 1795 m, near parking lot, Emangou Scenic Area, Lugangtou Village, Xinchengzi Town, Tanchang County, Longnan City, Gansu Province, China, 28 July 2021, K. Liu, Y. Ying & C. Xu. ***Paratype*** 2 ♂, 1 ♀, the same data as holotype.

Etymology. The name is taken from the type locality, Emangou Scenic Area; noun in apposition.

Diagnosis. The males of this species are similar to males of *Synagelides zhaoi* Peng, Li & Chen, 2003 (see Peng et al. 2003: 249, figs 2–5) in having a thick ventral femoral apophysis in retrolateral view and a golf-club-shaped embolus in ventral view, but differs from it in having (Figs 1C–H, 2) a triangular tibia (vs saddle-shaped), a forcipate retrolateral tibial apophysis (vs short and horn-shaped), the broad postero-prolateral cymbial apophysis (vs relatively narrow), a C-shaped terminal apophysis (vs S-shaped), and the mastoid tegular in retrolateral view (vs S-shaped). The female resembles *S. zhaoi* (see Peng et al. 2003: 249, figs 6, 7) in having a nose-shaped median septum and the C-shaped atrial rims, but it can be easily recognized by (Fig. 3C, D)

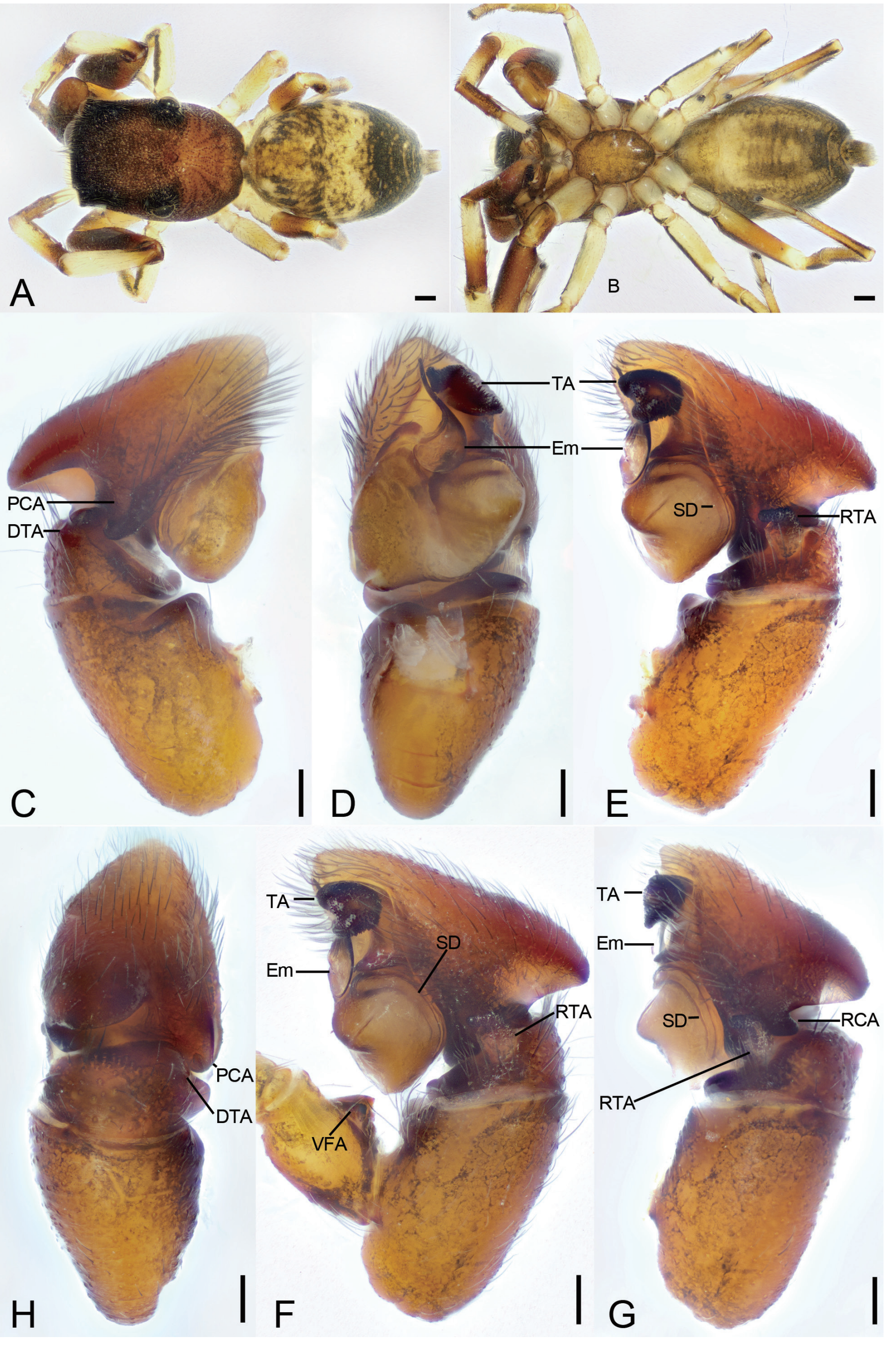

Figure 1. *Synagelides emangou* sp. nov., holotype male **A** habitus, dorsal view **B** same, ventral view **C** palp, prolateral view **D** same, ventral view **E** same, retrolateral view **F** same, detail of ventral femoral apophysis, retrolateral view **G** same, retrolateral view, slightly dorsal **H** same, dorsal view. Abbreviations: DTA – dorso-prolateral tibial apophysis, Em – embolus, PCA – postero-prolateral cymbial apophysis, RCA – postero-retrolateral cymbial apophysis, RTA – retrolateral tibial apophysis, SD – sperm duct, TA – terminal apophysis, VFA – ventral femoral apophysis. Scale bars: 0.2 mm (**A, B**); 0.05 mm (**C–E, G, H**); 0.1 mm (**F**).

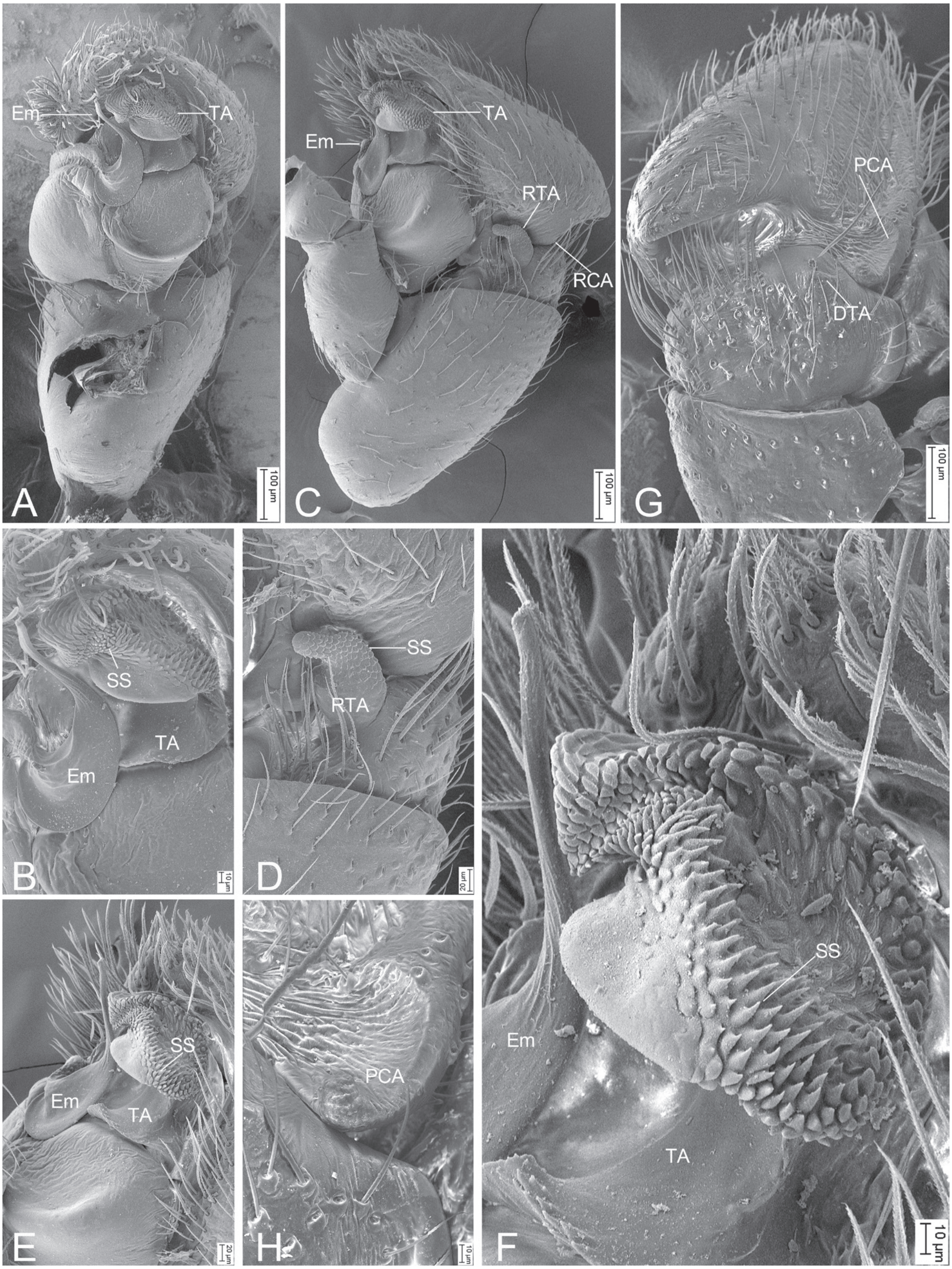

Figure 2. *Synagelides emangou* sp. nov., SEMs of male paratype **A** palp, ventral view, slightly frontal **B** same, detail of terminal apophysis and embolus, ventral view, slightly frontal **C** same, retrolateral view **D** same, detail of retrolateral tibial apophysis, retrolateral view **E** same, detail of terminal apophysis and embolus, retrolateral view **F** same, detail of terminal apophysis and embolus, retrolateral view **G** same, dorsal view **H** same, detail of postero-prolateral cymbial apophysis, dorsal view. Abbreviations: DTA – dorso-prolateral tibial apophysis, Em – embolus, PCA – postero-prolateral cymbial apophysis, RCA – postero-retrolateral cymbial apophysis, RTA – retrolateral tibial apophysis, SS – scale-like serrations, TA – terminal apophysis.

the relatively broad, tube-shaped copulatory ducts (vs slender) and the swollen spermathecae (vs relatively thin).

Description. Male (holotype, sp7-20210728-1, red label). ***Habitus*** as in Fig. 1A, B. Total length 3.59. Carapace 1.70 long, 1.23 wide. Eye sizes and interdistances: AME 0.31; ALE 0.15; PME 0.09; PLE 0.16; AME–AME 0.08; AME–ALE 0.08; PME–PME 0.90; ALE–ALE 1.09; PME–PLE 0.36; PLE–PLE 1.00; ALE–PLE 0.80; AME–PME 0.46; AME–PLE 0.91. MOA: 0.66 long; 0.66 anterior width, 1.02 posterior width. Fovea (Fig. 1A) round, hollowed. Chelicerae (Fig. 1B) with two promarginal teeth (proximal larger) and one large laminar retromarginal teeth. Sternum (Fig. 1B) shield-shaped, longer than wide, posterior end arch-shaped, smooth. Leg measurements: I 4.2 (1.29, 1.03, 1.05, 0.45, 0.38); II 2.62 (0.85, 0.41, 0.54, 0.55, 0.27); III 2.52 (0.74, 0.44, 0.58, 0.52, 0.24); IV 3.89 (1.13, 0.53, 0.95, 0.9, 0.38). Femur width: I 0.50; II 0.26; III 0.27; IV 0.35. Leg spination (Fig. 1A, B): I ti pv 1-2-1, rv 1-2-1; Met pv 0-1-1, rv 0-1-1. Pedicel 0.11. Abdomen 1.80 long, 1.25 wide.

Coloration (Fig. 1A, B). Carapace reddish brown, anterior part darker than posterior, posteriorly with radial grooves and 14–16 rows of short, white setae. Endites yellow, mottled. Labium dark yellow-brown, anteriorly with a single row of strong setae. Sternum, yellow-brown, mottled, with dark brown mottled stripes around margin. Legs: trochanter I yellow-brown, trochanters II–IV yellow, with dark brown stripe; femur I dark yellow-brown, femora II–IV yellow, with distinct prolateral and retrolateral dark brown stripes; patellae, tibiae, and metatarsi yellow, with dark brown lateral stripes; tarsi yellowish, proximal part darker than distal. Abdomen yellow to dark brown, anterior part yellow, mottled, posterior part dark brown with four paler chevron-shaped stripes medially; venter with a U-shaped dark yellow-brown marking postero-medially. Spinnerets yellowish brown, mottled.

Palp (Figs 1C–H, 2). Femur with a thick, strong tooth-like ventral apophysis. Patella swollen, with a ratio of ca 1.85 between its length and width. Tibia small and narrow with a forcipate stubby retrolateral apophysis, less than 1/2 length of cymbium, with numerous scale-like serrations on apical surface. Cymbium bullet-shaped in dorsal view, with a strong sclerotized postero-retrolateral and a long strong postero-prolateral apophysis. Tegulum broad, C-shaped in ventral view, with a clear mastoid apophysis in retrolateral view. Terminal apophysis arising from antero-retrolateral part of tegulum, strongly sclerotized, C-shaped in retrolateral view, with abundant little scale-like serrations on surface. Embolus golf-club-shaped in ventral view, longer than terminal apophysis, with very broad basal part and whip-shaped apical part.

Female (paratype, sp7-20210728-1, yellow label). ***Habitus*** as in Fig. 3A, B. As in male, except as noted. Total length 3.79. Carapace 1.51 long, 1.16 wide. Eye sizes and interdistances: AME 0.31; ALE 0.18; PME 0.06; PLE 0.21; AME–AME 0.05; AME–ALE 0.08; PME–PME 0.83; ALE–ALE 1.02; PME–PLE 0.32; PLE–PLE 1.00; ALE–PLE 0.67; AME–PME 0.42; AME–PLE 0.66. MOA: 0.66 long; 0.67 anterior width, 0.93 posterior width. Chelicerae (Fig. 3B) with two promarginal teeth (slight-

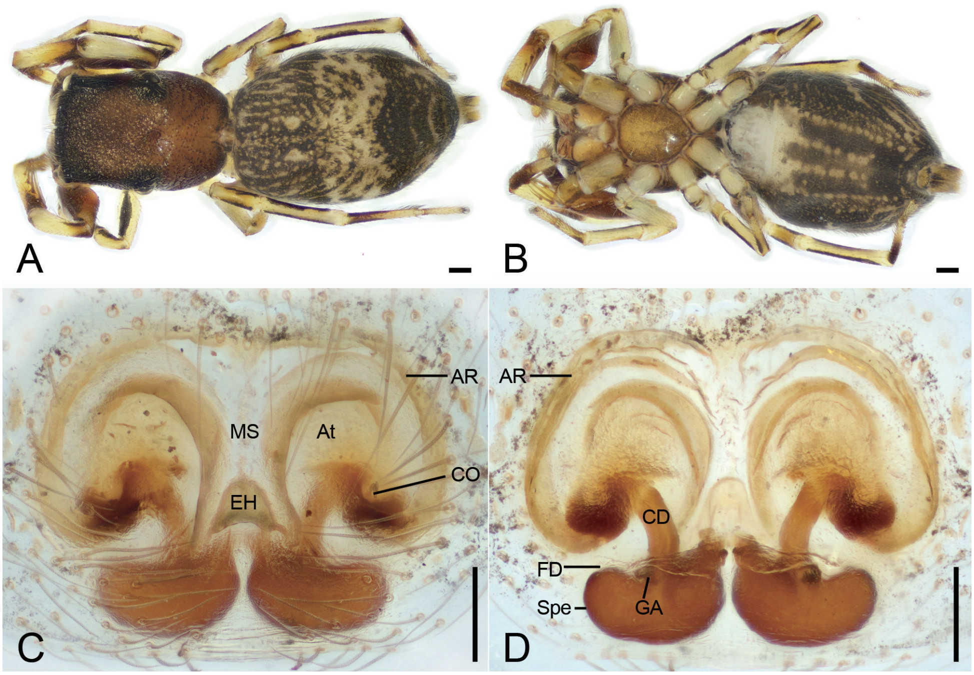

Figure 3. *Synagelides emangou* sp. nov., female paratype **A** habitus, dorsal view **B** same, ventral view **C** epigyne, ventral view **D** same, dorsal view. Abbreviations: AR – atrial rim, At – atrium, CD – copulatory duct, CO – copulatory opening, EH – epigynal hood, FD – fertilization duct, GA – glandular appendages, MS – median septum, Spe – spermatheca. Scale bars: 0.2 mm (**A, B**); 0.05 mm (**C, D**).

ly separated, proximal larger) and one large triangular retromarginal teeth. Sternum (Fig. 3B), posterior end triangular, relatively blunt. Leg measurements: I 3.17 (0.91, 0.76, 0.82, 0.35, 0.33); II2.3 (0.66, 0.34, 0.59, 0.37, 0.34); III 2.4 (0.71, 0.34, 0.52, 0.53, 0.3); IV 3.53 (1, 0.51, 0.89, 0.73, 0.4). Femur width: I 0.31; II 0.20; III 0.21; IV 0.21. Pedicel 0.11. Leg spination (Fig. 3A, B): I ti pv 2-2-0, rv 2-2-0; Met pv 1-0-1, rv 1-0-1. Pedicel 0.21. Abdomen 2.11 long, 1.44 wide.

Coloration (Fig. 3A, B). Darker than male. Ventral abdomen with three broad longitudinal dark brown stripes, posteriorly fusing.

Epigyne (Fig. 3C, D). Epigynal plate mask-shaped, with a nose-shaped median septum. Epigynal hood bell-shaped, arising from posterior part of median septum. Atrium relatively large, nearly covering 1/3 of epigynal field. Atrial rims C-shaped, slightly sclerotized, located at bilateral parts of epigyne. Copulatory ducts short, tube-shaped, with a slight curve posteriorly, connecting with submedial part of spermathecae. Glandular appendages very short, near the posterior copulatory ducts. Spermathecae kidney-shaped, swollen, slightly separated. Fertilization ducts relatively long, >2/3 length of spermathecae, transversely extended.

Distribution. Known only from the type locality in Gansu Province, China (Fig. 13).

Synagelides jinding Liu, sp. nov.

http://zoobank.org/5C75C451-4BB0-4602-A8CF-7DC9DC6A479C
Figs 4, 5

Material examined. ***Holotype*** ♂, 27°26'45.19"N, 114°11'17.53"E, 1223 m, Tupingao area, near Ropeway, Wugong Mountain National Forest Park, Taishan Town, Anfu County, Ji'an City, Jiangxi Province, China, 4 May 2021, K. Liu, Y. Ying, C. Xu & Q. Xiao leg.

Etymology. The name is taken from the famous Jinding Scenic Spot, which is very close to Tupingao area in the Wugong Mountain National Forest Park; noun in apposition.

Diagnosis. The male of this species is most similar to that of *Synagelides annae* Bohdanowicz, 1979 (see Bohdanowicz 1979: 56, figs 14–17) in having a sharp ventral femoral apophysis, an anticlockwise spiral embolus, a C-shaped terminal apophysis with hook-shaped tip, and the mastoid tegular apophysis in retrolateral view, but differs from it in having (Figs 4C–H, 5) the posterior cymbium with a long blunt retrolateral apophysis (vs absent), the parallel retrolateral tibial apophysis together with postero-retrolateral cymbial apophysis in retrolateral view (vs. convergent) and thick clavate retrolateral tibial apophysis (vs spine-like) with many scale-like serrations (vs absent). It also resembles those seven species *S. birmanicus* Bohdanowicz, 1987 (see Bohdanowicz 1987: 84, figs 66–72), *S. cavaleriei* (Schenkel, 1963) (see Bohdanowicz 1987: 66, figs 1, 2), *S. gosainkundicus* Bohdanowicz, 1987 (see Bohdanowicz 1987: 78, figs 45, 46), *S. kosi* Logunov & Hereward, 2006 (see Logunov and Hereward 2006: 285, figs 21, 22), *S. martensi* Bohdanowicz, 1987 (see Logunov and Hereward 2006: 287, figs 37–40), *S. oleksiaki* Bohdanowicz, 1987 (see Bohdanowicz 1987: 79, figs 47, 48), and *S. walesai* Bohdanowicz, 1987 (see Bohdanowicz 1987: 72, figs 23, 24), but it can be easily distinguished from them by the parallel retrolateral tibial apophysis together with postero-retrolateral cymbial apophysis (vs convergent).

Description. ***Habitus*** as in Fig. 4A, B. Total length 2.97. Carapace 1.50 long, 1.09 wide. Eye sizes and interdistances: AME 0.30; ALE 0.18; PME 0.08; PLE 0.17; AME–AME 0.07; AME–ALE 0.04; PME–PME 0.77; ALE–ALE 0.73; PME–PLE 0.30; PLE–PLE 0.95; ALE–PLE 0.75; AME–PME 0.38; AME–PLE 0.63. MOA: 0.64 long; 0.67 anterior width, 0.91 posterior width. Fovea (Fig. 4A) round, hollowed. Chelicerae (Fig. 4B) with two promarginal teeth (proximal larger) and one large laminar retromarginal teeth. Sternum (Fig. 4B) shield-shaped, longer than wide, posterior end arch-shaped, smooth. Leg measurements: I 3.36 (1.07, 0.71, 0.9, 0.36, 0.32); II 2.2 (0.67, 0.32, 0.46, 0.47, 0.28); III 2.33 (0.69, 0.28, 0.5, 0.55, 0.31); IV 2.25 (0.65, 0.28, 0.52, 0.55, 0.25). Femur width: I 0.31; II 0.21; III 0.21; IV 0.18. Leg spination (Fig. 4A, B): I ti pv 1-2-1, rv 1-2-1; Met pv 0-1-1, rv 0-1-1. Pedicel 0.09. Abdomen 1.37 long, 0.83 wide.

Coloration (Fig. 4A, B). Carapace yellow-brown, anterior part darker than posterior, posteriorly with radial grooves and 12–14 rows of short black setae. Endites yellowish, mottled. Labium yellowish brown, anteriorly with a single row of strong setae, posteriorly mottled. Sternum, yellow, with pale brown mottled spots around margin. Legs: trochanters I–IV yellow, with dark brown stripe; femur I dark yellow-brown, femora II–IV yellow, with prolateral dark brown stripes; patellae, tibiae, and metatarsi yellow, with dark brown lateral stripes; tarsi yellowish, proximal part darker than distal.

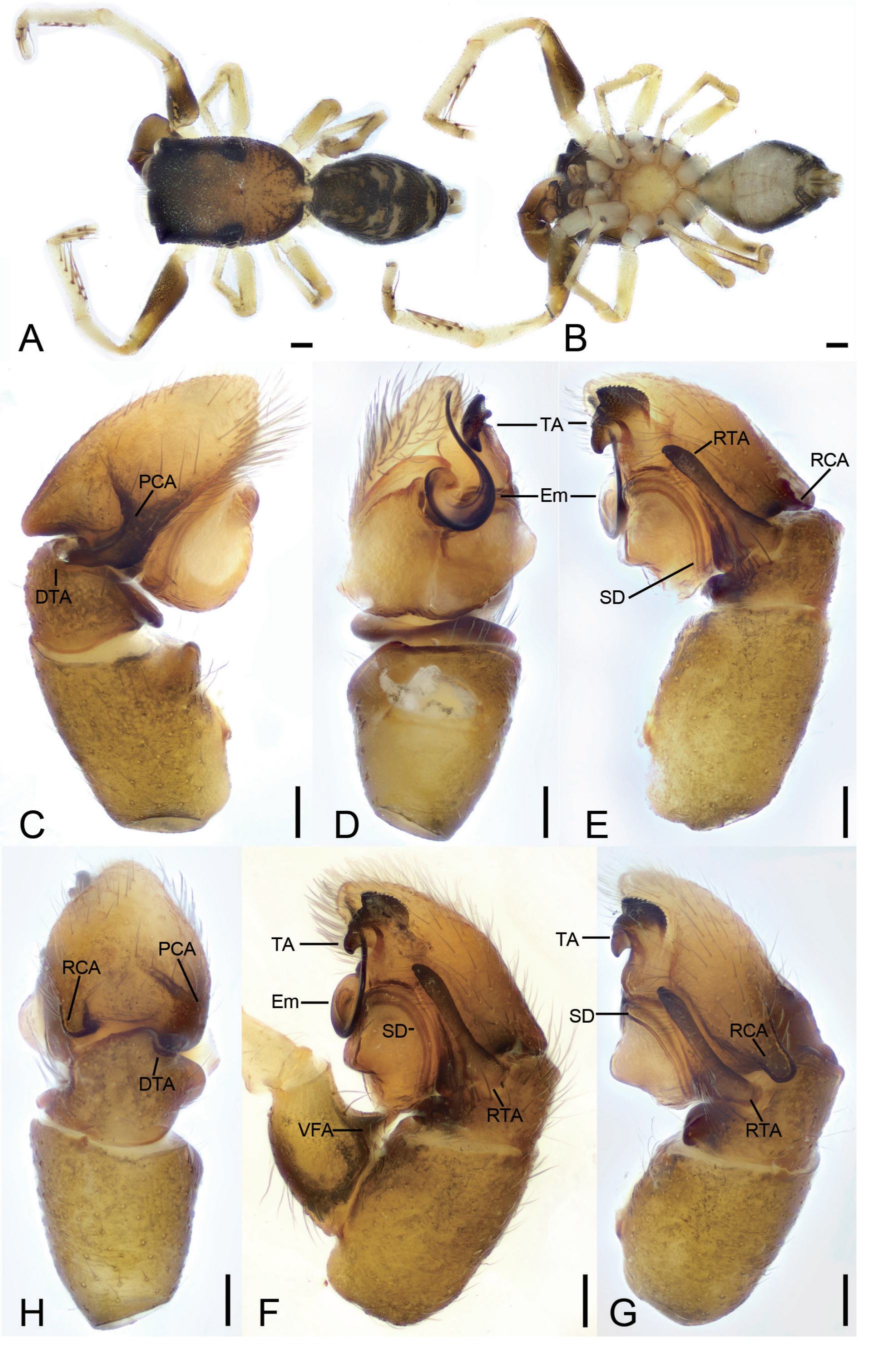

Figure 4. *Synagelides jinding* sp. nov., holotype male **A** habitus, dorsal view **B** same, ventral view **C** palp, prolateral view **D** same, ventral view **E** same, retrolateral view **F** same, detail of ventral femoral apophysis, retrolateral view **G** same, retrolateral view, slightly dorsal **H** same, dorsal view. Abbreviations: DTA – dorso-prolateral tibial apophysis, Em – embolus, PCA – postero-prolateral cymbial apophysis, RCA – postero-retrolateral cymbial apophysis, RTA – retrolateral tibial apophysis, SD – sperm duct, SS – scale-like serrations, TA – terminal apophysis, VFA – ventral femoral apophysis. Scale bars: 0.2 mm (**A, B**); 0.05 mm (**C–E, G, H**); 0.1 mm (**F**).

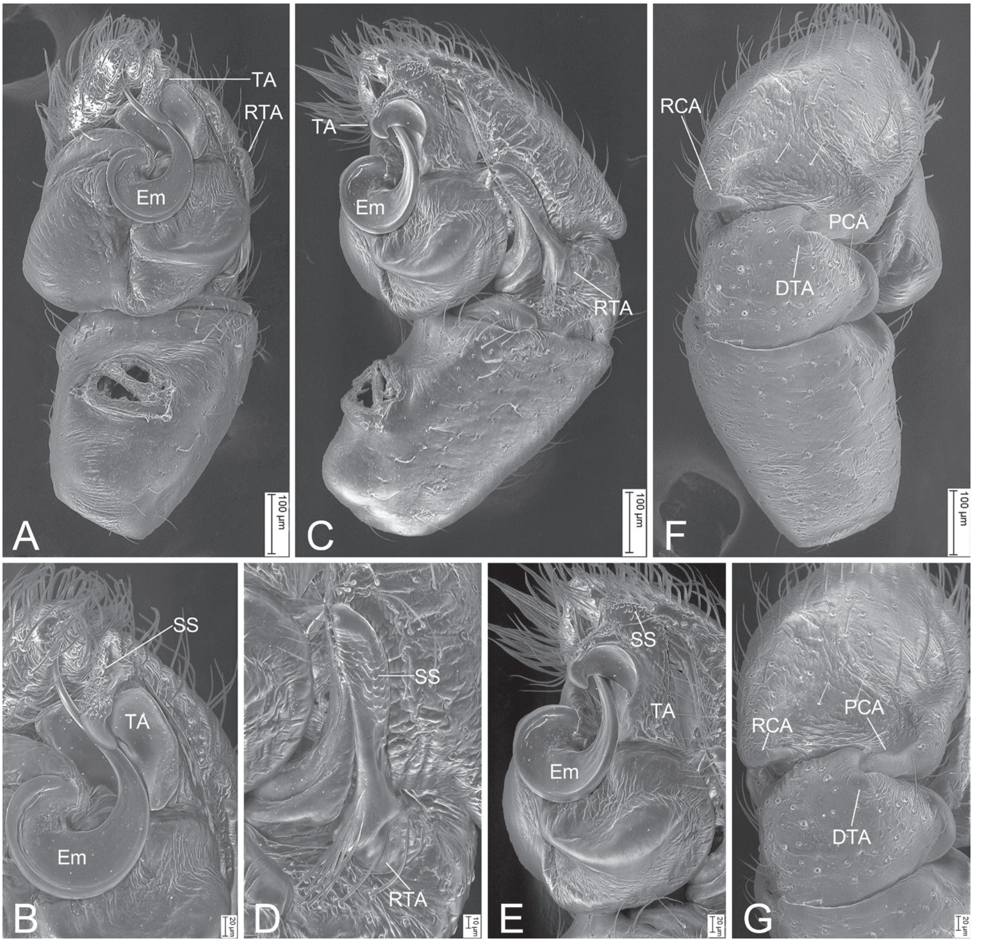

Figure 5. *Synagelides jinding* sp. nov., SEMs of holotype male **A** palp, ventral view **B** same, detail of terminal apophysis and embolus, ventral view **C** same, retrolateral view **D** same, detail of retrolateral tibial apophysis, retrolateral view **E** same, detail of terminal apophysis and embolus, retrolateral view **F** same, dorsal view, slightly prolateral **G** same, detail of postero-prolateral cymbial apophysis, postero-retrolateral cymbial apophysis and dorso-prolateral tibial apophysis, dorsal view. Abbreviations: DTA – dorso-prolateral tibial apophysis, Em – embolus, PCA – postero-prolateral cymbial apophysis, RCA – postero-retrolateral cymbial apophysis, RTA – retrolateral tibial apophysis, SS – scale-like serrations, TA – terminal apophysis.

Abdomen yellowish to dark brown, with three pairs of yellowish stripes in anterior part and one arch-shaped, yellowish stripe on subposterior part; venter yellowish to yellow. Spinnerets yellowish brown, mottled.

Palp (Figs 4C–H, 5). Femur with a strongly sharp, tooth-like ventral apophysis. Patella swollen, with a length–width ratio of ca 1.58. Tibia small and narrow, with a long strong clavate retrolateral apophysis which presents many little scale-like serrations on anterior surface and nearly longer than 1/2 length of cymbium, and a dorsal apophysis locking cymbial postero-prolateral apophysis. Cymbium bullet-shaped in dorsal view, with a long, strong, blunt, sclerotized postero-retrolateral and a long, strong, triangular, postero-prolateral apophysis. Tegulum broad, C-shaped extended in ventral view, with a clear mastoid apophysis and a thin sperm duct in retrolateral view. Terminal apophysis arising from antero-retrolateral part of tegulum, strongly sclerotized, Y-shaped in retrolateral view, with abundant little scale-like serrations on antero-retrolateral surface. Embolus with an anticlockwise spiral in ventral view, longer than terminal apophysis, with broad convoluted basal part and whip-shaped apical part.

Female. Unknown.

Comments. The male of this species is not conspecific with the female of *Synagelides triangulatus* sp. nov. for the following reasons. Firstly, the male abdomen has the two pairs of white stripes medially (vs a pair of spots and one chevron-shaped yellowish stripe in *S. triangulatus*) and the arch-shaped yellowish stripe located subposteriorly (vs absent in *S. triangulatus*).

Distribution. Known only from the type locality in Jiangxi Province, China (Fig. 13).

Synagelides serratus Liu, sp. nov.

http://zoobank.org/C6C0FB47-5AF8-43D9-9C3B-86E5239E4BF8

Figs 6–8

Material examined. ***Holotype*** ♂, 26°40'48.69"N, 115°25'07.79"E, 1031 m, Dawu Mountain, near Xilin Village, dawu Monuntain, Longjiatang Village, Donggu Town, Qingyuan District, Ji'an City, Jiangxi Province, China, 25 October 2020, K. Liu, Y. Ying & S. Yuan leg. ***Paratype*** 1 ♀, the same data as holotype.

Etymology. The name from the Latin word *serratus*, referring to the saw-like retrolateral apophysis; adjective.

Diagnosis. The male of this species is similar to that of *Synagelides annae* in having an anticlockwise spiral embolus and a C-shaped terminal apophysis (see Bohdanowicz 1979: 56, figs 14–17), but differs from it in having (Figs 6C–H, 7) the posterior cymbium with a short blunt retrolateral apophysis (vs absent), the femur with a spine-like ventral apophysis (vs relatively broadly triangular) in prolateral view, and the saw-like retrolateral tibial apophysis in retrolateral view (vs long and spine-like). It also resembles seven species, *S. birmanicus* Bohdanowicz, 1987 (see Bohdanowicz 1987: 84, figs 66–72), *S. cavaleriei* (Schenkel, 1963) (see Bohdanowicz 1987: 66, figs 1, 2), *S. gosainkundicus* Bohdanowicz, 1987 (see Bohdanowicz 1987: 78, figs 45, 46), *S. kosi* Logunov & Hereward, 2006 (see Logunov and Hereward 2006: 285, figs 21, 22), *S. martensi* Bohdanowicz, 1987 (see Logunov and Hereward 2006: 287, figs 37–40), *S. oleksiaki* Bohdanowicz, 1987 (see Bohdanowicz 1987: 79, figs 47, 48), and *S. walesai* Bohdanowicz, 1987 (see Bohdanowicz 1987: 72, figs 23, 24), but can be easily distinguished from them by the very short postero-retrolateral cymbial apophysis (vs relatively long). The female of this species resembles that of *S. cavaleriei* in the anteromedially located, bell-shaped epigynal hood and the elongated, touching spermathecae (see Peng 2020: 446, fig. 325a, b), but it can be easily separated in having (Fig. 8C, D) the copulatory

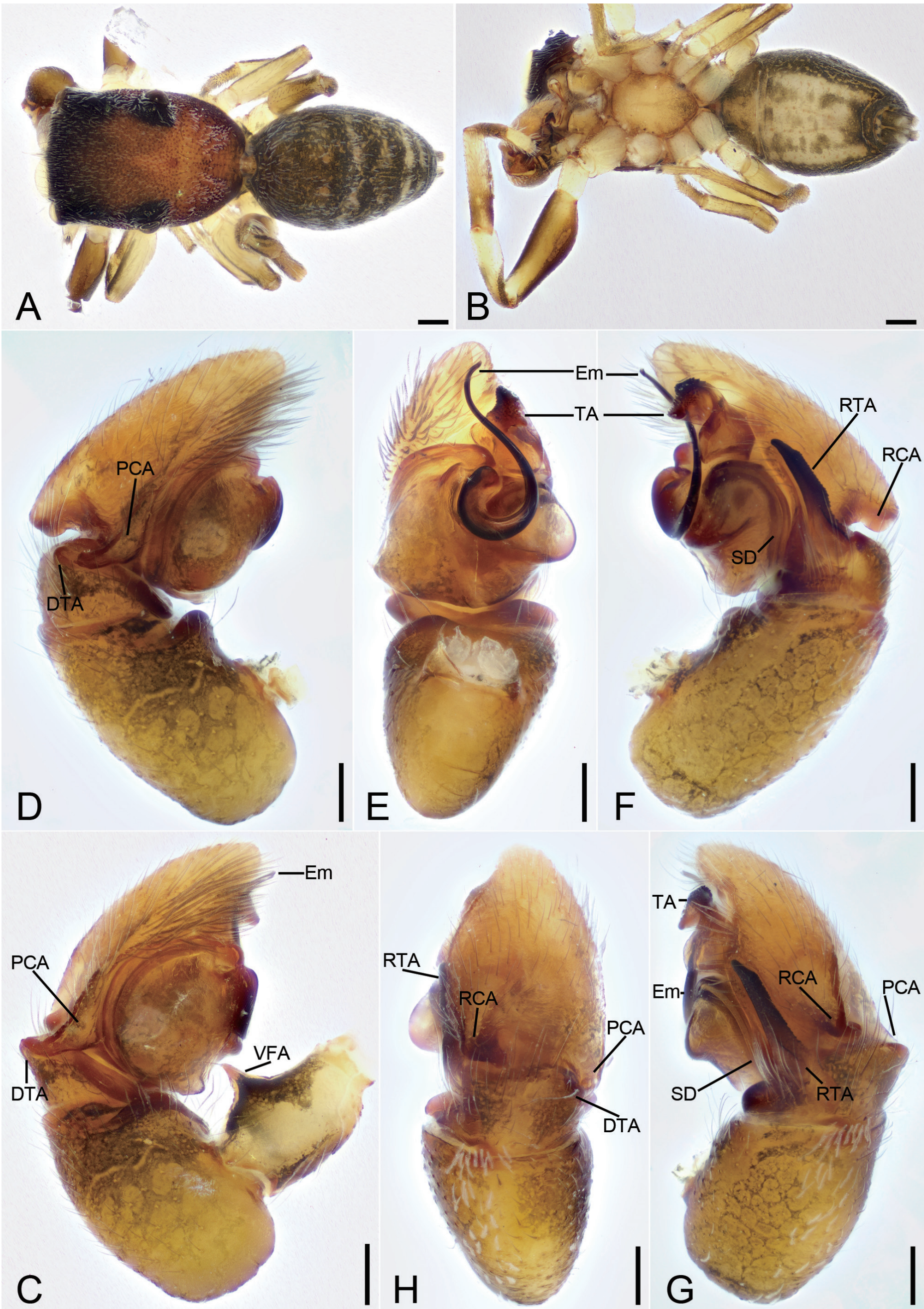

Figure 6. *Synagelides serratus* sp. nov., holotype male **A** habitus, dorsal view **B** same, ventral view **C** palp, detail of ventral femoral apophysis, prolateral view **D** same, prolateral view **E** same, ventral view **F** same, retrolateral view **G** same, retrolateral view, slightly dorsal **H** same, dorsal view. Abbreviations: DTA – dorso-prolateral tibial apophysis, Em – embolus, PCA – postero-prolateral cymbial apophysis, RCA – postero-retrolateral cymbial apophysis, RTA – retrolateral tibial apophysis, SD – sperm duct, SS – scale-like serrations, TA – terminal apophysis, VFA – ventral femoral apophysis. Scale bars: 0.2 mm (**A, B**); 0.1 mm (**C**); 0.05 mm (**D–H**).

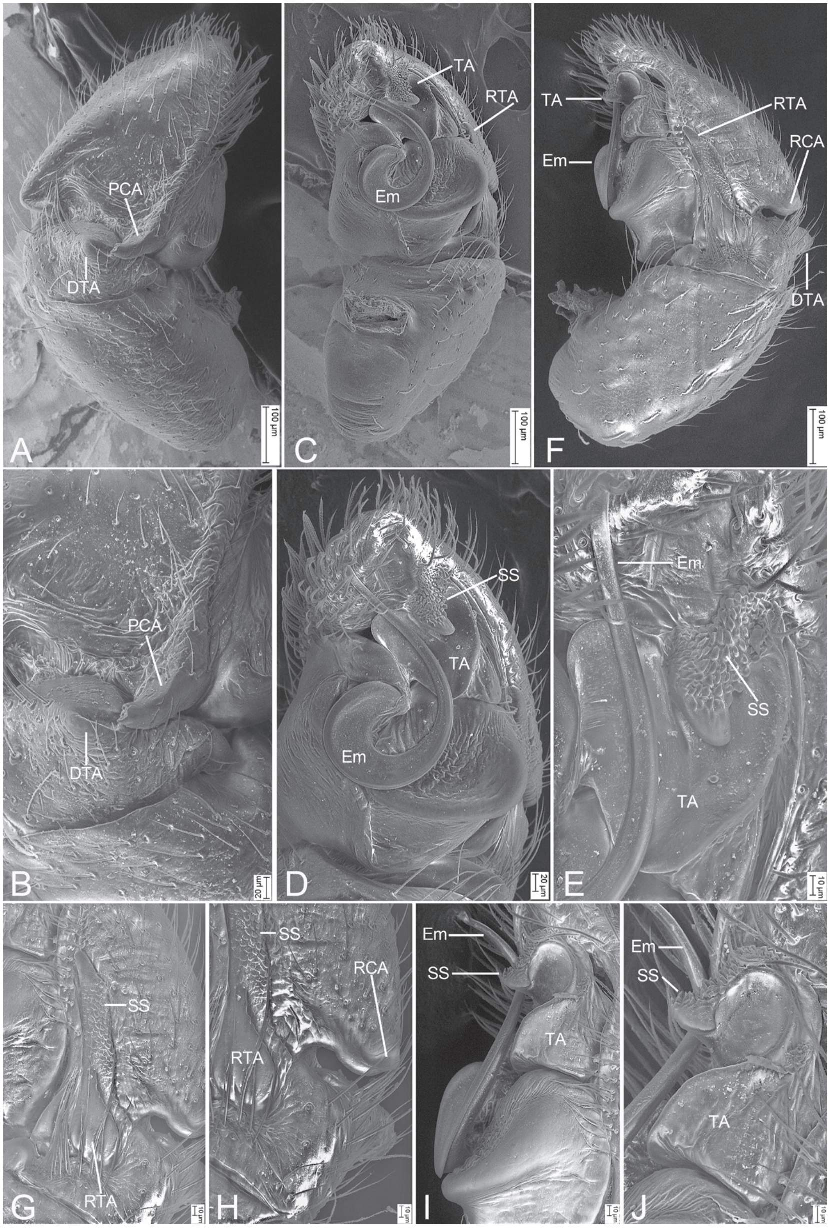

Figure 7. *Synagelides serratus* sp. nov., SEMs of holotype male **A** palp, prolateral view, strongly dorsal **B** same, detail of postero-prolateral cymbial apophysis and dorso-prolateral tibial apophysis, prolateral view, strongly dorsal **C** same, retrolateral view, slightly retrolateral **D** same, detail of retrolateral tibial apophysis, ventral view, slightly retrolateral **E** same, detail of terminal apophysis and embolus, ventral view, slightly retrolateral **F** same, retrolateral view **G** same, detail of retrolateral tibial apophysis, retrolateral view **H** same, detail of retrolateral tibial apophysis and postero-retrolateral cymbial apophysis, retrolateral view **I** same, detail of terminal apophysis and embolus, retrolateral view **J** same, detail of terminal apophysis and embolus, retrolateral view. Abbreviations: DTA – dorso-prolateral tibial apophysis, Em – embolus, PCA – postero-prolateral cymbial apophysis, RCA – postero-retrolateral cymbial apophysis, RTA – retrolateral tibial apophysis, SS – scale-like serrations, TA – terminal apophysis.

openings located subposteromedially (vs medially) and the broad part of copulatory ducts extending like a question mark (vs double C-shaped mark).

Description. Male (holotype, sp1-20201025-4, red label). ***Habitus*** as in Fig. 6A, B. Total length 2.89. Carapace 1.40 long, 0.97 wide. Eye sizes and interdistances: AME 0.26; ALE 0.15; PME 0.04; PLE 0.15; AME–AME 0.07; AME–ALE 0.05; PME–PME 0.77; ALE–ALE 0.69; PME–PLE 0.26; PLE–PLE 0.82; ALE–PLE 0.51; AME–PME 0.33; AME–PLE 0.45. MOA: 0.45 long; 0.58 anterior width, 0.85 posterior width. Fovea (Fig. 6A) round, hollowed. Chelicerae (Fig. 6B) with two promarginal teeth (proximal larger) and one large laminar retromarginal teeth. Sternum (Fig. 6B) shield-shaped, longer than wide, posterior end arch-shaped, smooth. Leg measurements: I 2.79 (0.87, 0.62, 0.7, 0.35, 0.25); II 1.93 (0.56, 0.33, 0.39, 0.38, 0.27); III 2.08 (0.64, 0.29, 0.4, 0.48, 0.27); IV 2.46 (0.72, 0.32, 0.52, 0.62, 0.28). Femur width: I 0.35; II 0.20; III 0.21; IV 0.18. Leg spination (Fig. 6A, B): I ti pv 2-1-1, rv 2-1-1; Met pv 1-1-0, rv 1-1-0. Pedicel 0.03. Abdomen 1.47 long, 0.89 wide.

Coloration (Fig. 6A, B). Carapace reddish brown, anterior part darker than posterior, posteriorly with radial grooves, and 10–14 rows of short scale-like white setae. Endites yellow, mottled. Labium yellow-brown, anteriorly with a single row of strong setae, posteriorly mottled. Sternum yellow with pale brown, mottled spots around margin. Legs: trochanters I–IV yellow, with dark brown stripe; femur I dark yellow-brown, femora II–IV yellow, with prolateral dark brown stripes; patellae, tibiae, and metatarsi yellow, with dark brown lateral stripes; tarsi yellowish. Abdomen dark brown, mottled, with four chevron-shaped yellowish stripes on posterior part; venter with many irregular dark brown spots. Spinnerets dark yellow-brown, mottled.

Palp (Figs 6C–H, 7). Femur with a very sharp, spine-like, ventral apophysis. Patella swollen, with a length–width ratio of ca 1.92. Tibia small and narrow, with a long, strong, saw-like retrolateral apophysis which presents many scale-like serrations on lateral surface and nearly as long as 1/2 length of cymbium, and a stubby dorsal apophysis locking cymbial postero-prolateral apophysis. Cymbium bullet-shaped in dorsal view, with a short, strong, blunt, sclerotized postero-retrolateral and a long, strong, triangular postero-prolateral apophysis. Tegulum very broad, with a clear mastoid apophysis in ventral view and a thin sperm duct in retrolateral view. Terminal apophysis C-shaped in retrolateral view, strongly sclerotized and curved, arising from antero-retrolateral part of tegulum, with abundant, little, scale-like serrations on distal surface. Embolus with an anticlockwise spiral in ventral view, longer than terminal apophysis, with relatively broad curved basal part and whip-shaped apical part.

Female (paratype, sp1-20201025-4, yellow label). ***Habitus*** as in Fig. 8A, B. As in male, except as noted. Total length 2.85. Carapace 1.24 long, 0.84 wide. Eye sizes and interdistances: AME 0.23; ALE 0.13; PME 0.05; PLE 0.12; AME–AME 0.10; AME–ALE 0.08; PME–PME 0.72; ALE–ALE 0.62; PME–PLE 0.23; PLE–PLE 0.78; ALE–PLE 0.53; AME–PME 0.38; AME–PLE 0.66. MOA: 0.56 long; 0.54 anterior width, 0.81 posterior width. Sternum (Fig. 8B), posterior end triangular, relatively blunt. Leg measurements: I 2.16 (0.7, 0.45, 0.54, 0.26, 0.21); II 1.56 (0.51, 0.16, 0.35, 0.29, 0.25); III 1.84 (0.55, 0.28, 0.36, 0.38, 0.27); IV 2.45 (0.7, 0.31, 0.59, 0.58, 0.27). Fe-

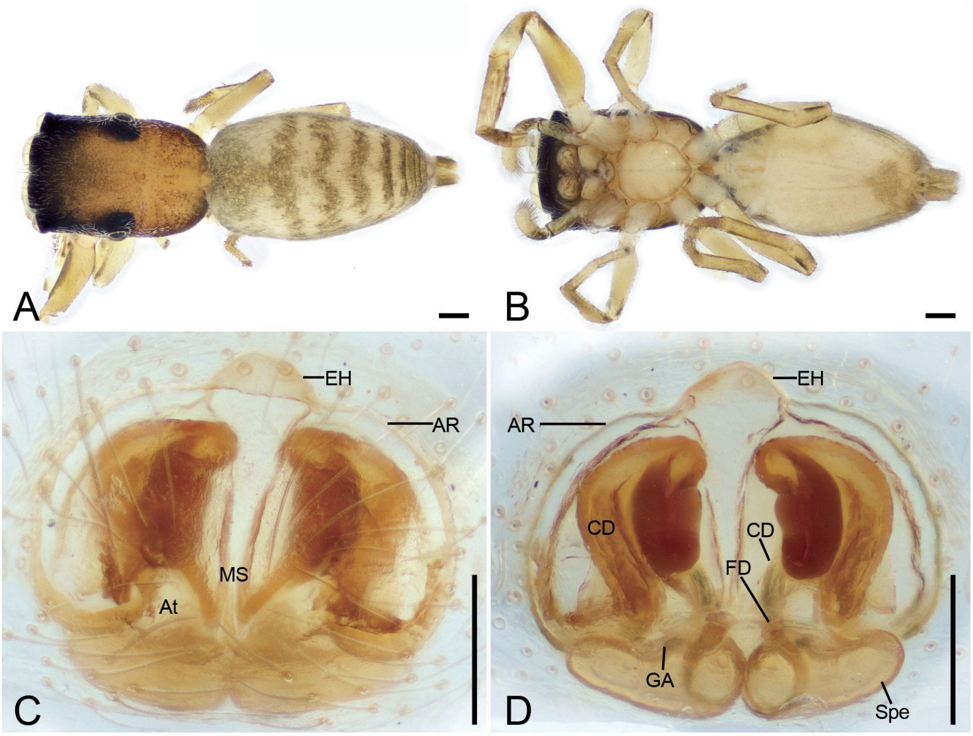

Figure 8. *Synagelides serratus* sp. nov., female paratype **A** habitus, dorsal view **B** same, ventral view **C** epigyne, ventral view **D** same, dorsal view. Abbreviations: AR – atrial rim, At – atrium, CD – copulatory duct, CO – copulatory opening, EH – epigynal hood, FD – fertilization duct, GA – glandular appendages, MS – median septum, Spe – spermatheca. Scale bars: 0.2 mm (**A, B**); 0.05 mm (**C, D**).

mur width: I 0.31; II 0.20; III 0.21; IV 0.21. Pedicel 0.11. Leg spination (Fig. 8A, B): I ti pv 2-2-0, rv 2-2-0; Met pv 1-0-1, rv 1-0-1. Pedicel 0.11. Abdomen 1.55 long, 0.92 wide.

Coloration (Fig. 8A, B). Paler than male. Carapace yellow-brown. Sternum yellowish, posteromedially with mottled dark brown stripe. Abdomen yellowish, with two transverse brown stripes in anterior part, two chevron-shaped brown stripes medially, and four transverse brown stripes posteriorly; venter yellowish, with a V-shaped marking medially and a large brown spot posteriorly.

Epigyne (Fig. 8C, D). Epigynal plate cap-shaped, with a short median septum. Epigynal hood broadly bell-shaped, arising from anteromedial atrial rim. Atrium small, widely separated. Atrial rim round, slightly sclerotized. Copulatory ducts very long, anterior part like a question mark, posterior part tubed with a slight curve medially, connecting with subposterior part of spermathecae. Glandular appendages very short, near the base of fertilization ducts. Spermathecae large, elongated, swollen, closely touching. Fertilization ducts relatively long, nearly as long as 1/2 length of spermathecae, transversely extended.

Distribution. Known only from the type locality in Jiangxi Province, China (Fig. 13).

Synagelides shuqiang **Liu, sp. nov.**
http://zoobank.org/1FC0A541-AB4C-40FB-85BC-B01AC3290902
Figs 9–11

Material examined. ***Holotype*** ♂, 24°55'35.36"N, 115°27'25.09"E, 716 m, Guizhumao Parking lot, near the county-boundary between Xunwu and Anyuan County, Ganzhou City, Jiangxi Province, China, 7 October 2020, K. Liu, Y. Ying, M. Zhang & J. Yan leg.

Etymology. The species is named in honor of Dr Shuqiang Li, a well-known arachnologist (Institute of Zoology, Chinese Academy of Sciences, Beijing); noun in apposition.

Diagnosis. The male of this species is most similar to that of *Synagelides hamatus* Zhu et al. 2005 (Zhu et al. 2005: 541, fig. 12D, E) and *S. palpalis* Żabka, 1985 (Wang et al. 2020: 16, fig. 17D) in having a convoluted embolus reaching cymbial tip and the shape of tegulum, but differs from them in having (Figs 9C–I, 10) a L-shaped terminal apophysis in ventral view (vs broadly hook-shaped in *S. hamatus* and S-shaped in *S. palpalis*) and the sword-shaped retrolateral tibial apophysis (vs forked in *S. hamatus* and spine-like in *S. palpalis*) slightly longer than 1/2 length of cymbium (vs much longer than 1/2 length of cymbium in *S. hamatus* and *S. palpalis*) in retrolateral view. It also resembles seven species, *S. birmanicus* Bohdanowicz, 1987 (see Bohdanowicz 1987: 84, figs 66–72), *S. cavaleriei* (Schenkel, 1963) (see Bohdanowicz 1987: 66, figs 1, 2), *S. gosainkundicus* Bohdanowicz, 1987 (see Bohdanowicz 1987: 78, figs 45, 46), *S. kosi* Logunov & Hereward, 2006 (see Logunov and Hereward 2006: 285, figs 21, 22), *S. martensi* Bohdanowicz, 1987 (see Logunov and Hereward 2006: 287, figs 37–40), *S. oleksiaki* Bohdanowicz, 1987 (see Bohdanowicz 1987: 79, figs 47, 48), and *S. walesai* Bohdanowicz, 1987 (see Bohdanowicz 1987: 72, figs 23, 24), but can be easily distinguished from them by the very short and broad postero-retrolateral cymbial apophysis in retrolateral view (vs relatively long and thin) and the triangular terminal apophysis in retrolateral view (vs C-shaped).

Description. ***Habitus*** as in Figs 9A, B, 11. Total length 4.63. Carapace 1.98 long, 1.44 wide. Eye sizes and interdistances: AME 0.48; ALE 0.23; PME 0.13; PLE 0.25; AME–AME 0.10; AME–ALE 0.10; PME–PME 1.14; ALE–ALE 1.06; PME–PLE 0.42; PLE–PLE 1.24; ALE–PLE 0.83; AME–PME 0.48; AME–PLE 0.96. MOA: 0.74 long; 0.92 anterior width, 1.28 posterior width. Fovea (Fig. 9A) round, hollowed. Chelicerae (Fig. 9B) with two promarginal teeth (proximal larger) and one large laminar retromarginal teeth. Sternum (Fig. 9B) shield-shaped, longer than wide, anterolateral sloping, posterior end arch-shaped. Leg measurements: I 5.03 (1.54, 1.44, 1.24, 0.49, 0.32); II 3.37 (1.03, 0.51, 0.83, 0.69, 0.31); III 3.25 (0.97, 0.48, 0.78, 0.68, 0.34); IV 4.35 (1.25, 1.29, 0.57, 0.84, 0.4). Femur width: I 0.42; II 0.26; III 0.28; IV 0.28. Leg spination (Fig. 9A, B): I ti pv 0-3-1, rv 0-3-1; Met pv 1-0-1, rv 1-0-1. Pedicel 0.20. Abdomen 2.46 long, 1.01 wide.

Coloration (Fig. 9A, B). Carapace reddish brown, anterior part darker than posterior, posteriorly with radial grooves, and 12–16 rows of short scale-like, black setae.

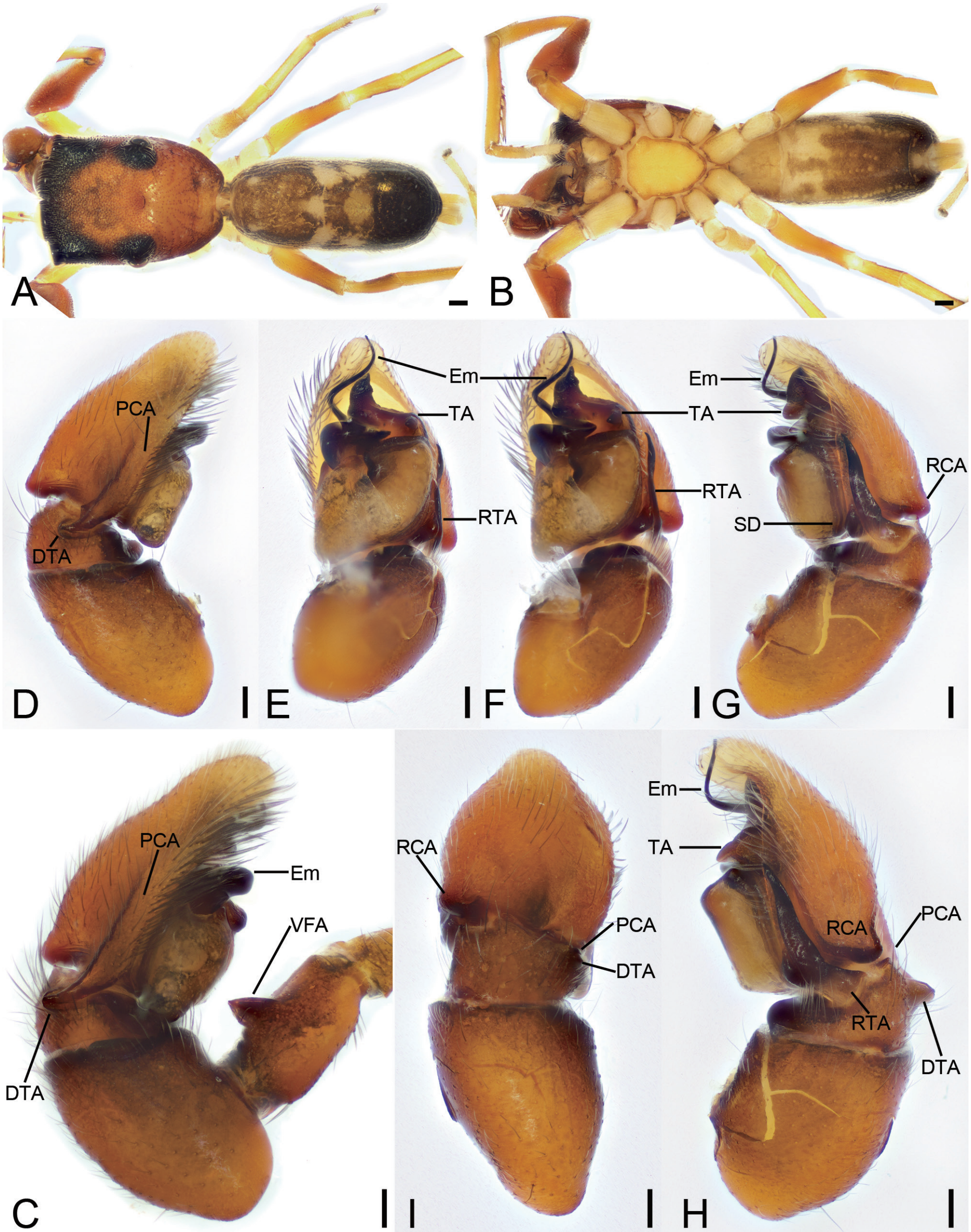

Figure 9. *Synagelides shuqiang* sp. nov., holotype male **A** habitus, dorsal view **B** same, ventral view **C** palp, detail of ventral femoral apophysis, prolateral view **D** same, prolateral view, slightly dorsal **E** same, ventral view **F** same, ventral view, slightly retrolateral **G** same, retrolateral view **H** same, retrolateral view, slightly dorsal **I** same, dorsal view. Abbreviations: DTA – dorso-prolateral tibial apophysis, Em – embolus, PCA – postero-prolateral cymbial apophysis, RCA – postero-retrolateral cymbial apophysis, RTA – retrolateral tibial apophysis, SD – sperm duct, SS – scale-like serrations, TA – terminal apophysis, VFA – ventral femoral apophysis. Scale bars: 0.2 mm (**A, B**); 0.1 mm (**C**); 0.05 mm (**D–I**).

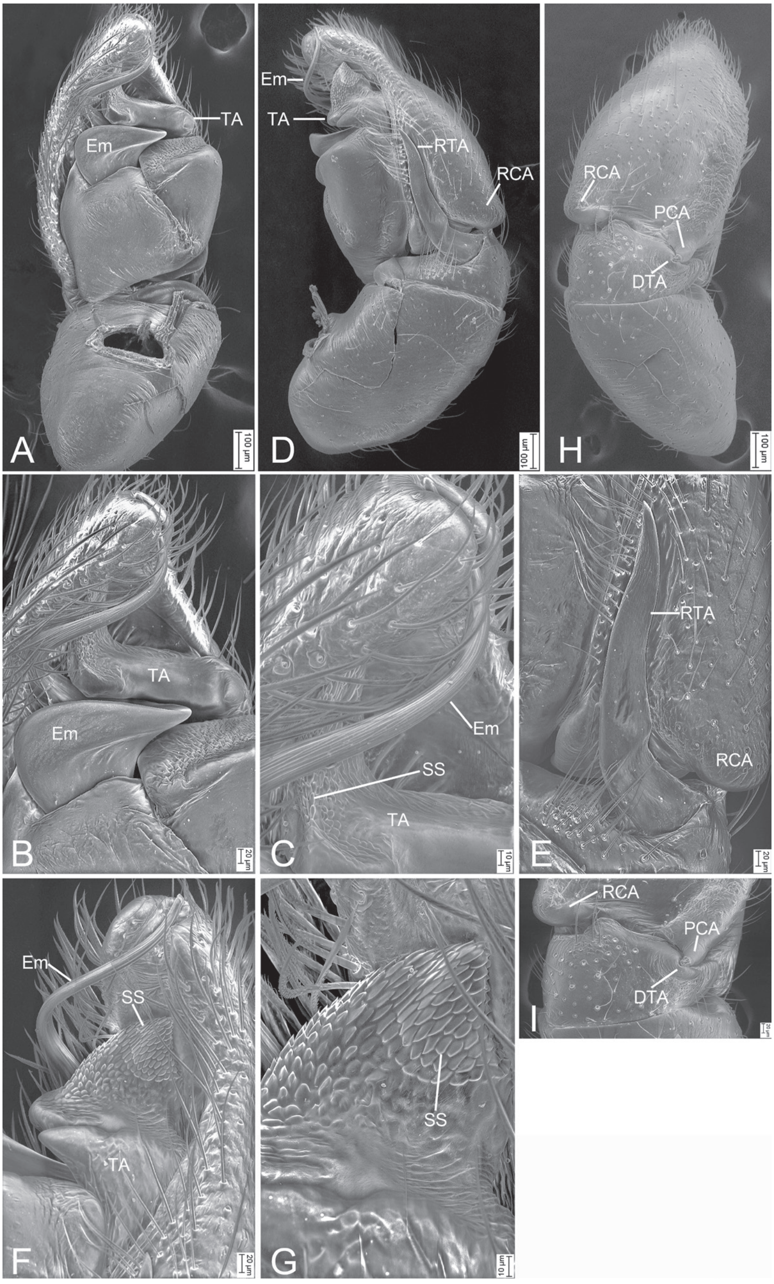

Figure 10. *Synagelides shuqiang* sp. nov., SEMs of holotype male **A** palp, ventral view **B** same, detail of terminal apophysis and embolus, ventral view **C** same, detail of terminal apophysis and embolus, ventral view **D** same, retrolateral view **E** same, detail of retrolateral tibial apophysis, retrolateral view **F** same, detail of terminal apophysis and embolus, retrolateral view **G** same, detail of terminal apophysis, retrolateral view **H** same, dorsal view **I** same, detail of postero-prolateral cymbial apophysis, postero-retrolateral cymbial apophysis and dorso-prolateral tibial apophysis, dorsal view. Abbreviations: DTA – dorso-prolateral tibial apophysis, Em – embolus, PCA – postero-prolateral cymbial apophysis, RCA – postero-retrolateral cymbial apophysis, RTA – retrolateral tibial apophysis, SS – scale-like serrations, TA – terminal apophysis.

