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DATA PAPER

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East Weddell Sea echinoids from the JR275 expedition

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Abstract

Information regarding the echinoids in this dataset is based on the Agassiz Trawl (AGT) and epibenthic sledge (EBS) samples collected during the British Antarctic Survey cruise JR275 on the RRS James Clark Ross in the austral summer 2012. A total of 56 (1 at the South Orkneys and 55 in the Eastern Weddell Sea) Agassiz Trawl and 18 (2 at the South Orkneys and 16 in the Eastern Weddell Sea) epibenthic sledge deployments were performed at depths ranging from ~280 to ~2060 m. This presents a unique collection for the Antarctic benthic biodiversity assessment of an important group of benthic invertebrates. In total 487 specimens belonging to six families, 15 genera, and 22 morphospecies were collected. The species richness per station varied between one and six. Total species richness represents 27% of the 82 echinoid species ever recorded in the Southern Ocean (David et al. 2005b, Pierrat et al. 2012, Saucède et al. 2014). The Cidaridae (sub-family Ctenocidarinae) and Schizasteridae are the two most speciose families in the dataset. They comprise seven and nine species respectively. This is illustrative of the overall pattern of echinoid diversity in the Southern Ocean where 65% of Antarctic species belong to the families Schizasteridae and Cidaridae (Pierrat et al. 2012).

Keywords

Echinoidea, Southern Ocean, Biodiversity

Project details

Project title: JR 275 RRS James Clark Ross 2012

Personnel: Huw Griffiths, Camille Moreau, Jennifer Jackson, Chester Sands, Rachel Downey, Adam Reed, Melanie Mackenzie, Paul Geissler, Katrin Linse

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Study extent description: The study area of this dataset was set in the Eastern Weddell Sea and focused on sampling the continental shelf, upper slope and overdeepened shelf basins of the Filchner Trough region of the Weddell Sea (Knust and Schröder 2014). This dataset presents species occurrences and species richness of the individual trawls (Agassiz Trawl and Epibenthic Sledge deployments). Our sampling regime was designed to investigate patterns of biodiversity, and once compared to other sources of material, biogeography and phylogeography in the benthos of this region of the Southern Ocean. The Filchner Trough region is an oceanographically interesting area that includes regions of cold Antarctic Bottom Water (ABW) production. One of the other characteristics of the area is the perennial sea ice cover and the presence of very large icebergs.

Design description: The South-Eastern Weddell Sea is a relatively under sampled area on the Antarctic continental shelf, according to a recent gap analysis carried out by Griffiths et al. (2011). EvolHist (Evolutionary History of the Polar Regions), a core project at the British Antarctic Survey, studied the South-Eastern Weddell Sea to assess the biodiversity at local and regional scales (comparable to the BIOPEARL 2006 cruise to the Scotia Sea and the BIOPEARL II 2008 cruise to the Bellingshausen and Amundsen Seas) and investigate the phylogenetic relationships of selected marine invertebrate taxa and their biogeography in reference to the climatological, oceanographical and geological history of the Weddell Sea. The results are used to determine of the role of Antarctica and extreme environments in general in evolutionary innovation and generation of global biodiversity. The species presence data are added to SOMBASE (South- ern Ocean Mollusc Database www.antarctica.ac.uk/sombase). SOMBASE generated a significant portion of the initial core data system upon which SCAR's Antarctic Biodiversity Information Facility (AntaBIF, www.biodiversity.aq) was built. As AntaBIF (and its predecessor, SCAR-MarBIN) is the Antarctic Node of the international OBIS and GBIF networks, the SOMBASE data system was designed to comply with the Darwin Core standards. Regarding the dataset, the existing Data Toolkit from AntaBIF was used (http://ipt.biodiversity.aq/), following the OBIS schema (http://iobis.org/data/schema-and-metadata). The data-

set was up- loaded in the ANTOBIS (Antarctic Ocean Biogeographic Information System) database (the geospatial component of SCAR-MarBIN), and the taxonomy was matched against the Register of Antarctic Marine Species, using the Taxon Match tool (http://www.scarmarbin.be/rams.php?p=match). The dataset meets the Darwin Core requirements and was designed around this data schema.

Sampling description: A single test location off the South Orkney Islands and a further six locations in the Eastern Weddell Sea at different depths ranging from 279 to 2058m have been sampled using an Agassiz Trawl (AGT) and an epibenthic sledge (EBS). Most of the Weddell Sea deployments were made along two transects, one running from south to north along the edge of the Filchner Trough and one running from west to east out of the Filchner Trough onto the shallower shelf. Two further localities in overdeepened basins close to the Brunt Ice shelf were sampled (Figure 1, Stations 33-40). At each site, three replicate Agassiz trawls (individual stations) were taken and where the substrate was suitable (not too rocky) a single EBS deployment was conducted. The JR275 cruise report is available from the British Oceanographic Data Centre (www.bodc.ac.uk/data/information_and_inventories/cruise_inventory/report/10598).

This dataset represents 48 AGT and 8 EBS deployments: consisting of a single deployment at the South Orkneys at 279m; 15 at depths of ~400m; four at ~500m; 21 at ~600m; two at ~700m and four deployments at each of ~1000m, ~1500m and ~2000m deep (Figure 1, Table 1).

The AGT had an inner mesh size of 1 cm and a mouth width of 2 m. The EBS consisted of an epi-(below) and a supra-(above) net. Each of these nets has a mesh size of 500µm and an opening of 100×33cm. The cod end of both nets is equipped with net-buckets containing a 300µm mesh window (Brenke 2005). The AGT and EBS were trawled for 10 minutes (depending on depth, seabed type and the condition of the animals in the initial trawl) on the sea bed at a 1 knot speed. Following Brenke (2005), since the EBS epi- and supra-nets collect the same fauna, they were pooled and treated as a single sample.

Quality control description: A species name was given to each specimen when it was possible. Identifications and taxonomic accuracies are based on David et al. (2005a, 2005b), Pierrat et al. (2012), and Saucède et al. (2014). When identification was inconclusive, e.g. for small specimens at very early stages of development, only family or genus names were assigned. These specimens were referred to as gen. *sp.* or genus name *sp.* respectively and might belong to one of the species listed in the dataset (Table 2). Specimens referred to as *Abatus sp.* 1 belong to none of the species listed in the dataset. The specimen referred to in the dataset as *Amphipneustes* aff. *similis* is very similar in morphology to *A. similis* but it presents distinctive morphological characters that are not diagnostic of the aforementioned species. While included in this dataset as *Amphipneustes* aff. *similis* it is likely that this will be described as a new species after further morphological and genetic analyses.

This dataset presents species occurrences and species richness of the individual AGT and EBS deployments.

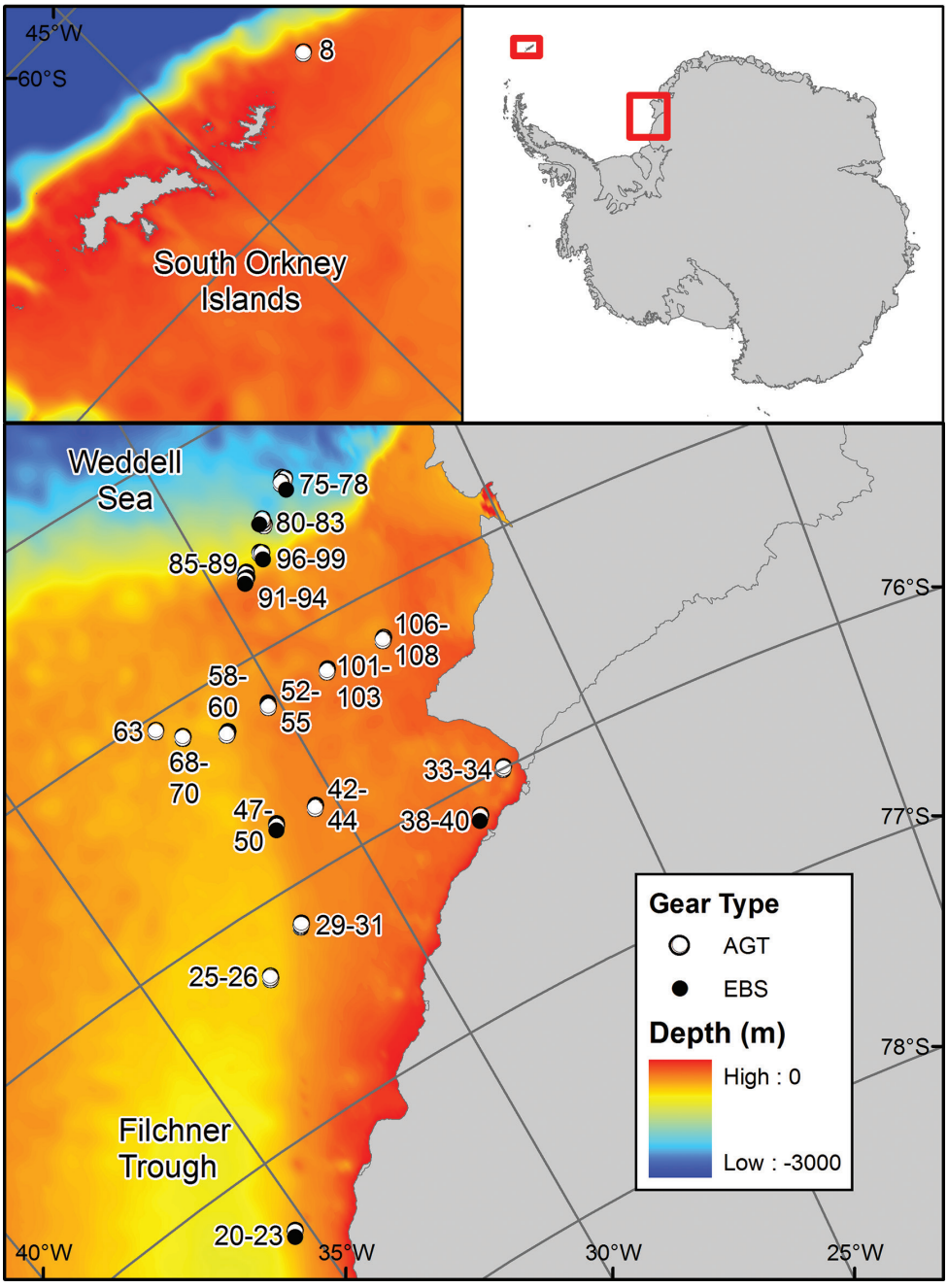

Figure 1. Sample locations for JR275 echinoid records.

Table 1. Sampling stations containing echinoid samples from JR275. AGT = Agassiz Trawl, EBS = Epibenthic sledge.

Station ID	Gear type	Start lat	End lat	Start long	End long	Min depth	Max depth	Date
8	AGT	-60.6774	-60.6775	-44.01327	-44.0144	279.04	281.57	12/02/2012
20	AGT	-77.359	-77.3576	-35.37029	-35.3642	654.34	654.35	19/02/2012
21	AGT	-77.3548	-77.3529	-35.35131	-35.3423	648.18	652.8	19/02/2012
23	EBS	-77.3569	-77.3579	-35.36059	-35.365	649.74	655.86	19/02/2012
25	AGT	-76.3295	-76.327	-32.90046	-32.8956	778.81	781.73	20/02/2012
26	AGT	-76.321	-76.3197	-32.88435	-32.8819	780.3	789.24	20/02/2012
29	AGT	-76.1991	-76.1982	-31.86015	-31.8556	575.95	578.97	20/02/2012
30	AGT	-76.1956	-76.1947	-31.84258	-31.8383	575.99	578.94	20/02/2012
31	AGT	-76.1919	-76.191	-31.82427	-31.8197	564.11	573	20/02/2012
33	AGT	-76.0231	-76.0222	-26.99542	-26.9909	605.21	610	21/02/2012
34	AGT	-76.0196	-76.0187	-26.97793	-26.9735	608	613	21/02/2012
38	AGT	-76.1697	-76.1685	-27.79567	-27.799	544.89	561	21/02/2012
39	AGT	-76.1694	-76.1689	-27.79659	-27.798	549.28	555.26	21/02/2012
40	EBS	-76.1669	-76.1657	-27.8038	-27.8073	533.05	550.82	21/02/2012
42	AGT	-75.7612	-75.7621	-30.43723	-30.4413	429.41	433.85	22/02/2012
43	AGT	-75.7645	-75.765	-30.45297	-30.4547	427.94	430	22/02/2012
44	AGT	-75.767	-75.7674	-30.46317	-30.4648	429.39	436.8	22/02/2012
47	AGT	-75.7406	-75.7418	-31.23803	-31.2413	578.94	584.88	22/02/2012
48	AGT	-75.7451	-75.7462	-31.25064	-31.2538	584.83	590.75	22/02/2012
49	AGT	-75.7496	-75.7508	-31.2636	-31.2668	583.36	584.94	22/02/2012
50	EBS	-75.7433	-75.7459	-31.24615	-31.2535	583.34	590.45	22/02/2012
52	AGT	-75.2434	-75.2447	-30.24534	-30.2472	418.73	419.21	23/02/2012
53	AGT	-75.2478	-75.2491	-30.25152	-30.2533	417.39	417.78	23/02/2012
54	AGT	-75.2526	-75.2539	-30.25835	-30.2602	418.7	419.11	23/02/2012
55	AGT	-75.2567	-75.258	-30.26436	-30.2662	418.38	418.61	23/02/2012
58	AGT	-75.2631	-75.2638	-31.12627	-31.131	604.29	607.13	23/02/2012
59	AGT	-75.2658	-75.2665	-31.14481	-31.1504	607.1	610.24	23/02/2012
60	AGT	-75.2686	-75.2692	-31.16355	-31.168	614.3	616.52	23/02/2012
63	AGT	-75.0852	-75.0866	-32.21766	-32.2177	609.48	612.28	24/02/2012
68	AGT	-75.1767	-75.1781	-31.8702	-31.869	655.78	676.11	24/02/2012
69	AGT	-75.1754	-75.1768	-31.87114	-31.87	654.87	657.46	24/02/2012
70	AGT	-75.1743	-75.1757	-31.87206	-31.8708	654.65	691.31	24/02/2012
75	AGT	-74.37	-74.3718	-28.10797	-28.1	2052.26	2053.91	26/02/2012
76	AGT	-74.3797	-74.3817	-28.06634	-28.059	2056.14	2058.19	26/02/2012
77	AGT	-74.3886	-74.3904	-28.1561	-28.1482	2006.54	2011.16	26/02/2012
78	EBS	-74.4047	-74.4065	-28.08486	-28.0769	2019.49	2026.16	26/02/2012
80	AGT	-74.5202	-74.5175	-28.75306	-28.7512	1537.72	1545.99	28/02/2012
81	AGT	-74.5084	-74.5057	-28.74527	-28.7436	1558.28	1570.08	28/02/2012
82	AGT	-74.4962	-74.4931	-28.73726	-28.7352	1580.27	1595.46	28/02/2012
83	EBS	-74.4853	-74.4846	-28.77472	-28.7847	1577.88	1588.23	28/02/2012
85	AGT	-74.6741	-74.675	-29.42462	-29.4344	586.74	604.49	29/02/2012
86	AGT	-74.6769	-74.6766	-29.45447	-29.4507	573.42	580.99	29/02/2012
88	AGT	-74.6747	-74.6745	-29.43061	-29.4284	592.71	602.27	29/02/2012
89	EBS	-74.6716	-74.6706	-29.39886	-29.3883	639.32	657.44	29/02/2012

Station ID	Gear type	Start lat	End lat	Start long	End long	Min depth	Max depth	Date
91	AGT	-74.7067	-74.7054	-29.50822	-29.5066	401.67	410	29/02/2012
92	AGT	-74.7013	-74.7009	-29.50091	-29.5002	427.17	428.55	29/02/2012
93	AGT	-74.6982	-74.6975	-29.49652	-29.4956	439.76	450.09	29/02/2012
94	EBS	-74.6919	-74.6893	-29.48786	-29.4842	476.94	494.03	29/02/2012
96	AGT	-74.6252	-74.6268	-29.05155	-29.0429	1018.91	1028.48	01/03/2012
97	AGT	-74.6304	-74.6319	-29.0236	-29.0151	985.75	1010.63	01/03/2012
99	EBS	-74.6341	-74.6357	-29.00812	-28.9996	958.98	986.19	01/03/2012
101	AGT	-75.2427	-75.2437	-29.00356	-29.0072	391.66	398.3	04/03/2012
102	AGT	-75.246	-75.2471	-29.01541	-29.019	392.77	396.83	04/03/2012
103	AGT	-75.2495	-75.2506	-29.02708	-29.0304	390.17	392.2	04/03/2012
106	AGT	-75.2389	-75.2397	-27.84859	-27.853	413.67	415.71	04/03/2012
108	AGT	-75.244	-75.2448	-27.87707	-27.8816	417.56	424.41	04/03/2012

Taxonomic coverage

General taxonomic coverage description: The present dataset focuses on the class Echinoidea (Echinodermata). It includes six families, 15 genera, and 22 species:

Class: Echinoidea

Family: Cidaridae, Echinidae, Plexechinidae, Pourtalesiidae, Schizasteridae, Urechinidae

Genus: *Aporocidaris*, *Ctenocidaris*, *Notocidaris*, *Rhynchocidaris*, *Sterechinus*, *Plexechinus*, *Pourtalesia*, *Abatus*, *Amphipneustes*, *Brachysternaster*, *Delopatagus*, *Tripylaster*, *Tripylus*, *Antrechinus*, *Cystechinus*

Species: *Aporocidaris milleri*, *Ctenocidaris gigantea*, *Ctenocidaris perrieri*, *Notocidaris gaussensis*, *Notocidaris lanceolata*, *Notocidaris mortenseni*, *Rhynchocidaris triplopora*, *Sterechinus antarcticus*, *Sterechinus dentifer*, *Plexechinus planus*, *Pourtalesia hispida*, *Abatus sp.* 1, *Amphipneustes* aff. *similis*, *Amphipneustes lorioli*, *Amphipneustes similis*, *Brachysternaster chesheri*, *Delopatagus brucei*, *Tripylaster philippii*, *Tripylus abatoides*, *Tripylus cordatus*, *Antrechinus nordenskjoldi*, *Cystechinus wyvillii*

Spatial coverage

General spatial coverage: East Weddell Sea, Antarctica

Coordinates: 60.68°S and 77.36°S; 44.01°W and 26.78°W

Temporal coverage: February 12, 2012–March 4, 2012

Natural collections description

Parent collection identifier: British Antarctic Survey **Collection name:** EvolHist Weddell Sea Echinoids

Collection identifier: Saucède

Specimen preservation method: Ethanol

Table 2. Presence only matrix of echinoid species from JR275.

			Station number																												
Family	**Genus**	**Species**	**8**	**20**	**21**	**23**	**25**	**26**	**29**	**30**	**31**	**33**	**34**	**38**	**39**	**40**	**42**	**43**	**44**	**47**	**48**	**49**	**50**	**52**	**53**	**54**	**55**	**58**	**59**	**60**
Cidaridae	*Aporocidaris*	*milleri*																												
	Ctenocidaris	*gigantea*																												
		perrieri																												
	gen.	*sp.*																												
	Notocidaris	*gaussensis*																												
		lanceolata													X															
		mortenseni																												
	Rhynchocidaris	*triplopora*	X																											
Echinidae	*Sterechinus*	*antarcticus*		X	X				X	X	X			X						X	X	X					X	X	X
		dentifer																												
		sp.				X	X	X				X	X			X									X		X			
Plexechinidae	*Plexechinus*	*planus*																												
Pourtalesiidae	*Pourtalesia*	*hispida*																												
		Sp.																												
Schizasteridae	*Abatus*	*sp.* 1																												
	Amphipneustes	aff. *similis*																				X								
		lorioli																X						X						X
		similis																		X				X		X		X		
	Brachysternaster	*chesheri*									X						X	X						X						
	Delopatagus	*brucei*																												
	gen.	*sp.*																					X							
	Tripylaster	*philippii*																												
	Tripylus	*abatoides*																												
		cordatus																	X											
Urechinidae	*Antrechinus*	*nordenskjoldi*																												

Table 2. Continued.

			Station number																												
Family	**Genus**	**Species**	**63**	**68**	**69**	**70**	**75**	**76**	**77**	**78**	**80**	**81**	**82**	**83**	**85**	**86**	**88**	**89**	**91**	**92**	**93**	**94**	**96**	**97**	**99**	**101**	**102**	**103**	**106**	**108**
Cidaridae	*Aporocidaris*	*milleri*					X																							
	Ctenocidaris	*gigantea*													X															
		perrieri													X													X		
	gen.	*sp.*							X									X				X								
	Notocidaris	*gaussensis*					X	X					X																	
		lanceolata																												
		mortenseni													X		X													
	Rhynchocidaris	*triplopora*													X				X	X	X									
Echinidae	*Sterechinus*	*antarcticus*	X		X	X									X	X	X			X							X			X
		dentifer					X		X		X	X	X																	
		sp.		X						X				X				X				X		X	X					
Plexechinidae	*Plexechinus*	*planus*											X																	
Pourtalesiidae	*Pourtalesia*	*hispida*						X	X				X																	
		Sp.								X																				
Schizasteridae	*Abatus*	*sp.* 1																X					X							
	Amphipneustes	aff. *similis*																												
		lorioli																									X	X	X	X
		similis															X													
	Brachysternaster	*chesheri*					X																							
	Delopatagus	*brucei*						X																						
	gen.	*sp.*																				X				X			X	
	Trippylaster	*philippii*											X																	
	Tripylus	*abatoides*													X															
		cordatus																												
Urechinidae	*Antrechinus*	*nordenskjoldi*													X			X							X					

Methods

Method step description:

– Agassiz trawl sampling in the Weddell Sea
– Once on board, the samples were photographed as total catch and then hand-sorted into groups varying from Phylum to species level collections. Representatives of many taxa were photographed in detail. The wet-mass (biomass) of the different taxa was assessed by using calibrated scales (with accuracy and resolution of 0.001 kg). Samples were fixed in 96% undenatured and precooled (at -20°C) ethanol (Linse 2008) and kept for a minimum of 48 hours in a -20°C freezer, with rotation of containers to ensure full preservation of material.
– Epibenthic sledge sampling in the Weddell Sea
– Once on the deck, the content of the samplers from the first deployment was immediately fixed in 96% undenatured and precooled (at -20°C) ethanol and kept for a minimum of 48 hours in a -20°C freezer.
– The taxonomic identification was performed in the British Antarctic Survey laboratory using a stereomicroscope.

Datasets

Dataset description
Object name: BAS_JR275_Echinoidea
Character encoding: UTF-8
Format name: Darwin Core Archive format
Format version: 1.0
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RESEARCH ARTICLE

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Status of *Exosphaeroma amplicauda* (Stimpson, 1857), *E. aphrodita* (Boone, 1923) and description of three new species (Crustacea, Isopoda, Sphaeromatidae) from the north-eastern Pacific

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Abstract

Exosphaeroma amplicauda (Stimpson, 1857) from the west coast of North America is reviewed and redescribed and revealed to be a group of closely related species. A neotype is designated and the species redescribed based on the neotype and topotypic specimens. *Exosphaeroma amplicauda* is known only from the coast of California, at Marin, Sonoma and San Mateo Counties. *E. aphrodita* (Boone, 1923), type locality La Jolla, California and previously considered *nomen dubium* is taken out of synonymy and re-validated. A further three species: *E. paydenae* **sp. n.**, *E. russellhansoni* **sp. n.**, and *E. pentcheffi* **sp. n.** are described herein. *Sphaeroma octonctum* Richardson, 1899 is placed into junior synonymy with *Exosphaeroma amplicauda*. A key to the Pacific West Coast *Exosphaeroma* is provided.

Keywords

Isopoda, Sphaeromatidae, *Exosphaeroma*, Alaska, Washington, California, intertidal

Table of contents

Introduction

The Sphaeromatidae is a large family, currently with 99 accepted genera (WoRMS, World Register of Marine Species, Bruce and Schotte 2013) and nearly 700 species. The phylogenetic relationships of the Sphaeromatidea were reviewed by Wetzer et al. 2013, but no family-wide treatment since the time of Hansen (1905) and the much later key of Harrison and Ellis (1991) are available. The most recent comprehensive treatment for the United States is Richardson's (1905) monograph, which to a degree was updated by Kensley and Schotte (1989). The number of described species and genera of North American Sphaeromatidae have slowly increased over the 20th century but many species remain poorly known and attributed to inappropriate genera. At last count, marine and freshwater sphaeromatids in North America included 21 genera with a total of 67 species (seven *species inquirenda*, *incertae sedis* or both).

The North American western coast lies within the East Pacific biogeographic zone, and the Sphaeromatidae are represented by 37 species in 11 genera, six of these regarded as *species inquirenda* and *incertae sedis* (see Appendix 1). While some western coast United States species have been described in detail (e.g. Bruce and Wetzer 2004; Carvacho and Haasmann 1984; Espinosa-Pérez and Hendrickx 2002; Hendrickx and Espinosa-Pérez 1998; Wetzer and Bruce 2007) many others remain poorly described, and unrecognizable by modern standards (see Appendix 1).

One such poorly-known North American species is *Exosphaeroma amplicauda* (Stimpson, 1857). The original description of *Exosphaeroma amplicauda* is brief with a single postage-stamp sized (1.5×2.0 cm) figure of the dorsum taken from specimens "found adhering to fragments of star-fishes picked up on the beach of Tomales Bay by Mr. Samuels, 6.4 mm long and deposited at the Smithsonian" (Stimpson 1857). Stimpson (1858) later provided a paragraph-long description without additional details.

The species was redescribed by Kussakin (1979) based on material collected from Amchitka Island, Alaska, some 2000 kilometers north of the type locality. Differences between Kussakin's (1979) description and fresh material of what appeared to be *E. amplicauda* from California, including the type location, prompted a re-evaluation of the species. Reviewing morphological and molecular data, we realize that there is a 'species flock' of five morphologically similar species on the western coast of North America. Such 'species flocks' have been reported for other sphaeromatid genera (e.g. *Paracassidina* – see Bruce 1994; *Oxinasphaera* – see Bruce 1997) and other families (e.g. Cymothoidae, see Bruce 1986; Cirolanidae, see Bruce 2004; Aegidae, see Bruce 2004, 2009; Serolidae, see Poore 1987), but this is the first such example in the East Pacific.

We redescribe *Exosphaeroma amplicauda* from the type locality Tomales Bay (central California coast) and *E. aphrodita* from San Diego, and describe three new closely related species: *E. paydenae* sp. n., Aleutians; *E. russellhansoni* sp. n., Puget Sound, *E. pentcheffi* sp. n., Palos Verdes Peninsula.

Abbreviations

LACM–Natural History Museum of Los Angeles County; USNM–United States National Museum, Smithsonian Institution; BM–British Museum; MCZ–Museum of Comparative Zoology Harvard; ANSP–Academy of Natural Sciences Philadelphia; UAF–University of Alaska, Fairbanks; AM–Amherst College, Massachusetts; PM–Yale Peabody Museum, Connecticut; RS–robust seta/e; PMS–plumose marginal setae; SEM–scanning electron microscopy; SCAMIT–Southern California Association of Marine Invertebrate Taxonomists. Latitudes and longitudes denoted with "~" are approximate and estimated from Google Earth.

Material and methods

Descriptions are based on the male holotype, female allotype, and topotypic paratypes. Specimens examined have been assigned a USNM or LACM catalog/type numbers. Numbers preceded by "RW" are field and station numbers. Species descriptions were prepared using DELTA (Dallwitz et al. 1997). Setal terminology broadly follows Watling (1989).

Specimens prepared for SEM were cleaned for 10–20 seconds in a Branson 1200 ultrasonic cleaner in a weak solution of Branson GP jewelry soap and distilled water. Specimens were then dehydrated with 100% ethanol. Specimens were placed in solutions of pure ethanol and distilled water in the ratios 2:1, 1:1, 1:2, and finally into 100% ethanol (20 minutes per treatment). Once dehydrated and in 100% ethanol, hexamethyldisilzane (HMDS) was used to replace the ethanol in the specimens. Specimens were transferred through ethanol and HMDS solutions in the following ratios 2:1, 1:1, 1:2 and finally into 100% HMDS (20 minutes per treatment). Specimens were transferred from the final 100% HMDS to fresh HMDS and allowed to evapo-

rate overnight. Specimens were mounted on carbon conductive tabs and coated with gold/palladium using an Emitech K550x sputter coater (Quorum Technologies, LTD, Kent, UK) and imaged using a Hitachi S-3000N variable pressure SEM (Hitachi, Troy, MI) at the LACM.

Drawings were made with the aid of a camera lucida and illustrations were electronically "inked" with Adobe Illustrator CS6. Whole body illustrations were made with a Wild M5D stereo dissecting scope. Appendages were illustrated by dissecting off the appendage and placing them in glycerol on a depression slide and then imaged using a Nikon Labophot-2 compound scope.