Figure 11. Photographs of living male specimens of *Synagelides shuqiang* sp. nov., from Ganzhou City in Jiangxi Province, China.

Endites yellow-brown, mottled. Labium yellow-brown, anteriorly with a single row of strong setae, posteriorly dark brown. Sternum, yellow, with pale brown mottled spots around margin. Legs: trochanter I yellow, trochanters II–IV yellowish; femur I reddish brown, femora II–IV yellow; tibiae, patellae, and metatarsi yellow; tarsi yellowish. Abdomen dark brown, mottled, with one broad yellowish stripe including a semicircular dark brown marking in medial part; venter yellow to dark brown, with three dark brown adjacent stripes, posterior part fusing. Spinnerets dark yellow.

Palp (Figs 9C–I, 10). Femur with a thick, strong, tooth-like ventral apophysis. Patella swollen, with a length–width ratio of ca 1.76. Tibia small and narrow, with a long, strong, sword-like, retrolateral apophysis which slightly longer than 1/2 length of cymbium and a ridge-like prolateral apophysis locking cymbial postero-prolateral apophysis. Cymbium bullet-shaped in dorsal view, with a short, strong, broad, sclerotized postero-retrolateral and a long, strong, thick postero-prolateral apophysis. Tegulum very broad, lacking mastoid apophysis in ventral view, with a thin sperm duct in retrolateral view. Terminal apophysis strongly sclerotized, L-shaped, and with a horn-like tip in ventral view, arising from antero-retrolateral part of tegulum, with abundant strong, scale-like serrations on anterior surface. Embolus an anticlockwise convolute in ventral view, longer than terminal apophysis, with relatively broad curved basal part, and whip-shaped apical part, apex extending beyond the cymbial tip.

Female. Unknown.

Comments. The male of this species is not conspecific with *Synagelides triangulatus* sp. nov. based on the following observations. Firstly, the male abdomen is elongated in dorsal view, nearly 2.5 times as long as wide, while in *S. triangulatus*, the length–width ratio is ca 1.5. Secondly, the abdomen has a clear constriction located medially (Fig. 11), but in the latter a constriction is absent (Fig. 12A, B). This species seems more successful than the latter in ant mimicry based on its habitus.

Distribution. Known only from the type locality in Jiangxi Province, China (Fig. 13).

Synagelides triangulatus Liu, sp. nov.

http://zoobank.org/25E61438-A86C-4156-AFC9-569E31D87ED0

Fig. 12

Material examined. ***Holotype*** ♀, 26°00'28.25"N, 114°08'47.43"E, 1046 m, near Viewing Platform, Wuzhifeng Scenic Spot, Wuzhifeng Town, Shangyou County, Ganzhou City, Jiangxi Province, China, 1 October 2020, K. Liu, Y. Ying, M. Zhang & J. Yan leg. ***Paratype*** 1 subadult male, the same data as holotype.

Etymology. The name is from the Latin word *triangulatus*, referring to the shape of the median septum; adjective.

Diagnosis. The female of this species is most similar to *Synagelides kosi* Logunov & Hereward, 2006 (Logunov and Hereward 2006: 285, figs 24, 32) and *S. jinggangshanensis* Liu et al., 2017 (Liu et al. 2017: 292, figs 1C, D, 2A, B; holotype examined) in having the C-shaped median part and the sloping, slender, tub-shaped posterior part of copulatory duct, but can be separated from them by (Fig. 12C, D) the broad, bell-shaped epigynal hood (vs relatively thin in *S. kosi* and *S. jinggangshanensis*), the relatively broad triangular median septum (vs nearly T-shaped in *S. kosi* and and *S. jinggangshanensis*), and the closely touching spermathecae (vs slightly separated in *S. kosi* and *S. jinggangshanensis*). It also resembles seven other species, *S. annae* (see Bohdanowicz 1979: 56, figs 14–17), *S. birmanicus* Bohdanowicz, 1987 (see Bohdanowicz 1987: 84, figs 66–72), *S. cavaleriei* (Schenkel, 1963) (see Bohdanowicz 1987: 66, figs 1, 2), *S. gosainkundicus* Bohdanowicz, 1987 (see Bohdanowicz 1987: 78, figs 45, 46), *S. martensi* Bohdanowicz, 1987 (see Logunov and Hereward 2006: 287, figs 37–40), *S. oleksiaki* Bohdanowicz, 1987 (see Bohdanowicz 1987: 79, figs 47, 48), and *S. walesai* Bohdanowicz, 1987 (see Bohdanowicz 1987: 72, figs 23, 24), but can be easily distinguished from them in having the spermathecae as long as median septum (vs shorter or longer).

Description. ***Habitus*** as in Fig. 12A, B. Total length 3.16. Carapace 1.39 long, 1.01 wide. Eye sizes and interdistances: AME 0.23; ALE 0.16; PME 0.06; PLE 0.16; AME–AME 0.09; AME–ALE 0.08; PME–PME 0.81; ALE–ALE 0.76; PME–PLE 0.26; PLE–PLE 0.89; ALE–PLE 0.70; AME–PME 0.37; AME–PLE 0.57. MOA: 0.55 long; 0.64 anterior width, 0.90 posterior width. Fovea (Fig. 12A) round, hollowed. Chelicerae (Fig. 12B) with two promarginal teeth (proximal larger) and one large laminar retromarginal teeth. Sternum (Fig. 12A, B) shield-shaped, longer than wide, posterior end arch-shaped. Leg measurements: I 2.97 (0.93, 0.68, 0.75, 0.33,

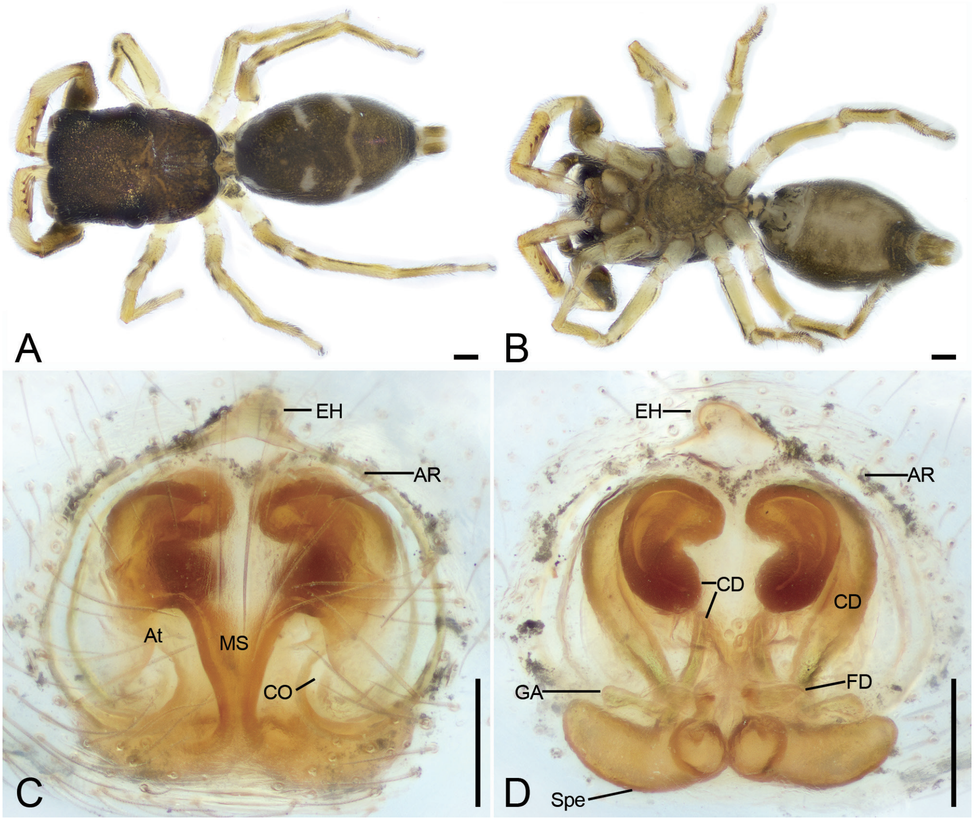

Figure 12. *Synagelides triangulatus* sp. nov., holotype female **A** habitus, dorsal view **B** same, ventral view **C** epigyne, ventral view **D** same, dorsal view. Abbreviations: AR – atrial rim, At – atrium, CD – copulatory duct, CO – copulatory opening, EH – epigynal hood, FD – fertilization duct, GA – glandular appendages, MS – median septum, Spe – spermatheca. Scale bars: 0.2 mm (**A, B**); 0.05 mm (**C, D**).

0.28); II 1.88 (0.6, 0.28, 0.3, 0.4, 0.3); III 2.34 (0.67, 0.37, 0.46, 0.57, 0.27); IV 3.06 (0.79, 0.39, 0.81, 0.73, 0.34). Femur width: I 0.29; II 0.17; III 0.18; IV 0.25. Leg spination (Fig. 12A, B): I ti pv 2-2-1, rv 2-2-0; Met pv 1-0-1, rv 1-0-1. Pedicel 0.18. Abdomen 1.57 long, 0.96 wide.

Coloration (Fig. 12A, B). Carapace dark reddish brown, anterior part darker than posterior, posteriorly with radial grooves, 14–16 rows of short black setae. Endites yellow-brown, mottled. Labium yellow-brown, anteriorly with two rows of strong setae. Sternum, yellow-brown, mottled, with dark brown, mottled stripes around margin. Legs: trochanters yellow, with dark brown stripe; femur I dark yellow-brown, femora II–IV yellow, with distinct prolateral and retrolateral dark brown stripes; patellae, tibiae, and metatarsi yellow, with dark brown lateral stripes; tarsi yellow. Abdomen dark yellow-brown, mottled, with three clear white spots consisting of abundant white setae antero-laterally and three chevron-shaped stripes (the medial one clear, others indistinct) medially; venter with many irregular yellow-brown spots postero-medially. Spinnerets yellow-brown, mottled.

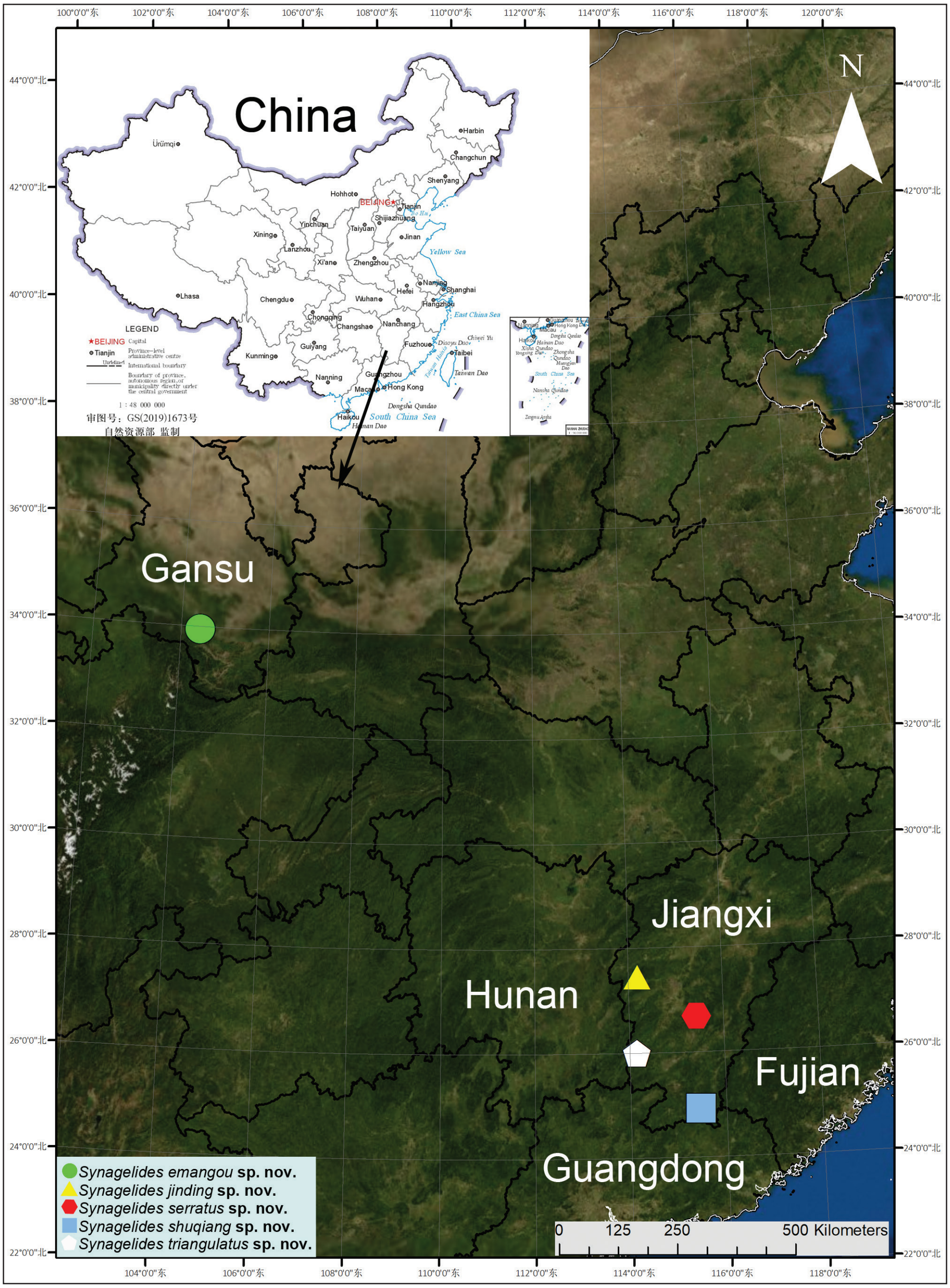

Figure 13. Records of *Synagelides emangou* sp. nov. from Gansu province; *S. jinding* sp. nov., *S. serratus* sp. nov., *S. shuqiang* sp. nov., and *S. triangulatus* sp. nov. from Jiangxi Province in China.

Epigyne (Fig. 12C, D). Epigynal plate apple-shaped, with a triangular median septum. Epigynal hood broadly bell-shaped, arising from anteromedial atrial rim. Atrium relatively large, separated by the median septum. Atrial rim round, slightly sclerotized. Copulatory ducts very long, anterior part like a question mark, medial part C-shaped, posterior part slender tube-shaped, connecting with subposterior part of spermathecae. Glandular appendages long, near the base of fertilization ducts, shorter than 1/2 length of spermathecae. Spermathecae large, elongated, swollen, closely touching, posteriorly globular. Fertilization ducts relatively broad, nearly as long as 1/3 length of spermathecae, transversely extended.

Male. Unknown.

Distribution. Known only from the type locality in Jiangxi Province, China (Fig. 13).

Acknowledgements

We are grateful to Cheng Xu, Yuan-hao Ying, Meng-zhen Zhang, Jing Yan, Si-liang Yuan, and Qi-xin Xiao (College of Life Sciences, Jinggangshan University, China) for collecting the specimens. We are grateful to the reviewers especially Dr Suresh Benjamin, Dr Wayne Maddison, and the subject editor Dr Dimitar Dimitrov for providing significant comments, Dr Nathalie Yonow, Dr Robert Forsyth and Dr Zdravka Zorkova for improving the English of the manuscript. This study was supported by the Natural Science Foundation of China (32000301/32160243), the Science and Technology Foundation of Jiangxi Provincial Department of Education (GJJ211017), and PhD Research Startup Foundation of Jinggangshan University (JZB2010).

References

Bohdanowicz A (1979) Descriptions of spiders of the genus *Synagelides* (Araneae: Salticidae) from Japan and Nepal. Acta Arachnologica 28(2): 53–62. https://doi.org/10.2476/asjaa.28.53

Bohdanowicz A (1987) Salticidae from the Nepal Himalayas: The genus *Synagelides* Bösenberg & Strand 1906. Courier Forschungsinstitut Senckenberg 93: 65–86.

Kanesharatnam N, Benjamin SP (2020) First record of *Synagelides* Strand, 1906 (Araneae: Salticidae) from Sri Lanka: description of four endemic species from tropical wet forest of the island. Zootaxa 4790(1): 43–56. https://doi.org/10.11646/zootaxa.4790.1.2

Li SQ, Lin YC (2021) Species Catalogue of China. Vol. 2. Animals. Invertebrates (I). Arachnida: Araneae. Science Press, Beijing, 549 pp.

Liu KK, Chen ZW, Xu X, Peng XJ (2017) Three new species of *Synagelides* Strand, 1906 from China (Araneae: Salticidae). Zootaxa 4350(2): 291–300. https://doi.org/10.11646/zootaxa.4350.2.5

Logunov DV, Hereward J (2006) New species and synonymies in the genus *Synagelides* Strand in Bösenberg & Strand, 1906 (Araneae: Salticidae). Bulletin-British Arachnological Society 13: 281–292.

Maddison WP (2015) A phylogenetic classification of jumping spiders (Araneae: Salticidae). The Journal of Arachnology 43(3): 231–292. https://doi.org/10.1636/arac-43-03-231-292

Peng XJ (2020) Fauna Sinica, Invertebrata 53, Arachnida: Araneae: Salticidae. Science Press, Beijing, 612 pp.

Peng XJ, Li SQ, Chen J (2003) Description of *Synagelides zhaoi* sp. nov. from Hubei, China (Araneae, Salticidae). Dong Wu Fen Lei Xue Bao 28: 249–251.

Wang C, Mi XQ, Irfan M, Peng XJ (2020) On eight species of the spider genus *Synagelides* Strand, 1906 from China (Araneae: Salticidae). European Journal of Taxonomy 724(1): 1–33. https://doi.org/10.5852/ejt.2020.724.1153

World Spider Catalog (2021) World Spider Catalog. Natural History Museum Bern. Version 22.5. https://wsc.nmbe.ch/ [accessed 17 October 2021]

Zhu MS, Zhang JX, Zhang ZS, Chen HM (2005) Arachnida: Araneae. In: Yang MF, Jin DC (Eds) Insects from Dashahe Nature Reserve of Guizhou. Guizhou People's Publishing House, Guiyang, 490–555.

ZooKeys 1102: 83–106 (2022)
doi: 10.3897/zookeys.1102.79102
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The ornithological collection of the Zoological Museum of Babeș-Bolyai University, Cluj-Napoca, Romania – Part 1: the catalogue of bird skin specimens

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Academic editor: George Sangster | Received 9 December 2021 | Accepted 14 April 2022 | Published 19 May 2022

http://zoobank.org/C7F83179-399D-41AA-AE13-C4A0CD5DC23F

Citation: Osváth G, Papp E, Benkő Z, Kovács Z (2022) The ornithological collection of the Zoological Museum of Babeș-Bolyai University, Cluj-Napoca, Romania – Part 1: the catalogue of bird skin specimens. ZooKeys 1102: 83–106. https://doi.org/10.3897/zookeys.1102.79102

Abstract

This paper reviews the bird skin collection housed in the Zoological Museum of Babeș-Bolyai University, Cluj-Napoca, Romania. The collection includes 925 specimens, belonging to 193 species from 53 families and 20 orders, collected between 1859 and 2021. Due to its historical background and the presence of rare species, it is considered to be one of most important ornithological collections in Eastern Europe. Such a collection can serve as a basis for valuable ornithological studies. Furthermore, a map representation with new distribution data for bird species is provided, which represents a source of information for the status of the avifauna of the Carpathian basin in the 19th and 20th centuries.

Keywords

Aves, biodiversity, bird skin, museum, ornithology, ornithological collections

Introduction

Museum collections are important primary data sources for addressing fundamental questions in morphology, systematics, biogeography and biodiversity conservation (Causey et al. 2004; Vágási et al. 2016; Bartoccioni 2017; Pap et al. 2017, 2019, 2020;

Osváth et al. 2018, 2020; Meineke et al. 2019). Collections generally comprise specimens from different time periods and areas; thus, well-labelled preserved specimens provide information on how the environment and species distribution has changed over extended time periods (Solow and Roberts 2006; MacLean et al. 2019; Gotelli et al. 2021). The importance of keeping specimens in collections and making them publicly available is increasing, particularly in the case of old collections, which cover long time periods (Roselaar 2003; Waeber et al. 2017; Mikula et al. 2018).

An important ornithological collection is held in the Zoological Museum of Babeș-Bolyai University, Cluj-Napoca, Romania (Fig. 1). The collection is unique in the region in many ways: it covers a long time span, it contains a variety of species, belonging to different families and orders, and it is composed of the work of several naturalists and employees of the museum. Bird skins account for approximately half of the total

Figure 1. Bird skin specimens from the ornithological collection of the Zoological Museum of Babeș-Bolyai University, Cluj-Napoca, Romania.

ornithological collection and they were only partially catalogued. Information about the collection had been published, particularly in the early stages of the museum's history (e.g., Herman 1865, 1868, 1869; Apáthy 1910b, 1910a, 1911; Filipaşcu et al. 1965; Filipaşcu 1966), but the revision of the full collection had not been carried out and all specimen data had not been made public until now.

Hence, our aim was to systematically verify the species identification of the bird skin specimens in the Zoological Museum of Babeş-Bolyai University ornithological collection to provide a catalogue of these birds, including the following information: list of species, number of specimens per species, up to date taxonomic nomenclature, and collection data (date, location, collector).

Materials and methods

We examined each bird skin in the collection and the data cards documenting the identification, locality, date, sex and catalogue number. After this, we checked the species identification of specimens, and we determined the sex and age of birds, where possible. The scientific name and the taxonomy of birds was updated following Handbook of the Birds of the World and BirdLife International Taxonomic Checklist v. 5 (2020).

Some specimens lacked a data card but had old inventory numbers. Therefore, in order to maximise the information content of these specimens, we researched contemporary museum registers and early museum-related reports for data. Following identification, all available specimen data were entered into the updated digital catalogue of the bird skin collection. All collection locality information was georeferenced.

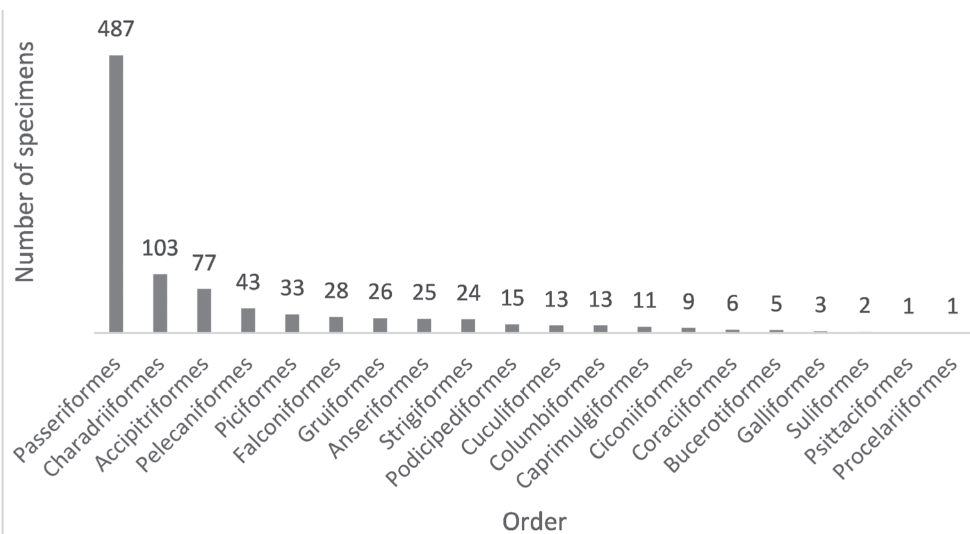

Figure 2. Total number of bird skin specimens per order represented in the ornithological collection of the Zoological Museum of Babeş-Bolyai University, Cluj-Napoca, Romania.

Table 1. Bird skin specimens held by the Zoological Museum of Babeș-Bolyai University, Romania, including their updated identification and scientific name, locality of collection, name of collector (surname, given name), date of collection, and sex and age of birds. The full catalogue of bird skin collection is provided in the Suppl. material 1: Table S1. A blank cell indicates no available data.

Species	Location	Name of collector	Data	Sex	Age	Order
Acanthis flammea	Cluj-Napoca (CJ)	Zwörner Sándor	23.01.1904	M	adult	Passeriformes
Acanthis flammea	Cluj-Napoca (CJ)	Korodi-Gál János	16.02.1973	M	juvenile	Passeriformes
Acanthis flammea	Cluj-Napoca (CJ)	Korodi-Gál János	16.02.1973	M	adult	Passeriformes
Acanthis flammea	Cluj-Napoca (CJ)	Korodi-Gál János	16.02.1973	M	juvenile	Passeriformes
Acanthis flammea	Cluj-Napoca (CJ)	Korodi-Gál János	16.02.1973	F	adult	Passeriformes
Acanthis flammea	Cluj-Napoca (CJ)	Korodi-Gál János	16.02.1973	F	adult	Passeriformes
Acanthis flammea	Cluj-Napoca (CJ)	Korodi-Gál János	16.02.1973	F	adult	Passeriformes
Acanthis flammea	Cluj-Napoca (CJ)	Korodi-Gál János	16.02.1973	F	adult	Passeriformes
Acanthis flammea	Cluj-Napoca (CJ)	Korodi-Gál János	16.02.1973	M	adult	Passeriformes
Accipiter gentilis	Aghireș (CJ)	Führer Lajos	29.02.1906	M	adult	Accipitriformes
Accipiter gentilis	Micești (CJ)	Führer Lajos	03.10.1908	F	juvenile	Accipitriformes
Accipiter gentilis	Cluj-Napoca (CJ)	Führer Lajos	02.07.1905	M	juvenile	Accipitriformes
Accipiter gentilis	Turea (CJ)	Führer Lajos	26.08.1905	M	juvenile	Accipitriformes
Accipiter gentilis				M	adult	Accipitriformes
Accipiter gentilis				F	juvenile	Accipitriformes
Accipiter gentilis				M	juvenile	Accipitriformes
Accipiter nisus	Cluj-Napoca (CJ)	Ajtai K. Gyula	xx.08.1892	F	juvenile	Accipitriformes
Accipiter nisus	Turea (CJ)	Führer Lajos	26.08.1905	F	juvenile	Accipitriformes
Accipiter nisus	Turea (CJ)	Führer Lajos	15.07.1905	F	adult	Accipitriformes
Accipiter nisus		Zwörner Sándor	03.10.1903	M	juvenile	Accipitriformes
Acrocephalus arundinaceus	Apahida (CJ)	Führer Lajos	xx.05.1911	F	adult	Passeriformes
Acrocephalus arundinaceus	Apahida (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Acrocephalus arundinaceus	Apahida (CJ)	Führer Lajos	xx.05.1911	F	adult	Passeriformes
Acrocephalus arundinaceus	Apahida (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Acrocephalus arundinaceus	Apahida (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Acrocephalus arundinaceus	Apahida (CJ)	Führer Lajos	xx.09.1909	F	adult	Passeriformes
Acrocephalus arundinaceus	Apahida (CJ)	Führer Lajos	xx.09.1909	M	adult	Passeriformes
Acrocephalus palustris	Cluj-Napoca (CJ)	Führer Lajos	xx.05.1911		adult	Passeriformes
Acrocephalus palustris	Florești (CJ)	Führer Lajos	xx.05.1913	M	adult	Passeriformes
Acrocephalus palustris						Passeriformes
Acrocephalus palustris						Passeriformes
Acrocephalus palustris	Cluj-Napoca (CJ)	Führer Lajos	xx.05.1911			Passeriformes
Acrocephalus palustris						Passeriformes
Acrocephalus schoenabaenus	Apahida (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Acrocephalus schoenabaenus	Apahida (CJ)	Führer Lajos	xx.10.1909	M	juvenile	Passeriformes
Acrocephalus schoenabaenus	Apahida (CJ)	Führer Lajos	xx.10.1909	F		Passeriformes
Acrocephalus schoenabaenus			xx.xx.1911		adult	Passeriformes
Acrocephalus schoenabaenus					adult	Passeriformes
Acrocephalus schoenabaenus			xx.xx.1911			Passeriformes
Acrocephalus schoenabaenus						Passeriformes
Acrocephalus scirpaceus						Passeriformes
Actitis hypoleucos	Cluj-Napoca (CJ)	Führer Lajos	xx.06.1911	M	juvenile	Charadriiformes
Actitis hypoleucos	Hortobágy (HU)		xx.04.1907	F		Charadriiformes
Actitis hypoleucos	Geaca (CJ)	Herman Ottó	xx.04.1867	F	adult	Charadriiformes

Species	Location	Name of collector	Data	Sex	Age	Order
Actitis hypoleucos	Gilău (CJ)	Führer Lajos	xx.05.1911	F	adult	Charadriiformes
Actitis hypoleucos	Gilău (CJ)	Führer Lajos	xx.05.1911	F	adult	Charadriiformes
Actitis hypoleucos	Gilău (CJ)	Führer Lajos	xx.06.1911	F	juvenile	Charadriiformes
Actitis hypoleucos	Gilău (CJ)	Führer Lajos	xx.06.1911	M	adult	Charadriiformes
Actitis hypoleucos	Mociu (CJ)	Führer Lajos	xx.10.1909	M	juvenile	Charadriiformes
Actitis hypoleucos	Mociu (CJ)	Führer Lajos	xx.10.1909	M	adult	Charadriiformes
Actitis hypoleucos	Mociu (CJ)	Führer Lajos	xx.10.1909	F	adult	Charadriiformes
Actitis hypoleucos	Mociu (CJ)	Führer Lajos	xx.06.1910	M		Charadriiformes
Actitis hypoleucos	Răscruci (CJ)	Führer Lajos	xx.11.1909	M	juvenile	Charadriiformes
Actitis hypoleucos	Răscruci (CJ)	Führer Lajos	xx.11.1909	F	juvenile	Charadriiformes
Actitis hypoleucos	Szentgothárd (HU)	Ajtai K. Gyula	23.05.1910	M	adult	Charadriiformes
Actitis hypoleucos					adult	Charadriiformes
Aegithalos caudatus	Cluj-Napoca (CJ)	Führer Lajos	xx.01.1910	F	adult	Passeriformes
Aegithalos caudatus	Cluj-Napoca (CJ)	Ajtai K. Gyula	20.02.1910	M	adult	Passeriformes
Aegithalos caudatus	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1909	M	adult	Passeriformes
Aegithalos caudatus	Cluj-Napoca (CJ)	Führer Lajos	21.12.1902	F	adult	Passeriformes
Aegithalos caudatus	Feleacu (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Aegithalos caudatus	Micești (CJ)	Führer Lajos	xx.11.1909	F	adult	Passeriformes
Aegithalos caudatus	Micești (CJ)	Führer Lajos	xx.01.1909	M	adult	Passeriformes
Aegithalos caudatus					adult	Passeriformes
Aegithalos caudatus					adult	Passeriformes
Aegithalos caudatus					adult	Passeriformes
Aegypius monachus	Bucium (SJ)		24.06.1903	F	adult	Accipitriformes
Alauda arvensis	Apahida (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Alauda arvensis	Apahida (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Alauda arvensis	Cluj-Napoca (CJ)	Vincze Ferencz	14.03.1965	M	adult	Passeriformes
Alauda arvensis						Passeriformes
Alauda arvensis						Passeriformes
Alcedo atthis	Florești (CJ)	Führer Lajos	16.08.1912	M		Coraciiformes
Anas acuta	Ocna Mureș (AB)	Führer Lajos	17.03.1903	M	adult	Anseriformes
Anas crecca	Geaca (CJ)	Vincze Ferencz	30.09.1971	F		Anseriformes
Anas crecca	Geaca (CJ)	Vincze Ferencz	08.10.1971	M	juvenile	Anseriformes
Anas crecca	Geaca (CJ)	Vincze Ferencz	08.10.1971	F		Anseriformes
Anas platyrhynchos	Hăghig (CV)	Führer Lajos	11.01.1903	F		Anseriformes
Anas platyrhynchos				F		Anseriformes
Anser albifrons	Cefa (BH)	Vincze Ferencz	19.12.1970	F	juvenile	Anseriformes
Anser albifrons					juvenile	Anseriformes
Anser fabalis	Hortobágy (HU)	Teleky O.	xx.04.1907	F		Anseriformes
Anser fabalis						Anseriformes
Anthus campestris	Suatu (CJ)	Führer Lajos	xx.06.1911	M		Passeriformes
Anthus cervinus		Führer Lajos				Passeriformes
Anthus spinoletta	Răscruci (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Anthus trivialis	Apahida (CJ)	Führer Lajos	xx.10.1909	F		Passeriformes
Anthus trivialis	Apahida (CJ)	Führer Lajos	xx.10.1909	F		Passeriformes
Anthus trivialis	Cuzăplac (SJ)	Kómis Lajos	18.10.1913	M		Passeriformes
Anthus trivialis	Florești (CJ)	Führer Lajos	xx.03.1913			Passeriformes
Anthus trivialis						Passeriformes
Aquila heliaca	Sibiu (SB)	Führer Lajos	xx.08.1907	F	adult	Accipitriformes
Aquila heliaca	Sibiu (SB)	Führer Lajos	xx.08.1907	M	juvenile	Accipitriformes
Ardea alba	Mociu (CJ)	Führer Lajos	xx.10.1909	M		Pelecaniformes
Ardea alba	Mociu (CJ)	Führer Lajos	xx.10.1909	F		Pelecaniformes
Ardea cinerea	Băgara (CJ)	Führer Lajos	xx.04.1910	F	adult	Pelecaniformes
Ardea cinerea	Cefa (BH)	Vincze Ferencz	23.06.1970	M	adult	Pelecaniformes
Ardea cinerea	Cefa (BH)	Vincze Ferencz	23.06.1970	M	adult	Pelecaniformes
Ardea cinerea	Cefa (BH)	Vincze Ferencz	23.06.1970	M	adult	Pelecaniformes
Ardea cinerea	Cefa (BH)	Vincze Ferencz	23.06.1970	F	juvenile	Pelecaniformes

Species	Location	Name of collector	Data	Sex	Age	Order
Ardea cinerea	Cefa (BH)	Vincze Ferencz	23.06.1970	F	juvenile	Pelecaniformes
Ardea cinerea	Mociu (CJ)	Führer Lajos	xx.04.1910	M	adult	Pelecaniformes
Ardea cinerea	Răscruci (CJ)	Führer Lajos	xx.10.1909	F	juvenile	Pelecaniformes
Ardea cinerea	Țaga (CJ)	Ajtai K. Gyula	03.05.1910	F	immatur	Pelecaniformes
Ardea cinerea			xx.xx.1911		adult	Pelecaniformes
Ardea cinerea			xx.xx.1911		adult	Pelecaniformes
Ardea cinerea			xx.xx.1911		adult	Pelecaniformes
Ardea cinerea			xx.xx.1911		adult	Pelecaniformes
Ardea purpurea	Băgara (CJ)	Führer Lajos	xx.04.1910	F	adult	Pelecaniformes
Ardea purpurea	Geaca (CJ)	Vincze Ferencz	15.09.1972	F	juvenile	Pelecaniformes
Ardea purpurea	Geaca (CJ)	Führer Lajos	xx.xx.1911		adult	Pelecaniformes
Ardea purpurea					juvenile	Pelecaniformes
Ardeola ralloides	Cefa (BH)	Vincze Ferencz	24.06.1970	M	adult	Pelecaniformes
Asio flammeus	Apahida (CJ)	Führer Lajos	xx.03.1911	F	adult	Strigiformes
Asio flammeus	Borș (BH)	Führer Lajos	15.01.1906	F	adult	Strigiformes
Asio flammeus	Borș (BH)	Führer Lajos	15.01.1906	M	adult	Strigiformes
Asio flammeus	Cluj-Napoca (CJ)	Kómis Lajos	30.11.1913	F	adult	Strigiformes
Asio flammeus					adult	Strigiformes
Asio flammeus				M	adult	Strigiformes
Asio flammeus				F	adult	Strigiformes
Asio flammeus				F	adult	Strigiformes
Asio flammeus					adult	Strigiformes
Asio flammeus					adult	Strigiformes
Asio flammeus				F	adult	Strigiformes
Asio otus	Baia Mare (MM)	Sitar Cristian	xx.12.2010		adult	Strigiformes
Asio otus	Cefa (BH)	Vincze Ferencz	19.12.1970	F	adult	Strigiformes
Asio otus	Hortobágy (HU)	Nagy Jenő	xx.04.1907	M	adult	Strigiformes
Asio otus	Przewtoka (UA)	Kómis Lajos	06.04.1916	M	adult	Strigiformes
Asio otus	Turda (CJ)		xx.04.1893		adult	Strigiformes
Asio otus					adult	Strigiformes
Athene noctua		Führer Lajos	xx.xx.1911		adult	Strigiformes
Athene noctua	Sărmășel - Gară (MS)	Osváth Gergely	14.05.2020		adult	Strigiformes
Aythya ferina	Cefa (BH)	Vincze Ferencz	24.06.1970	F	juvenile	Anseriformes
Aythya ferina	Geaca (CJ)	Vincze Ferencz	04.06.1970	M	adult	Anseriformes
Aythya nyroca	Apahida (CJ)	Führer Lajos	xx.09.1909	F		Anseriformes
Aythya nyroca	Cefa (BH)	Vincze Ferencz	24.06.1970	F		Anseriformes
Aythya nyroca	Geaca (CJ)	Vincze Ferencz	03.06.1970	F		Anseriformes
Aythya nyroca	Geaca (CJ)	Vincze Ferencz	30.09.1971	F		Anseriformes
Aythya nyroca	Geaca (CJ)	Vincze Ferencz	03.06.1970	F	adult	Anseriformes
Aythya nyroca					adult	Anseriformes
Bombycilla garrulus	Cluj-Napoca (CJ)	Zwörner Sándor	18.12.1903	M		Passeriformes
Bombycilla garrulus	Cluj-Napoca (CJ)	Führer Lajos	10.11.1903	M		Passeriformes
Bombycilla garrulus	Cluj-Napoca (CJ)	Führer Lajos	10.11.1903	M		Passeriformes
Bombycilla garrulus	Cluj-Napoca (CJ)	Führer Lajos	10.11.1903	F		Passeriformes
Bombycilla garrulus				M		Passeriformes
Bombycilla garrulus				M		Passeriformes
Bombycilla garrulus				M		Passeriformes
Bombycilla garrulus				M		Passeriformes
Bombycilla garrulus				M		Passeriformes
Bombycilla garrulus				M		Passeriformes
Buteo buteo	Apahida (CJ)	Führer Lajos	xx.07.1912	F		Accipitriformes
Buteo buteo	Apahida (CJ)	Führer Lajos	xx.07.1912	M		Accipitriformes
Buteo buteo	Ardeal		xx.12.1863	M		Accipitriformes
Buteo buteo	Borșa (CJ)	Führer Lajos	29.03.1906	M		Accipitriformes
Buteo buteo	Cluj-Napoca (CJ)	Fülöp Herman	25.02.1960	M		Accipitriformes
Buteo buteo	Cluj-Napoca (CJ)		xx.02.1913	M		Accipitriformes

Species	Location	Name of collector	Data	Sex	Age	Order
Buteo buteo	Cluj-Napoca (CJ)	Führer Lajos	19.07.1905	M		Accipitriformes
Buteo buteo	Cluj-Napoca (CJ)	Ajtai K. Gyula	11.10.1909	F		Accipitriformes
Buteo buteo	Cristian (BV)	Lánczy I.	25.01.1903	F		Accipitriformes
Buteo buteo	Dej (CJ)	Zwörner Sándor	08.01.1904			Accipitriformes
Buteo buteo	Făgăraş (BV)	Zwörner Sándor	01.05.1903	M		Accipitriformes
Buteo buteo	Floreşti (CJ)		xx.xx.1913	F		Accipitriformes
Buteo buteo	Floreşti (CJ)	Führer Lajos	xx.10.1913	M		Accipitriformes
Buteo buteo	Grădina Zoologică din Târgu Mureş	Bereczki Boldizsár	15.02.1985			Accipitriformes
Buteo buteo	Grădina Zoologică din Târgu Mureş	Bereczki Boldizsár	15.02.1985			Accipitriformes
Buteo buteo	Miskolc (HU)	Herman Ottó?	xx.12.1863	F		Accipitriformes
Buteo buteo						Accipitriformes
Buteo buteo						Accipitriformes
Buteo buteo						Accipitriformes
Buteo buteo						Accipitriformes
Buteo buteo						Accipitriformes
Buteo buteo						Accipitriformes
Buteo buteo						Accipitriformes
Buteo buteo						Accipitriformes
Buteo buteo		Fülöp Herman				Accipitriformes
Buteo buteo						Accipitriformes
Buteo buteo	Delniţa (CJ)	Miklós Réka, Osváth Gergely	12.10.2020		immatur	Accipitriformes
Buteo lagopus	Apahida (CJ)		xx.02.1913	F	adult	Accipitriformes
Buteo lagopus	Cluj-Napoca (CJ)	Führer Lajos	07.02.1905	F	adult	Accipitriformes
Buteo lagopus	Cluj-Napoca (CJ)	Herman Ottó?	xx.xx.1865	M	adult	Accipitriformes
Buteo lagopus				M	adult	Accipitriformes
Buteo lagopus				F?	adult	Accipitriformes
Buteo lagopus				F	adult	Accipitriformes
Buteo rufinus	Europa de Sud-Est			M		Accipitriformes
Buteo rufinus	Răscruci (CJ)	Führer Lajos	xx.10.1909	M		Accipitriformes
Calidris minuta	Apahida (CJ)	Führer Lajos	xx.05.1911	M	adult	Charadriiformes
Calidris minuta					adult	Charadriiformes
Calidris minuta	Someşeni (CJ)	Führer Lajos	xx.05.1911	M	adult	Charadriiformes
Calidris pugnax	Cătina (CJ)	Zwörner Sándor	11.05.1904	F	adult	Charadriiformes
Calidris pugnax	Hortobágy (HU)	Nagy Jenő	xx.04.1907	F	adult	Charadriiformes
Calidris pugnax				M	adult	Charadriiformes
Caprimulgus europaeus	Cluj-Napoca (CJ)	Führer Lajos	xx.04.1911	M		Caprimulgiformes
Caprimulgus europaeus	Cluj-Napoca (CJ)	Führer Lajos	10.10.1912	F		Caprimulgiformes
Caprimulgus europaeus	Cluj-Napoca (CJ)	Führer Lajos	xx.04.1911	M		Caprimulgiformes
Caprimulgus europaeus	Cluj-Napoca (CJ)	Führer Lajos	xx.04.1911	M		Caprimulgiformes
Caprimulgus europaeus	Cluj-Napoca (CJ)	Führer Lajos	xx.04.1911	M		Caprimulgiformes
Caprimulgus europaeus	Feleacu (CJ)	Führer Lajos	xx.04.1911	F		Caprimulgiformes
Caprimulgus europaeus	Floreşti (CJ)	Vincze Ferencz	18.05.1970	F		Caprimulgiformes
Caprimulgus europaeus						Caprimulgiformes
Caprimulgus europaeus						Caprimulgiformes
Caprimulgus europaeus						Caprimulgiformes
Caprimulgus europaeus						Caprimulgiformes
Carduelis carduelis	Pădureni (CJ)	Vincze Ferencz	02.02.1985		adult	Passeriformes
Certhia familiaris	Cuzăplac (SJ)	Kómis Lajos	xx.04.1912	F		Passeriformes
Certhia familiaris	Feleacu (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Certhia familiaris	Feleacu (CJ)	Führer Lajos	xx.04.1911	M	adult	Passeriformes
Certhia familiaris						Passeriformes
Certhia familiaris						Passeriformes
Certhia familiaris						Passeriformes
Charadrius alexandrinus	Hortobágy (HU)	Teleki I.	xx.04.1907	F		Charadriiformes

Species	Location	Name of collector	Data	Sex	Age	Order
Charadrius dubius	Cluj-Napoca (CJ)	Zwörner Sándor	15.04.1904	F		Charadriiformes
Charadrius dubius	Florești (CJ)	Führer Lajos	xx.04.1913	M		Charadriiformes
Charadrius dubius	Cluj-Napoca (CJ)	Führer Lajos	xx.05.1911	F		Charadriiformes
Charadrius dubius	Cluj-Napoca (CJ)	Führer Lajos	xx.05.1911	M		Charadriiformes
Charadrius dubius	Cluj-Napoca (CJ)	Zwörner Sándor	18.04.1904	M		Charadriiformes
Chlidonias hybrida	Apahida (CJ)	Führer Lajos	xx.09.1909	F	adult	Charadriiformes
Chlidonias hybrida	Apahida (CJ)	Führer Lajos	xx.09.1909	F	adult	Charadriiformes
Chlidonias hybrida	Apahida (CJ)	Führer Lajos	xx.09.1909	M	adult	Charadriiformes
Chlidonias hybrida	Apahida (CJ)	Führer Lajos	xx.10.1909	M	adult	Charadriiformes
Chlidonias hybrida	Apahida (CJ)	Führer Lajos	xx.10.1909	F	adult	Charadriiformes
Chlidonias niger					juvenile	Charadriiformes
Chlidonias niger	Apahida (CJ)	Führer Lajos	xx.09.1909	M	adult	Charadriiformes
Chlidonias niger	Brașov (BV)	Zwörner Sándor	08.07.1903	M	adult	Charadriiformes
Chlidonias niger	Geaca (CJ)	Vincze Ferencz	30.08.1971	F	juvenile	Charadriiformes
Chloris chloris	Cluj-Napoca (CJ)		04.03.1985	M	adult	Passeriformes
Chloris chloris	Cuzăplac (SJ)	Kómis Lajos	16.10.1913	F	adult	Passeriformes
Chloris chloris				F	adult	Passeriformes
Chloris chloris				F	adult	Passeriformes
Ciconia ciconia	Dezmir (CJ)	Fülöp Herman	18.08.1958	F	juvenile	Ciconiiformes
Ciconia ciconia	Grădina Zoologică din Turda	Vincze Ferencz	10.11.1971	M	adult	Ciconiiformes
Ciconia ciconia	Someșeni (CJ)	Vincze Ferencz	10.10.1972	M	adult	Ciconiiformes
Ciconia ciconia			xx.xx.1911		adult	Ciconiiformes
Ciconia ciconia			xx.xx.1911		adult	Ciconiiformes
Ciconia ciconia					adult	Ciconiiformes
Ciconia nigra	Răscruci (CJ)	Führer Lajos	xx.10.1909	F	juvenile	Ciconiiformes
Ciconia nigra				F	juvenile	Ciconiiformes
Ciconia nigra		Führer Lajos	xx.xx.1911	M	adult	Ciconiiformes
Cinclus cinclus	Bradu (NT)	Vincze Ferencz	10.05.1971	F		Passeriformes
Cinclus cinclus	Cluj-Napoca (CJ)	Ajtai K. Gyula	18.11.1909	M		Passeriformes
Cinclus cinclus	Someșul rece (CJ)	Vincze Ferencz	06.09.1970	M	juvenile	Passeriformes
Cinclus cinclus			xx.xx.1912			Passeriformes
Cinclus cinclus			xx.xx.1912			Passeriformes
Cinclus cinclus			xx.xx.1912			Passeriformes
Cinclus cinclus						Passeriformes
Cinclus cinclus	Mara (MM)	Deák József	10.08.1961			Passeriformes
Circaetus gallicus	Sibiu (SB)	Führer Lajos	xx.07.1907	M		Accipitriformes
Circus aeruginosus	Florești (CJ)	Führer Lajos	xx.xx.1911	M	juvenile	Accipitriformes
Circus aeruginosus	Hăghig (CV)	Führer Lajos	01.05.1903	F	adult	Accipitriformes
Circus cyaneus				F	adult	Accipitriformes
Clanga clanga	Bonțida (CJ)	Führer Lajos	xx.02.1910	F	juvenile	Accipitriformes
Clanga clanga	Bonțida (CJ)	Führer Lajos	xx.02.1910	M?	juvenile	Accipitriformes
Clanga clanga	Gilău (CJ)	Führer Lajos	23.03.1896	F		Accipitriformes
Clanga pomarina	Apahida (CJ)	Führer Lajos	xx.04.1911	F		Accipitriformes
Clanga pomarina	Cuzăplac (SJ)	Führer Lajos	20.01.1914	F	juvenile	Accipitriformes
Clanga pomarina	Feleacu (CJ)	Führer Lajos	xx.05.1911	F		Accipitriformes
Clanga pomarina					adult	Accipitriformes
Clanga pomarina					adult	Accipitriformes
Clanga pomarina					adult	Accipitriformes
Coccothraustes coccothraustes	Someșeni (CJ)		12.09.1972	M		Passeriformes
Columba oenas	Cluj-Napoca (CJ)	Führer Lajos	xx.06.1911	F	adult	Columbiformes
Columba oenas	Cordoș (MS)	Führer Lajos	xx.07.1911	M	adult	Columbiformes
Columba oenas	Feleacu (CJ)	Führer Lajos	xx.04.1911	M	adult	Columbiformes
Columba oenas					adult	Columbiformes
Columba oenas					adult	Columbiformes
Columba oenas		Führer Lajos	xx.xx.1911		adult	Columbiformes

Species	Location	Name of collector	Data	Sex	Age	Order
Coracias garrulus	Bicaz (NT)	Führer Lajos	xx.07.1910	F		Coraciiformes
Corvus cornix	Someșeni (CJ)	Neuwirth János	24.03.1903	M		Passeriformes
Corvus frugilegus						Passeriformes
Corvus frugilegus						Passeriformes
Corvus monedula	Cluj-Napoca (CJ)	Zwörner Sándor	02.02.1904	M	adult	Passeriformes
Corvus monedula	Cluj-Napoca (CJ)	Zwörner Sándor	19.11.1903	F		Passeriformes
Corvus monedula	Turea (CJ)	Führer Lajos	23.08.1903	M	adult	Passeriformes
Corvus monedula				M		Passeriformes
Coturnix coturnix	Apahida (CJ)	Führer Lajos	xx.09.1909	M	juvenile	Galliformes
Coturnix coturnix	Gilău (CJ)	Führer Lajos	xx.09.1909	M		Galliformes
Crex crex	Apahida (CJ)	Zwörner Sándor	05.06.1903	F		Gruiformes
Crex crex	Cluj-Napoca (CJ)		05.09.1902	M		Gruiformes
Crex crex	Geaca (CJ)	Herman Ottó	xx.04.1867	M	adult	Gruiformes
Cuculus canorus	Aghireș (CJ)	Führer Lajos	xx.09.1909	M	adult	Cuculiformes
Cuculus canorus	Aghireș (CJ)	Führer Lajos	xx.09.1909	M	adult	Cuculiformes
Cuculus canorus	Ceahlău (NT)	Vincze Ferencz	08.05.1971	M	adult	Cuculiformes
Cuculus canorus	Cluj-Napoca (CJ)	Vincze Ferencz	25.09.1971	F	juvenile	Cuculiformes
Cuculus canorus	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1912	M	adult	Cuculiformes
Cuculus canorus	Cluj-Napoca (CJ)	Führer Lajos	xx.04.1911	M	adult	Cuculiformes
Cuculus canorus	Cluj-Napoca (CJ)	Führer Lajos	xx.04.1911	M	adult	Cuculiformes
Cuculus canorus	Cluj-Napoca (CJ)	Führer Lajos	xx.04.1911	M	adult	Cuculiformes
Cuculus canorus	Cluj-Napoca (CJ)	Führer Lajos	xx.xx.1912	M	juvenile	Cuculiformes
Cuculus canorus	Feleacu (CJ)	Führer Lajos	xx.04.1911	F	adult	Cuculiformes
Cuculus canorus	Feleacu (CJ)	Führer Lajos	xx.04.1911	M	adult	Cuculiformes
Cuculus canorus	Pănade (AB)	Führer Lajos	xx.09.1909	M	adult	Cuculiformes
Cuculus canorus	Turnu Roșu (SB)	Ajtai K. Gyula	12.04.1910	M	adult	Cuculiformes
Cyanistes caeruleus	Cluj-Napoca (CJ)	Führer Lajos	18.11.1913	M		Passeriformes
Cyanistes caeruleus	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	M		Passeriformes
Cyanistes caeruleus	Cluj-Napoca (CJ)	Führer Lajos	xx.03.1910	M		Passeriformes
Cyanistes caeruleus	Cluj-Napoca (CJ)	Ajtai K. Gyula	11.02.1910	M		Passeriformes
Cyanistes caeruleus	Florești (CJ)	Neuwirth János	26.03.1903	M		Passeriformes
Cyanistes caeruleus	Micești (CJ)	Führer Lajos	xx.11.1909	M		Passeriformes
Cyanistes caeruleus						Passeriformes
Cyanistes caeruleus						Passeriformes
Cyanistes caeruleus						Passeriformes
Delichon urbicum	Apahida (CJ)	Führer Lajos	xx.09.1909	M		Passeriformes
Delichon urbicum	Apahida (CJ)	Führer Lajos	xx.09.1909	M		Passeriformes
Delichon urbicum	Apahida (CJ)	Führer Lajos	xx.09.1909	M		Passeriformes
Dendrocopos leucotos	Almașu (SJ)	Kómis Lajos	15.01.1914	M	adult	Piciformes
Dendrocopos major	Cluj-Napoca (CJ)	Zwörner Sándor	14.02.1903	F	adult	Piciformes
Dendrocopos major	Plesca (SJ)	Führer Lajos	26.03.1903	F	adult	Piciformes
Dendrocopos major				M	adult	Piciformes
Dendrocopos major				F	adult	Piciformes
Dendrocopos major	Alba Iulia (AB)	Savu George, Osváth Gergely	23.02.2018	M	adult	Piciformes
Dryobates minor	Feleacu (CJ)	Führer Lajos	xx.04.1909	M		Piciformes
Dryobates minor	Feleacu (CJ)	Führer Lajos	xx.04.1909	M		Piciformes
Dryocopus martius	Colibița (BN)	Vincze Ferencz	06.05.1971	M		Piciformes
Dryocopus martius	Măguri-Răcătău (CJ)	Vincze Ferencz	03.08.1970	F		Piciformes
Dryocopus martius						Piciformes
Egretta garzetta	Cefa (BH)	Vincze Ferencz	26.07.1970	M		Pelecaniformes
Egretta garzetta	Cefa (BH)	Vincze Ferencz	23.0.06.1970	m		Pelecaniformes
Emberiza citrinella	Cluj-Napoca (CJ)	Fülöp Herman	31.01.1960	M		Passeriformes
Emberiza citrinella	Someșeni (CJ)	Vincze Ferencz	25.11.1972	M		Passeriformes
Emberiza citrinella						Passeriformes
Emberiza citrinella					immatur	Passeriformes
Emberiza citrinella				M?	immatur	Passeriformes
Eremophila alpestris	Florești (CJ)	Führer Lajos	xx.04.1911	M	adult	Passeriformes

Species	Location	Name of collector	Data	Sex	Age	Order
Eremophila alpestris	Florești (CJ)	Führer Lajos	xx.04.1911	M	adult	Passeriformes
Erithacus rubecula	Cluj-Napoca (CJ)	Führer Lajos	xx.08.1905	M		Passeriformes
Erithacus rubecula	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Erithacus rubecula	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Erithacus rubecula	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Erithacus rubecula	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	M		Passeriformes
Erithacus rubecula	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	M		Passeriformes
Erithacus rubecula	Făget (CJ)	Führer Lajos	xx.10.1909	F		Passeriformes
Erithacus rubecula	Florești (CJ)	Führer Lajos	xx.03.1913	M		Passeriformes
Erithacus rubecula			xx.10.1910	F		Passeriformes
Erithacus rubecula						Passeriformes
Estrilda troglodytes	Apahida (CJ)	Führer Lajos	xx.09.1912	M	adult	Passeriformes
Eupsaltria australis	Victoria (AU)	Gasilemaine	xx.07.1897			Passeriformes
Falco cherrug	Bonțida (CJ)	Führer Lajos	xx.04.1911	F		Falconiformes
Falco cherrug	Bonțida (CJ)	Führer Lajos	xx.04.1911	F	adult	Falconiformes
Falco cherrug	Răscruci (CJ)	Führer Lajos	xx.02.1910	M		Falconiformes
Falco cherrug	Răscruci (CJ)	Führer Lajos	xx.11.1909	M		Falconiformes
Falco cherrug				M	adult	Falconiformes
Falco cherrug				F	adult	Falconiformes
Falco cherrug				M	adult	Falconiformes
Falco cherrug				F	juvenile	Falconiformes
Falco cherrug				F	adult	Falconiformes
Falco cherrug				M	adult	Falconiformes
Falco cherrug				F	adult	Falconiformes
Falco cherrug	Răscruci (CJ)		xx.03.1911	M	adult	Falconiformes
Falco naumanni	Cluj-Napoca (CJ)	Führer Lajos	01.09.1905	M	adult	Falconiformes
Falco peregrinus	Aghireș (CJ)		xx.03.1910	M	adult	Falconiformes
Falco peregrinus				F	juvenile	Falconiformes
Falco subbuteo	Cluj-Napoca (CJ)	Herman Ottó?	xx.xx.1864	M	juvenile	Falconiformes
Falco subbuteo	Cluj-Napoca (CJ)	Herman Ottó?	xx.xx.1864	F	adult	Falconiformes
Falco subbuteo	Cluj-Napoca (CJ)	Herman Ottó?	xx.xx.1864	M	adult	Falconiformes
Falco subbuteo	Geaca (CJ)	Vincze Ferencz	07.09.1970	M	adult	Falconiformes
Falco subbuteo	Turea (CJ)		27.08.1965	M	adult	Falconiformes
Falco subbuteo					adult	Falconiformes
Falco subbuteo					adult	Falconiformes
Falco tinnunculus	Cluj-Napoca (CJ)	Zwörner Sándor	26.04.1903	M	adult	Falconiformes
Falco tinnunculus	Florești (CJ)	Vincze Ferencz	13.08.1970	M	adult	Falconiformes
Falco tinnunculus	Galiția de Est		29.04.1916	F		Falconiformes
Falco tinnunculus				F	juvenile	Falconiformes
Falco tinnunculus				M	juvenile	Falconiformes
Falco vespertinus	Răscruci (CJ)	Führer Lajos	xx.05.1910	F	adult	Falconiformes
Ficedula albicollis	Feleacu (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Ficedula albicollis	Gilău (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Ficedula albicollis	Gilău (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Ficedula albicollis	Gilău (CJ)	Führer Lajos	xx.06.1911	M	adult	Passeriformes
Ficedula albicollis				M	adult	Passeriformes
Ficedula hypoleuca	Aghireș (CJ)	Führer Lajos	xx.09.1909	M	adult	Passeriformes
Ficedula hypoleuca	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1909	M	adult	Passeriformes
Ficedula hypoleuca	Cluj-Napoca (CJ)	Führer Lajos	xx.08.1912	M	adult	Passeriformes
Ficedula hypoleuca	Făget (CJ)	Führer Lajos	xx.09.1909	M	juvenile	Passeriformes
Ficedula hypoleuca	Feleacu (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Ficedula hypoleuca	Gilău (CJ)	Führer Lajos	xx.05.1911	F	adult	Passeriformes
Ficedula hypoleuca	Gilău (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Ficedula hypoleuca	Gilău (CJ)	Führer Lajos	xx.06.1911	M	adult	Passeriformes
Ficedula hypoleuca				M	adult	Passeriformes
Ficedula parva	Făget (CJ)	Führer Lajos	xx.09.1909	F	juvenile	Passeriformes
Ficedula parva	Făget (CJ)	Führer Lajos	xx.09.1909	M	juvenile	Passeriformes

Species	Location	Name of collector	Data	Sex	Age	Order
Ficedula parva	Făget (CJ)	Führer Lajos	xx.05.1911		juvenile	Passeriformes
Fringilla montifringilla				F		Passeriformes
Fringilla montifringilla				F		Passeriformes
Fringilla montifringilla				M		Passeriformes
Fringilla montifringilla				M		Passeriformes
Fulica atra	Geaca (CJ)	Herman Ottó	xx.03.1867			Gruiformes
Fulica atra	Geaca (CJ)	Herman Ottó	xx.03.1867	M		Gruiformes
Fulica atra	Geaca (CJ)	Vincze Ferencz	15.10.1971	M		Gruiformes
Fulica atra	Geaca (CJ)	Vincze Ferencz	15.10.1971	F		Gruiformes
Fulica atra		Vincze Ferencz	22.11.1973			Gruiformes
Fulica atra		Vincze Ferencz	22.11.1973			Gruiformes
Fulmarus glacialis					adult	Procelariiformes
Galerida cristata	Apahida (CJ)	Führer Lajos	27.10.1912	M		Passeriformes
Galerida cristata	Cluj-Napoca (CJ)	Zwörner Sándor	25.04.1904	M		Passeriformes
Galerida cristata	Cluj-Napoca (CJ)	Führer Lajos	20.02.1913	M		Passeriformes
Galerida cristata	Cluj-Napoca (CJ)	Führer Lajos	13.03.1903	M		Passeriformes
Galerida cristata	Ţaga (CJ)	Fülöp Herman	31.01.1960	F		Passeriformes
Galerida cristata	Ţaga (CJ)	Fülöp Herman	31.01.1960	M		Passeriformes
Galerida cristata						Passeriformes
Gallinula chloropus	Apahida (CJ)	Führer Lajos	xx.11.1909	M	adult	Gruiformes
Gallinula chloropus	Sucutard (CJ)	Vincze Ferencz	20.10.1971		juvenile	Gruiformes
Gallinula chloropus	Ţaga (CJ)	Ajtai K. Gyula	02.05.1910	M	adult	Gruiformes
Gallinula chloropus					adult	Gruiformes
Gallinago gallinago	Aghireş (CJ)	Führer Lajos	xx.09.1909	M		Charadriiformes
Gallinago gallinago	Apahida (CJ)	Führer Lajos	xx.08.1912		juvenile	Charadriiformes
Gallinago gallinago	Mociu (CJ)	Führer Lajos	xx.11.1909	F		Charadriiformes
Gallinago gallinago	Mociu (CJ)	Führer Lajos	xx.11.1909	M		Charadriiformes
Gallinago gallinago						Charadriiformes
Gypaetus barbatus	Tibet (Asia)			M	adult	Accipitriformes
Gyps fulvus		Führer Lajos	xx.07.1907	F	juvenile	Accipitriformes
Haliaeetus albicilla	Răscruci (CJ)	Führer Lajos	xx.11.1909	F	juvenile	Accipitriformes
Haliaeetus albicilla	Zau de Câmpie (MS)	Führer Lajos	xx.08.1907	F	juvenile	Accipitriformes
Haliaeetus albicilla	Zau de Câmpie (MS)	Führer Lajos	xx.08.1907	F	immatur	Accipitriformes
Haliaeetus albicilla	Zau de Câmpie (MS)	Führer Lajos	xx.07.1907	F	subadult	Accipitriformes
Haliaeetus albicilla	Zau de Câmpie (MS)	Führer Lajos	xx.08.1907	F	immatur	Accipitriformes
Hieraaetus pennatus	Răscruci (CJ)	Führer Lajos	xx.10.1909	M	juvenile	Accipitriformes
Hieraaetus pennatus	Răscruci (CJ)	Führer Lajos	xx.10.1909	M	juvenile	Accipitriformes
Hieraaetus pennatus	Răscruci (CJ)	Führer Lajos	xx.10.1909	M	juvenile	Accipitriformes
Hieraaetus pennatus	Răscruci (CJ)	Führer Lajos	xx.10.1909	M		Accipitriformes
Hieraaetus pennatus						Accipitriformes
Himantopus himantopus	Mociu (CJ)	Führer Lajos	xx.11.1909	F	juvenile	Charadriiformes
Himantopus himantopus						Charadriiformes
Hippolais icterina	Cluj-Napoca (CJ)	Korodi-Gál János	28.05.1965	M	adult	Passeriformes
Hippolais icterina	Cluj-Napoca (CJ)	Korodi-Gál János	28.05.1965	F	adult	Passeriformes
Hippolais icterina	Cluj-Napoca (CJ)	Korodi-Gál János	28.05.1965	M	adult	Passeriformes
Hippolais icterina	Cluj-Napoca (CJ)	Korodi-Gál János	28.05.1965	M	adult	Passeriformes
Hirundo rustica	Apahida (CJ)	Führer Lajos	xx.09.1909	F	adult	Passeriformes
Hirundo rustica	Apahida (CJ)	Führer Lajos	xx.09.1909	F	adult	Passeriformes
Hirundo rustica	Apahida (CJ)	Führer Lajos	xx.09.1909	F	juvenile	Passeriformes
Hirundo rustica	Apahida (CJ)	Führer Lajos	xx.09.1909	F	adult	Passeriformes
Hirundo rustica	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	1y		Passeriformes
Hirundo rustica	Floreşti (CJ)	Führer Lajos	xx.05.1913	F	adult	Passeriformes
Hirundo rustica	Floreşti (CJ)	Führer Lajos	xx.05.1913	F	adult	Passeriformes
Hirundo rustica				F		Passeriformes
Iduna pallida	Cluj-Napoca (CJ)	Korodi-Gál János	28.05.1965	F	adult	Passeriformes
Ixobrychus minutus	Răscruci (CJ)	Führer Lajos	xx.10.1909	M	adult	Pelecaniformes
Jynx torquilla	Floreşti (CJ)	Führer Lajos	xx.04.1913	M		Piciformes

Species	Location	Name of collector	Data	Sex	Age	Order
Jynx torquilla	Gilău (CJ)	Führer Lajos	xx.09.1909	F		Piciformes
Jynx torquilla	Viștea (CJ)	Führer Lajos	xx.09.1909	F		Piciformes
Lanius collurio	Baciu (CJ)	Ajtai K. Gyula	26.05.1910	M		Passeriformes
Lanius collurio	Cluj-Napoca (CJ)	Führer Lajos	01.08.1905	M		Passeriformes
Lanius collurio	Cluj-Napoca (CJ)	Führer Lajos	27.07.1905	F		Passeriformes
Lanius collurio	Cluj-Napoca (CJ)		xx.07.1891	M		Passeriformes
Lanius collurio	Cluj-Napoca (CJ)	Führer Lajos	xx.05.1910	M		Passeriformes
Lanius collurio	Cluj-Napoca (CJ)	Vincze Ferencz	03.08.1970	F		Passeriformes
Lanius collurio	Cluj-Napoca (CJ)	Führer Lajos	xx.08.1912	F	juvenile	Passeriformes
Lanius collurio	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909		juvenile	Passeriformes
Lanius collurio	Cuzăplac (SJ)		16.07.1913	F		Passeriformes
Lanius collurio	Gilău (CJ)	Führer Lajos	xx.10.1909		juvenile	Passeriformes
Lanius collurio	Gilău (CJ)	Führer Lajos	xx.10.1909		juvenile	Passeriformes
Lanius collurio				M		Passeriformes
Lanius collurio				M		Passeriformes
Lanius excubitor	Cuzăplac (SJ)	Kómis Lajos	16.12.1913	M	adult	Passeriformes
Lanius excubitor	Florești (CJ)	Führer Lajos	xx.12.1912		juvenile	Passeriformes
Lanius excubitor	Florești (CJ)	Führer Lajos	xx.12.1912	M	adult	Passeriformes
Lanius excubitor	Someșeni (CJ)	Vincze Ferencz	22.10.1972	M	adult	Passeriformes
Lanius minor	Baciu (CJ)	Führer Lajos	xx.05.1910	M	adult	Passeriformes
Lanius minor						Passeriformes
Larus canus	Apahida (CJ)	Führer Lajos	xx.02.1910	M	immatur	Charadriiformes
Larus canus	Hortobágy (HU)	Nagy Jenő	xx.04.1907	F	adult	Charadriiformes
Larus canus	Zau de Câmpie (MS)		xx.03.1911	F	adult	Charadriiformes
Larus canus	Zau de Câmpie (MS)		xx.03.1911	M	adult	Charadriiformes
Larus fuscus	Someșeni (CJ)		xx.10.1902	F	juvenile	Charadriiformes
Larus marinus					adult	Charadriiformes
Larus michahellis	Apahida (CJ)	Führer Lajos	xx.11.1909	F		Charadriiformes
Larus michahellis	Apahida (CJ)	Führer Lajos	xx.11.1909	F		Charadriiformes
Larus michahellis					immatur	Charadriiformes
Larus michahellis					adult	Charadriiformes
Larus ridibundus	Apahida (CJ)	Führer Lajos	xx.10.1909	F	adult	Charadriiformes
Larus ridibundus	Apahida (CJ)	Führer Lajos	xx.10.1909	F	juvenile	Charadriiformes
Larus ridibundus	Apahida (CJ)	Führer Lajos	xx.11.1909	M	juvenile	Charadriiformes
Larus ridibundus	Dezmir (CJ)	Führer Lajos	xx.11.1909	F	juvenile	Charadriiformes
Larus ridibundus	Mociu (CJ)	Führer Lajos	xx.11.1909	M	juvenile	Charadriiformes
Larus ridibundus	Mociu (CJ)	Führer Lajos	xx.06.1910	F	adult	Charadriiformes
Larus ridibundus	Mociu (CJ)	Führer Lajos	xx.06.1910	M	adult	Charadriiformes
Larus ridibundus	Mociu (CJ)	Führer Lajos	xx.06.1910	M	adult	Charadriiformes
Larus ridibundus					adult	Charadriiformes
Larus ridibundus	Zau de Câmpie (MS)		xx.04.1911		adult	Charadriiformes
Larus ridibundus	Zau de Câmpie (MS)		xx.04.1911		immatur	Charadriiformes
Larus ridibundus					juvenile	Charadriiformes
Larus ridibundus					adult	Charadriiformes
Leiopicus medius	Aghireș (CJ)	Führer Lajos	xx.09.1909	M		Piciformes
Leiopicus medius	Feleacu (CJ)	Führer Lajos	xx.05.1911	M		Piciformes
Leiopicus medius	Feleacu (CJ)	Führer Lajos	xx.05.1911	F		Piciformes
Leiopicus medius	Feleacu (CJ)	Führer Lajos	xx.05.1911	M		Piciformes
Leiopicus medius	Feleacu (CJ)	Führer Lajos	xx.05.1911	M		Piciformes
Leiopicus medius	Feleacu (CJ)	Führer Lajos	xx.05.1911	M		Piciformes
Leiopicus medius	Feleacu (CJ)	Führer Lajos	xx.05.1911	M		Piciformes
Leiopicus medius	Micești (CJ)	Führer Lajos	xx.11.1909	F		Piciformes
Leiopicus medius	Micești (CJ)	Führer Lajos	xx.11.1909	M		Piciformes
Leiopicus medius	Micești (CJ)	Führer Lajos	xx.11.1909	M		Piciformes
Leiopicus medius	Unguraș (CJ)	Führer Lajos	xx.09.1909	F		Piciformes
Leiopicus medius		Führer Lajos	xx.09.1909	F		Piciformes
Lichenostomus fuscus	Victoria (AU)	Gasilemaine	xx.07.1897			Passeriformes

Species	Location	Name of collector	Data	Sex	Age	Order
Limosa limosa	Someşeni (CJ)	Vincze Ferencz	26.07.1973	M	juvenile	Charadriiformes
Limosa limosa	Ungaria (HU)		xx.04.1911	M	adult	Charadriiformes
Linaria cannabina	Cuzăplac (SJ)	Kómis Lajos	xx.07.1913	F		Passeriformes
Linaria cannabina	Cuzăplac (SJ)	Kómis Lajos	23.10.1913	M		Passeriformes
Linaria cannabina				M		Passeriformes
Linaria cannabina				M		Passeriformes
Locustella luscionides	Apahida (CJ)	Führer Lajos	xx.05.1911			Passeriformes
Locustella luscionides	Apahida (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Locustella luscionides	Apahida (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Locustella luscionides	Apahida (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Locustella luscionides	Apahida (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Locustella luscionides	Apahida (CJ)	Führer Lajos	xx.05.1911			Passeriformes
Locustella luscionides						Passeriformes
Locustella luscionides						Passeriformes
Locustella luscionides						Passeriformes
Locustella luscionides			xx.xx.1911			Passeriformes
Locustella luscionides			xx.xx.1911			Passeriformes
Loxia curvirostra	Cluj-Napoca (CJ)	Vincze Ferencz	13.10.1970	M	adult	Passeriformes
Loxia curvirostra	Cluj-Napoca (CJ)	Vincze Ferencz	13.10.1970	F	adult	Passeriformes
Loxia curvirostra	Cluj-Napoca (CJ)	Fülöp Herman	11.12.1959	F	adult	Passeriformes
Lullula arborea	Feleacu (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Lullula arborea	Feleacu (CJ)	Führer Lajos	xx.05.1911	F	adult	Passeriformes
Lullula arborea	Feleacu (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Lullula arborea	Plesca (SJ)	Neuwirth János	15.03.1903	F	adult	Passeriformes
Lullula arborea					adult	Passeriformes
Lullula arborea					adult	Passeriformes
Luscinia luscinia	Aghireş (CJ)	Führer Lajos	xx.09.1909	F		Passeriformes
Luscinia luscinia	Aghireş (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Luscinia luscinia	Cluj-Napoca (CJ)	Führer Lajos	xx.05.1911	F		Passeriformes
Luscinia luscinia	Cluj-Napoca (CJ)	Führer Lajos	xx.05.1911	F		Passeriformes
Luscinia luscinia	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Luscinia luscinia	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Luscinia luscinia	Făget (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Luscinia luscinia	Făget (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Luscinia luscinia	Făget (CJ)	Führer Lajos	xx.09.1909	F		Passeriformes
Luscinia luscinia	Făget (CJ)	Führer Lajos	xx.10.1909	F		Passeriformes
Luscinia luscinia	Răscruci (CJ)	Führer Lajos	xx.10.1909	F		Passeriformes
Luscinia megarhynchos	Aghireş (CJ)	Führer Lajos	xx.05.1911	F		Passeriformes
Luscinia megarhynchos	Cluj-Napoca (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Luscinia megarhynchos	Cluj-Napoca (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Luscinia megarhynchos	Cluj-Napoca (CJ)	Führer Lajos	xx.08.1912	M		Passeriformes
Lymnocryptes minimus	Aghireş (CJ)	Führer Lajos	xx.09.1909	F		Charadriiformes
Lymnocryptes minimus	Aghireş (CJ)	Führer Lajos	xx.09.1909	M		Charadriiformes
Lymnocryptes minimus	Răscruci (CJ)	Führer Lajos	xx.11.1909	M		Charadriiformes
Lymnocryptes minimus						Charadriiformes
Lymnocryptes minimus	Răscruci (CJ)	Führer Lajos	xx.11.1909	F		Charadriiformes
Lymnocryptes minimus	Răscruci (CJ)	Führer Lajos	xx.11.1909	F		Charadriiformes
Lymnocryptes minimus	Răscruci (CJ)	Führer Lajos	xx.11.1909	M		Charadriiformes
Mareca strepera	Apahida (CJ)	Führer Lajos	xx.04.1911	F		Anseriformes
Mareca strepera	Apahida (CJ)	Führer Lajos	xx.11.1909	M		Anseriformes
Melopsittacus undulatus				M	adult	Psittaciformes
Mergus merganser	Cluj-Napoca (CJ)	Zwörner Sándor	15.10.1903	F	adult	Anseriformes
Merops apiaster	Bucureşti (B)	Vincze Ferencz	12.05.1969	M	adult	Coraciiformes
Merops apiaster	Canaraua Fetei (CT)	Vincze Ferencz	12.05.1969			Coraciiformes
Merops apiaster		Führer Lajos	xx.05.1911	M		Coraciiformes
Merops apiaster		Führer Lajos	xx.05.1911	M		Coraciiformes
Milvus migrans	Apahida (CJ)		xx.11.1911	M	juvenile	Accipitriformes

Species	Location	Name of collector	Data	Sex	Age	Order
Milvus migrans					juvenile	Accipitriformes
Monticola saxatilis						Passeriformes
Morus bassanus	Norvegia	Lehne W.	xx.xx.1969		adult	Suliformes
Morus bassanus					juvenile	Suliformes
Motacilla alba	Apahida (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Motacilla alba	Apahida (CJ)	Führer Lajos	xx.10.1909	F		Passeriformes
Motacilla alba	Apahida (CJ)	Führer Lajos	xx.09.1909	M		Passeriformes
Motacilla alba	Apahida (CJ)	Führer Lajos	xx.11.1909	F		Passeriformes
Motacilla alba	Cluj-Napoca (CJ)	Zwörner Sándor	02.04.1904	F		Passeriformes
Motacilla alba	Cluj-Napoca (CJ)	Führer Lajos	28.09.1912	M	juvenile	Passeriformes
Motacilla alba	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	M	juvenile	Passeriformes
Motacilla alba	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	M	juvenile	Passeriformes
Motacilla alba	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	M	juvenile	Passeriformes
Motacilla alba	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912		juvenile	Passeriformes
Motacilla alba	Cluj-Napoca (CJ)	Führer Lajos	xx.03.1910	M		Passeriformes
Motacilla alba	Cluj-Napoca (CJ)	Führer Lajos	xx.01.1909	F		Passeriformes
Motacilla alba	Florești (CJ)	Führer Lajos	xx.04.1913	M		Passeriformes
Motacilla alba						Passeriformes
Motacilla alba				M		Passeriformes
Motacilla alba				M		Passeriformes
Motacilla cinerea	Colibița (BN)	Vincze Ferencz	07.05.1971	F		Passeriformes
Motacilla cinerea				M		Passeriformes
Motacilla cinerea				F		Passeriformes
Motacilla cinerea				M		Passeriformes
Motacilla cinerea				F		Passeriformes
Muscicapa striata	Cluj-Napoca (CJ)	Führer Lajos	10.10.1912	M	juvenile	Passeriformes
Muscicapa striata	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	F	juvenile	Passeriformes
Muscicapa striata	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M	juvenile	Passeriformes
Muscicapa striata	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	M	adult	Passeriformes
Muscicapa striata	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	M	juvenile	Passeriformes
Muscicapa striata	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	M	juvenile	Passeriformes
Muscicapa striata	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	F	juvenile	Passeriformes
Muscicapa striata	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	F	juvenile	Passeriformes
Muscicapa striata	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912		juvenile	Passeriformes
Muscicapa striata	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	F	juvenile	Passeriformes
Myiarchus cinerascens	California (USA)	Xantus János	xx.xx.1859	F	adult	Passeriformes
Nucifraga caryocatactes	Măguri-Răcătău (CJ)	Vincze Ferencz	03.08.1970	M		Passeriformes
Nucifraga caryocatactes						Passeriformes
Nucifraga caryocatactes						Passeriformes
Nycticorax nycticorax	Cefa (BH)	Vincze Ferencz	19.12.1970	M	adult	Pelecaniformes
Nycticorax nycticorax	Cefa (BH)	Vincze Ferencz	25.06.1970	F	juvenile	Pelecaniformes
Nycticorax nycticorax	Cefa (BH)	Vincze Ferencz	25.06.1970	F	juvenile	Pelecaniformes
Nycticorax nycticorax	Cefa (BH)	Vincze Ferencz	25.06.1970	M	juvenile	Pelecaniformes
Nycticorax nycticorax	Cefa (BH)	Vincze Ferencz	25.06.1970	M	juvenile	Pelecaniformes
Nycticorax nycticorax	Gilău (CJ)	Führer Lajos	xx.09.1909	M	adult	Pelecaniformes
Nycticorax nycticorax	Mociu (CJ)	Führer Lajos	xx.05.1910	M	adult	Pelecaniformes
Nycticorax nycticorax	Dej (CJ)	Führer Lajos	24.06.1903	M	adult	Pelecaniformes
Nycticorax nycticorax	Dej (CJ)	Führer Lajos	17.06.1903	M	adult	Pelecaniformes
Nycticorax nycticorax	Răscruci (CJ)	Führer Lajos	xx.10.1909		juvenile	Pelecaniformes
Nycticorax nycticorax	Răscruci (CJ)	Führer Lajos	xx.10.1909		juvenile	Pelecaniformes
Nycticorax nycticorax	Răscruci (CJ)	Führer Lajos	xx.10.1909		juvenile	Pelecaniformes
Nycticorax nycticorax	Răscruci (CJ)	Führer Lajos	xx.10.1909		juvenile	Pelecaniformes
Oenanthe oenanthe	Baciu (CJ)	Vincze Ferencz	25.07.1910	F	juvenile	Passeriformes
Oenanthe oenanthe	Gilău (CJ)	Führer Lajos	xx.04.1911	M	adult	Passeriformes
Oenanthe oenanthe	Gilău (CJ)	Führer Lajos	xx.04.1911	M	adult	Passeriformes
Oenanthe oenanthe	Gilău (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Oenanthe oenanthe	Gilău (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes

Species	Location	Name of collector	Data	Sex	Age	Order
Oenanthe oenanthe	Păniceni (CJ)	Führer Lajos	xx.04.1911	M	adult	Passeriformes
Oenanthe oenanthe	Păniceni (CJ)	Führer Lajos	xx.04.1911	M	adult	Passeriformes
Oenanthe oenanthe	Păniceni (CJ)	Führer Lajos	xx.04.1911	M	adult	Passeriformes
Oenanthe oenanthe	Păniceni (CJ)	Führer Lajos	xx.04.1911	F	adult	Passeriformes
Oenanthe oenanthe	Viţa (CJ)	Führer Lajos	xx.09.1912	F	adult	Passeriformes
Oriolus oriolus	Bucureşti (B)	Vincze Ferencz	12.05.1969	F	adult	Passeriformes
Oriolus oriolus	Brăncoveneşti (MS)	Vincze Ferencz	12.05.1971	M	adult	Passeriformes
Oriolus oriolus	Lita (CJ)	Vincze Ferencz	16.05.1983	M	adult	Passeriformes
Otus scops					adult	Strigiformes
Otus scops					adult	Strigiformes
Otus scops					adult	Strigiformes
Parus major	Cluj-Napoca (CJ)	Führer Lajos	30.10.1902	F		Passeriformes
Parus major	Cluj-Napoca (CJ)	Ajtai K. Gyula	20.01.1910	M		Passeriformes
Parus major	Cluj-Napoca (CJ)	Ajtai K. Gyula	20.01.1910	M		Passeriformes
Parus major	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1909	M		Passeriformes
Parus major	Cluj-Napoca (CJ)	Führer Lajos	xx.11.1909	M		Passeriformes
Parus major	Cluj-Napoca (CJ)	Führer Lajos	xx.11.1909	M		Passeriformes
Parus major						Passeriformes
Parus major				F		Passeriformes
Parus major				F		Passeriformes
Passer domesticus	Sucutard (CJ)	Fülöp Herman	31.01.1960	F	adult	Passeriformes
Passer domesticus	Sucutard (CJ)	Fülöp Herman	31.01.1960	F	adult	Passeriformes
Passer domesticus	Sucutard (CJ)	Fülöp Herman	31.01.1960	M	adult	Passeriformes
Perdix perdix	Baciu (CJ)	Vincze Ferencz	12.05.1970	F		Galliformes
Periparus ater	Albac (AB)		xx.03.1913	M		Passeriformes
Periparus ater	Albac (AB)		xx.03.1913	M		Passeriformes
Periparus ater	Albac (AB)		xx.03.1913	F		Passeriformes
Periparus ater	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1909	M		Passeriformes
Periparus ater	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1909	F		Passeriformes
Periparus ater	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1909	F		Passeriformes
Periparus ater	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1909	M		Passeriformes
Periparus ater	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1909	M		Passeriformes
Periparus ater	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1909	M		Passeriformes
Periparus ater	Cluj-Napoca (CJ)	Führer Lajos	xx.11.1909	M		Passeriformes
Periparus ater						Passeriformes
Periparus ater						Passeriformes
Periparus ater						Passeriformes
Periparus ater						Passeriformes
Pernis apivorus				M	adult	Accipitriformes
Phoenicurus ochruros	Feleacu (CJ)	Führer Lajos	xx.04.1911	M	adult	Passeriformes
Phoenicurus ochruros	Feleacu (CJ)	Führer Lajos	xx.04.1911	M	adult	Passeriformes
Phoenicurus ochruros	Feleacu (CJ)	Führer Lajos	xx.04.1911	M	adult	Passeriformes
Phoenicurus phoenicurus	Cluj-Napoca (CJ)	Vincze Ferencz	26.05.1965	M	adult	Passeriformes
Phoenicurus phoenicurus	Cuzăplac (SJ)	Kómis Lajos	02.12.1903	F		Passeriformes
Phoenicurus phoenicurus	Feleacu (CJ)	Führer Lajos	xx.04.1911	M		Passeriformes
Phoenicurus phoenicurus	Feleacu (CJ)	Führer Lajos	xx.04.1911	M		Passeriformes
Phoenicurus phoenicurus	Gilău (CJ)	Führer Lajos	xx.10.1909	M	juvenile	Passeriformes
Phoenicurus phoenicurus				M		Passeriformes
Phoenicurus phoenicurus						Passeriformes
Phoenicurus phoenicurus						Passeriformes
Phoenicurus phoenicurus				M		Passeriformes
Phylloscopus collybita						Passeriformes
Phylloscopus collybita	Floreşti (CJ)	Führer Lajos	xx.04.1913	M	adult	Passeriformes
Phylloscopus collybita	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Phylloscopus collybita	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Phylloscopus collybita	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	F		Passeriformes
Phylloscopus collybita	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912		juvenile	Passeriformes

Species	Location	Name of collector	Data	Sex	Age	Order
Phylloscopus collybita	Feleac (CJ)	Führer Lajos	xx.05.1911	F		Passeriformes
Phylloscopus collybita	Feleac (CJ)	Führer Lajos	xx.05.1911	F		Passeriformes
Phylloscopus collybita	Gilău (CJ)	Führer Lajos	xx.09.1909	M		Passeriformes
Phylloscopus collybita	Gilău (CJ)	Führer Lajos	xx.09.1909	F		Passeriformes
Phylloscopus collybita						Passeriformes
Phylloscopus collybita						Passeriformes
Phylloscopus collybita						Passeriformes
Phylloscopus collybita						Passeriformes
Phylloscopus collybita						Passeriformes
Phylloscopus collybita						Passeriformes
Phylloscopus collybita						Passeriformes
Phylloscopus collybita						Passeriformes
Pica pica	Cluj-Napoca (CJ)	Führer Lajos	xx.03.1912	M		Passeriformes
Pica pica	Cluj-Napoca (CJ)	Zwörner Sándor	14.02.1904	M		Passeriformes
Pica pica						Passeriformes
Picus canus	Ciurila (CJ)	Führer Lajos	xx.11.1909	M	adult	Piciformes
Picus canus	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1912	F		Piciformes
Picus canus	Cluj-Napoca (CJ)	Führer Lajos	xx.11.1909	F	adult	Piciformes
Picus canus	Cuzăplac (SJ)	Kómis Lajos	03.12.1913	F	adult	Piciformes
Picus canus				M	adult	Piciformes
Picus viridis				F	adult	Piciformes
Picus viridis				F	adult	Piciformes
Platalea leucorodia	Delta Dun?rii	Fülöp Herman	15.04.1950		adult	Pelecaniformes
Platalea leucorodia	Dobrogea	Führer Lajos	xx.xx.1911	M	adult	Pelecaniformes
Platalea leucorodia	Dobrogea	Führer Lajos	xx.xx.1911	F	adult	Pelecaniformes
Platalea leucorodia	Dobrogea	Führer Lajos	xx.xx.1911	M	adult	Pelecaniformes
Platalea leucorodia	Dobrogea	Führer Lajos	xx.xx.1911	M	adult	Pelecaniformes
Platalea leucorodia	Dobrogea	Führer Lajos	xx.xx.1911	F	adult	Pelecaniformes
Platalea leucorodia	Mociu (CJ)	Führer Lajos	xx.07.1910	M	adult	Pelecaniformes
Podiceps cristatus	Cefa (BH)	Vincze Ferencz	26.06.1970	M		Podicipediformes
Podiceps cristatus	Cefa (BH)	Vincze Ferencz	26.06.1970	M	adult	Podicipediformes
Podiceps cristatus	Cefa (BH)	Vincze Ferencz	26.06.1970	M	adult	Podicipediformes
Podiceps cristatus	Cefa (BH)	Vincze Ferencz	26.06.1970	M	adult	Podicipediformes
Podiceps cristatus	Cluj-Napoca (CJ)	Zwörner Sándor	xx.10.1962	F	adult	Podicipediformes
Podiceps cristatus						Podicipediformes
Podiceps grisegena	Geaca (CJ)	Vincze Ferencz	03.06.1970	M	adult	Podicipediformes
Podiceps nigricollis	Apahida (CJ)	Führer Lajos	xx.10.1909	F		Podicipediformes
Podiceps nigricollis	Dej (CJ)	Varró Dezső	07.08.1944	M		Podicipediformes
Poecile lugubris	Cuzăplac (SJ)	Kómis Lajos	04.01.1914	M	adult	Passeriformes
Poecile lugubris	Gilău (CJ)	Führer Lajos	xx.06.1911	M		Passeriformes
Poecile lugubris	Gilău (CJ)	Führer Lajos	xx.06.1911	F	adult	Passeriformes
Poecile lugubris	Gilău (CJ)	Führer Lajos	xx.05.1911	F	adult	Passeriformes
Poecile lugubris					adult	Passeriformes
Poecile palustris	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1909	F		Passeriformes
Poecile palustris	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1909	M		Passeriformes
Poecile palustris	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1909	M		Passeriformes
Poecile palustris	Cluj-Napoca (CJ)	Führer Lajos	15.10.1912	M		Passeriformes
Poecile palustris	Cluj-Napoca (CJ)	Führer Lajos	15.10.1912	M		Passeriformes
Poecile palustris	Cuzăplac (SJ)	Kómis Lajos	16.10.1913	F		Passeriformes
Poecile palustris	Micești (CJ)	Führer Lajos	xx.11.1909	M		Passeriformes
Poecile palustris	Micești (CJ)	Führer Lajos	xx.02.1910	F		Passeriformes
Poecile palustris	Micești (CJ)	Führer Lajos	xx.02.1910	M		Passeriformes
Poecile palustris						Passeriformes
Poecile palustris						Passeriformes
Poecile palustris						Passeriformes
Poecile palustris						Passeriformes
Pomatostomus superciliosus	Victoria (AU)	Gasilemaine	xx.09.1897			Passeriformes

Species	Location	Name of collector	Data	Sex	Age	Order
Porzana porzana	Apahida (CJ)	Führer Lajos	xx.10.1909	F	juvenile	Gruiformes
Porzana porzana	Apahida (CJ)	Führer Lajos	xx.10.1909	M	juvenile	Gruiformes
Porzana porzana	Apahida (CJ)	Zwörner Sándor	06.10.1903	M	juvenile	Gruiformes
Porzana porzana	Florești (CJ)	Führer Lajos	xx.05.1911	M	adult	Gruiformes
Porzana porzana	Mociu (CJ)	Führer Lajos	xx.11.1909	F	juvenile	Gruiformes
Porzana porzana	Mociu (CJ)	Führer Lajos	xx.11.1909	M	juvenile	Gruiformes
Porzana porzana	Mociu (CJ)	Führer Lajos	xx.11.1909	M	adult	Gruiformes
Prunella collaris			xx.xx.1911			Passeriformes
Prunella collaris			xx.xx.1911			Passeriformes
Prunella collaris			xx.xx.1911			Passeriformes
Prunella collaris			xx.xx.1911			Passeriformes
Prunella collaris						Passeriformes
Prunella modularis	Cuzăplac (SJ)	Kómis Lajos	16.10.1913	M	adult	Passeriformes
Prunella modularis	Feleacu (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Prunella modularis	Feleacu (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Prunella modularis						Passeriformes
Prunella modularis						Passeriformes
Prunella modularis						Passeriformes
Prunella modularis						Passeriformes
Pycnonotus cafer	Sindanglaya	Xántus János	30.06.1870			Passeriformes
Pyrrhula phyrrhula	Cluj-Napoca (CJ)	Fülöp Herman	14.03.1954	F	adult	Passeriformes
Pyrrhula phyrrhula	Cluj-Napoca (CJ)		14.03.1954	M	adult	Passeriformes
Pyrrhula phyrrhula	Cluj-Napoca (CJ)		14.03.1955	M	adult	Passeriformes
Pyrrhula phyrrhula	Cluj-Napoca (CJ)	Fülöp Herman	23.02.1960	M	adult	Passeriformes
Pyrrhula phyrrhula				M	adult	Passeriformes
Pyrrhula phyrrhula				M		Passeriformes
Recurvirostra avosetta	Someșeni (CJ)	Führer Lajos	xx.09.1912		juvenile	Charadriiformes
Regulus ignicapillus	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	F		Passeriformes
Regulus ignicapillus	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	F		Passeriformes
Regulus ignicapillus	Feleacu (CJ)	Führer Lajos	xx.04.1911	M		Passeriformes
Regulus ignicapillus	Feleacu (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Regulus regulus	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Regulus regulus	Cluj-Napoca (CJ)	Führer Lajos	xx.04.1911	M		Passeriformes
Regulus regulus	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Regulus regulus	Cluj-Napoca (CJ)	Ajtai K. Gyula	20.01.1910	M		Passeriformes
Regulus regulus	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1909	F		Passeriformes
Regulus regulus	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1909	M		Passeriformes
Regulus regulus	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1909	F		Passeriformes
Regulus regulus	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1909	M		Passeriformes
Regulus regulus	Feleacu (CJ)	Führer Lajos	xx.04.1911	M		Passeriformes
Regulus regulus	Feleacu (CJ)	Führer Lajos	xx.04.1911	M		Passeriformes
Regulus regulus	Feleacu (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Regulus regulus	Feleacu (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Regulus regulus	Feleacu (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Regulus regulus	Feleacu (CJ)	Führer Lajos	xx.04.1911	M		Passeriformes
Regulus regulus	Feleacu (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Regulus regulus	Feleacu (CJ)	Führer Lajos	xx.04.1911	M		Passeriformes
Regulus regulus	Feleacu (CJ)	Führer Lajos	xx.04.1911	M		Passeriformes
Regulus regulus	Feleacu (CJ)	Führer Lajos	xx.xx.1911	M		Passeriformes
Regulus regulus	Gilău (CJ)	Führer Lajos	xx.09.1909	F		Passeriformes
Regulus regulus	Micești (CJ)	Führer Lajos	xx.11.1909	F		Passeriformes
Regulus regulus	Micești (CJ)	Führer Lajos	xx.11.1909	M		Passeriformes
Regulus regulus						Passeriformes
Regulus regulus						Passeriformes
Regulus regulus						Passeriformes
Regulus regulus						Passeriformes
Regulus regulus						Passeriformes

Species	Location	Name of collector	Data	Sex	Age	Order
Regulus regulus						Passeriformes
Regulus regulus						Passeriformes
Regulus regulus						Passeriformes
Remiz pendulinus	Ungaria (HU)	Führer Lajos	xx.06.1911	F		Passeriformes
Remiz pendulinus	Ungaria (HU)	Führer Lajos	xx.06.1911	F		Passeriformes
Remiz pendulinus	Ungaria (HU)	Führer Lajos	xx.06.1911	F		Passeriformes
Remiz pendulinus	Ungaria (HU)	Führer Lajos	xx.06.1911	F		Passeriformes
Remiz pendulinus	Ungaria (HU)	Führer Lajos	xx.06.1911	M		Passeriformes
Remiz pendulinus	Ungaria (HU)	Führer Lajos	xx.06.1911	M		Passeriformes
Remiz pendulinus	Ungaria (HU)	Führer Lajos	xx.06.1911	M		Passeriformes
Remiz pendulinus	Ungaria (HU)	Führer Lajos	xx.06.1911	M		Passeriformes
Saxicola rubetra	Apahida (CJ)	Führer Lajos	xx.09.1909	M	adult	Passeriformes
Saxicola rubetra	Baciu (CJ)	Führer Lajos	26.05.1910	F	adult	Passeriformes
Saxicola rubetra	Florești (CJ)	Führer Lajos	xx.04.1913			Passeriformes
Saxicola rubicola	Apahida (CJ)	Führer Lajos	xx.09.1909	M	adult	Passeriformes
Saxicola rubicola	Cluj-Napoca (CJ)	Vincze Ferencz	18.03.1965	M	adult	Passeriformes
Saxicola rubicola	Cluj-Napoca (CJ)	Neuwirth János	14.03.1903	M	adult	Passeriformes
Saxicola rubicola	Cuzăplac (SJ)	Kómis Lajos	11.07.1913	F	juvenile	Passeriformes
Saxicola rubicola	Cuzăplac (SJ)	Kómis Lajos	11.07.1913	M	adult	Passeriformes
Saxicola rubicola	Fânațele Clujului (CJ)	Neuwirth János	xx.04.1903	F	adult	Passeriformes
Scolopax rusticola	Feleacu (CJ)	Führer Lajos	xx.xx.1911			Charadriiformes
Sitta europaea	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1912	M		Passeriformes
Sitta europaea	Cluj-Napoca (CJ)	Führer Lajos	xx.04.1911	M	adult	Passeriformes
Sitta europaea	Feleac (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Sitta europaea	Feleac (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Spatula querquedula	Geaca (CJ)	Fülöp Herman	29.03.1957	M	adult	Anseriformes
Spatula querquedula	Geaca (CJ)	Fülöp Herman	29.03.1957	f	adult	Anseriformes
Spatula querquedula	Apahida (CJ)	Führer Lajos	xx.04.1911			Anseriformes
Spatula querquedula	Someșeni (CJ)	Vincze Ferencz	26.07.1973	F		Anseriformes
Spinus spinus	Florești (CJ)	Ráthonyi Károly	16.12.1943	M		Passeriformes
Sterna hirundo	Apahida (CJ)	Führer Lajos	xx.09.1909	F	adult	Charadriiformes
Sterna hirundo	Apahida (CJ)	Führer Lajos	xx.09.1909	M	adult	Charadriiformes
Sternula albifrons					adult	Charadriiformes
Streptopelia turtur	Cluj-Napoca (CJ)	Führer Lajos	xx.08.1912		adult	Columbiformes
Streptopelia turtur	Gilău (CJ)	Führer Lajos	xx.09.1909	M	adult	Columbiformes
Streptopelia turtur					adult	Columbiformes
Streptopelia turtur					adult	Columbiformes
Streptopelia turtur					adult	Columbiformes
Streptopelia turtur					adult	Columbiformes
Streptopelia turtur					adult	Columbiformes
Strix uralensis	Jibou (SJ)	Zwörner Sándor	20.04.1903	F		Strigiformes
Strix uralensis						Strigiformes
Sturnus vulgaris	Colibița (BN)	Vincze Ferencz	06.05.1971	M	adult	Passeriformes
Sturnus vulgaris						Passeriformes
Sylvia atricapilla	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	M		Passeriformes
Sylvia atricapilla	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	M		Passeriformes
Sylvia atricapilla	Cluj-Napoca (CJ)	Führer Lajos	xx.09.1912	M	juvenile	Passeriformes
Sylvia atricapilla	Făget (CJ)	Führer Lajos	xx.09.1909	F	juvenile	Passeriformes
Sylvia atricapilla	Feleacu (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Sylvia atricapilla	Gilău (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Sylvia atricapilla	Gilău (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Sylvia atricapilla	Gilău (CJ)	Führer Lajos	xx.05.1911	M	adult	Passeriformes
Sylvia atricapilla	Gilău (CJ)	Führer Lajos	xx.10.1909	M	juvenile	Passeriformes
Sylvia atricapilla				M	adult	Passeriformes
Sylvia atricapilla				F		Passeriformes
Sylvia communis						Passeriformes
Sylvia communis	Baciu (CJ)	Ajtai K. Gyula	26.06.1910	M		Passeriformes

Species	Location	Name of collector	Data	Sex	Age	Order
Sylvia communis	Cluj-Napoca (CJ)	Führer Lajos	xx.06.1910	F		Passeriformes
Sylvia communis	Florești (CJ)	Führer Lajos	xx.04.1913	M		Passeriformes
Sylvia communis	Gilău (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Sylvia communis						Passeriformes
Sylvia communis						Passeriformes
Sylvia communis						Passeriformes
Sylvia communis						Passeriformes
Sylvia curruca	Aghireș (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Sylvia curruca	Cluj-Napoca (CJ)	Führer Lajos	xx.06.1911			Passeriformes
Sylvia curruca						Passeriformes
Sylvia nisoria	Gilău (CJ)	Führer Lajos	xx.05.1911	M		Passeriformes
Sylvia nisoria	Gilău (CJ)	Führer Lajos	xx.05.1911	F		Passeriformes
Tachybaptus ruficollis	Geaca (CJ)	Vincze Ferencz	15.10.1970	M		Podicipediformes
Tachybaptus ruficollis	Geaca (CJ)	Vincze Ferencz	30.08.1971	F		Podicipediformes
Tachybaptus ruficollis	Hăghig (CV)		28.12.1902	F		Podicipediformes
Tachybaptus ruficollis	Mociu (CJ)	Führer Lajos	xx.10.1909	F		Podicipediformes
Tachybaptus ruficollis	Mociu (CJ)	Führer Lajos	xx.11.1909	F		Podicipediformes
Tachybaptus ruficollis	Mociu (CJ)	Führer Lajos	xx.11.1909	M		Podicipediformes
Tringa erythropus	Mociu (CJ)	Führer Lajos	xx.10.1909	M	adult	Charadriiformes
Tringa erythropus	Mociu (CJ)	Führer Lajos	xx.10.1909	M	adult	Charadriiformes
Tringa erythropus	Mociu (CJ)	Führer Lajos	xx.10.1909	F	adult	Charadriiformes
Tringa glareola	Gilău (CJ)	Führer Lajos	xx.05.1911	M	adult	Charadriiformes
Tringa glareola	Someșeni (CJ)	Vincze Ferencz	24.07.1973	M	juvenile	Charadriiformes
Tringa glareola					adult	Charadriiformes
Tringa nebularia	Mociu (CJ)	Führer Lajos	xx.11.1909	M		Charadriiformes
Tringa nebularia	Mociu (CJ)	Führer Lajos	xx.10.1909	M		Charadriiformes
Tringa nebularia	Mociu (CJ)	Führer Lajos	xx.10.1909	M		Charadriiformes
Tringa nebularia	Mociu (CJ)	Führer Lajos	xx.10.1909	M		Charadriiformes
Tringa nebularia	Mociu (CJ)	Führer Lajos	xx.10.1909	M		Charadriiformes
Tringa nebularia	Mociu (CJ)	Führer Lajos	xx.11.1909	F		Charadriiformes
Tringa nebularia						Charadriiformes
Tringa ochropus	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Charadriiformes
Tringa ochropus	Țaga (CJ)	Ajtai K. Gyula	04.05.1910	M		Charadriiformes
Tringa ochropus						Charadriiformes
Tringa ochropus						Charadriiformes
Tringa ochropus					adult	Charadriiformes
Tringa ochropus						Charadriiformes
Tringa totanus	Mociu (CJ)	Führer Lajos	xx.11.1909	F	juvenile	Charadriiformes
Troglodytes troglodytes	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Troglodytes troglodytes	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Troglodytes troglodytes	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1912	M		Passeriformes
Troglodytes troglodytes	Cluj-Napoca (CJ)	Führer Lajos	10.10.1912	M		Passeriformes
Troglodytes troglodytes	Cluj-Napoca (CJ)	Führer Lajos	xx.12.1912	M		Passeriformes
Troglodytes troglodytes	Cluj-Napoca (CJ)	Führer Lajos	xx.11.1909	M		Passeriformes
Troglodytes troglodytes	Cuzăplac (SJ)	Kómis Lajos	03.11.1913	M	adult	Passeriformes
Troglodytes troglodytes	Cuzăplac (SJ)	Kómis Lajos	20.12.1913	F		Passeriformes
Troglodytes troglodytes	Florești (CJ)	Führer Lajos	xx.01.1913	M		Passeriformes
Troglodytes troglodytes						Passeriformes
Troglodytes troglodytes						Passeriformes
Turdus iliacus	Făget (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes
Turdus merula	Cuzăplac (SJ)	Kómis Lajos	14.10.1913	M	juvenile	Passeriformes
Turdus merula	Viștea (CJ)	Ajtai K. Gyula	17.03.1910	M	adult	Passeriformes
Turdus merula				F	adult	Passeriformes
Turdus merula						Passeriformes
Turdus merula	Dumitra (AB)	Osváth Gergely	28.03.2018	M		Passeriformes
Turdus migratorius	California (USA)	Xántus János	xx.xx.1859	M		Passeriformes
Turdus philomelos	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	M		Passeriformes

Species	Location	Name of collector	Data	Sex	Age	Order
Turdus philomelos	Cluj-Napoca (CJ)	Zwörner Sándor	xx.10.1903	M		Passeriformes
Turdus philomelos	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1909	F		Passeriformes
Turdus philomelos	Micești (CJ)	Führer Lajos	xx.11.1909	M		Passeriformes
Turdus philomelos	Cluj-Napoca (CJ)	Vizauer Tibor Csaba	01.10.2021		juvenile	Passeriformes
Turdus pilaris	Căpușul Mare (CJ)		24.03.1984	M		Passeriformes
Turdus pilaris	Făget (CJ)		24.03.1954	F		Passeriformes
Turdus pilaris	Făget (CJ)		24.03.1954			Passeriformes
Turdus pilaris					adult	Passeriformes
Turdus torquatus	Ceahlău (NT)	Vincze Ferencz	09.05.1971	F		Passeriformes
Turdus viscivorus	Borșa (CJ)	Kómis Lajos	26.12.1913	M		Passeriformes
Turdus viscivorus	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1912	M		Passeriformes
Turdus viscivorus	Cluj-Napoca (CJ)	Führer Lajos	xx.10.1912	F		Passeriformes
Turdus viscivorus	Cluj-Napoca (CJ)	Führer Lajos	xx.02.1913	F		Passeriformes
Turdus viscivorus	Cluj-Napoca (CJ)	Zwörner Sándor	08.01.1903	F		Passeriformes
Turdus viscivorus	Cluj-Napoca (CJ)	Führer Lajos	08.01.1913	M		Passeriformes
Turdus viscivorus	Cluj-Napoca (CJ)	Führer Lajos	10.01.1913	F		Passeriformes
Turdus viscivorus	Cluj-Napoca (CJ)	Führer Lajos	05.01.1913	M		Passeriformes
Turdus viscivorus	Cuzăplac (SJ)	Kómis Lajos	21.12.1913	F		Passeriformes
Turdus viscivorus						Passeriformes
Upupa epops	Aghireș (CJ)	Führer Lajos	xx.09.1909	M		Bucerotiformes
Upupa epops	Aghireș (CJ)	Führer Lajos	xx.09.1909	F		Bucerotiformes
Upupa epops	Cluj-Napoca (CJ)	Ajtai K. Gyula	26.05.1910	F		Bucerotiformes
Upupa epops	Gilău (CJ)	Führer Lajos	xx.09.1909	F		Bucerotiformes
Upupa epops						Bucerotiformes
Vanellus vanellus	Cătina (CJ)	Zwörner Sándor	04.10.1903	M	juvenile	Charadriiformes
Vanellus vanellus	Hortobágy (HU)	Nagy Jenő	xx.04.1907	M	adult	Charadriiformes
Vanellus vanellus	Hortobágy (HU)	Nagy Jenő	xx.04.1907	F	adult	Charadriiformes
Zapornia parva	Mociu (CJ)	Führer Lajos	xx.11.1909	M	juvenile	Gruiformes
Zapornia parva	Mociu (CJ)	Führer Lajos	xx.11.1909	F	juvenile	Gruiformes
Zapornia parva	Mociu (CJ)	Führer Lajos	xx.11.1909	M	juvenile	Gruiformes
Zapornia parva	Răscruci (CJ)	Führer Lajos	xx.10.1909	M	juvenile	Gruiformes
Zapornia parva	Ungaria (HU)	Führer Lajos	xx.05.1911	F	adult	Gruiformes
Zapornia parva	Ungaria (HU)	Führer Lajos	xx.05.1911	F	adult	Gruiformes

Collection summary

In total, we identified 925 specimens in the scientific bird skin collection housed in the Zoological Museum of Babeș-Bolyai University (Table 1; for detailed catalogue see Suppl. material 1: Table S1), belonging to 193 species from 53 families and 20 orders (Fig. 2). The orders with the most specimens were Passeriformes (487), Charadriiformes (103), Accipitriformes (77), Pelecaniformes (43), Piciformes (33), Falconiformes (28), and Gruiformes (26). Twelve orders (Anseriformes, Strigiformes, Podicipediformes, Columbiformes, Cuculiformes, Caprimulgiformes, Bucerotiformes, Ciconiiformes, Coraciiformes, Galliformes, Suliformes, Procelariiformes, and Psittaciformes) were represented by 25 or fewer specimens (Fig. 2).

The origins of 242 of 925 bird skin specimens are unknown, while three specimens were procured from different zoological gardens. 93.55% (639 out of 683) of specimens with known data were collected from Transylvania; only 43 specimens were collected outside this region, from different parts of Romania, Hungary, Ukraine, Bulgaria, Poland, and Norway (Fig. 3a, b). The collection includes eight exotic specimens:

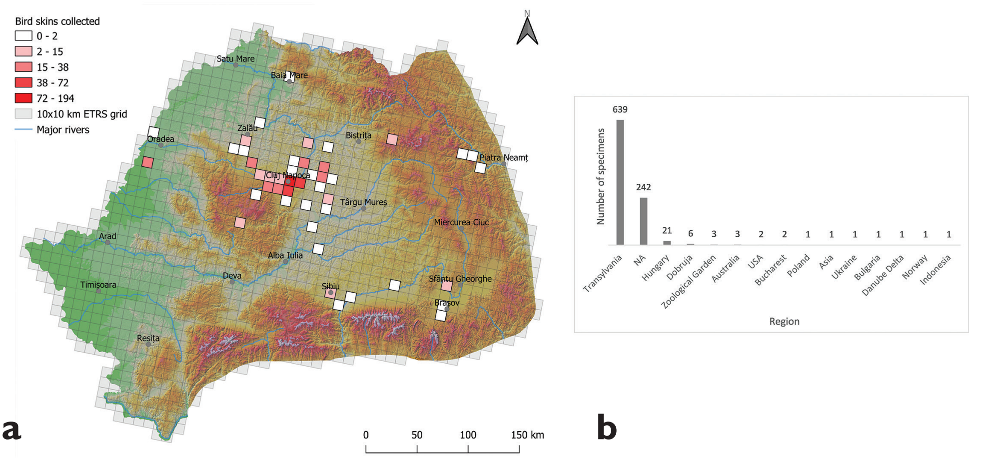

Figure 3. a The geographical distribution of the bird skin collection in the Zoological Museum of Babeș-Bolyai University with the number of bird specimens collected from each region (NA=data not available) **b** localities of birds collected in Transylvania.

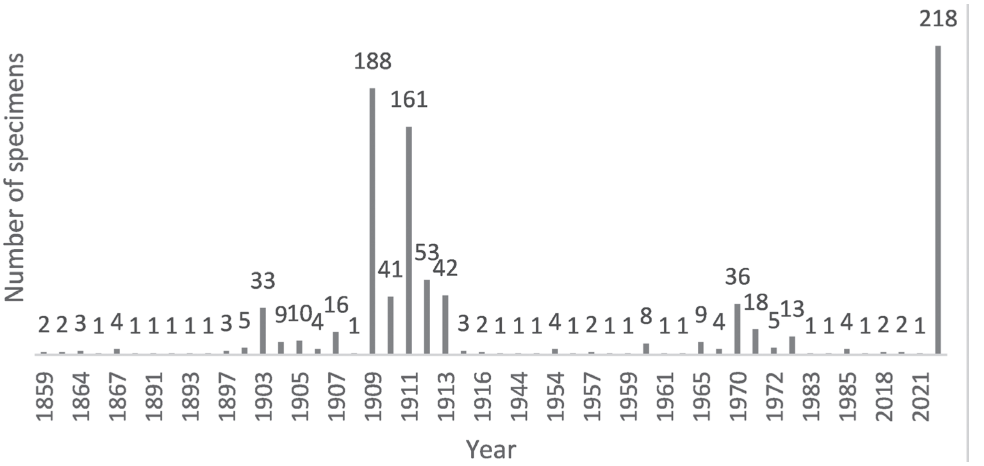

Figure 4. Temporal distribution of numbers of bird skin specimens added to the Zoological Museum of Babeș-Bolyai University Cluj-Napoca, Romania. (NA=218).

one with unknown data (*Melopsittacus undulatus*), three from Australia (*Eupsaltria australis*, *Lichenostomus fuscus*, *Pomatostomus superciliosus*), two from the USA (*Myiarchus cinerascens*, *Turdus migratorius*) one from Indonesia (*Pycnonotus cafer*), and one collected from Transylvania that is often kept as pet (*Estrilda troglodytes*) (Table 1; Suppl. material 1: Table S1).

The bird skin specimens in the collection housed in the Zoological Museum of Babeș-Bolyai University were collected between 1859 and 2021 (Fig. 4). However, we were unable to identify the year of collection/acquisition for 218 individuals. The oldest specimens were collected by János Xántus during his Californian expeditions between 1857 -1859, and donated to the museum in 1959 (Frivaldszky 1865). The oldest native species in the collection with known data were collected by Ottó Herman in 1867. Most of the specimens were collected between 1909 and 1913 by Lajos Führer (460 specimens), followed by Ferencz Vincze (72 specimens) between 1970 and 1973. In total, the bird skin collection has had 26 different contributors (Table 1; Suppl. material 1: Table S1).

The collection also includes rarities and important avifaunistic data, for example one specimen of the Cinereous Vulture *Aegypius monachus*, two specimens of the Eastern Imperial Eagle *Aquila heliaca*, and one Lesser Kestrel *Falco naumanni*, all collected between 1903 and 1907 from Transylvania (Table 1). The full catalogue of bird skin collection is provided in the Suppl. material 1: Table S1.

Acknowledgements

We are very thankful to many students from the Faculty of Biology and Geology of Babeș-Bolyai University and to the volunteers from the Zoological Museum of Babeș-Bolyai University, particularly Orsolya Kovács, Mátyás Sztojka, Helga Tóth-Pál, and Gergő Varga. We would also like to thank Cosmin-Dragomir David and Hunor Prázsmári for their help reorganizing the bird skin collection and entering the data into the primary database. We are grateful to Szilárd Daróczi from Milvus Group for his help identifying some problematic specimens. We thank the editor and reviewers for their constructive comments and valuable suggestions, which have helped improve the quality of the paper.

References

Apáthy I (1910a) Az állattár jelentése. Az Erdélyi Múzeum-Egylet Évkönyve: 52–53.

Apáthy I (1910b) Jelentés az állattárról. Az Erdélyi Múzeum-Egylet Évkönyve: 60–63.

Apáthy I (1911) Az állattár jelentése. Az Erdélyi Múzeum-Egylet Évkönyve: 60–65.

Bartoccioni F (2017) Big data in biogeography: From museum collection to citizen science. Biogeographia 32(1): 1–3. https://doi.org/10.21426/B632137017

Causey D, Janzen DH, Peterson AT, Vieglais D, Krishtalka L, Beach JH, Wiley EO (2004) Museum Collections and Taxonomy. Science 305(5687): 1106b–1107b. https://doi.org/10.1126/science.305.5687.1106b

Filipașcu A (1966) Păsări rare în colecția ornitologică a Muzeului Zoologic din Cluj. Revista Muzeelor 3: 325–326.

Filipașcu A, Munteanu D, Filipașcu S (1965) A kolozsvári „Állattani Múzeum" Madárgyűjteménye. Vertebrata Hungarica 7: 13–14.

Frivaldszky J (1865) Rövid Vázlata azon szerzeményeknek, melyekkel Xántus János a m.n. Múzeum állattani osztályát gazdagította. In: Szabó J (Eds). A magyar orvosok és természetvizsgálók 1864 Augustus 24-től - September 2-ig Maros-Vásárhelytt tartott X. nagygyűlésének történeti vázlata és munkálatai. Pest, 268–273.

Gotelli NJ, Booher DB, Urban MC, Ulrich W, Suarez AV, Skelly DK, Russell DJ, Rowe RJ, Rothendler M, Rios N, Rehan SM, Ni G, Moreau CS, Magurran AE, Jones FAM, Graves GR, Fiera C, Burkhardt U, Primack RB (2021) Estimating species relative abundances from museum records. Methods in Ecology and Evolution 2021: 1–13. https://doi.org/10.1111/2041-210X.13705

Herman O (1865) Állattani közlések I. Az Erdélyi Múzeum-Egylet Évkönyve 3: 87–91.

Herman O (1868) Állattani közlések II. Az Erdélyi Múzeum-Egylet Évkönyve 4: 48–54.

Herman O (1869) Állattani közlemények V. Az Erdélyi Múzeum-Egylet Évkönyve 5: 92–96.

MacLean HJ, Nielsen ME, Kingsolver JG, Buckley LB (2019) Using museum specimens to track morphological shifts through climate change. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences 374(1763): e20170404. https://doi.org/10.1098/rstb.2017.0404

Meineke EK, Davies TJ, Daru BH, Davis CC (2019) Biological collections for understanding biodiversity in the Anthropocene. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences 374(1763): e20170386. https://doi.org/10.1098/rstb.2017.0386

Mikula P, Csanády A, Hromada M (2018) A critical evaluation of the exotic bird collection of the Šariš museum in bardejov, Slovakia. ZooKeys 2018: 139–152. https://doi.org/10.3897/zookeys.776.24462

Osváth G, Daubner T, Dyke G, Fuisz TI, Nord A, Pénzes J, Vargancsik D, Vágási CI, Vincze O, Pap PL (2018) How feathered are birds? Environment predicts both the mass and density of body feathers. Portugal S (Ed.). Functional Ecology 32: 701–712. https://doi.org/10.1111/1365-2435.13019

Osváth G, Vincze O, David D-C, Nagy LJ, Lendvai ÁZ, Nudds RL, Pap PL (2020) Morphological characterization of flight feather shafts in four bird species with different flight styles. Biological Journal of the Linnean Society. Linnean Society of London 131(1): 192–202. https://doi.org/10.1093/biolinnean/blaa108

Pap PL, Vincze O, Wekerle B, Daubner T, Vágási CI, Nudds RL, Dyke GJ, Osváth G (2017) A phylogenetic comparative analysis reveals correlations between body feather structure and habitat. Functional Ecology 31(6): 1241–1251. https://doi.org/10.1111/1365-2435.12820

Pap PL, Vincze O, Vágási CI, Salamon Z, Pándi A, Bálint B, Nord A, Nudds RL, Osváth G (2019) Vane macrostructure of primary feathers and its adaptations to flight in birds. Biological Journal of the Linnean Society. Linnean Society of London 126(2): 256–267. https://doi.org/10.1093/biolinnean/bly189

Pap PL, Osváth G, Daubner T, Nord A, Vincze O (2020) Down feather morphology reflects adaptation to habitat and thermal conditions across the avian phylogeny. Evolution 74(10): 2365–2376. https://doi.org/10.1111/evo.14075

Roselaar CS (2003) An inventory of major European bird collections. Bull. B.O.C. 123A: 253–337.

Solow AR, Roberts DL (2006) Museum collections, species distributions, and rarefaction. Diversity & Distributions 12(4): 423–424. https://doi.org/10.1111/j.1366-9516.2006.00259.x

Vágási CI, Pap PL, Vincze O, Osváth G, Erritzøe J, Møller AP (2016) Morphological Adaptations to Migration in Birds. Evolutionary Biology 43(1): 48–59. https://doi.org/10.1007/s11692-015-9349-0

Waeber PO, Gardner CJ, Lourenco WR, Wilme L (2017) On specimen killing in the era of conservation crisis - A quantitative case for modernizing taxonomy and biodiversity inventories. PLoS ONE 12(9): 1–16. https://doi.org/10.1371/journal.pone.0183903

Supplementary material 1

The catalogue of bird skin specimens held by the Zoological Museum of Babeş-Bolyai University, Cluj-Napoca, Romania

Authors: Gergely Osváth, Edgár Papp, Zoltán Benkő, Zsolt Kovács

Data type: xslx. file.

Explanation note: The catalogue of bird skin specimens held by the Zoological Museum of Babeş-Bolyai University, Cluj-Napoca, Romania, including their new and ols inventory numbers, updated species identification and scientific name, locality, country and region of collection, gps coordinates, name of collector, date of collection, sex and age of birds.

Link: https://doi.org/10.3897/zookeys.1102.79102.suppl1

ZooKeys 1102: 107–148 (2022)
doi: 10.3897/zookeys.1102.82388
https://zookeys.pensoft.net

RESEARCH ARTICLE

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Revision of the new Australasian orb-weaving spider genus *Salsa* (Araneae, Araneidae)

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Academic editor: Dimitar Dimitrov | Received 17 February 2022 | Accepted 22 April 2022 | Published 20 May 2022

http://zoobank.org/BCA0CCE5-141D-46DA-9D65-0DCA6B74DE69

Citation: Framenau VW, de S. Castanheira P (2022) Revision of the new Australasian orb-weaving spider genus *Salsa* (Araneae, Araneidae). ZooKeys 1102: 107–148. https://doi.org/10.3897/zookeys.1102.82388

Abstract

A new Australasian genus in the orb-weaving spider family Araneidae Clerck, 1757 is described to include seven species: *Salsa fuliginata* (L. Koch, 1871) **comb. nov.** (type species; = *Epeira rubicundula* Keyserling, 1887) **syn. nov.**) (Australia, introduced to New Zealand); *S. brisbanae* (L. Koch, 1867) **comb. nov.** (Australia); *S. canalae* (Berland, 1924) **comb. nov.** (New Caledonia); *S. neneba* **sp. nov.** (Papua New Guinea); *S. recherchensis* (Main, 1954) **comb. nov.** (Australia); *S. rueda* **sp. nov.** (Australia); and *S. tartara* **sp. nov.** (Australia; Lord Howe Island endemic). *Salsa* **gen. nov.** belongs to the Australasian informal backobourkiine clade and differs from other genera of this clade by a distinct abdominal shape (single posterior abdominal tubercle) and ventral colouration (pale lateral spindle-shaped bands), male pedipalp morphology (C-shaped median apophysis that has teeth-like tubercles inside the basal arch) and the shape of the female epigyne scape (partially translucent and generally shorter than the epigyne plate). Based mainly on male pedipalp morphology within the backobourkiines, *Salsa* **gen. nov.** has closest morphological affinities with *Acroaspis* Karsch, 1878 and *Socca* Framenau, Castanheira & Vink, 2022.

Keywords

Australia, backobourkiines, Pacific, South-east Asia, systematics, taxonomy

Introduction

When Dondale (1966) transferred an Australian orb-weaving spider species from *Araneus* Clerck, 1757 to *Cyclosa* Menge, 1866, *C. fuliginata* (L. Koch, 1872) (e.g., Fig. 1A–D), he realised that this placement was not without problems as the carapace shape of males and females was unlike that of other *Cyclosa*. The problem was compounded by the fact that the first detailed diagnosis of the genus was not published until much later (Levi 1977). Chrysanthus (1961) had earlier reviewed some *Cyclosa* from south-east Asia but did not provide a diagnosis for the genus. With Levi's (1977, 1999) reviews of the genus it became clear that the Australian species was misplaced in *Cyclosa* based on both somatic and genitalic characters, but no further taxonomic treatment of the species has been conducted since Dondale (1966).