Specimens were measured by tracing their dorsal surface along their longitudinal axis with the aid of a camera lucida. A scale bar in the same plane as the specimens allowed calculation of total body length. All lengths reported were mesured in this fashion and may slightly overestimate total body length because pereonites and pleonites are expanded in this position. The lengths given in the "Material Examined" are of the largest specimen of each species and sex. Not all specimens were measured. If a length is provided and multiple specimens were present in a lot, the length refers to largest specimen. In all species mature males appear larger than females, but body lengths for mature adults are similar. Males in all species have much broader uropods than females, which contributes to this illusion. Large sexually mature males tend to be rare compared to females and subadults. Gravid females are rare. Smaller non-gravid individuals cannot be sexed. Females of the different species are virtually indistinguishable and cannot be confidently assigned to a species without an accompanying male. It appears that the largest males guard harems. No individual male-female mate guarding was observed (as occurs in *Exosphaeroma inornata* Dow, 1958 which also occurs on the Pacific west coast). All species described herein occur in aggregates either under rocks or amongst dead barnacle tests.

We provide dorsal and lateral line drawings of all males for each species. We also provide dorsal and lateral SEMs of both males and females of each species.

Taxonomy

Key to the north-eastern Pacific species of *Exosphaeroma* of the North American West Coast

This key is based on adult ♂ characters. Also note that weak pereon tubercles are visible only with SEM and not necessarily evident with light microscopy – e.g., compare Figures 1 and 21.

1 Pereonites 1–7, pleon, and pleotelson without ornamentation; pleotelson to overall body length ratio 0.21; apex of posterior margin of pleotelson rounded and truncate; uropodal endopods posterior margin evenly rounded; sex ratio nearly 1:1; individual mate guarding ..... ***Exosphaeroma inornata*** (Fig. 26)

– Pleon with tubercles; pleotelson and uropods long, pleotelson to overall body length ratio 0.30 or greater; posterior margin of pleotelson acuminate; uropodal endopods posterior margin falcate; large adult males rare, one alpha male guarding many females and juveniles (harem guarding) **2**

2 Pereonites 5–7 without tubercles; pleon with 1 anterior and 1 posterior weak tubercles on either side of longitudinal axis; pleotelson dorsal surface without ornamentation; appendix masculina straight, distally narrowing, distal apex acute, length 16.0 basal width ..... ***Exosphaeroma paydenae*** **sp. n.** (Figs 5; 8B; 22)

– Pereonite 7 with weak or strong median process; pleon with 1 medium tubercle on either side of longitudinal axis; pleotelson dorsal surface with tubercle **3**

3 Pereonites 5 and 6 without ornamentation, pereonite 7 with weak median process; pleon with 1 medium tubercle on either side of longitudinal axis; pleotelson dorsal surface with 2 small anterior tubercles; appendix masculina distal end curving mesially, apex weakly hooked mesially, length 11.4 basal width ..... ***Exosphaeroma russellhansoni*** **sp. n.** (Figs 9; 12B; 23)

– Pereonite 5 without ornamentation, pereonite 6 with 1 lateral weak tubercle, pereonite 7 with weak median process, and paired weak lateral tubercles; pleon with 1 medium tubercle on either side of longitudinal axis; pleotelson dorsal surface with 1 anterior median strong tubercle and 2 weak medial tubercles; appendix masculina apically narrowly rounded, length 13.0 basal width ..... ***Exosphaeroma aphrodita*** (Figs 17; 20B; 25)

– Pereonites 5 and 6 with tubercles; pereonite 7 with median process, and tubercles; pleon with 1 posterior strong tubercle, on either side of longitudinal axis; pleotelson dorsal surface with tubercles **4**

4 Pereonites 5 and 6 with 1 median weak tubercle, and 1 weak lateral tubercle; pereonite 7 with weak median process and paired lateral tubercles; pleotelson dorsal surface with 2 small anterior tubercles; appendix masculina distal end curving mesially, straightening at distal tip, length 15.4 basal width .... ***Exosphaeroma amplicauda*** (Figs 1; 4B; 21)

– Pereonites 5–6 each with 7 longitudinal rows of strong tubercles, pereonite 7 with strong median process with 3 lateral tubercles; pleotelson dorsal surface with 3 strong medial tubercles on either side of the longitudinal axis, with 1 strong medial tubercle between the longitudinal axis and lateral margin, pleotelson covered with numerous, additional, small tubercles; appendix masculina distally narrowing to an acute rounded tip, length 15 basal width .... ***Exosphaeroma pentcheffi*** **sp. n.** (Figs 13; 16B; 24)

Exosphaeroma **Stebbing, 1900**

Restricted synonymy: *Exosphaeroma* Stebbing, 1900: 553. – Bruce 2003: 327.

Type species. *Sphaeroma gigas* Leach, 1818; by original designation (Stebbing 1900).

Remarks. A diagnosis and comprehensive synonymy was provided by Bruce (2003). The genus occurs in shallow water in all the world oceans and is one of the few sphaeromatid genera extending to southern reaches of the Southern Ocean. Greatest diversity is found in the Southern Hemisphere. The genus has groups of morphologically similar species, including those species close to the type species, and a group of species with a broad rim to the pleotelson ventral margin, while some species have broad uropods and a posteriorly produced pleotelson apex. At present, the relationships between these different species groups remains unassessed.

Exosphaeroma amplicauda (Stimpson, 1857), *E. aphrodita* and the three new species described herein form a distinct group within the genus *Exosphaeroma*. This group of species is characterised by a posteriorly produced and somewhat posteriorly depressed pleotelson, with an acute apex, flattened ventrolateral margins, and the posterior margin overriding a shallow exit channel; the uropods are distally wide and the exopod is distally broadly falcate. The dorsum varies from smooth to nodular. Typically mature males of the "*amplicauda* group" have a large pleotelson and enlarged posterior coxal plates and cannot completely roll up or fold. Some similar species are known from the Southern Hemisphere, including *Exosphaeroma alveola* Bruce, 2003 (southeastern Australia); *E. antikraussi* Barnard, 1940, *E. kraussi* Tattersall, 1913, *E. planum* Barnard, 1914 and *E. varicolor* Barnard, 1914 (all South Africa); and *E. montis* (Hurley & Jansen, 1977) (New Zealand). All other North American *Exosphaeroma* have an evenly rounded pleotelson, with a narrow ventral margin, and uropods that are not posteriorly wide.

Other *Exosphaeroma* occurring between Alaska and the Mexican border that are morphologically not closely related to the Pacific west coast species include *E. inornata* (known from Puget Sound, Washington to central-southern Baja California Norte, Mexico). *E. inornata* differs from the "*amplicauda* group" in that *E. inornata* lacks marked sexual dimorphism. Males mate guard individual females with males clasping and holding females until mating. *E. inornata* can roll up into perfect balls, and their bodies are unornamented. This distinguishes them clearly from the "*amplicauda*" clade (*E. amplicauda*, *E. aphrodita,* and the three new species described here).

The type specimens of *E. rhomburum* (USNM 22573) were borrowed and consist of two specimens from Monterey Bay, neither specimen is an adult male. Richardson's (1899b: 835) original species description only figures the pleotelson, and she did not note whether the description was based on a male or female. We were not able to further evaluate the status of this species.

In collections from the type locality at Tomales Bay in 2009 for *E. amplicauda*, we found "family groups" with all life stages (gravid and non-gravid females, subadult males, juveniles, and adult males). These family groups consisted of ca. 10–30 individuals, but in which adult, fully mature males are rare, leading us to conclude that males in these species guard harems rather than guard individual females. For every 10 individuals, we found one, sometimes two, large adult males. We found no evidence for multiple male morphs in these collections [e.g., alpha, beta, gamma males in *Paracerceis sculpta* as described by Shuster (1989)].

***Exosphaeroma amplicauda* (Stimpson, 1857)**
Figures 1–4, 21, 27, 28

Sphaeroma amplicauda Stimpson, 1857: 510; Richardson 1899a: 835; 1899b: 179; 1900: 222.
Exosphaeroma amplicauda. – Richardson 1905: 288, 289, fig. 301, 302; Gurjanova 1936: 122, fig. 69; Schultz 1969: 131, fig. 190.
Sphaeroma octoncum Richardson 1905: 293.
Exosphaeroma octoncum. – Iverson 1974: 166. – Richardson 1905: 293, fig. 309, 310. – Schotte 2012: online.
Not *Exosphaeroma amplicauda*. – Gurjanova 1936: 122, fig. 69. – Kussakin 1979: 399, figs 254, 255 [= *Exosphaeroma paydenae* sp. n.].

Material examined. NEOTYPE (here designated): ♂ (5.1 mm): California, Marin County, Tomales Bay, north end of bay across from Hog Island, boat launch parking lot, 38.201°N, 122.922°W, intertidal, from underside of rocks, fixed and preserved in 95% ethanol, 9 Jan 2009, coll. R. Wetzer & A. Wall. RW09.003.1, LACM CR-2014.1.

Non-type material. 2 ♂ (RW09.003.2, LACM CR-2014.1), 3 ♀ (RW09.003.3, LACM CR-2014.1) [used for SEM], 1 ♂, ~40 ♀ and juveniles: same locality as RW09.003, LACM CR-2014.1. 6 ♂ (8.1 mm), 4 ♀ (7.1 mm), 10 juveniles (RW09.004.1), plus 2 ♂ and 4 ♀ prepared as SEM (RW09.004.2): intertidal, from underside of rocks, "family group", coll. A. Wall. RW09.004, LACM CR-2014.2. 7 ♂ (5.8 mm), ~20 ♀ (6.8 mm) and juveniles, and 3 ♀ used for SEM: intertidal, from underside of rocks, "family group", coll. A. Wall. RW09.005, LACM CR-2014.3. 2 ♂ (8.4 mm), ~25 ♀ (7.4 mm), and juveniles: intertidal, from empty *Balanus glandula* shells, coll. N.D. Pentcheff, RW09.006.1, LACM CR-2014.4. 1 ♂ (7.7 mm), 2 ♀ (6.5 mm), and 2 juveniles: E. side in cove across from Hog Island (Nick's Cove), ~38.197°N, ~122.935°W, 1 Nov 1971, A.0030, coll. E.W. Iverson & J. Carlton. RW04.020.1, LACM CR-2014.5. California, Monterey County, Monterey Bay, 4 specimens (labeled *E. octoncum*), all are ♀. Acc. No. 03472, USNM 22574 (part).

Description of male. *Body* length 1.6 width; pereonites 5–6 each with 1 median weak tubercle, and 1 weak lateral tubercle; pereonite 7 with weak median process and paired lateral tubercles (Figures 1A, B; 21A, D). *Pleon* with 1 posterior strong tubercle on either side of longitudinal axis (Figures 1A, B; 21A, D). *Pleotelson* length 0.82 width, dorsal surface with 2 small anterior tubercles; ventrolateral ridge extending posteriorly 0.75 of total length, with long setae (Figures 1A, B; 21A, C, D).

Antennula peduncle article 1 length 1.7 width, anterior medial margin with 2 palm setae; article 2 length 1.4 width, inferior distal margin with 2 palm setae; article 3 length 3.2 width; flagellum with 9 articles (Figure 2B). *Antenna* reaching anterior margin of pereonite 2; flagellum with 14 articles (Figure 2A).

Left mandible incisor with 3 cusps; lacinia mobilis with 3 cusps; lacinia mobilis spine row comprised of 5 curved, serrate spines (Figures 2E, 27D). *Right mandible*

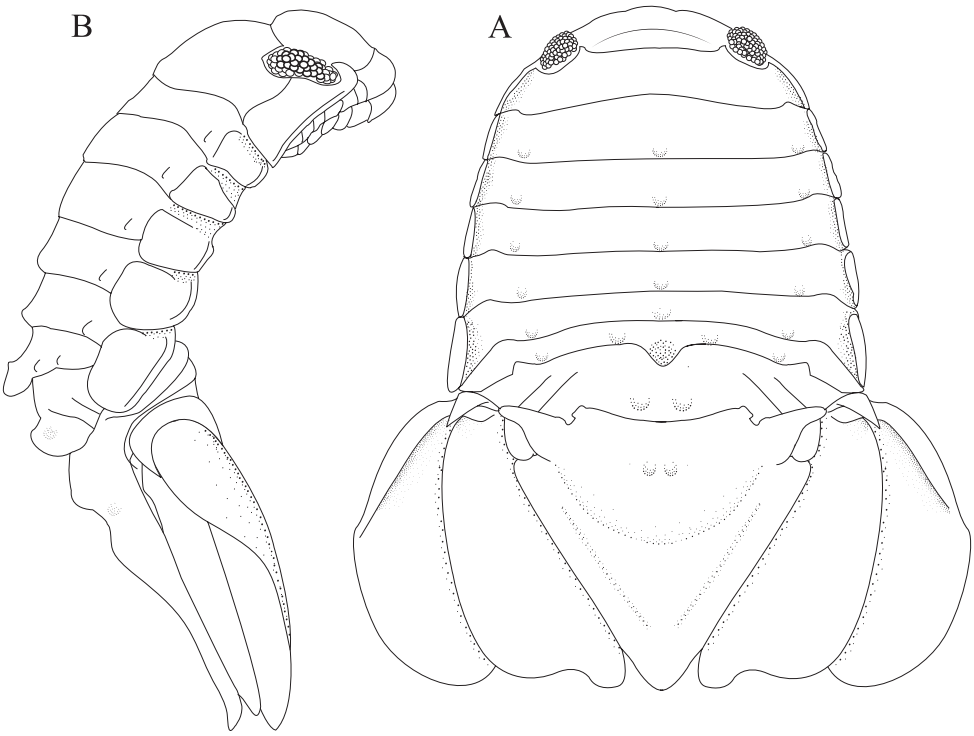

Figure 1. *Exosphaeroma amplicauda* male neotype LACM CR-2014.1. **A** dorsal **B** lateral.

incisor with 4 cusps; spine row comprised of 6 curved, serrate spines; crushing surfaces strongly ridged (Figures 2D, 27D). *Maxillula* mesial lobe with 4 circumplumose RS; lateral lobe with 6 long, curved, pectinate RS (Figures 2F; 27E, F, G). *Maxilla* mesial lobe with 6 plumose RS on gnathal surface; middle lobe with 4 long, curved, pectinate RS; lateral lobe with 4 long, curved, pectinate RS (Figures 2G; 27E, G). *Maxilliped* endite distal surface with 5 plumose setae, and 2 simple RS; distomesial margin with 1 coupling hook; palp article 2 distal apex with 9 long, simple RS; article 3 distal apex with 12 long, simple RS, lateral distal angle with 1 long, simple RS; article 4 distal apex with 9 long, simple RS, lateral distal angle with 1 long, simple RS; article 5 distal apex with 7 long, simple RS (Figures 2H; 27E, G).

Pereopod 1 (Figure 3A) *basis* superior margin without palm setae, inferior distal angle with 1 long, simple seta, inferior medial margin setal patch absent; *ischium* length 2.4 width, superior margin with 4 long, simple setae, inferior distal angle with 1 long, simple seta; *merus* 0.42 ischium length, superior distal angle with 2 long, simple setae; *carpus* inferior distal angle with 1 long, simple seta; *propodus* length 2.5 width, 0.82 ischium length, superior distal angle with 2 long, simple setae, inferior margin with 3 long, simple setae; *dactylus* length 1.7 width, length 0.33 propodus length, inferior margin covered with scales, distal margin with 4 simple setae (Figure 3A). *Pereopod 3* (Figures 3B, 27A) *basis* superior margin without palm setae, inferior distal angle with

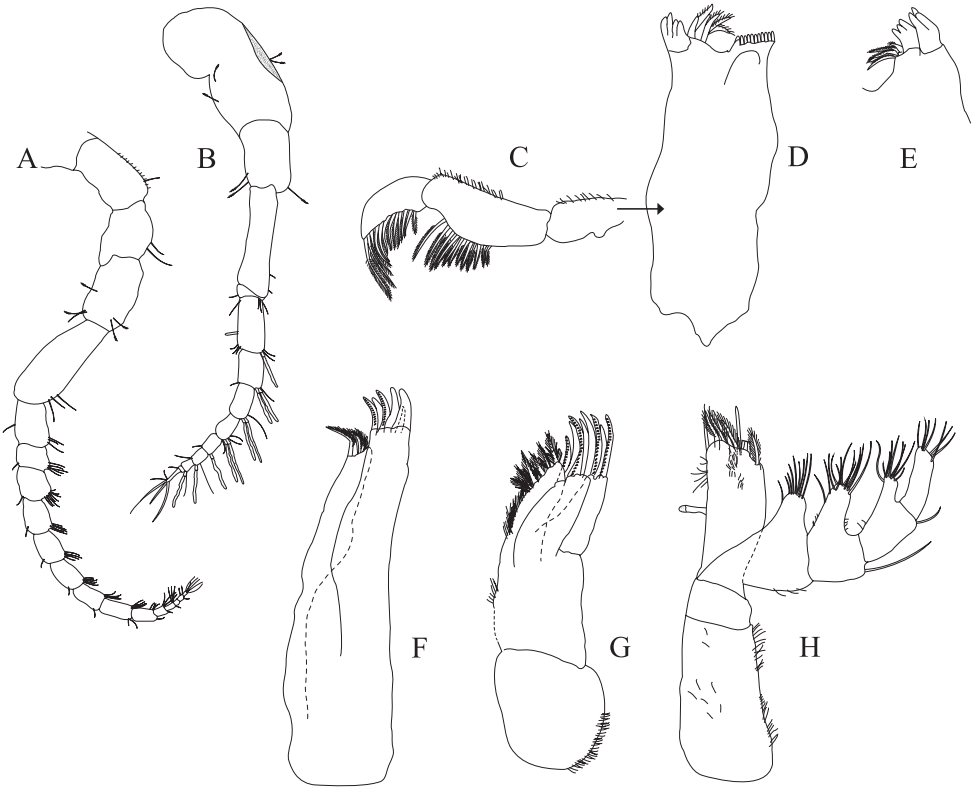

Figure 2. *Exosphaeroma amplicauda* male neotype LACM CR-2014.1. **A** left antenna **B** left antennula, basal article broken **C** right mandible palp **D** right mandible **E** left mandible **F** left maxillula **G** left maxilla **H** left maxilliped.

1 long simple seta, inferior proximal margin with setal patch present; *ischium* length 2.5 width, superior margin with 3 long, simple RS, inferior distal angle with 1 simple RS, and with setal patch absent; *merus* lobate, length 1.4 width, 0.57 ischium length, superior distal angle with cluster of 4 simple RS, inferior margin covered in setal mat; *carpus* length 0.71 merus length, 1.2 width, superior margin with 1 long, simple seta on distal angle, inferior margin with setal mat and 1 long, simple seta; *propodus* weakly curved, length 2.5 width, 2.3 carpus length, superior distal margin with 1 palm seta, inferior margin first 0.67 covered in setal mat; *dactylus* length 1.3 width, length 0.36 propodus length, inferior margin distal 0.75 covered with scales, distal margin with 3 long, simple setae (Figures 3B, 27A). *Pereopod 7* (Figures 3C; 27B, C) *basis* superior margin with palm setae absent, inferior proximal margin with setal patch absent, inferior distal angle with long, simple setae absent; *ischium* length 2.9 width, superior margin with 3 long, simple RS; *merus* lobate, merus length 1.8 width, merus length 0.66 ischium length, superior distal angle with 4 RS, inferior margin with setal mat, inferior distal angle with biserrate setae absent; *carpus* length 2.5 width, carpus length 1.3 merus length, inferior margin with setal mat, superior distal angle with a cluster

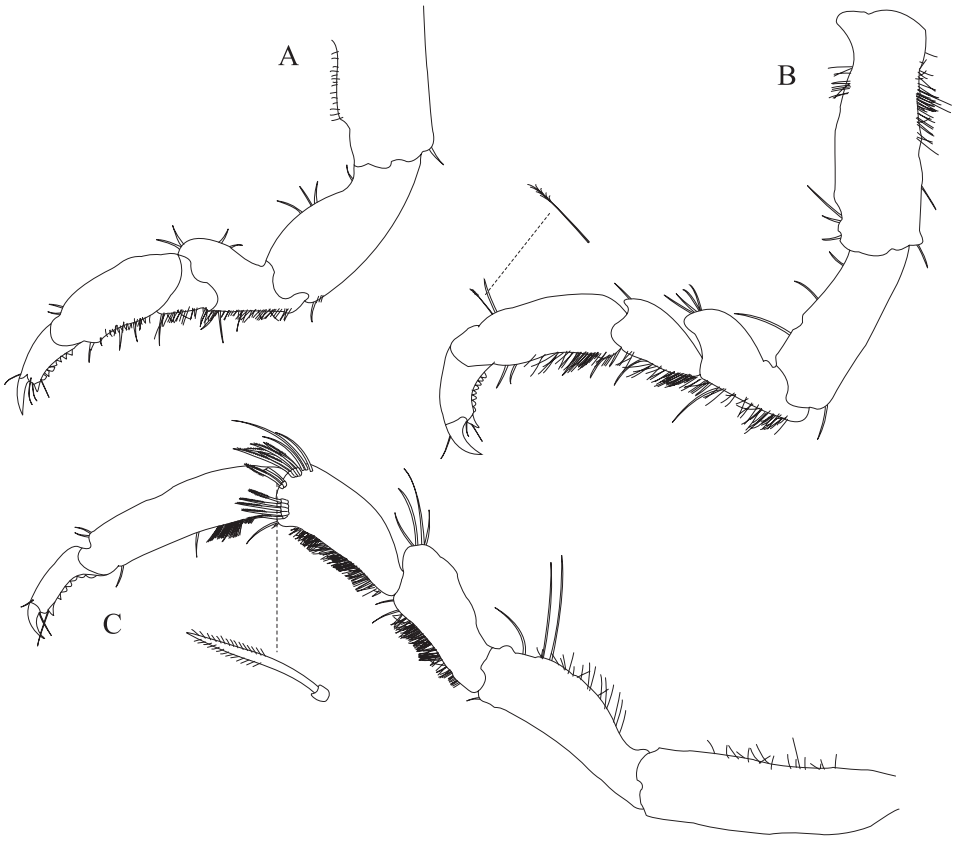

Figure 3. *Exosphaeroma amplicauda* male neotype LACM CR-2014.1. **A** left pereopod 1 **B** left pereopod 3 **C** left pereopod 7.

of 5 long, biserrate setae, superior distal angle with a cluster of 3 long, simple, RS, distomesial margin with a cluster of 3 long, biserrate setae, inferior distal angle with a cluster of 5 long, biserrate setae, 1 long, simple RS; *propodus* weakly curved, length 4.0 width, length 1.3 carpus length, inferior margin proximal 0.33 with setal mat, superior distal angle with 2 long, simple setae, inferior margin with 2 long, simple setae, with palm setae absent; *dactylus* length 1.8 width, dactylus length 0.28 propodus length, margin with scales, distal margin with 3 simple setae (Figures 3C; 27B, C).

Penial process length 2.5 basal width (Figure 21B, C).

Pleopod 1 peduncle length 0.48 width, with a cluster of 3 coupling hooks; endopod mesial margin heavily covered in fine, simple setae; exopod length 1.7 width, ventral surface without fine, simple setae (Figure 4A). *Pleopod 2 appendix masculina* proximally swollen, distally narrowing, distal end curving mesially, straightening at distal tip, length 15.4 basal width (Figure 4B). *Pleopod 3* peduncle with a cluster of 3 coupling hooks, distolateral angle with 1 large, plumose seta (Figure 4C). *Pleopod 4* peduncle length 0.48 width, distolateral angle with 1 large, plumose seta; endopod distal apex 1

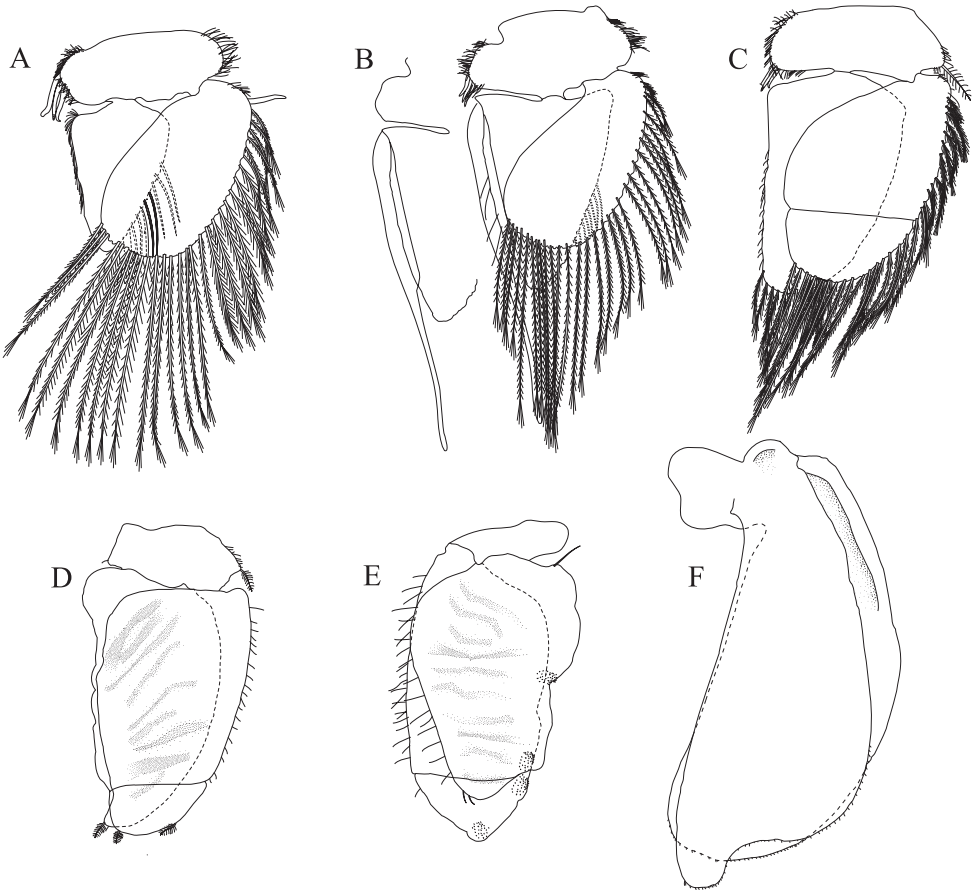

Figure 4. *Exosphaeroma amplicauda* male neotype LACM CR-2014.1. **A–E** left pleopods 1–5, respectively **F** right uropod.

large, plumose seta; exopod distal margin with 2 plumose setae (Figure 4D). *Pleopod 5* exopod proximolateral margin with palm setae absent; exopod with transverse suture entire, endopod with 1 scale patch; exopod with 3 scale patches (Figure 4E). *Uropod* exopod length 2.3 width; rolled proximolateral margin weakening moving distally; mesial margin without setae; endopod length 2.5 width, extends past exopod, mesial margin without setae (Figures 4F; 21A, C, D).

Description of female. *Body* length 2.7 width; pereonites 1–7 without tubercles, pereonite 7 distomesial margin convex (Figure 21E, F). *Pleon* with 1 posterior tubercle on either side of longitudinal axis (Figure 21E, F). *Pleotelson* length 2.6 width, dorsal surface with 2 medium tubercles on either side of longitudinal axis; posterior margin of pleotelson acuminate (Figure 21E, F). *Uropod* exopod proximolateral margin weakly rolled; endopod posterior margin tapering to evenly rounded tip, length 4.8 width, extends past exopod (Figure 21E, F).

Size. Largest ♂ to 8.4 mm, largest ♀ to 7.5 mm.

Color. Without chromatophores: preserved specimen pale buff, whitish.

Remarks. *Exosphaeroma amplicauda* is most morphologically similar to *Exosphaeroma russellhansoni* sp. n. but can be distinguished by: pereonites 5 and 6 with one weak median tubercle, and one weak lateral tubercle; pereonite 7 with weak median process and paired lateral tubercles. (Figures 1A, B; 21A, D). Appendix masculina distal end curving mesially, straightening at distal tip, length 15.4 basal width (Figure 4B).

E. russellhansoni sp. n. is characterized by: pereonite 5–6 each without ornamentation, pereonite 7 with weak median process (Figures 9A, B; 23A, D). Appendix masculina distal end curving mesially, apex weakly hooked mesially, length 11.4 basal width (Figure 12B). *E. amplicauda* is strongly sexually dimorphic; females lack dorsal tubercles on pereonites 1–7. Overall for all species in this 'species flock' the males have a larger pleotelson and uropods. Weak pereon tubercles are visible only with SEM and not necessarily evident with light microscopy. Tubercles visible with light microscopy are figured in the line drawings (compare Figures 1 and 21).

We searched all probable museum collections for Stimpson's type specimens, but to no avail (see Acknowledgements). It is highly likely that the type specimens are lost. The original and subsequent description (Stimpson 1857, 1858) do not allow for definitive identification of the species. There are five morphologically similar species in the northeast Pacific. A neotype is here designated to stabilize the use of the name *Exosphaeroma amplicauda* (Stimpson, 1857) and conserve Stimpson's concept for the species.

We borrowed the types of *Sphaeroma octonctum* Richardson, 1899 (USNM Cat. No. 22574); Richardson (1899) noted that there were five specimens from the type locality, Monterey Bay). We received only four specimens–three had been previously dissected, some with pleopods removed, and only one specimen was entire. None of these specimens are adult males, and these specimens are indistinguishable from female *Exosphaeroma amplicauda* from Tomales Bay. We place *Sphaeroma octonctum* into junior synonymy with *Exosphaeroma amplicauda*.