Figure 1. Life images of *Salsa* gen. nov. species **A–D** *S. fuliginata* (L. Koch, 1872), comb. nov. **A** male, Brymer Park, Hamilton, New Zealand, North Island **B** male, Flagstaff, Hamilton, North Island, New Zealand **C** female, Rotorua North, Hamilton, North Island, New Zealand **D** male, Ringwood East, Victoria, Australia (WAM T100137) **E** *S. recherchensis* (Main, 1954), comb. nov., female, Stirling Range National Park, Western Australia (WAM T81440). Images: **A–C** Bryce McQuillan **D, E** V.W. Framenau.

Scharff et al.'s (2020) multi-loci molecular phylogenetic study of world-wide Araneidae Clerck, 1757 included many Australian species, but not *C. fuliginata* to facilitate its appropriate generic placement. A morphologically similar species, *Araneus recherchensis* (Main, 1954) (e.g., Fig. 1E) represented a putative new genus (termed 'NGEN02') in that study, nesting with high support in a clade referred to as 'backobourkiines' and with closest affinities to *Acroaspis* Karsch, 1878, *Plebs* Joseph & Framenau, 2012 and *Socca* Framenau, Castanheira & Vink, 2022 ('NGEN05' in that study) (Scharff et al. 2020).

The Australian backobourkiines are currently the focus of a comprehensive taxonomic and systematic investigation with the aim to revise their constituent genera, but also to potentially characterise and diagnose this group as formal subfamily of the Araneidae based on both morphological and molecular data. This project has already identified a number of new genera, some of which were suggested by the molecular study of Scharff et al. (2020), such as *Hortophora* Framenau & Castanheira, 2021, *Socca* and others (e.g., Joseph and Framenau 2012; Framenau et al. 2021a, c, 2022).

Our morphological studies confirmed that *C. fuliginata* and *A. recherchensis* are indeed congeneric and belong to a new genus. The aim of this study is therefore to taxonomically revise this new genus of Australasian orb-weaving spiders as hypotheses for future systematic work on the backobourkiines.

Materials and methods

Descriptions and terminology follow recent publications on Australian and New Zealand orb-weaving spiders (e.g., Joseph and Framenau 2012; Framenau et al. 2021a, b, c, 2022). Redescriptions of historically named species are based on recently collected, well-preserved material instead of the usually damaged and discoloured type specimens. Colour patterns were described based on specimens preserved in ca. 75% ethanol.

The description of the views of the male pedipalp relate to their position as a limb. A full view of the bulb with the cymbium in the background is a retrolateral view as in Araneidae the pedipalp is twisted so that the cymbium is situated mesally. Our standard views of the pedipalp therefore generally show the ventral view, to illustrate the diagnostic median apophysis, or the dorsal view with the tegulum in full view, as the cymbium is situated to the side in our images. Like in our recent papers (Framenau et al. 2021a, c, 2022), the term 'conductor lobe' is preferred over 'paramedian apophysis' for a structure originating at the base of the conductor in the male pedipalp (see also Framenau et al. 2010, 2021c for discussions on this sclerite). The designation of an apical structure of the pedipalp bulb as terminal apophysis is this study is consistent with Dondale's (1966) application of this term and also Framenau et al.'s (2022) use for a similar, but tri-partite apophysis in *Socca*. In *Salsa* gen. nov., the terminal apophysis may carry two appendices, a basal 'prong' and an apical 'process'. Our nomenclature, however, does not necessarily suggest homologies of these structures to those in other araneids but serves primarily to facilitate the description of the pedipalp morphology of males. Evaluating homologies of male pedipalp sclerites within the backobourkiines and against world-wide Araneidae will be the subject of future phylogenetic studies once all putative genera of backobourkiines have been revised. In this study, pedipalps were expanded by alternatively submerging them for 10 min in 10% KOH and distilled water until fully expanded.

The female epigyne consists of two main parts, the base (encapsulating the internal genitalia) and the scape. We refer to the central part of the base in ventral view as atrium which, in posterior view, becomes the central division. We cleared selected epigynes by submerging them in warm, 10% KOH for ca. 20 min. For observation and imaging, samples were transferred into lactic acid on a microscopic glass slide under a cover slip, which further cleared internal structures.

Throughout the course of this study, which commenced in 2005, microscopic photographs were taken with two different stereo-imaging systems. A setup at the Natural History Museum, Copenhagen (Denmark) allowed taking images with a Nikon D300 digital SLR camera attached via a C-mount adapter to a Leica M16A stereomicroscope. Images of different focal plains were stacked with Automontage (v. 5.02) software from Syncroscopy to increase depth of field. Two Nikon R1C1 wireless speedlights were used to illuminate the exposures. A second set-up at the Harry Butler Institute, Murdoch University (Australia) supported taking microscopic images in different focal planes (ca. 20–30 images) with a Leica DMC4500 digital camera mounted to a Leica M205C stereomicroscope and combined using the Leica Application Suite X, v. 3.6.0.20104. All photos were edited and mounted with Photoshop CC 2020.

All measurements are given in millimetres. They were taken with an accuracy of one tenth of a millimetre, with the exception of eye and labium measurements taken with an accuracy of one hundredth of a millimetre.

Maps were compiled in the software package QGis v. 2.14.0 Girona (https://qgis.org/en/site/; accessed 21 December 2021). Geographic coordinates were extracted directly from original labels or the registration data as provided by the museums. When no detailed geographic information was available, localities were estimated based on Google Earth v. 9.1.39.3 (https://earth.google.com/web/ accessed 21 December 2021) to the closest minute of Latitude and Longitude.

The taxonomic part of this study lists all species in alphabetical order, except for the type-species of the new genus, which is treated first.

Abbreviations

Morphology:

ALE anterior lateral eyes;
AME anterior median eyes;
PLE posterior lateral eyes;
PME posterior median eyes;

Collections:

AM	Australian Museum, Sydney (Australia);
BNHM	Naturhistorisches Museum Basel (Switzerland);
CMNZ	Canterbury Museum, Christchurch (New Zealand);
CVIC	La Trobe University, Bendigo (Australia);
LUNZ	Entomology Research Museum, Lincoln University (New Zealand);
MONZ	Museum of New Zealand Te Papa Tongarewa, Wellington (New Zealand);
MPI	Ministry of Primary Industries Manatū Ahu Matua, Auckland (New Zealand);
MV	Museums Victoria, Melbourne, Australia;
NHMD	Natural History Museum of Denmark, Zoological Museum, University of Copenhagen (Denmark);
NHMUK	Natural History Museum, London (England, United Kingdom);
NHMW	Naturhistorisches Museum, Wien (Austria);
QM	Queensland Museum, Brisbane (Australia);
QVMAG	Queen Victoria Museum & Art Gallery, Launceston (Australia);
SAM	South Australian Museum, Adelaide (Australia);
WAM	Western Australian Museum, Perth (Australia);
ZMB	Museum für Naturkunde, Zentralinstitut der Humboldt-Universität, Berlin (Germany);
ZMH	Zoologisches Institut und Zoologisches Museum, Universität Hamburg (Germany).

Results

Salsa gen. nov. includes comparatively common species; a total of 263 males, 1,069 females (11 with egg sacs), and 321 juveniles in 616 records (i.e., vials) were examined for this study in Australian and overseas institutions (Table 1). *Salsa* gen. nov. contains seven species, five from Australia (of which one also occurs in New Zealand), one from New Caledonia, and one from Papua New Guinea (Table 1). In Australia, the highest diversity of *Salsa* gen. nov. is in the eastern states, where four of the five species occur. A single species, *S. recherchensis* comb. nov., is know from Western Australia and occurs into South Australia (Table 1).

Taxonomy

Family Araneidae Clerck, 1757

***Salsa* gen. nov.**
http://zoobank.org/92B3923D-E576-4925-B79C-85FD0F6CDBBB

Type species. *Epeira fuliginata* L. Koch, 1872. Designated here.

Etymology. The genus-group name refers to the Latin dance style Salsa, associated with the music genre of the same name. It is the favourite dance style of the senior

Table 1. Summary of distribution, type specimen and other material examined and of species of *Salsa* gen. nov.

Species	Comments	Distribution	Type specimen	Other material examined
S. fuliginata (L. Koch, 1872), comb. nov.	Type species of *Salsa*; senior syn. of *E. rubicundula* (Keyserling)	NSW, SA, Tas, Vic; also New Zealand	Holotype female, Sydney (NSW) (NHMW)	162 males, 509 females (8 with egg sac), 105 juveniles (in 360 records)
S. brisbanae (L. Koch, 1867), comb. nov.		NSW, Qld, SA, Tas, Vic	Holotype female, Brisbane (Qld) (ZMH Rack (1961)-catalogue no. 226)	57 males, 208 females (2 with egg sac), 39 juveniles (in 146 records)
S. canalae (Berland, 1924), comb. nov.		New Caledonia	Holotype female, Mount Canala (New Caledonia) (BNHM)	1 male, 7 females (in 8 records)
S. neneba sp. nov.		Papua New Guinea	Holotype female, Neneba (Papua New Guinea) (QM S111920)	
S. recherchensis (Main, 1954), comb. nov.		SA, WA	Holotype female, Fig. of Eight Island, Recherche Archipelago, (WA) (WAM 55/4984)	34 males, 321 females, 175 juveniles (in 74 records)
S. rueda sp. nov.		NSW, Tas, Vic	Holotype male, Tubrabucca (NSW) (MV K-14856)	6 males, 14 females (1 with egg sac), 1 juvenile (in 15 records)
S. tartara sp. nov.		NSW (endemic to Lord Howe Island)	Male holotype, Goat House Cave area, Lord Howe Island (NSW) (AM KS.70737)	1 male, 5 females (in 6 records)

Abbreviations: NSW – New South Wales, SA – South Australia, Tas – Tasmania, Vic – Victoria, WA – Western Australia.

author, but also a very popular dance style in Latin America, from where the junior author is. The name also refers to the Spanish/Italian word "salsa", which means "sauce" or "gravy". The gender of the genus-group name is feminine.

Diagnosis. *Salsa* gen. nov. can only be properly diagnosed against the six backobourkiine genera that have been formally revised using modern taxonomic methods: *Backobourkia* Framenau, Dupérré, Blackledge & Vink, 2010, *Hortophora*, *Lariniophora* Framenau, 2011, *Novakiella* Court & Forster, 1993, *Plebs* and more recently *Socca* (Framenau et al. 2010; Framenau 2011; Joseph and Framenau 2012; Framenau et al. 2021a, c, 2022). Other established backobourkiine genera such as *Acroaspis*, *Carepalxis* L. Koch, 1872, and possibly *Singa* C.L. Koch, 1836 (see Scharff et al. 2020) are still awaiting revisions in Australia and without a modern circumscription of these genera, *Salsa* gen. nov. cannot be diagnosed from these.

We here identify the following synapomorphies to diagnose species in *Salsa* gen. nov. within the backobourkiines: single posterior abdominal tubercle (e.g., Figs 12A, 18A); venter with lateral pale elongate, ovoid, or spindle-shaped bands (e.g., Figs 6B, 7B, 9B, 10B); male pedipalp with C-shaped median apophysis and teeth-like tubercles inside its basal arch (e.g., Figs 2B, 3A–D, 4, 6C); female epigyne scape transparent and generally shorter than the epigyne plate (e.g., Figs 7C, D, 10C, 13C–E).

Salsa gen. nov. species differ from those of *Backobourkia* by the lack of a distinctive anterior triangular or comma-shaped white marking and the lack of strong spine-like setae found on the dorsum of the abdomen. Males of *Salsa* gen. nov. can be identified from those of *Backobourkia* by the absence of a basal flange on the median apophysis of the male pedipalp and females by the generally much wider atrium and central division on the epigyne (Framenau et al. 2010).

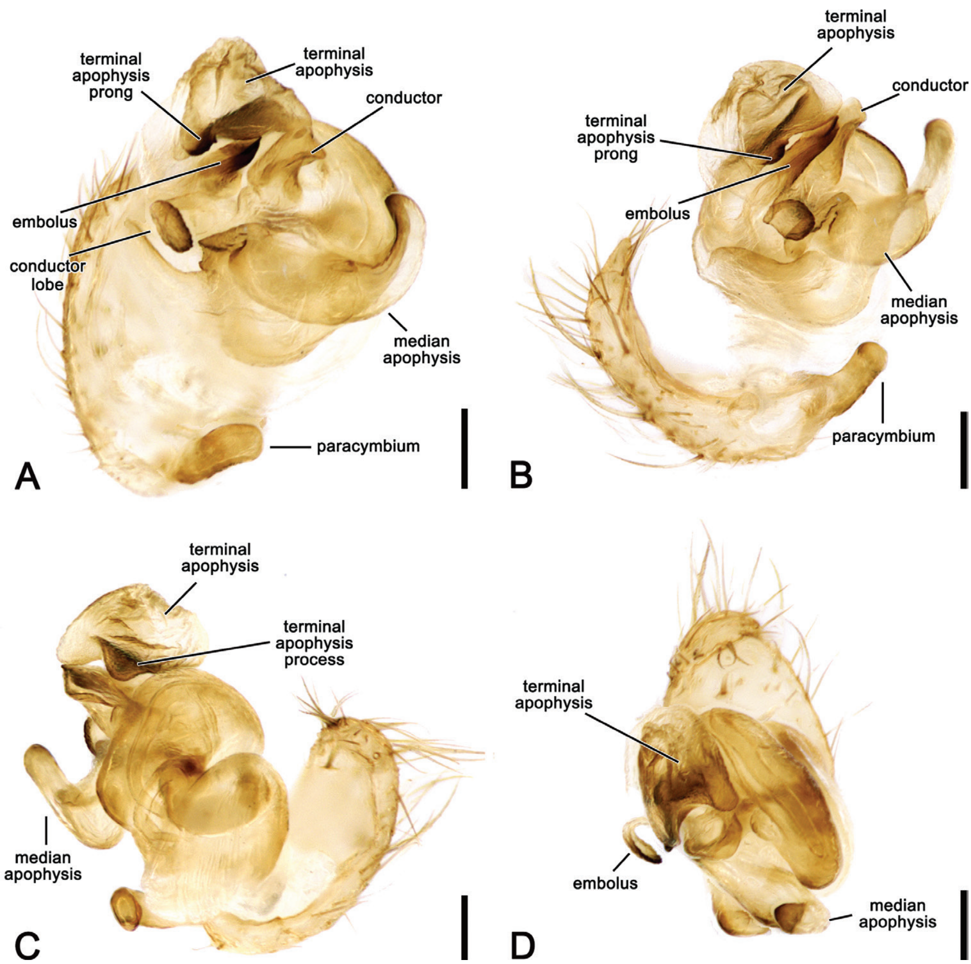

Figure 2. *Salsa fuliginata* (L. Koch, 1872), comb. nov., expanded left pedipalp of male (MV K-14867 (CVIC 1163)) **A** ventral view **B** ventral view **C** dorsal view **D** apical view. Scale bars: 0.2 mm. Arrow in **A, B** points to the tubercle on median apophysis arch.

Salsa gen. nov. species differ from those of *Hortophora* in the generally smaller size (although sizes can sometimes overlap in smaller specimens of *Hortophora*); the shape of the median apophysis (C-shaped in *Salsa* gen. nov. but elongate transverse in *Hortophora* and generally with two apical tips), and the comparatively much shorter scape of the female epigyne (Framenau et al. 2021a).

The subtriangular to ovoid abdomen of *Salsa* gen. nov. greatly differs from the elongate abdomen of *Lariniophora*. *Salsa* gen. nov. males lack the bilobed outgrowth on the median apophysis characteristic for *Lariniophora*, and females lack the elevated epigyne base (Framenau 2011).

Male *Salsa* gen. nov. differ from those of *Novakiella* by the more elongate and curved median apophysis of the male pedipalp (shorter and pointing basally in *Novakiella*) and an inconspicuous conductor lobe (prominent in *Novakiella*) (Framenau et al. 2021c).

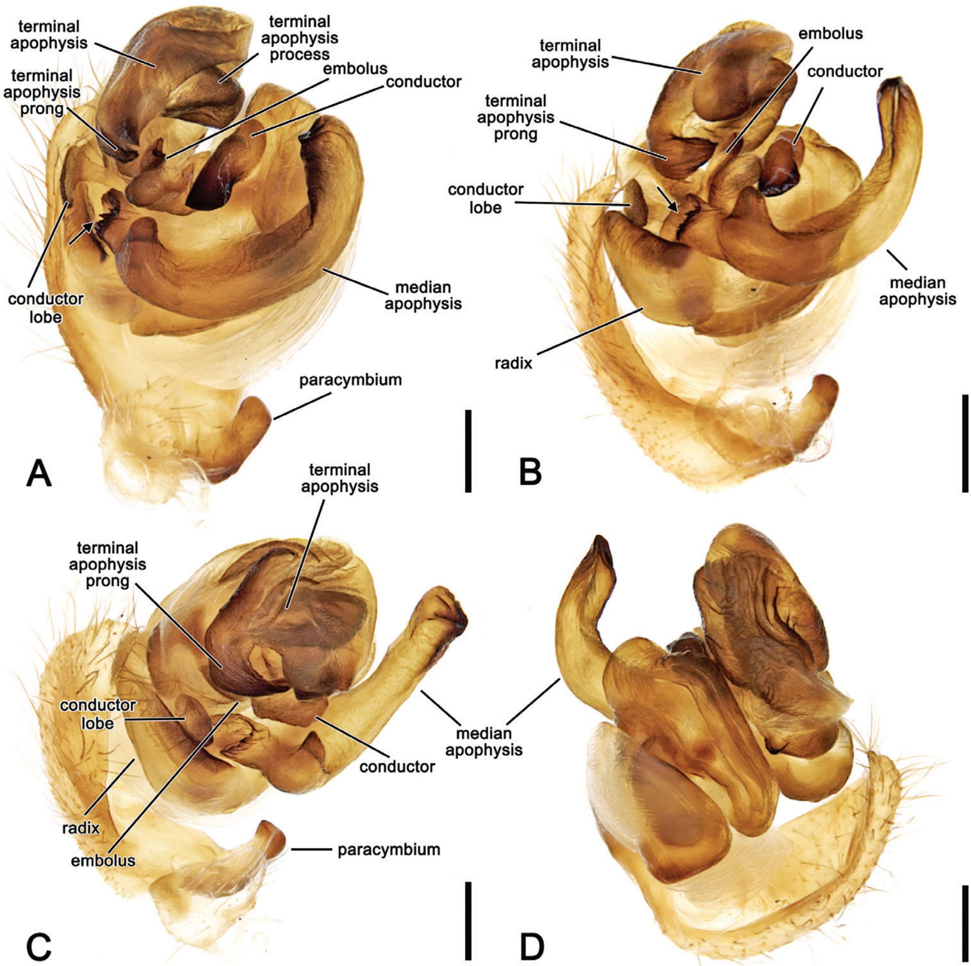

Figure 3. *Salsa rueda* sp. nov., expanded left pedipalp of male holotype (MV K-14856) **A** ventral view **B** baso-ventral view **C** apico-ventral view **D** apical view. Arrow in **A, B** points to the tubercle on median apophysis arch. Scale bars: 0.2 mm.

The epigyne base in female *Novakiella* is triangular (Framenau et al. 2021c), whereas it is subquadrate in *Salsa* gen. nov.

Species of *Salsa* gen. nov. differ from those of *Plebs* by the less elongate abdomen and its ventral colouration, that has lateral bands in *Salsa* gen. nov. but an inverted Ü-shaped pattern in *Plebs* (Joseph and Framenau 2012). The median apophysis of male *Plebs* is elongate transverse with two apical tips (C-shaped with a single tip in *Salsa* gen. nov. males) and the female epigyne has a wider atrium and the scape is comparatively shorter in *Salsa* gen. nov. than it is in *Plebs*.

Species of *Salsa* gen. nov. differ from those of *Socca* by the number of posterior abdominal humps (one in *Salsa* gen. nov. and usually five in *Socca*), the shape of the

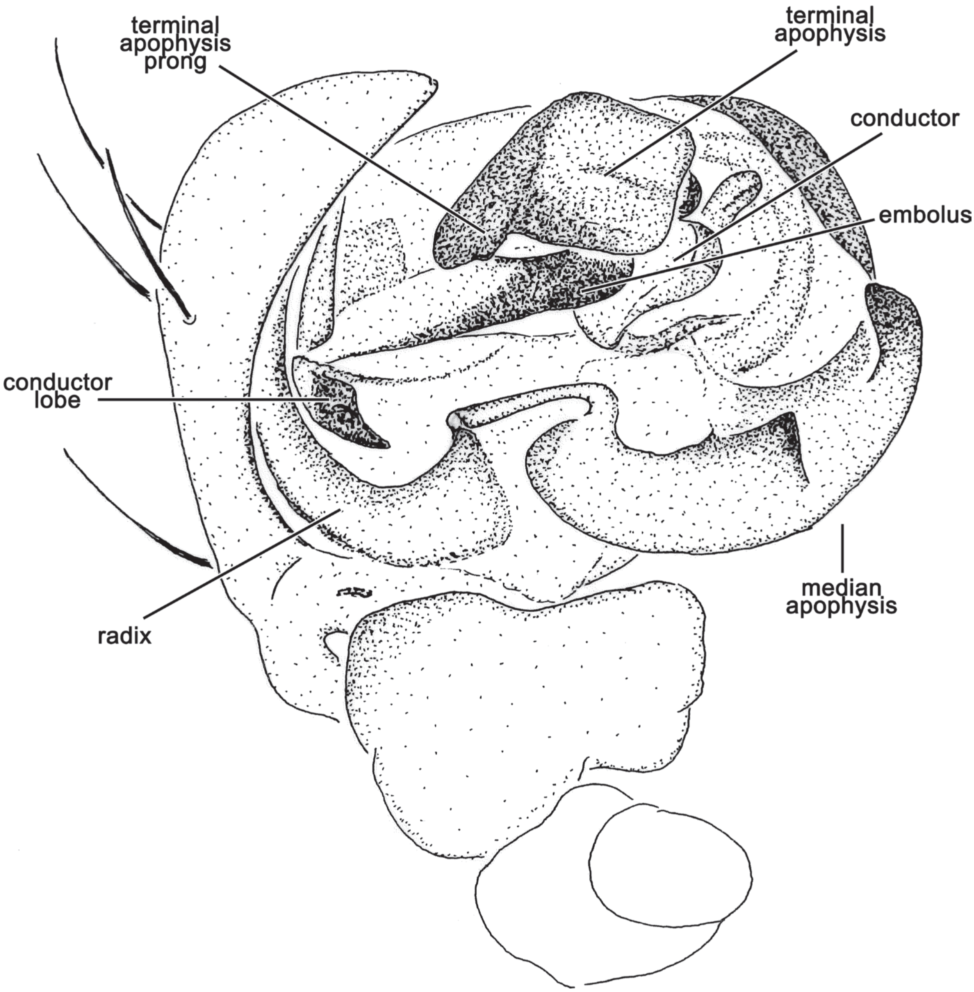

Figure 4. *Salsa fuliginata* (L. Koch, 1872), comb. nov., male pedipalp, ventral view (WAM T67910). Scale bar: 0.2 mm.

terminal apophysis (distinctly tri-partite with central lamellar appendix in *Socca* but entire in *Salsa* gen. nov. sometimes with prong and process) (Framenau et al. 2022).

Description. Median-sized orb-weaving spiders, males (ca. total length 3.2–6.1) smaller than females (ca. total length 6.5–10.5). Carapace longer than wide, pear-shaped and with cephalic region considerably narrower in males than in females; colouration variable from yellowish brown to reddish brown, normally covered with yellowish white setae (e.g., Figs 6A, 7A, 9A, 10A, 12A). Fovea longitudinal in males and transversal in females (e.g., Figs 6A, 7A, 9A, 10A, 12A). Anterior median eyes largest, row of posterior eyes slightly recurved, lateral eyes almost touching, posterior lateral eyes apart from posterior median eyes by more than their diameter; anterior median eyes slightly protruding from the carapace (e.g., Figs 6A, 7A, 9A, 10A, 12A).

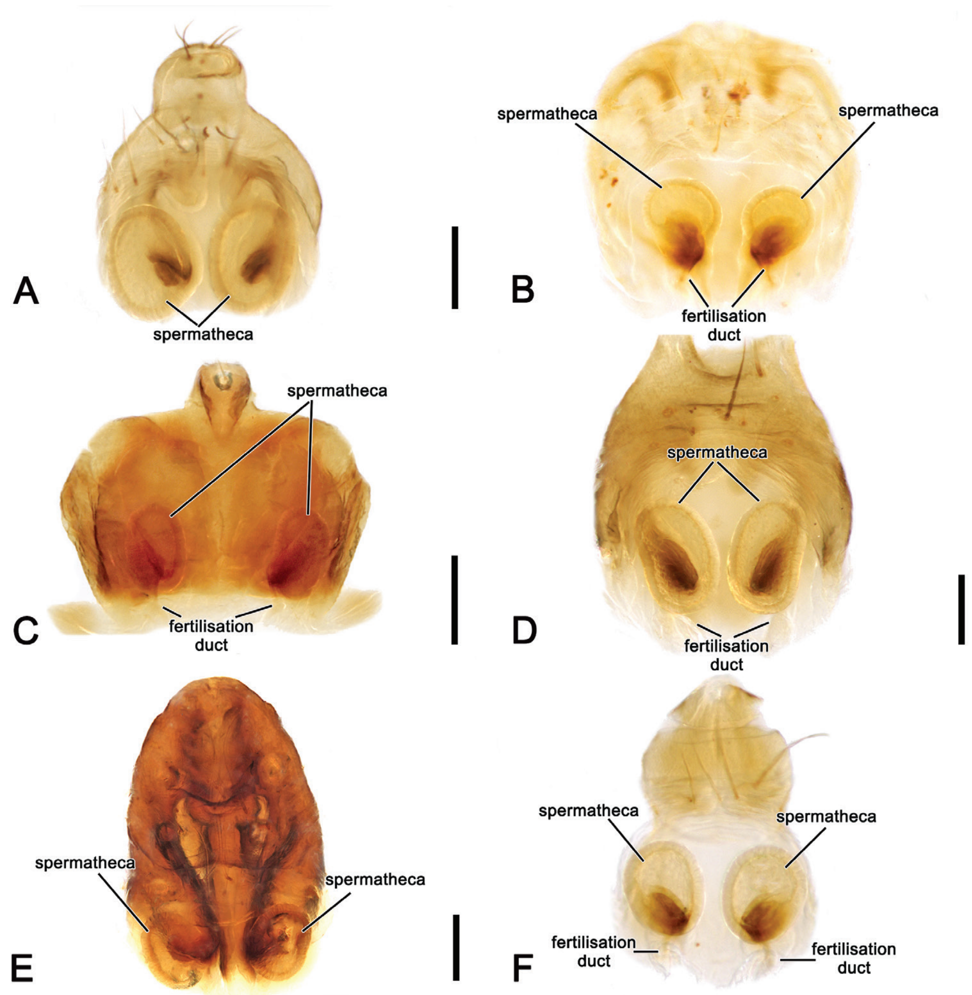

Figure 5. *Salsa* gen. nov. female epigynes, cleared posterior view **A** *S. fuliginata* (L. Koch, 1872), comb. nov. (CVIC 173) **B** *S. brisbanae* (L. Koch, 1867), comb. nov. (AM KS.131087) **C** *S. canalae* comb. nov. Berland, 1924, comb. nov. (WAM T75921) **D** *S. recherchensis* (Main, 1954), comb. nov. (WAM T77362) **E** *S. rueda* sp. nov. **F** *S. tartara* sp. nov. (AM KS.7061). Scale bars: 0.2 mm.

Sternum longer than wide (except on females of *S. canalae* comb. nov., in which it is as long as wide), comparatively narrower in males than females, with a sparse to dense cover of setae (e.g., Figs 6B, 7B, 9B, 10B, 12B). Labium wider than long, with anterior glabrous pale edge. Endites with glabrous paler antero-mesal section, that of males with lateral tooth. Chelicerae fangs with four promarginal teeth, of which the second-basal and/or apical are generally largest (reduced to three in *S. brisbanae* comb. nov. male and *S. fuliginata* comb. nov. male and female, with median largest), three retromarginal teeth with basal often largest. Legs (e.g., Figs 6A, B, 7A, B 9A, B): Leg formula I > II > IV > III. Abdomen slightly longer than wide, varying

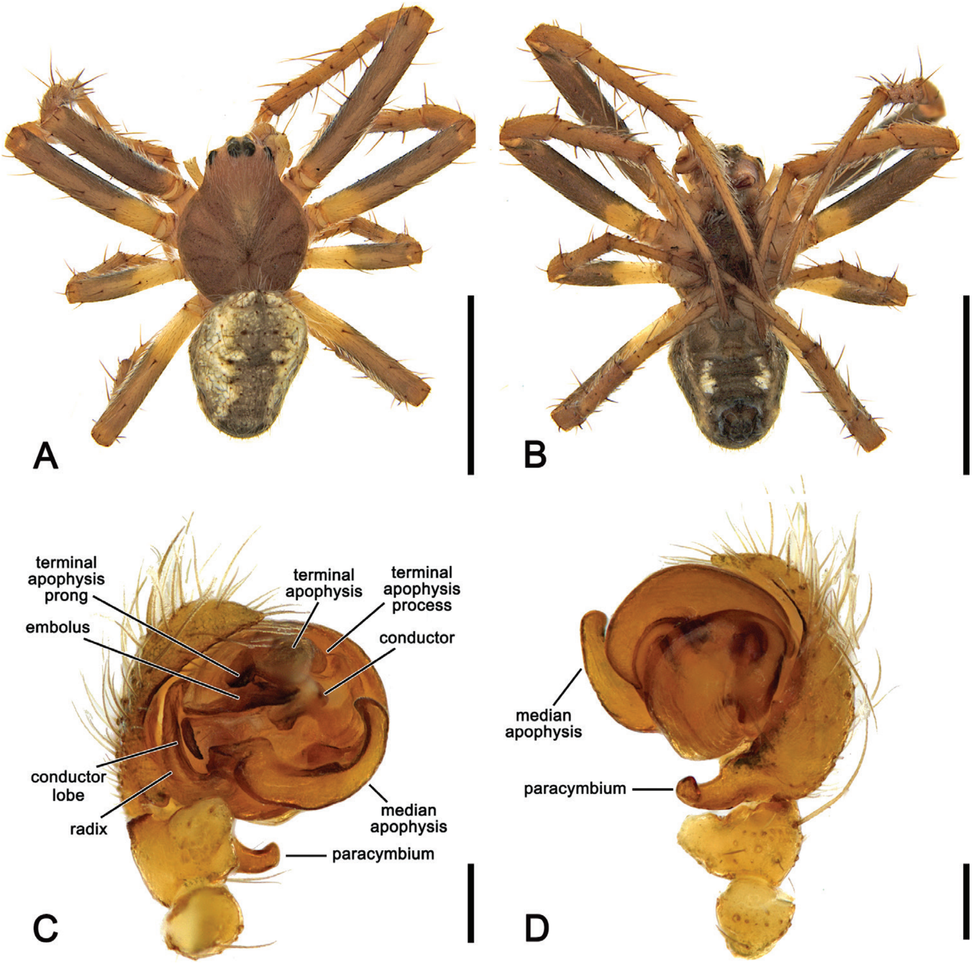

Figure 6. *Salsa fuliginata* (L. Koch, 1872), comb. nov., male (MV K-14867 (CVIC 1163)) **A** dorsal habitus **B** ventral habitus **C** left pedipalp, ventral view **D** left pedipalp, dorsal view. Scale bars: 2 mm (**A, B**); 0.2 mm (**C, D**).

in shape from oval to sub-triangular, normally with inconspicuous humeral humps, abdomen otherwise without specialised setae, sigillae, condyles or other specific structures; colour dorsally with pale brown to beige background with variable darker folium pattern (Fig. 1A, B). Venter of variable colour, centrally generally darkest and generally with pale lateral ovoid, elongate or spindle-shaped bands (e.g., Figs 6A, B, 7A, B, 9A, B).

Male pedipalp patella with a single macroseta (e.g., Figs 2A–D, 3A–D, 4, 6C, D), except in *S. canalae* comb. nov. and *S. tartara* sp. nov. (Figs 12C, D, 22C, D); paracymbium of variable length, hook-like (e.g., Figs 6D, 9D, 12D, 17D); median apophysis C-shaped, generally with numerous tubercles in the basal arch (e.g., Figs 2A–D, 3A–D, 4, 6C); radix elongate (e.g., Figs 2A–C, 3A–D, 4, 6C); basal conductor lobe conspicuous, very wide anteriorly (e.g., Figs 6C, 9C, 12C); terminal apophysis slightly inflated, sub-rectangular and sometimes bearing a basal prong and/or an apical process varying in length (e.g., Figs 6C, 9C, 12C); distal haematodocha sometimes with an inflated apical section, but always inconspicuous (e.g., Figs 6C, 9C, 12C); conductor inflated and bilobed with a median dent and rounded borders (e.g., Figs 2A–D, 3A–D, 4, 6C); embolus compact and short, generally hidden by terminal apophysis in ventral view (e.g., Figs 2A–D, 3A–D, 4, 6C).

Epigyne base oval (rectangular in *S. rueda* sp. nov.), partially to strongly sclerotised with very wide atrium and central division, sometimes bearing a conspicuous ridge (e.g., Figs 7C, E, F, 10C, 13C, D); scape with wide base, transparent and generally curved apically, without or with just a few short setae, and in all but *S. canalae* comb. nov. shorter than the epigyne length (e.g., Figs 7C, E, F, 10C, 13C, D); spermathecae ovoid to spherical and very wide (Fig. 5A–F).

Included species. See Table 1.

Distribution. *Salsa* gen. nov. is mostly known from Australia. However, *S. canalae* comb. nov. occurs only in New Caledonia, *S. neneba* sp. nov. only in Papua New Guinea, and *S. fuliginata* comb. nov. can also be found in New Zealand (Figs 8; 11; 14; 16; 21).

Males (male of *S. neneba* sp. nov. unknown)

1	Pedipalp patella with two setae (Fig. 12A, 22D)	**2**
–	Pedipalp patella with one seta (e.g., Fig. 9D)	**3**
2	Abdomen with a pointed posterior end (Fig. 12A, B); pedipalp terminal apophysis with finger-like basal prong (Fig. 12C); only known from New Caledonia (Fig. 14)	***S. canalae* comb. nov.**
–	Abdomen with a rounded posterior end (Fig. 22A, B); pedipalp terminal apophysis without a basal prong (Fig. 22C); endemic to Lord Howe Island (Fig. 21)	***S. tartara* sp. nov.**
3	Median apophysis elongate, reaching past the tegulum's apical portion in dorsal view (Fig. 19D); terminal apophysis with a strong and elongated basal prong (Figs 3A–C, 19C)	***S. rueda* sp. nov.**
–	Median apophysis short, not reaching past the tegulum's apical portion; terminal apophysis basal prong short and not conspicuous (e.g., Fig. 2A, B)	**4**
4	Median apophysis with acute heavily sclerotised apical tip that points basally (Fig. 9C)	***S. brisbanae* comb. nov.**
–	Median apophysis tip blunt (Figs 6C, 17C)	**5**
5	Median apophysis elongate, apically pointing towards bulb; terminal apophysis apical process blunt and rounded (Figs 2A–C; 4, 6C)	***S. fuliginata* comb. nov.**
–	Pedipalp median apophysis short, not apically pointing towards bulb; terminal apophysis apical process very strong with a pointed tip (Fig. 17C)	***S. recherchensis* comb. nov.**

Females

1	Epigyne scape reaching past the posterior edge of the epigyne base (Fig. 13C–E); only known from New Caledonia (Fig. 14)	***S. canalae*** **comb. nov.**
–	Epigyne scape not reaching past posterior edge of the epigyne base (e.g., Figs 10C; 15C; 20C)	**2**
2	Epigyne base much longer than wide in ventral view (Figs 20C, 22C)	**3**
–	Epigyne base as long as wide or only slightly longer	**4**
3	Epigyne centrally with narrow ridge (Fig. 20C)	***S. rueda*** **sp. nov.**
–	Epigyne centrally without narrow ridge (Fig. 22C)	***S. tartara*** **sp. nov.**
4	Epigyne base almost round with narrow lateral borders; atrium without transverse ridges (Fig. 10C, E)	***S. brisbanae*** **comb. nov.**
–	Epigyne not round but irregular or ovoid, transverse ridges often present	**5**
5	Epigyne borders sinuous antero-laterally and atrium with two transverse ridges (Fig. 15C); only known from Papua New Guinea (Fig. 16)	***S. neneba*** **sp. nov.**
–	Epigyne base inconspicuous (Fig. 7F) or antero-laterally not sinuous (Fig. 18C)	**6**
6	Epigyne base inconspicuous as epigyne plate is hidden in abdomen due to a rotation of the epigyne into the abdomen; heart-shaped atrium (i.e. Fig. 7C) not exposed (Fig. 7F); scape generally intact	***S. fuliginata*** **comb. nov.**
–	Epigyne conspicuous with heart-shaped atrium exposed (Fig. 18C); scape generally broken off	***S. recherchensis*** **comb. nov.**

Salsa fuliginata **(L. Koch, 1871), comb. nov.**

Figs 1A–D, 2A–D, 4, 5A, 6A–D, 7A–F, 8

Epeira fuliginata Koch 1872: 106–107, plate 8, fig. 7, 7a, 7b.
Epeira rubicundula Keyserling 1887: 164–165, pl. 14, fig. 1, a, b. Syn. nov.
Araneus fuliginatus (L. Koch): Simon 1895: 804; Hogg 1900: 74; Rainbow 1911: 186; Bonnet 1955: 505.
Araneus rubicundulus (Keyserling): Rainbow 1911: 192.
Cyclosa fuliginata (L. Koch): Dondale 1966: 1162–1164, fig. 3G–J.

Type specimen. ***Holotype*** female, Sydney (33°52'S, 151°13'E, New South Wales, Australia) (NHMW-Zoo-Ar-29914). Photographs examined.

Holotype of *Epeira rubicundula* Keyserling, 1887, female, Sydney (3°53'S, 151°13'E, New South Wales, Australia). Depository unknown, not examined (see Remarks).

Other material examined. 162 males, 509 females (8 with egg sac), 105 juveniles (in 360 records) (see Suppl. material 1)

Diagnosis. The genital morphology of males of *S. fuliginata* comb. nov. is most similar to that of *S. recherchensis* comb. nov., however, the median apopohysis is relatively longer and more slender in *S. fuliginata* comb. nov. and the terminal apophysis lacks the

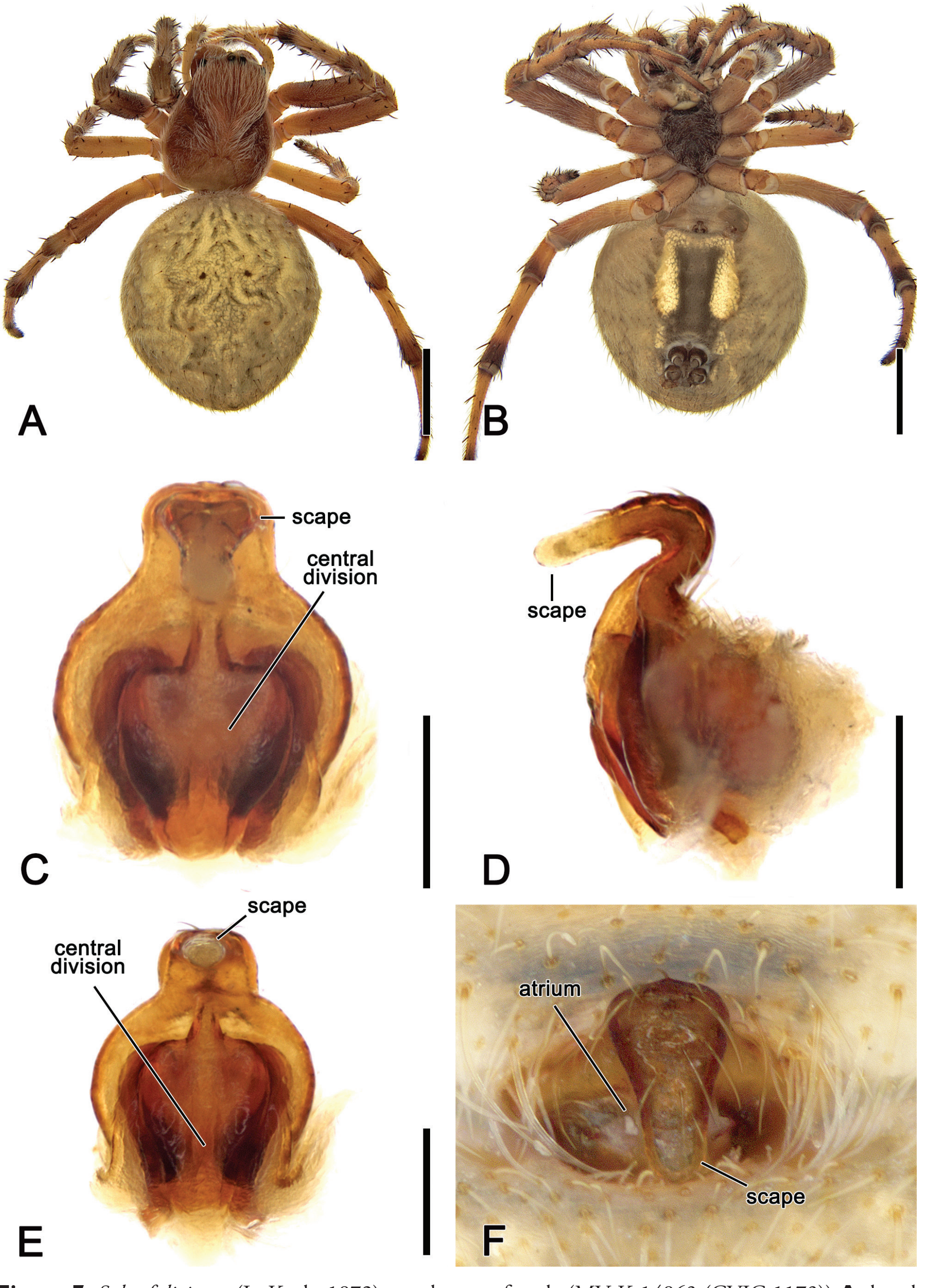

Figure 7. *Salsa fuliginata* (L. Koch, 1872), comb. nov., female (MV K-14863 (CVIC 1173)) **A** dorsal habitus **B** ventral habitus **C** epigyne, postero-ventral view **D** epigyne, lateral view **E** epigyne, posterior view **F** epigyne in situ, ventral view (MV K-4866). Scale bars: 2 mm (**A, B**); 0.2 mm (**C–E**).

distinct spine-like prong present in *S. recherchensis* comb. nov. (Fig. 6C vs. Fig. 17C). The epigyne of female *S. fuliginata* comb. nov. is most similar to that of S. *recherchensis* comb. nov., but in S. *fuliginata* comb. nov. the atrium is not visible due to a rotation of the epigyne into the abdomen (Fig. 7F), whereas the atrium is visible ventrally in *S. recherchensis* comb. nov. (Fig. 18C). In addition, the apical section of the scape is straight in lateral view in *S. fuliginata* comb. nov. (Fig. 7D), but curved in *S. recherchensis* comb. nov. (Fig. 18G).

Redescription. Male (based on MV K-14867 (CVIC 1163)): Total length 3.2. Carapace 1.8 long, 1.4 wide, dark orange-brown, with dark streaks from fovea and yellow setae throughout (Fig. 6A). Eye diameter AME 0.13, ALE 0.11, PME 0.07, PLE 0.07; row of eyes: AME 0.34, PME 0.32, PLE 0.83. Chelicerae orange-brown; with three promarginal teeth (median largest) and three retromarginal teeth (basal largest). Legs brown, femora basally, trochanters and coxae yellow-brown (Fig. 6A, B). Leg formula I > II > IV > III; length of segments (femur + patella + tibia + metatarsus + tarsus = total length): I – 2.2 + 0.9 + 1.6 + 1.7 + 0.7 = 7.1, II – 1.9 + 0.7 + 1.3 + 1.4 + 0.6 = 5.9, III – 1.2 + 0.4 + 0.7 + 0.8 + 0.4 = 3.5, IV – 1.7 + 0.6 + 1.0 + 1.1 + 0.6 = 5.0. Labium 0.22 long, 0.36 wide (Fig. 6B). Sternum 0.9 long, 0.7 wide and brown (Fig. 6B). Abdomen 1.6 long, 1.3 wide, dorsum beige with olive-grey irregular large folium, laterally dark brown mottled in black (Fig. 6A); venter dark brown with two elongate longitudinal white patches behind epigastric furrow (Fig. 6B). Pedipalp (Figs 2A–D, 4, 6C, D): length of segments (femur + patella + tibia + cymbium = total length): 0.4 + 0.2 + 0.2 + 0.5 = 1.3; paracymbium short and slightly curved; median apophysis basally pronounced with a reduced basal process, elongated and C-shaped with a blunt tip; conductor lobe robust, connecting to conductor basally of embolus; terminal apophysis sub-rectangular, bearing a thumb-like projection apically; conductor flat, poorly sclerotised; embolus elongate, pronounced and straight.

Female (based on MV K-14863 (CVIC1173)): Total length 9.0. Carapace 3.5 long, 2.7 wide; with colour as in male and covered by yellow setae (Fig. 7A). Eye diameter AME 0.18, ALE 0.16, PME 0.13, PLE 0.13; row of eyes: AME 0.50, PME 0.49, PLE 1.73. Chelicerae orange-brown, three promarginal teeth (median largest) and three retromarginal teeth of similar size. Legs orange-brown mottled in pale brown (Fig. 7A, B). Pedipalp length of segments (femur + patella + tibia + tarsus = total length): 1.0 + 0.5 + 0.6 + 1.1 = 3.2. Leg formula I > II > IV > III; length of segments (femur + patella + tibia + metatarsus + tarsus = total length): I – 3.5 + 1.6 + 2.9 + 2.9 + 1.1 = 12.0, II – 3.2 + 1.4 + 2.4 + 2.5 + 1.0 = 10.5, III – 2.0 + 1.0 + 1.2 + 1.2 + 0.7 = 6.1, IV – 3.1 + 1.3 + 2.2 + 2.4 + 0.8 = 9.8. Labium 0.49 long, 0.72 wide, dark brown; endites dark brown to brown (Fig. 7B). Sternum 1.6 long, 1.5 wide, dark brown with grey setae (Fig. 7B). Abdomen 5.4 long, 4.9 wide; dorsum and laterally olive-grey with dorsal darker folium pattern (Fig. 7A); venter dark olive-grey with lateral elongate ovoid pale bands connected with pale band behind epigastric furrow (Fig. 7B). Epigyne wider than long in ventral view (Fig. 7F); atrium/central division heart-shaped (Fig. 7C, E); scape elongate sub-triangular (Fig. 7C, F); spermathecae spherical and very large (Fig. 5A).

Variation. Total length males 3.2–5.5 (n = 7); females 4.5–9.2 (n = 10). As in many orb-weaving spiders, colour patterns in *S. fuliginata* comb. nov. can vary considerably,

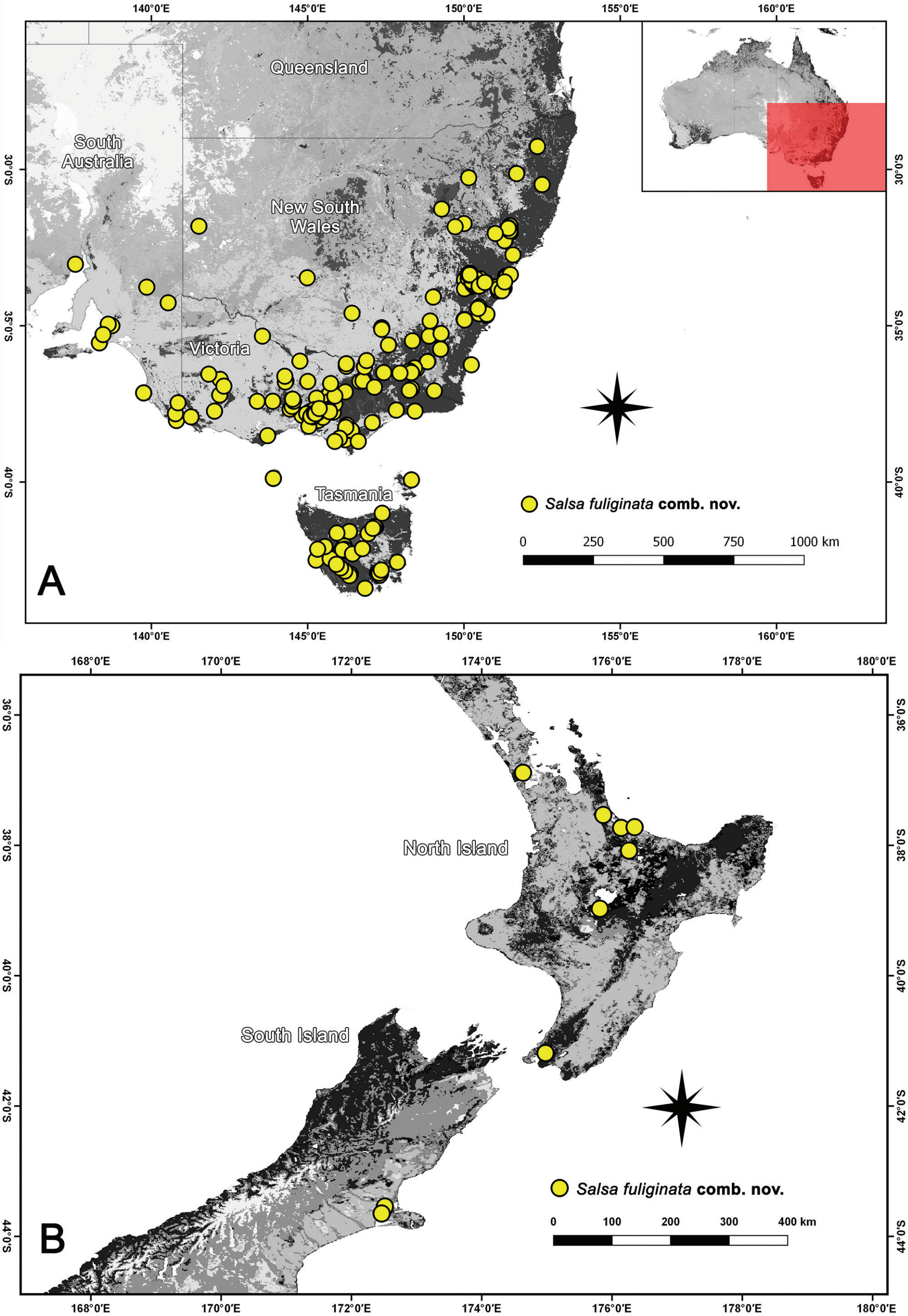

Figure 8. Distribution records of *Salsa fuliginata* (L. Koch, 1872), comb. nov. in Australia.

mainly in how distinct the folium is and how well it is delineated. Colour shades range from pale beige to orange- and reddish brown to dark brown (e.g., Fig. 1A–D).

Remarks. Renner (1988) listed a 'cotyp' in the Stuttgart Museum that was destroyed in WWII. However, the original description clearly states (L. Koch 1872, p. 107: "Von Sydney. Ein Exemplar im k. k. Museum zu Wien" (= From Sydney. One Specimen in the Vienna Museum), which means the female specimen present in the NHMW should be considered the single holotype and the specimen destroyed in the Stuttgart Museum was not of taxonomic relevance.

Rack (1961) listed a female collected in Sydney as holotype of *Epeira rubicundula* from the ZMH (Rack (1961)-catalogue no. 270). This specimen, however, does not match the original description by Keyserling (1887), but is clearly a female of *S. brisbanae* comb. nov. Keyserling's (1887) illustration of the female clearly shows the small subtriangular scape of *S. fuliginata* comb. nov. with a very small epigyne plate, also typical for that species. We could not find a female specimen in any historical collection (NHMUK, ZMH, ZMB) that matched the description of *E. rubicundula* and was labelled as such. We therefore consider the holotype of this species lost. The original description, however, leaves no doubt that this species is conspecific with *S. fuliginata* comb. nov. and we therefore consider *E. rubicundula* a junior synonym of *S. fuliginata* comb. nov.

Life history and habitat preferences. Mature males of *S. fuliginata* comb. nov. are more common from October to January, with much lower numbers occurring in other months, especially September and February. Very few adults were found between these two months, with no males recorded for August. Equally, females are spring/summer-mature, with the majority of specimens being collected between October and January, but with comparatively more specimens in September and February than males. Few females have been collected between February and September, but differently from males there are no specimens collected in July and one that was collected in August.

Salsa fuliginata comb. nov. does not seem to be very habitat-specific as it has been found in a variety of forests to more open habitats with lower vegetation. Habitat descriptions on labels with specimens include "dry sclerophyll forest", "open forest", "shrubs", and "bushes"; but also "garden" and "swamps".

Distribution. The distribution of *S. fuliginata* comb. nov. encompasses four Australian states: New South Wales, South Australia, Tasmania, and Victoria (Fig. 8A). This species is also found in New Zealand (Fig. 8B).

***Salsa brisbanae* (L. Koch, 1867), comb. nov.**

Figs 5B, 9A–D, 10A–E, 11

Epeira brisbanae Koch 1867: 176–177; Koch 1872: 111–112, plate 6, fig. 4; Keyserling 1887: 161–164, plate 13, figs 6, 6a–d, 7, 7a.

Araneus brisbanae (L. Koch): Simon 1895: 804; Rainbow 1911: 183; Dalmas 1917: 387–388.

Araneus brisbanensis (L. Koch): Bonnet 1955: 448.

Type specimen. ***Holotype*** of *Epeira brisbanae* L. Koch, 1872, female, Brisbane (27°28'S, 153°01'E, Queensland, Australia) (ZMH (Rack 1961)-catalogue no. 226). Examined.

Other material examined. 57 males, 208 females (2 with egg sac), 39 juveniles (in 146 records) (see Suppl. material 1).

Diagnosis. Male *S. brisbanae* comb. nov. can be distinguished from all other *Salsa* gen. nov. species by the unique morphology of the pedipalp median apophysis that has a very acute, basally pointed tip (Fig. 9C) (median apophysis generally rounded C-shaped in all other species). Female genitalia are probably most similar to those of S. *canalae* comb. nov., but the scape of *S. brisbanae* comb. nov. is shorter than the epigyne plate (Fig. 10C), whereas it is longer than the plate in *S. canalae* comb. nov. (Fig. 13C, D).

Redescription. Male (based on NHMD 12231). Total length 4.4. Carapace 2.3 long, 1.9 wide, dark brown, slightly paler anteriorly (Fig. 9A). Eye diameter AME 0.12, ALE 0.11, PME 0.14, PLE 0.09; row of eyes: AME 0.32, PME 0.33, PLE 0.90. Chelicerae pale brown; with three promarginal teeth (median largest) and three retromarginal teeth (basal largest). Legs brown, femora basally yellow-brown (Fig. 9A, B). Leg formula I > II > IV > III; length of segments (femur + patella + tibia + metatarsus + tarsus = total length): I – 2.5 + 1.1 + 2.0 + 1.6 + 0.7 = 7.9, II – 2.2 + 1.0 + 1.4 + 1.5 + 0.6 = 6.7, III – 1.4 + 0.6 + 0.7 + 0.7 + 0.5 = 3.9, IV – 2.0 + 0.7 + 1.3 + 1.4 + 0.6 = 6.0. Labium 0.27 long, 0.35 wide, brown; endites beige (Fig. 9B). Sternum 1.1 long, 0.7 wide, dark brown with black radial shading (Fig. 9B). Abdomen 2.1 long, 1.7 wide, posteriorly pointed; dorsum with beige background and large, irregular, olive-grey, folium, laterally pale olive-grey with black streaks (Fig. 9A); venter dark grey, laterally with two elongate white bands (Fig. 9B). Pedipalp (Fig. 9C, D) length of segments (femur + patella + tibia + cymbium = total length): 0.3 + 0.2 + 0.1 + 0.65 = 1.25; paracymbium strong and curved apically; median apophysis transverse, terminating in an acute and basally pointed tip; denticles in basal arch of median apophysis distinct; conductor lobe narrow; terminal apophysis enlarged, sub-rectangular, bearing a reduced basal prong; conductor bilobed; embolus short, heavily sclerotised.

Female (based on AM KS.131087): Total length 6.9. Carapace 3.0 long, 2.3 wide; dark brown, cephalic area paler (Fig. 10A). Eye diameter AME 0.14, ALE 0.09, PME 0.07, PLE 0.07; row of eyes: AME 0.41, PME 0.38, PLE 1.35. Chelicerae orange-brown, four promarginal teeth (apical and second basal largest) and three retromarginal teeth of similar size. Legs brown, patellae and tibiae apically slightly darker (Fig. 10A, B). Pedipalp length of segments (femur + patella + tibia + tarsus = total length): 0.9 + 0.5 + 0.5 + 1.0 = 2.9. Leg formula I > II > IV > III; length of segments (femur + patella + tibia + metatarsus + tarsus = total length): I – 2.4 + 1.1 + 1.8 + 1.9 + 0.9 = 8.1, II – 2.1 + 1.1 + 1.5 + 1.7 + 0.7 = 7.1, III – 1.2 + 0.7 + 0.8 + 0.8 + 0.5 = 4.0, IV – 2.1 + 1.0 + 1.4 + 1.5 + 0.6 = 6.6. Labium 0.36 long, 0.59 wide, dark brown; endites dark brown (Fig. 10B). Sternum 1.3 long, 1.1 wide, orange-brown, with some paler discolourations (Fig. 10B). Abdomen 4.7 long, 4.6 wide; dorsum beige with olive-brown folium, laterally covered by orange-brown streaks (Fig. 10A); venter olive-grey centrally with

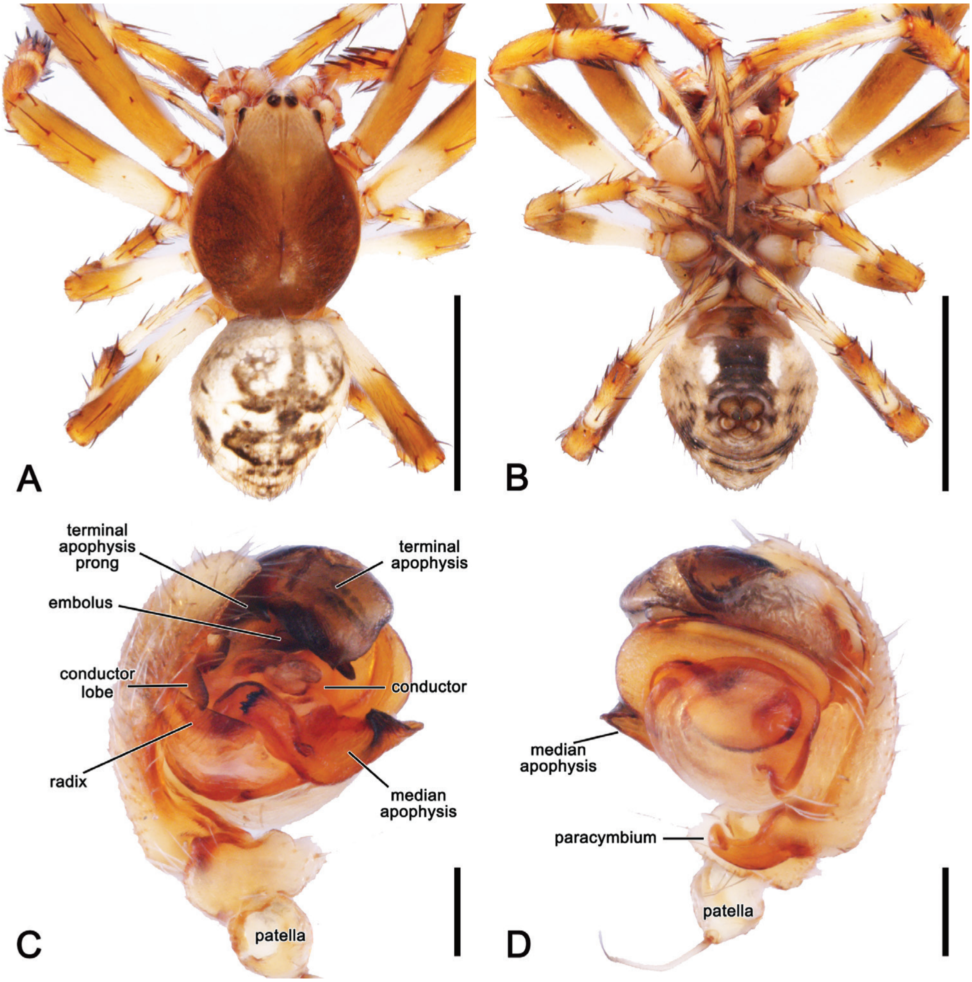

Figure 9. *Salsa brisbanae* (L. Koch, 1867), comb. nov., male (NHMD 12231) **A** dorsal habitus **B** ventral habitus **C** left pedipalp, ventral view **D** left pedipalp, dorsal view. Scale bars: 2 mm (**A, B**); 0.2 mm (**C, D**).

paler mottles, laterally with elongate white bands (Fig. 10B). Epigyne base almost circular, slightly wider than long, with narrow elevated borders and therefore atrium extends almost over whole base (Fig. 10C); scape slightly less than half of epigyne base, slightly wrinkled and its sides parallel (Fig. 10C); central division wide and abruptly tapering dorsally; spermathecae narrow pointing apically (Fig. 5B).

Variation. Only one other male was measured, total length 3.9; females total lengths 6.9–7.9 (n = 4). Like in other species of the genus, the colour variations in *S. brisbanae* comb. nov. can be considerable and range from pale to dark brown tones in live specimens with the folium pattern on the abdomen more or less distinct.