Distribution. California: Marin, Sonoma, and San Mateo Counties.

***Exosphaeroma paydenae* sp. n.**

http://zoobank.org/D9B0B1E1-3BA3-4564-9AE9-F502034B553C
Figures 5–8, 22, 28

Exosphaeroma amplicauda. – Gurjanova 1936: 122, fig. 69. – Kussakin 1979: 399, Figs 254, 255.

Material examined. HOLOTYPE: ♂ (7.8 mm): Alaska, Aleutian Islands, Kiska Harbor, ~52.00°N, ~177.31°E, ca. 1873, beach, low water, USNM 20474, 211(1025), coll. W.H. Dall [Specimen label reads "Alaska, Kyoka Harbor." per Marilyn Schotte, 15 Nov 2004 USNM 20474 reads "Aleutian Islands, Kiska Harbor" – maybe a transcription error on the label; specimens denoted as USNM 20474 are also possibly collected ca. 1873 similar to USNM 13312.] USNM 1251663.

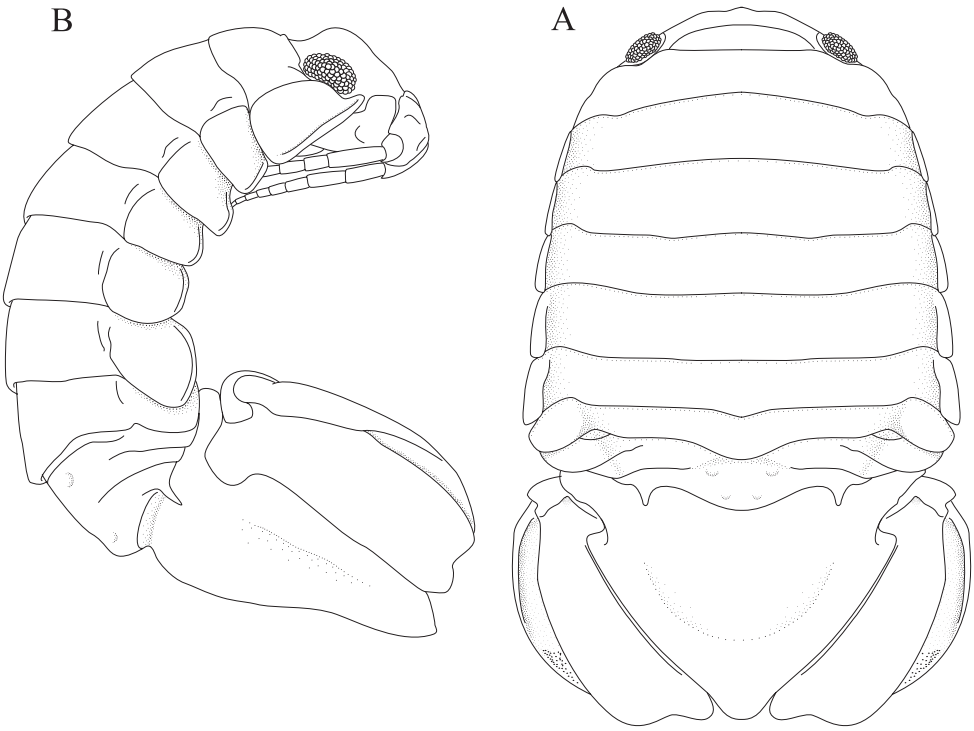

Figure 5. *Exosphaeroma paydenae* sp. n., male holotype USNM 20474. **A** dorsal **B** lateral.

PARATYPES: Allotype: ♀ (8.6 mm, whole animal figured): same locality as USNM 1251663, USNM 1251664. 1 ♂, 9 ♀, 2 juveniles, plus 1 ♂ and 1 ♀ prepared as SEM: all same locality as USNM 20474. 8 ♂ (8.0 mm), 1 ♂ broken: north coast of Amchitka, ~51.3°N, 179°E, 1 Jan 1873, USNM 13312, 284(1044), coll. W.H. Dall, USNM 1251665.

Description of male. *Body* length 1.6 width; pereonites 5–7 each without ornamentation (Figures 5A, B; 22A, B). *Pleon* with 1 anterior weak tubercle on either side of longitudinal axis, 1 posterior weak tubercle on either side of longitudinal axis (Figures 5A, B; 22A). *Pleotelson* length 0.59 width, dorsal surface without ornamentation; ventrolateral ridge entire, with few setae (Figures 5A, B; 22A, D).

Antennula peduncle article 1 length 1.5 width, anterior medial margin with palm setae absent; article 2 length 1.1 width, inferior distal margin with palm setae absent; article 3 length 2.6 width; flagellum with 9 articles (Figure 6B). *Antenna* reaching posterior margin of pereonite 3, peduncle article 1 with fine, simple setae on superior margin; flagellum with 11 articles (Figure 6A).

Left mandible incisor with 3 cusps; lacinia mobilis with 2 cusps; lacinia mobilis spine row comprised of 6 curved, serrate spines (Figure 6F). *Right mandible* incisor with 3 cusps; spine row comprised of 7 curved, serrate spines; crushing surfaces strongly ridged (Figure 6E). *Maxillula* mesial lobe with 4 circumplumose RS, and 2

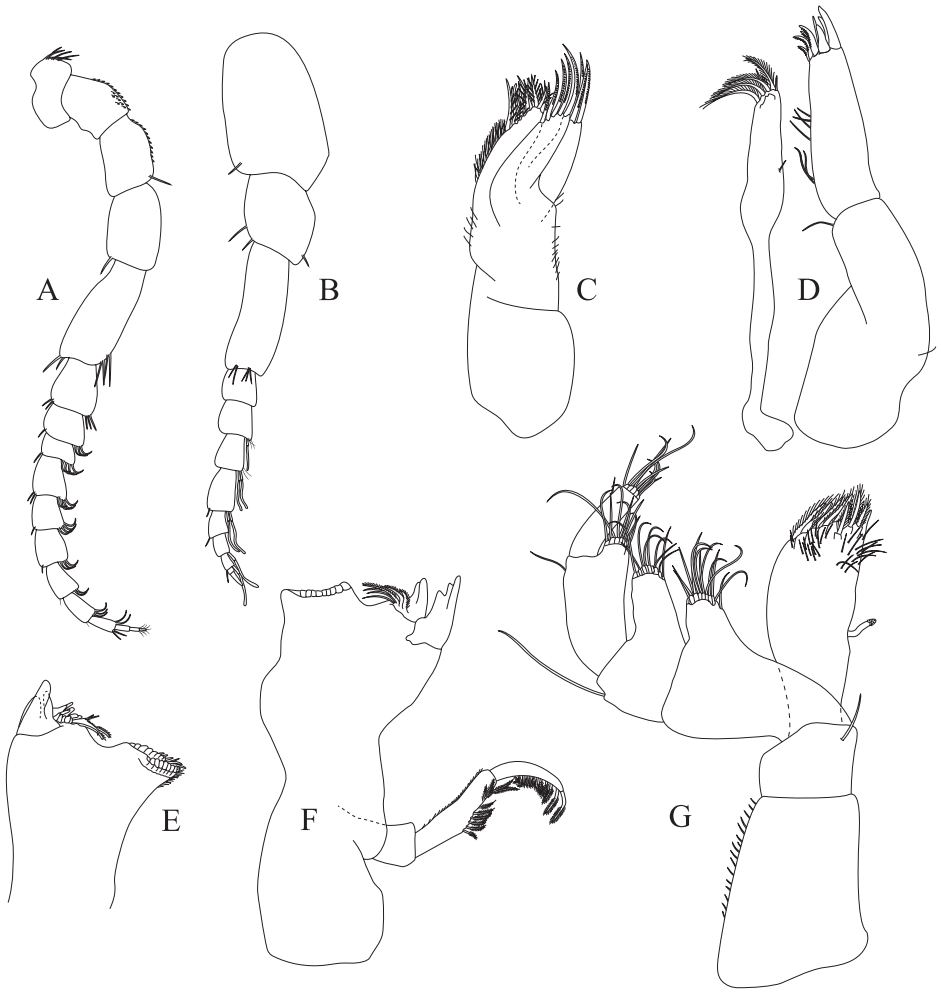

Figure 6. *Exosphaeroma paydenae* sp. n., male holotype USNM 20474. **A** right antenna **B** right antennula **C** right maxilla **D** right maxillula **E** right mandible **F** left mandible **G** right maxilliped.

long, simple setae; lateral lobe with 7 long, curved, pectinate RS, gnathal surface with 1 curved, simple RS (Figure 6D). *Maxilla* mesial lobe with 1 long, straight RS, and 8 plumose RS on gnathal surface; middle lobe with 5 long, curved, pectinate RS; lateral lobe with 3 long, curved, pectinate RS (Figure 6C). *Maxilliped* endite distal surface with 8 plumose setae, and 1 simple RS; distomesial margin with 1 coupling hook; palp article 1 with 1 long, simple RS; article 2 distal apex with 12 long, simple RS; article 3 distal apex with 9 long, simple RS, lateral distal angle with 1 long, simple RS; article 4 distal apex with 9 long, simple RS, lateral distal angle with 1 long, simple RS; article 5 distal apex with 9 long, simple RS (Figure 6G).

Pereopod 1 (Figure 7A) *basis* superior margin without palm setae, inferior distal angle without long, simple setae, inferior medial margin setal patch absent; *ischium*

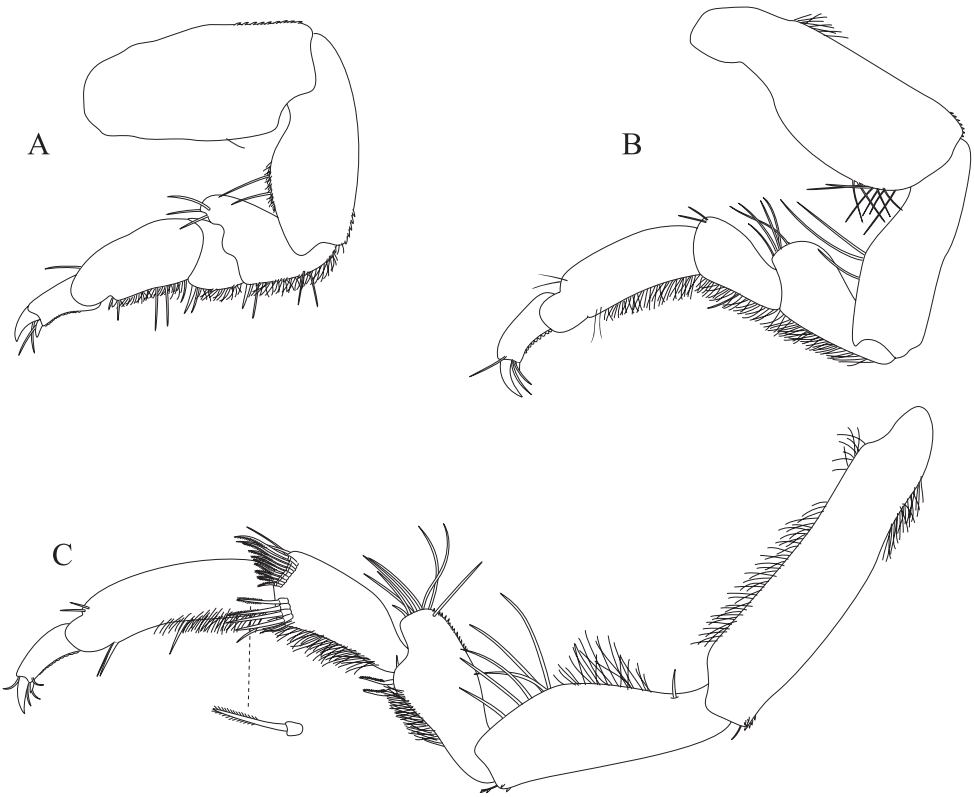

Figure 7. *Exosphaeroma paydenae* sp. n., male holotype USNM 20474. **A** right pereopod 1 **B** right pereopod 3 **C** right pereopod 7.

length 1.9 width, superior margin with 2 long, simple setae, inferior distal angle without long, simple setae; *merus* 0.58 ischium length, superior distal angle with 3 long, simple setae; *carpus* inferior distal angle with 2 long, simple setae; *propodus* length 2.1 width, 0.83 ischium length, superior distal angle with 1 long, simple seta, inferior margin with 3 long, simple setae; *dactylus* length 1.1 width, length 0.3 propodus length, inferior margin covered with fine scales, distal margin with 2 simple setae (Figure 7A). *Pereopod 3* (Figure 7B) *basis* superior margin without palm setae, inferior proximal margin with setal patch present; *ischium* length 2.6 width, superior margin with 3 long, simple RS, inferior distal angle with long, simple RS absent, and with setal patch absent; *merus* weakly lobate, length 1.4 width, 0.53 ischium length, superior distal angle with a cluster of 5 long, simple RS, inferior margin covered in setal mat; *carpus* length 0.88 merus length, 1.5 width, superior margin with 2 long, simple setae on distal angle, inferior margin with setal mat, and 1 long, simple seta; *propodus* weakly curved, length 2.9 width, 1.7 carpus length, superior distal margin without palm setae, inferior margin covered in setal mat; *dactylus* length 1.6 width, length 0.33 propodus length, inferior margin first 0.75 covered with scales, distal margin with 3 long, simple

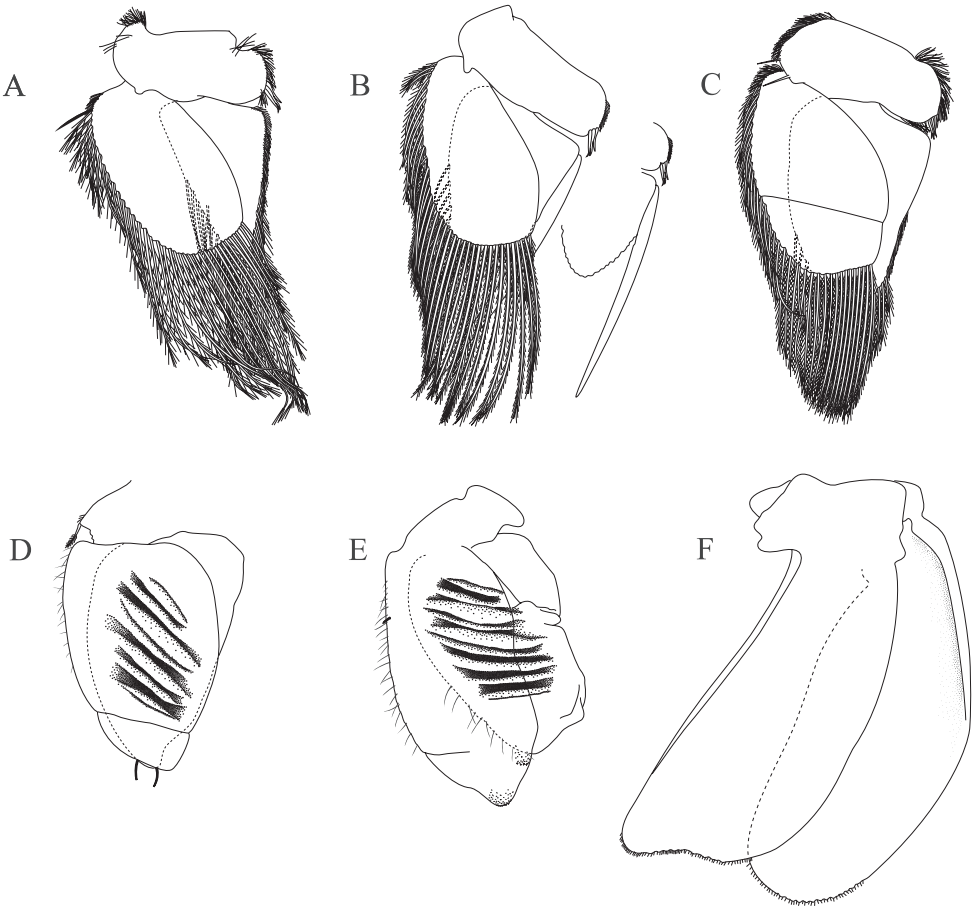

Figure 8. *Exosphaeroma paydenae* sp. n., male holotype USNM 20474. **A–E** right pleopods 1–5, respectively **F** right uropod.

setae (Figure 7B). *Pereopod 7* (Figure 7C) *basis* superior margin with palm setae absent, inferior proximal margin with setal patch, inferior distal angle with long, simple setae absent; *ischium* length 2.6 width, superior margin with 7 long, simple RS; *merus* lobate, merus length 1.6 width, merus length 0.56 ischium length, superior distal angle with 9 RS, inferior margin with setal mat, inferior distal angle with 2 biserrate setae; *carpus* length 1.8 width, carpus length 0.96 merus length, inferior margin with setal mat, superior distal angle with a cluster of 9 long, biserrate setae, superior distal angle with a cluster of 2 long, simple, RS, inferior distal angle with a cluster of 4 long, biserrate setae, inferior distal angle with 1 long, simple RS; *propodus* weakly curved, length 3.9 width, length 1.8 carpus length, inferior margin first 0.75 with setal mat, inferior distal margin with 2 long, simple setae, and with palm setae absent; *dactylus* length 2.0 width, dactylus length 0.26 propodus length, inferior margin with fine scales, distal margin with 4 simple setae (Figure 7C).

Penial process length 3.2 basal width (Figure 22C, D).

Pleopod 1 peduncle length 0.46 width, with a cluster of 3 coupling hooks; endopod mesial margin entirely covered with fine, simple setae; exopod length 1.7 width, ventral surface without fine, simple setae (Figure 8A). *Pleopod 2 appendix masculina* straight, distally narrowing, distal apex acute, length 16.0 basal width (Figure 8B). *Pleopod 3* peduncle with a cluster of 3 coupling hooks, distolateral angle with 2 long, simple setae (Figure 8C). *Pleopod 4* peduncle distolateral angle with 1 long, palm seta; endopod distal apex without plumose setae; exopod distal margin with 2 simple setae (Figure 8D). *Pleopod 5* exopod proximolateral margin with palm setae absent; exopod with transverse suture starting laterally moving mesially, incomplete; exopod with 2 scale patches (Figure 8E). *Uropod* exopod length 2.5 width; rolled proximolateral margin weakening moving toward lateral, medial margin; mesial margin without setae; endopod length 2.8 width, extends past exopod, mesial margin without setae (Figures 8F; 22A, B, D).

Description of female. *Body* length 2.2 width; pereonites 1–7 without tubercles, pereonite 7 distomesial margin weakly convex (Figure 22E, F). *Pleon* with 1 posterior weak tubercle on either side of longitudinal axis (Figure 22E, F). *Pleotelson* length 1.8 width, dorsal surface with 2 tubercles on either side of longitudinal axis; posterior margin of pleotelson acuminate (Figure 22E, F). *Uropod* exopod proximolateral margin rolled weakly; endopod posterior margin tapering to an evenly rounded tip, length 2.9 width, extends past exopod (Figure 22E, F).

Size. Largest ♂ 8.0 mm, largest ♀ 8.6 mm.

Color. Without chromatophores. Preserved specimen pale cream.

Remarks. *Exosphaeroma paydenae* sp. n., unlike other *Exosphaeroma* sp. in this 'species flock', lacks strong sexual dimorphism. Males have overall larger pleotelson and uropods than females. *E. paydenae* sp. n. is morphologically most similar to *Exosphaeroma russellhansoni* sp. n. *E. paydenae* sp. n. can be identified by: pereonites 1–7 without tubercles; pleon with one anterior weak tubercle on either side of longitudinal axis, one posterior weak tubercle on either side of longitudinal axis; pleotelson dorsal surface without ornamentation (Figures 5A, B; 22A, B).

Exosphaeroma russellhansoni sp. n., in contrast to *E. paydenae* has only one weak tubercle on either side of longitudinal axis of its pleon; pleotelson dorsum, with 2 small anterior tubercles (Figures 9A, B; 23A, D). Weak pereon tubercles are visible only with SEM and not necessarily evident with light microscopy. Tubercles visible with light microscopy are figured in the line drawings (compare Figures 5 and 22).

Kussakin (1979) provided new figures for what he considered to be specimens of *E. amplicauda* from Alaska. In his description he wrote "one sample (three specimens) from Alaska was examined from the collections of the Zoological Institute, Academy of Sciences of the USSR." We here recognize the Alaska specimens as *E. paydenae* sp. n., which does not overlap in occurrence with species from further south, all described herein.

Distribution. Alaska, Aleutians.

Etymology. This species is named to honor LACM Trustee and long supporter of science at the Natural History Museum of Los Angeles County, Joan Payden. She

is thanked for her gracious philanthropy which in part supported ARW as an undergraduate student researcher. ARW's research experience describing and redescribing the *Exosphaeroma* along our coast piqued his interest in marine isopods and launched his career in Crustacea at the LACM.

Exosphaeroma russellhansoni sp. n.

http://zoobank.org/9A4E9501-0543-4615-B473-03F54F2C632A
Figures 9–12, 23, 28

Material examined. HOLOTYPE: ♂ (7.0 mm): Washington, Puget Sound, Seattle, Puget Sound Naval Supply Depot, Smith Cove, ~47.5°N, ~122.2°W, under rocks in sand, 11 Aug 1973. A.0030, coll. E.W. Iverson. RW04.010.1, LACM CR-2014.6.

PARATYPES: Allotype gravid ♀ (6.7 mm): same data as holotype, LACM CR-2014.6. 1 ♂ dissected, appendages figured (RW04.010.3), 1 ♂ (RW04.010.4, LACM CR-2014.6.4) and 2 ♀ (6.7 mm RW04.010.5, LACM CR-2014.6.5) prepared as SEM, plus ~70 additional specimens (all life stages RW04.010.6): same locality as RW04.010, LACM CR-2014.6. 3 ♀ (7.2 mm), 1 subadult ♂: south end of San Juan Island, Cattle Point, 48.451°N, 122.967°W, rocky intertidal barnacles from *Semibalanus cariosus*, fixed and preserved in 95% ethanol, 7 Apr 2004, coll. R. Wetzer & N.D. Pentcheff. RW04.036.1, LACM CR-2014.7. 1 ♂ (7.9 mm), 1 subadult intermolt: northeast of San Juan Island, Reuben Tarte County Park, 48.612°N, 123.098°W, scrapings of vertical rock surface in intertidal, fixed and preserved in 95% ethanol, 9 Apr 2004, coll. R. Wetzer & N.D. Pentcheff. RW04.041.1, LACM CR-2014.8. 6 ♂ (8.3 mm), 4 ♀ (8.7 mm), 2 ♂ dissected for mandibles and figured: San Juan Island, old man's farm, ~48.6°N, ~122.9°W, under rocks, 30 Jul 1950. USNM Acc. No. 187867, coll. L. Peternick and P. Illg. USNM 1251666. 3 ♂, 1 gravid ♀, 1 subadult: San Juan Islands, False Bay, 1 Aug 1975, transferred to 95% ethanol 5 Oct 2012, coll. R.R. Hessler. RW12.215.1, LACM CR-2014.9.

Description of male. *Body* length 1.6 width; pereonite 5–6 each without ornamentation, pereonite 7 with weak median process (Figures 9A, B; 23A, D). *Pleon* with 1 medium tubercle on either side of longitudinal axis (Figures 9A, B; 23A, D). *Pleotelson* length 0.65 width, dorsal surface with 2 small anterior tubercles; ventrolateral ridge entire, with long setae (Figures 9A, B; 23A, C, D).

Antennula peduncle article 1 length 1.2 width, anterior medial margin with 1 palm seta; article 2 length 1.2 width, inferior distal margin with 3 palm setae; article 3 length 2.9 width; flagellum with 9 articles (Figure 10B). *Antenna* reaching medium margin of pereonite 2, peduncle article 1 with numerous fine simple setae on anterior posterior margin; flagellum with 13 articles (Figure 10A).

Left mandible incisor with 3 cusps; lacinia mobilis with 2 cusps; lacinia mobilis spine row comprised of 6 curved, serrate spines; crushing surfaces strongly ridged, with 2 serrate spines (Figure 10E). *Maxillula* mesial lobe with 4 circumplumose RS; lateral

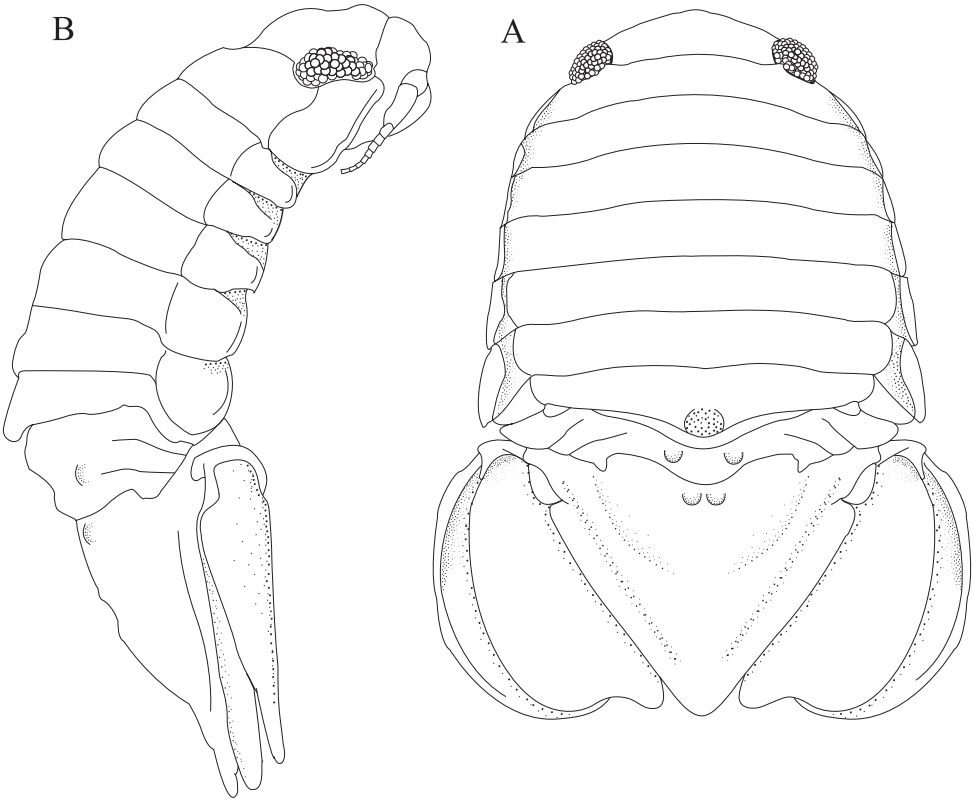

Figure 9. *Exosphaeroma russellhansoni* sp. n. male holotype LACM CR-2014.6. **A** dorsal **B** lateral.

lobe with 9 long, curved, pectinate RS (Figure 10F). *Maxilla* mesial lobe with 6 plumose RS on gnathal surface; middle lobe with 4 long, curved, pectinate RS; lateral lobe with 4 long, curved, pectinate RS (Figure 10D). *Maxilliped* endite distal surface with 11 plumose setae; distomesial margin 2 coupling hooks, and 2 large stout plumose setae, and 1 large simple RS; palp article 2 distal apex with 15 long, simple RS; article 3 distal apex with 17 long, simple RS, lateral distal angle with 1 long, simple RS; article 4 distal apex with 8 long, simple RS, lateral distal angle with 1 long, simple RS; article 5 distal apex with 9 long, simple RS (Figure 10C).

Pereopod 1 (Figure 11A) *basis* superior margin with 1 palm seta, inferior distal angle with 1 long, simple seta, inferior medial margin setal patch present; *ischium* length 1.9 width, superior margin with 3 long, simple setae, inferior distal angle with 1 long, simple seta; *merus* 0.45 ischium length, superior distal angle with 3 long, simple setae; *carpus* inferior distal angle with 1 long, simple seta; *propodus* length 2.3 width, 0.93 ischium length, superior distal angle without long, simple setae, inferior margin with 1 long, simple seta; *dactylus* length 1.5 width, length 0.46 propodus length, inferior margin covered with scales, distal margin with 3 simple setae (Figure 11A). *Pereopod 3* (Figure 11B) *basis* superior margin with 1 palm seta, inferior distal angle with 1

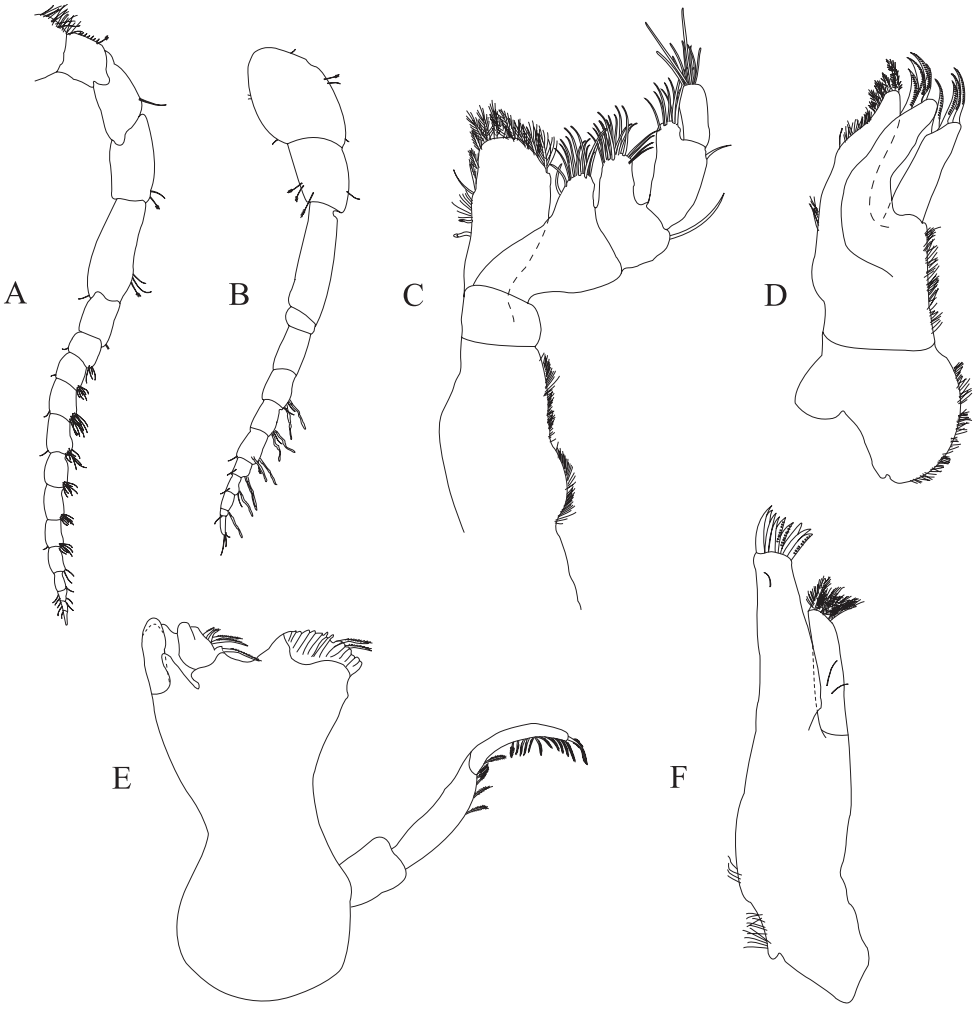

Figure 10. *Exosphaeroma russellhansoni* sp. n., male paratype LACM CR-2014.6. Male paratype RW04.010.3 **A** right antenna **B** right antennula, basal article broken **C** left maxilliped **D** left maxilla **E** male paratype left mandible **F** right maxillula.

long simple seta, inferior proximal margin with setal patch absent; *ischium* length 2.4 width, superior margin with 5 long, simple RS, inferior distal angle with 1 simple RS, and with setal patch absent; *merus* lobate, length 0.95 width, 0.4 ischium length, superior distal angle with a cluster of 5 simple RS, inferior margin covered in setal mat; *carpus* length 1.3 merus length, 1.4 width, superior margin with 1 long, simple seta on distal angle, inferior margin with setal mat, and long, simple setae absent; *propodus* weakly curved, length 2.6 width, 1.7 carpus length, superior distal margin with 1 palm seta, inferior margin first 0.67 covered in setal mat; *dactylus* length 1.2 width, length 0.33 propodus length, inferior margin proximal half with scales, distal

Figure 11. *Exosphaeroma russellhansoni* sp. n., male holotype LACM CR-2014.6. **A** left pereopod 1 **B** left pereopod 3 **C** left pereopod 7.

margin with 3 long, simple setae (Figure 11B). *Pereopod 7* (Figure 11C) *basis* superior margin with palm setae absent, inferior proximal margin with setal patch absent, inferior distal angle with 1 long, simple seta present; *ischium* length 3.0 width, superior margin with 10 long, simple RS; *merus* lobate, merus length 1.7 width, merus length 0.53 ischium length, superior distal angle with 9 RS, inferior margin with setal mat, inferior distal angle with biserrate setae absent; *carpus* length 2.5 width, carpus length 1.3 merus length, inferior margin with setal mat, superior distal angle with a cluster of 7 long, biserrate setae, superior distal angle with a cluster of 3 long, simple, RS, inferior distal angle with a cluster of 5 long, biserrate setae, inferior distal angle with 1 long, simple RS; *propodus* weakly curved, length 4.0 width, length 1.2 carpus length, inferior margin with setal mat absent, superior distal angle with 2 long, simple setae, inferior distal margin with 3 long, simple setae, and with palm setae absent; *dactylus* length 1.6 width, dactylus length 0.24 propodus length, inferior margin with scales, distal margin with 2 simple setae (Figure 11C).

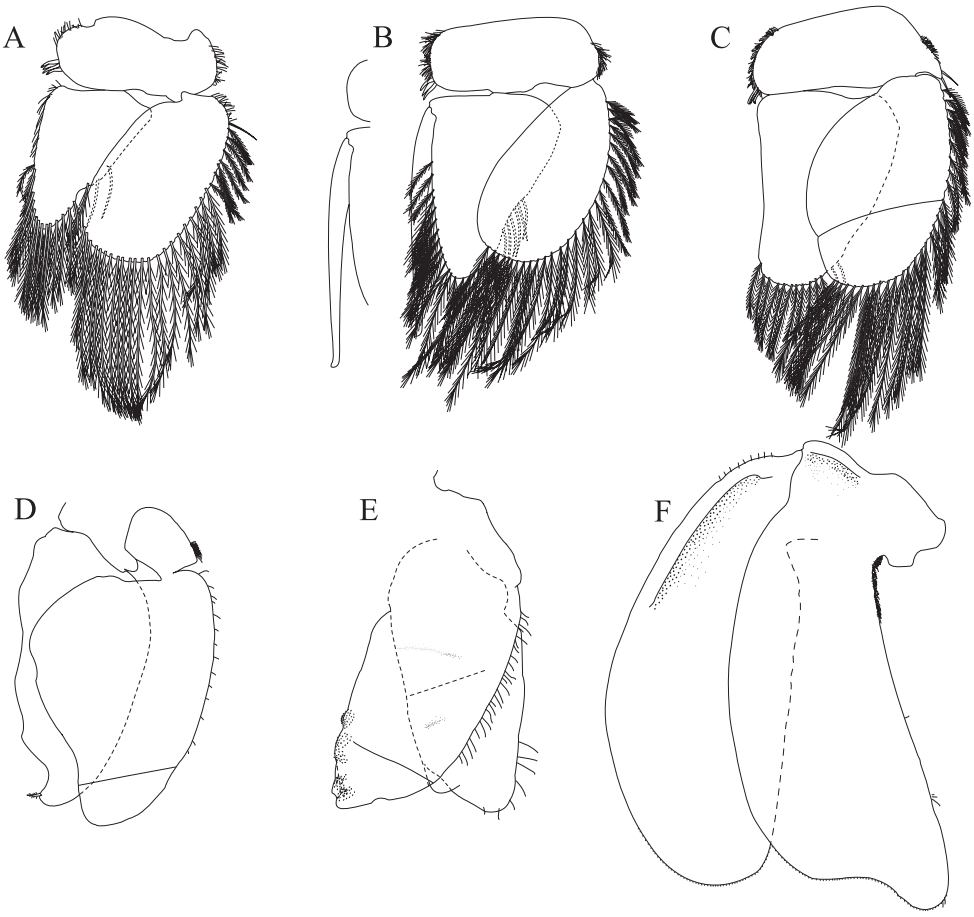

Figure 12. *Exosphaeroma russellhansoni* sp. n., male paratype LACM CR-2014.6. **A–E** left pleopods 1–5, respectively **F** left uropod.

Penial process length 2.7 basal width (Figure 23B).

Pleopod 1 peduncle length 0.41 width, with a cluster of 4 coupling hooks; endopod mesial margin lightly covered in fine, simple setae; exopod length 1.8 width, ventral surface without fine, simple setae (Figure 12A). *Pleopod 2 appendix masculina* proximally swollen, distally narrowing, distal end curving mesially, apex weakly hooked mesially, length 11.4 basal width (Figure 12B). *Pleopod 3* peduncle with a cluster of 3 coupling hooks, distolateral angle with 2 long, simple setae (Figure 12C). *Pleopod 4* peduncle distolateral angle with fine setal patch; endopod distal apex 1 large, plumose seta; exopod distal margin without setae (Figure 12D). *Pleopod 5* exopod proximolateral margin with palm setae absent; exopod with distal transverse suture starting laterally, incomplete; exopod with 4 scale patches (Figure 12E). *Uropod* exopod length 2.4 width; rolled proximolateral margin weakening moving toward lateral, medial margin; mesial margin without setae; endopod length 2.7 width, extends past exopod, mesial proximal margin with setal patch (Figures 12F; 23A, C, D).

Description of female. *Body* length 2.7 width; pereonites 1–7 without tubercles, pereonite 7 distomesial margin convex (Figure 23E, F). *Pleon* with 1 weak posterior tubercle on either side of longitudinal axis (Figure 23E, F). *Pleotelson* length 0.75 width, dorsum without tubercles; posterior margin of pleotelson acuminate (Figure 23E, F). *Uropod* exopod proximolateral margin rolled weakly; endopod length 3.7 width, extends past exopod (Figure 23E, F).

Size. Largest ♂ 8.3 mm, largest ♀ 8.7 mm.

Color. Without chromatophores. Preserved specimen pale buff, whitish.

Remarks. *E. russellhansoni* sp. n. is morphologically most similar to *E.amplicauda* but can be easily distinguished by: pereonite 5–6 each without ornamentation, pereonite 7 with weak median process (Figures 9A, B; 23A, D). Appendix masculina distal end curving mesially, apex weakly hooked mesially, length 11.4 basal width (Figure 12B).

E. amplicauda is distinguished by: pereonites 5 and 6 with one weak median tubercle, and one weak lateral tubercle; pereonite 7 with weak median process and paired lateral tubercles (Figures 1A, B; 21A, D). Appendix masculina distal end curving mesially, straightening at distal tip, length 15.4 basal width (Figure 4B). *E. russellhansoni* sp. n. is strongly sexually dimorphic; females lacking dorsal tubercles on pereonites 1–7. Weak pereon tubercles are visible only with SEM, but not necessarily evident with light microscopy, and therefore are omitted from line drawings (compare Figures 9 and 23).

Distribution. Washington, Puget Sound and San Juan Island.

Etymology. Named to honor Russell Kenneth Hanson, ARW's only maternal uncle who has shaped the person Adam is today by so graciously sharing with Adam his insatiable curiosity, life-long pursuit of perfection and tireless work ethic.

***Exosphaeroma pentcheffi* sp. n.**

http://zoobank.org/82947847-B852-4628-AE6E-66DDCEEDCEDF

Figures 13–16, 24, 28

Material examined. HOLOTYPE ♂ (4.6 mm): California, Los Angeles County, Palos Verdes Peninsula, Pt. Fermin, shore at Paseo del Mar, ~0.5 mi. W of Gaffey Street, 33.71°N, 118.3°W, mid-low intertidal, chipping overhanging rock with hammer and *Phragmatopoma* tubes on underside of rock, 0.99 m depth, fixed and preserved in 95% ethanol, 27 Mar 2004, coll. R. Wetzer, N.D. Pentcheff, and LMU students. RW04.030.1, LACM CR-2014.10.

PARATYPES: Allotype ♀ (4.6 mm) (whole animal figured): shore at Paseo del Mar, ~0.5 mi. W of Gaffey Street, 33.71°N, 118.3°W, mostly barnacles, some algal turf, medium to high intertidal, paint scraper, fixed and preserved in 95% ethanol, 16 Feb 2004, coll. R. Wetzer. RW04.002.1, LACM CR-2014.11. 1 ♂ accidently destroyed after being imaged (RW04.255, LACM CR-2014.12), 1 ♂, 3 ♀ (RW04.030.2), plus 1 ♀ (4.6 mm) prepared as SEM: RW04.030.3, LACM CR-2014.10. 3♀(RW04.002.2), plus 1 ♂ (RW04.002.3) and 1 ♀ (RW04.002.4) prepared for SEM: shore at Paseo del

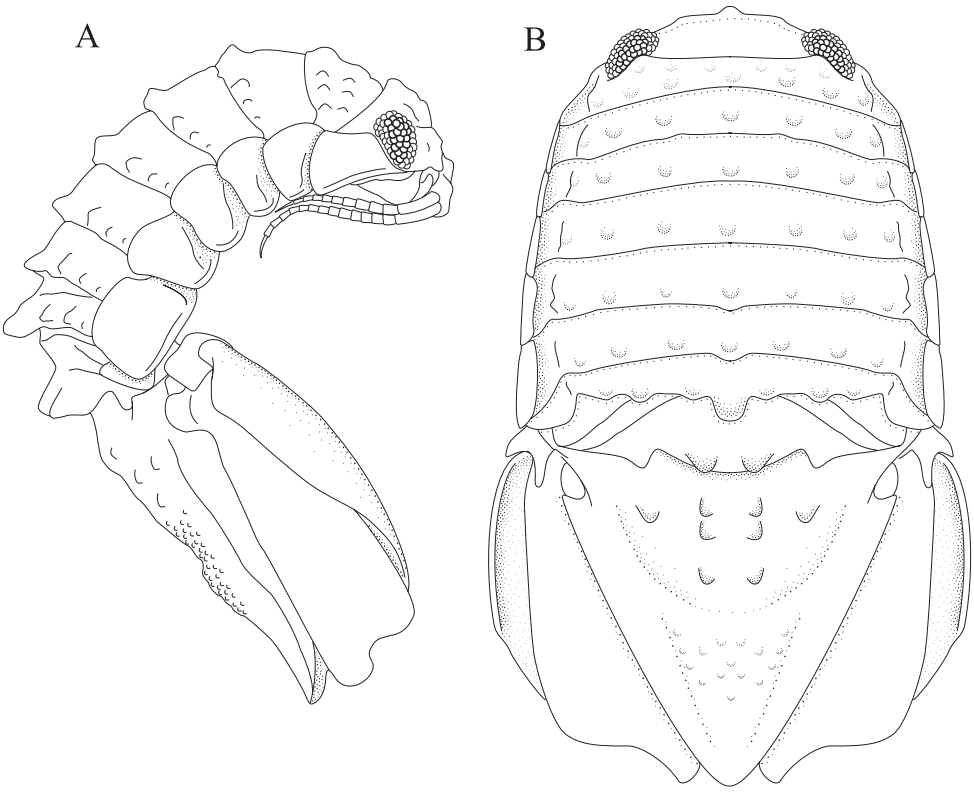

Figure 13. *Exosphaeroma pentcheffi* sp. n., male holotype LACM CR-2014.10. **A** lateral **B** dorsal.

Mar, ~0.5 mi. W of Gaffey Street, 33.71°N, 118.3°W, mostly barnacles, some algal turf, medium to high intertidal, paint scrapper, fixed and preserved in 95% ethanol, 16 Feb 2004, coll. R. Wetzer. RW04.002, LACM CR-2014.11. 1 ♂ (5.1 mm), 2 ♀: shore at Paseo del Mar, ~0.5 mi. W of Gaffey Street, 33.71°N, 118.3°W, found in bottom of bucket with sea stars, mid- to low intertidal, fixed and preserved in 95% ethanol, 16 Feb 2004. Loyola Marymount University Invertebrate Class, N.D. Pentcheff, coll. E. Pattison and K. Stanley. RW04.003.1, LACM CR-2014.13.

Description of male. *Body* length 1.8 width; pereonites 5–6 each with 7 longitudinal rows of strong tubercles, pereonite 7 with strong median process with 3 lateral tubercles (Figures 13A, B; 24A, D). *Pleon* with 1 medium tubercle on posterior margin, on either side of longitudinal axis (Figures 13A, B; 24A, D). *Pleotelson* length 0.85 width, dorsal surface with 3 strong medial tubercles on either side of the longitudinal axis, with 1 strong medial tubercle between the longitudinal axis and lateral margin, pleotelson covered with numerous, additional, small tubercles; ventrolateral ridge extending posteriorly 0.80 of total length, with long setae (Figures 13A, B; 24A, C, D).

Antennula peduncle article 1 length 1.4 width, anterior medial margin with 2 palm setae; article 2 length 1.1 width, inferior distal margin with 3 palm setae; article 3 length 3.1 width; flagellum with 9 articles (Figure 14B). *Antenna* reaching anterior

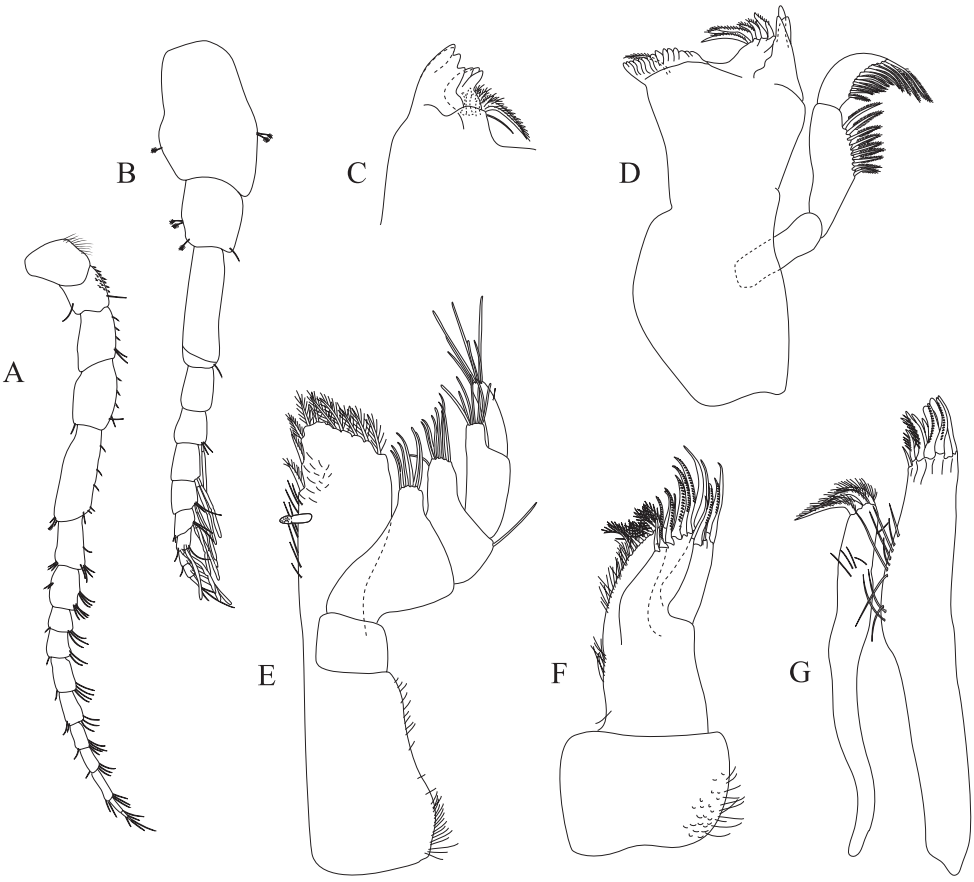

Figure 14. *Exosphaeroma pentcheffi* sp. n., male holotype LACM CR-2014.10. **A** left antenna **B** left antennula **C** left mandible **D** right mandible **E** left maxilliped **F** left maxilla **G** left maxillula.

margin of pereonite 2, peduncle article 1 with fine, simple setae on superior margin; flagellum with 11 articles (Figure 14A).

Left mandible incisor with 4 cusps; lacinia mobilis with 3 cusps; lacinia mobilis spine row comprised of 8 curved, serrate spines, and 1 curved, robust, simple spine (Figure 14C). *Right mandible* incisor with 3 cusps; spine row comprised of 7 curved, serrate spines; crushing surfaces strongly ridged, with 1 serrate spine (Figure 14D). *Maxillula* mesial lobe with 4 circumplumose RS; lateral lobe with 10 long, curved, pectinate RS, gnathal surface with 1 curved, simple RS (Figure 14G). *Maxilla* mesial lobe with 1 long, straight RS, and 8 plumose RS on gnathal surface; middle lobe with 8 long, curved, pectinate RS; lateral lobe with 5 long, curved, pectinate RS (Figure 14F). *Maxilliped* endite distal surface with 7 plumose setae, and 3 simple RS; distomesial margin with 1 coupling hook, and 3 large stout plumose setae; palp article 2 distal apex with 6 long, simple RS; article 3 distal apex with 8 long, simple RS, lateral distal angle

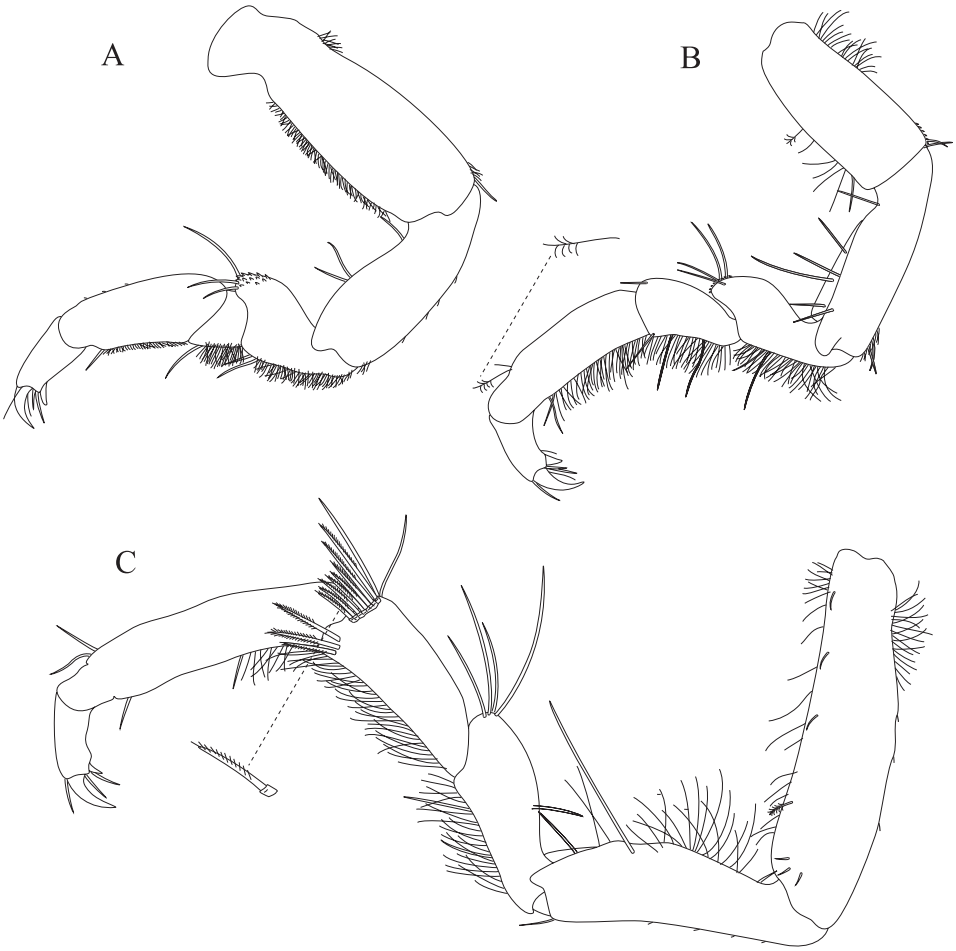

Figure 15. *Exosphaeroma pentcheffi* sp. n., male holotype LACM CR-2014.10. **A** left pereopod 1 **B** left pereopod 3 **C** left pereopod 7.

with 1 long, simple RS; article 4 distal apex with 7 long, simple RS; article 5 distal apex with 7 long, simple RS (Figure 14E).

Pereopod 1 (Figure 15A) *basis* superior margin without palm setae, inferior distal angle with 1 long, simple seta, inferior medial margin setal patch absent; *ischium* length 2.3 width, superior margin with 3 long, simple setae, inferior distal angle without long, simple setae; *merus* 0.50 ischium length, superior distal angle with 3 long, simple setae; *carpus* inferior distal angle with 1 long, simple seta; *propodus* length 2.7 width, 1.0 ischium length, superior distal angle without long, simple setae, inferior margin with 1 long, simple seta; *dactylus* length 1.4 width, length 0.36 propodus length, inferior margin without setal scales, distal margin with 4 simple setae (Figure 15A). *Pereopod 3* (Figure 15B) *basis* superior margin with 1 palm seta, inferior distal angle with 2 long simple setae, inferior proximal margin with setal patch present; *ischium* length

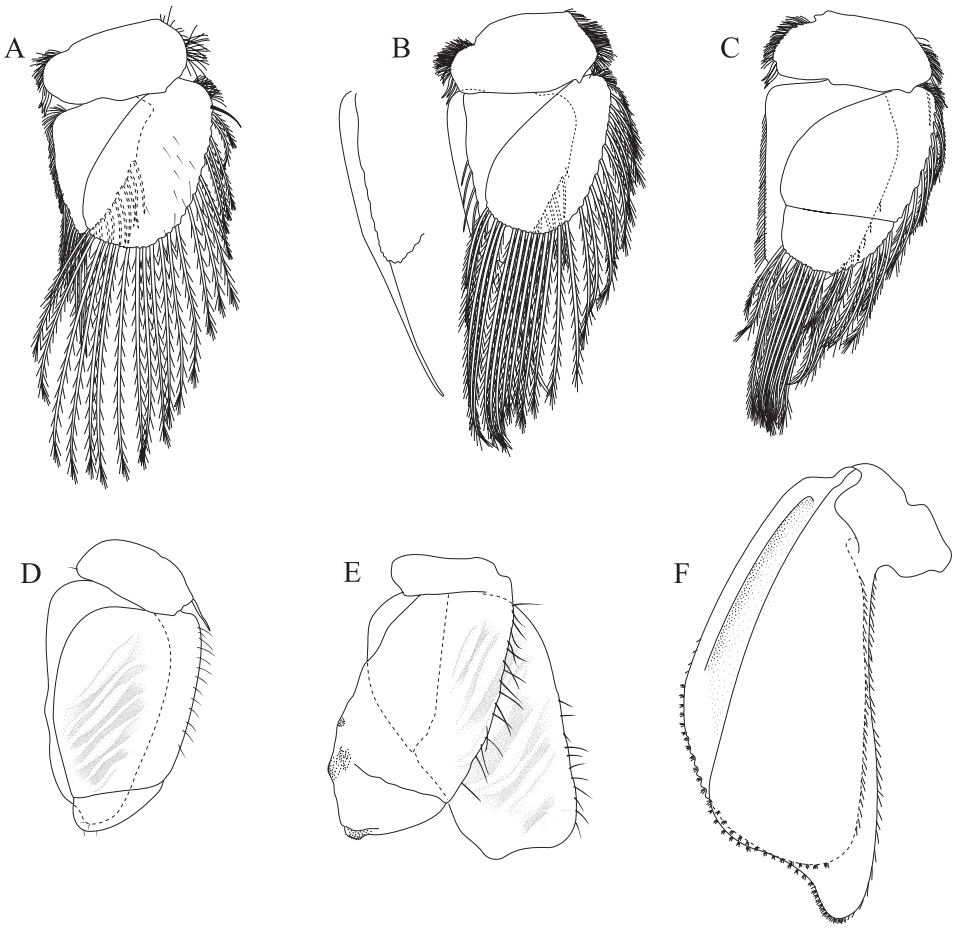

Figure 16. *Exosphaeroma pentcheffi* sp. n., male holotype LACM CR-2014.10. **A–E** left pleopods 1–5, respectively **F** left uropod.

3.1 width, superior margin with 6 long, simple RS, inferior distal angle with 2 long, simple RS, and with setal patch present; *merus* lobate, length 2.2 width, 0.73 ischium length, superior distal angle with 4 long, simple RS, inferior margin covered in setal mat; *carpus* superior margin with 1 long, simple seta on distal angle, inferior margin with setal mat, and 3 long, simple setae; *propodus* weakly curved, length 3.2 width, 1.8 carpus length, superior distal margin with 1 palm seta, inferior margin covered in setal mat; *dactylus* length 1.6 width, length 0.30 propodus length, inferior margin without scales, distal margin with 4 long, simple setae (Figure 15B). *Pereopod 7* (Figure 15C) *basis* superior margin with 1 palm seta, inferior proximal margin with setal patch, inferior distal angle with long, simple setae absent; *ischium* length 2.8 width, superior margin with 2 long, simple RS; *merus* lobate, merus length 2.1 width, merus length 0.63 ischium length, superior distal angle with 4 RS, inferior margin with setal mat, inferior distal angle with biserrate setae absent; *carpus* length 2.3 width, carpus length

1.1 merus length, inferior margin with setal mat, superior distal angle with a cluster of 8 long, biserrate setae, superior distal angle with a cluster of 2 long, simple, RS, inferior distal angle with a cluster of 3 long, biserrate setae; *propodus* weakly, curved, length 5.0 width, length 1.6 carpus length, inferior margin first 0.33 with setal mat, superior distal angle with 2 long, simple setae, inferior margin with 2 long, simple setae, and with palm setae absent; *dactylus* length 1.7 width, dactylus length 0.22 propodus length, inferior margin without fine scales, distal margin with 3 long, simple setae (Figure 15C).

Penial process length 3.0 basal width (Figure 24B).