Life history and habitat preferences. Male and female specimens of *S. brisbanae* comb. nov. have mainly been found between October and May, with only few

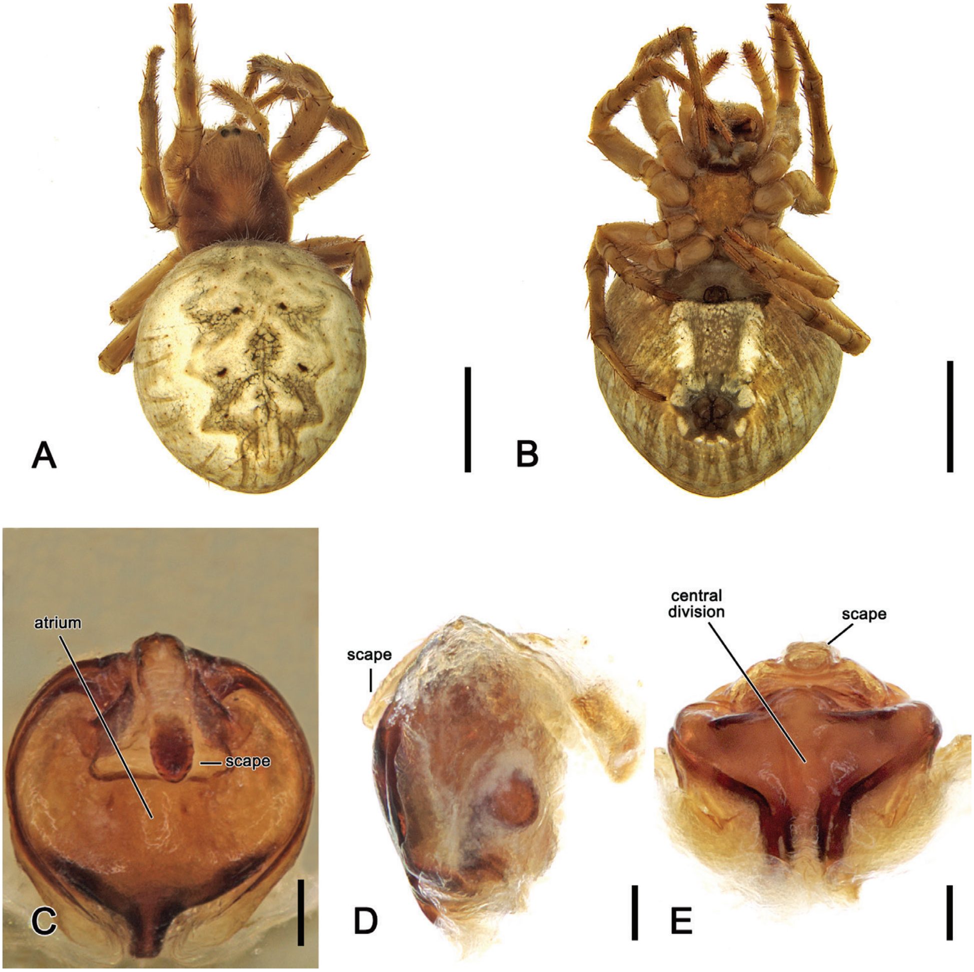

Figure 10. *Salsa brisbanae* (L. Koch, 1867), comb. nov., female (AM KS.131087) **A** dorsal habitus **B** ventral habitus **C** epigyne, ventral view **D** epigyne, lateral view **E** epigyne, posterior view. Scale bars: 2 mm (**A, B**); 0.2 mm (**C–E**).

specimens collected from June to September. Although mature spiders can therefore be found all year round, the species should be considered as mainly late-summer to autumn mature. Most specimens were apparently collected on leaves and bark as labels indicate sweeping and beating as the main collection techniques that were used to capture the spiders.

Salsa brisbanae comb. nov. does not seem to be very habitat-specific, with specimens being collected in completely different environments, mostly in lower vegetation. Habitat descriptions on labels with specimens include “rainforest”, “shrubs”, “grass”, and “foliage”; but also “dune” and “lagoon vegetation”. Plant species that were cited at collection sites include *Acacia longifolia* (long-leaved wattle), *Leptospermum laevigatum* (coast tea tree), and *Monotoca elliptica* (tree broom heath).

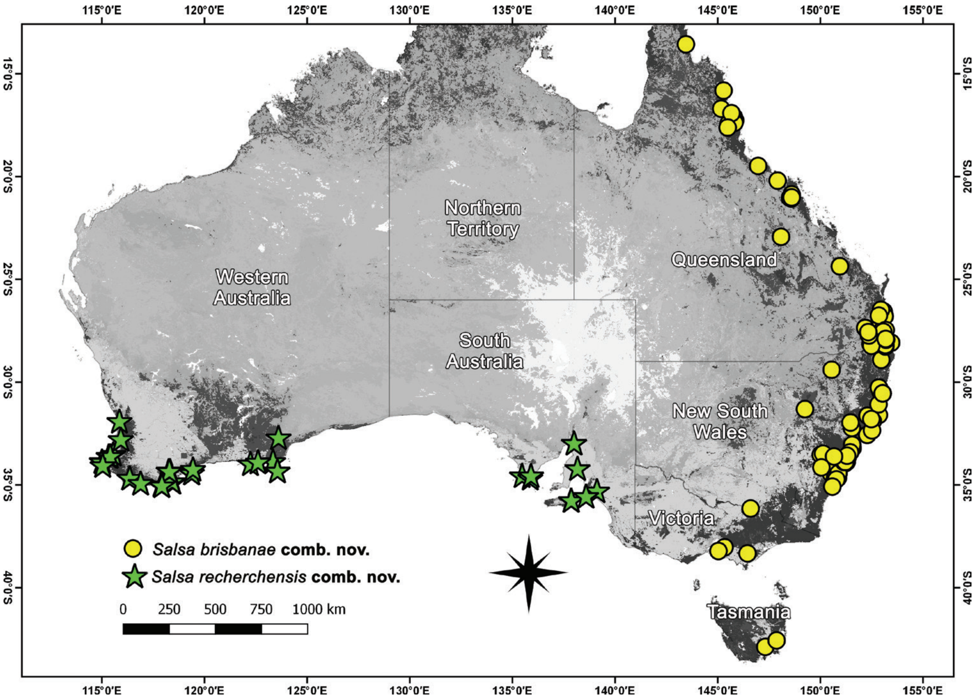

Figure 11. Distribution records of *Salsa brisbanae* (L. Koch, 1867), comb. nov. and *Salsa recherchensis* (Main, 1954), comb. nov. in Australia.

Distribution. *Salsa brisbanae* comb. nov. occurs in Queensland, New South Wales, Victoria and Tasmania (Fig. 11). The species was recorded by Keyserling (1887) from New Zealand (see also Dalmas 1917), but this record is likely based on a misidentification (Paquin et al. 2008). The species was apparently also recorded from Papua New Guinea (World Spider Catalog 2022), but we could not find any original citation that suggests this distribution.

***Salsa canalae* (Berland, 1924), comb. nov.**
Figs 5C, 12A–D, 13A–F, 14

Araneus canalae Berland 1924: 222, fig. 126, 127; Berland 1931: 666; Berland 1932: 296, 298–299.
Araneus canalensis Berland. Bonnet 1955: 459.

Type specimen. ***Holotype*** female, Mount Canala (21°31'S, 165°58'E, New Caledonia), F. Sarasin and J. Roux (NHMB 979a). Photographs examined.

Other material examined. 1 male, 7 females (in 8 records)(see Suppl. material 1).

Diagnosis. Males of *S. canalae* comb nov. shares with *S. tartara* sp. nov. two patellar setae on the pedipalp (Fig. 12C, D vs. Fig. 22C, D). However, *S. canalae* comb nov. is distinguished by prominent, heavily sclerotised conductor of *S. tartara* sp. nov. which is short and inconspicuous in *S. canalae* comb. nov. Female genitalia are most similar to those of *S. brisbanae* comb. nov., but differ from those and other *Salsa* gen. nov. species by the epigyne scape, that is longer than the epigyne plate and exceeds its posterior margin (Fig. 13C, D).

Redescription. Male (based on WAM T75922) Total length 5.5. Carapace 2.9 long, 2.5 wide, pear-shaped and pale brown, covered with short white setae (Fig. 12A). Eye diameter AME 0.20, ALE 0.18, PME 0.13, PLE 0.11; row of eyes: AME 0.54, PME 0.47, PLE 1.22. Chelicerae yellowish brown; with four promarginal teeth (second basal largest) and three retromarginal teeth (basal largest). Legs yellowish brown mottled in pale brown, bearing thick setae on patella, tibia and metatarsus (Fig. 12A, B). Leg formula I > II > IV > III; length of segments

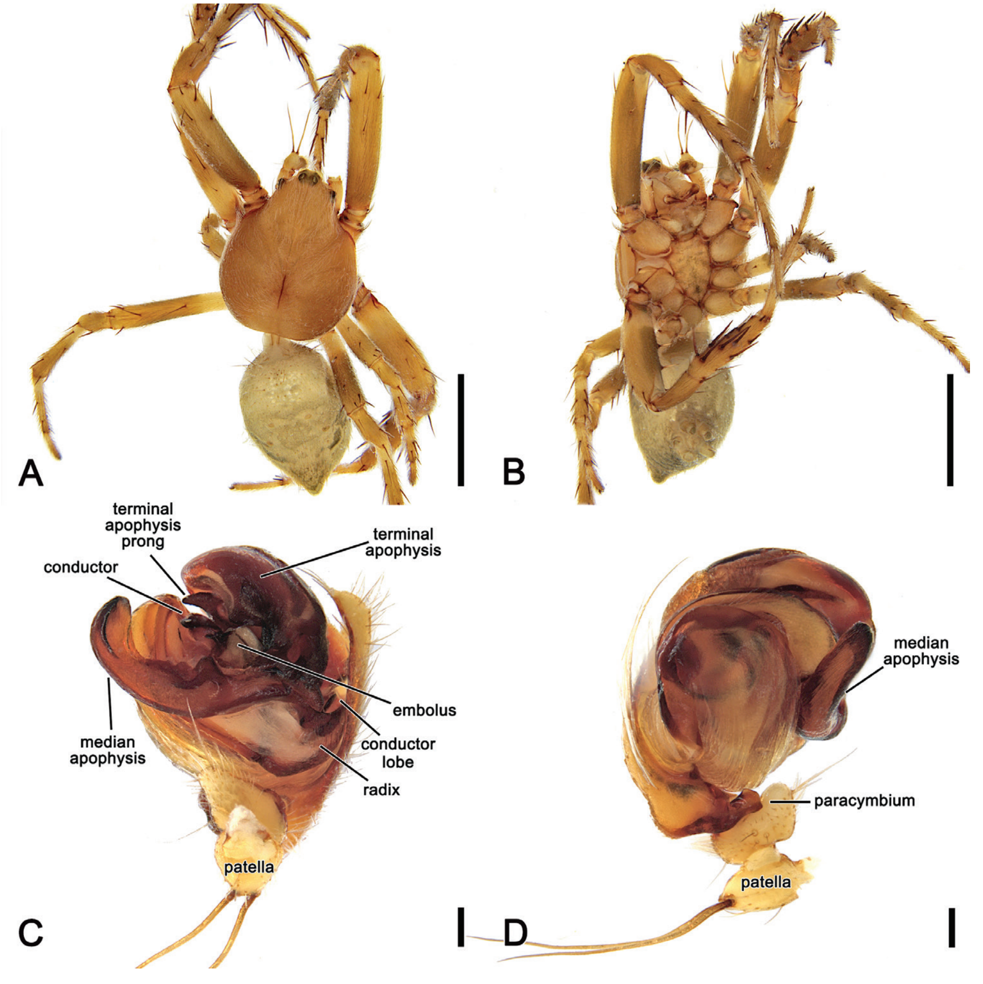

Figure 12. *Salsa canalae* Berland, 1924, comb. nov., male (WAM T75922) **A** dorsal habitus **B** ventral habitus **C** left pedipalp, ventral view **D** left pedipalp, dorsal view. Scale bars: 2 mm (**A, B**); 0.2 mm (**C, D**).

(femur + patella + tibia + metatarsus + tarsus = total length): I – 2.8 + 1.2 + 2.2 + 1.7 + 0.9 = 8.8, II – 2.2 + 1.0 + 1.6 + 1.6 + 0.8 = 7.2, III – 1.4 + 0.6 + 0.8 + 0.8 + 0.5 = 4.1, IV – 2.1 + 0.9 + 1.5 + 1.5 + 0.7 = 6.7. Labium 0.31 long, 0.47, and endites yellowish brown, paler anteriorly (Fig. 12B). Sternum 1.3 long, 0.8 wide, yellowish brown mottled dark and bearing dark brown contour (Fig. 12B). Abdomen 2.5 long, 1.8 wide, with pointed conical posterior portion after spinnerets, dorsum, sides, and venter beige mottled in grey (Fig. 12A, B). Pedipalp (Fig. 12C, D) length of segments (femur + patella + tibia + cymbium = total length): 0.5 + 0.2 + 0.15 + 0.9 = 1.75; patella with two setae; paracymbium reduced and straight; median apophysis elongated, with a thick basal process, a notched apical section on an acute and apically curved rounded tip; conductor lobe small; terminal apophysis subrectangular, apically projected and inflated, bearing a finger-like lobe from its basis; conductor flat with sclerotised borders; embolus short and strong, very sclerotised.

Female (based on WAM T75921): Total length 8.3. Carapace 3.5 long, 3.1 wide; dark brown and bearing long white setae throughout (Fig. 13A). Eye diameter AME 0.20, ALE 0.18, PME 0.14, PLE 0.13; row of eyes: AME 0.52, PME 0.45, PLE 1.88. Chelicerae dark brown, four promarginal teeth (apical and basal largest), and three retromarginal (basal largest). Legs orange-brown, slightly darker on femur and joints (Fig. 13A, B). Pedipalp length of segments (femur + patella + tibia + tarsus = total length): 1.0 + 0.5 + 0.7 +1.1 = 3.3. Leg formula I > II > IV > III; length of segments (femur + patella + tibia + metatarsus + tarsus = total length): I – 3.2 + 1.4 + 2.7 + 2.4 + 1.1 = 10.8, II – 2.8 + 1.5 + 2.2 + 2.2 + 0.9 = 9.6, III – 1.9 + 0.9 + 1.0 + 1.0 + 0.7 = 5.5, IV – 2.8 + 1.2 + 2.0 + 2.1 + 0.9 = 9.0. Labium 0.54 long, 0.86 wide and endites dark brown, beige on anterior border (Fig. 13B). Sternum 1.5 long, 1.5 wide and brown (Fig. 13B). Abdomen 5.5 long, 5.2 wide; dorsum with beige background brindled in olive-grey (Fig. 13A); sides olive-grey (Fig. 13B); venter olive-grey with two thick rounded white patches (Fig. 13B). Epigyne subquadrate with broadly rounded antero-lateral borders and wide atrium and basis (Fig. 13C, D); scape almost twice the length of epigyne base, from a slightly wide base gradually narrowing a thin section (Fig. 13C–E); central division goblet-like, very wide anteriorly, ca. as wide as the epigyne base, and tapering basally (Fig. 13F); spermathecae oval and apart by more than its diameter (Fig. 5C).

Variation. Only one male was available for measurements (see above); female total lengths 5.8 and 6.4 (n = 2). All our specimens were of very similar colouration, but Berland (1932) reported numerous females with considerable colour variations, specifically of the abdomen, without providing any further detail.

Life history and habitat preferences. The mature male described here was found in April, mature females examined between February and June; however, specimen numbers are too small to confidently interpret the phenology of the species. There was no information on habitat with any specimen labels.

Distribution. Distributed throughout New Caledonia (Fig. 14), including Nouméa (cited in Berland 1932).

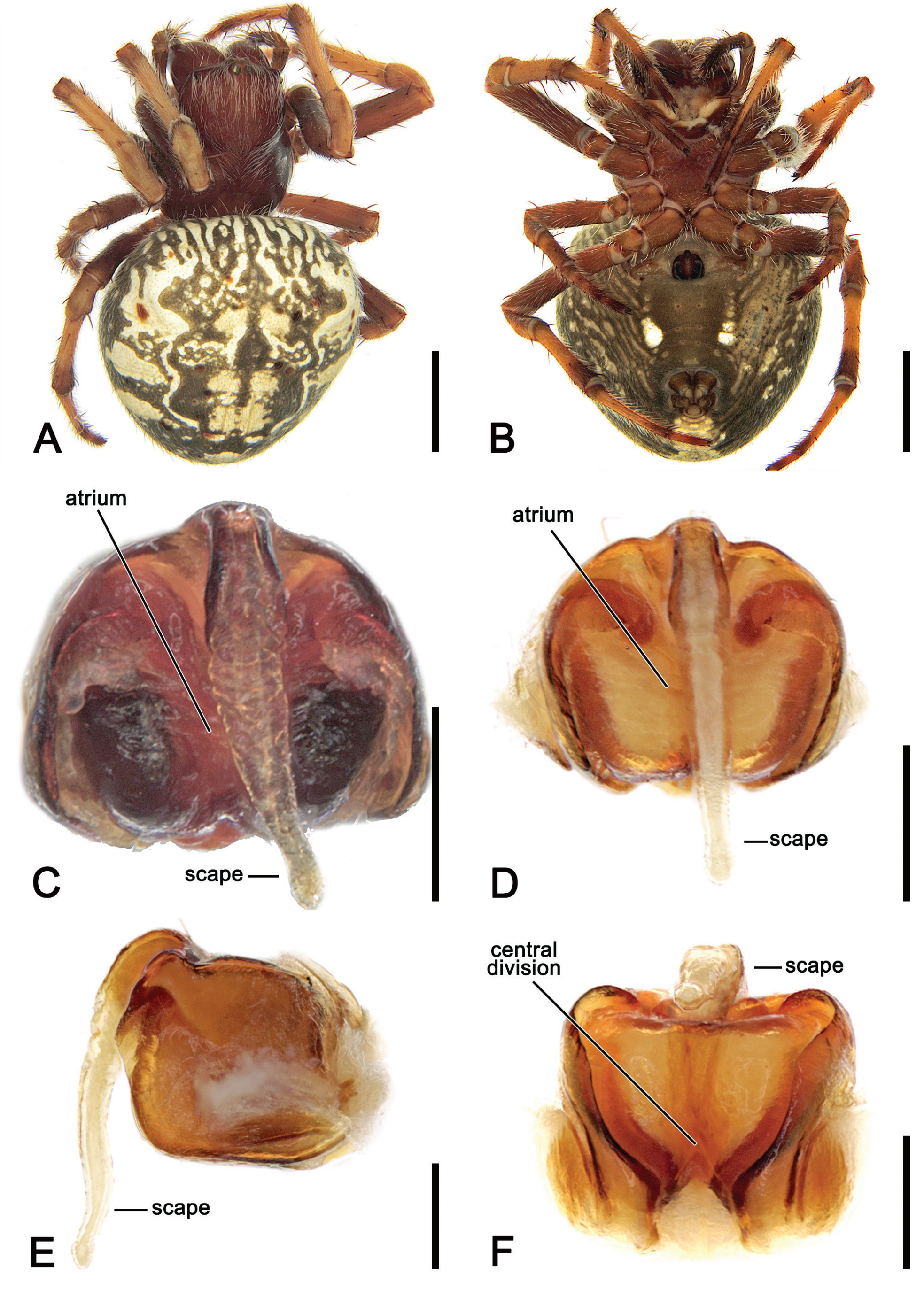

Figure 13. *Salsa canalae* Berland, 1924, comb. nov., female **A** dorsal habitus (WAM T75921) **B** ventral habitus (WAM T75921) **C** epigyne, ventral view (WAM T75921) **D** epigyne variation, ventral view (WAM T75923) **E** epigyne variation, lateral view (WAM T75923) **F** epigyne variation, posterior view (WAM T75923). Scale bars: 2 mm (**A, B**); 0.2 mm (**C–F**).

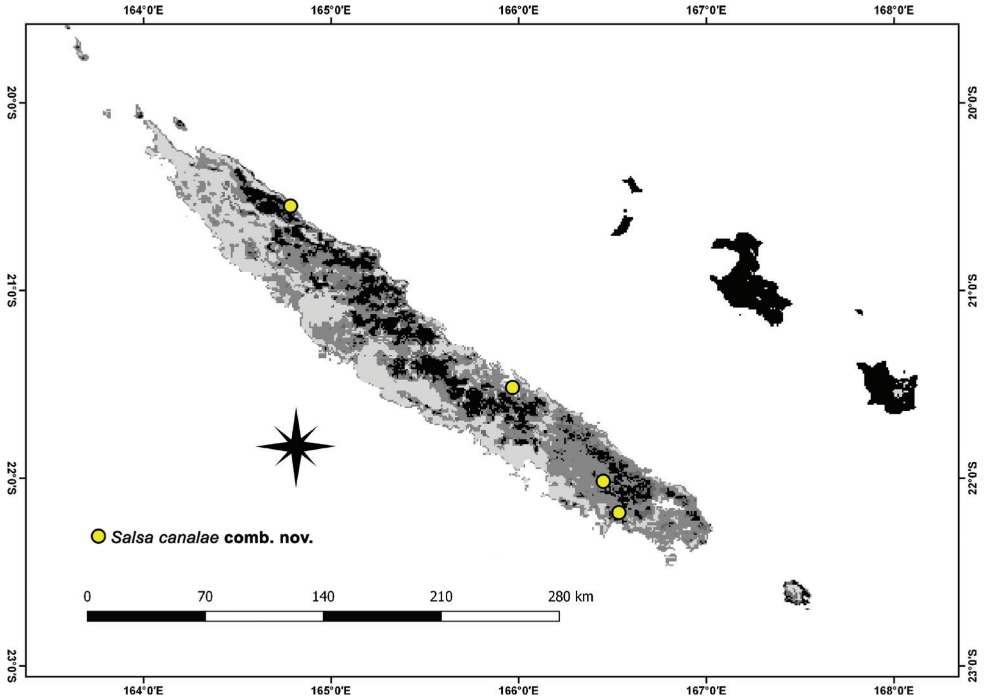

Figure 14. Distribution records of *Salsa canalae* Berland, 1924, comb. nov. in New Caledonia.

Salsa neneba **sp. nov.**
http://zoobank.org/BB329767-2803-47B2-9EF1-EDD0D35CE775
Figs 15A–C, 16

Type specimen. ***Holotype*** female, Neneba (8°45'S, 147°30'E, Papua New Guinea), 9 November 1896 (QM S111920).

Other material examined. Only known from holotype.

Etymology. The specific epithet is a noun in apposition referring to the type locality.

Diagnosis. Males of *S. neneba* sp. nov. are unknown. Genitalia of female specimens of *S. neneba* sp. nov. can be recognised by the somewhat sinuous antero-lateral edges of the epigyne plate and the transverse edges in the atrium (Fig. 15C).

Description. Male. Unknown.

Female (based on holotype, QM S111920): Total length 10.5. Carapace 4.5 long, 3.2 wide; dark reddish brown and covered by white setae anteriorly from fovea (Fig. 15A). Eye diameter AME 0.23, ALE 0.18, PME 0.20, PLE 0.16; row of eyes: AME 0.68, PME 0.56, PLE 2.25. Chelicerae reddish brown, four promarginal teeth (apical and second basal largest) and three retromarginal teeth (apical smallest). Legs yellowish brown, femora slightly darker (Fig. 15A, B). Pedipalp length of segments (femur + patella + tibia + tarsus = total length): 1.2 + 0.5 + 0.8 + 1.1 = 3.6. Leg formula I > II > IV > III; length of segments (femur + patella + tibia + metatarsus + tarsus = total length): I – 3.8 + 1.7 + 3.2 + 2.8 + 1.0 = 12.5, II

– 3.5 + 1.6 + 2.6 + 2.6 + 0.9 = 11.2, III – 2.1 + 1.0 + 1.2 + 1.3 + 0.7 = 6.3, IV – 3.3 + 1.4 + 2.3 + 2.3 + 0.8 = 10.1. Labium 0.58 long, 0.77 wide, reddish brown; endites reddish brown (Fig. 15B). Sternum 2.0 long, 1.8 wide, reddish brown (Fig. 15B). Abdomen 6.1 long, 5.0 wide; posterior hump distinct (Fig. 15A, B); dorsum colouration poorly preserved, beige with indistinct greyish folium pattern (Fig. 15A); venter olive-brown with two spindle-shaped pale lateral bands (Fig. 15B). Epigyne ca. as long as wide, with sinuous antero-lateral borders and transvers ridges within the atrium (Fig. 15C); scape slightly longer than half the length of the epigyne base, slightly narrowest centrally (Fig. 15C); epigyne not dissected to investigate posterior and internal morphology as only known from fragile holotype.

Variation. Only known from holotype.

Life history and habitat preferences. Unknown.

Distribution. Currently only known from type locality, Neneba in Papua New Guinea (Fig. 16).

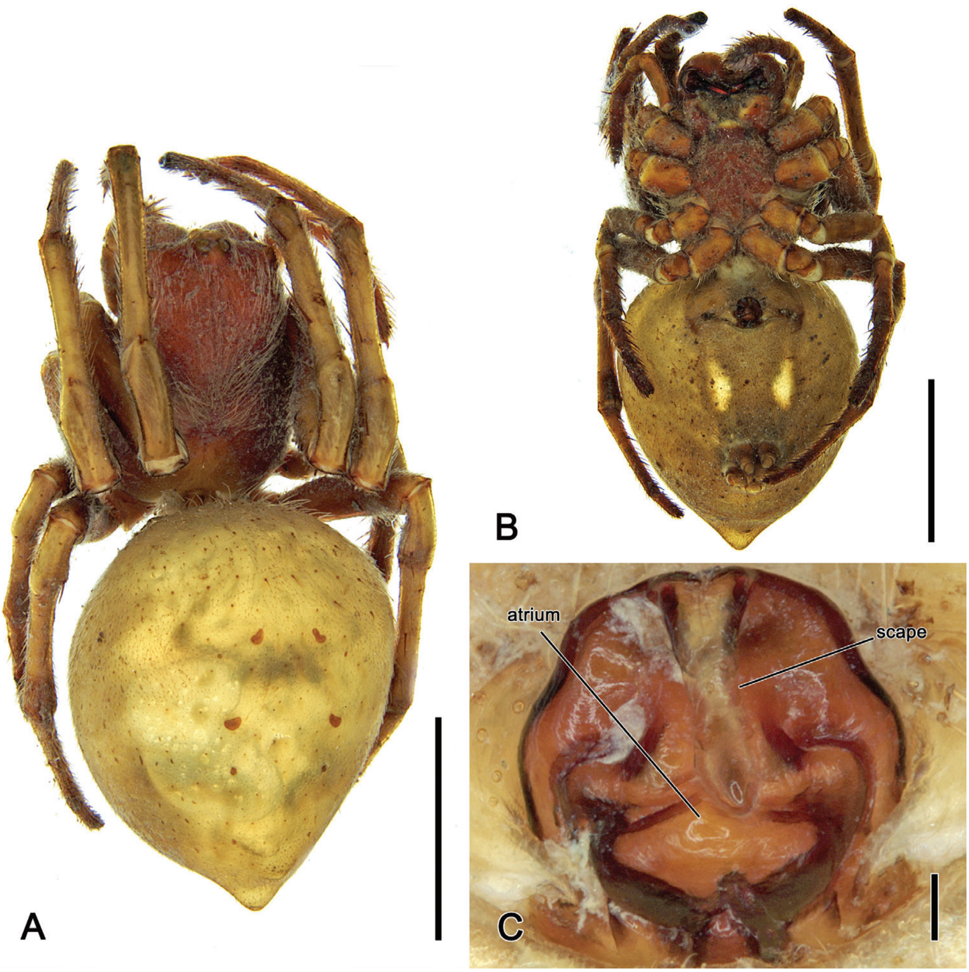

Figure 15. *Salsa neneba* sp. nov., female holotype (QM S111920) **A** dorsal habitus **B** ventral habitus **C** epigyne, ventral view. Scale bars: 5 mm (**A, B**); 0.1 mm (**C**).

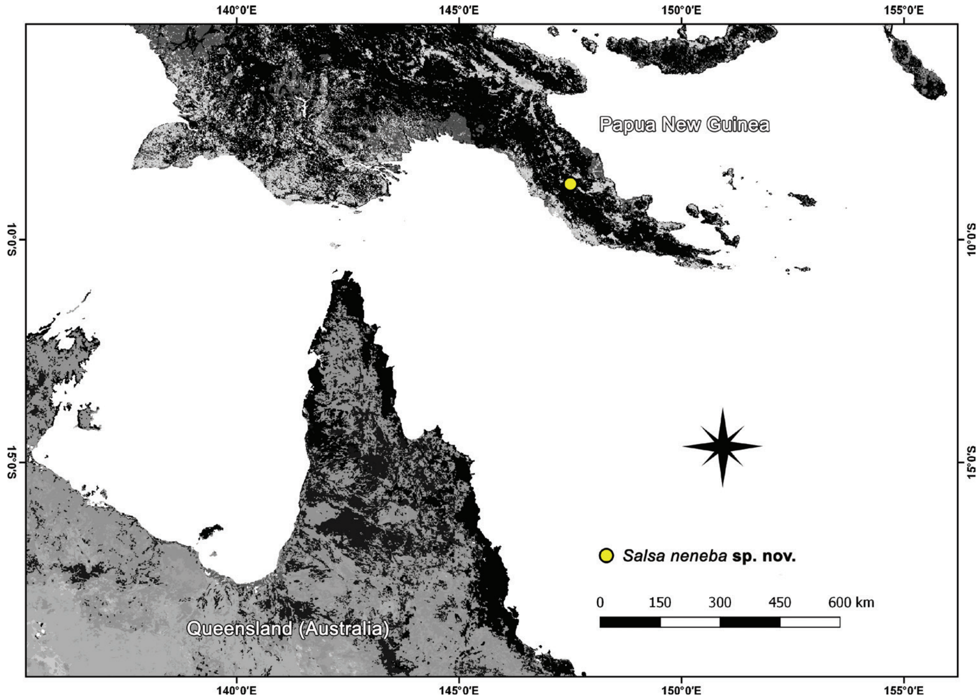

Figure 16. Distribution records of *Salsa neneba* sp. nov.

Salsa recherchensis **(Main, 1954), comb. nov.**
Figs 5D, 11, 17A–D, 18A–G

Aranea recherchensis Main 1954: 41, pl. 3, figs 5, 8.

Type specimen. ***Holotype*** female, Figure of Eight Island, Recherche Archipelago, (34°01'S, 122°14'E, Western Australia, Australia), 7 November 1950, V. Serventy (WAM 55/4984). Examined.

Other material examined. 34 males, 321 females, 175 juveniles (in 74 records) (see Suppl. material 1).

Diagnosis. The genital morphology of male *S. recherchensis* comb. nov. is most similar to that of *S. fuliginata* comb. nov.; however, *S. recherchensis* comb. nov. males can be distinguished by the comparatively shorter median apophysis and the distinct basal spine-like prong on the terminal apophysis (Fig. 6C vs. Fig. 17C). The epigyne of female *S. recherchensis* comb. nov. is most similar to that of S. *fuliginata* comb. nov. However, in ventral view, the epigyne plate of *S. fuliginata* comb. nov. is inconspicuous (Fig. 7F), whereas it is pronounced in *S. recherchensis* comb. nov. (Fig. 18C).

Redescription. Male (based on WAM T73696). Total length 5.1. Carapace 2.9 long, 2.4 wide, brown, paler in cephalic area and with yellowish setae throughout (Fig. 17A). Eye diameter AME 0.18, ALE 0.14, PME 0.09, PLE 0.09; row of eyes: AME 0.50, PME 0.43, PLE 1.39. Chelicerae brown; with four promarginal teeth (second basal and apical largest) and three retromarginal teeth (basal largest). Legs brown, femora basally yellow-brown, except in leg I (Fig. 17A, B). Leg formula I > II > IV > III; length of segments (femur + patella + tibia + metatarsus + tarsus = total length): I – 4.2 + 1.6 + 3.2 + 3.3 + 1.0 = 13.3, II – 3.4 + 1.3 + 2.2 + 2.8 + 1.0 = 10.7, III – 2.2 + 0.9 + 1.1 + 1.4 + 0.7 = 6.3, IV – 3.2 + 1.1 + 2.2 + 2.5 + 0.9 = 10.0. Labium 0.34 long, 0.56 wide, brown; endites orange-brown (Fig. 17B). Sternum 1.5 long, 1.0 wide, brown (Fig. 17B). Abdomen 2.3 long, 2.1 wide, dorsum with dark grey, irregular folium on a beige background, laterally olive-grey (Fig. 17A); venter olive-grey, laterally with two elongate, curved longitudinal bands (Fig. 17B). Pedipalp length of segments (femur + patella + tibia + cymbium = total length): 0.6 + 0.2 + 0.15 + 0.8 = 1.75; paracymbium stout and slightly curved apically (Fig. 17D); median apophysis short with thick rounded tip, numerous small teeth-like tubercles inside basal

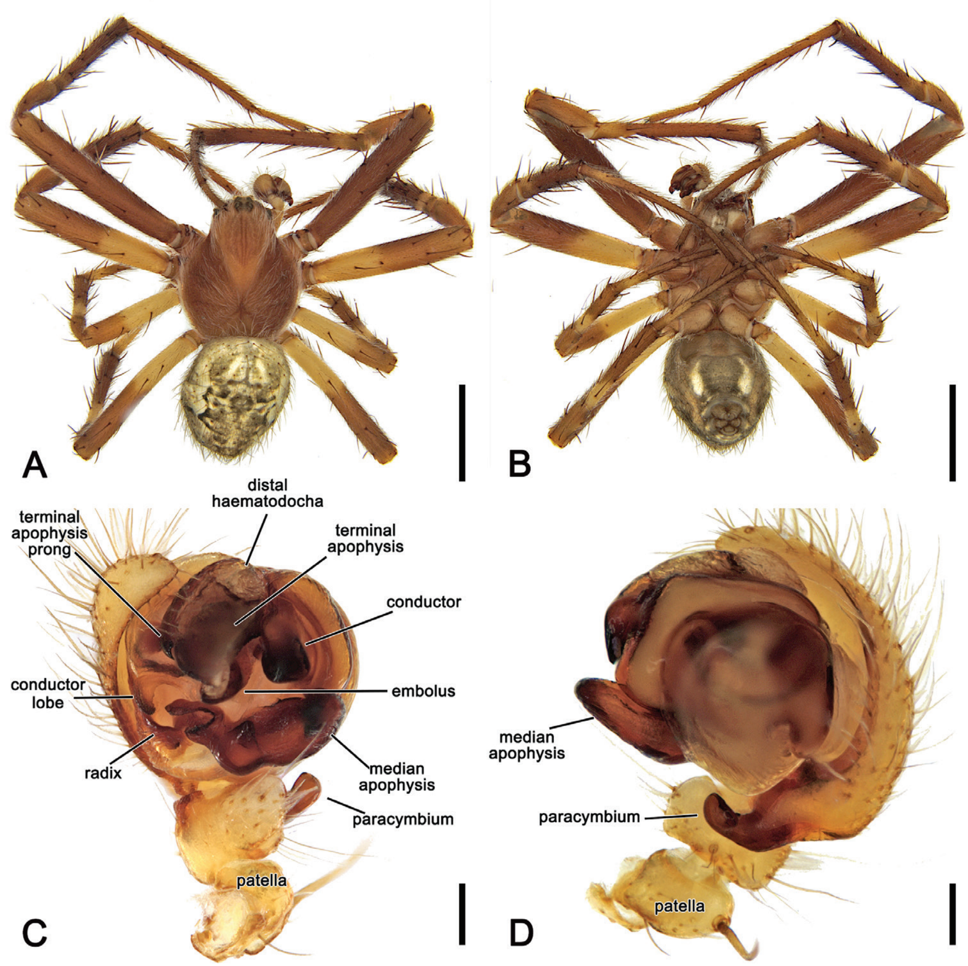

Figure 17. *Salsa recherchensis* (Main, 1954), comb. nov., male (WAM T77696) **A** dorsal habitus **B** ventral habitus **C** left pedipalp, ventral view **D** left pedipalp, dorsal view. Scale bars: 2 mm (**A, B**); 0.2 mm (**C, D**).

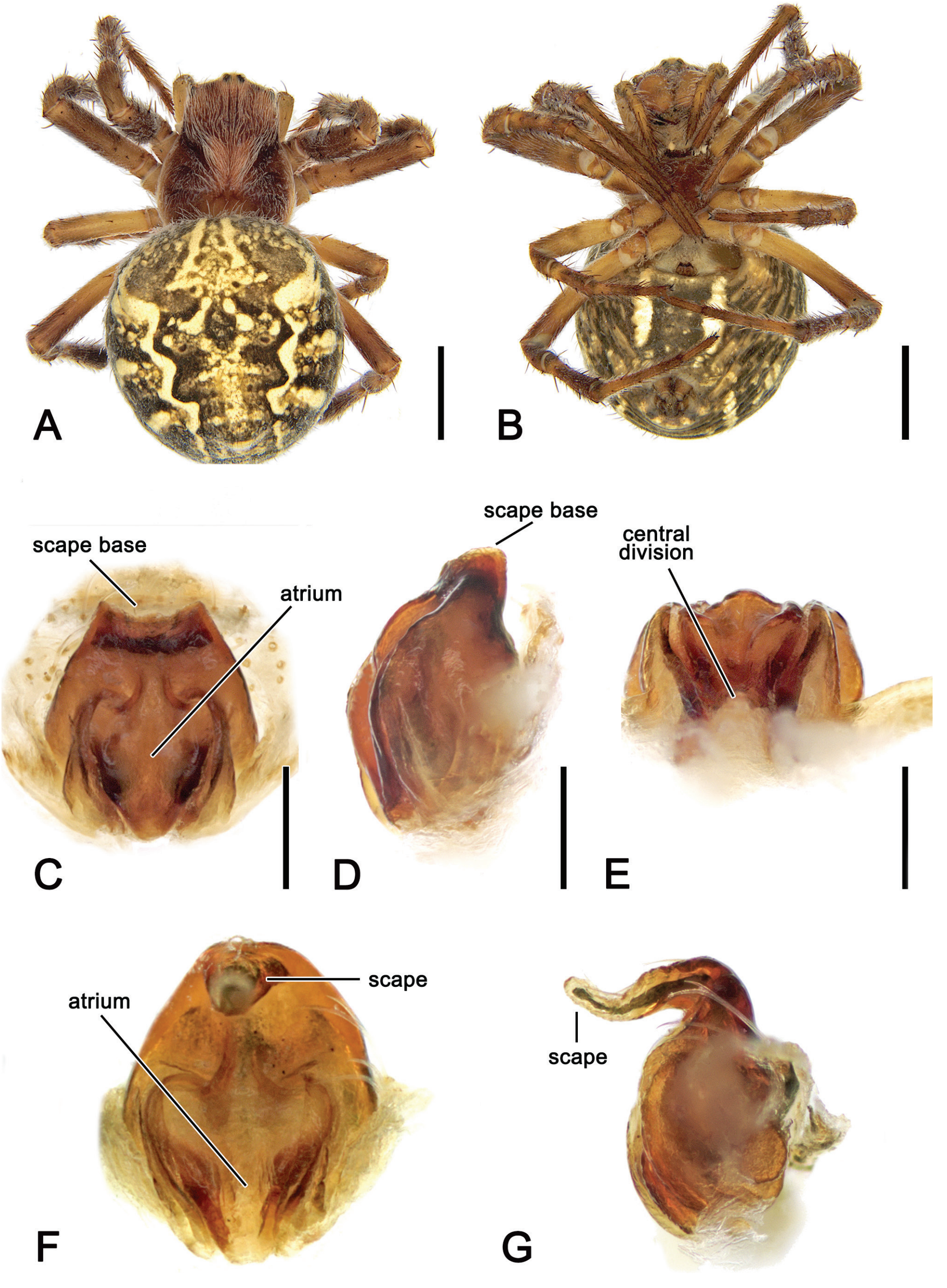

Figure 18. *Salsa recherchensis* (Main, 1954), comb. nov., female (WAM T77362) **A** dorsal habitus **B** ventral habitus **C** epigyne, ventral view **D** epigyne, lateral view **E** epigyne, posterior view **F** variation of epigyne, ventral view (WAM 92/2120) **G** variation of epigyne, lateral view (WAM 92/2120). Scale bars: 2 mm (**A, B**); 0.2 mm (**C–E**).

arch (Fig. 17C); conductor lobe short (Fig. 17C); terminal apophysis conspicuous, subrectangular and bearing spine-like basal prong (Fig. 17C); conductor slightly folding over itself, broadly lapped and heavily sclerotised (Fig. 17C, D); embolus short (Fig. 17C).

Female (based on WAM T77362): Total length 8.0. Carapace 3.7 long, 2.7 wide; similar to male but slightly darker and more setae (Fig. 18A). Eye diameter AME 0.20, ALE 0.18, PME 0.13, PLE 0.11; row of eyes: AME 0.52, PME 0.47, PLE 1.76. Chelicerae pale brown, four promarginal teeth (apical and second basal largest) and three retromarginal teeth (basal largest). Legs pale brown mottled in dark (Fig. 18A, B). Pedipalp length of segments (femur + patella + tibia + tarsus = total length): 0.9 + 0.5 + 0.7 + 1.1 = 3.2. Leg formula I > II > IV > III; length of segments (femur + patella + tibia + metatarsus + tarsus = total length): I – 3.4 + 1.5 + 2.7 + 2.9 + 1.1 = 11.6, II – 2.8 + 1.3 + 2.3 + 2.4 + 1.0 = 9.8, III – 2.0 + 1.0 + 1.3 + 1.3 + 0.7 = 6.3, IV – 3.0 + 1.2 + 2.0 + 2.2 + 0.8 = 9.2. Labium 0.34 long, 0.72 wide, dark brown; endites dark brown (Fig. 18B). Sternum 1.5 long, 1.4 wide, dark brown (Fig. 18B). Abdomen 5.1 long, 4.7 wide; folium pattern as in male, but more distinct (Fig. 18A, B). Epigyne base slightly longer than wide; atrium heart-shaped (Fig. 18C); central division ca. as wide as the epigyne base, slightly narrowing dorsally (Fig. 18E); spermathecae spherical (Fig. 5D); scape (Fig. 18F, G.) (WAM 90/2120) broadest at base, tapering, curved in lateral view.

Variation. Only a single male was measured for this study; female total length 4.5–8.0 (*n* = 6). The colour variation in this species is very similar to that of *S. fuliginata* comb. nov. and *S. brisbanae* comb. nov. with abdominal shades of beige to reddish brown and more or less conspicuous folium pattern. Of the six females measured for this study, all but one had their scapes broken off.

Life history and habitat preferences. All specimens were collected between October and May, with peak collection numbers in November and January. There is not much information about habitat preferences of *Salsa recherchensis* comb. nov., but they seem to be more common in lower vegetation layers based on descriptions on specimen labels, which include “web in garden”, “understorey Karri forest”, “bushes”, “granite”, “between limestone”, and “camp”.

Distribution. *Salsa recherchensis* comb. nov. is the only species of the genus found in Western Australia, although its range extends into southern South Australia (Fig. 11).

Salsa rueda sp. nov.

http://zoobank.org/5D907A83-BDB5-48E0-B976-0B993B9D94C2
Figs 1B, 3A–D, 5E, 19A–D, 20A–E, 21

Type specimen. ***Holotype*** male, Tubrabucca (31°52'S, 151°25'E, New South Wales, Australia), 19 January 1049, RTMP, ANB (MV K-14856).

Other material examined. 6 males, 14 females (1 with egg sac), 1 juvenile (in 15 records) (see Suppl. material 1).

Etymology. The specific epithet is a noun in apposition and refers to a specific Salsa dancing style, Rueda de Casino, in which changing pairs of dancers from a circle and dance moves are being called out by a single person. It is a noun in apposition.

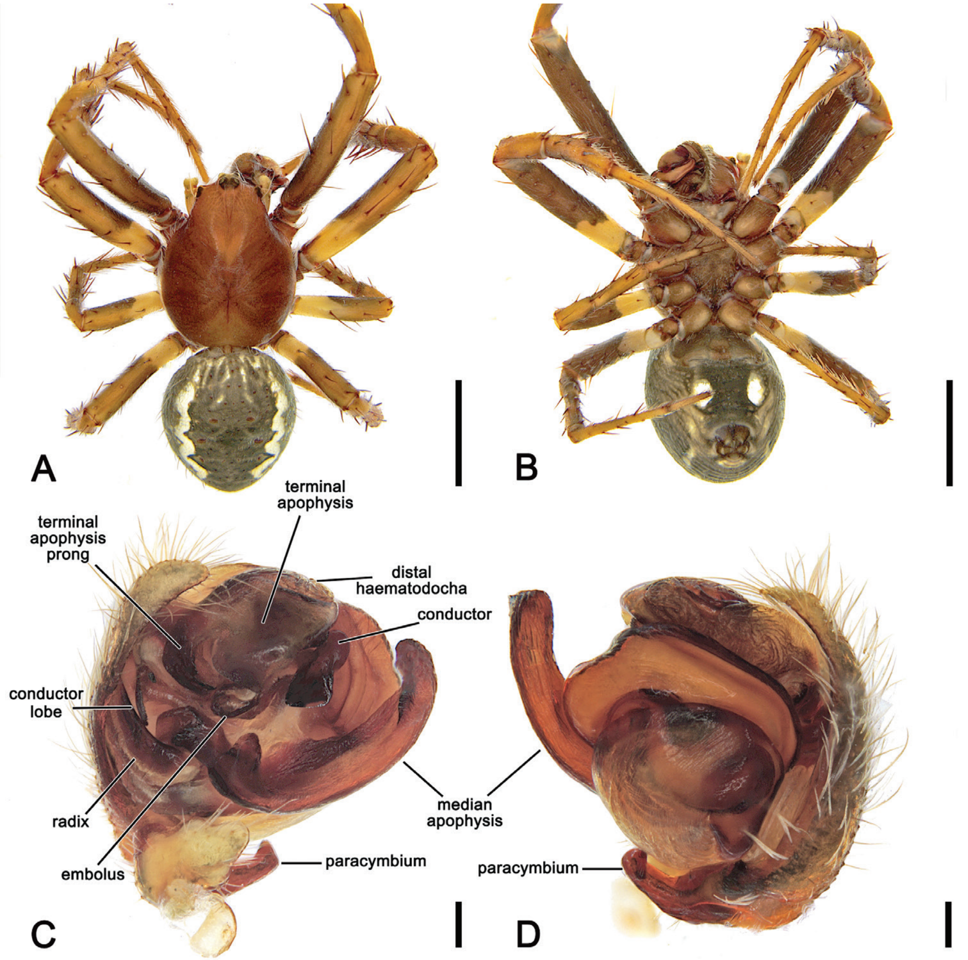

Figure 19. *Salsa rueda* sp. nov., male holotype (MV K-14856) **A** dorsal habitus **B** ventral habitus **C** left pedipalp, ventral view **D** left pedipalp, dorsal view. Scale bars: 2 mm (**A, B**); 0.2 mm (**C, D**).

Diagnosis. Males of *S. rueda* sp. nov. are identified from all other species of the genus by the highly elongated median apophysis of the pedipalp and the enlarged basal, curved prong on the terminal apophysis (Figs 3A–C, 19C). Females can be distinguished from all other species by shape of the epigyne base, which is much longer than wide and has a central longitudinal ridge (Fig. 20A).

Description. Male (based on holotype, MV K-14856). Total length 6.1. Carapace 3.3 long, 2.6 wide, brown, slightly paler in cephalic area and posteriorly (Fig. 19A). Eye diameter AME 0.16, ALE 0.14, PME 0.09, PLE 0.09; row of eyes: AME 0.47, PME 0.43, PLE 1.37. Chelicerae orange-brown; with four promarginal teeth (basal and apical largest) and three retromarginal teeth (basal largest). Legs shades of brown, femora basally yellow-brown in legs II, III and IV (Fig. 19A, B). Leg formula I > II > IV > III; length of segments (femur + patella + tibia + metatarsus + tarsus = total length): I – 4.5 + 1.5 + 2.8 + 2.6 + 1.0 = 12.4, II – 3.0 + 1.4 + 2.0 + 2.4 + 0.9 = 9.7, III – 1.7 + 0.9 + 1.2 + 1.2 + 0.6 = 5.6, IV – 2.6 + 1.1 + 1.8 + 2.2 + 0.8 = 8.5. Labium 0.36 long, 0.56, brown; endites brown (Fig. 19B). Sternum 1.5 long, 1.2 wide, dark brown (Fig. 19B). Abdomen 2.7 long, 2.6 wide, dorsal folium uniformly olive-grey bordered by broad wavy pale bands (Fig. 19A); venter dark olive-grey with two ovoid lateral white patches (Fig. 19B). Pedipalp length of segments (femur + patella + tibia + cymbium = total length): 0.6 + 0.2 + 0.1 + 1.1 = 2.0; paracymbium slightly curved with conspicuous base (Figs 3A, B, 19D); median apophysis bearing a rounded basal process, elongated C-shaped; basal arch with numerous tubercles (Figs 3A–D, 19C); conductor lobe broad (Figs 3A–C, 19C); terminal apophysis sub-rectangular with a curved, heavily sclerotised basal prong (Figs 3A–C, 19C); conductor heavily sclerotised, spatulate (Figs 3A–C, 19C); embolus strong and slightly sinuous (Figs 3A–C, 19C).

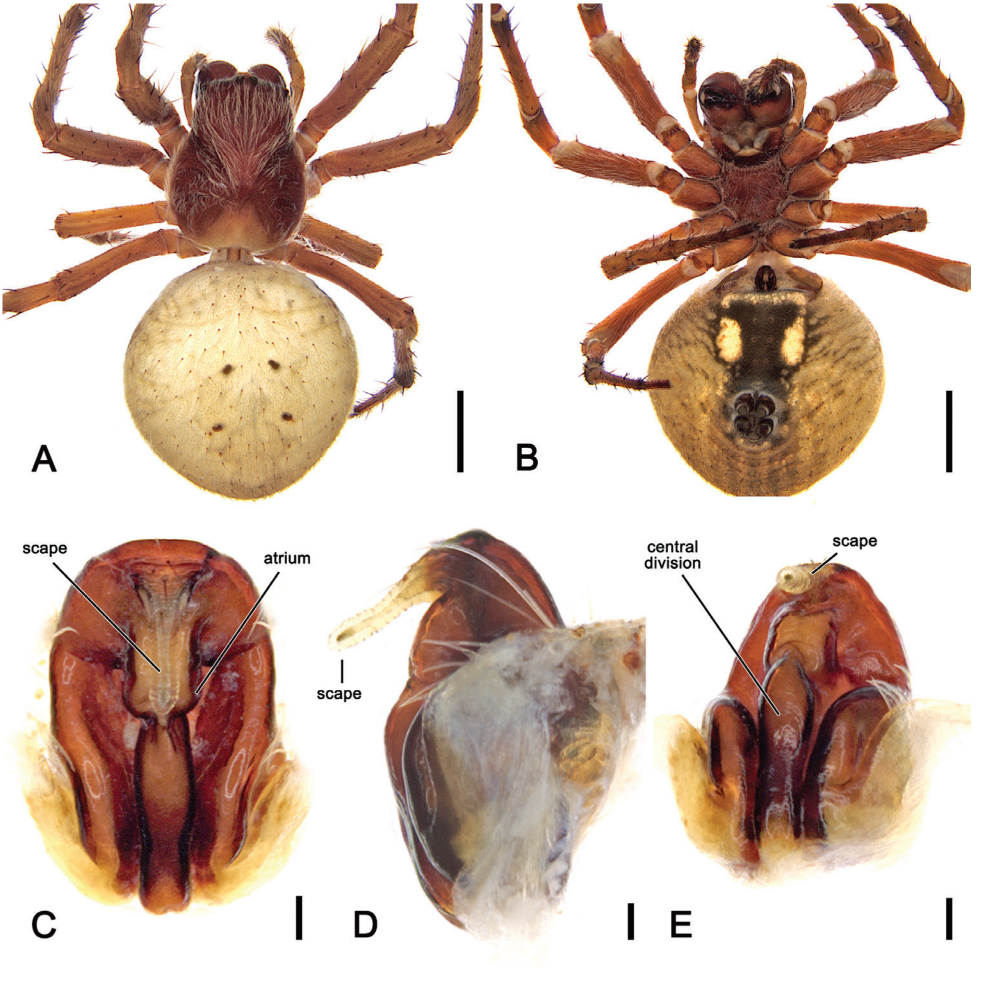

Figure 20. *Salsa rueda* sp. nov., female (AM KS.50201) **A** dorsal habitus **B** ventral habitus **C** epigyne, ventral view **D** epigyne, lateral view **E** epigyne, posterior view. Scale bars: 2 mm (**A, B**); 0.1 mm (**C–E**).

Female (based on AM KS.50201): Total length 10.5. Carapace 4.2 long, 3.5 wide; reddish brown, slightly paler in cephalic area and posteriorly, covered by white setae specifically in cephalic area (Fig. 20A). Eye diameter AME 0.18, ALE 0.16, PME 0.13, PLE 0.11; row of eyes: AME 0.54, PME 0.52, PLE 2.18. Chelicerae reddish brown, four promarginal teeth (apical and second basal largest) and three retromarginal teeth (basal largest). Legs orange-brown (Fig. 20A, B). Pedipalp length of segments (femur + patella + tibia + tarsus = total length): 1.1 + 0.4 + 0.7 + 1.3 = 3.5. Leg formula I > II > IV > III; length of segments (femur + patella + tibia + metatarsus + tarsus = total length): I – 4.0 + 1.7 + 3.5 + 3.3 + 1.2 = 13.7, II – 3.7 + 1.6 + 2.8 + 2.9 + 1.1 = 12.1, III – 2.5 + 1.1 + 1.4 + 1.5 + 0.8 = 7.3, IV – 3.5 + 1.6 + 2.2 + 2.6 + 1.0 = 10.9. Labium 0.58 long, 0.86 wide, dark brown; endites dark brown (Fig. 20B). Sternum 1.8 long, 1.6 wide, dark reddish brown (Fig. 20B). Abdomen 6.0 long, 6.0 wide; dorsum beige with indistinct darker folium pattern (Fig. 20A); venter black and laterally with elongate white patches and pale transverse band behind epigastric furrow (Fig. 20B). Epigyne much longer than wide; atrium with central elevated section and a transverse ridge anteriorly (Fig. 20C); scape shorter than half the length of epigyne base (Fig. 20C, D); central division a conspicuous narrow ridge (Fig. 20E). Spermathecae rounded and located on the basis of the genitalia, separated by the width of the median ridge (Fig. 5E).

Variation. Total length males 6.0–6.8 (n = 5); females 7.2–10.5 (n = 4). The colour variations in *S. rueda* sp. nov. are probably the most uniform with the patterns in the folium often little expressed (Figs 19A, 20A). There was no evidence of scape breakage in any of the females examined by us.

Life history and habitat preferences. Specimens were collected in December and January, with a single female from March, indicating this species to be summer-mature. There was no habitat information on any of the specimen labels.

Distribution. *Salsa rueda* sp. nov. were found in the Australian Capital Territory, New South Wales, Victoria, and Tasmania (Fig. 21).

Salsa tartara sp. nov.

http://zoobank.org/EADD2CE5-3A7B-4832-9D09-770F2BEA5ECB
Figs 5F, 21, 22A–D, 23A–E

Type specimen. ***Holotype*** male, Lord Howe Island, Goat House Cave area (31°33'50"S, 159°05'11"E, New South Wales, Australia), 23 February 2001, G. Milledge (AM KS.70737).

Other material examined. 1 male, 5 females (in 6 records) (see Suppl. material 1).

Etymology. The specific epithet is a noun in apposition and refers to the tartar sauce, “salsa tartara” in Spanish, one of the favourite salsas of the junior author’s wife.

Diagnosis. Like *S. canalae* comb. nov. males, those of S. *tartara* sp. nov. have two patellar setae on the pedipalp; however, can be separated by the strong curved conductor (Fig. 22C) that is absent in *S. canalae* comb. nov. Female epigynes are much longer than wide, similar to those of *S. rueda* sp. nov., but they lack the longitudinal central ridge of that species (Fig. 20C vs. Fig. 23C).

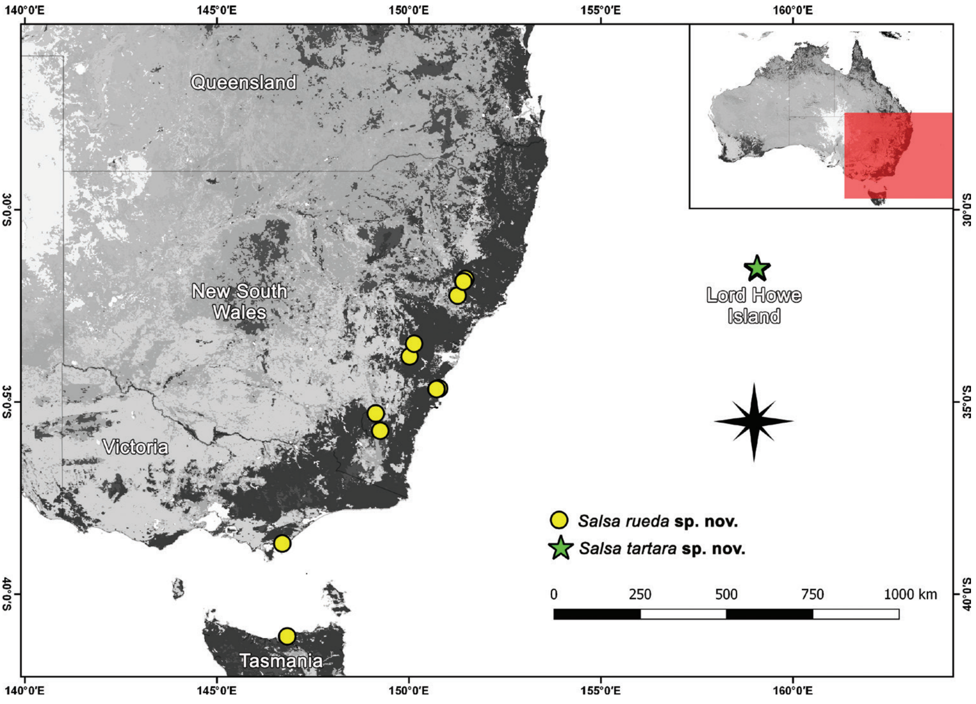

Figure 21. Distribution records of *Salsa rueda* sp. nov. and *Salsa tartara* sp. nov.

Description. Male (based on holotype, AM KS.70737) Total length 4.0. Carapace 2.1 long, 1.7 wide, brown, slightly paler in cephalic area (Fig. 22A). Eye diameter AME 0.14, ALE 0.13, PME 0.09, PLE 0.09; row of eyes: AME 0.43, PME 0.38, PLE 1.40. Chelicerae orange-brown; with four promarginal teeth (second basal largest) and three retromarginal teeth (basal largest). Legs yellowish brown mottled in grey on joints; femora I and II basally orange-brown (Fig. 22A, B). Leg formula I > II > IV > III; length of segments (femur + patella + tibia + metatarsus + tarsus = total length): I – 2.4 + 1.1 + 1.9 + 1.9 + 0.8 = 8.1, II – 2.0 + 0.9 + 1.6 + 1.7 + 0.7 = 6.9, III – 1.2 + 0.6 + 0.7 + 0.7 + 0.45 = 3.65, IV – 1.6 + 0.7 + 1.2 + 1.2 + 0.6 = 5.3. Labium 0.31 long, 0.45, brown; endites orange-brown (Fig. 22B). Sternum 1.0 long, 0.8 wide, orange-brown with dusky discolourations (Fig. 22B). Abdomen 2.2 long, 1.9 wide, dorsum with beige background and olive-grey, irregular folium, laterally dark olive-grey with dark streaks (Fig. 22A); venter olive-brown, laterally with thin, irregular white lines (Fig. 22B). Pedipalp length of segments (femur + patella + tibia + cymbium = total length): 0.4 + 0.15 + 0.15 + 0.6 = 1.3; paracymbium short with pronounced base and slightly curved apically (Fig. 22D); median apophysis C-shaped, basally pronounced and with an acute and apically curved pointed tip (Fig. 22C); conductor lobe spatulate (Fig. 22C); terminal apophysis sub-rectangular; conductor strongly sclerotised and curved basally (Fig. 22C); embolus short and strongly sclerotised.

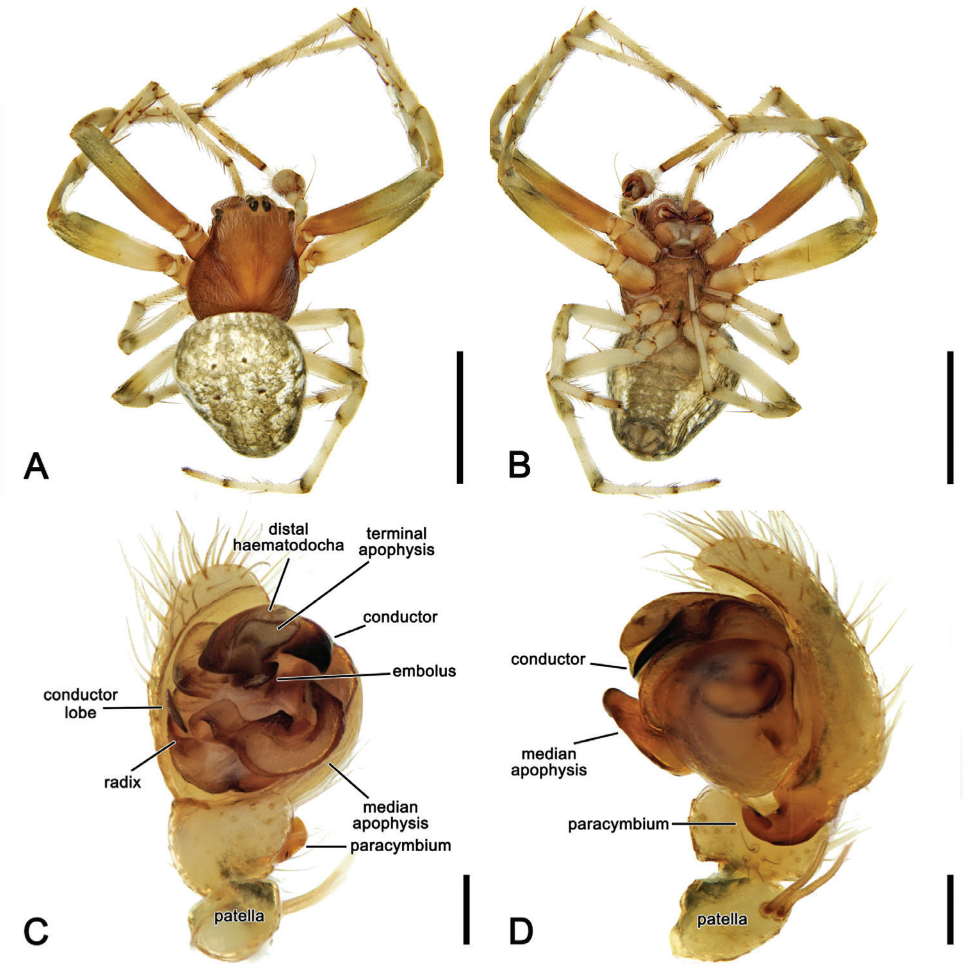

Figure 22. *Salsa tartara* sp. nov., male holotype (AM KS.70737) **A** dorsal habitus **B** ventral habitus **C** left pedipalp, ventral view **D** left pedipalp, dorsal view. Scale bars: 2 mm (**A, B**); 0.2 mm (**C, D**).