Pleopod 1 peduncle length 0.56 width, with a cluster of 3 coupling hooks; endopod mesial margin covered in fine, simple setae; exopod length 1.7 width, ventral surface with fine, simple setae (Figure 16A). *Pleopod 2 appendix masculina* distally narrowing to an acute rounded tip, length 15 basal width (Figure 16B). *Pleopod 3* peduncle with a cluster of 3 coupling hooks, distolateral angle with 2 large, simple setae (Figure 16C). *Pleopod 4* peduncle length 0.46 width, distolateral angle with 1 large, simple seta; endopod distal apex without plumose setae; exopod distal margin with 2 simple setae (Figure 16D). *Pleopod 5* exopod proximolateral margin with palm setae absent; exopod with transverse suture starting laterally moving mesially, incomplete; exopod with 4 scale patches (Figure 16E). *Uropod* exopod length 2.4 width; rolled proximolateral margin weakening moving toward lateral, distal margin; mesial margin with evenly spaced fine simple setae; endopod length 2.8 width, extends past exopod, distal apex with short, simple setal patch, dorsal surface covered with numerous small tubercles, mesial margin with evenly spaced fine simple setae (Figures 16F; 24A, C, D).

Description of female. *Body* length 2.3 width; pereonites 2–6 each with 7 longitudinal rows of strong tubercles, pereonite 7 distomesial margin convex with strong median process, and 3 lateral tubercles (Figure 24E, F). *Pleon* with 1 posterior strong tubercle on either side of longitudinal axis (Figure 24E, F). *Pleotelson* length 0.61 width, dorsal surface with 3 strong medial tubercles on either side of the longitudinal axis, with 1 strong medial tubercle between the longitudinal axis and lateral margin, pleotelson covered with numerous, additional, small tubercles (Figure 24E, F). *Uropod* exopod proximolateral margin rolled; endopod length 3.6 width, extends past exopod, dorsal surface covered with numerous small tubercles, mesial margin without setae (Figure 24E, F).

Size. Largest ♂ 6.8 mm, largest ♀ 4.6 mm.

Colour. No chromatophores: preserved specimen pale buff, whitish.

Remarks. *Exosphaeroma pentcheffi* sp. n. unlike the other *Exosphaeroma* species in this 'species flock' lacks strong sexual dimorphism and is unique in that females shares the same dorsal ornamentation as males; males differ from females in having slightly stronger tubercles, longer pleotelson and longer uropods. Females of *E. pentcheffi* sp. n. are the only females of this 'species flock' that can reliably be identified at the species level. *E. pentcheffi* sp. n. males can be identified by: pereonites 5 and 6 having 7 longitudinal rows of strong tubercles, pereonite 7 with a strong median process with

3 lateral tubercles; pleotelson dorsum with 3 strong medial tubercles on either side of the longitudinal axis, with 1 strong medial tubercle between the longitudinal axis and lateral margin, pleotelson covered with numerous, additional, small tubercles (Figures 13A, B; 24A, D, E, F). Weak pereon tubercles are visible only with SEM and not necessarily evident with light microscopy. Tubercles visible with light microscopy are figured in the line drawings (compare Figures 13 and 24).

Distribution. California, Los Angeles County, Palos Verdes Peninsula.

Etymology. This beautiful species is named for N. Dean Pentcheff, expert isopod collector, superb field and dive buddy, travel companion and IT support par excellence. Dean is commended for his reliable patience, support and solid friendship.

Exosphaeroma aphrodita Boone, 1923

Figures 17–20, 25, 28

Exosphaeroma aphrodita Boone, 1923. – Bruce 2003: 369. – Espinosa and Hendrickx 2006: 238. – Brusca et al. 2007: 537. – Bruce and Schotte 2012: online.

Material examined. LECTOTYPE, here designated: 1 ♂ USNM 1251667 with mandibles dissected: California, San Diego County, La Jolla, Scripps Institute pier pilings, 6 Nov 1915. USNM Acc. No. 53848, #1045-1-4. Identified as *Exosphaeroma amplicauda* by P.L. Boone.

PARALECTOTYPES: 5 ♂ (USNM 1251667), with mandibles dissected. USNM 53848.

Non-type Material: 1 ♂: Scripps, ~32.87°N, ~117.26°W, littoral in algae, March 1938, coll. Olga Hartman and Loyola e Silva. USNM 1251668. 1 ♂ (RW01.002.1), 1 ♂, 3 ♀, (RW01.002.2) plus 1 ♂ (RW01.002.3) and 3 ♀ (RW01.002.4) prepared as SEM: Scripps Institute of Oceanography, beneath seaward end of Scripps Pier, ~32.87°N, ~117.26°W, to 8 m, among detritus at base of pilings, water temp. 59 °F, SCUBA, fixed and preserved in 95%, 7 Jan 2001, coll. T. Haney. RW01.002, LACM CR-2014.14. 1 ♂ (broken): San Diego, pilings, 1 Jul 1996. USNM Acc. No. 180084, Sta. No. 256. USNM 1251669.

Description of male. *Body* length 2.0 width; pereonites 5 without ornamentation, pereonite 6 with 1 lateral weak tubercle, pereonite 7 with weak median process, and paired weak lateral tubercles (Figures 17A, B; 25A, C). *Pleon* with 1 medium tubercle on either side of longitudinal axis (Figures 17A, B; 25A, C). *Pleotelson* length 0.89 width, dorsal surface with 1 anterior median strong tubercle and 2 weak medial tubercles; ventrolateral ridge extending posteriorly 0.75 of total length, with long setae (Figures 17A, B; 25A, B, C).

Antennula peduncle article 1 length 1.5 width, anterior medial margin with palm setae absent; article 2 length 1.3 width, inferior distal margin with 1 palm seta; article 3 length 2.9 width; flagellum with 8 articles (Figure 18B). *Antenna* reaching posterior

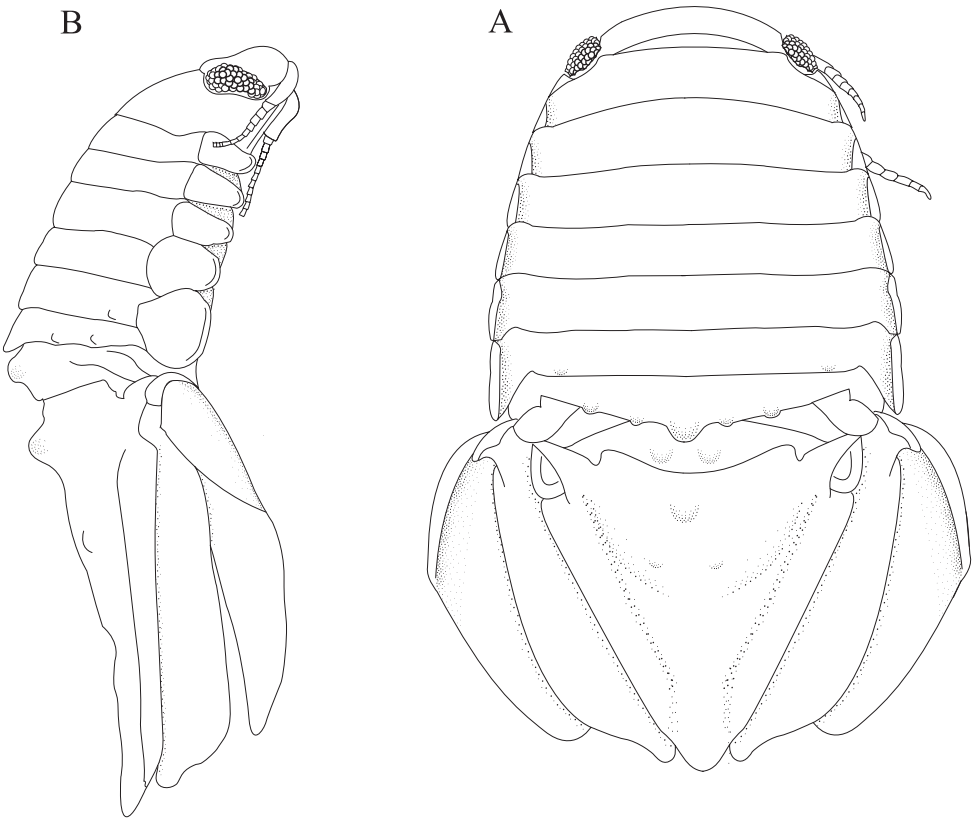

Figure 17. *Exosphaeroma aphrodita* male lectotype LACM CR-2014.14. **A** dorsal **B** lateral.

margin of pereonite 3, peduncle article 1 superior margin without palm setae; flagellum with 12 articles (Figure 18A).

Left mandible incisor with 2 cusps; lacinia mobilis with 2 cusps; lacinia mobilis spine row comprised of 6 curved, serrate spines (Figure 18C). *Right mandible* incisor with 4 cusps; spine row comprised of 5 curved, serrate spines; crushing surfaces strongly ridged (Figure 18D). *Maxillula* mesial lobe with 5 circumplumose RS; lateral lobe with 6 long, curved, pectinate RS (Figure 18F). *Maxilla* mesial lobe with 3 long, curved RS, and 6 plumose RS on gnathal surface; middle lobe with 8 long, curved, pectinate RS; and 7 long, curved RS; lateral lobe with 3 long, curved, pectinate RS (Figure 18G). *Maxilliped* endite distal surface with 2 plumose setae; distomesial margin with 1 coupling hook; palp article 2 distal apex with 1 long, simple RS; article 3 distal apex with 3 long, simple RS, lateral distal angle with 1 long, simple RS; article 4 distal apex with 3 long, simple RS, lateral distal angle with 1 long, simple RS; article 5 distal apex with 3 long, simple RS (Figure 18E).

Pereopod 1 (Figure 19A) *basis* superior margin with 1 palm seta, inferior distal angle with 1 long, simple seta, inferior medial margin setal patch absent; *ischium*

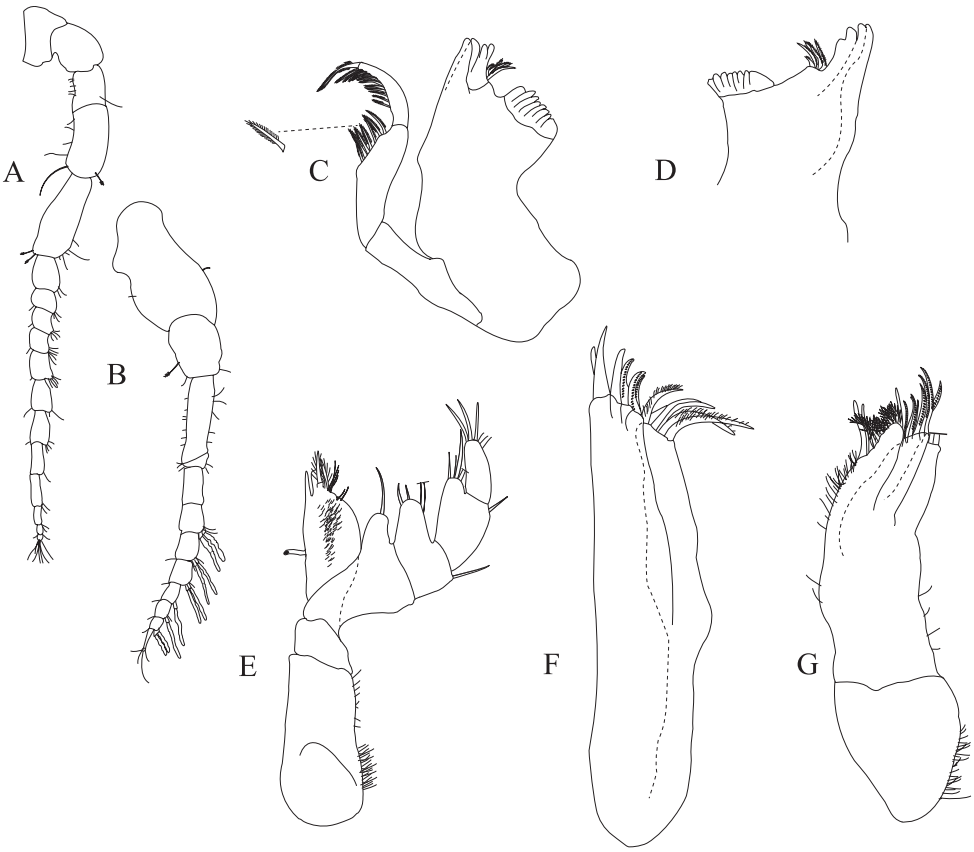

Figure 18. *Exosphaeroma aphrodita* male lectotype LACM CR-2014.14. **A** left anntenna **B** left antennula **C** left mandible **D** right mandible **E** left maxilliped **F** left maxillula **G** left maxilla.

length 2.3 width, superior margin with 3 long, simple setae, inferior distal angle without long, simple setae; *merus* 0.40 ischium length, superior distal angle with 3 long, simple setae; *carpus* inferior distal angle with 1 long, simple seta; *propodus* length 2.1 width, 0.60 ischium length, superior distal angle with 1 long, simple seta, inferior margin with 3 long, simple setae; *dactylus* length 1.5 width, length 0.55 propodus length, inferior margin distal 0.67 covered with scales, distal margin with 2 simple setae (Figure 19A). *Pereopod 3* (Figure 19B) *basis* superior margin without palm setae, inferior distal angle with 1 long simple seta, inferior proximal margin with setal patch absent; *ischium* length 3.2 width, superior margin with 3 long, simple RS, inferior distal angle with 1 simple RS, and with setal patch absent; *merus* lobate, length 1.4 width, 0.56 ischium length, superior distal angle with a cluster of 3 RS, inferior margin covered in setal mat; *carpus* length 0.90 merus length, 1.9 width, superior margin with 1 long, simple seta on distal angle, inferior margin with setal mat, and 1 long, simple seta; *propodus* weakly curved, length 3.2 width, 2.0 carpus

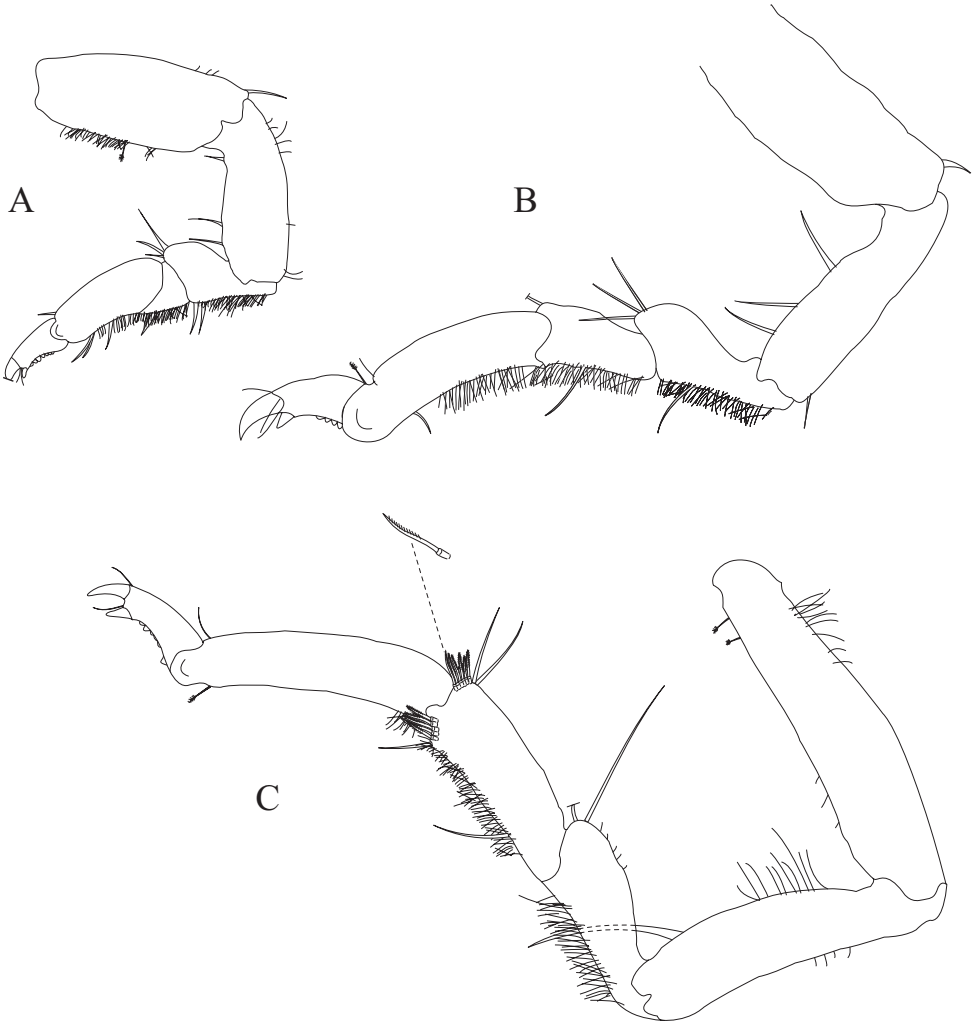

Figure 19. *Exosphaeroma aphrodita* male lectotype LACM CR-2014.14. **A** left pereopod 1 **B** left pereopod 3 **C** left pereopod 7.

length, superior distal margin with 1 palm seta, inferior margin first 0.67 covered in setal mat; *dactylus* length 1.3 width, length 0.45 propodus length, inferior margin with scales, distal margin with 3 long, simple setae (Figure 19B). *Pereopod 7* (Figure 19C) *basis* superior margin with 2 palm setae, inferior proximal margin with setal patch, inferior distal angle with long, simple setae absent; *ischium* length 3.7 width, superior margin with 1 long, simple RS; *merus* weakly lobate, merus length 2.0 width, merus length 0.65 ischium length, superior distal angle with 2 RS, inferior margin with setal mat, inferior distal angle with biserrate setae absent; *carpus* length 2.9 width, carpus length 1.1 merus length, inferior margin with setal mat, superior

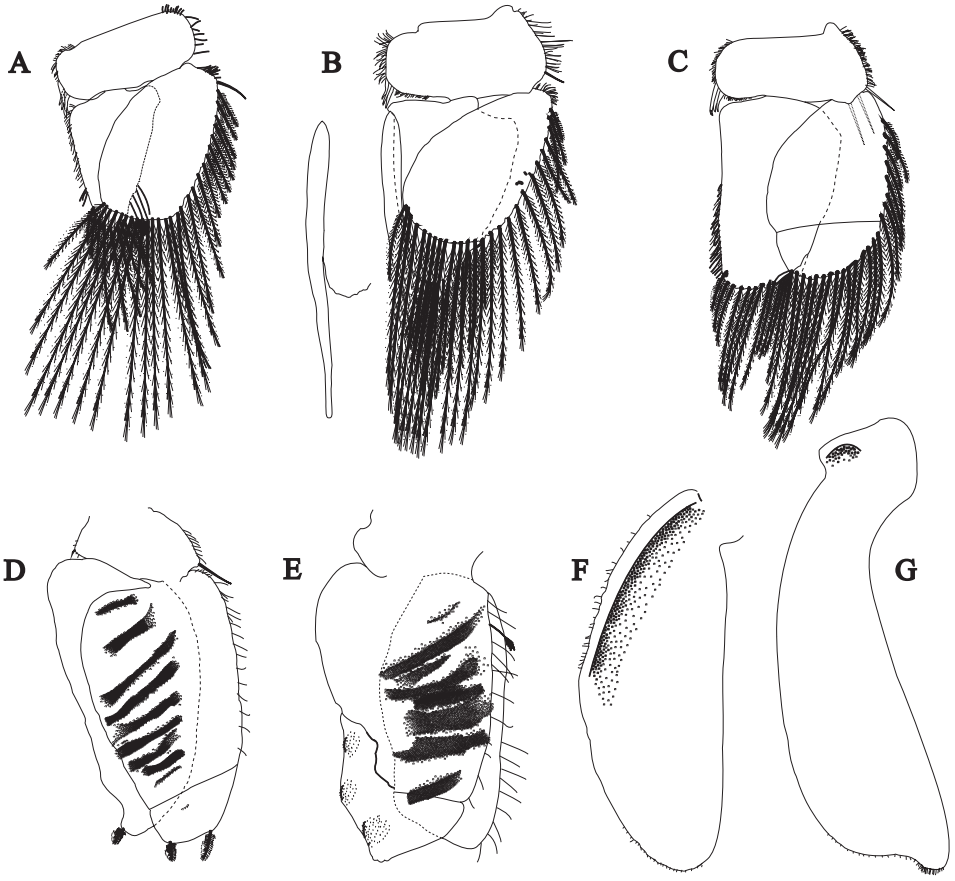

Figure 20. *Exosphaeroma aphrodita* male lectotype LACM CR-2014.14. **A–E** left pleopods 1–5, respectively **F** left uropod exopod **G** left uropod endopod.

distal angle with a cluster of 6 long, biserrate setae, superior distal angle with a cluster of 2 long, simple, RS, inferior distal angle with a cluster of 5 long, biserrate setae, inferior distal angle with 1 long, simple RS; *propodus* weakly curved, length 4.2 width, length 1.3 carpus length, inferior margin with setal patch, superior distal angle with 1 long, simple seta, inferior distal margin with simple, setae absent, and with 1 palm seta; *dactylus* length 2.0 width, dactylus length 0.27 propodus length, inferior margin with scales starting medially moving distally, distal margin with 2 simple setae (Figure 19C).

Penial process length 3.1 basal width (Figure 25B, D).

Pleopod 1 peduncle length 0.42 width, with a cluster of 4 coupling hooks; endopod mesial margin lightly covered in fine, simple setae; exopod length 1.6 width, ventral surface without fine, simple setae (Figure 20A). *Pleopod 2 appendix mas-*

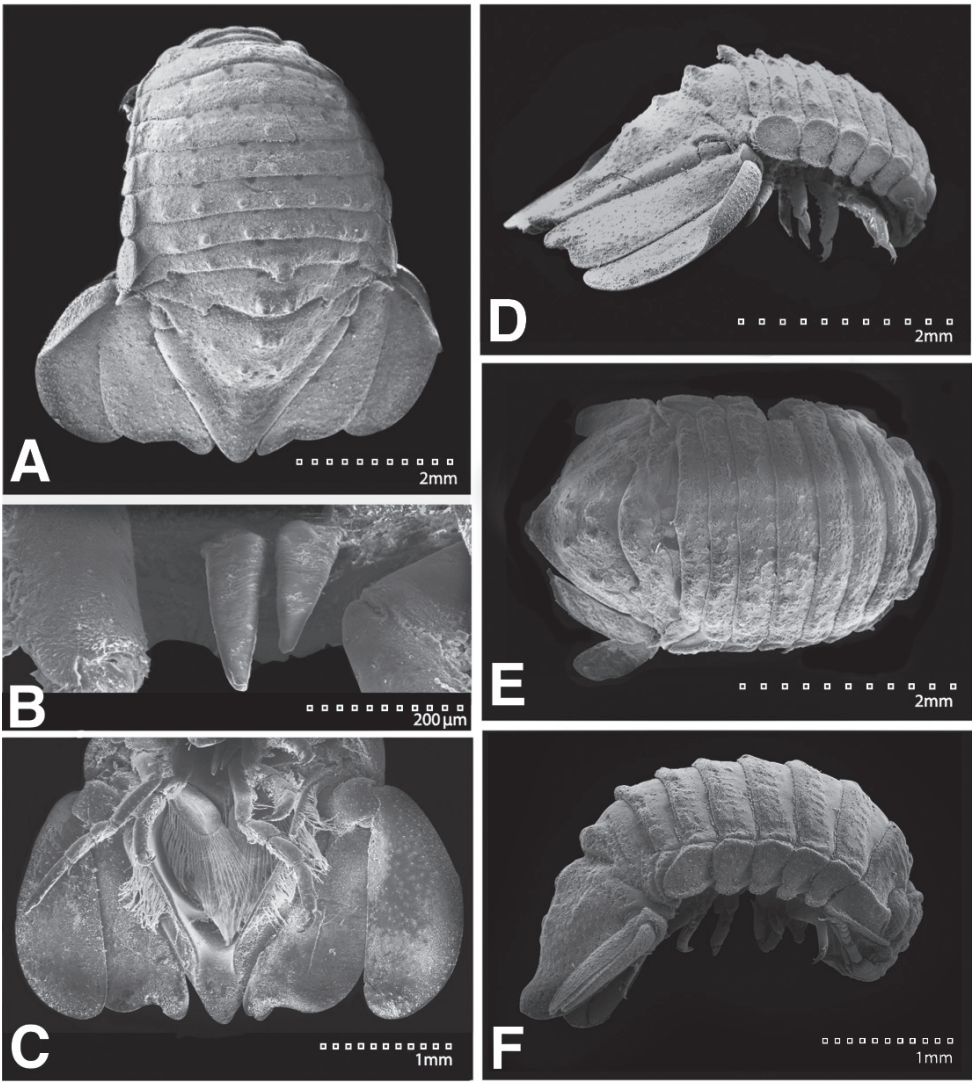

Figure 21. SEMs of *Exosphaeroma amplicauda* LACM CR-2014.1.1. **A** male dorsal **B** penes **C** male pleotelson ventral **D** male lateral **E** female dorsal **F** female lateral.

culina apically narrowly rounded, length 13.0 basal width (Figure 20B). *Pleopod 3* peduncle with a cluster of 3 coupling hooks, distolateral angle with 3 large, simple setae (Figure 20C). *Pleopod 4* peduncle length 0.61 width, distolateral angle with 1 large, simple seta; endopod distal apex 1 large, plumose seta; exopod distal margin with 2 plumose setae (Figure 20D). *Pleopod 5* exopod proximolateral margin with 1 palm seta; exopod with transverse suture entire; exopod with 3 scale patches (Figure 20E). *Uropod* exopod length 2.4 width; rolled proximolateral margin weaken-

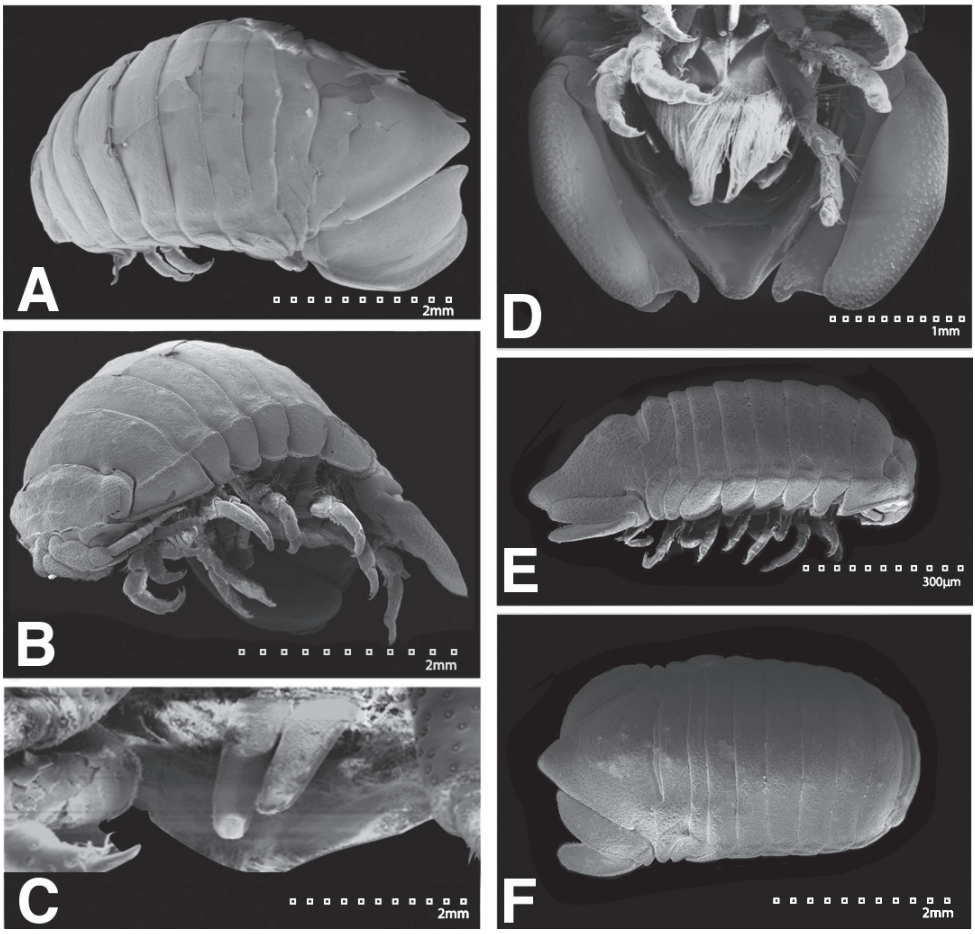

Figure 22. SEMs of *Exosphaeroma paydenae* sp. n. paratype USNM 20474. **A** USNM 20474x male dorsal **B** male lateral **C** penes **D** male pleotelson ventral **E** USNM 20474xi female lateral **F** female dorsal.

ing moving toward lateral, medial margin; mesial margin without setae; endopod length 3.1 width, extends past exopod, mesial margin without setae (Figures 20F, G; 25A, B, C).

Description of female. *Body* length 2.9 width; pereonites 1–7 without tubercles, pereonite 7 distomesial margin weakly convex (Figure 25E, F). *Pleon* with 1 weak posterior tubercle on either side of longitudinal axis (Figure 25E, F). *Pleotelson* length 0.65 width, dorsal surface without visible tubercles; posterior margin of pleotelson acuminate (Figure 25E, F).

Uropod exopod rolled proximolateral margin rolled weakly; endopod length 3.4 width, extends past exopod, mesial margin without setae (Figure 25E, F).

Size. Largest ♂ 8.3 mm, largest ♀ 8.7 mm.

Color. No chromatophores: preserved specimen pale buff, whitish.

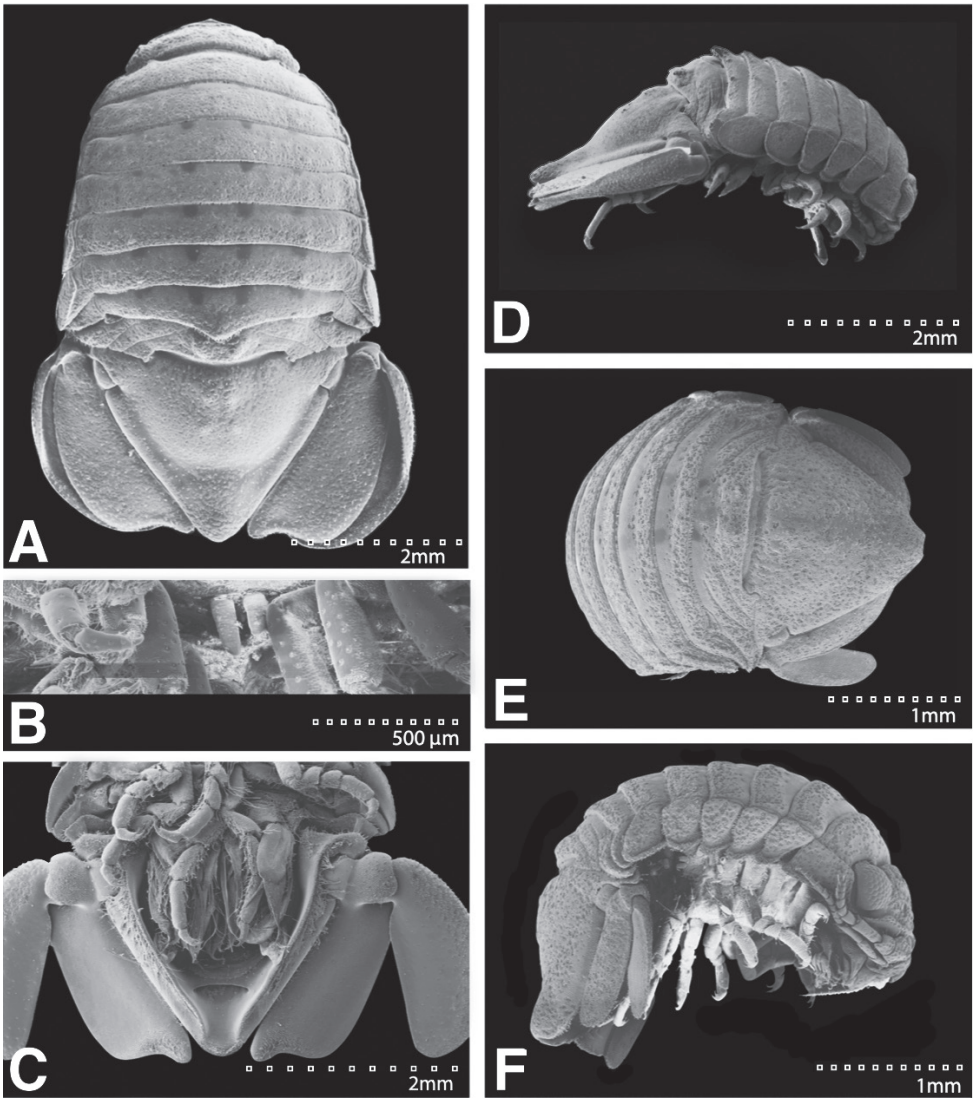

Figure 23. SEMs of *Exosphaeroma russellhansoni* sp. n., paratype. LACM CR-2014.6.4. **A** male dorsal **B** penes **C** male pleotelson ventral **D** male lateral **E** LACM CR-2014.6.5 female dorsal **F** female lateral.

Remarks. *Exosphaeroma aphrodita* can best be identified by: pereonite 5 without ornamentation, pereonite 6 with one lateral weak tubercle, pereonite 7 with weak median process, and paired weak lateral tubercles; pleotelson dorsum with one anterior median strong tubercle and two weak medial tubercles. *E. aphrodita* is strongly sexually dimorphic; females lack dorsal tubercles on the pereonites. Weak pereon tubercles are visible only with SEM and not necessarily evident with light microscopy. Tubercles visible with light microscopy are figured in the line drawings (compare Figures 17 and 25).

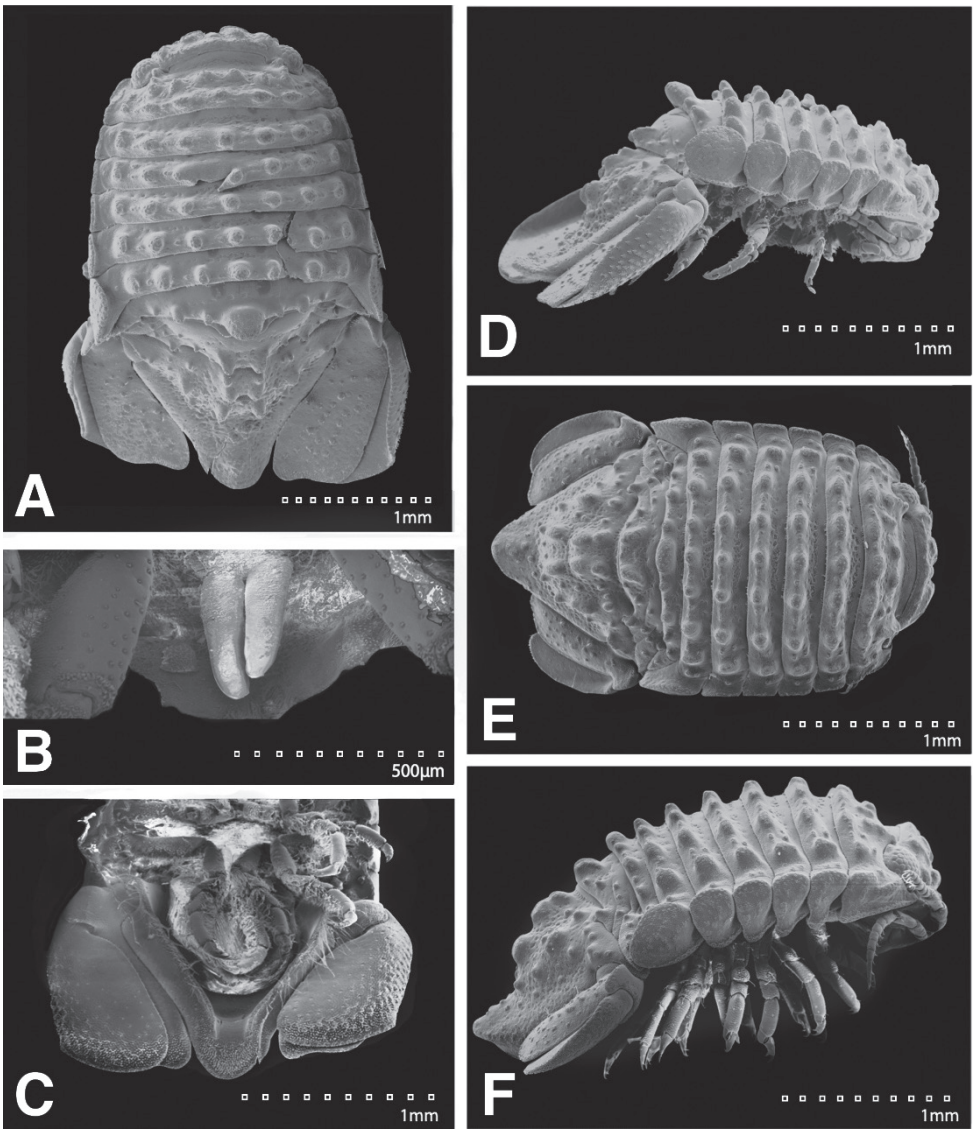

Figure 24. SEMs of *Exosphaeroma pentcheffi* sp. n. paratype LACM CR-2014.12. **A** male dorsal **B** penes **C** male pleotelson ventral **D** male lateral; LACM CR-2014.11 **E** female dorsal **F** female lateral.

Exosphaeroma aphrodita, considered *nomen dubium* by Brusca et al. (2007), is here revalidated. Pearl Lee Boone described this species and several other isopods and tanaids without providing figures (Boone 1923, pp. 147–156). The original description states that "the type and additional material were collected at La Jolla, California and are in the collections of the United States National Museum." We examined all of the USNM material available. We conclude that the species is valid.

Distribution. California, San Diego–La Jolla.

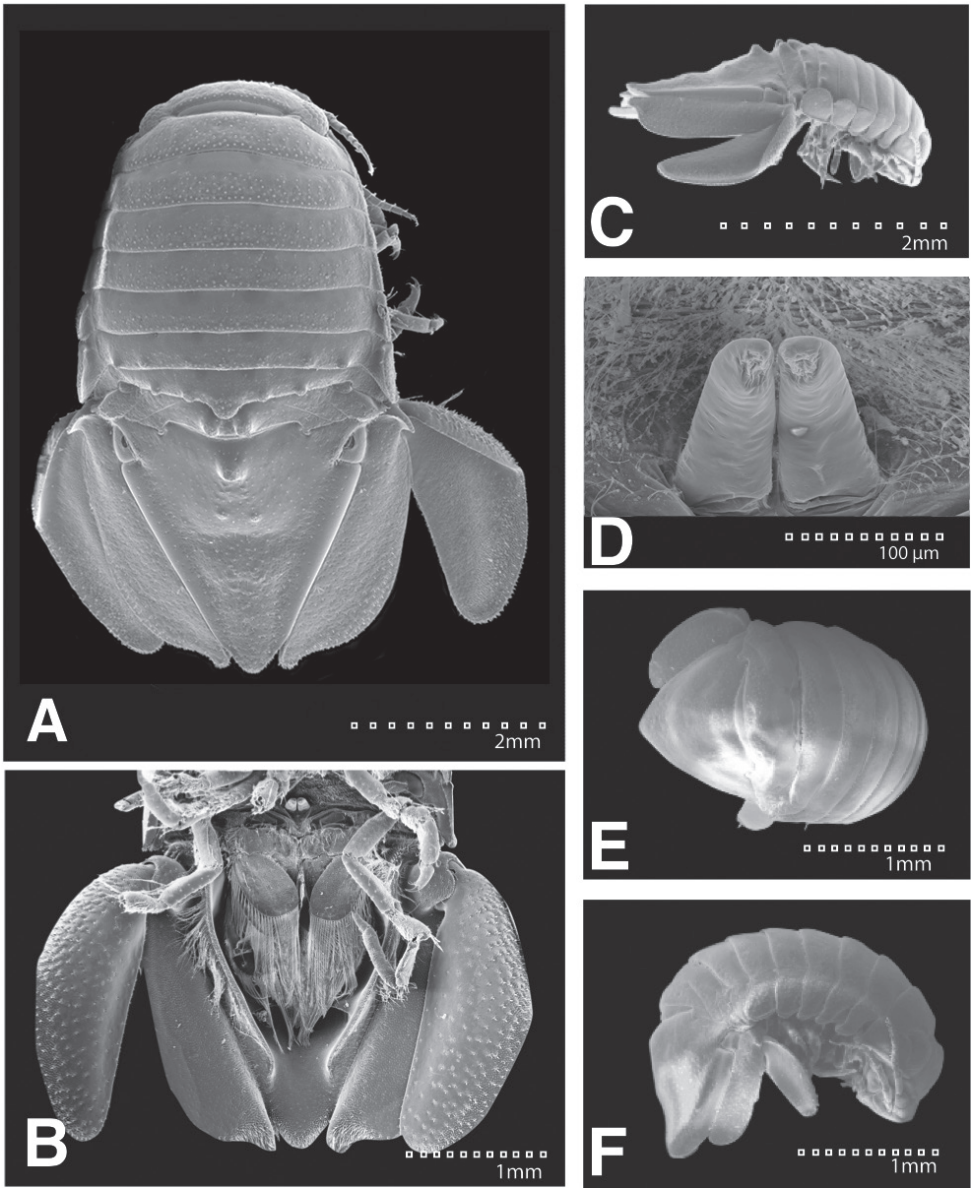

Figure 25. SEMs of *Exosphaeroma aphrodita* LACM CR-2014.14. **A** male dorsal **B** male pleotelson ventral **C** male lateral **D** penes **E** female dorsal **F** female lateral.

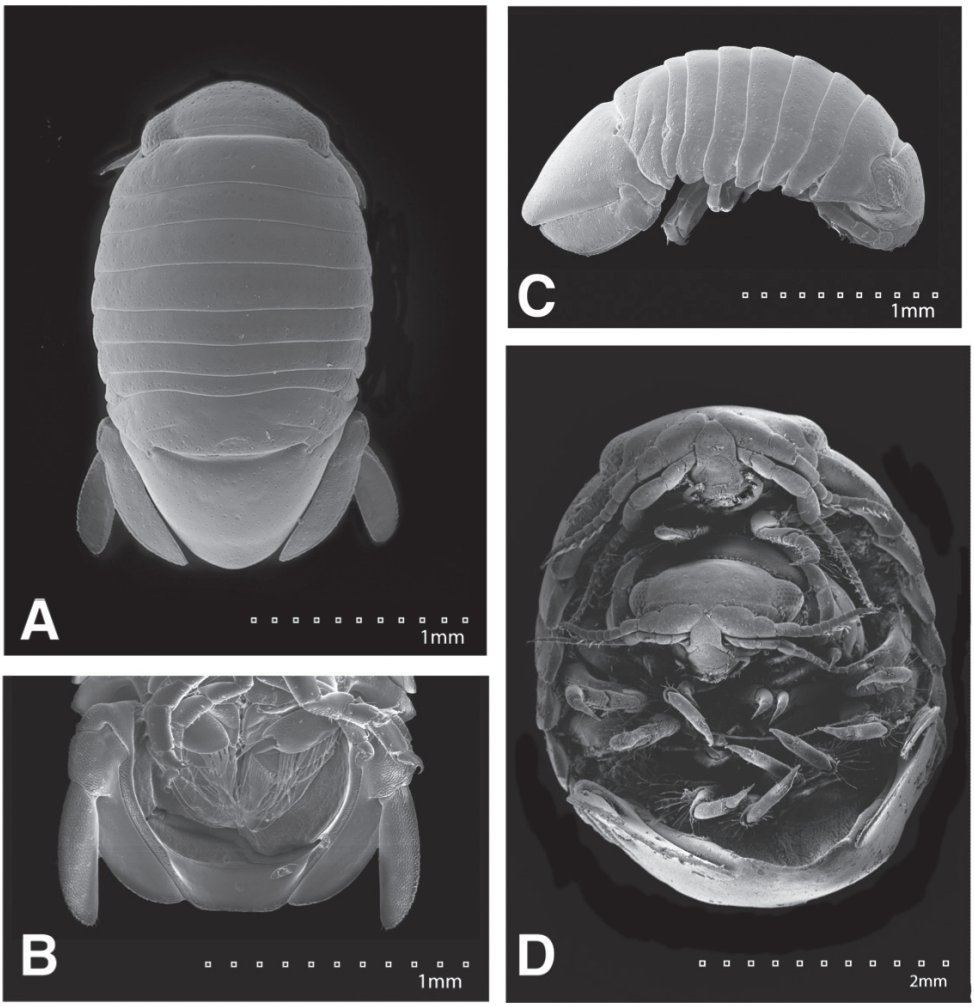

Figure 26. *Exosphaeroma inornata* male RW05.315, USA, California, Los Angeles County, Palos Verdes Peninsula, San Pedro, Pt. Fermin, shore at Paseo del Mar, ~0.5 mi. W of Gaffey Street, 33.71°N, 118.3°W. **A** male dorsal **B** male pleotelson ventral **C** male lateral **D** RW05.106, Pacific, Mexico, Baja California Norte, west of El Rosario, south of Bocana el Rosario, north of Punta Baja, 30.013°N, 115.797°W, male mate-guarding female (male uropods were removed).

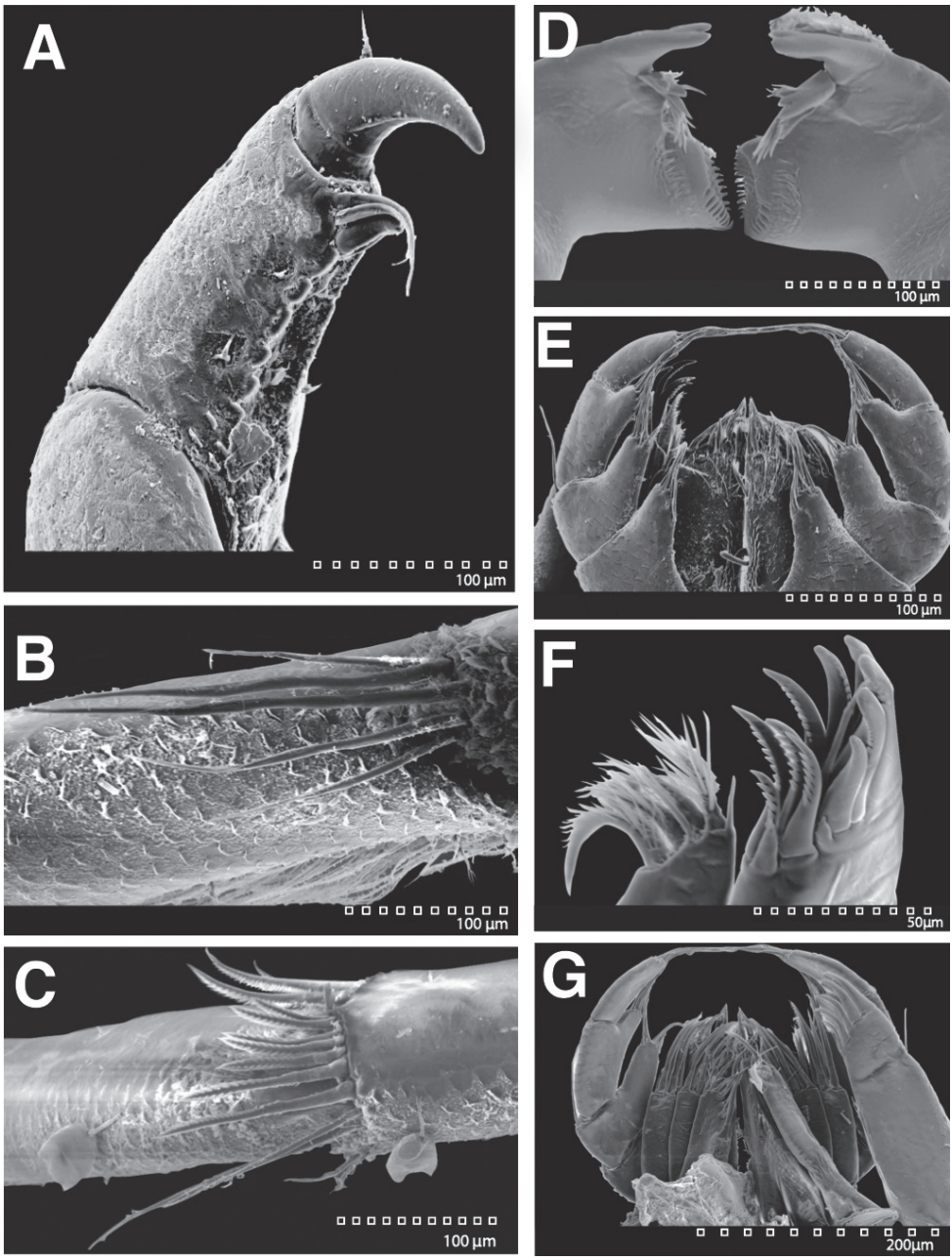

Figure 27. SEM images of *Exosphaeroma amplicauda* LACM CR-2014.1.1. **A** pereopod 3 dactylus scales **B** pereopod 7 merus distal setal patch **C** pereopod 7 carpus distal setal patch **D** left and right mandibles ventral **E** left and right maxillipeds, maxillulae, and maxillae dorsal **F** left maxillula **G** maxilliped and other mouth parts dorsal.

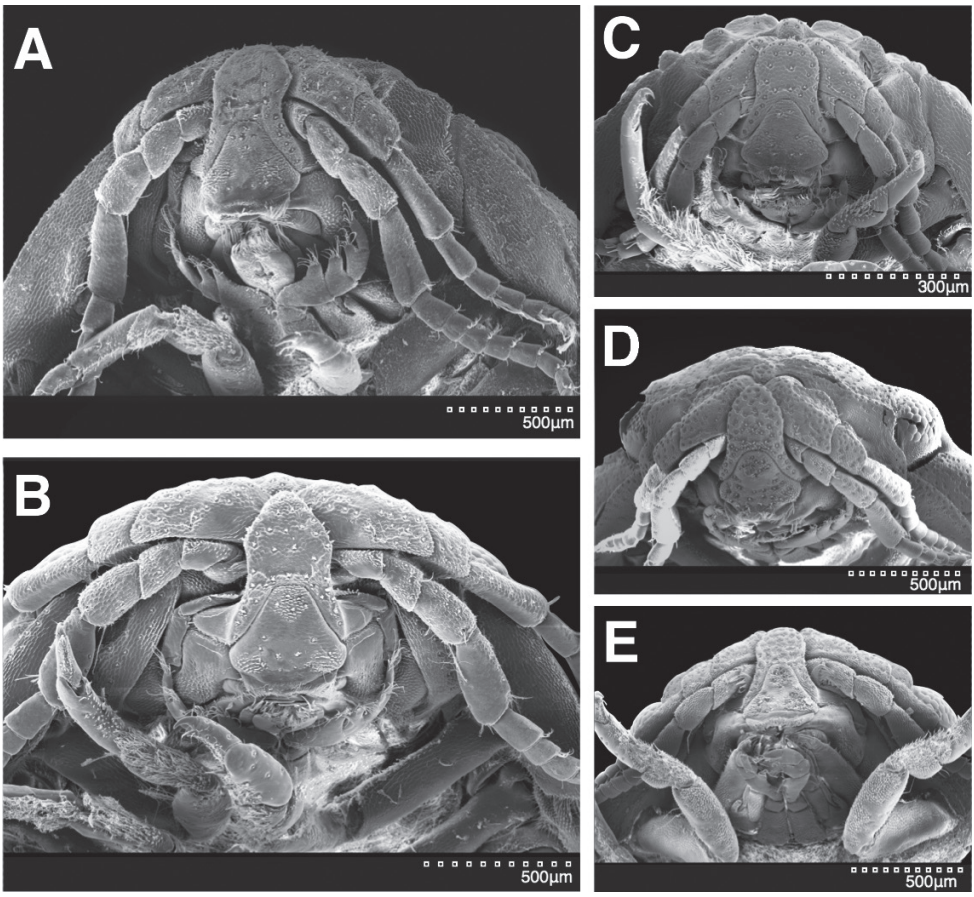

Figure 28. SEM images of epistomes. **A** *Exosphaeroma amplicauda* LACM CR-2014.1.1 **B** *Exosphaeroma aphrodita* LACM CR-2014.14 **C** *Exosphaeroma pentcheffi* sp. n. LACM CR-2014.12 **D** *Exosphaeroma russellhansoni* sp. n. LACM CR-2014.6.4 **E** *Exosphaeroma paydenae* sp. n. USNM 1251663.

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Appendix 1

Sphaeromatidae of the western coast of North America (Alaska to Mexico)

***Cassidinidea* Hansen, 1905**

Cassidinidea mexicana Hendrickx & Espinoza-Pérez, 1998. Gulf of California, Mexico.

***Dynoides* Barnard, 1914**

Dynoides crenulatus Carvacho & Haasmann, 1984. Pacific Mexico.

Dynoides dentisinus Shen, 1929. Introduced. Kussakin 1979; Kussakin and Malyutina 1993.

Dynoides elegans (Boone, 1923) [formerly *Clianella elegans* Li (2000)]. California.

Dynoides saldani Carvacho & Haasmann, 1984. Pacific Mexico (SCAMIT 2013).

"Dynamene"

Dynamene benedicti Richardson, 1899. Monterey Bay, California. Correct generic placement uncertain; Kussakin 1979; excluded from the genus by Harrison and Holdich (1982); Brusca et al. 2007.

Dynamene dilatata Richardson, 1899; Monterey Bay, California. Correct generic placement uncertain; Kussakin 1979; Brusca et al. 2007.

Dynamene glabra Richardson, 1899. Oregon to California. Correct generic placement uncertain; Kussakin 1979; excluded from the genus by Harrison and Holdich 1982; SCAMIT 2013.

Dynamene sheareri Hatch, 1947. Oregon. Correct generic placement uncertain; redescribed by George and Strömberg (1968); excluded from the genus by Harrison and Holdich 1982; Brusca et al. 2007 (SCAMIT 2013).

Dynamene tuberculosa Richardson, 1899. California. Correct generic placement uncertain; SCAMIT 2013.

***Dynamenella* Hansen, 1905**

Dynamenella conica (Boone, 1923). California. Correct generic placement uncertain.

***Exosphaeroma* Stebbing, 1900**

Exosphaeroma amplicauda (Stimpson, 1857); = *Exosphaeroma octoncum* (Richardson, 1897). Marin County to Monterey, California. Brusca et al. 2007; SCAMIT 2013.

Exosphaeroma aphrodita Boone, 1923. San Diego, California.

Exosphaeroma bruscai Espinosa-Perez & Hendrickx, 2002. Pacific Mexico.

Exosphaeroma inornata Dow, 1958; = *E. media* George & Strömberg, 1968. Puget Sound, Washington to Southern California. Iverson 1978, 1982; Brusca et al. 2007.

Exosphaeroma paydenae **sp. n.** Alaska.

Exosphaeroma pentcheffi **sp. n.** Los Angeles, California.

Exosphaeroma rhomburum (Richardson, 1899); Monterey Bay, California. *Incertae sedis*, males not known.

Exosphaeroma russelhansoni **sp. n.** Washington.

***Gnorimosphaeroma* Menzies, 1954**

Gnorimosphaeroma insulare (Van Name, 1940), Washington. Menzies 1954; Hoestlandt 1977; Brusca et al. 2007.

Gnorimosphaeroma noblei Menzies, 1954. Washington to California. Kussakin 1979; Brusca et al. 2007.

Gnorimosphaeroma oregonense (Dana, 1852). Alaska to northern California. Menzies 1954; Kussakin 1979, Brusca et al. 2007, SCAMIT 2013.

Gnorimosphaeroma rayi Hoestland, 1969. Nunomura 1998; Brusca et al. 2007.

***Paracerceis* Hansen, 1905**

Paracerceis cordata (Richardson, 1899). California. Kussakin 1979; Brusca et al. 2007.

Paracerceis gilliana (Richardson, 1899); California.

Paracerceis granulosa (Richardson, 1899); Cerros Island, California.

Paracerceis richardsoni Lombardo, 1988. Pacific Mexico. Espinosa-Pérez and Hendrickx 2002.

Paracerceis sculpta (Holmes, 1904). San Clemente Island, California. Globally translocated and widespread. Menzies 1962; Harrison and Holdich 1982; Nunomura 1988; Loyola e Silva et al. 1999; Brusca et al. 2007.

Paracerceis spinulosa Espinosa-Perez & Hendrickx, 2002. Sonora, Mexico.

***Paradella* Harrison & Holdich, 1982**

Paradella dianae (Menzies, 1962). Brusca et al. 2007.

Paradella tiffany Bruce & Wetzer, 2004; Baja California, Mexico.

Paradella garsonrum Wetzer & Bruce, 2007; Baja California, Mexico.

***Pseudosphaeroma* Chilton, 1909**

Pseudosphaeroma sp. cf. *campbellensis* Bruce & Wetzer, 2008. Introduced species San Francisco to Morro Bay, California. Not *P. campbellensis* of Hurley and Jansen (1977) and Harrison (1984).

***Sphaeroma* Latreille, 1802**

Sphaeroma quoianum Milne Edwards, 1840 [= *Sphaeroma pentodon* Richardson, 1904]. Introduced to San Francisco and San Diego, California. Baker 1926; Hale 1929; Kussakin 1979; Harrison and Holdich 1984; Brusca et al. 2007; (SCAMIT 2013).

Sphaeroma serratum (Fabricius, 1787). Worldwide. Kussakin 1979; Jacobs 1987.

Sphaeroma walkeri Stebbing, 1905. Introduced to San Diego, California. Carlton and Iverson 1981; Pires 1982; Brusca et al. 2007, Kussakin 1979.

***Striella* Glynn, 1968**

Striella sp. La Paz, Gulf of California (LACM collections, UC Mexus station 43).

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Redescription of *Brochopeltis mjoebergi* Verhoeff, 1924 and description of a second *Brochopeltis* species from Australia (Diplopoda, Polydesmida, Paradoxosomatidae)

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Abstract

Brochopeltis mjoebergi Verhoeff, 1924 is redescribed from type and new material, a lectotype is designated and *B. mjoebergi queenslandica* Verhoeff, 1924 is synonymised with *B. mjoebergi*. *B. mediolocus* **sp. n.** is the first native paradoxosomatid described from Australia's Northern Territory.