Female (based on AM KS.70661): Total length 6.5. Carapace 2.5 long, 2.1 wide; colouration and setae largely as in male (Fig. 23A). Eye diameter AME 0.16, ALE 0.14, PME 0.11, PLE 0.10; row of eyes: AME 0.47, PME 0.45, PLE 1.92. Chelicerae colour hue as in male, four promarginal teeth (apical and second basal largest) and three retromarginal (basal largest). Legs similar to male but leg I femora basally not orange (Fig. 23A, B). Pedipalp length of segments (femur + patella + tibia + tarsus = total length): 0.7 + 0.3 + 0.4 + 0.8 = 2.2. Leg formula I > II > IV > III; length of segments (femur + patella + tibia + metatarsus + tarsus = total length): I – 2.4 + 1.1 + 1.9 + 2.0 + 0.8 = 8.2, II – 2.0 + 1.0 + 1.7 + 1.6 + 0.7 = 7.0, III – 1.4 + 0.6 + 0.7 + 0.7 + 0.5 = 3.9, IV – 1.9 + 0.9 + 1.3 + 1.4 + 0.7 = 6.2. Labium 0.18 long, 0.29 wide, brown; endites dark brown (Fig. 23B). Sternum 1.2 long, 1.0 wide, dark brown (Fig. 23B).

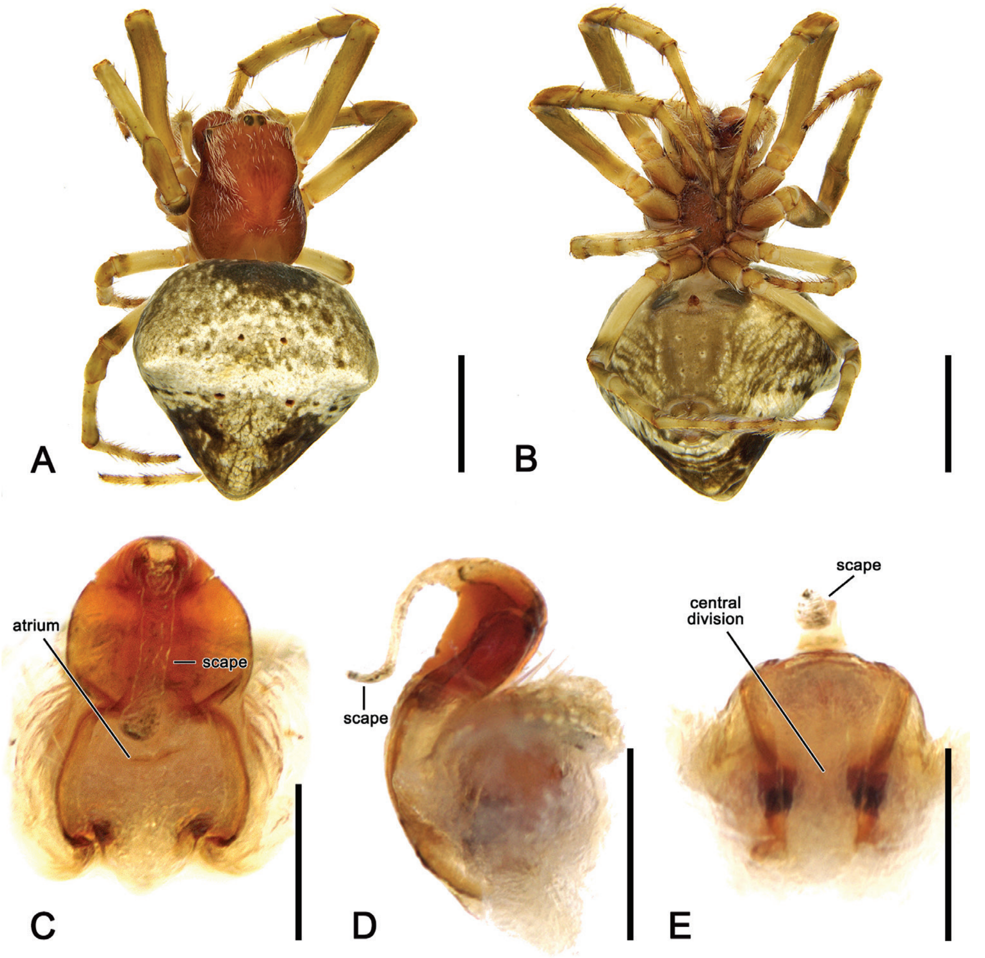

Figure 23. *Salsa tartara* sp. nov., female (AM KS.70661) **A** dorsal habitus **B** ventral habitus **C** epigyne, ventral view **D** epigyne, lateral view **E** epigyne, posterior view. Scale bars: 2 mm (**A, B**); 0.2 mm (**C–E**).

Abdomen 4.0 long, 4.2 wide, sub-triangular with distinct humeral humps, dorsally mottled olive-grey and white, with darker spots anteriorly and postero-laterally; folium pattern indistinct (Fig. 23A); venter as in male (Fig. 23B). Epigyne plate longer than wide and composed of two separate sections; borders thin and atrium wide; scape slightly longer than half of epigyne base, sinuous in lateral view (Fig. 23C, D); central division almost sub-rectangular, somewhat wider ventrally (Fig. 23E). Spermathecae enlarged, occupying most of the epigyne area (Fig. 5F).

Variation. Only one additional male was measured, total length 5.1; females 5.2–7.2 (*n* = 5). Four of the five specimens we analysed had broken-off scapes. There is little colour variation in the specimens examined for this study, although most females have a more prominent folium, similar to the male examined here.

Life history and habitat preferences. All mature specimens of *S. tartara* sp. nov. were collected in February and March, but collection numbers are too low to interpret the phenology of this species and may reflect a collection bias of expeditions to Lord Howe Island. But it appears that the species is (late) summer-mature to autumn-mature. There is no habitat information on the labels of any of the specimens collected, with the exception of one specimen collected in 'litter'.

Distribution. *Salsa tartara* sp. nov. is currently only known from Lord Howe Island and should be considered endemic to this island (Fig. 21).

Discussion

Recent large-scale molecular studies of world-wide Araneidae (e.g., Kallal and Hormiga 2018; Kallal et al. 2018; Scharff et al. 2020) have transformed our understanding of the evolutionary history of the family, in particular as it applies to the Australian fauna. The subfamily Araneinae Clerck, 1757 as circumscribed by Scharff and Coddington (1997) based on a preliminary morphological phylogenetic analysis has been shown to be highly paraphyletic and Australian taxa fall into a number of new groupings at the subfamily level, such as 'backobourkiines' and 'zealaraneines' (Scharff et al. 2020). These groupings, although well supported statistically, were not assigned formal subfamily status due to their limited taxonomic and systematic knowledge. However, they now allow us to tackle the taxonomy of Australian araneids in a much more systematic fashion, including our ongoing extensive revision of the 'backobourkiines' of which the current study forms a part (e.g., Framenau et al. 2010, 2021a, c, 2022; Framenau 2011). Male genitalic characters that unite the backobourkiines include a basal arch of the median apophysis that reaches over the radix and the presence of a single patellar spine (i.e., two patellar spines in eriophorines and zealaraneines) (Scharff et al. 2020).

In *Salsa* gen. nov. the arch of the median apophysis is internally armed with numerous small denticles (e.g., Fig. 3A, 9C). Modifications of this arch in other genera are not uncommon. In *Backobourkia*, the basal arch is apically extended into a long flange (Framenau et al. 2010). In an undescribed genus represented by *Araneus dimidiatus* (L. Koch, 1871) and *Araneus mulierarius* (Keyserling, 1887) ("NGEN03" in Scharff et al. 2020) there is a single long spine inside the arch (VWF unpublished data). The latter was not part of the backobourkiines in Scharff et al.'s (2020) study but formed a statistically unsupported clade with the largely Australian *Dolophones* Walckenaer, 1837 and the cosmopolitan *Cyclosa* Clerck, 1757. However, there is good morphological support of NGEN03 to be part of the backobourkiines as they have the two putative synapomorphies of the male pedipalp as mentioned above (VWF unpublished data). The functional role of these basal modifications of the median apophysis are not known, but it is perceivable that internal tubercles or a spine play a role in stabilising the link between the median apophysis and the radix during the expansion of the pedipalp during copulation.

Two species of *Salsa* gen. nov., namely *S. canalae* comb. nov. and *S. tartara* sp. nov., have two spines on the male pedipalp patella. Two patellar spines appear more common in traditional araneine genera (see Scharff and Coddington 1997) and are also present in eriophorines and zealaraneines as defined by Scharff et al. (2020). It therefore appears that the presence of two spines may represent the plesiomorphic condition and therefore a reversal in those two *Salsa* gen. nov. species amongst the backobourkiines with only a single spine. This reversal to two patellar spines has similarly occurred in *Hortophora cucullus* Framenau & Castanheira, 2021 (Framenau et al. 2021a), but the evolutionary significance, i.e., the functional roles of these spines, remains unknown.

Salsa gen. nov. clearly constitutes a natural grouping within the backobourkiines and is well diagnosed by genitalic and somatic characters, such as the C-shaped median apophysis of the male pedipalp, the single posterior abdominal hump or the ventral colouration of the abdomen. Molecular data places *Salsa* gen. nov. in a clade with *Acroaspis* and *Socca* (Scharff et al. 2020) and this association is supported by characters of the male pedipalp, in particular the shape of the sclerite that we considered the terminal apophysis. It is a sclerite, that amongst the Araneidae as a whole is difficult to homologise. It originates apically at the embolic division together with the embolus and, if present, the subterminal apophysis. These structures arise from the stipes (see Coddington 1990; Comstock 1910), the latter sclerite being poorly defined in *Salsa* gen. nov., if present at all. In the backobourkiines, we can identify two major shapes of the terminal apophysis: in *Backobourkia*, *Lariniophora*, *Novakiella*, and *Hortophora* it is inflated and sometimes bubble-shaped with a terminal spine, and in *Plebs*, *Socca*, *Acroaspis*, and *Salsa* gen. nov. it is flat lamellar, sometimes with processes (Framenau et al. 2010, 2021a, c, 2022; Framenau 2011, 2019; Joseph and Framenau 2012;). The terminal apophysis of *Salsa* gen. nov. is most similar to the one of *Socca* and *Acroaspis*, with a basal shape of a triangular to sub-rectangular plate (Fig. 6C, 9C, 17C). In *Acroaspis*, this plate is covered centrally by an elongate, triangular and lamellar process, at least in the only species with a published illustration, *Acroaspis lancearia* (Keyserling, 1887) (Framenau 2019: fig. 1B). In *Socca* this structure is further modified so that the lamellar process divides the terminal apophysis plate to form a tri-partite complex (Framenau et al. 2022).

The epigynes of most *Salsa* gen. nov. have a large exposed plate, except for *S. fuliginata* comb. nov. (Fig. 7F). However, a comparison with *S. recherchensis* comb. nov. shows an intriguing 'twist'. Both epigynes are in fact very similar, but its base in *S. fuliginata* comb. nov. is rotated into the abdomen, illustrating that the boundary between the atrium and central division is somewhat arbitrary and depending on the position of the epigyne. The posterior view in *S. fuliginata* comb. nov. and the ventral view in *S. recherchensis* comb. nov. views are very similar between the two species displaying a heart-shaped atrium/central division (Fig. 7C, E vs. Fig. 18C, F). This epigyne rotation is not present in any other backobourkiine we have treated so far, and is not known to us in any other araneid genera, and suggests caution when trying to homologise structures in the epigyne based on position.

Salsa gen. nov. is a largely Australian genus, but contains three 'island' endemics, which are, based on our current knowledge, only present on Lord Howe Island, New Caledonia, and Papua New Guinea. A single species was introduced from Australia to New Zealand, but the means of this introduction, i.e., natural or facilitated by man, are unknown. Similar distribution patterns can be found in other backobourkiines, all of which have the centre of their distribution in Australia. The most widespread genus is *Plebs*, species of which can be found from Australia into SE Asia, China, and India (Joseph and Framenau 2012). *Hortophora* is also mainly Australian, but some species are found in the Pacific region (Framenau et al. 2021a). *Backobourkia* and *Novakiella* are exclusively Australian, although just like in *Salsa* gen. nov., one species each was introduced to New Zealand (Framenau et al. 2010, 2021c). The same seems the case for *Acroaspis*, but until the genus is taxonomically revised in detail, it remains unclear if the single New Zealand species, *A. decorosa* (Urquhart, 1894) can also be found in Australia. The distribution of *Carepalxis* currently includes the Nearctic but a recent study suggests that the first males described from there are not conspecific with the Australian species (Ferreira-Sousa and Motta 2022). The type species of *Carepalxis*, *C. montifera* L. Koch, 1872, is from Australia, but as in *Acroaspis*, further biogeographic analyses require a detailed revision of the genus.

The presence of *S. fuliginata* comb. nov. in New Zealand is curious. First records of the species in the country date back to the late 1800s, as two females of the Graf Erich von Keyserling (1833–1889) collection are present in the NHMUK (see Material examined of that species). However, the species was not included in a comprehensive revision of New Zealand's large orb-weaving spiders (Court and Forster 1988) and it must be assumed that the species did not persist in the country following the records from the late 1800s. Recent records based on museum specimens and images support the presence of the species only from 2008 with a female imaged in Hamilton on the North Island by B. McQuillan (Fig. 1C). However, it is also possible that the historic females in the NHMUK collection were mislabeled specimens from Australia.

Acknowledgements

We thank (in no particular order) Peter Lillywhite, Joseph Schubert, Catriona McPhee, Ken Walker, Richard Marchant (MV), Robert Raven (retired), Owen Seeman, Wendy Hebron (QM), David Hirst (retired), Matthew Shaw (SAM), Graham Milledge, Helen Smith (AM), Jason Dunlop (ZMB), Janet Beccaloni (NHMUK), Hieronymus Dastych (retired), Danilo Harms, Nadine Dupérré (ZMH), Jan Pedersen and Nikolaj Scharff (NHMD), Mark Harvey, Julianne Waldock (WAM), Jenny Shield (CVIC), and John Douglas (QVMAG) for the loan of specimens in their care or assistance when visiting their respective institutions. PdeS particularly thanks Janet Beccaloni and Nikolaj Scharff for recently hosting him during visits to the NHMUK and NHMD respectively. We thank Holger Frick (BNHM) and Christoph Hörweg (NHMW) for sending images of type material of *S. canalae* comb. nov. and *S. fuliginata* comb. nov. respectively. We thank Phil Sirvid (MONZ), Stacey Goodwin (MPI), Johno Ridden (CMNZ), Cor Vink (LUNZ) and Bryce McQuillan for providing collection data and images of *S. fuliginata* comb. nov. from New Zealand that improved the geographic relevance of this paper. Bryce McQuillan provided live images of *S. fuliginata* comb. nov. from New Zealand (Fig. 1A–C).We thank Cor Vink and Robert Kallal for constructive comments that improved the quality of the manuscript.

Funding for revisions of the Australian Araneidae was provided by the Australian Biological Resources Study (ABRS) (grant no. 205-24 [2005–2008] to VWF and N. Scharff and grant number 4-EHPVRMK [2021–2023] to VWF, PSC, N. Scharff, D. Dimitrov, A. Chopra and R. Baptista). Additional funding was provided by a SYNTHESYS project grant (GB-TAF-TA3-008) to PSC to visit the NHMUK in London.

References

Berland L (1924) Araigées de la Nouvelle-Calédonie et des Iles Loyalty. Nova Caledonia. Zoologie 3: 159–255. https://www.biodiversitylibrary.org/part/41179

Berland L (1931) Sur quelques araignées envoyées de Nouvelle Calédonie par M. Risbec. Bulletin du Muséum National d'Histoire Naturelle 3(2): 666–672. https://www.biodiversitylibrary.org/partpdf/329247

Berland M (1932) Araignées recueillies en Nouvelle-Calédonie par M. T. D. A. Cockerell. Records of the Australian Museum 18(6): 295–299. https://doi.org/10.3853/j.0067-1975.18.1932.732

Bonnet P (1955) Bibliographia araneorum. 2 (1). Douladoure, Toulouse, 918 pp.

Chrysanthus Fr (1961) Spiders from south New Guinea IV. Nova Guinea. Zoology (Jena, Germany) 10: 195–214.

Coddington JA (1990) Ontogeny and homology in the male palpus of orb-weaving spiders and their relatives, with comments on phylogeny (Araneoclada: Araneoidea, Deinopoidea). Smithsonian Contributions to Zoology 496(496): 1–52. https://doi.org/10.5479/si.00810282.496

Comstock JH (1910) The palpi of male spiders. Annals of the Entomological Society of America 3: 161–185. https://doi.org/10.1093/aesa/3.3.161

Court DJ, Forster RR (1988) The spiders of New Zealand: Part VI. Araneidae-Araneinae. Otago Museum Bulletin 6: 68–124.

Dalmas Rd (1917) Aragnées de Nouvelle Zélande. Annales de la Société Entomologique de France 86: 317–430.

Dondale CD (1966) The spider fauna (Araneida) of deciduous orchards in the Australian Capital Territory. Australian Journal of Zoology 14(6): 1157–1192. https://doi.org/10.1071/ZO9661157

Ferreira-Sousa L, Motta PC (2022) Diagnostic notes on the spider orb-weaving genera *Carepalxis* and *Ocrepeira* (Araneae: Araneidae), with description of three new species from Central Brazil. Zootaxa 5087(2): 389–399. https://doi.org/10.11646/zootaxa.5087.2.9

Framenau VW (2011) *Lariniophora*, a new monotypic orb-weaving spider genus from Australia (Araneae: Araneidae: Araneinae). Records of the Western Australian Museum 26(2): 191–201. https://doi.org/10.18195/issn.0312-3162.26(2).2011.191-201

Framenau VW (2019) Generic and family transfers, and nomina dubia for orb-weaving spiders (Araneae, Araneidae) in the Australasian, Oriental and Pacific regions. Evolutionary Systematics 3: 1–27. https://doi.org/10.3897/evolsyst.3.33454

Framenau VW, Castanheira PdS, Vink CJ (2022) Taxonomy and systematics of the new Australo-Pacifc orb-weaving spider genus *Socca* (Araneae: Araneidae). New Zealand Journal of Zoology. https://doi.org/10.1080/03014223.2021.2014899

Framenau VW, Dupérré N, Blackledge TA, Vink CJ (2010) Systematics of the new Australasian orb-weaving spider genus *Backobourkia* (Araneae: Araneidae: Araneinae). Arthropod Systematics & Phylogeny 68: 79–111. https://www.senckenberg.de/wp-content/uploads/2019/08/68_1_framenau_79-111.pdf

Framenau VW, Baptista RLC, Oliveira FSM, Castanheira PdS (2021a) Taxonomic revision of the new spider genus *Hortophora*, the Australasian Garden Orb-weavers (Araneae, Araneidae). Evolutionary Systematics: 275–334. https://doi.org/10.3897/evolsyst.5.72474

Framenau VW, Vink CJ, McQuillan BN, Simpson AH (2021b) A new genus for a large orb-weaving spider (Araneae, Araneidae) from New Zealand. New Zealand Journal of Zoology 1–14. https://doi.org/10.1080/03014223.2021.1951309

Framenau VW, Vink CJ, Scharff N, Baptista RLC Castanheira PdS (2021c) Review of the Australian and New Zealand orb-weaving spider genus *Novakiella* (Araneae, Araneidae). Zoosystematics and Evolution 97: 393–405. https://doi.org/10.3897/zse.97.67788

Hogg HR (1900) A contribution to our knowledge of the spiders of Victoria; including some new species and genera. Proceedings of the Royal Society of Victoria 13: 68–123. https://www.biodiversitylibrary.org/part/5640

Joseph MM, Framenau VW (2012) Systematic review of a new orb-weaving spider genus (Araneae: Araneidae), with special reference to the Australasian-Pacific and South-East Asian fauna. Zoological Journal of the Linnean Society 166(2): 279–341. https://doi.org/10.1111/j.1096-3642.2012.00845.x

Kallal RJ, Hormiga G (2018) Systematics, phylogeny and biogeography of the Australasian leaf-curling orb-weaving spiders (Araneae: Araneidae: Zygiellinae), with a comparative analysis of retreat evolution. Zoological Journal of the Linnean Society 184: 1055–1141. https://doi.org/10.1093/zoolinnean/zly014

Kallal RJ, Fernández R, Giribet G, Hormiga G (2018) A phylotranscriptomic backbone of the orb-weaving spider family Araneidae (Arachnida, Araneae) supported by multiple methodological approaches. Molecular Phylogenetics and Evolution 126: 129–140. https://doi.org/10.1016/j.ympev.2018.04.007

Keyserling E (1887) Die Arachniden Australiens nach der Natur beschrieben und abgebildet. 2. Theil. 3. Lieferung. Bauer & Raspe, Nürnberg, 153–232.

Koch L (1867) Beschreibungen neuer Arachniden und Myriapoden. II. Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien 17: 173–250.

Koch L (1872) Die Arachniden Australiens nach der Natur beschrieben und abgebildet. 1. Theil. 2. Lieferung. Verlag von Bauer und Raspe, Nürnberg, 105–368. https://doi.org/10.5962/bhl.title.121660

Levi HW (1977) The American orb-weaver genera *Cyclosa*, *Metazygia* and *Eustala* north of Mexico (Araneae, Araneidae). Bulletin of the Museum of Comparative Zoology 148: 61–127. https://www.biodiversitylibrary.org/part/2948

Levi HW (1999) The Neotropical and Mexican Orb Weavers of the genera *Cyclosa* and *Allocyclosa* (Araneae: Araneidae). Bulletin of the Museum of Comparative Zoology 155: 299–379. https://www.biodiversitylibrary.org/part/38827

Main BY (1954) Spiders and Opiliones. Part 6 of the Archipelago of the Recherche. Australian Geographical Society Reports 1: 37–53.

Paquin P, Vink CJ, Dupérré N, Sirvid P, Court DJ (2008) Nomina dubia and faunistic issues with New Zealand spiders (Araneae). Insecta Mundi 46: 1–6. https://digitalcommons.unl.edu/insectamundi/574/

Rack G (1961) Die Entomologischen Sammlungen des Zoologischen Staatsinstituts und Zoologischen Museums Hamburg. II. Teil. Chelicerata II: Araneae. Mitteilungen des Hamburgischen Zoologischen Museums und Instituts 59: 1–60. https://hamburg.leibniz-lib.de/sammlungen/zoologie/arachnologie/dokumente/rack-1961-katalog-araneae.pdf

Rainbow WJ (1911) A census of Australian Araneidae. Records of the Australian Museum 9(2): 107–319. https://doi.org/10.3853/j.0067-1975.9.1911.928

Renner F (1988) Liste der im Krieg vernichteten Typen des Königlichen Naturalienkabinetts in Stuttgart. TUB-Dokumentation. Kongresse und Tagungen 38: 319–329.

Scharff N, Coddington JA (1997) A phylogenetic analysis of the orb-weaving spider family Araneidae (Arachnida, Araneae). Zoological Journal of the Linnean Society 120(4): 355–434. https://doi.org/10.1111/j.1096-3642.1997.tb01281.x

Scharff N, Coddington JA, Dimitrov D, Agnarsson I, Framenau VW, Szűts T, Blackledge TA (2020) Phylogeny of the orb-weaving spider family Araneidae (Araneae, Araneoidea). Cladistics 36(1): 1–21. https://doi.org/10.1111/cla.12382

Simon E (1895) Histoire Naturelle des Araignées. Deuxième édition. Tome premier. Fascicule 4. Librairie Encyclopédique de Roret, Paris, 761–1084.

World Spider Catalog (2022). Version 23.0. http://wsc.nmbe.ch [accessed 22 April 2022]

Supplementary material 1

Other material examined

Authors: Volker W. Framenau, Pedro de S. Castanheira

Data type: docx file

Explanation note: Other material examined: *Salsa fuliginata* comb. nov., *Salsa brisbanae* comb. nov., *Salsa canalae* comb. nov., *Salsa recherchensis* comb. nov., *Salsa rueda* sp. nov., *Salsa tartara* sp. nov.

Link: https://doi.org/10.3897/zookeys.1102.82388.suppl1

ZooKeys 1102: 149–161 (2022)
doi: 10.3897/zookeys.1102.79229
https://zookeys.pensoft.net

RESEARCH ARTICLE

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A redescription of the poorly known Central American toad *Incilius tacanensis* (Anura, Bufonidae), with a summary of its biology and conservation status

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Academic editor: Luis Ceríaco | Received 11 December 2021 | Accepted 18 April 2022 | Published 20 May 2022

http://zoobank.org/00365810-1B7C-4A46-9D04-C320172C0814

Citation: McCartthy K, Shinn O, Luna-Reyes R, Mendelson III JR (2022) A redescription of the poorly known Central American toad *Incilius tacanensis* (Anura, Bufonidae), with a summary of its biology and conservation status. ZooKeys 1102: 149–161. https://doi.org/10.3897/zookeys.1102.79229

Abstract
Based on examination of most of the existing museum specimens of the rare bufonid frog *Incilius tacanensis*, we present a redescription and new diagnosis for this species. The species is limited to small region of the Pacific chain of volcanoes in southeastern Chiapas, Mexico, and adjacent areas of Guatemala. The species has not been observed in the wild since 1984 and may have been reduced or eliminated by regional epidemics of chytridiomycosis.

Resumen
Basándonos en la revisión de la mayoría de los especímenes de museo existentes del raro sapo bufónido *Incilius tacanensis*, presentamos una redescripción y una nueva diagnosis para esta especie. La especie se limita a una pequeña región de la cadena de volcanes del Pacífico en el sureste de Chiapas, México, y áreas adyacentes de Guatemala. La especie no se ha observado en la naturaleza desde 1984 y puede haber sido reducida o eliminada por epidemias regionales de quitridiomicosis.

Keywords
Amphibian, chytridiomycosis, Guatemala, Mexico, Volcán Tacaná

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* These authors contributed equally to the project.

Palabras clave
Anfibio, Guatemala, México, quitridiomicosis, Volcán Tacaná

Introduction

Incilius (= *Bufo*) *tacanensis* was described by Philip Smith in 1952. The original description was based on eight specimens from the vicinity of Volcán Tacaná from both Chiapas, Mexico, and Guatemala. Smith (1952) included a photograph of the preserved holotype (UMMZ 88359) and the paper serves as a complete and accurate description of the holotype and seven paratypes. However, except for listings on regional or national checklists, there have been no reports on any aspect of the biology of the species. In Mexico, *Incilius tacanensis* is not considered at risk in the Norma Oficial Mexicana (SEMARNAT, 2010), and is assigned in the low vulnerability category in the Environmental Vulnerability Score (EVS) proposed by Wilson et al. (2013) and Johnson et al. (2015a), and also used by Johnson et al. (2015b) for the herpetofauna of Chiapas. The species is listed as Endangered on the IUCN Red List (IUCN SSC Amphibian Specialist Group, 2020), based on the criteria of its small geographic ranges (approx. 1313 km^2) and continuing loss of habitat in the region. The Red List assessment mentions that amphibian chytridiomycosis may represent a conservation threat for the species but owing to the absence of any recent observations or records in collections, the disease has not been formally documented. The Red List assessment identifies research needs for the species as "additional research is needed on its natural history, population size, and distribution." Using museum specimens, this report aims to address some of these needs.

Materials and methods

We recorded traditional morphometric measurements and qualitative descriptions from museum specimens, using the terminology of Mendelson et al. (2012); all measurements presented in mm. We made small incisions in the abdomens of apparently mature individuals to verify sex by direct examination of the gonads and to estimate numbers of eggs in females.

In order to test for the presence of the pathogenic amphibian chytrid fungus *Batrachochytrium dendrobatidis* (Bd), we sampled the skin of preserved specimens with rayon-tipped swabs with plastic handles (Dryswab^{TM} Fine Tip MW113; United States: www.mwe-usa.com). We used a single swab for each specimen, rubbing it five times across each of the following surfaces: ventral surfaces of each hand and foot, pelvic patch, ventrum, lateral and dorsal surfaces of the body. Real-Time PCR assays were conducted by the laboratory of Ana Longo at the University of Florida. To quantify the presence and amount of Bd from each swab sample, we performed quantitative polymerase chain reactions following the protocol of Boyle et al. (2004) using an Applied Biosystems QuantStudio 3 System. We extracted the DNA from swabs using 50 µL of the reagent

PrepMan Ultra (Applied Biosystems Cat. 4318930). We used a 146 bp synthetic fragment as a standard for Bd (gBlock, IDTDNA; ITS Hap01; Longo et al. 2013) and created a serial dilution ranging from 10^6 copies to 10 copies. Swab samples were run in triplicate.

To our knowledge, there are 29 museum specimens of *I. tacanensis* worldwide, discounting mis-identified specimens we encountered in the course of our work. We examined most of these specimens (Appendix 1) either physically or in the form of photographs provided by museum curators. Our morphometric data only includes adult specimens. Museum acronyms follow Sabaj-Perez (2022).

Taxonomy

***Incilius tacanensis* P. Smith, 1952**
Figs 1–3

Bufo tacanensis P. Smith, 1952: 176. Holotype: UMMZ 88359. Type-locality: at 1500 m on Volcán de Tacaná, Union Juárez, Chiapas, Mexico.
Cranopsis tacanensis Frost et al., 2006a
Ollotis tacanensis Frost et al., 2006b
Incilius tacanensis Frost et al., 2009

Description. Mean SVL in males 36 mm, females 46 mm; cranial crests prominent in most specimens, with the supraorbital and postorbital crests forming an arched L-shaped structure about each eye; preorbital and pretympanic crests present, indistinct; canthal crests present, prominent, extending to above the nostrils; parietal crests prominent, oriented sharply posteromedially, extending to near midline of body; supratympanic crest absent; suborbital crest present but indistinct in some individuals; tympanum is not externally visible; tibia lengths in males range from 43–51% of SVL in males, 40–42% SVL in females; foot length ranges from 43–55% SVL in males, 41–44% in females. Webbing on the foot extends to the tip of every toe, except Toe III, which is webbed only to the second subarticular tubercle. Outer metatarsal tubercle small, rounded, elevated and non-keratinized; inner metatarsal tubercle larger, ovoid, and also non-keratinized. Tips of digits possess small, rounded tips. Morphometric variation is summarized in Table 1, and adult specimens are illustrated in Fig. 1.

Texture of the dorsal skin is smooth with scattered small, sharply pointed tubercles, becoming more numerous and dense, laterally and on the limbs. The ventral skin is roughly granular, with weakly pointed tubercles. The lateral row of tubercles is present as a series of small, sharply pointed tubercles that are slightly larger than similar, unorganized proximal tubercles. The parotoid glands are large, rounded, about 1.25 × diameter of eyelid. Tibial and rictal glands are absent. Vocal slit unilateral.

In preservative, dorsal coloration is dull brown with dark brown lateral stripes following the lateral tubercles; some cream spots present on legs in some specimens. Ventrum is dark cream with a diffuse dark brown marbled pattern that extends onto

Figure 1. Comparison of dorsal and ventral aspects of typical adult females (left) and males (right) of *Incilius bocourti* (male: MVZ 256842, female: MVZ 256843 and *I. tacanensis* (male: UIMNH 25473, female: UIMNH 55156). Note the diagnostic differences in size and dorsal skin texture.

Table 1. Morphometric variation in adult *Incilius tacanensis.* Mean ± 1 SD above range (in parentheses); all measurements in mm.

Variable	Females *N* = 15	Males *N* = 2
Snout-vent length	51.2 + 4.9 (38.5–57.2)	— (35.3–37.3)
Tibia length	21.8 + 1.4 (18.9–23.6)	— (16.1–18.3)
Foot length	22.0 + 2.1 (17.9–24.8)	— (16.1–19.3)
Head length	16.9 + 1.2 (13.7–17.9)	— (12.1–13.1)
Head width	17.5 + 1.5 (14.1–19.8)	— (12.5–13.3)
Eye diameter	5.8 + 0.7 (4.4–6.9)	— (4.1–4.6)
Eye-nostril distance	4.3 + 0.4 (3.3–4.9)	— (3.7–4.0)
Parotoid length	8.1 + 1.0 (7.1–10.5)	— (5.2–6.0)
Parotoid width	5.2 + 0.6 (3.9–6.3)	— (3.6–3.8)

the legs. In general, males tend to be more uniform dull brown than are the moderately patterned females.

Diagnosis. No other bufonid in Mexico or Guatemala has webbing on the feet as extensively developed as in *I. tacanensis* (Fig. 2). Within the range of this species, only *Incilius bocourti* (Brocchi, 1877) also lacks an externally evident tympanum. *Incilius bocourti* differs from *I. tacanensis* by lacking vocal slits (vs. present, unilateral), having little webbing on the feet (vs. extensive), reaching sizes up to 70 mm in males and 80 mm in females (vs. 37 mm, 57 mm), by having very large, distinctly oval parotoid glands with length more than 2 × diameter or eyelid (vs. rounded, about 1.25 × eyelid). *Incilius bocourti* is strongly sexually dimorphic in coloration, with males being nearly uniform greenish yellow and females being dark reddish brown. Based on museum specimens, *I. tacanensis* appears to be generally uniformly dull brown. The heads of the two species are illustrated in Fig. 3.

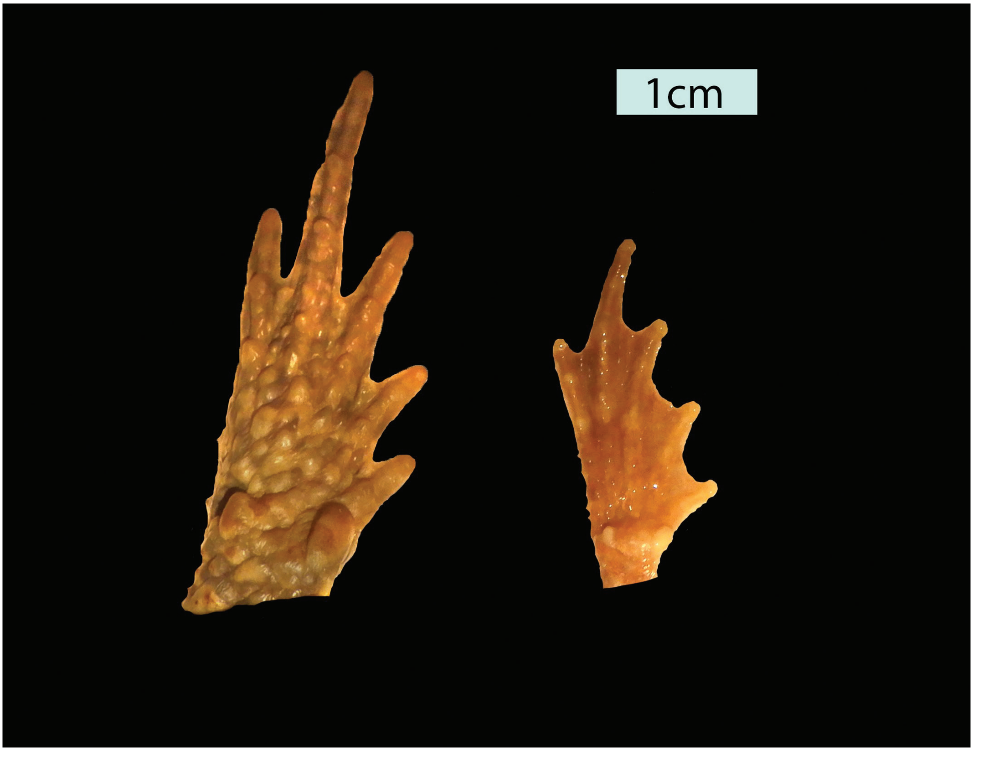

Figure 2. Details of the webbing of the feet of *Incilius bocourti* (left; MVZ 256842) and *I. tacanensis* (right; CAS 70691). The webbing is more extensive on the feet of *I. tacanensis.*

Distribution and ecology. *Incilius tacanensis* has a small geographic distribution apparently restricted to moderately high elevations (ca 1500–1700 m) between the Cerro Mozotal, Chiapas, Mexico to the west to Volcán Zunil in Quetzaltenango, Guatemala to the east (Fig. 4). Despite considerable collecting efforts over many decades in Departamento San Marcos, Guatemala (reviewed by Rovito et al. 2009), no records are available from this intervening region. This distribution represents but a small portion of the Fuegan Faunal Area defined by Campbell and Vannini (1989a), and evidently does not include the Sierra Madre de Chiapas, Montañas de Cuilco, nor the Central Plateau of Chiapas. However, details of the geographic distribution of this species must be considered conservatively, as it is evident that this small, cryptic species is not readily encountered even in areas where it is known to occur. Detailed habitat notes are not available for any of the museum specimens, but the species apparently occurs in leaf litter in rainforest and cloudforest habitats.

In fact, information is lacking on various aspects of its biology, including intra and interspecific ecological interactions. It is known that the collection of the holotype (March 1938) and two paratypes (January 1940 and April 1949) was carried out in the dry season, although five of the paratypes were collected in the rainy season (August 1924 and 1950; Smith 1952).

Figure 3. Details of the heads of adult females of *Incilius tacanensis* (left: MVZ 159445) and *I. bocourti* (right: UTA A-13008), showing diagnostic differences in the cranial crests, parotoid glands, and general shape. *Incilius bocourti* is a much larger species than is *I. tacanensis* (see Fig. 1), so these images are not at the same scale in order to facilitate direct comparisons.

This region is heavily cultivated in coffee, but we have no evidence that the species occurs in any form of coffee fields, unlike some other anurans in the area that can become quite abundant in areas of coffee production [e.g., *Craugastor rhodopis* (Cope, 1867) (Seib 1985)].

Oviductal eggs were present in females collected in July and August, suggesting that breeding occurs in the wet season. Clutch sizes were estimated (i.e., eggs were not removed and individually counted) between approximately 50–400 eggs. The eggs are small and pigmented.

Incilius tacanensis is superficially similar in size and sexual dimorphism to *I. epioticus* (Cope, 1875), *I. chompipe* (Vaughan and Mendelson 2007), and *I. guanacaste* (Vaughan & Mendelson, 2007) in Costa Rica. Those species have large (ca 5 mm diameter), unpigmented eggs and are now known to undergo direct development (Gray and Bland 2016). Unlike these diminutive (females about 35 mm SVL, males about 25 mm; Vaughan and Mendelson 2007) Costa Rican species, we presume that *I. tacanensis* has typical aquatic larvae. However, these larvae and all other aspects of reproduction in this species remain unknown.

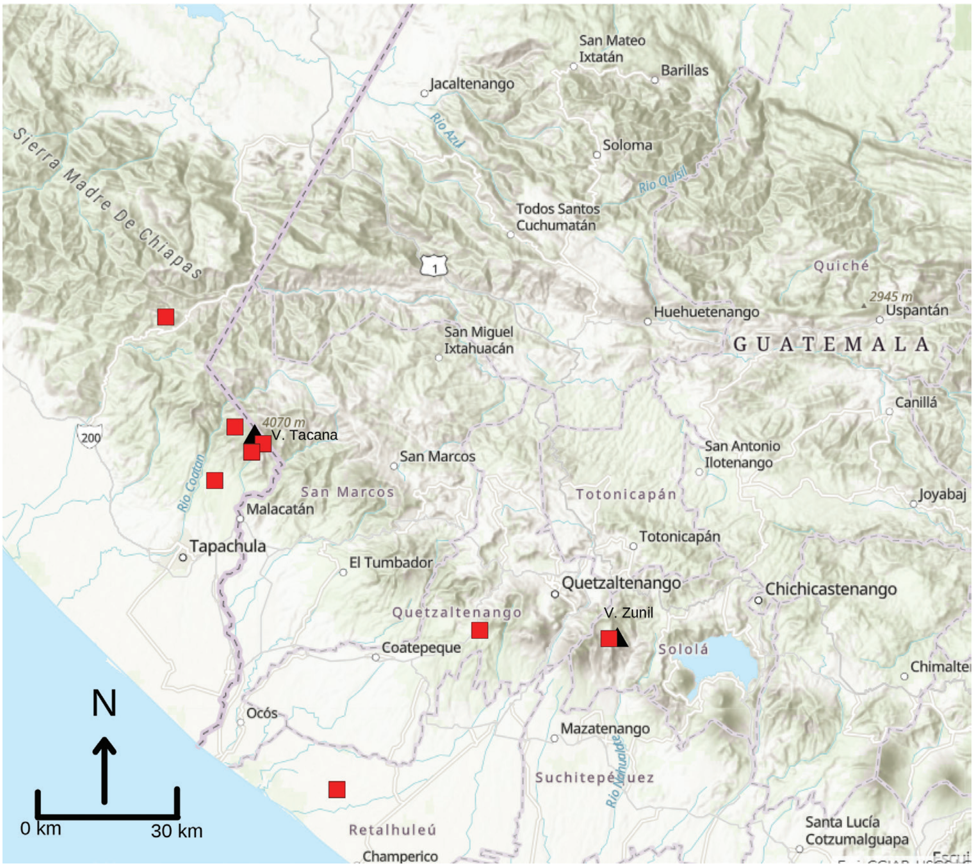

Figure 4. Map of the southern border regions of Guatemala and Chiapas, Mexico. Black triangles represent Volcán Tacaná and Volcán Zunil. Red squares represent museum specimens examined in this study. Note that some squares represent more than a single specimen. The record on the coastal plain of Quetzaltenango, Guatemala, is UMMZ 102472 which bears the locality Granja Lorena; we suspect that this is generalized locality information and the toad likely was collected to the north at higher elevation.

The results of the real-time PCR analyses for the Bd pathogen for 15 specimens for 15 specimens of *I. tacanensis* collected between 1924–1978 and four *I. bocourti* from 1989–2012 all were negative (Table 2).

Discussion

It appears that the last specimens (MVZ 191568–69) collected were found on Cerro Mozotal, Chiapas, Mexico on 22 October 1984 by Robert L. Seib. We know of no confirmed sightings or specimens since that time, despite considerable field work in the region over the subsequent decades by various teams. We know of no photograph of the

Table 2. Results of Real-Time PCR assays for amphibian chytridiomycosis (*Batrachochytrium dendrobatidis;* Bd) from preserved museum specimens of *Incilius bocourti* and *I. tacanensis*. Complete locality data are listed in the Appendix 1.

Species	Specimen	Country	State	Date	Bd +/–
I. bocourti	MVZ 256842	Mexico	Chiapas	18 June 2012	–
I. bocourti	MVZ 256843	Mexico	Chiapas	25 June 2012	–
I. bocourti	UTA A-50918	Guatemala	Huehuetenango	17 June 1996	–
I. bocourti	UTA A-28855	Guatemala	Huehuetenango	29 July 1989	–
I. tacanensis	CAS 70691	Guatemala	Suchitepequez	3 August 1924	–
I. tacanensis	CAS 139889	Mexico	Chiapas	16 August 1974	–
I. tacanensis	FMNH 35063	Guatemala	Quetzaltenango	31 January 1940	–
I. tacanensis	UIMNH 24873	Mexico	Chiapas	- August 1950	–
I. tacanensis	UIMNH 55152	Mexico	Chiapas	30 July 1963	–
I. tacanensis	UIMNH 55153	Mexico	Chiapas	8 August 1963	–
I. tacanensis	UIMNH 55154	Mexico	Chiapas	8 August 1963	–
I. tacanensis	UIMNH 55155	Mexico	Chiapas	8 August 1963	–
I. tacanensis	UIMNH 55156	Mexico	Chiapas	8 August 1963	–
I. tacanensis	UIMNH 55157	Mexico	Chiapas	8 August 1963	–
I. tacanensis	UIMNH 55158	Mexico	Chiapas	8 August 1963	–
I. tacanensis	UIMNH 24874	Mexico	Chiapas	8 August 1963	–
I. tacanensis	UMMZ 102472	Guatemala	Quetzaltenango	21 April 1949	–
I. tacanensis	MVZ 170329	Mexico	Chiapas	30 July 1978	–
I. tacanensis	MVZ 170330	Mexico	Chiapas	30 July 1978	–

species in life; one photograph of a living specimen (MVZ 264134) has been widely circulated on the internet, but in fact represents a mis-identified individual of *I. bocourti*.

Incilius tacanensis currently is listed as Endangered (criteria B1ab[iii]) on the Red List of Threatened Species of the International Union for Conservation of Nature (IUCN CSS Amphibian Specialist Group, 2020), but based on the guidelines for using the IUCN Red List categories and criteria (IUCN Standards and Petitions Committee, 2022) we suggest that the Red List be updated to include it in the Critically Endangered category, as the species is considered to be facing an extremely high risk of extinction in the wild, with populations of restricted distribution that are also severely fragmented by the continuous loss of habitat both in extent and quality, to the low number of historical localities from which the extant specimens were recorded, which is reflected in the absence of records in almost 40 years, and the presumed negative effects of amphibian chytridiomycosis caused by *Batrachochytrium dendrobatidis* (Bd). We also suggest that the Mexican federal government include the species in the Norma Oficial Mexicana (SEMARNAT 2010) in the risk category of endangered (P), based on criteria A, B, C and D of El Método de Evaluación del Riesgo de Extinción de las Especies Silvestres en México (MER), mainly considering the following aspects: for presenting a very restricted distribution (4 points) with little distribution in Mexico, less than 5% of the national territory; for occupying a hostile or very limiting habitat (3 points) with respect to the requirements for the natural development of the taxon; medium vulnerability (2 points), presenting a reproductive strategy where eggs and tadpoles are found in large to small bodies of lentic or lotic water; and the high human impact (4 points) due to the strong fragmentation of the habitat and the change in land use that occurs in the region. For the assignment of the risk category of endangered (P), the total ranges between 12 and 14 points.

With regards to the EVS, Wilson et al. (2013) and Johnson et al. (2015a, b) included *I. tacanensis* in the low category by assigning it a total of 9 points (4 for geographical distribution + 4 for ecological distribution + 1 point for the type of reproductive mode). The 4 points for ecological distribution consider that the species occurs in five vegetation formations; however, Johnson (1989) in his biogeographical analysis of the herpetofauna of the northwestern nuclear Central America mentions that the species is distributed in only two vegetation formations (lower montane rain forest and montane rain forest) for which it reaches a value of 7 points in the ecological distribution section, and a total of 12 considering the other aspects, for which it would be included in the medium category of the EVS that considers a range 10–13, even if three vegetation formations are considered by including the premontane tropical forest as different from the two formations already mentioned. It should be noted that Smith (1952) in the paper describing the species does not refer to the type of habitat or vegetation formation where the specimens were recorded, and there is no formally published information that considers various ecological aspects. Despite the proposal to change the category from low to medium, due to the argument that the species occurs in a smaller number of vegetation formations, it is necessary to point out the limitations of the EVS, in cases such as *I. tacanensis*, a taxon that has a limited distribution and is possibly extinct but is considered in the low category of this measure.

With regards to chytridiomycosis, we note that the timing of the last records, in 1984, corresponds closely to estimated epidemics in the region. Mendelson et al. (2014) estimated an outbreak of chytridiomycosis in the Sierra de las Minas, Guatemala, in 1983. Other reports of chytrid-induced declines from southern Mexico and Guatemala, similarly all are concentrated in the late 1970s and early 1980s (Lips et al. 2004; Rovito et al. 2009; Cheng et al. 2011; Scheele et al. 2019). It is perhaps noteworthy that extensive local collections on the slopes of Volcán Santa María, Quetzaltenango, Guatemala, in 1987 and 1988 (Campbell and Vannini 1989b) failed to discover this species. Although there are no historical records of *I. tacanensis* from this particular volcano, it is well within the estimated range of the species and bears seemingly appropriate habitats. Basanta et al. (2021) produced historical data for presence and distribution of Bd in Mexico. Their results indicate that Bd has been present in Mexico, in some genetic form, since at least the late 1800s, but their data indicate a drastic increase in prevalence during the period of 1970–1985, and further increasing afterwards.

The effects of chytridiomycosis on individuals and populations of *I. tacanensis* are completely unknown, but it is worth noting that some – but certainly not all – species in the genus are severely negatively affected (e.g., *I. periglenes*; Crump et al, 1992; Schachat et al., 2015). Muñoz Alonso (no date, probably 2010) reported that El Tacaná (15°02'10"N, 72°08'29"W, municipality of Cacahoatán), is one of 10 localities in Chiapas where chytridiomycosis has been recorded, confirmed in tree frogs *Plectrohyla* *matudai* Hartweg, 1941 and *P. sagorum* Hartweg, 1941; these localities occur at elevations ranging between 900 and 1200 m. These areas represent montane cloudforest habitats (bosque de pino) and semi-evergreen tropical forest (selva mediana subperennifolia). While our small and chronologically random sampling for Bd is inconclusive, considered together, one can envision a parsimonious scenario in which *I. tacanensis* was driven to extinction by Bd in the mid-1980s.

Acknowledgements

We are grateful for loans of specimens from University of Illinois Natural History Survey, California Academy of Sciences, Museum of Vertebrate Zoology at University of California Berkeley, Amphibian and Reptile Diversity Research Center at University of Texas Arlington, Museum of Zoology at University of Michigan, and University of Kansas. Sean Rovito kindly provided details from his field efforts in the vicinity of Volcán Tacaná. We are very grateful to Ana Longo for her generosity in analyzing swabs for Bd in her laboratory at University of Florida. Victor Hugo Reynoso Rosales and Omar Hernández Ordóñez kindly provided photographs of specimens in the IBUNAM collection. Adam G. Clause provided very useful comments on the manuscript. Fig. 3 was prepared by Taylor Cooper.

References

Basanta MD, Byrne AQ, Rosenblum EB, Piovia-Scott J, Parra-Olea G (2021) Early presence of *Batrachochytrium dendrobatidis* in Mexico with a contemporary dominance of the global panzootic lineage. Molecular Ecology 30(2): 424–437. https://doi.org/10.1111/mec.15733

Boyle DG, Boyle DB, Olsen V, Morgan JAT, Hyatt AD (2004) Rapid quantitative detection of chytridiomycosis (*Batrachochytrium dendrobatidis*) in amphibian samples using real-time Taqman PCR assay. Diseases of Aquatic Organisms 60: 141–148. https://doi.org/10.3354/dao060141

Campbell JA, Vannini JP (1989a) The distribution of amphibians and reptiles in Guatemala and Belize. The Western Foundation of Vertebrate Zoology 4: 1–21.

Campbell JA, Vannini JP (1989b) Listado preliminar de la herpetofauna de Finca El Faro, El Palmar, Quetzaltenango, Guatemala. Fundación Interamericana de Investigación Tropical. Publicación Ocasional 1: 1–10.

Cheng TL, Rovito SM, Wake DB, Vredenburg VT (2011) Coincident mass extirpation of neotropical amphibians with the emergence of the infectious fungal pathogen Batrachochytrium dendrobatidis. Proceedings of the National Academy of Sciences of the United States of America 108(23): 9502–9507. https://doi.org/10.1073/pnas.1105538108

Crump ML, Hensley FR, Clark KL (1992) Apparent decline of the golden toad: Underground or extinct? Copeia 1992(2): 4133–4420. https://doi.org/10.2307/1446201

Frost DR, Grant T, Faivovich J, Bain RH, Haas A, Haddad CF, De Sa RO, Channing AL, Wilkinson MA, Donnellan SC, Raxworthy CJ, Campbell JA, Blotto BL, Moler P, Drewes RC, Nussbaum RA, Lynch JD, Green DM, Wheeler WC (2006a) The amphibian tree of life. Bulletin of the American Museum of Natural History 297: 1–291. https://doi.org/10.1206/0003-0090(2006)297[0001:TATOL]2.0.CO;2

Frost DR, Grant T, Mendelson III Jr (2006b) *Ollotis* Cope, 1875 is the oldest name for the genus currently referred to as *Cranopsis* Cope, 1875. Copeia 2006(3): e558. https://doi.org/10.1643/0045-8511(2006)2006[558:OCITON]2.0.CO;2

Frost DR, Mendelson JR III, Pramuk JB (2009) Further notes on the nomenclature of Middle American toads (Bufonidae). Copeia 2009(2): e418. https://doi.org/10.1643/CH-08-204

Gray AR, Bland AW (2016) Notes on the reproduction of the endemic Costa Rican toad, *Incilius chompipe* (Anura Bufonidae). Mesoamerican Herpetology 3: 464–467.

IUCN SSC Amphibian Specialist Group (2020) *Incilius tacanensis*. *The IUCN Red List of Threatened Species* 2020: eT54773A53950956. https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T54773A53950956.en [Downloaded on 20 September 2021]

IUCN Standards and Petitions Committee (2022) Guidelines for Using the IUCN Red List Categories and Criteria. Version 15. Prepared by the Standards and Petitions Committee. https://www.iucnredlist.org/documents/RedListGuidelines.pdf

Johnson JD (1989) A biogeographic analysis of the herpetofauna of northwestern nuclear Central America. Milwaukee Public Museum Contributions in Biology and Geology 76: 1–66.

Johnson JD, Mata-Silva V, García-Padilla E, Wilson LD (2015a) The herpetofauna of Chiapas, Mexico: Composition, physiographic distribution, and conservation status. Mesoamerican Herpetology 2: 272–329.

Johnson JD, Mata-Silva V, Wilson LD (2015b) A conservation reassessment of the Central American herpetofauna based on the EVS measure. Amphibian & Reptile Conservation 9(2): 1–94 [e100].

Lips KR, Mendelson III JR, Muñoz-Alonso A, Canseco-Márquez L, Mulcahy DG (2004) Amphibian population declines in montane southern Mexico: Resurveys of historical localities. Biological Conservation 119(4): 555–564. https://doi.org/10.1016/j.biocon.2004.01.017

Longo AV, Rodriguez D, da Silva Leite D, Toledo LF, Mendoza Almeralla C, Burrowes PA, Zamudio KR (2013) ITS1 copy number varies among *Batrachochytrium dendrobatidis* strains: Implications for qPCR estimates of infection intensity from field-collected amphibian skin swabs. PLoS One 8(3): e59499. https://doi.org/10.1371/journal.pone.0059499

Mendelson III JR, Mulcahy DG, Snell S, Acevedo ME, Campbell JA (2012) A new golden toad (Bufonidae: *Incilius*) from northwestern Guatemala and Chiapas, Mexico. Journal of Herpetology 46(4): 473–479. https://doi.org/10.1670/11-140

Mendelson JR III, Jones MEB, Pessier AP, Toledo G, Kabay EH, Campbell JA (2014) On the timing of an epidemic of amphibian chytridiomycosis in the highlands of Guatemala. South American Journal of Herpetology 9(2): 151–153. https://doi.org/10.2994/SAJH-D-14-00021.1

Muñoz-Alonso A (no date) Riqueza, diversidad y estatus de los anfibios amenazados del sureste de México; una evaluación para determinar las posibles causas de la declinación de sus poblaciones. El Colegio de la Frontera Sur-Arizona State University-Critical Ecosystem Partnership Fund. San Cristóbal de las Casas, Chiapas, México. 55 pp.

Rovito SM, Parra-Olea G, Vásquez-Almazán CR, Papenfuss TJ, Wake DB (2009) Dramatic declines in neotropical salamander populations are an important part of the global amphibian crisis. Proceedings of the National Academy of Sciences of the United States of America 106(9): 3231–3236. https://doi.org/10.1073/pnas.0813051106

Sabaj-Perez M (2022) Standard symbolic codes for institutional resource collections in herpetology and ichthyology: an online reference. Version 9.0 (14 February 2022). American Society of Ichthyologists and Herpetologists, Washington, D.C. Electronically accessible from: http://www.asih.org/ [accessed 29 March 2022]

Schachat SR, Mulcahy DG, Mendelson III Jr (2015) Conservation threats and the utility of IUCN Red List rankings in the context of phylogeny. Conservation Biology. https://doi.org/10.1111/cobi.12567

Scheele BC, Pasmans F, Berger L, Skerratt LF, Martel A, Beukema W, Acevedo AA, Burrowes PA, Carvalho T, Catenazzi A, De La Riva I, Fisher MC, Flechas SV, Foster CN, Frías-Álvarez P, Garner TWJ, Gratwicke B, Guayasamin JM, Hirschfeld M, Kolby JE, Kosch TA, La Marca E, Lindenmeyer DB, Lips KR, Maneyro R, McDonald CA, Mendelson JR III, Palacios-Rodriguez P, Parra-Olea G, Richards-Zawacki CL, Rödel MO, Rovito SM, Soto-Azat C, Toledo LF, Voyles J, Weldon C, Whitfield SM, Wilkinson M, Zamudio KR, Canessa S (2019) The aftermath of amphibian fungal panzootic reveals unprecedented loss of biodiversity. Science 363: 1459–1463. https://doi.org/10.1126/science.aav0379

Seib RL (1985) Euryphagy in a tropical snake, *Coniophanes fissidens*. Biotropica 17(1): 57–64. https://doi.org/10.2307/2388380

SEMARNAT (Secretaría de Medio Ambiente y Recursos Naturales) (2010) Norma Oficial Mexicana NOM-059. Protección ambiental de especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-Lista de especies en riesgo. Proyecto de Modificación. Agosto 2018. México D.F., México. Diario Oficial de la Federación.

Smith PW (1952) A new species of toad from the highlands of Guatemala and Chiapas. Copeia 1952(3): 175–177. https://doi.org/10.2307/1439700

Vaughan A, Mendelson III Jr (2007) Taxonomy and ecology of the Central American toads of the genus *Crepidophryne* (Anura: Bufonidae). Copeia 2007(2): 304–314. https://doi.org/10.1643/0045-8511(2007)7[304:TAEOTC]2.0.CO;2

Wilson LD, Johnson JD, Mata-Silva V (2013) A conservation reassessment of the amphibians of Mexico based on the EVS measure. Amphibian & Reptile Conservation 7(1): 97–127[e69].

Appendix I

Specimens of *I. tacanensis* verified by photographs or physical examination.

The specimens here referred to *I. bocourti* and *I. luetkeni* had been catalogued in their respective collections as *I. tacanensis*.

Incilius bocourti

Guatemala: Huehuetenango: Sierra de los Cuchumatanes, 30.4 km (by road) SSW San Juan Ixcoy (UTA A-28855); 5.1 km WSW Patacal (UTA A-50918). Mexico: Chiapas: Summit of Cerro Mozotal, Mpio. Motozintla (MVZ 272788); 1.8 km NE (by rd) of summit of Cerro Mozotal on road to Motozintla, Mpio. Motozintla (MVZ 256842); Ejido Boqueron, 14 km W (by road) of Niquivil, Mpio. Motozintla (MVZ 256843); Mpio. Motozintla, Ejido El Carrizal, Cerro el Mozotal (CZRHE 2603); Mpio. Motozintla, Pinabeto, alrededor del pueblo (CZRHE 2795); Mpio. Motozintla, cerca de Pinabeto, al sur del pueblo (CZRHE 2775); Mpio. El Porvenir, 0.79 km NE de Cañada, 5.32 km NW de El Porvenir (CZRHE 3010); Mpio. Motozintla, Ejido El Carrizal, Cerro El Mozotal (CZRHE 2598); Mpio. Motozintla, Ejido Libertad Calera (CZRHE 2823); Mpio. El Porvenir, El Porvenir (CZRHE 3014); Top of Cerro Tzontehuitz, near San Cristobal de las Casas (MVZ 264134).

Incilius luetkenii

Guatemala: El Progreso: Morazan (AMNH 183098).

Incilius tacanensis

Guatemala: Suchitepequez: Volcán Zunil (CAS 70691); Quetzaltenango: Finca Montecristo, Rio Samala (FMNH 35063); Granja Lorena (UMMZ 102472). Mexico: Chiapas: 1500 m on Volcán de Tacaná (UMMZ 88359); 8 km N Juárez (KU 94009); Colonia Talquian, Volcán Tacaná (MVZ 159445–48); Volcán Tacaná, above Cacahuatan (UIMNH 6177–78, 24873–74); Union Juárez (UIMNH 55152); near Talquian (UIMNH 55152–58); Volcán Tacaná, 3 km N of Union Juárez (CAS 139889–90); Colonia Talquian, 3 km N (by road) Union Juárez, Volcán Tacaná (MVZ 170329, 170330); Cerro Mozotal, 16.7 mi (via road to Siltepec) from pass on continental divide above Huixtla (MVZ 191569); Volcán de Tacaná, above Cacahuatan (USNM 139721); Union Juárez, Ejido Talquian y Chiquihuites (IBUNAM-CNAR 5407, 2 specimens).

ZooKeys 1102: 163–176 (2022)
doi: 10.3897/zookeys.1102.81247
https://zookeys.pensoft.net

RESEARCH ARTICLE

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A new species of *Arrhopalites* Börner (Collembola, Symphypleona, Arrhopalitidae) from China, with a key to the Asian species of the *caecus* group

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Academic editor: Wanda M. Weiner | Received 8 February 2022 | Accepted 26 April 2022 | Published 20 May 2022

http://zoobank.org/858E5369-0684-4DE7-AE5C-5482472191BA

Citation: Nunes Godeiro N, Zhang F, Cavalcante Bellini B (2022) A new species of *Arrhopalites* Börner (Collembola, Symphypleona, Arrhopalitidae) from China, with a key to the Asian species of the *caecus* group. ZooKeys 1102: 163–176. https://doi.org/10.3897/zookeys.1102.81247

Abstract

The second species of *Arrhopalites* from China is described and illustrated and an identification key to the Asian species of the *caecus* group is presented. *Arrhopalites brevicornis* **sp. nov.** is the eleventh species of the *caecus* group recorded in Asia and it can be clearly differentiated by the unguiculus III with 2 internal teeth (0–1 in all other species). Also, the combination of antennae less than 2 times the size of the head, antennal segment IV without annulations, 1+1 eyes, dorsal head with 9 spines, 2+2 regular spines per side on the anal valves, circumanal chaetae without basal serrations, subanal appendage long and apically serrated, manubrium with 5+5, and dorsal dens with 16 chaetae is unique among the Asian species of the *caecus* group.