Keywords

Diplopoda, Polydesmida, Paradoxosomatidae, Queensland, Northern Territory, Australia

Introduction

Paradoxosomatid species in the Australian genera *Brochopeltis* Verhoeff, 1924, *Helicopodosoma* Verhoeff, 1924 and *Tholerosoma* Mesibov, 2006 have unbranched gonopod telopodites with the prostatic groove opening at the telopodite tip. The taxonomic placement of these genera is uncertain. *Brochopeltis* and *Helicopodosoma* species have a medial process on the male leg 1 femur, a diagnostic feature of the subfamily Australiosomatinae. Both genera were placed in the tribe Antichiropodini within Australiosomatinae by Jeekel (1968). However, Jeekel (1979: 652) later suggested that *Brochopeltis*, *Helicopodosoma*, *Australodesmus* Chamberlin, 1920 and *Mjoebergodesmus* Verhoeff, 1924 were distinctive enough to merit each being placed in its own tribe.

Tholerosoma species lack a process on the male leg 1 femur (Mesibov 2006), and I left the genus without a subfamily assignment in my original description.

The three genera are hard to place because the gonopod is so simple in structure. There are no obvious clues to intergeneric relationships in the non-gonopodal characters, and gonopod simplification could have occurred in more than one ancestral lineage. Verhoeff (1924: 33) clearly recognised this problem when discussing *Brochopeltis*: "...it is wrong to judge genera solely according to the gonopods, particularly when these, as is here the case, are so simplified through secondary regression of the tibiotarsus, that very similar organs could also arise in this way in related genera independently of one another" (my translation).

Gonopod simplification also makes it difficult to place a recently discovered species from Australia's Northern Territory in a genus. In this paper I tentatively assign this species to *Brochopeltis* because of similarities to *B. mjoebergi* Verhoeff, 1924 in both gonopod and paranota structure. I also redescribe *B. mjoebergi* and designate a lectotype for it.

Materials and methods

"Male" and "female" in the text refer to adult individuals. Specimens are stored in 70–80% ethanol in their respective repositories. Gonopods were cleared in 80% lactic acid and temporarily mounted in a 1:1 glycerol:water mixture for optical microscopy. Body measurements were estimated with a Nikon SMZ800 binocular dissecting microscope using an eyepiece scale. Colour images were manually stacked using a Canon EOS 1000D digital SLR camera mounted on the Nikon SMZ800 fitted with a beam splitter, then processed with Zerene Stacker 1.04. Figs 5B and 5C were captured as screenshots from the output of a 1.3 megapixel digital video eyepiece camera mounted in one ocular tube of a Tasco LMSMB binocular microscope. Preliminary gonopod drawings were traced from prints of screenshots captured in the same way. Images and drawings were prepared for publication using GIMP 2.8.

Suppl. material 1 tabulates data for known specimen lots of *Brochopeltis* species as of 15 April 2015 (data also available online in Mesibov 2006–2015). Locality details are given with latitude and longitude based on the WGS84 datum. My estimate of the uncertainty for a locality is the radius of a circle around the given position, in metres or kilometres. The locality map was generated using QGIS 1.75.

Abbreviations in text and Suppl. material 1: AM = Australian Museum, Sydney, Australia; ANIC = Australian National Insect Collection, Canberra, Australia; MAGNT = Museum and Art Gallery of the Northern Territory, Darwin, Australia; NHRS = Naturhistoriska Riksmuseet, Stockholm, Sweden; NT = Northern Territory, Australia; NTEIRC = Northern Territory Economic Insect Reference Collection, Darwin, Australia; Qld = Queensland, Australia; QM = Queensland Museum, Brisbane, Australia; ZMB = Museum für Naturkunde, Berlin, Germany; ZSM = Zoologische Staatssammlung München, Munich, Germany.

Results

Order Polydesmida Pocock, 1887

Suborder Strongylosomatidea Brölemann, 1916
Family Paradoxosomatidae Daday, 1889
Subfamily Australiosomatinae Brölemann, 1916
Tribe Antichiropodini Brölemann, 1916

Genus *Brochopeltis* Verhoeff, 1924

Brochopeltis: Verhoeff 1924: 32; 1932: 1577, 1605. Attems 1926: 144; 1929: 261, 266; 1931: 137; 1937: 31, 275. Jeekel 1968: 20, 27, 30, 126; 1971: 218; 1979: 652, 654. Hoffman 1980: 166. Humphreys and Shear 1993: 181. Nguyen and Sierwald 2013: 1155.

Type species. *Brochopeltis mjoebergi* Verhoeff, 1924, by monotypy.
Other assigned species. *B. mediolocus* sp. n.

Brochopeltis mjoebergi Verhoeff, 1924

Figs 1, 2A, 3A, 3B, 5; Fig. 4 (map)

Brochopeltis mjöbergi: Verhoeff 1924: 33 (misprinted here as *mjöbergii*; see Remarks), Fig. 20 in pl. 2; 1932: Fig. 980 (p. 1597). Attems 1937: 275, 276, Fig. 343 (p. 275).
Brochopeltis mjoebergi: Jeekel 1968: 19, 30; 1971: 218. Nguyen and Sierwald 2013: 1155.
Brochopeltis mjöbergi queenslandica: Verhoeff 1924: 35. Attems 1937: 276. **syn. n.**
Brochopeltis mjoebergi queenslandica: Jeekel 1968: 19, 30. Nguyen and Sierwald 2013: 1155. **syn. n.**

Lectotype (here designated). 1 male, Herberton, Qld, E. Mjöberg, 1913, NHRS KASI000000031, in 2 pieces in separate vial.

Paralectotypes. NHRS: 2 entire females and parts of 3 males, 2 females and 1 juvenile, males with gonopods intact, collecting details as for lectotype, KASI000000031, in alcohol with printed label "Queensl. / Mjöberg" and Verhoeff labels "Brochopeltis / mjöbergi Verh. / Herberton" (in pencil) and "Brochopeltis Mjöbergi Verh. / Queensl. Herberton. / [Colleg.] Mjöberg. [Determ.] Verhoeff." (in pen); slide mount of 1 right and 1 left gonopod and 2 male eighth legs, Atherton, Qld, same collector and year, slide 266, KASI000000026, Verhoeff label "Brochopeltis mjöbergi Verh. / Atherton, 8.B. / Queensland. a2", Johns label "Lectotype ♂ / parts of body in alcohol. / P.M. Johns 10.viii.67"; 1 male, body broken into 4 parts and missing ring 7, same collecting details, KASI000000026, in alcohol with Johns label "Lectotype ♂ / genitalia on slide / P.M. Johns 10.viii.67"; slide mount of 1 right and 1 left gonopod, same collect-

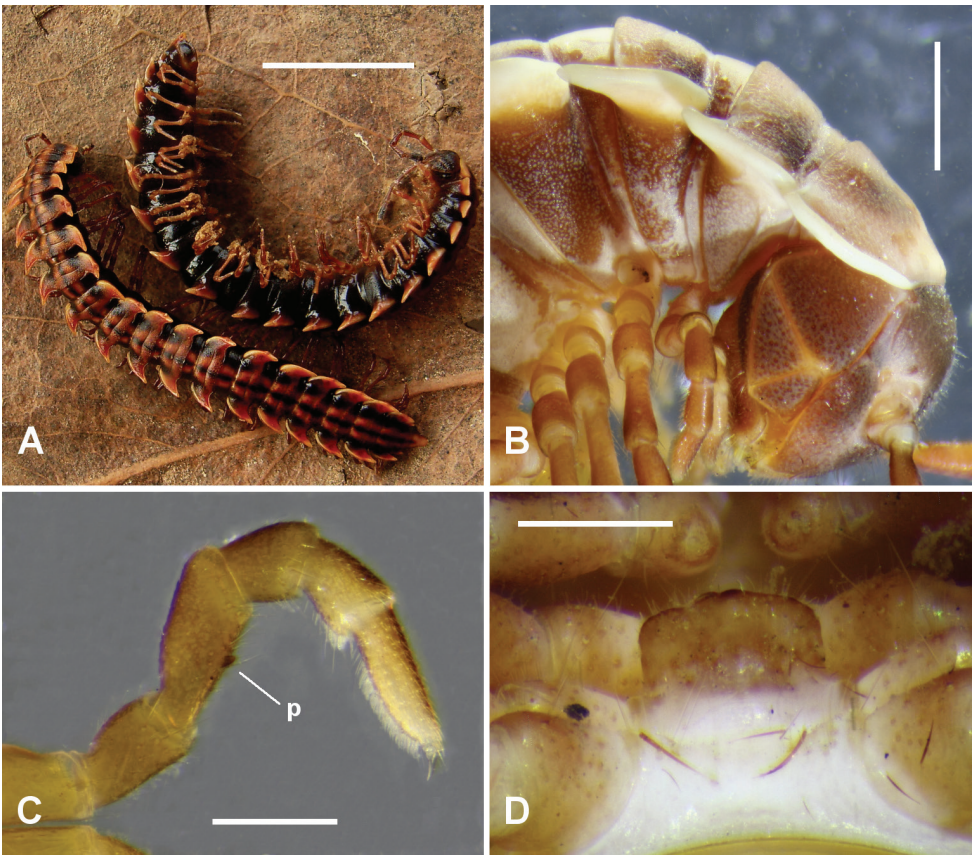

Figure 1. *Brochopeltis mjoebergi* Verhoeff, 1924. **A** female (top) and male (bottom) ex QM S74491 **B** male ex QM S74490. **A** habitus **B** right lateral view of anterior rings **C** anterior view of right leg 1 showing femoral process (**p**) **D** sternal lamella, posterior view. Scale bars: 10 mm (**A**); 1 mm (**B**); 0.5 mm (**C, D**).

ing details, NHRS slide 267, KASI000000028, Verhoeff label "Brochopeltis mjöbergi Verh. / Atherton. / Queensland. a1", Johns label "Paralectotype ♂ / Body in alcohol / P.M. Johns 10.viii.67"; 2 entire females and parts of at least another 3 females, same collecting details, KASI000000028, in alcohol with printed labels "Queensl. / Mjöberg" and "Jan.", label in pencil "Atherton / scrub / Jan 1913", Verhoeff label in pen "Brochopeltis Mjöbergii Verh. / Atherton. Januar. /[Colleg.] Mjöberg. [Determ.] Verhoeff.", Johns label "Paralectotypes 5♀♀ / P.M. Johns 10.viii.67", also a smaller vial with rings 7-8 and 9? from 1 male, ring 7 without gonopods, Johns label "Paralectotype ♂ / genitalia on slide / P.M. Johns 10.viii.67"; parts of 3 females, same collecting details, KASI000000027, in alcohol with two printed labels "Queensl. / Mjöberg", Verhoeff label "Brochopeltis / mjöbergi Verh. / Atherton" (in pencil) and Johns label "Paralectotypes 3♀♀ / P.M. Johns 10.viii.67". **ZMB (not examined):** 1 male, Queensland, 1913, E. Mjöberg, ZMB 5710 (listed in Moritz and Fischer 1978; see Remarks). **ZSM (not examined):** 1 specimen in alcohol, Atherton, Qld, Janu-

ary 1913, E. Mjöberg, ZSM/Myr-20033548.00; 2 specimens in alcohol, same details, ZSM/Myr-20052193.00; 1 right and 1 left gonopod and 2 male first legs mounted on slide, same details, ZSM-A-20033548.

Lectotype of *Brochopeltis mjoebergi queenslandica* (here designated). Male, Bellenden Ker, Qld, E. Mjöberg, 1913, comprising (1) slide mount of 1 right and 1 left gonopod, slide 265, KASI000000029, Verhoeff label "Brochopeltis / mjöbergi / queenslandica / Verh. / Bellenden Ker. / Queensland b1", Johns label "Lectotype ♂ / body in alcohol / P.M. Johns 10.viii.67", and (2) body in alcohol in small vial, broken between rings 5 and 6 and rings 9 and 10, KASI000000029, Johns label "Lectotype ♂ / genitalia on slide / P.M. Johns 10.viii.67".

Paralectotype of *Brochopeltis mjoebergi queenslandica*. NHRS: Male, collecting details as for lectotype, in alcohol in small vial, body broken into four parts, ring 7 isolated and with intact gonopods, KASI000000030, printed label "Queensl. / Mjöberg", Johns label "Paralectotype / P.M. Johns 10.viii.67".

B. mjoebergi queenslandica lectotype and paralectotype vials in larger vial with two Verhoeff labels "Brochopeltis mjöbergi / queenslandica Verh. / Bellenden Ker" (in pencil) and "Brochopeltis Mjöbergi queens- / Bellenden Ker. landica Verh. / [Colleg.] Mjöberg. [Determ.] Verhoeff." (in pen).

Other material. 25 males, 15 females and 1 juvenile in **AM**, **ANIC** and **QM** (see Suppl. material 1 for details).

Description. (Based on lectotype and specimens collected 5-10 km from type locality in 1998.) Male/female approximate measurements: length 35/38 mm, midbody paranota width 5.2/5.4 mm, prozonite width 3.5/4.4 mm, maximum vertical diameter 3.5/4.4 mm. Well-coloured animals (Fig. 1A) very dark brown (almost black) on flanks and along narrow, longitudinal, mid-dorsal band, lighter reddish brown ventrally and in broad, paramedian, dorsal bands; paranota with pale margins; head and antennae dark brown, the antennae lighter basally; legs medium brown; body colour fades with long-term storage in alcohol.

Male with vertex and frons sparsely setose, clypeus moderately setose; vertigial sulcus distinct, ending at dorsal level of antennal sockets; post-antennal groove shallow; antennal sockets separated by ca 1.3× socket diameter. Antenna filiform, reaching dorsally to rear of ring 3; antennomeres with relative lengths (2=3)>(4=5=6); 6 apically widest. In dorsal view, head narrower than collum paranota; relative ring widths collum < (2=3=4) < (5 to17). Collum with lateral margin strongly produced as paranotum, anterior and lateral margins smoothly convex, posterior margin more or less straight. Paranota on haplo- and diplosegments with margins thickened dorsally, so dorsal paranotal surface appears slightly depressed. Ring 2 paranotum with lateral margin slightly lower than lateral margins of collum and ring 3 paranota (Fig. 1B); posterior corner produced posteriorly as broad triangle. Paranota of rings 3 and 4 curving posteriorly, almost sickle-shaped, posterior corners bluntly rounded. Paranota on diplosegments 5-17 set at ca 3/4 ring height, directed slightly dorsally with posterior corner highest; anterior margin curving smoothly into nearly longitudinal lateral margin, posterior corner strongly produced as bluntly pointed triangle almost reaching waist of next

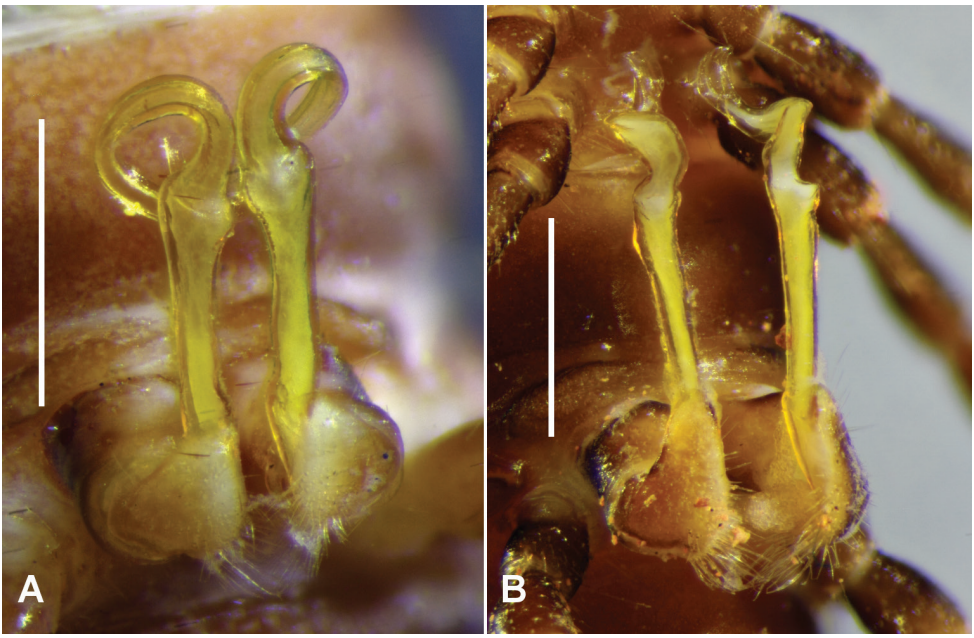

Figure 2. A *Brochopeltis mjoebergi* Verhoeff, 1924, male ex QM S74490 **B** *B. mediolocus* sp. n., male paratype, NTEIRC 63895. Right ventrolateral views of gonopods in situ. Scale bars = 1.0 mm.

ring; lateral margin thicker on pore-bearing rings. Paranota reduced but still prominent on rings 18 and 19, with strongly produced posterior corners. Pleural keels on rings 2-4 only, on rings 3, 4 reduced to small, rounded, posterolaterally directed processes. Prozonites and metazonites bare and finely textured, giving dull appearance; transverse furrow at ca 1/2 metazonite length, distinct, ca 2/3 ring width, not reaching paranotal base; waist short, shallow, faintly sculptured with low longitudinal ridges; limbus a narrow, thin, continuous sheet. Pore formula normal; ozopore small, round, opening laterally on thickened paranotal margin almost at level of posterior metazonite margin. Spiracles on diplosegments above and just anterior to leg bases; spiracular filters forming rounded fold in inverted, tight U-shape in spiracular opening; anterior spiracle with anterodorsal portion of rim produced to partly cover strongly emergent, anterodorsal portion of filter. Midbody sternites very sparsely setose, as wide as long, transverse impression more distinct than longitudinal impression; no cones or projections on any sternites. Midbody legs slender, relative podomere lengths femur>tarsus >prefemur>(postfemur= tibia); femur ca 1.3× as long as tarsus; anterior leg prefemora not swollen dorsally. Pre-anal ring sparsely setose; epiproct extending past anal valves, in dorsal view tapering and truncate, tip ca 1/4 width of pre-anal ring; hypoproct paraboloid; spinnerets in rectangular array, much wider than long.

Leg 1 (Fig. 1C) with very small, rounded process at ca 2/3 length of medial femur surface, directed slightly anteromedially. Gonopore small, round, opening on short distomedial bulge of leg 2 coxa. Sternal lamella (Fig. 1D) ca 90% of width between leg

4 bases, short, more or less vertical; lateral margins straight, vertical; corners rounded; ventral margin very slightly convex. Dense brush setae on tarsi of legs 1-7 only.

Gonopod aperture just wide enough to accommodate gonocoxae, 1/3-1/2 ring 7 prozonite width. Gonopod telopodites (Figs 2A, 3A, B) parallel, almost reaching leg 6 bases when retracted; sternite between legs 6 and 7 bases slightly excavate. Rounded, transverse ridge just anterior to aperture on either side, the two ridges confluent medially.

Gonocoxa short, the anterodistal surface with low, rounded protuberance bearing sparse, long setae on distal side. Prefemur large, C-shaped, the distal end projecting posterolaterally as rounded extension reaching ca 1/5 telopodite height; long setae on posterior and posteromedial surfaces of prefemur. Cannula small, arising from gonocoxa apex. Telopodite beyond prefemur without branches, the basal portion straight and slightly expanded distally; at ca 2/3 telopodite height, telopodite constricted, flattening and curving anterolaterally in wide spiral to level of starting point of curve and anterior to it, then curving anterolaterally, the apex slightly expanded with distal margin rounded. Prostatic groove (Figs 3A, 3B) running straight on medial surface of basal portion of telopodite beyond prefemur, then following curve of telopodite to open at apex.

Female without leg modifications; epigynum 1/4-1/3 ring width, slightly raised in small rounded triangle medially; cyphopods not examined.

Distribution. In forest litter within a range envelope of ca 1500 km^2 on and near the Atherton Tableland, in the Wet Tropics of far north Queensland (Fig. 4).

Remarks. *Types*. Verhoeff (1924: 35) reported that apart from a few pairs of *B. mjoebergi* ("[a]usser einigen Pärchen") from Atherton collected in January, he examined three males and four females from Herberton and one male and a juvenile from "Cedar Creek" (Ravenshoe). *B. mjoebergi queenslandica* was based on two males from Bellenden Ker. All collections were by Erik Mjöberg in early 1913 (Ferrier 2006).

Most of the syntypes are accounted for, with a few discrepancies. The NHRS material comprises parts of two males and eight females from Atherton; parts of four (not three) males, four females and a juvenile from Herberton; and parts of two males from Bellenden Ker. ZSM has parts of at least two males from Atherton (J. Spelda, in litt.), and ZMB has one male labeled "Queensland" collected by Mjöberg in 1913 (J. Dunlop, in litt.). The latter may be the Ravenshoe male but if so the Ravenshoe juvenile appears to be missing.

The lectotypifications by P.M. Johns (see label information in types section, above) were never published. I have designated an entire male from Herberton in the type series as the *B. mjoebergi* lectotype because the slide-mounted gonopods of Atherton males are distorted (see also below, on subspecies *queenslandica*).

Species epithet. The spelling *mjöbergii* on p. 33 in Verhoeff (1924) is apparently a typesetting error. The name is spelled *mjöbergi* on pp. 35, 133 and 138 with *Brochopeltis*, and an additional 26 times in Verhoeff (1924) with the new taxa *Cyliosoma queenslandicum mjöbergi*, *Monographis mjöbergi*, *Poratobolus mjöbergi*, *Rhinotus mjöbergi* and *Siphonophora mjöbergi*. The spelling *mjöbergi* is also used on all but one of the handwritten Verhoeff labels I have seen.

Subspecies queenslandica. Verhoeff distinguished this subspecies mainly on minor variation in colour pattern, writing "Structure otherwise as in the preceding form, the

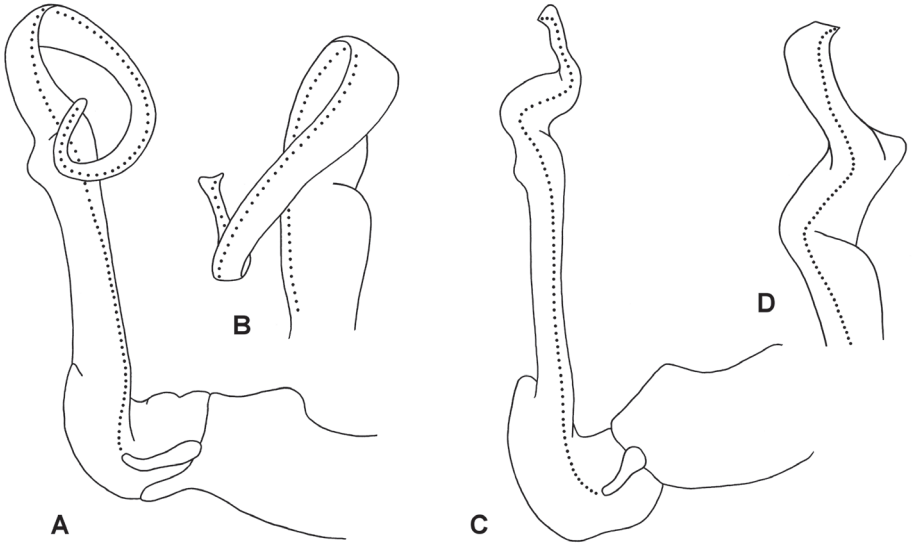

Figure 3. Right gonopods of *Brochopeltis mjoebergi* Verhoeff, 1924, male ex QMS 74490 (**A, B**), and *B. mediolocus* sp. n., male ex NTEIRC 63897 (**C, D**) **A, C** Medial views **B** anterolateral view **D** anterior view. Drawings not to scale, setation not shown; dotted lines indicate course of prostatic groove.

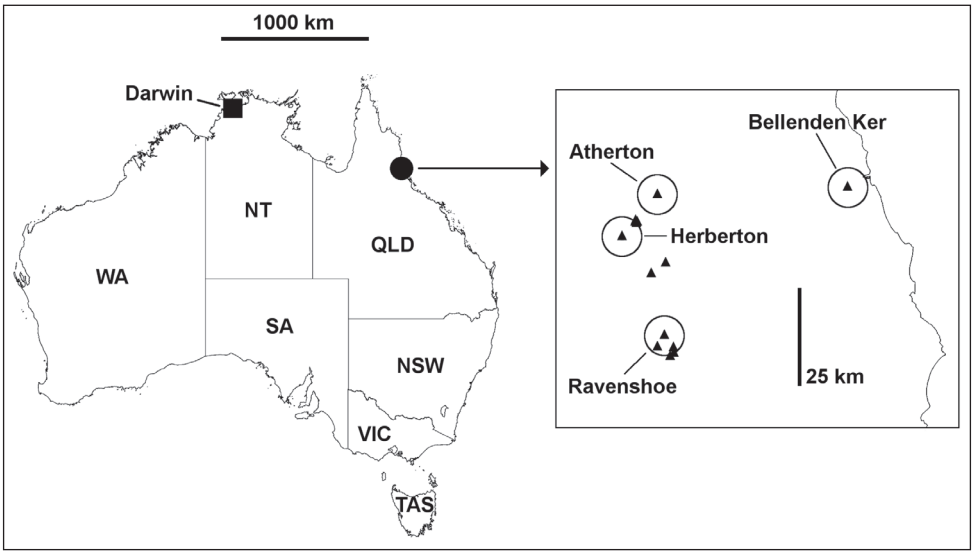

Figure 4. Main map. Locality for *Brochopeltis mediolocus* sp. n. (square) and locality area for *B. mjoebergi* Verhoeff, 1924 (circle). **Inset**. Localities for *B. mjoebergi* Verhoeff, 1924 (triangles) in far north Queensland; type localities are named and buffered with 5 km-radius circles. Mercator projections.

gonopods also agreeing with those of the other, but the solenomere bends not sharply bent, but totally rounded, thus even more strongly spirally curved" (Verhoeff 1924: 35, my translation). The supposed gonopod difference is an artefact produced during

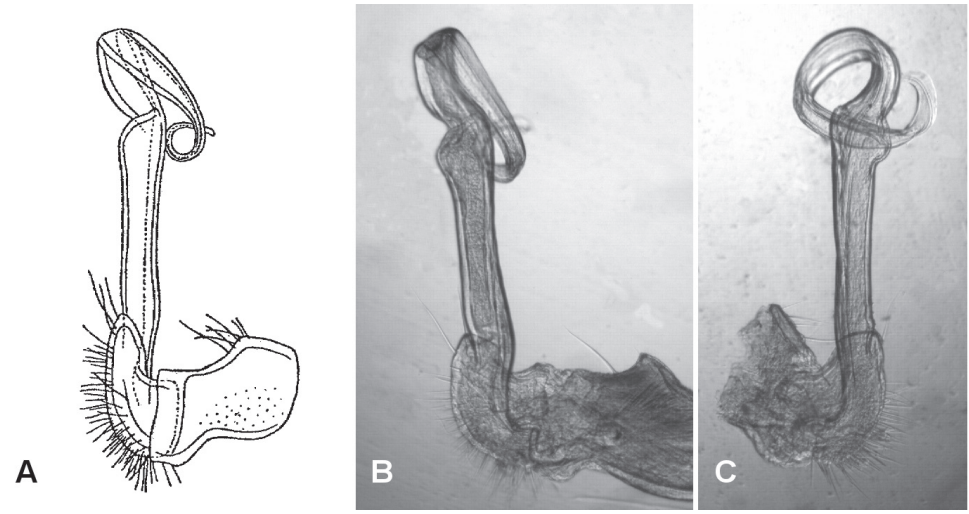

Figure 5. A, B *Brochopeltis mjoebergi* Verhoeff, 1924 **C** *B. mjoebergi queenslandica* Verhoeff, 1924 **A** Lateral view of left gonopod of syntype, from Verhoeff (1924), fig. 20 **B** Medial view of right gonopod of paralectotype as mounted on slide by Verhoeff, NHRS slide 266, KASI000000026 **C** Lateral view of right gonopod of lectotype as mounted on slide by Verhoeff, NHRS slide 265, KASI000000029. Images not to same scale.

slide preparation (Fig. 5). Verhoeff mounted the spiral acropodites of the gonopods of the *mjoebergi queenslandica* lectotype more or less in the plane of the spiral, while those of the *mjoebergi mjoebergi* paralectotypes are mounted with the spirals compressed and bent. The intact gonopods of the *mjoebergi queenslandica* paralectotype spiral in just the same way as gonopods of *mjoebergi mjoebergi* from Herberton. The subspecies *queenslandica* is here made a synonym of the nominate subspecies.

Other notes. *B. mjoebergi* appears to be abundant in rainforest and open forest on the western side of the Atherton Tableland (Fig. 4). I have not seen this large and easily recognised millipede in collections from elsewhere in the Queensland Wet Tropics. The region has been entomologically well sampled since Mjöberg's expedition and is home to many other described and undescribed paradoxosomatids.