Keywords

Appendiciphora, grassland, Katiannoidea, springtails, taxonomy

Introduction

Arrhopalitidae Stach, 1956 comprises species of *Arrhopalites* Börner, 1906, *Pygmarrhopalites* Vargovitsh, 2009 and *Troglopalites* Vargovitsh, 2012. Currently this family gathers 141 species described worldwide, with 41 of them belonging to *Arrhopalites* (Bellinger et al. 1996–2022). Vargovitsh (2013) divided the genus into three species groups based on the ventral (anterior) dental chaetotaxy: *diversus* group, with the chaetal formula of 3, 2, 1, 1 from the apex to the basis of the structure; *caecus* group, with 3, 2, 1, 1, 1 chaetae; and *harveyi* group with 3, 2, 2, 1, 1 chaetae. This division, as well as the support for the family and genera, have not been tested yet with the use of molecular phylogenetics, which could clarify different points of view about the systematics of Arrhopalitidae internal systematics (Zeppelini 2011; Vargovitsh 2013). Also, such kind of study could verify the phylogenetic signal of the dental chaetotaxy within *Arrhopalites*, which is widely used among the Symphypleona to separate species groups, but may be, at least in few genera, an arbitrary feature to gather unrelated taxa (see Cipola et al. 2021: 37–38). Nevertheless, Vargovitsh's groups of *Arrhopalites* currently provide clear data to quickly compare species within the genus (Vargovitsh 2013).

Despite its extensive territory, only one species of *Arrhopalites* was recorded from China so far, *A. pukouensis* Wu & Christiansen, 1997, described from Jiangsu Province, in the eastern region of the country. Another species (*A. nanjingensis* Lin & Chen, 1997) was originally described as *Arrhopalites*, but it was transferred to *Pygmarrhopalites* by Vargovitsh (2009). So, herein we describe in detail a second species of *Arrhopalites* from China and provide an identification key to the Asian species of the *caecus* group.

Materials and methods

Specimens were collected in the field with entomological aspirators and transferred to plastic containers in the laboratory of Entomology, Nanjing Agricultural University (NJAU), China, where they are being cultured. Specimens used for description were sorted in September 2021 and transported to Shanghai Natural History Museum, where the following steps were developed. Under a stereomicroscopy Teelen XTL-207, specimens were bleached and diaphanized, first in 5% KOH and after in 10% lactophenol for three minutes/each. Hoyer's liquid was used to mount the specimens between a slide and a glass coverslip. Slides were dried in an oven at 50 °C for 10 days (Christiansen and Bellinger 1980, 1998). A Leica DM2500 microscope with a drawing tube was used to draw the illustrations, which were posteriorly vectorized with Corel Draw 2018 v20. Habitus of the species was photographed in 70% ethanol under a Leica S8AP0 stereomicroscope attached to a Leica DMC4500 camera, using Leica Application Suite software. Slides with type specimens mounted in Hoyer's liquid along with 78 specimens preserved in 98% ethanol are deposited at the collection of Shanghai Natural History Museum (SNHM).

The terminology used in descriptions follows Fjellberg (1999) for the labial palp papillae, Cipola et al. (2014) for the labral chaetotaxy, Nayrolles (1988) for the proximal tibiotarsi chaetotaxy, Betsch and Waller (1994) for head and anterior large abdomen chaetotaxy, Vargovitsh (2009, 2012, 2013) for the posterior large abdomen chaetotaxy and Betsch (1997) for the small abdomen chaetotaxy. On the dens we considered as the dorsal chaetae the sum of the dorsal, dorso-internal and dorso-lateral rows. Drawings and observations were made based in the entire type series.

The abbreviations used in the text and drawings are: Abd = abdominal segment(s); Ant antennal segment(s); and Th = thoracic segment(s).

Taxonomy

Order Symphypleona Börner, 1901 sensu Bretfeld, 1986
Suborder Appendiciphora Bretfeld, 1986
Superfamily Katiannoidea Bretfeld, 1994
Family Arrhopalitidae Stach, 1956 *sensu* Bretfeld, 1999
Genus *Arrhopalites* Börner, 1906

***Arrhopalites brevicornis* sp. nov.**
http://zoobank.org/FED6DB53-B746-424D-93B0-105DA1AFA930
Figs 1–4, Table 1

Type material. ***Holotype*** on slide "SNHM00001": female, Jilin Province, China, 44°33'N, 123°31'E, 2013, in soil samples from the Ecological Research Station for Grassland Farm, July 2013, Bing Zhang leg. ***Paratypes*** on slides: 9 females on slides, same data as holotype. Besides the type material, 78 specimens are kept in 98% ethanol at the SNHM, plus several paratype slides are kept at the laboratory of Entomology, NJAU, China.

Diagnosis. Female. Antennae short, about 1.4 times the head length. Ant IV not subdivided and short, about twice or less the length of Ant III. Eyes 1+1. Clypeal area a–f lines with 7(+1)/7/5/4–5/5/6 chaetae respectively, plus 3 central chaetae with unclear homologies, frontal area A–C lines with 1/1/2(+1) short stout spines. Small abdomen, dorsal anal valve with 2 cuticular spines per side and 4 sword-shaped smooth chaetae (ms1, mps1–3), ventral anal valves with 2 cuticular spines each and 3 sword-shaped smooth chaetae (mi3, mpi1–2), subanal appendage long, similar in length to mi3, mpi1–2, with a spatulated and apically serrated apex. Manubrium with 5 chaetae on each side, dens ventral formula from the apex to the basis as 3,2,1,1,1, dorsally with 16 chaetae. Mucro with both edges serrated, apically swollen. Ungues I slender, III broad, all with an underdeveloped tunica, unguiculus III with 2 inner teeth.

Description. Female. Body (head + trunk) length of type series (females, N = 4) ranging between 0.71 and 0.81 mm, average 0.74 mm, holotype with 0.75 mm. Habitus as in Fig. 1. Specimens pale yellowish with brownish spots of pigment on frontal

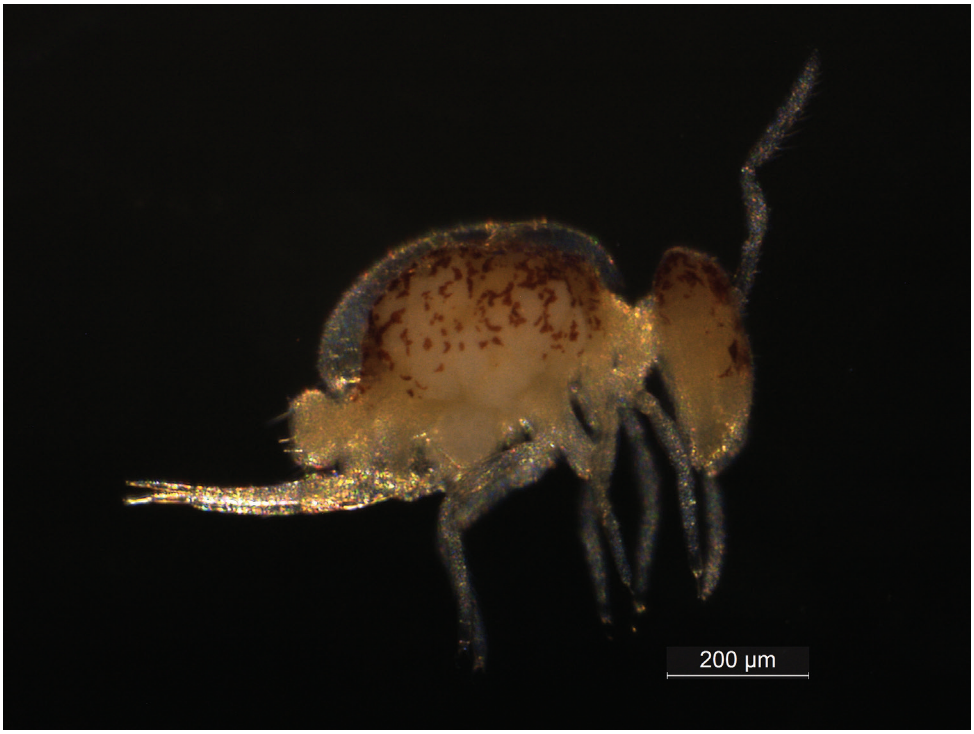

Figure 1. *Arrhopalites brevicornis* sp. nov.: habitus of specimen fixed in ethanol.

and dorsal head and dorso-lateral large abdomen. Body chaetae smooth and acuminate, with the exception of the subanal appendage.

Head (Figs 1, 2). Antennae shorter than the body, with 0.32 mm in the holotype (Fig. 1), ratio antennae: head length of the holotype 1.3:1, type series average 1.4:1. Holotype antennal segments ratio of Ant I:II:III:IV as 1:1.6:2.3:4.3, and of type series (*N* = 4) as 1:1.3–2.7:2.1–3.3:3.8–6.7. Ant IV short and stout, about twice or less the size of Ant III (in holotype, ratio Ant III:IV = 1:1.87), without subsegments, with about 87 regular chaetae of different sizes distributed in apparently 13 whorls (Fig. 2A). Ant III slightly swollen with 17 chaetae, Ape, Ae, Ap, Ai, Aa, Api, and Aai present, Api slightly reduced, Aai as the accessory microsensillum, sense rods not swollen inside separate invaginations (Fig. 2B). Ant II with 13 regular chaetae, Ant I with 7, the two more apical reduced (Fig. 2C). Eyes 1+1, head length (eyes to mouth) of holotype 0.25 mm. Clypeal area a–f lines with 7(+1)/7/5/4–5/5/6 chaetae respectively, plus 3 central chaetae of unclear homologies; interantennal area α and β lines with 2/1(+1) short chaetae respectively, plus 2+2 small oval organs (pseudopores) and 1+1 large circles lacking tegument granules near the lateral chaetae on α line; frontal area A–C lines with 1/1/2(+1) short stout spines, D line with 2 elongate thinner erect chaetae (Fig. 2D). Ventral groove with 2 surrounding chaetae from lines a and b, labial basomedian field with 4, basolateral field with 5 chaetae (Fig. 2E). Labial papilla E lateral

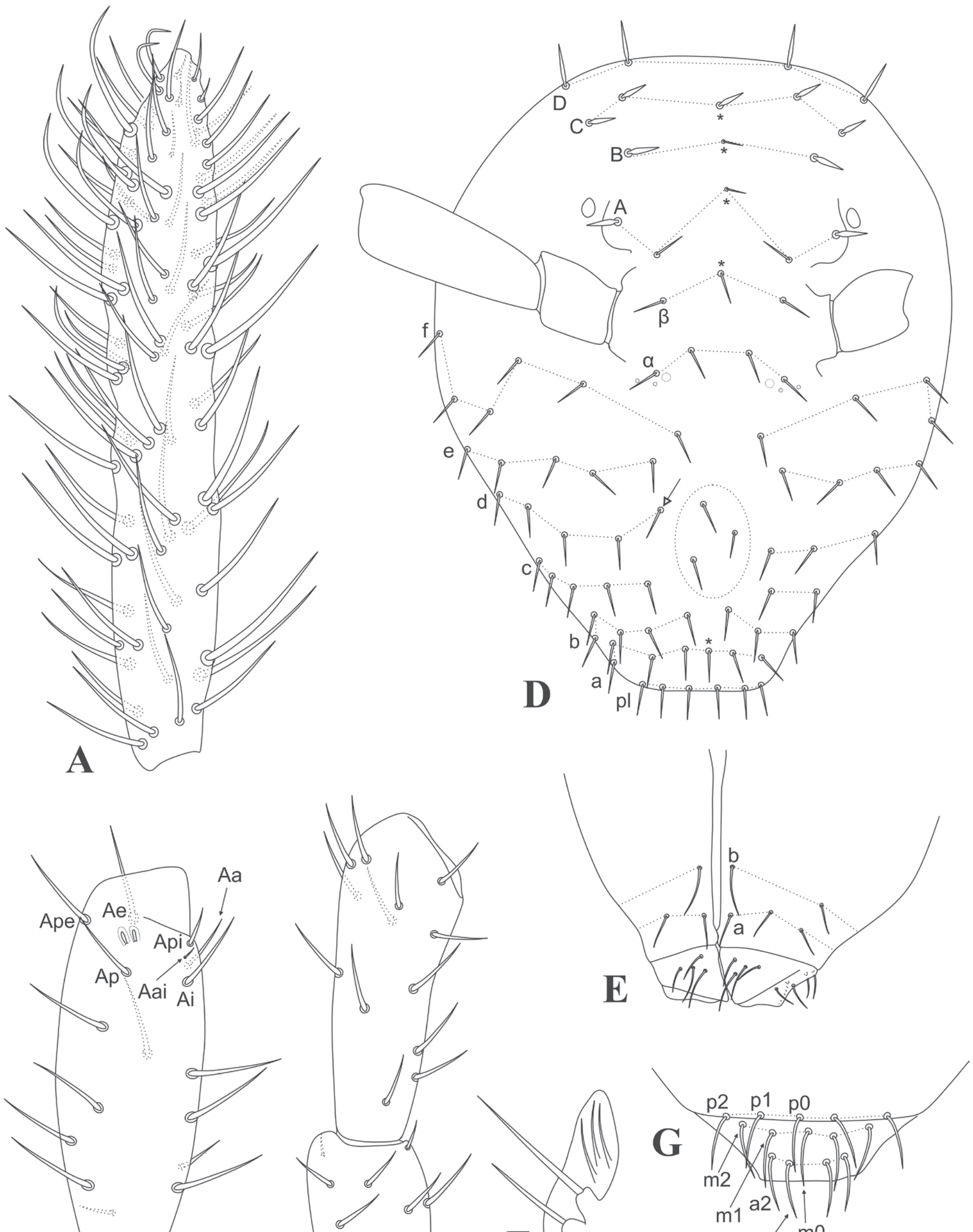

Figure 2. *Arrhopalites brevicornis* sp. nov. head **A** left Ant IV (dorsal side) **B** left Ant III (ventral side) **C** left Ant I–II (dorsal side) **D** anterior head – left side shows the complete chaetotaxy, * marks unpaired chaetae, white arrow points to chaeta present or absent, large dashed circle on central clypeal region marks asymmetrical chaetae **E** ventral head chaetotaxy – right side shows the complete chaetotaxy, including labial basomedian and basolateral fields **F** left maxillary outer lobe and sublobal plate **G** prelabral chaetae and labrum.

finger-shaped, not reaching the papilla apex, other labial structures unclear. Maxillary outer lobe apical chaeta longer than the basal one, sublobal plate with three sublobal hairs (Fig. 2F). Distal margin of the clypeus with 3 prelabral chaetae, labral chaetotaxy with 2(+1) p, 2(+1) m and 2 a chaetae, all subequal (Fig. 2G).

Trunk (Fig. 3A, B). Trunk length of holotype 0.5 mm. Large abdomen: thorax continuous with abdomen, without any constrictions. Th II with 1 a and 3 m chaetae; Th III with 1 a and 3 m chaetae; Abd I with 5 a, 4 m and 1 p chaetae, respectively. Three chaetae (1–3) on the upper side of bothriotrichum A, plus accessory a1 nearby its alveolus; b1 accessory chaeta between B and C bothriotricha, c2 just under C, c1 absent; bothriotricha A–C misaligned, with B bothriotrichum closer to C than A; dorso-posterior longitudinal series dI-1, dII-1, dIII-1 with 5–7, 9–10 and 6–8 chaetae, respectively; two rows with 3 chaetae each between C and D bothriotricha; D with 4 surrounding chaetae posteriorly; parafurcal area (furcula basis) with 8 regular chaetae; ventral complex with 1 chaeta (Fig. 3A). Small abdomen of the female: dorsal anal valve with as2–4, ms1–5?, mps1–3, and ps1–2 chaetae, ms1 and mps1–3 sword-shaped and smooth, 2 cuticular spines surrounding mps2; ventral anal valves each with ai1–6, ami1–2, mi1–5, mpi1–2, and pi1–3 chaetae, mi3 and mpi1–2 sword-shaped and smooth, mi5 as the subanal appendage long (similar in length to mi3, mpi1–2) with a spatulated and apically serrated apex (sometimes one of the lateral edges is also distally serrated), curved toward the genital opening, 2 cuticular spines surrounding mpi2 (Fig. 3B). Genital plate of the female unclear.

Abdominal appendages (Fig. 3C–F) Collophore with 1 distal chaeta on each side, with a pair of a little wrinkled, almost smooth, sacs. Tenaculum with 3 teeth on each ramus plus the basal tubercle, with a single unpaired apical chaeta. Furcal size length in holotype: manubrium = 75 μm; dens = 113 μm; and mucro = 75 μm (ratio 1:1.5:1). Manubrium with 5 dorsal chaetae on each side, the most proximal thinner than the others (Fig. 3C); dens ventral (or anterior) formula from the apex to the basis as 3,2,1,1,1, all chaetae enlarged except for the most proximal one, (Fig. 3D); dens dorsally (or posteriorly) with 16 chaetae, 7 of them on the lateral edges of the more distal region more robust, almost spine-like (Fig. 3E). Mucro apically swollen with both edges serrated from the basis until almost the apex (Fig. 3F).

Legs. (Figs 3A, 4) Epicoxae, subcoxae and coxae I–III with 1,0,1/1,1,4/1,1,4 chaetae, respectively, coxae II–III with 1 long and 1 tiny chaeta each (Fig. 3A). Trochanters I–III with 4 chaetae each, II–III with 1 chaeta each modified as an anterior trochanteral organ (Fig. 4A–C). Femurs I–III with 13/13/14 chaetae respectively, of which 1/1/3 as reduced chaetae (Fig. 4A–C). Tibiotarsi without oval organs, tibiotarsus I region F with 3 chaetae (FPae, FPe, and FPpe), whorls I–V with 9,8,8,8,9 chaetae respectively, whorl I without clearly modified chaetae except for a larger dorsal one, whorl V with 2 ventro-distal chaetae (Fig. 4D). Tibiotarsus II region F with 3 chaetae (FPae, FPe, and FPpe), whorls I–V with 9,8,8,8,7 chaetae respectively, whorl I without clearly modified chaetae except for a slightly larger dorsal one, whorl V with 1 ventro-distal chaeta (Fig. 4E). Tibiotarsus III region F with 4 chaetae (FPae, FPe, FPpe, and FSa), whorls I–V with 9,8,8,8,7 chaetae respectively, whorl

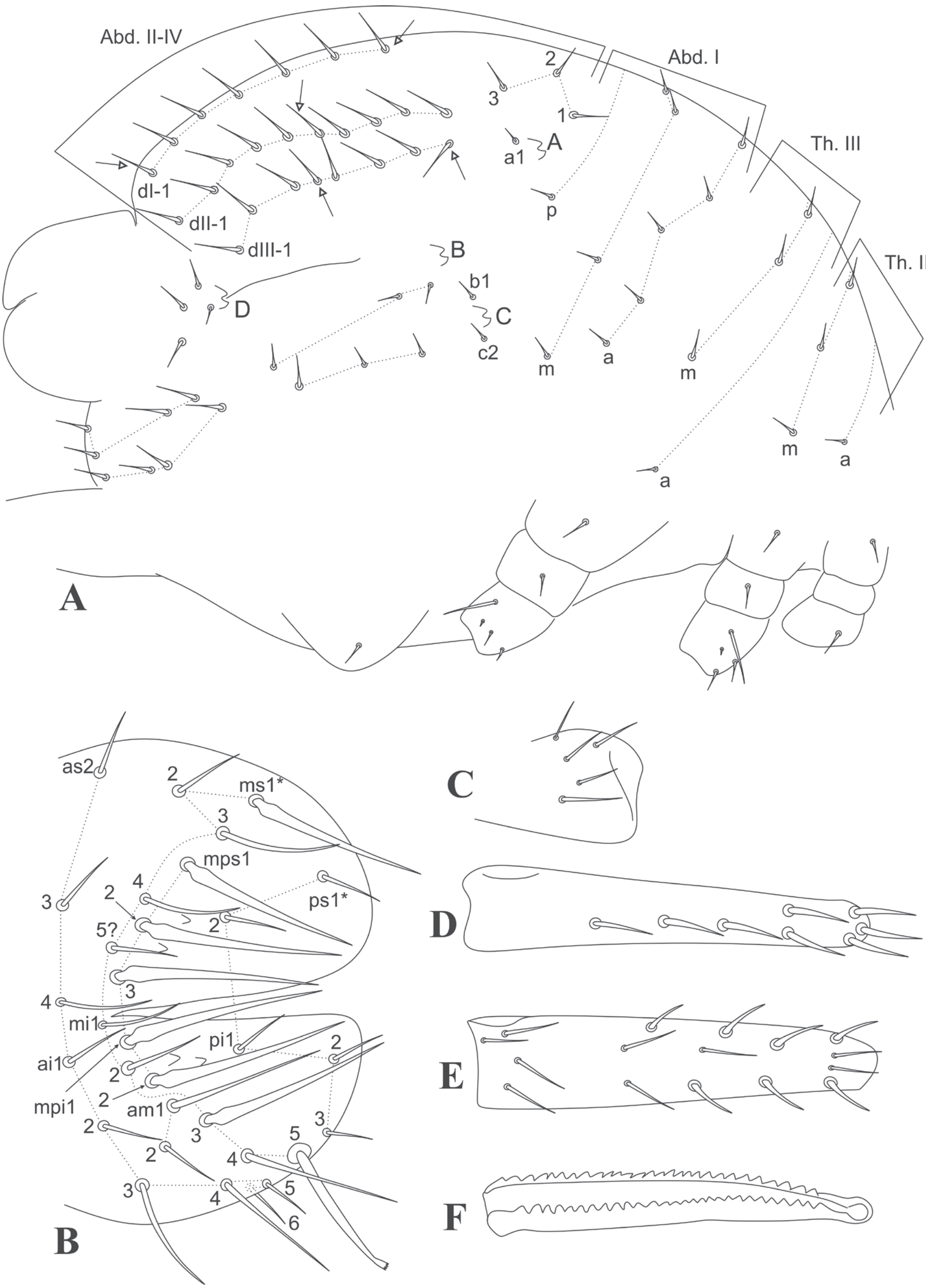

Figure 3. *Arrhopalites brevicornis* sp. nov. trunk, proximal legs and furca **A** large abdomen and coxae chaetotaxy (right side) **B** female's small abdomen (left side) **C** right manubrial chaetotaxy (dorsal side) **D** right dens ventral chaetotaxy **E** right dens dorsal chaetotaxy **F** mucro.

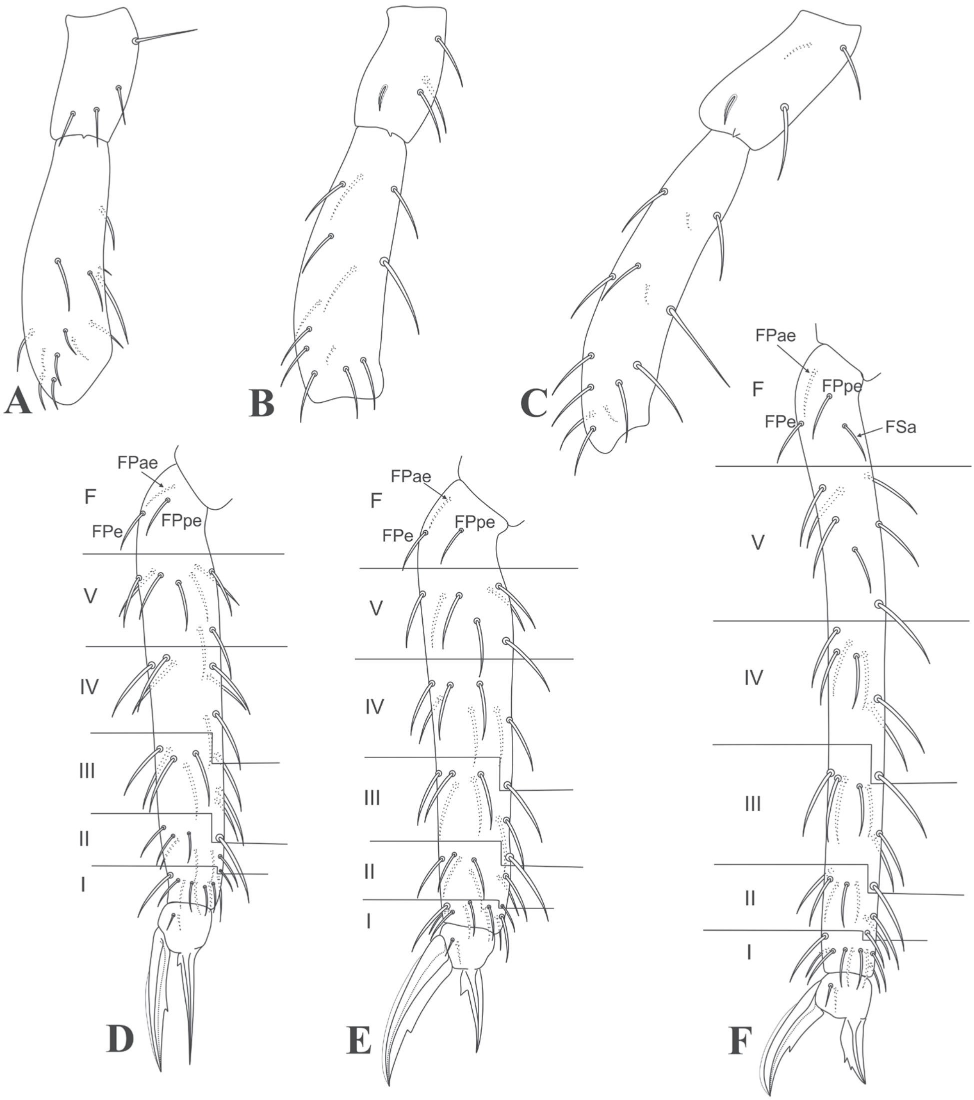

Figure 4. *Arrhopalites brevicornis* sp. nov. legs **A–C** trochanters and femurs I–III (anterior side), respectively **D–F** tibiotarsi and empodial complexes I–III (anterior side), respectively.

I without clearly modified chaetae except for a slightly larger dorsal one, whorl V with 1 ventro-distal chaeta (Fig. 4F). Foot complexes I–III with 2 pretarsal chaetae each, 1 anterior and 1 posterior; ungues (claws) without cavity or pseudonychia, but with an underdeveloped tunica covering about 2/3 up to 3/4 of the dorsal ungues, lateral lamellae apparently lacking teeth, each unguis with one internal tooth; unguis I slender, III broad (Fig. 4D–F). Unguiculi (empodia) never surpassing the ungues, unguiculus I almost reaching the apex of unguis I, unguiculi II–III clearly shorter; unguiculi I–II with one proximal internal tooth each, unguiculus III with 2 more distal teeth (Fig. 4D–F).

Male. Not found, species possibly parthenogenetic.

Etymology. The new species was named after its short antenna (from Latin *brevi-* = short; *cornis* = "horns", antennae).

Distribution and habitat. The new species was collected and only recorded in Jilin Province, Changling County, at the Ecological Research Station for Grassland Farm (ERSGF). This region is characterized by a semi-arid continental monsoon climate, with cold, dry winters and warm, rainy summers. Annual mean temperature in the region ranges from 4.68 to 6.48 °C, and annual precipitation is 280 to 400 mm with about 70% falling in the June-August period (Changling County Climate Station, Jilin Province). Changling County is located at a transitional zone of cropping and grazing, with high economical potential. However, drastic environmental disturbances are happening in this region, like sand and dust storms, emergence of saline-alkali soils, and land over-utilization.

Remarks. *Arrhopalites brevicornis* sp. nov. belongs to the *A. caecus* (Tullberg, 1871) group of species *sensu* Vargovitsh (2013), according to its ventral (or anterior) dental chaetotaxy (3, 2, 1, 1, 1). Currently, there are ten other Asian species of the genus which belong to this group: *A. antrobius* Yosii, 1954, *A. abchasicus* Vargovitsh, 2013, *A. caecus*, *A. coreanus* Park & Kang, 2007, *A. gul* Yosii, 1966, *A. macronyx* Vargovitsh, 2012, *A. minor* Park & Kang, 2007, *A. minutus* Yosii, 1970, *A. potapovi* Vargovitsh, 2015 and *A. pukouensis*, (Bellinger et al. 1996–2022; Vargovitsh 2012, 2013, 2015). *Arrhopalites brevicornis* sp. nov. can be distinguished from all of them especially by the unguiculus III with 2 internal teeth (0–1 in all other species). Also, the combination of antennae less than 2 times the size of the head, Ant IV without annulations, 1+1 eyes, dorsal head with 9 spines, 2+2 regular spines per side on the anal valves, circumanal chaetae without basal serrations, subanal appendage long and apically serrated, similar in length to mi3, mpi1–2, manubrium with 5+5 and dorsal dens with 16 chaetae is unique among the Asian species of the *caecus* group (see Table 1).

Concerning the species recorded from localities closer to Jilin Province, China, the South Korean *A. coreanus*, *A. gul* and *A. minor* share a similar color pattern, number of eyes, the presence of dorsal spines on head and number of dorsal dens chaetae with the new species. However the later differs from them by: the absence of Ant IV annulations (7 of *A. gul*); antennae less than 2 times the size of the head (at least two times in *A. coreanus* and *A. gul*); all ungues tunicate (without tunica on *A. gul*); female's subanal appendage apically serrated (pointed in *A. coreanus* and *A. minor*, and blunt in *A. gul*); dorsal anal valve chaeta ms1 not forked (forked in *A. coreanus*); circumanal chaetae without basal serrations (with in *A. gul*) and manubrium with 5+5 chaetae (4+4 in *A. gul*, 9+9 in *A. minor*).

The only other species of the *caecus* group registered from China is *A. pukouensis*, from Nanjing, Jiangsu District, approximately 1800 km distant from the type location of the new species. Both species are vastly different as *A. pukouensis* is unpigmented (vs. pigmented), has no eyes and dorsal head spines (vs. 1+1 eyes and 9 spines, respectively), its ungues are devoid of tunica (*vs.* present); its female's anal valves have no cuticular spines and their subanal appendage is short (vs. 2+2 spines per side and the

Table 1. Comparison between the Asian species of *Arrhopalites* from the *caecus* group.

Species	*A. antrobius*	*A. abchasicus*	*A. caecus*	*A. coreanus*	*A. gul*	*A. macronyx*	*A. minor*	*A. minutus*	*A. potapovi*	*A. pukouensis*	*A. brevicornis* sp. nov.
Distribution	Japan	Abkhazia	Cosmopolitan	S. Korea	S. Korea	Abkhazia	S. Korea	Japan	Russia	China	China
Cave species	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No
Body size (mm)	1.3	0.9	up to 1.0	0.7	1.2	1.2	0.5	0.5	up to 0.88	up to 1.3	0.71–0.81
Color pattern	unpigmented	unpigmented or with dorsal spots	unpigmented or with dorsal spots	with dorsal spots	unpigmented or with dorsal spots	with dorsal spots	with lateral spots	unpigmented	unpigmented, only eyes pigmented or with dorsal spots	unpigmented	with dorso-lateral spots
Ant IV annulations	4	5–7	(-)	(-)	7	7–8	(-)	(-)	(-/+)5–6	(-)	(-)
Ant at least 2× longer than head	Yes	Yes	No	Yes	Yes	Yes	No	No	No	No	No
Head dorsal spines	?	9	6–13	10 (possibly more)	(+)	(-)	9	13	13	(-)	9
Eyes	0+0	1+1	1+1	1+1	1+1	0+0?	1+1	1+1	1+1	0+0	1+1
Ungues I;II;III tunica	(+);(+);(+)	(–);(-);(-)	(-/+);(+);(+)	(+);(+);(+)	(-);(-);(-)	(-);(-);(-)	(+);(+);(+)	(-);(-);(+)	(-/+);(-/+);(-/+)	(-);(-);(-)	(+);(+);(+)
Ungues I–III inner tooth	(+)	(-/+)	(+)	(+)	(-/+)	(-)	(+)	(+)	(+)	(+)	(+)
Unguiculus III inner teeth	0	1	1	1	0–1	1	1	0	0–1	1	2
FAV cuticular spines (per side)	2+2	2+2 to 0+0	2+2	0+0	0+0	0+0	0+0	2+2	2+2(1+1 enlarged)	0+0	2+2
Subanal appendage shape	long, apically pointed	long, apically serrated	long, apically serrated	long, apically pointed	short, apically blunt	long, apically pointed	long, apically pointed	short, apically serrated	short, apically serrated	short, apically serrated	long, apically serrated
ms1 chaeta shape	not forked	not forked	not forked	forked	not forked	not forked	not forked	not forked	not forked	not forked	not forked
Circumanal basally serrate chaetae	(-)	(+)	(+)	(-)	(+)	(+)	(-)	(-)	(+)	(-)	(-)
Tenaculum chaetae	1	1	1–2	1	1	1–2	1	?	1	1	1
Manubrium dorsal chaetae	?	5+5	?	5+5	4+4	5+5	9+9	4+4	5+5	5+5	5+5
Dorsal dens chaetae	more than 10	16	15?	16	16	16	14–16	14	15	15	16

Legends: Ant = antennal segment(s); S. = South; (-) = absent; (+) = present; (-/+) = absent or present; FAV = Female's anal valves. Data based on the original descriptions, with the exception of *A. caecus* (based on Bretfeld 1999; Fjellberg 2007; and Vargovitsh 2013).

subanal appendage is long, respectively) and its dorsal dens shows 15 chaetae (vs. 16 in the new species). A detailed comparison of the morphology and the known distribution of all the cited species is presented in Table 1. We also provide a key of all Asian species of *caecus* group below.

Identification key to the Asian species of *caecus* group

1	Females' subanal appendage pointed	**2**
–	Females' subanal appendage blunt or apically serrated	**5**
2	Ungues without tunica; at least part of the circumanal chaetae of females basally serrate	***A. macronyx* Vargovitsh, 2012**
–	Ungues with tunica; all circumanal chaetae of females basally smooth	**3**
3	Eyes absent; unguiculus III without inner teeth; female's anal valves with 2+2 cuticular spines per side (Fig. 3B)	***A. antrobius* Yosii, 1954**
–	Eyes 1+1; unguiculus III with one inner tooth; female's anal valves lacking cuticular spines	**4**
4	Dorsal head with 10 or more spines; dorsal anal valve ms1 chaeta forked; manubrium with 5+5 dorsal chaetae	***A. coreanus* Park & Kang, 2007**
–	Dorsal head with 9 spines; dorsal anal valve ms1 chaeta not forked; manubrium with 9+9 dorsal chaetae	***A. minor* Park & Kang, 2007**
5	Antennae at least two times longer than head length	**6**
–	Antennae shorter, less than two times the head length	**7**
6	Body size about about 0.9 mm; manubrium with 5+5 dorsal chaetae	***A. abchasicus* Vargovitsh, 2013**
–	Body size about about 1.2 mm; manubrium with 4+4 dorsal chaetae	***A. gul* Yosii, 1966**
7	Eyes absent; ungues III without tunica; female's anal valves without cuticular spines	***A. pukouensis* Wu & Christiansen, 1997**
–	Eyes 1+1; ungues III with tunica; female's anal valves with 2+2 cuticular spines per side	**8**
8	Female's anal valves with 1+1 large modified cuticular spines per side	***A. potapovi* Vargovitsh, 2015**
–	Female's anal valves with only small cuticular spines (Fig. 3B)	**9**
9	Unguiculus III with one inner tooth; female's anal valves circumanal chaetae basally serrate	***A. caecus* (Tullberg, 1871)**
–	Unguiculus III toothless or with two inner teeth; female's anal valves circumanal chaetae basally smooth	**10**
10	Dorsal head with 13 spines; ungues I–II without tunica; unguiculus III toothless; manubrium with 4+4 dorsal chaetae; dorsal dens with 14 chaetae	***A. minutus* Yosii, 1970**
–	Dorsal head with 9 spines; ungues I–II with tunica; unguiculus III with 2 inner teeth; manubrium with 5+5 dorsal chaetae; dorsal dens with 16 chaetae.	***A. brevicornis* sp. nov.**

Discussion

The current knowledge on the Chinese Symphypleona is still incipient, despite the recent efforts from different research groups in describing the local springtail fauna and studying its systematics. So far only 17 species of the order were recorded from China, mostly from dicyrtomids of the genera *Papirioides* Folsom, 1924 (6 spp.) and *Ptenothrix* Börner, 1906 (5 spp.) (Folsom, 1924; Denis, 1929; Lin and Xia, 1985; Itoh and Zhao, 1993; Chen and Christiansen, 1996; Guo and Chen, 1996; Wu and Chen, 1996; Li et al. 2007). The other records are from Arrhopalitidae (3 spp., including *A. brevicornis* sp. nov.) and Sminthuridae (2 spp.) and there is a single species of Bourletiellidae (Lin and Chen 1997; Wu and Christiansen 1997; Li et al. 2008; Chen et al. 2019). Due to the vast area of the country and its many different terrestrial habitats, it is likely these numbers are very far from representing the real richness of the Symphypleona from China, and further efforts should be done to better comprehend this particular fauna. Also, adequate strategies to manage the grazing intensity in Chinese grasslands are crucial to preserve endemic species from these regions.

Acknowledgements

The first author is funded by the Research Foundation of Shanghai Science and Technology Museum and Postdoctoral fund of Haibo Program of Pudong New Area in 2021. The second author is funded by National Natural Science Foundation of China (31970434) and National Science & Technology Fundamental Resources Investigation Program of China (2018FY100300). The senior author is funded by CNPQ/PQ2021, Process # 309114/2021-7. We also thank the reviewer Kyung-Hwa Park for helpful comments on this article.

References

Bellinger PF, Christiansen KA, Janssens F (1996–2022) Checklist of the Collembola of the world. http://www.collembola.org [accessed 18 January 2022]

Betsch J-M (1997) An ontogenetically focused chaetotaxial scheme in Symphypleona (collembolan): The 6th abdominal segment. Pedobiologia 41: 13–18.

Betsch J-M, Waller A (1994) Chaetotaxic nomenclature of the head, thorax and abdomen in Symphypleona (Insecta, Collembola). Acta Zoologica Fennica 195: 5–12.

Börner C (1901) Neue Collembolenformen und zur Nomenclatur der Collembola Lubbock. Zoologischer Anzeiger: 24(638–658): 696–712.

Börner C (1906) Das System der Collembolen nebst Beschreibung neuer Collembolen des Hamburger Naturhistorischen Museums. Mitteilungen aus dem Naturhistorischen Museum in Hamburg 23: 147–188.

Bretfeld G (1986) Phylogenetic systematics of the higher taxa of Symphypleona Borner, 1901 (Insecta, Entognatha, Collembola). Proceedings of 2nd International Seminary of Apterygota 1: 302–311.
Bretfeld G (1994) *Sturmius epiphytus* n. gen. n. spec. from Colombia, a taxon of the Symphypleona (Insecta, Colembola) with an unexpected character combination. Description and position in non-Linnean and Linnean classifications of the Symphypleona. Zoological Systematics and Evolution Resources 32: 264–281. https://doi.org/10.1111/j.1439-0469.1994.tb00487.x
Bretfeld G (1999) Synopses on Palaearctic Collembola, Volume 2. Symphypleona. Abhandlungen und Berichte des Naturkundemuseums Görlitz 71(1): 1–318.
Chen J, Christiansen KA (1996) A new species of *Ptenothrix* from China (Collembola: Dicyrtomidae). The Florida Entomologist 79(4): 586–591. https://doi.org/10.2307/3496072
Chen CG, Chen T, Hua BZ, Wan TR (2019) Structure and functions of the ventral tube of the clover springtail *Sminthurus viridis* (Collembola: Sminthuridae). Scientific Reports 9: e897. https://doi.org/10.1038/s41598-018-37354-4
Christiansen K, Bellinger P (1980) The Collembola of North America, North of the Rio Grande: A taxonomic analysis. Grinnell College, Grinnell.
Christiansen K, Bellinger P (1998) The Collembola of North America, North of the Rio Grande: A taxonomic analysis. Grinnell College, Grinnell.
Cipola NG, Morais JW, Bellini BC (2014) A new species of *Seira* (Collembola: Entomobryidae: Seirini) from Northern Brazil, with the addition of new chaetotaxic characters. Zoologia 31(5): 489–495. https://doi.org/10.1590/S1984-46702014000500009
Cipola NG, Medeiros GDS, Oliveira VAMD, Barbosa LGDM, Lycarião TA, Bellini BC (2021) Contributions to the Taxonomy of *Arlesminthurus* Bretfeld and *Calvatomina* Yosii (Collembola, Symphypleona, Appendiciphora), with the Description of New Species from Northeastern Brazil. Insects 12(433): 1–41. https://doi.org/10.3390/insects12050433
Denis JR (1929) Notes sur les Collemboles recolts dans ses voyages par le Prof. F. Silvestri. Bolletino del Laboratorio die Zoologia Agraria 22: 305–320.
Fjellberg A (1999) The Labial Palp in Collembola. Zoologischer Anzeiger 237: 309–330.
Fjellberg A (2007) The Collembola of Fennoscandia and Denmark, Part II: Entomobryomorpha and Symphypleona. Fauna Entomologica Scandinavica 42: 1–264. https://doi.org/10.1163/ej.9789004157705.i-265
Folsom JW (1924) East Indian Collembola. Bulletin of the Museum of Comparative Zoology 65: 505–517.
Guo JY, Chen JX (1996) A new species of *Ptenothrix* (*Papirioides*) (Collembola: Dicyrtomidae) from China. Entomotaxonomia 18: 235–238.
Itoh R, Zhao LJ (1993) A new species of the genus *Papirioides* (Collembola, Sminthuridae) from Xishuangbanna, China. Japanese Journal of Entomology 61: 847–851.
Li ZH, Chen JX, Li J (2007) A new species of the genus *Papirioides* (Collembola: Dicyrtomidae) from China. Zootaxa 1499(1): 61–68. https://doi.org/10.11646/zootaxa.1499.1.3
Li ZH, Hua C, Chen JX (2008) *Bourletiella*, a genus new to China, with redescription to *Bourletiella arvalis* (Fitch) (Collembola, Symphypleona). Dong Wu Fen Lei Xue Bao 33(4): 807–809. [in Chinese with abstract in English]

Lin R, Chen JX (1997) A new species of the genus *Arrhopalites* (Collembola: Sminthuridae) from China. Insect Science 4(2): 135–138. https://doi.org/10.1111/j.1744-7917.1997.tb00082.x

Lin SX, Xia F (1985) Four new species of *Ptenothrix* from Dinghu Mountain, Guangdong (Collembola: Dicyrtomidae). Entomotaxonomia 7(1): 61–67.

Nayrolles P (1988) Chetotaxie tibiotarsale des collemboles symphyplèones. Travaux du Laboratoire d'Ecobiologie des Arthropodes Édaphiques, Toulouse 5(4): 1–19.

Park KH, Kang JS (2007) Three new species of *Arrhopalites* (Collembola, Symphypleona, Arrhopalitidae) from Korea. Entomological Research 37(3): 157–162. https://doi.org/10.1111/j.1748-5967.2007.00106.x

Stach J (1956) The apterygotan fauna of Poland in relation to the World-fauna of this group of insects, family: Sminthuridae. Polska Akademia Nauk, PWN, Kraków, 287 pp.

Tullberg T (1871) Förteckning öfver Svenska Podurider. Öfversigt af Kongliga Vetenskaps-Akademiens Förhandlingar- Stockholm 28: 143–155.

Vargovitsh RS (2009) New cave Arrhopalitidae (Collembola: Symphypleona) from the Crimea (Ukraine). Zootaxa 2047(1): 1–47. https://doi.org/10.11646/zootaxa.2047.1.1

Vargovitsh RS (2012) New troglomorphic Arrhopalitidae (Collembola: Symphypleona) from the Western Caucasus. Zootaxa 3174(1): 1–21. https://doi.org/10.11646/zootaxa.3174.1.1

Vargovitsh RS (2013) Cavernicolous *Arrhopalites abchasicus* sp. nov. (Collembola: Symphypleona: Arrhopalitidae) from the West Caucasus with a key to the World species of the genus. Zootaxa 3666(1): 16–30. https://doi.org/10.11646/zootaxa.3666.1.2

Vargovitsh RS (2015) *Arrhopalites potapovi* sp. nov. (Collembola, Symphypleona) from Russia. Zootaxa 3955(1): 101–112. https://doi.org/10.11646/zootaxa.3955.1.5

Wu M, Chen JX (1996) A new species of the subgenus *Papirioides* from China (Collembola: Dicyrtomidae). Entomologia Sinica 3(2): 138–144. https://doi.org/10.1111/j.1744-7917.1996.tb00219.x

Wu M, Christiansen K (1997) A new species of *Arrhopalites* from China (Collembola: Sminthuridae). The Florida Entomologist 80(2): 266–269. https://doi.org/10.2307/3495560

Yosii R (1954) Höhlencollembolen Japans I. Kontyû 20(3–4): 62–70.

Yosii R (1966) Results of the speleological survey in South Korea 1966. IV. Cave Collembola of South Korea. Bulletin of the National Science Museum 9(4): 541–561.

Yosii R (1970) On some Collembola of Japan and adjacent countries II. Contributions from the Biological Laboratory. Kyoto University 23: 1–32.

Zeppelini D (2011) Phylogeny of *Arrhopalites s.l.* (Collembola: Symphypleona: Arrhopalitidae): testing the monophyly of the recently erected genera *Arrhopalites s.s.* and *Pygmarrhopalites*. Invertebrate Systematics 25(2): 91–105. https://doi.org/10.1071/IS10044

ZooKeys 1102: 177–190 (2022)
doi: 10.3897/zookeys.1102.82228
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Scleractinian coral (Cnidaria, Hexacorallia, Scleractinia) diversity of the Mersing Islands, Peninsular Malaysia

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Academic editor: James Reimer | Received 14 February 2022 | Accepted 20 April 2022 | Published 20 May 2022

http://zoobank.org/ABA3ED30-4521-4A5F-8939-2BAE25E4793A

Citation: Lee JN, Adzis KAA, Afiq-Rosli L, Tanzil JTI, Chan AA, Ismail MN, Akmal KF, Affendi YA (2022) Scleractinian coral (Cnidaria, Hexacorallia, Scleractinia) diversity of the Mersing Islands, Peninsular Malaysia. ZooKeys 1102: 177–190. https://doi.org/10.3897/zookeys.1102.82228

Abstract

We present a comprehensive checklist of scleractinian (hard) corals for the Mersing Islands, Malaysia based on surveys conducted at 24 reefs across protected and unprotected marine areas. A total of 261 species of corals from 16 families and one *incertae sedis* (*Pachyseris* spp.) were recorded, along with ten records that are new for the east coast of Peninsular Malaysia. Compared against the IUCN Red List, 46.7% of coral species found in the Mersing Islands were of Least Concern (LC), 29.5% as Near Threatened (NT) and 16.4% Vulnerable (V). Only one recorded species, *Pectinia maxima* (Moll & Best, 1984), was listed as Endangered (EN). Baseline species diversity data are essential for the monitoring and management of marine biodiversity, especially within marine protected areas. With both protected and unprotected coral reef areas in the vicinity of the widely scattered Mersing Islands, the diversity and distribution of coral species can be used as the basis for area-based conservation and management strategies. The diversity and abundance of scleractinian corals of each island or area should be surveyed periodically to ensure the appropriate level of protection is afforded to retain scleractinian biodiversity in this region.

Keywords
Biodiversity, conservation, hard coral, Johor, marine protected area, South China Sea

Introduction

Scleractinian corals, commonly referred to as hard corals, are a group of animals belonging to the order Scleractinia under the Phylum Cnidaria. These organisms are the backbone of coral reefs, which support high species diversity, provide goods and services (e.g., food, coastal protection, tourism), and provide substantive support to people worldwide (Praveena et al. 2012; Huang et al. 2016; Hoegh-Guldberg et al. 2019). Coral reefs in Malaysia are estimated to cover about 4,006 km^2 (Praveena et al. 2012), with most reefs found in Sabah and along the east coast of Peninsular Malaysia, and in limited areas in Sarawak and the west coast of Peninsular Malaysia (UNEP 2007). A total of 398 species of scleractinian corals (Huang et al. 2015) and 925 species of reef fishes (Chong et al. 2010) have thus far been recorded from the shallow fringing reefs along the coasts of Peninsular Malaysia alone. These reefs are located at Sunda Shelf, within and near the western edge of the Coral Triangle, a marine biodiversity hotspot that is home to 627 species of zooxanthellate corals (Veron et al. 2015).

Malaysia, as a megadiverse country, is dedicated to fulfilling the Convention on Biological Diversity (CDB) agreement (Tong 2020). With the launch of the National Policy on Biological Diversity in 2016, Malaysia aims to further safeguard both key terrestrial and marine ecosystems, as well as species and genetic diversity (Goal 3) (Ministry of Natural Resources and Environment 2016). Knowledge and data on the biodiversity of Malaysia's vast marine areas will therefore be crucial for stakeholders and policy makers to identify suitable areas for ecological protection. To date, studies that have reported on the reef-building coral biodiversity around Peninsular Malaysia are somewhat limited. A review by Affendi and Rosman (2011) found only six research articles on scleractinian diversity published for the coral reef-rich areas along the east coast of Peninsular Malaysia, most of which were based on surveys conducted only around highly visited tourist islands that are under the jurisdiction of the Department of Fisheries Malaysia (DOF), e.g., Pulau Redang and Pulau Tioman (e.g., Toda et al. 2007; Akmal et al. 2019).

The Mersing Islands comprise one of the largest archipelagos off the east coast of Peninsular Malaysia. With 58 islands (Said et al. 2021), this region is not only known for its coral reefs but also for its seagrass ecosystems (Ooi et al. 2011; Ponnampalam et al. 2015). Geologically, the Mersing Islands originated ~350 million years ago, and they are currently evaluated as a potential National Geopark for their unique geological and cultural heritage (Said et al. 2021). This elevated status will not only affect the islands but also the surrounding marine life, both in terms of increased protection and increased tourism. Biodiversity data in the area will therefore be extremely valuable to advise any development and/or management plans for the Mersing Islands. A sole report that recorded 155 species of scleractinian corals from four islands (Pulau Dayang, Pulau Pemanggil, Pulau Tinggi and Batu Tikus) (Harborne et al. 2000) was the main literature source for coral biodiversity in the Mersing Islands prior to this study, aims to provide a comprehensive updated species checklist of scleractinian corals for the coral reefs around the Mersing Islands.

Methods

The study area comprised islands on the east coast of Johor, Peninsular Malaysia, referred to as the Mersing Islands. Underwater surveys were carried out during two expeditions, one in 2012 ("Marine Park Biodiversity Expedition)" and one in 2016 ("Johor 8 Islands Expedition"). Parts of the Mersing Islands (Fig. 1) are protected under the unique overlapping protection by both Malaysia's Federal (known as Johor Marine Park) and Johor State jurisdictions, i.e., these reefs are protected under the Fisheries Act of 1985 (Federal) as well as by the Johor State government, following the establishment of the Johor National Park in 1990. Both authorities promote the protection, preservation and management of the natural breeding ground and habitat of aquatic life. In 2013, the protected area that falls within Mersing Islands was renamed 'Sultan Iskandar Marine Park', and entrance and activities within the Marine Park are strictly controlled by Johor National Park Corporation, leading to a significant reduction of tourism activities in the area (Hassan 2013).

Coral species diversity surveys were conducted at Pulau Aur, Pulau Pemanggil, Pulau Besar, Pulau Sibu and Pulau Tinggi (Fig. 1) in 2012, when a total of 13 reefs were surveyed (depth range: 3–12 m) using 100 m transects perpendicular to the shoreline, for a total of 19 transects. Further surveys were conducted in 2016 for one reef at Pulau Tinggi using SCUBA timed swims (English et al. 1997), and seven reefs via transects perpendicular to the shoreline (Pulau Lima Kecil, Pulau Lima Besar, Pulau Tokong Rakit, Tokong Gantang, Tokong Chondong, Tokong Belalai and Tokong Chupak) (Fig. 1). The reefs surveyed in 2012 were all part of a larger marine protected area (MPA), whereas the reefs surveyed in 2016 were all outside the MPA (i.e., unprotected, non-MPA).

Corals were identified to species level based on distinct features of their morphological structure according to Veron (2000), using photographs and videos recorded during the survey. All identified species were standardized according to the World Register of Marine Species (Hoeksema and Cairns 2021) to account for synonyms and taxonomic change. The relative abundance and conservation status of each species were gathered from Veron (2000) and the IUCN Red List (IUCN 2019). Conservation categories that were used are Not Evaluated (NE), Data Deficient (DD), Least Concern (CC), Near Threatened (NT), Vulnerable (VU), Endangered (EN) and Critically Endangered (CR).

Results

A total of 261 scleractinian coral species from 16 families and one *incertea sedis* were recorded during the 2012 (MPA; 243 species) and 2016 (non-MPA; 261 species)

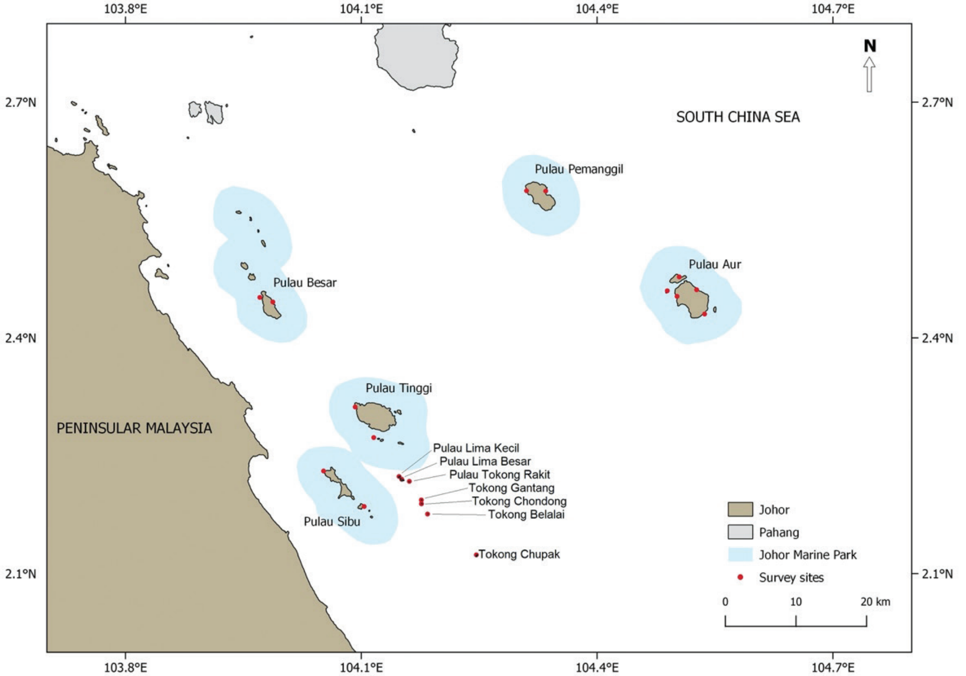

Figure 1. Survey areas at the Mersing Islands. Johor Marine Park protected area are two nautical miles away from the low tide shoreline of each gazetted island

expeditions. Table 1 shows the checklist of scleractinian corals from Mersing Islands, with species arranged alphabetically by family and including records (155 species) from the previous survey published by Harborne et al. (2000). The current study found ten new records of scleractinian corals from the Mersing Islands in the larger Peninsular Malaysia east coast area (Fig. 1), i.e. *Acropora pectinata* (Brook, 1892); *Astreopora explanata* Veron, 1985; *Coeloseris mayeri* Vaughan, 1918; *Halomitra pileus* (Linnaeus, 1758); *Acanthastrea rotundoflora* Chevalier, 1975; *Favites vasta* (Klunzinger, 1879); *Paramontastraea serageldini* (Veron, 2000); *Seriatopora hystrix* Dana, 1846; *Goniopora gracilis* (Milne Edwards & Haime, 1849); and *Pavona divaricata* Lamarck, 1816 (Fig. 2).

Of the 16 families recorded, Acroporidae was the richest with a total of 79 species: 39 *Acropora* species, 28 *Montipora* species and four from other genera (Table 1). Six per cent (16) of species from the list were considered 'rare' in abundance according to Veron (2000), whereby the species can be common in a specific area but rare overall. According to the IUCN Red List, many coral species we observed were classified as of Least Concern (46.7%), Near Threatened (29.5%) or Vulnerable (18.8%). Only one species, *Pectinia maxima*, was categorised as Endangered (EN). The remaining species were Not Evaluated (3.8%) or classified as Data Deficient (0.8%).

Table 1. Checklist of scleractinian corals from the Mersing Islands according to (a) Harborne et al. (2000); (b) Marine Park Biodiversity Expedition 2012; and (c) Johor 8 Islands Expedition 2016. Species denoted with an asterisk (*) are those considered to represent new records for the east coast of Peninsular Malaysia.

Order Scleractinia (17)	a	b	c	Abundance (sensu Veron, 2000)	IUCN Status
Family Acroporidae (79)					
Acropora abrotanoides (Lamarck, 1816)		/		Sometimes common	LC
Acropora anthocercis (Brook, 1893)			/	Sometimes common	VU
Acropora aspera (Dana, 1846)	/	/		Sometimes common	VU
Acropora austera (Dana, 1846)		/		Usually uncommon	NT
Acropora cerealis (Dana, 1846)	/		/	Common	LC
Acropora clathrata (Brook, 1891)		/	/	Common	LC
Acropora cytherea (Dana, 1846)	/	/	/	Common	LC
Acropora digitifera (Dana, 1846)	/	/	/	Sometimes common	NT
Acropora divaricata (Dana, 1846)	/	/	/	Common	NT
Acropora florida (Dana, 1846)	/	/	/	Common	NT
Acropora gemmifera (Brook, 1892)	/	/		Common	LC
Acropora globiceps (Dana, 1846)		/		Common	VU
Acropora grandis (Brook, 1892)		/		Common	LC
Acropora hemprichii (Ehrenberg, 1834)		/		Common	VU
Acropora hoeksemai Wallace, 1997	/	/	/	Common	VU
Acropora horrida (Dana, 1846)	/	/		Uncommon	VU
Acropora humilis (Dana, 1846)	/	/		Common	NT
Acropora hyacinthus (Dana, 1846)	/	/	/	Common	NT
Acropora intermedia (Brook, 1891)			/	Unknown	NE
Acropora latistella (Brook, 1892)	/	/	/	Common	LC
Acropora loripes (Brook, 1892)	/	/		Common	NT
Acropora microphthalma (Verrill, 1869)	/	/		Common	LC
Acropora millepora (Ehrenberg, 1834)	/	/	/	Common	NT
Acropora monticulosa (Brüggemann, 1879)	/	/		Uncommon	NT
Acropora muricata (Linnaeus, 1758)	/	/	/	Common	NT
Acropora nasuta (Dana, 1846)	/	/		Common	NT
**Acropora pectinata* Veron, 2000		/		Uncommon	DD
Acropora robusta (Dana, 1846)	/	/		Common	LC
Acropora samoensis (Brook, 1891)	/	/		Usually uncommon	LC
Acropora sarmentosa (Brook, 1892)	/	/		Common	LC
Acropora secale (Studer, 1878)	/			Common	NT
Acropora selago (Studer, 1879)	/		/	Sometimes common	NT
Acropora solitaryensis Veron & Wallace, 1984	/	/		Rare	VU
Acropora subulata (Dana, 1846)		/		Common	LC
Acropora tenuis (Dana, 1846)	/			Common	NT
Acropora valenciennesi (Milne Edwards, 1860)		/		Common	LC
Acropora valida (Dana, 1846)	/			Sometimes common	LC
Acropora vaughani Wells, 1954		/		Uncommon	VU
Acropora yongei Veron & Wallace, 1984	/	/		Common	LC
Alveopora daedalea (Forskål, 1775)		/		Uncommon	VU
Alveopora spongiosa Dana, 1846			/	Usually uncommon	NT
Anacropora forbesi Ridley, 1884		/		Uncommon	LC
Anacropora matthaii Pillai, 1973	/			Rare	VU
**Astreopora explanata* Veron, 1985			/	Sometimes common	NE
Astreopora gracilis Bernard, 1896			/	Sometimes common	LC
Astreopora listeri Bernard, 1896		/		Usually uncommon	LC
Astreopora myriophthalma (Lamarck, 1816)	/	/		Common	LC
Astreopora ocellata Bernard, 1896		/		Usually rare	LC
Isopora brueggemanni (Brook, 1893)	/	/		Common	VU
Isopora cuneata (Dana, 1846)		/		Common	VU
Isopora palifera (Lamarck, 1816)	/	/		Common	NT

Order Scleractinia (17)	a	b	c	Abundance (sensu Veron, 2000)	IUCN Status
Montipora aequituberculata Bernard, 1897	/	/	/	Common	LC
Montipora cactus Bernard, 1897		/		Common	VU
Montipora caliculata (Dana, 1846)		/		Uncommon	VU
Montipora cebuensis Nemenzo, 1976	/	/		Uncommon	VU
Montipora confusa Nemenzo, 1967		/		Uncommon	NT
Montipora danae Milne Edwards & Haime, 1851		/		Common	LC
Montipora delicatula Veron, 2000		/		Uncommon	VU
Montipora digitata (Dana, 1846)		/		Common	LC
Montipora effusa (Dana, 1846)		/		Uncommon	NT
Montipora florida Nemenzo, 1967		/		Common	VU
Montipora foliosa (Pallas, 1766)		/		Common	NT
Montipora foveolata (Dana, 1846)		/		Seldom common	NT
Montipora gaimardi Bernard, 1897	/	/		Sometimes common	VU
Montipora hispida (Dana, 1846)	/	/	/	Usually uncommon	LC
Montipora informis Bernard, 1897		/		Common	LC
Montipora malampaya Nemenzo, 1967	/			Common	VU
Montipora mollis Bernard, 1897	/	/		Common	LC
Montipora monasteriata (Forskål, 1775)		/		Common	LC
Montipora nodosa (Dana, 1846)		/		Usually uncommon	NT
Montipora palawanensis Veron, 2000		/		Uncommon	NT
Montipora peltiformis Bernard, 1897		/		Uncommon	NT
Montipora stellata Bernard, 1897		/		Common	LC
Montipora tuberculosa (Lamarck, 1816)	/	/		Common	LC
Montipora turgescens Bernard, 1897			/	Common	LC
Montipora turtlensis Veron & Wallace, 1984		/		Common	VU
Montipora venosa (Ehrenberg, 1834)		/		Uncommon	NT
Montipora verrucosa (Lamarck, 1816)		/		Sometimes common	LC
Montipora verruculosa Veron, 2000		/		Uncommon	VU
Famili Agariciidae (15)					
**Coeloseris mayeri* Vaughan, 1918		/	/	Uncommon	LC
Gardineroseris planulata (Dana, 1846)	/	/		Usually uncommon	LC
Leptoseris explanata Yabe & Sugiyama, 1941	/	/		Uncommon	LC
Leptoseris foliosa Dinesen, 1980		/		Uncommon	LC
Leptoseris hawaiiensis Vaughan, 1907		/		Uncommon	LC
Leptoseris mycetoseroides Wells, 1954	/		/	Sometimes common	LC
Leptoseris scabra Vaughan, 1907		/		Usually uncommon	LC
Pavona bipartita Nemenzo, 1979	/			Uncommon	VU
Pavona cactus (Forskål, 1775)	/	/		Common	VU
Pavona clavus Dana, 1846			/	Common	LC
Pavona danai (Milne Edwards, 1860)		/		Uncommon	VU
Pavona decussata (Dana, 1846)	/	/	/	Common	VU
**Pavona divaricata* Lamarck, 1816			/	Unknown	NE
Pavona explanulata (Lamarck, 1816)	/	/	/	Common	LC
Pavona varians Verrill, 1864	/			Common	LC
Famili Astrocoeniidae (3)					
Palauastrea ramosa Yabe & Sugiyama, 1941		/		Common	NT
Stylocoeniella armata (Ehrenberg, 1834)		/		Rare	LC
Stylocoeniella guentheri (Bassett-Smith, 1890)	/	/		Uncommon	LC
Famili Dendrophylliidae (10)					
Duncanopsammia peltata (Esper, 1790)	/	/	/	Common	VU
Tubastraea coccinea Lesson, 1830	/		/	Unknown	NE
Tubastraea diaphana (Dana, 1846)	/			Unknown	NE
Tubastraea faulkneri Wells, 1982			/	Unknown	NE
Tubastraea micranthus (Ehrenberg, 1834)	/		/	Unknown	NE
Turbinaria frondens (Dana, 1846)			/	Common	LC
Turbinaria irregularis Bernard, 1896	/			Common	LC
Turbinaria mesenterina (Lamarck, 1816)	/	/	/	Common	VU

Order Scleractinia (17)	a	b	c	Abundance (sensu Veron, 2000)	IUCN Status
Turbinaria reniformis Bernard, 1896		/	/	Sometimes common	VU
Turbinaria stellulata (Lamarck, 1816)	/	/	/	Usually uncommon	VU
Famili Diploastreidae (1)					
Diploastrea heliopora (Lamarck, 1816)	/	/	/	Common	NT
Famili Euphylliidae (8)					
Euphyllia cristata Chevalier, 1971		/		Uncommon	VU
Euphyllia glabrescens (Chamisso & Eysenhardt, 1821)	/		/	Uncommon	NT
Euphyllia paraglabrescens Veron, 1990		/		Rare	VU
Fimbriaphyllia ancora (Veron & Pichon, 1980)	/	/	/	Seldom common	VU
Fimbriaphyllia divisa (Veron & Pichon, 1980)	/	/		Seldom common	NT
Fimbriaphyllia paradivisa (Veron, 1990)		/		Uncommon	VU
Galaxea astreata (Lamarck, 1816)	/	/		Common	VU
Galaxea fascicularis (Linnaeus, 1767)	/	/	/	Uncommon	NT
Famili Fungiidae (20)					
Ctenactis crassa (Dana, 1846)	/			Usually uncommon	LC
Ctenactis echinata (Pallas, 1766)	/	/	/	Common	LC
Cycloseris explanulata (van der Horst, 1922)	/	/		Uncommon	LC
Cycloseris vaughani (Boschma, 1923)		/		Rare	LC
Danafungia horrida (Dana, 1846)	/			Uncommon	NE
Danafungia scruposa (Klunzinger, 1879)	/			Uncommon	LC
Fungia fungites (Linnaeus, 1758)	/	/	/	Common	NT
**Halomitra pileus* (Linnaeus, 1758)		/	/	Usually uncommon	LC
Heliofungia actiniformis (Quoy & Gaimard, 1833)		/		Common	VU
Herpolitha limax (Esper, 1792)	/	/		Common	LC
Lithophyllon concinna (Verrill, 1864)	/	/		Common	LC
Lithophyllon repanda (Dana, 1846)		/		Common	LC
Lithophyllon undulatum Rehberg, 1892	/	/	/	Usually uncommon	NT
Lobactis scutaria (Lamarck, 1801)		/		Common	LC
Pleuractis granulosa (Klunzinger, 1879)	/			Usually uncommon	LC
Pleuractis moluccensis (Van der Horst, 1919)	/			Usually uncommon	LC
Pleuractis paumotensis (Stutchbury, 1833)	/	/		Common	LC
Podabacia crustacea (Pallas, 1766)	/	/	/	Usually uncommon	LC
Polyphyllia talpina (Lamarck, 1801)	/	/	/	Common	LC
Sandalolitha robusta (Quelch, 1886)	/	/		Common	LC
Famili Lobophylliidae (23)					
Acanthastrea echinata (Dana, 1846)	/	/	/	Usually uncommon	LC
Acanthastrea hemprichii (Ehrenberg, 1834)	/	/	/	Uncommon	VU
Acanthastrea pachysepta (Chevalier, 1975)		/		Usually uncommon	NT
**Acanthastrea rotundoflora* Chevalier, 1975			/	Usually uncommon	NT
Cynarina lacrymalis (Milne Edwards & Haime, 1848)		/		Seldom common	NT
Echinophyllia aspera (Ellis & Solander, 1786)	/	/	/	Rare	LC
Echinophyllia glabra (Nemenzo, 1959)		/		Common	LC
Homophyllia australis (Milne Edwards & Haime, 1848)	/	/		Uncommon	LC
Lobophyllia agaricia (Milne Edwards & Haime, 1849)	/	/	/	Uncommon	LC
Lobophyllia corymbosa (Forskål, 1775)	/		/	Sometimes common	LC
Lobophyllia diminuta Veron, 1985		/		Uncommon	VU
Lobophyllia flabelliformis Veron, 2000		/	/	Usually uncommon	VU
Lobophyllia hataii Yabe, Sugiyama & Eguchi, 1936		/	/	Uncommon	LC
Lobophyllia hemprichii (Ehrenberg, 1834)	/	/	/	Common	LC
Lobophyllia radians (Milne Edwards & Haime, 1849)	/	/	/	Common	LC
Lobophyllia recta (Dana, 1846)	/	/	/	Common	LC
Lobophyllia robusta Yabe & Sugiyama, 1936	/			Uncommon	LC
Lobophyllia valenciennesii (Milne Edwards & Haime, 1849)		/		Uncommon	LC
Lobophyllia vitiensis (Brüggemann, 1877)	/	/		Usually uncommon	NT
Micromussa lordhowensis (Veron & Pichon, 1982)	/	/	/	Sometimes common	NT
Oxypora crassispinosa Nemenzo, 1979		/		Uncommon	LC
Oxypora echinata (Saville Kent, 1871)		/	/	Usually rare	LC
Oxypora lacera (Verrill, 1864)	/		/	Common	LC

Order Scleractinia (17)	a	b	c	Abundance (sensu Veron, 2000)	IUCN Status
Famili Merulinidae (57)					
Astraeosmilia tumida (Matthai, 1928)	/	/		Uncommon	NT
Astrea curta Dana, 1846	/		/	Common	LC
Coelastrea aspera (Verrill, 1866)		/	/	Common	LC
Cyphastrea microphthalma (Lamarck, 1816)		/	/	Common	LC
Cyphastrea ocellina (Dana, 1846)		/		Rare	VU
Cyphastrea serailia (Forskål, 1775)			/	Common	LC
Dipsastraea amicorum (Milne Edwards & Haime, 1849)	/			Uncommon	LC
Dipsastraea favus (Forskål, 1775)		/	/	Common	LC
Dipsastraea helianthoides (Wells, 1954)			/	Sometimes common	NT
Dipsastraea maritima (Nemenzo, 1971)	/			Uncommon	NT
Dipsastraea pallida (Dana, 1846)	/			Less common	LC
Dipsastraea speciosa (Dana, 1846)			/	Common	LC
Dipsastraea veroni (Moll & Best, 1984)		/	/	Rare	NT
Echinopora gemmacea (Lamarck, 1816)	/		/	Usually uncommon	LC
Echinopora horrida Dana, 1846		/	/	Uncommon	NT
Echinopora lamellosa (Esper, 1791)		/	/	Common	LC
Echinopora mammiformis (Nemenzo, 1959)		/	/	Common	NT
Echinopora pacifica Veron, 1990	/	/	/	Usually uncommon	NT
Favites abdita (Ellis & Solander, 1786)	/	/	/	Common	NT
Favites complanata (Ehrenberg, 1834)		/		Sometimes common	NT
Favites flexuosa (Dana, 1846)		/	/	Sometimes common	NT
Favites halicora (Ehrenberg, 1834)	/	/	/	Usually uncommon	NT
Favites magnistellata (Milne Edwards & Haime, 1849)	/		/	Usually uncommon	NT
Favites melicerum (Ehrenberg, 1834)		/		Rare	NT
Favites pentagona (Esper, 1790)		/	/	Sometimes common	LC
Favites valenciennesii (Milne Edwards & Haime, 1849)		/		Usually uncommon	NT
**Favites vasta* (Klunzinger, 1879)			/	Uncommon	NT
Goniastrea edwardsi Chevalier, 1971	/	/		Common	LC
Goniastrea favulus (Dana, 1846)	/	/	/	Uncommon	NT
Goniastrea pectinata (Ehrenberg, 1834)	/	/	/	Common	LC
Goniastrea retiformis (Lamarck, 1816)		/	/	Common	LC
Goniastrea stelligera (Dana, 1846)	/	/	/	Common	NT
Hydnophora exesa (Pallas, 1766)	/	/	/	Common	NT
Hydnophora grandis Gardiner, 1904	/	/		Usually uncommon	LC
Hydnophora microconos (Lamarck, 1816)	/	/	/	Uncommon	NT
Hydnophora rigida (Dana, 1846)		/	/	Sometimes common	LC
Leptoria phrygia (Ellis & Solander, 1786)	/	/	/	Common	NT
Merulina ampliata (Ellis & Solander, 1786)	/	/	/	Usually common	LC
Merulina cylindrica (Milne Edwards & Haime, 1849)	/		/	Uncommon	LC
Merulina scabricula Dana, 1846	/	/		Common	LC
Mycedium elephantotus (Pallas, 1766)	/	/	/	Common	LC
Orbicella annularis (Ellis & Solander, 1786)		/		Rare	NE
Oulophyllia bennettae (Veron, Pichon & Wijsman-Best, 1977)	/	/		Uncommon	NT
Oulophyllia crispa (Lamarck, 1816)	/	/	/	Uncommon	NT
Paramontastraea salebrosa (Nemenzo, 1959)		/		Rare	VU
**Paramontastraea serageldini* (Veron, 2000)			/	Rare	VU
Pectinia alcicornis (Saville Kent, 1871)		/	/	Usually uncommon	VU
Pectinia lactuca (Pallas, 1766)		/		Common	VU
Pectinia maxima (Moll & Best, 1984)		/		Uncommon	EN
Pectinia paeonia (Dana, 1846)	/	/	/	Common	NT
Platygyra acuta Veron, 2000		/		Sometimes common	NT
Platygyra daedalea (Ellis & Solander, 1786)	/		/	Common	LC
Platygyra lamellina (Ehrenberg, 1834)	/	/	/	Usually uncommon	NT
Platygyra pini Chevalier, 1975		/	/	Usually uncommon	LC
Platygyra sinensis (Milne Edwards & Haime, 1849)	/	/	/	Usually uncommon	LC

Order Scleractinia (17)	a	b	c	Abundance (sensu Veron, 2000)	IUCN Status
Platygyra verweyi Wijsman-Best, 1976		/		Usually uncommon	NT
Trachyphyllia geoffroyi (Audouin, 1826)		/		Rare	NT
Famili Plerogyridae (2)					
Physogyra lichtensteini (Milne Edwards & Haime, 1851)		/	/	Common	VU
Plerogyra sinuosa (Dana, 1846)	/	/	/	Usually uncommon	NT
Famili Plesiastreidae (1)					
Plesiastrea versipora (Lamarck, 1816)	/	/		Unknown	LC
Famili Pocilloporidae (7)					
Pocillopora damicornis (Linnaeus, 1758)	/	/	/	Common	LC
Pocillopora grandis Dana, 1846		/		Common	NT
Pocillopora meandrina Dana, 1846		/		*Common	LC
Pocillopora verrucosa (Ellis & Solander, 1786)	/	/		Common	LC
**Seriatopora hystrix* Dana, 1846		/		Common	LC
Stylophora pistillata (Esper, 1792)		/		Common	NT
Stylophora subseriata (Ehrenberg, 1834)	/	/		Common	LC
Famili Poritidae (21)					
Goniopora columna Dana, 1846		/	/	Common	NT
Goniopora djiboutiensis Vaughan, 1907			/	Common	LC
**Goniopora gracilis* (Milne Edwards & Haime, 1849)			/	Unknown	NE
Goniopora lobata Milne Edwards, 1860		/	/	Common	NT
Goniopora norfolkensis Veron & Pichon, 1982		/		Uncommon	LC
Goniopora planulata (Ehrenberg, 1834)		/		Usually uncommon	VU
Goniopora stokesi Milne Edwards & Haime, 1851		/		Uncommon	NT
Porites annae Crossland, 1952	/	/	/	Common	NT
Porites attenuata Nemenzo, 1955		/		Common	VU
Porites australiensis Vaughan, 1918		/		common	LC
Porites cylindrica Dana, 1846	/	/		Common	NT
Porites densa Vaughan, 1918		/		Sometimes common	NT
Porites evermanni Vaughan, 1907	/	/	/	Usually uncommon	DD
Porites latistellata Quelch, 1886		/		Uncommon	LC
Porites lichen (Dana, 1846)		/		Common	LC
Porites lobata Dana, 1846		/	/	Common	NT
Porites lutea Milne Edwards & Haime, 1851		/	/	Common	LC
Porites monticulosa Dana, 1846		/		Common	LC
Porites nigrescens Dana, 1846		/		Sometimes common	VU
Porites rus (Forskål, 1775)	/	/		Common	LC
Porites solida (Forskål, 1775)	/	/	/	Common	LC
Famili Psammocoridae (6)					
Psammocora columna Dana, 1846	/	/	/	Sometimes common	LC
Psammocora contigua (Esper, 1794)	/	/		Common	NT
Psammocora digitata Milne Edwards & Haime, 1851	/	/	/	Usually uncommon	NT
Psammocora exesa Dana, 1846	/	/		Common	LC
Psammocora haimiana Milne Edwards & Haime, 1851		/		Uncommon	LC
Psammocora profundacella Gardiner, 1898	/			Uncommon	LC
Famili Rhizangiidae (1)					
Pseudosiderastrea tayamai Yabe & Sugiyama, 1935	/			Uncommon	NT
Famili Leptastreidae (3)					
Leptastrea aequalis Veron, 2000		/		Rare	VU
Leptastrea purpurea (Dana, 1846)	/	/	/	Common	LC
Leptastrea transversa Klunzinger, 1879		/		Uncommon	LC
Famili Scleractinia incertae sedis (4)					
Pachyseris foliosa Veron, 1990		/		Uncommon	LC
Pachyseris gemmae Nemenzo, 1955		/	/	Rare	NT
Pachyseris rugosa (Lamarck, 1801)	/	/		Common	VU
Pachyseris speciosa (Dana, 1846)	/	/	/	Common	LC

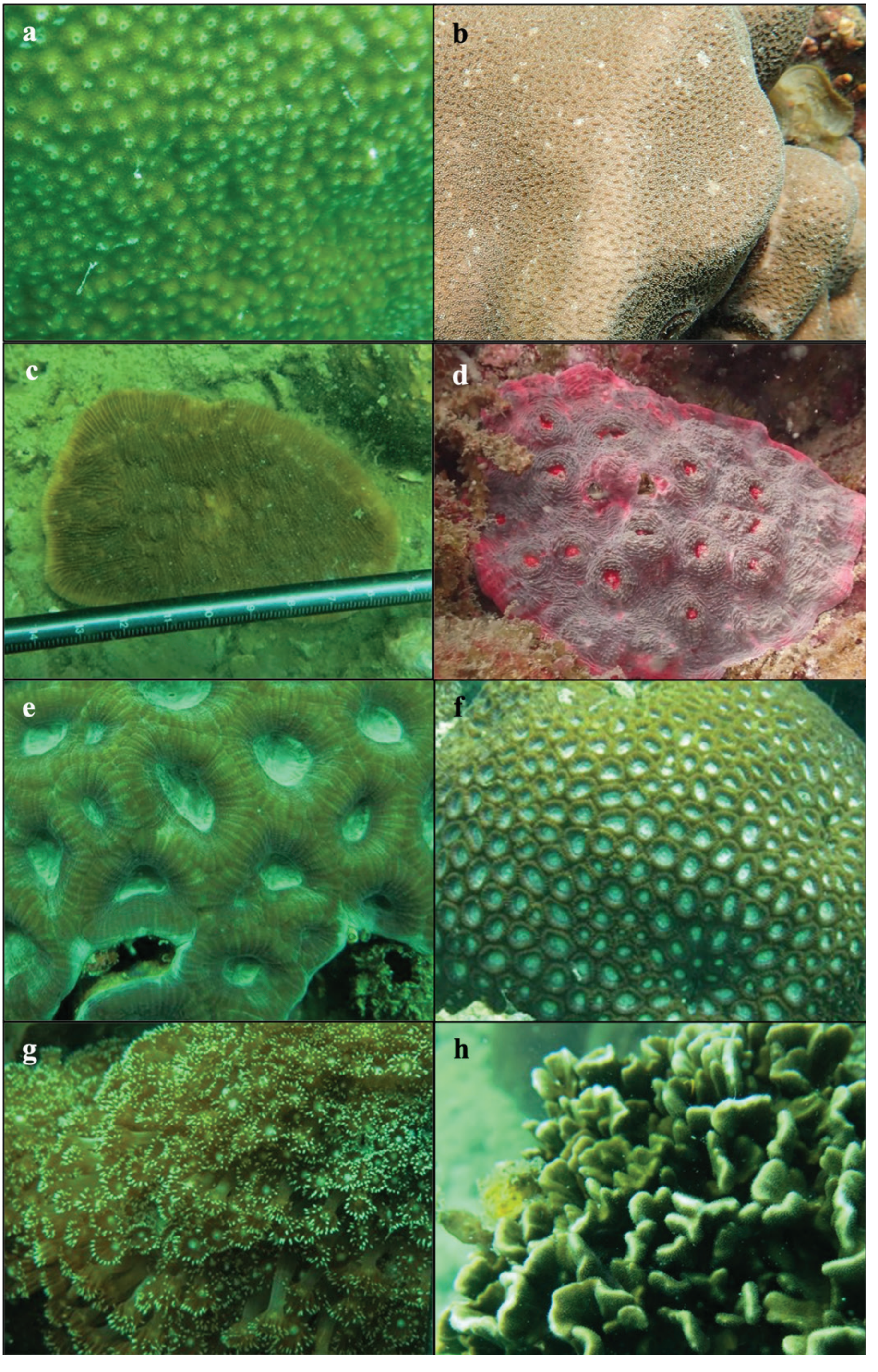

Figure 2. New records of scleractinian corals for the east coast of Peninsular Malaysia **a** *Astreopora explanata* **b** *Coeloseris mayeri* **c** *Halomitra pileus* **d** *Acanthastrea rotundoflora* **e** *Favites vasta* **f** *Paramontastraea serageldini* **g** *Goniopora gracilis*, and **h** *Pavona divaricata*.

Discussions and conclusions

The current study provides an updated species checklist of scleractinian corals from coral reefs around the Mersing Islands. A total of 261 scleractinian species were recorded, including ten new records for the east coast of Peninsular Malaysia, from where 398 species were previously reported (Huang et al. 2015). Compared to previous findings by Harborne et al. (2000) (155 species recorded from a subset of reefs around the Mersing Islands), we find the coral diversity around the Mersing Islands to be comparable, if not slightly higher, than other reefs in the region, i.e., Pulau Tioman with 239 species (Akmal et al. 2019) (i.e., north of the Mersing Islands) and Singapore with 255 species (Huang et al. 2009) (i.e., south of the Mersing Islands). The South China Sea in the Central Indo Pacific holds a high biodiversity of scleractinian corals, with a total recorded number of 571 species. The diversity found around the Mersing Islands represents ~ 45% of the total recorded coral fauna of the South China Sea and ~65% of the total recorded fauna from the east coast of Peninsular Malaysia. Previous records and records from the current study account for a total of 413 scleractinian coral species for reefs along the east coast of Peninsular Malaysia. These include eight new records of coral species at Pulau Tioman and Pulau Redang by Akmal et al. (2019) and the ten (10) new records from this study.

The ten new records of coral species for the east coast of Peninsular Malaysia found during this study are known to be widely distributed in the Indo-West Pacific Ocean (east coast of Africa to Japan and Melanesia) (Veron 2000; Cairns and Hoeksema 2022; GBIF 2022). Two of these species (*Acanthastrea rotundoflora* and *Seriatopora hystrix*) had previously been reported from Singapore's southern islands (Huang et al. 2009), whereas another species (*Pavona divaricata*) was previously recorded from the west coast of Peninsular Malaysia (Affendi and Rosman 2011). However, we note that all the newly recorded coral species found were rarely observed in our surveys, suggesting that their occurrence along the east coast of Peninsular Malaysia may be relatively low. Given the vastness of the coral reef area around the Mersing Islands and the complexity of reef ecosystems, together with seagrass meadows, such as those at Pulau Tinggi (Ooi et al. 2011) and Pulau Besar (Lee et al. 2010), we posit that the current account of coral diversity in this region may yet be underestimated. Further surveys around the Mersing Islands are likely to yield new findings, as visual surveys have only been conducted once at each study reef site. Although hard scleractinian corals form the basis of coral reef ecosystems, information about other reef-related species' diversity and abundance is also crucial for marine area planning (e.g., determining management strategies and protection status). Based on the results of the current study, we propose that more surveys should be conducted around the Mersing Islands, extending investigations to other taxa where possible.

Biodiversity and taxonomic studies on the scleractinian corals of Peninsular Malaysia are in their infancy compared to neighbouring regions, e.g., Singapore (Huang et al. 2009) and Sabah, East Malaysia (Waheed and Hoeksema 2013, 2014; Waheed et al. 2015). Given recent findings around the region, such as the new genus and species records of *Micromussa analusensis* by Ng et al. (2019), the increased occurrence and records of *Pocillopora acuta* (Poquita-Du et al. 2017; Torres and Ravago-Gotanco 2018), and the cryptic speciation in *Pachyseris speciosa* (Bongaerts et al. 2021; Feldman et al. 2021), we can expect important scleractinian discoveries for the Mersing Islands (and other coral reefs in Malaysia) should we aim to further explore and examine these underexplored reefs.

Acknowledgements

We thank the Department of Fisheries Malaysia (formally known as Department of Marine Park Malaysia during both expeditions); EKOMAR from Universiti Kebangsaan Malaysia; and Institute of Biological Sciences and Team Sea Habitats from Universiti Malaya for organizing the expeditions. This study was supported by the Department of Fisheries Malaysia. We also express our special thanks to the reviewers and academic editor, who provided comments that helped improve the manuscript.

References

Affendi YA, Rosman FR (2011) Current knowledge on scleractinian coral diveristy of Peninsular Malaysia. In: Kamarrudin I, Mohamed CAR, Rozaimi MJ, Kee Alfian BAA, Fitra AZ, Lee JN (Eds) Malaysia's Marine Biodiversity: inventory and current status. Department of Marine Park Malaysia, Putrajaya, 21–31.

Akmal KF, Shahbudin S, Faiz MHM, Hamizan YM (2019) Diversity and abundance of scleractinian corals in the East Coast of Peninsular Malaysia: A case study of Redang and Tioman Islands. Ocean Science Journal 54(3): 435–456. https://doi.org/10.1007/s12601-019-0018-6

Bongaerts P, Cooke IR, Ying H, Wels D, den Haan S, Hernandez-Agreda A, Brunner CA, Dove S, Englebert N, Eyal G, Forêt S, Grinblat M, Hay KB, Harii S, Hayward DC, Lin Y, Mihaljević M, Moya A, Muir P, Sinniger F, Smallhorn-West P, Torda G, Ragan MA, van Oppen MJH, Hoegh-Guldberg O (2021) Morphological stasis masks ecologically divergent coral species on tropical reefs. Current Biology 31(11): 2286–2298. [e8] https://doi.org/10.1016/j.cub.2021.03.028

Cairns S, Hoeksema B (2022) World List of Scleractinia. In: Bánki O, Roskov Y, Döring M, Ower G, Vandepitte L, Hobern D, Remsen D, Schalk P, DeWalt RE, Keping M, Miller J, Orrell T, Aalbu R, Adlard R, Adriaenssens EM, Aedo C, Aescht E, Akkari N, Alfenas-Zerbini P, et al. (Eds) Catalogue of Life Checklist (ver. (03/2022)). https://doi.org/10.48580/dfpd-3g9

Chong VC, Lee PKY, Lau CM (2010) Diversity, extinction risk and conservation of Malaysian fishes. Journal of Fish Biology 76(9): 2009–2066. https://doi.org/10.1111/j.1095-8649.2010.02685.x

English S, Wilkinson C, Baker V (1997) Survey Manual for Tropical Marine Resources. Australia Institute of Marine Science, Australia, 390 pp.

Feldman B, Afiq-Rosli L, Simon-Blecher N, Bollati E, Wainwright BJ, Bongaerts P, Huang D, Levy O (2021) Distinct lineages and population genomic structure of the coral *Pachyseris speciosa* in the small equatorial reef system of Singapore. Coral Reefs. https://doi.org/10.1007/s00338-021-02160-4

GBIF (2022) Global Biodiversity Information. Facility occurrences, version 2 April 2022.

Harborne A, Fenner D, Barnes A, Beger M, Harding S, Roxburgh T (2000) Status Report On The Coral Reefs Of The East Coast Of Peninsular Malaysia. Coral Cay Conservation Ltd, Malaysia, 88 pp.

Hassan H (2013) Taman Laut Sultan Iskandar: tarikan pelancongan, tumpuan penyelam skuba. http://www.utusan.com.my

Hoegh-Guldberg O, Pendleton L, Kaup A (2019) People and the changing nature of coral reefs. Regional Studies in Marine Science 30: e100699. https://doi.org/10.1016/j.rsma.2019.100699

Hoeksema BW, Cairns S (2021) World List of Scleractinia. http://www.marinespecies.org/scleractinia [on 2021–01–20]

Huang D, Tun KPP, Chou LM, Todd PA (2009) An inventory of zooxanthellate scleractinian corals in Singapore, including 33 new records. The Raffles Bulletin of Zoology 22: 69–80. https://doi.org/10.26107/RBZ-2020-0056

Huang D, Licuanan WY, Hoeksema BW, Chen CA, Ang PO, Huang H, Lane DJW, Vo ST, Waheed Z, Affendi YA, Yeemin T, Chou LM (2015) Extraordinary diversity of reef corals in the South China Sea. Marine Biodiversity 45(2): 157–168. https://doi.org/10.1007/s12526-014-0236-1

Huang D, Hoeksema BW, Affendi YA, Ang PO, Chen CA, Huang H, Lane DJW, Licuanan WY, Vibol O, Vo ST, Yeemin T, Chou LM (2016) Conservation of reef corals in the South China Sea based on species and evolutionary diversity. Biodiversity and Conservation 25(2): 331–344. https://doi.org/10.1007/s10531-016-1052-7

IUCN (2019) The IUCN Red List of Threatened Species Version 2019-3. https://www.iucnredlist.org [on 2019–11–13]

Lee JN, Ahmad SB, Badriah H, Adzis KAA, Rahman MAA, Senik S, Mohamed CAR (2010) Preliminary notes of seagrasses from Pulau Besar, Johor. In: Mohamed CAR, Sahrani FK, Manaf AA, Omar M, Cob AC, Lee JN (Eds) The Studies of Johor East Coast: Preserve Mersing Heritage. Marine Ecosystem Research Centre, UKM, Bangi, Malaysia, 167–172.

Ministry of Natural Resources and Environment (2016) National Policy on Biological Diversity 2016-2025. Ministry of Natural Resources and Environment (NRE), Malaysia, 112 pp.

Ng CSL, Jain SS, Nguyen NTH, Sam SQ, Kikuzawa YP, Chou LM, Huang D (2019) New genus and species record of reef coral *Micromussa analusensis* in the southern South China Sea. Marine Biodiversity Records 12(1): e17. https://doi.org/10.1186/s41200-019-0176-3

Ooi JLS, Kendrik GA, Van Niel KP, Affendi YA (2011) Knowledge gaps in tropical Southeast Asian seagrass systems. Estuarine, Coastal and Shelf Science 92(1): 118–131. https://doi.org/10.1016/j.ecss.2010.12.021

Ponnampalam LS, Fairul Izmal JH, Adulyanukosol K, Ooi JLS, Reynolds JE III (2015) Aligning conservation and research priorities for proactive species and habitat management: The case of dugongs Dugong dugon in Johor, Malaysia. Oryx 49(4): 743–749. https://doi.org/10.1017/S0030605313001580

Poquita-Du RC, Ng CSL, Loo JB, Afiq-Rosli L, Tay YC, Todd PA, Chou LM, Huang D (2017) New evidence shows that *Pocillopora* '*Pocilloporadamicornis*-like' corals in Singapore are actually *Pocillopora acuta* (Scleractinia: Pocilloporidae). Biodiversity Data Journal 5: e11407. https://doi.org/10.3897/BDJ.5.e11407

Praveena SM, Siraj SS, Aris AZ (2012) Coral reefs studies and threats in Malaysia: A mini review. Reviews in Environmental Science and Biotechnology 11(1): 27–39. https://doi.org/10.1007/s11157-011-9261-8

Said MZ, Komoo I, Mohamad ET, Ali CA, Ahmad N, Wahid MEA, Rajimin MF (2021) Geological, biological, cultural and local wisdom heritage a key element of Mersing Geopark development. Bulletin of the Geological Society of Malaysia 71: 89–98. https://doi.org/10.7186/bgsm71202108

Toda T, Okashita T, Maekawa T, Kee Alfian BAA, Rajuddin MKM, Nakajima R, Chen W, Takahashi KT, Othman BHR, Terazaki M (2007) Community structure of coral reefs around Peninsular Malaysia. Journal of Oceanography 63: 113–123. https://10.1007/s10872-007-0009-6

Tong PS (2020) More policies and laws, is it better for biodiversity conservation in Malaysia? Conservation Science and Practice 235(8): 1–11. https://doi.org/10.1111/csp2.235

Torres AF, Ravago-Gotanco R (2018) Rarity of the "common" coral *Pocillopora damicornis* in the western Philippine archipelago. Coral Reefs 37(4): 1209–1216. https://doi.org/10.1007/s00338-018-1729-3

UNEP (2007) National Reports on Coral Reefs in the Coastal Water of the South China Sea. UNEP/GEF?SCS Technical Publications No. 11, Thailand, 118 pp.

Veron JEN (2000) Corals of the world. Volume 1–3. Australian Institute of Marine Science, Townsville, Australia.

Veron JEN, Stafford-Smith M, De Vantier L, Turak E (2015) Overview of distribution patterns of zooxanthellate Scleractinia. Frontiers in Marine Science 1: e81. https://doi.org/10.3389/fmars.2014.00081

Waheed Z, Hoeksema BW (2013) A tale of two winds: Species richness patterns of reef corals around the Semporna peninsula, Malaysia. Marine Biodiversity 43(1): 37–51. https://doi.org/10.1007/s12526-012-0130-7

Waheed Z, Hoeksema BW (2014) Diversity patterns of scleractinian corals at Kota Kinabalu, Malaysia, in relation to exposure and depth. The Raffles Bulletin of Zoology 62: 66–82.

Waheed Z, van Mil HGJ, Syed Hussein MA, Jumin R, Golam Ahad B, Hoeksema BW (2015) Coral reefs at the northernmost tip of Borneo: An assessment of scleractinian species richness patterns and benthic reef assemblages. PLoS ONE 10(12): e0146006. https://doi.org/10.1371/journal.pone.0146006

ZooKeys 1102: 191–200 (2022)
doi: 10.3897/zookeys.1102.82466
https://zookeys.pensoft.net

RESEARCH ARTICLE

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First occurrence of the little-known genus *Noteriades* (Hymenoptera, Megachilidae) from Vietnam: discovery of a new species and a key to the Southeast Asian fauna

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Academic editor: Thorleif Dörfel | Received 18 February 2022 | Accepted 27 April 2022 | Published 20 May 2022

http://zoobank.org/792651E7-279C-4986-8D39-310B2FFD6E15

Citation: Tran NT, Engel MS, Truong LX, Nguyen LTP (2022) First occurrence of the little-known genus *Noteriades* (Hymenoptera, Megachilidae) from Vietnam: discovery of a new species and a key to the Southeast Asian fauna. ZooKeys 1102: 191–200. https://doi.org/10.3897/zookeys.1102.82466

Abstract

The little-known megachiline genus *Noteriades* Cockerell, 1931 is recorded from Vietnam for the first time. A new species, *Noteriades hangkia* Tran, Engel & Nguyen **sp. nov.** is described and figured based on a series of females collected from the provinces of the northern and central highlands of Vietnam. The genus is briefly discussed and a new subtribe is established, Noteriadina Engel, Tran & Nguyen **subtrib. nov.** of Megachilini. Lastly, an identification key and distribution map are provided for those species occurring in Southeast Asia.

Abstract in Vietnamese

Lần đầu tiên ở Việt Nam, một giống ong ít được biến đến có tên *Noteriades* Cockerell, 1931 đã được phát hiện. Trong giống này, *Noteriades hangkia* Tran, Engel & Nguyen, **sp. nov.** được mô tả là loài mới cho khoa học cùng hình ảnh minh họa dựa trên các cá thể cái thu thập được ở một số tỉnh miền Bắc và Tây Nguyên của Việt Nam. Từ việc thảo luận về kết quả nghiên cứu của giống, một phân tộc mới, Noteriadina Engel, Tran & Nguyen, **subtrib. nov.** đã được thiết lập. Khóa định loại đến loài và bản đồ phân bố của các loài thuộc giống này ở Đông Nam châu Á cũng được đưa ra.

Keywords

Anthophila, Apoidea, Megachilinae, morphology, resin bees, taxonomy

Introduction

The megachiline bee genus *Noteriades* Cockerell is a seemingly relict genus, with comparatively few species occurring in both temperate and tropical regions of sub-Saharan Africa and southern Asia (Michener 2007). Traditionally, the genus was classified in the tribe Osmiini and among the *Heriades*-group of genera owing to its distinctly hoplitiform body habitus and size (Michener 2007), but as originally hypothesized by Griswold (1985) *Noteriades* has recently been recovered as the sister group to Megachilini (Praz et al. 2008; Gonzalez et al. 2012, 2019). Today, the genus is classified as the extant sister group to all other Megachilini (Gonzalez et al. 2019), a noteworthy position as the tribe otherwise includes the famous leaf-cutter and resin bees of the genus *Megachile* Latreille and its relatives (Michener 2007; Gonzalez et al. 2019). Unfortunately, nothing is known of the biology of any species of *Noteriades*, the discovery of which melittologists are encouraged to seek.

Griswold and Gonzalez (2011) provided a provisional list of species for *Noteriades*, including 16 species, with most occurring in Africa. In Southeast Asia, there currently occur three species: *Noteriades jenniferae* Griswold & Gonzalez, 2011; *N. pulchripes* (Cameron, 1897); and *N. spinosus* Griswold & Gonzalez, 2011 which have been found in India, Thailand, and Myanmar. A further four species, all described from northern India (Gupta 1993), are of uncertain generic affiliation, are poorly documented, and in need of revision. Indeed, there is reason to believe they are misidentified and belong to another genus of Osmiini (perhaps even as synonyms of other species), as evidenced by the tridentate mandibles and seeming absence of a mediolongitudinal carina on the clypeus (Gupta 1993). For the moment, these species are best considered as *nomina dubia*.

Here, we report the genus *Noteriades* for the first time from Vietnam, represented by a new species. We provide a description and figures for the species, and an identification key and distributional map for all Southeast Asian species. In addition, given the considerable morphological disparity between *Noteriades* and the remainder of Megachilini, we establish a new subtribe for the genus.

Materials and methods

Specimens examined in the present study are deposited in the hymenopteran collections of the Institute of Ecology and Biological Resources (**IEBR**), Hanoi, Vietnam and the Division of Entomology (Snow Entomological Collection), University of Kansas Natural History Museum, Lawrence, Kansas, USA (**SEMC**). Adult morphological and color characters were examined with a Nikon SMZ745 stereomicroscope, while images were photographed with a Nikon SMZ800N digital stereomicroscope, and with an ILCE-5000L/WAP2 digital camera attached to the stereomicroscope. Stacked focus images were prepared using with Helicon Focus 7. Finally, all files were processed with Adobe Photoshop CS6. The morphological terminology used in the description follows Engel (2001) and Michener (2007), with certain body metrics following those of Niu et al. (2004): specifically, **body length:** measured from the base of the antennal torulus to metasomal apex (in dorsal view), **head length:** measured from the medio-apical margin of the clypeus to the upper margin of the vertex (in facial view), **head width:** measured at the widest point of the head across the compound eyes (in facial view), **eye width:** the greatest width of the compound eye (in profile), **genal width:** the greatest width of the gena (in profile), **mesosomal width:** measured between the outer rims of the tegulae (in dorsal view).

The abbreviations F, S, and T (followed by Arabic or Roman numerals) refer to numbered flagellomeres, metasomal sterna, and metasomal terga, respectively. The classification of Megachilini adopted herein is that of the extensive morphological and molecular treatment of Gonzalez et al. (2019).

Systematics

Tribe Megachilini Latreille, 1802

Noteriadina Engel, Tran & Nguyen, subtrib. nov.

http://zoobank.org/AA0BBF9D-5715-4ADF-895C-0776BF3C9F24

Type genus. *Noteriades* Cockerell, 1931.

Diagnosis. Small to modest-sized (4.5–10.2 mm), non-metallic, hoplitiform bees lacking integumental maculation; mandible of female quadridentate, without differentiated cutting edges, mandible of male bidentate; malar space linear; clypeus slightly projecting over clypeal-labral articulation; clypeus and often supraclypeal area with mediolongitudinal carina; paraocular area with dense appressed pubescence; preoccipital carina complete. Pronotum not enlarged nor surrounding mesoscutum anteriorly; pronotal lobe and omaulus carinate, with defined omaular surface; mesoscutellum flat, carinate posteriorly, overhanging metanotum (scarcely so in *N. pulchripes*); propodeum wholly vertical, without basal subhorizontal zone; outer surfaces of pro- and mesotibiae apically with an acute angle and distinct notch anteriorly, therefore appearing bispinose in apical view; arolia present on all legs in both sexes (absent in Megachilina except *Matangapis* Baker & Engel and *Heriadopsis* Cockerell). Metasomal tergum I carinate dorsally at angle between anterior- and dorsal-facing surfaces; tergum VI of female nearly vertical except for apical flange-like hyaline margin, without preapical carina, tergum VI of male without preapical carina (present in Megachilina); terga V and VI of male strongly curved ventrally (only terga I–IV visible in dorsal view), covering tergum VII and sterna III–VI (no so in Megachilina); sternum I of male produced over its apical margin subapically, forming double carina (not so in Megachilina); volsella distinct, with well-developed digitus and cuspis, with heavily sclerotized denticles resembling those of short-tongued bee families and *Pararhophites* Friese. Refer to Gonzalez et al. (2019) for the supraspecific classification of Megachilini.

Genus *Noteriades* Cockerell, 1931

Heriades (*Noteriades*) Cockerell, 1931: 332. Type species: *Megachile tricarinata* Bingham, 1903, by original designation.

Diagnosis. As for the subtribe (*vide supra*).

***Noteriades hangkia* Tran, Engel & Nguyen, sp. nov.**
http://zoobank.org/6F3809A1-E0A4-4188-9406-FF430B21F594
Figs 1–6

Type material. ***Holotype.*** Vietnam: ♀, Hoà Binh, Mai Chàu, Hang Kia, alt. 1200 m, 12.vi.2008 [12 June 2008], Liên Thị Phương Nguyễn, Phong Huy Phạm leg." [IEBR].

Paratypes. Vietnam: 1♀, same data as holotype [SEMC]; 1♀, Tuyên Quang, Hàm Yên, Yên Thuận, Cao Đường, Cham Chu NR, 22°20'16.4"N, 103°51'09.4"E, alt. 670 m, 16.v.2019 [16 May 2019], Cường Quang Nguyễn, Liên Thị Phương Nguyễn leg.; 2♀♀, Kon Tum, Sa Thầy, Chư Mom Ray NP, 14°47'24.5"N, 107°59'46.5"E, alt. 729 m, 25.iv.2016 [25 April 2016], Liên Thị Phương Nguyễn, Đắc Đại Nguyễn, Ngát Thị Trần leg.; 6♀♀, Kon Tum, Sa Thầy, Chư Mom Ray NP, Ro Koi RS, 14°27'25"N, 107°36'22"E, alt. 267 m, 25.iv.2022 [25 April 2022], Liên Thị Phương Nguyễn, Ngát Thị Trần leg. [IEBR].

Diagnosis. The female of this species is most similar to that of *N. jenniferae* as both have the apical margin of the clypeus crenulate, the mediolongitudinal carina distinctly extends onto the supraclypeal area; and the apical margin of the mesoscutellum is rounded, without apicolateral spines. The new species can be distinguished in the female from latter species by the following characters: F1 shorter than F2 (F1 about as long as F2 in *N. jenniferae*); the rim of the antennal torulus mesodorsally extended into a short lamellate tubercle (the rim of the antennal torulus unmodified and not mesodorsally extended in *N. jenniferae*); mesosoma approximately as long as broad (mesosoma longer than broad in *N. jenniferae*). In addition, the new species differs from both *N. jenniferae* and *N. spinosus* by the generally shiny face and mesoscutum, which is matte in the latter two species.

Description. ♀: Body length 8.0–8.5 mm (holotype = 8.5 mm), forewing length 5.5–6.0 mm (holotype = 6.0 mm).

Structure. Head slightly broader than long, approximately 1.1× as broad as long (Fig. 3). Compound eyes subparallel, 2.5× as long as broad, about 1.3× genal width. Mandible quadridentate, without differentiated cutting edges. Clypeus slightly convex on basal half, 1.8× as broad as long, apical margin crenulate, mediolongitudinal carina distinct, extending onto supraclypeal area (Fig. 3). Supraclypeal area slightly convex. Juxtantennal carina absent. Interantennal distance about 1.6× median ocellar diameter; antennal torulus with rim mesodorsally extended into short lamellate tubercle (Fig. 4), scape about 2.6× as long as broad, pedicel approximately 1.5× as long as broad and about 2× F1 in length, F1 broader than long and about 0.75× F2 in length,

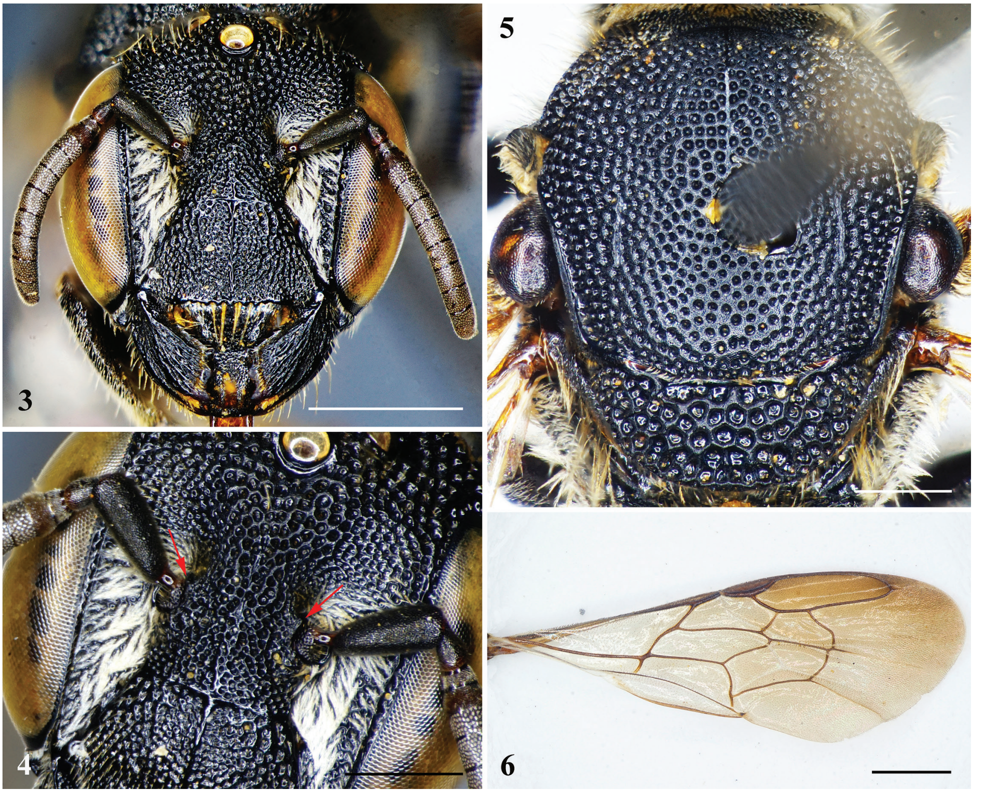
Figures 1, 2. *Noteriades hangkia* Tran, Engel & Nguyen, sp. nov., holotype, female **1** habitus in lateral view **2** habitus in dorsal view. Scale bars: 1 mm.

F3–F9 subequal in length, F10 longest flagellomere, longer than broad. Mesosoma approximately as long as broad (Fig. 5); mesoscutum without spine or sharp angle apicolaterally; mesoscutellum apical margin rounded, without apicolateral spines (Fig. 5). Forewing prestigma about as long as 1Rs; pterostigma longer than broad (Fig. 6), margin inside marginal cell convex; marginal cell apex broadly rounded and minutely appendiculate, offset from anterior wing margin; 1Rs not perfectly aligned with 1M, 1M weakly arched anteriorly, distad 1cu-a by about 2–2.5× vein width, thus forming exceedingly short 2M+Cu; Rs+M faintly sinuate; two submarginal cells (i.e., 1rs-m absent), first submarginal cell broader than second submarginal cell; 1Rs straight, about as long as r-rs; r-rs arising at pterostigmal midlength; 1m-cu strongly distad 1Rs; 2m-cu basad 2rs-m (in some paratypes, 2m-cu confluent with 2rs-m), 2rs-m strongly arched. Pretarsal claws with arolia on all legs. Anterior-facing surface of T1 strongly concave (Fig. 2) and dorsally rimmed by strong carina. Pygidial plate absent.

Sculpturing and texture. Integument of head and mesosoma generally shiny. Mandible and labrum irregularly punctate, punctures slightly coarser on mandible basally, outer ridges smooth and shiny. Clypeus with contiguous punctures of unequal sizes, puncture sizes laterally and along base larger than on remainder of surface (Fig. 3). Supraclypeal area with contiguous punctures, puncture sizes as on base and sides of clypeus. Frons with contiguous, large, coarse punctures (Fig. 4). Punctures on vertex and gena larger and coarser than on frons, punctures largest on gena. Pronotum with dense coarse punctures, punctures smaller than those on mesoscutum. Mesoscutum with largely contiguous, coarse punctures of subequal sizes, punctures of disc more separated, separated by 0.2–0.5× a puncture width, integument between faintly imbricate; tegula imbricate and impunctate; axilla with contiguous coarse punctures, punctures about 0.5× size of those on remainder of mesoscutellum; mesoscutellum with contiguous, large, coarse punctures, punctures much coarser than those on gena, almost appearing areolate (Fig. 5). Mesepisternum with large, coarse punctures on upper half, separated by about 0.3–0.5× a puncture width, lower half with smaller, denser punctures, such punctures nearly contiguous (Fig. 1). Anterior-facing surface of T1 smooth, shining, impunctate; dorsal-facing surface of T1 and remaining metasomal terga with nearly contiguous, smaller punctures resembling those of frons, except laterally punctures noticeably larger, coarser, and contiguous; S1 with small, sparse punctures; S2–S6 with small, dense punctures, except marginal zones impunctate.

Color. Body black except antenna beneath, tegula, tarsi, and metasomal sterna apical margins dark reddish brown. Wings light brown with faint green mixed coppery highlights in ventral view, membrane of marginal cell and apex darker brown than remainder of remigium and lighter in radial and first cubital cells; veins brown to dark brown, prestigma and pterostigma dark brown.

Pubescence. Paraocular area from epistomal sulcus to slightly above antennal toruli with long, dense, plumose, appressed, white setae, some setae tinged yellowish (Fig. 1). Apical margin of clypeus with sparse, erect, yellow to tawny yellow setae. Outer surfaces of mandible and labrum with minute, erect, yellow to tawny yellow setae, particularly numerous in grooves of mandible. Dorsal surface of pronotal collar,



Figures 3–6. *Noteriades hangkia* Tran, Engel & Nguyen, sp. nov., holotype, female **3** head in facial view **4** head in anterolateral oblique view showing lamellate extensions from antennal torular rims (red arrows) **5** mesosoma in dorsal view **6** forewing, dorsal view. Scale bars: 1 mm (**3, 5–6**); 0.5 mm (**4**).

pronotal lobe, lateral surfaces of coxae with short, minutely branched, yellow to yellow tawny setae, those more dorsally on pronotal lobe off white; metanotum and propodeum with longer, erect, minutely branched, yellow setae. Retrolateral surfaces of tarsi with dense, erect, yellowish setae. Metasomal T1–T4 with apical fasciae composed of yellowish plumose setae, medially interrupted on T1–T2, interruption with weak vibrissae composed of scattered, minute, simple setae on T1 (Fig. 2), otherwise discs with scattered short, suberect, yellowish, simple setae, such setae more prominent laterally and progressively longer on T4–T5; S2–S6 with yellowish scopal setae (Fig. 1).

♂: *Latet*.

Etymology. The specific epithet is a toponym for the locality at which the holotype was collected, the Hang Kia commune in Hoa Binh Province. The name is treated as a noun in apposition.

Comments. The discovery of *N. hangkia* in the northern and central highlands of Vietnam extends the distribution of the genus *Noteriades* in Southeast Asia (Fig. 7). In fact, it is likely that the genus shall be found eventually in Laos, Cambodia, and southernmost China.

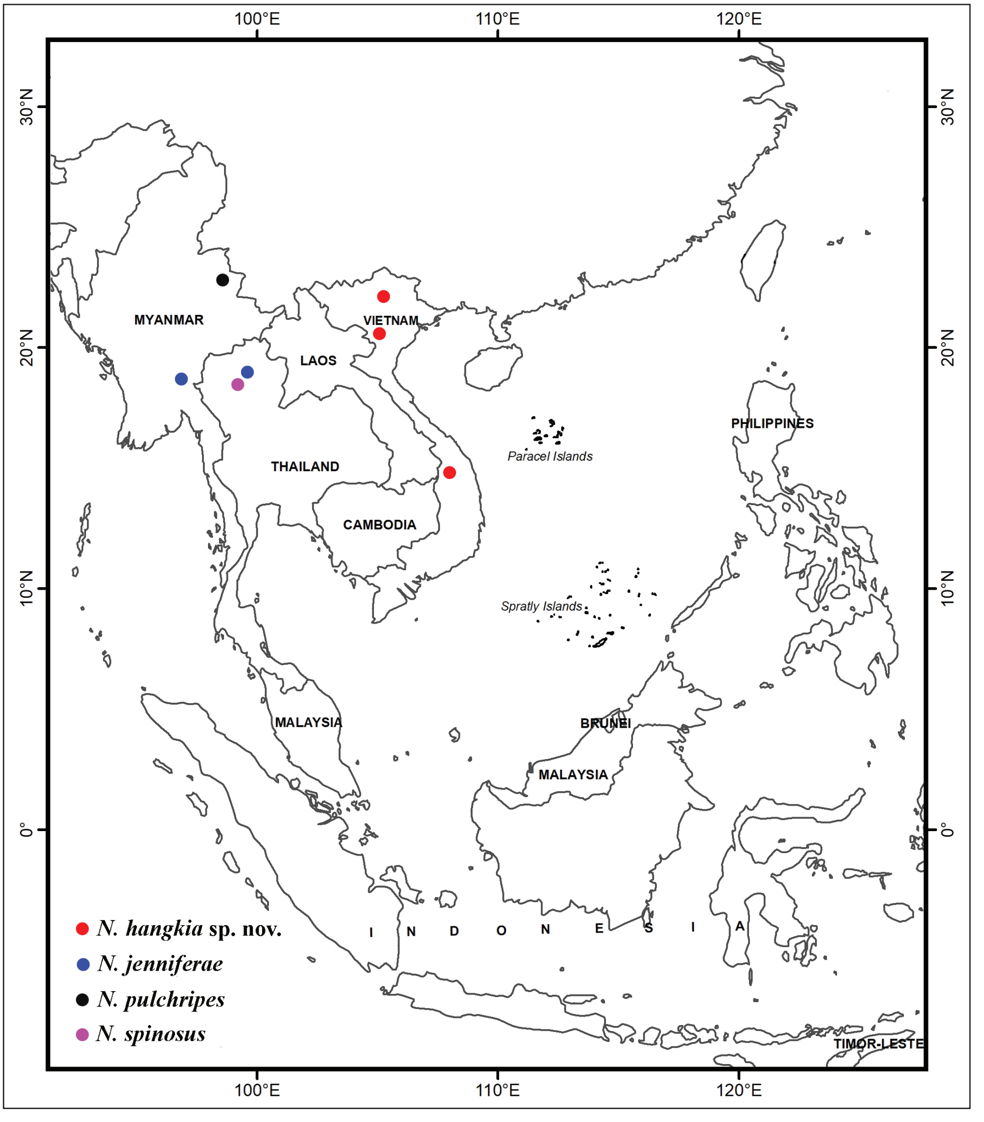


Figure 7. Distribution map of Southeast Asian species of *Noteriades* Cockerell (Megachilinae: Megachilini: Noteriadina).

Key to the species of *Noteriades* occurring in Southeast Asia

Characters for the key were extracted from the original descriptions of the species (Cameron 1897; Griswold and Gonzalez 2011).

1	Mesoscutellum with short apicolateral spines	**2**
–	Mesoscutellum rounded apically, without spines laterally	**3**

2 Mesoscutellar spines broadly triangular, not curved mesally; apical fascia of silvery setae on tergum II not interrupted medially..... ***N. pulchripes* (Cameron, 1897)**

– Mesoscutellar spines curved mesally; apical fascia of white setae on tergum II interrupted medially .... ***N. spinosus* Griswold & Gonzalez, 2011**

3 F1 shorter than F2; rim of antennal torulus mesodorsally extended to form short lamellate tubercle; mesosoma approximately as long as broad; face and mesoscutum generally shiny .... ***N. hangkia* Tran, Engel & Nguyen, sp. nov.**

– F1 about as long as F2; rim of antennal torulus unmodified, without mesodorsal lamellate extension; mesosoma longer than broad; face and mesoscutum generally matte .... ***N. jenniferae* Griswold & Gonzalez, 2011**

Acknowledgements

We are grateful to T. Griswold and an anonymous reviewer for helpful comments on the manuscript. The present study was supported by the Vietnam Academy of Science and Technology under grant number ĐLTE00.04/22-23, while the first author was funded by Vingroup JSC and supported by the Masters, PhD Scholarship Programme of the Vingroup Innovation Foundation (VINIF), Institute of Big Data, code [VINIF.2021.TS.089].

References

Bingham CT (1903) On the Hymenoptera collected by Mr. W.L. Distant in the Transvaal, South Africa, with descriptions of supposed new species. Annals and Magazine of Natural History, Series 7 12(67): 46–69. https://doi.org/10.1080/00222930308678829

Cameron P (1897) Hymenoptera Orientalia, or contributions to a knowledge of the Hymenoptera of the Oriental zoological region. Part V. Manchester Memoirs 41(4): 134–135.

Cockerell TDA (1931) Heriadine and related bees from Liberia and Belgian Congo (Hymenoptera, Apoidea). Revue de Zoologie et de Botanique Africaines 20: 331–341.

Engel MS (2001) A monograph of the Baltic amber bees and evolution of the Apoidea (Hymenoptera). Bulletin of the American Museum of Natural History 259: 1–192. https://doi.org/10.1206/0003-0090(2001)259%3C0001:AMOTBA%3E2.0.CO;2

Gonzalez VH, Griswold T, Praz CJ, Danforth BN (2012) Phylogeny of the bee family Megachilidae (Hymenoptera: Apoidea) based on adult morphology. Systematic Entomology 37(2): 261–286. https://doi.org/10.1111/j.1365-3113.2012.00620.x

Gonzalez VH, Gustafson GT, Engel MS (2019) Morphological phylogeny of Megachilini and the evolution of leaf-cutter behavior in bees (Hymenoptera: Megachilidae). Journal of Melittology 85(85): 1–123. https://doi.org/10.17161/jom.v0i85.11541

Griswold TL (1985) A Generic and Subgeneric Revision of the *Heriades* Genus-group. Doctoral dissertation, Utah State University, Logan, [xii +] 165 pp.

Griswold T, Gonzalez VH (2011) New species of the Eastern Hemisphere genera *Afroheriades* and *Noteriades* (Hymenoptera, Megachilidae), with keys to species of the former. ZooKeys 159: 65–80. https://doi.org/10.3897/zookeys.159.2283

Gupta RK (1993) Taxonomic Studies on the Megachilidae of North-Western India (Insecta, Hymenoptera, Apoidea). Indian Council of Agricultural Research, New Delhi, [iii +] 288 pp.

Michener CD (2007) The Bees of the World [2nd edn.]. Johns Hopkins University Press, Baltimore, MD, [xvi+[i]+]953 pp. [+20 pls]

Niu ZQ, Wu YR, Huang DW (2004) A taxonomic study on the subgenus *Seladonia* (Hymenoptera, Halictidae, *Halictus*) in China with description of one new species. Zoological Studies (Taipei, Taiwan) 43(4): 647–670.

Praz CJ, Müller A, Danforth BN, Griswold T, Widmer A, Dorn S (2008) Phylogeny and biogeography of bees of the tribe Osmiini (Hymenoptera: Megachilidae). Molecular Phylogenetics and Evolution 49(1): 185–197. https://doi.org/10.1016/j.ympev.2008.07.005

ZooKeys 1102: 201–202 (2022)
doi: 10.3897/zookeys.1102.79148
https://zookeys.pensoft.net

LETTER TO THE EDITOR

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Letter for Qiu et al. (2021) regarding 'The distribution and behavioral characteristics of plateau pikas (*Ochotona curzoniae*)'

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Academic editor: Jesus Maldonado | Received 10 December 2021 | Accepted 12 January 2022 | Published 20 May 2022

http://zoobank.org/0D524EED-873C-4EF8-BE92-7BCDEBC322F7

Citation: Li W-J (2022) Letter for Qiu et al. (2021) regarding 'The distribution and behavioral characteristics of plateau pikas (*Ochotona curzoniae*)'. ZooKeys 1102: 201–202. https://doi.org/10.3897/zookeys.1102.79148

Dear Editor,

While reading the paper 'The distribution and behavioral characteristics of plateau pikas (*Ochotona curzoniae*)' (Qiu et al. 2021), I found that the authors of this paper appear to have made a mistake in reporting the surface temperature of their research area. The reasons are as follows:

The study was carried out in August 2019 in Dari County of Qinghai Province, China (Qiu et al. 2021). I would like to point out that the historic high air temperature in Dari County was 23.2 °C (Wang et al. 2018), but in the paper by Qiu et al. (2021), the highest surface temperature was reported as 48 °C, and was more than twice the historic high temperature recorded for their research area. The reason for this discrepancy was that the surface temperature recorded in images was the temperature that was detected by the temperature receptors of the field infrared camera. There was no shelter provided for the field infrared camera in alpine meadow grasslands and the temperature of the camera increased rapidly under direct sunshine. However, the authors in this study incorrectly used the temperature recorded by the camera directly and the values shown for the temperature gradient in figure 6 of Qiu et al. (2021) were out of the range of the normal air temperature conditions. Therefore, their conclusion that the preferable temperature for pikas may be around 31~35 °C was incorrect. The altitude of the distribution areas of plateau pikas is more than 3,000 m, and cool condition are preferred by the pikas; if the temperature is more than 25 °C, the pikas will die. Therefore, I suggest that the authors of Qiu et al. (2021) provide a statement of their results about temperature and behavior, or re-analyze of the data according to the temperature from the Meteorological Bureau of Dari County.

This is a common problem in research projects that use temperature recordings recorded directly from images from field infrared cameras, which often produce incorrect air temperature readings when the cameras are under direct sunshine. Therefore, I suggest that if the temperature recorded by the camera is to be used in the research, that the camera be housed in a proper instrument weather shelter, or that the temperature be recorded or obtained separately.

Acknowledgements

This study was financially supported by the Natural Science Foundation of Qinghai Province (2019-ZJ-919).

References

Qiu J, Ma C, Jia Y-H, Wang J-Z, Cao S-K, Li F-F (2021) The distribution and behavioral characteristics of plateau pikas (*Ochotona curzoniae*). ZooKeys 1059: 157–171. https://doi.org/10.3897/zookeys.1059.63581

Wang H, Zhao Z-X, Wang X-Y (2018) Analysis of trends and periodicity of temperature change of Dari County from 1956–2015. Modern Agricultural Science and Technology 2018(18): 214–215. [In Chinese]