An anonymous Australian collector who calls *B. mjoebergi* "fire millipede" posted a YouTube video in August 2014 documenting how this species can be kept in captivity (https://www.youtube.com/watch?v=hg6IlPF0YCo; accessed 9 March 2015).

***Brochopeltis mediolocus* Mesibov, sp. n.**
http://zoobank.org/84765FF0-6D65-4687-80E9-B93028BE6059
Figs 2B, 6, 7; Fig. 4 (map)

Holotype. Male, Anzac Parade (turf farm), Middle Point, NT, -12.5677 131.319 ± 200 m, 18 February 2015, M. Neal, ex ground at edge of pasture, MAGNT NTM-M000056.

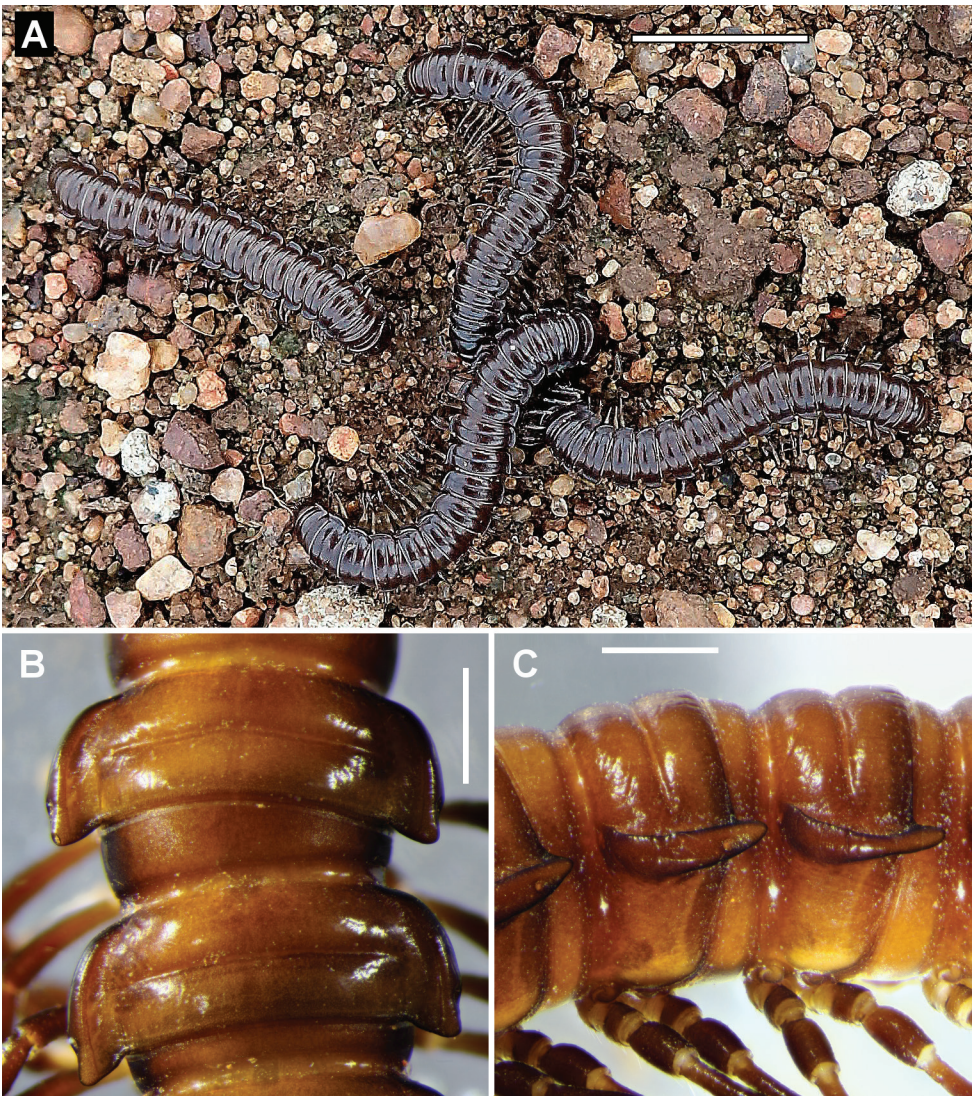

Figure 6. *Brochopeltis mediolocus* sp. n. **A** Live individuals at type locality, February 2015; image by Michael Neal **B** Dorsal and **C** lateral views of midbody rings of male paratype ex NTEIRC 63897. Scale bars: 10 mm (**A**)(approximate); 1 mm (**B, C**).

Paratypes. NTEIRC: 2 males, details as for holotype, 63897; 5 females, 13 juveniles, details as for holotype, 63898; 1 male, same details but 16 February 2015, in large numbers on ground, 63895.

Other material. NTEIRC: 5 females, 117 juveniles (collected with types, not examined; see Suppl. material 1 for details).

Diagnosis. Differs from *B. mjoebergi* in distal portion of gonopod telopodite bent but directed distally, not curving in wide spiral; with dorsum uniform in colour, not

with pale, paramedian longitudinal bands and pale paranota on a darker background; and with tarsal brushes on all male legs except last two pairs, rather than on legpairs 1-7 only.

Description. Male/female approximate measurements: length 29/30 mm, midbody paranota width 3.6/3.8 mm, prozonite width 2.7/3.0 mm, maximum vertical diameter 2.6/3.0 mm. Live, well-coloured animals more or less uniformly dark brown in body colour, shiny (Fig. 6A). In alcohol, body colour brown (Fig. 6B, C), darker on paranota and posterior metazonite margin, lighter ventrally and in pleural keel area; head and antennae dark brown with lighter spot just above antennal socket; legs darker than body.

Male with vertex and frons almost bare, clypeus sparsely setose; vertigial sulcus distinct, ending at dorsal level of antennal sockets; post-antennal groove moderately deep; antennal sockets separated by ca 1.3× socket diameter. Antenna filiform, reaching dorsally to rear of ring 3; antennomeres with relative lengths (2=3)>(4=5)>6 and with 5 and 6 subequal in apical width. Head slightly narrower than collum in dorsal view, both narrower than ring 2; rings 2-17 subequal in width. Collum D-shaped in dorsal view, the lateral margin lifted slightly as a narrow paranotum, posterior corner rounded. Paranota on haplo- and diplosegments with margins thickened dorsally, so that dorsal paranotal surface appears slightly depressed. Ring 2 paranotum (Fig. 7A) with lateral margin lower than lateral margins of collum and ring 3 paranota; subtrapezoidal with rounded corners, extended slightly anteriorly and posteriorly. Ring 3 paranotum shorter than ring 2 paranotum; posterior corner extending posteriorly, rounded. Ring 4 paranotum intermediate in length between paranota of rings 2 and 3; posterior corner slightly extended posteriorly. Paranota on diplosegments 5-17 (Fig. 6B, C) set at ca 1/2 ring height; anterior corner strongly rounded; lateral margin further from the body posteriorly, thicker on pore-bearing rings; posterior corner rounded, progressively extending further posteriorly and passing posterior metazonite edge from about ring 10. Paranota greatly reduced but still prominent on rings 18, 19. Pleural keels (Fig. 7B) distinct on rings 2-8, reduced posteriorly to progressively smaller bulges, not detectable on rings 16-19; keels on rings 3-8 with well-defined lateral margins with posterior corners projecting a little posteriorly. Prozonites and metazonites (Fig. 6B, C) smooth, bare; transverse furrow at ca 1/2 metazonite length, distinct, extending laterally to paranotal base; waist short, shallow, not obviously sculptured; limbus a narrow, thin, continuous sheet. Pore formula normal; ozopore small, round, opening laterally on thickened paranotal margin almost at level of posterior metazonite margin. Spiracles on diplosegments above and just anterior to leg bases; anterior spiracle subquadrangular, posterior spiracle subtriangular; spiracular rim low, filter slightly emergent, forming rounded fold in inverted, tight U-shape in spiracular opening. Midbody sternites very sparsely setose, as wide as long, transverse impression wider than longitudinal impression; no cones or projections on any sternites. Midbody legs with relative podomere lengths femur>>(tibia=tarsus)>(prefemur=postfemur); femur ca 1.7× as long as tarsus; anterior leg prefemora only slightly swollen dorsally. Pre-anal ring sparsely setose; epiproct extending past anal valves, in dorsal view tapering and truncate, tip ca

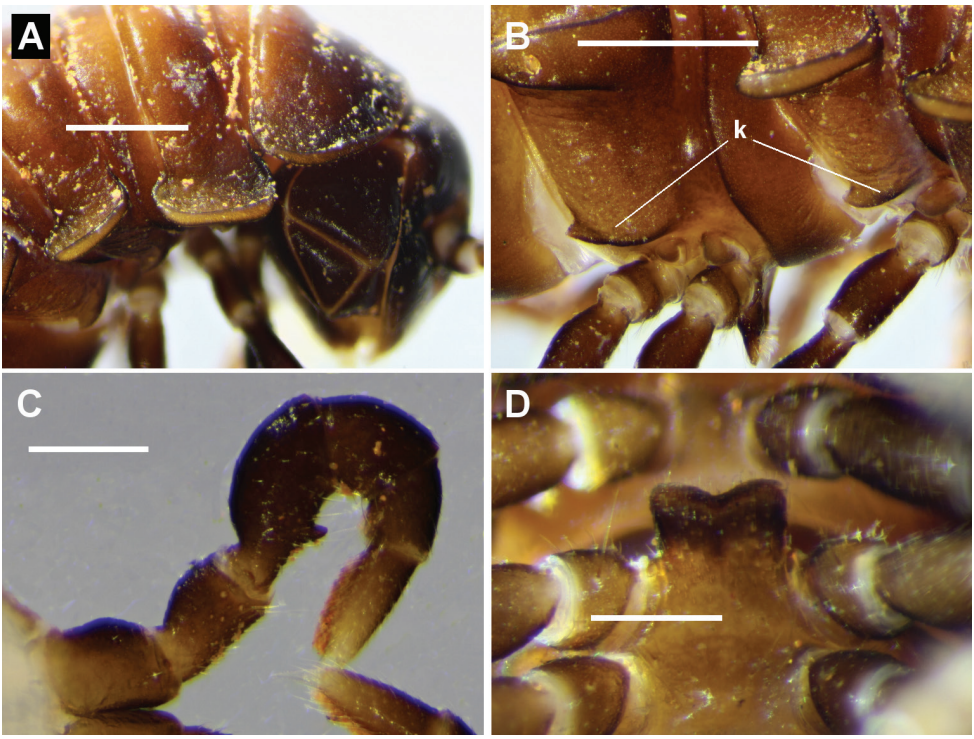

Figure 7. *Brochopeltis mediolocus* sp. n. **A–C** male paratype, NTEIRC 63895 **D** male paratype ex NTEIRC 63897 **A** Right lateral view of anterior rings **B** right lateral view of pleural keels (**k**) on rings 4 and 5, anterior to right **C** right leg 1, anterior view **D** sternal lamella, posteroventral view. Scale bars: 1 mm (**A, B**); 0.5 mm (**C, D**).

1/5 width of pre-anal ring; hypoproct rounded-trapezoidal; spinnerets in rectangular array, wider than long.

Leg 1 (Fig. 7C) with small, short, rounded process at ca 1/2 length of medial femur surface, directed mediodistally and slightly anteriorly. Gonopore small, round, opening on short distomedial bulge of leg 2 coxa. Sternal lamella (Fig. 7D) ca 90% of width between leg 4 bases, leaning slightly anteriorly; lateral margins straight, vertical; corners rounded; ventral margin medially incised. Dense brush setae on tarsi of all but last 2 legpairs, on some anterior legs also at distal end of tibia.

Gonopod aperture just wide enough to accommodate gonocoxae, 1/3–1/2 ring 7 prozonite width. Gonopod telopodites (Figs 2B, 3C, D) straight, parallel, reaching leg 7 bases when retracted; sternite between leg 7 bases slightly excavate. Rounded, transverse ridge just anterior to aperture on either side, the two ridges nearly confluent medially.

Gonocoxa short, the anterodistal surface with low, ridge-like protuberance bearing sparse, long setae on distal side. Prefemur large, C-shaped, the distal end projecting posterolaterally as rounded extension reaching ca 1/4 telopodite height; numerous long setae on posterior and posteromedial surfaces of prefemur. Cannula small, arising

from gonocoxa apex. Telopodite beyond prefemur without branches, the basal half straight and slightly expanded distally; at ca 2/3 telopodite height, telopodite flattening slightly and curving anterolaterally, then constricting and bending sharply anteriorly, curving mediodistally and flattening further, the apical margin rounded distally with lateral margin produced as small triangle. Prostatic groove (Fig. 3C, D) running straight on medial surface of basal half of telopodite beyond prefemur, then following bends and curves of telopodite to open at tip of apical triangular projection.

Female without leg modifications; epigynum ca 1/4 ring 2 width, very slightly raised medially in small rounded triangle; cyphopods not examined.

Distribution. So far known only from the type locality, a farm ca 50 km southeast of Darwin in the monsoon tropics of Australia (Fig. 4).

Name. Latin *medius*, "middle", + *locus*, "place", for the type locality, Middle Point; noun used as adjective.

Remarks. I am tentatively assigning this species to *Brochopeltis* not only because the gonopods are similar, but because *B. mediolocus* sp. n. and *B. mjoebergi* share two features which I have not yet noted in other Australian Antichiropodini. One is the lifting and extension of the lateral collum margins as paranota. The second possible synapomorphy is the pronounced dorsal thickening of paranotal margins.

The types were collected on a farm and it is possible that *B. mediolocus* sp. n. is not locally native, but has been introduced to Middle Point from elsewhere in tropical Australia. The only previous record of Paradoxosomatidae from the northern portion of the Northern Territory (Australia's "Top End") is of the introduced Asian species *Orthomorpha coarctata* (De Saussure, 1860) in urban Darwin (Jeekel 1982).

Acknowledgements

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Supplementary material 1

Specimen records

Authors: Robert Mesibov

Data type: Tab Separated Value File (TSV)

Explanation note: Specimen records of *Brochopeltis* species as of 15 April 2015.

ZooKeys 504: 75–91 (2015)
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http://zookeys.pensoft.net

RESEARCH ARTICLE

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The male of *Megacormus granosus* (Gervais, 1844) with comments on its hemispermatophore (Scorpiones, Euscorpiidae)

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Abstract

The male of *Megacormus granosus* is described for the first time and the female redescribed. A homology scheme proposed recently is applied to hemispermatophore structures. The specimens were collected in an oak forest from Pico de Orizaba Volcano at an average altitude of 2340 m. All adult males were collected by pitfall traps, whereas all adult females and both sex immatures were collected using Berlese funnels, suggesting that males are comparatively more mobile within the leaf litter layer, probably due to mating season.

Keywords

Euscorpiidae, Orizaba, Veracruz, Mexico

Introduction

The Mexican genus *Megacormus* (Karsh, 1881) is comprised of four species, *M. granosus* (Gervais, 1844); *M. segmentatus* Pocock, 1900; *M. gertschi* Díaz Nájera, 1966 and *M. grubbsi* Sissom, 1994. All species of *Megacormus* are restricted to the slopes of the Sierra Madre Oriental and the costal lowlands of the Gulf of Mexico, ranging in altitude from

300 m to over 2300 m. They prefer habitats with high relative humidity such as oak, oak-pine and evergreen tropical forest, and are found in these communities within the leaf litter, outcrop crevices, decaying logs or under rocks. Their distribution includes the states of Hidalgo, Oaxaca, Puebla, Querétaro, San Luis Potosí, Tamaulipas, and Veracruz (Sissom 2000).

Megacormus granosus was originally described as a species of *Scorpio* Linnaeus, 1758 from a single female (Soleglad 1976), but its description and illustrations became obsolete as more scorpion diversity was discovered. The only character used to define this species was the dense granulation on the cuticular dorsal surfaces (Figures 1, 2). The second described species of the genus was *M. segmentatus* Pocock, 1900, distinguished by the presence of a distinct furrow between the pectinal marginal and median lamella, which is absent in *M. granosus*. Subsequently *M. segmentatus* was considered as a subspecies of *M. granosus* by Hoffmann (1931). The third species, *M. gertschi*, was diagnosed by having a greater number of trichobothria on the patella prolateral surface and the presence of scalloping on pedipalp chela fingers. The first comprehensive revision of these taxa was done by Soleglad (1976), who recognized three species by reverting *M. granosus segmentatus* status to its original designation as *M. segmentatus.* Sissom (1994) added a fourth species and illustrated for the first time the hemispermatophores of *M. grubbsi* and *M. segmentatus*, but to date the hemispermatophore of *M. granosus* has never been documented. Although Sissom's (1994) extended descriptions, diagnoses and key to the species of *Megacormus* are in use, variation of diagnostic characters, *i.e.* trichobothrial counts, pectinal counts, etc., are not documented appropriately due to the paucity of specimens in scientific collections, except perhaps for *M. gertschi* (Sissom 1994) and in this contribution *M. granosus*.

The hemispermatophore constitutes one of the most informative character systems in suprageneric phylogenetic studies, at least in Bothriuridae Simon, 1880 and Vaejovidae Thorell, 1876 (Mattoni et al. 2011, González-Santillán and Prendini 2014); it has shown little value in diagnosing species of Euscorpiidae (Jacob et al. 2004) or Diplocentridae (Santibañez-López and Francke 2013) however. These results are congruent with the prediction of Song and Bucheli (2010) and the hypothesis of Peretti (2010), that the complex interaction of genitalic functional units is informative at several levels of the phylogeny and taxonomic hierarchy, but structures in related species that perform the same function tend to have the same selective pressure, thus presenting little variation. The hemispermatophore of the genus *Megacormus* is putatively informative (Sissom 1994: p. 269, figures 8–10), but its microstructure has never been studied in detail.

The unsatisfactory working terminology and concomitant absence of homologies in the hemispermatophore of the Order Scorpiones have promoted a plethora of nomenclatures, hindering the correct interpretation of homologies (Lamoral 1979, Stockwell 1989). Recently, González-Santillán and Prendini (2013, 2014) consolidated a terminology used by previous authors (Stockwell 1989, Sissom 1994), upon

which they established a homology scheme for the hemispermatophore of the subfamily Syntropinae (Vaejovidae). In this contribution we extend that terminology and homologies to the scorpion family Euscorpiidae Laurie, 1896, when possible, applying it to the hemispermatophore of *M. granosus*.

Methods

All scorpions were collected by sifting leaf litter processed with Berlese funnels and pitfall traps. Specimens are deposited in the Laboratorio de Aracnología de la Facultad de Ciencias, Universidad Nacional Autónoma de México (UNAM), Mexico. Measurements in mm were taken with an ocular micrometer. Illustrations were produced with a Nikon SMZ 1000 dissecting stereomicroscope and a Nikon Eclipse E200 with a camera lucida. Photomicrographs were taken with a digital camera Nikon DS-U3 under LED illumination and Ultraviolet (UV) light using a 20W Techno Lite® bulb mounted in a desktop stand lamp. Hemispermatophores were digested with pancreatine (Alvarez-Padilla and Hormiga 2007), cleared with clove oil and mounted in temporary slides for illustration (Coddington 1983).

Nomenclature follows Stahnke (1970) except for pedipalp and metasomal carination, leg setation, spinules and the hemispermatophore, which follows González-Santillán and Prendini (2013), and some capsular terminology used by Jacob et al. (2004) for the genus *Euscorpius*, the putative sister group of *Megacormus*. Pedipalp chela dentition is modified from Soleglad and Sissom (2001) by recognizing six denticle types: retrolateral (Rl), retrolateral accessory (Reac), median (Me), median accessory (Meac), prolateral (Pl) and prolateral accessory (Prac). Prolateral and retrolateral translucent macrosetae delimit 10 positions denoted by roman numerals (Position I–X, Figures 12, 13), where a set or subset of those denticles are localized, following the illustration in González-Santillán and Prendini (2013, fig. 12). Hemispermatophore abbreviations are as follow: cap, capsule; c-lp, crown-like process; dl, distal lamina; dsp, dorsal spiculate process; dt, dorsal trough; t, trunk; tf, truncal flexure; vsp, ventral spiculate process; vt, ventral trough.

Locality description

Specimens were collected in a 15–20-year old oak forest near the boundary of the Pico de Orizaba National Park ca. two kilometers southwest from Atotonilco de Calcahualco, Veracruz. Two plots, of one hectare each, were established with the following central coordinates. Plot I 19°8'17.4"N, 97°12'16.2"W, altitude 2,300 m. Plot II 19°8'30.2"N, 97°12'21.5"W, altitude 2388 m. Three expeditions were conducted, two in May 21–30 th and October 4–14th 2012 and the third in February 15–24th 2013.

Results

Systematics

Family Euscorpiidae Laurie, 1896
Genus *Megacormus* Karsch, 1881

***Megacormus granosus* (Gervais, 1844)**

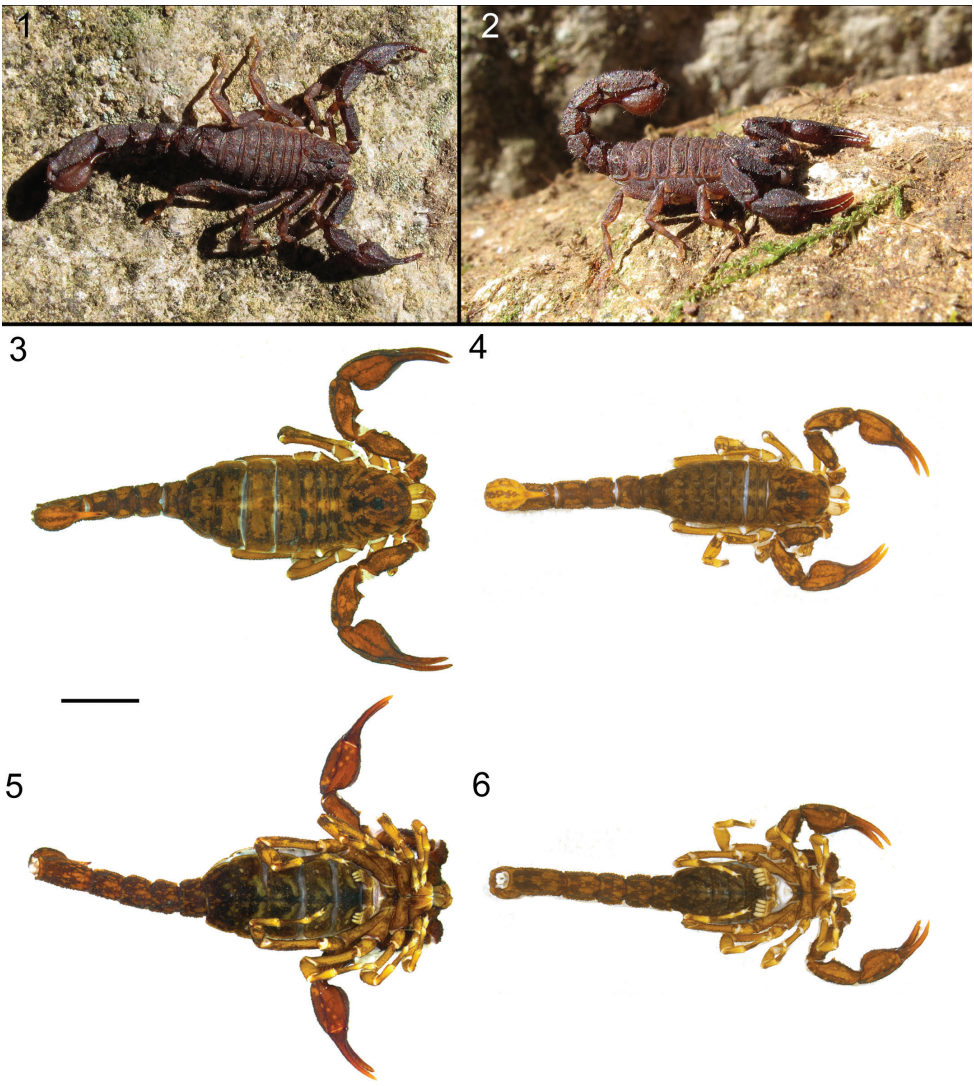
Scorpio granosus Gervais 1844a: 233; 1844b: 65.
Chactas granosus: Karsch 1879: 111.
Megacormus granosus: Karsch 1881: 17; Kraepelin 1894: 151; 1899: 162; Pocock 1900: 417; 1902: 18: Borelli 1909: 224; Werner 1935: 285; Hoffmann 1938: 317; Stahnke 1973: 113; Díaz Nájera 1975: 4.

Type material. MEXICO: Holotype female, depository unknown (Sissom 2000).

Diagnosis. *M. granosus* is most similar to *M. segmentatus* by sharing pedipalp chela fingers margin straight lacking proximal notch and median lobe; nineteen trichobothria on patella retrolateral and seven on ventral surface. It can be separated from *M. segmentatus* by having entirely densely granular surfaces on the femur, patella, tibia dorsal surfaces, prolateral leg surfaces, carapace, and tergites (Figures 1, 2), instead of having scattered fine granulation. *M. granosus* is distinguished from *M. gertschi*, *M. grubbsi*, and *M. segmentatus* by having the marginal and median lamella indistinguishable in females and vestigial in males, instead of having median lamella furrow in both sexes deep, completely separating marginal from median lamella. Males of *M. granosus* have pedipalp chela fingers margin straight, but the male pedipalp fingers margin of *M. gertschi* and *M. grubbsi* are emarginated, bearing a proximal notch and median lobe that creates a gap when fingers close. *M. granosus* has three trichobothria in series *et*, *em*, and six in *v*, whereas *M. gertschi* has four, five and eight in *et*, *em* and *v* respectively; and *M. grubbsi* has four in *em*.

Redescription. The following redescription supplements Soleglad's (1976) description and is based on 10 adult males, 3 adult females, 2 subadult females, 1 subadult male, 8 juvenile females and 4 juvenile males. Character variation is reported for the sexes as noted.

Color and infuscation: Base color yellowish to orange. Carapace: tergites, prolateral surface of legs, sternum, genital operculum, pectinal basal piece, fused lamella, metasoma, and telson, with dense, marbled infuscation (Figures 3–6). Chelicerae: manus base color yellowish with reticulated longitudinal infuscation, fingers moderately infuscate proximally. Pedipalps: base color orange with fuscous markings, all carinae densely infuscate. All trichobothrial bases with a bright yellowish areola. Legs: retrolateral surface yellowish. Spiracles light beige. Pectinal teeth whitish to light beige. Sternite III median and submedian surface densely infuscate, sternite IV–VII median carina infuscate, other surface immaculate. Telson vesicle ventral surface with three broad bands of infuscation flanking two submedian bands of yellowish base color, all surface infuscate dorsally. Aculeus base faintly infuscate, reddish distally.



Figures 1–6. *Megacormus granosus* (Gervais, 1844). **1** ♂ habitus alive **2** ♂ habitus alive **3, 4** habitus, dorsal ♀ and ♂ **5, 6** habitus ventral ♀ and ♂. Scale bar 2.0 mm.

Chelicerae: Manus dorsal surface smooth, lustrous, with three macrosetae distally, decreasing in size from median to lateral surface. Movable finger, retrolateral margin with subdistal and medial denticles triangular, subequal; distal and basal denticle slightly larger; prolateral margin with three smaller, triangular, subequal denticles, situated in distal half of the finger; retrolateral distal finger size half of prolateral distal finger. Fixed finger margin with three denticles, proximal two adjacent and distal separate; distal denticle elongate and sharp (Figure 7); ventral surface of manus, fixed and movable finger with an interspaced tuff of setae with curved tips. Serrula absent.

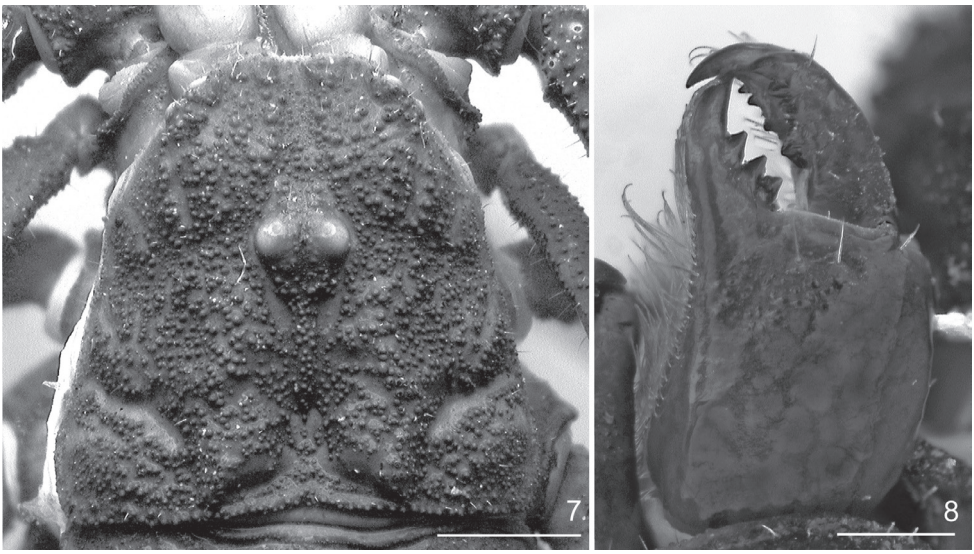
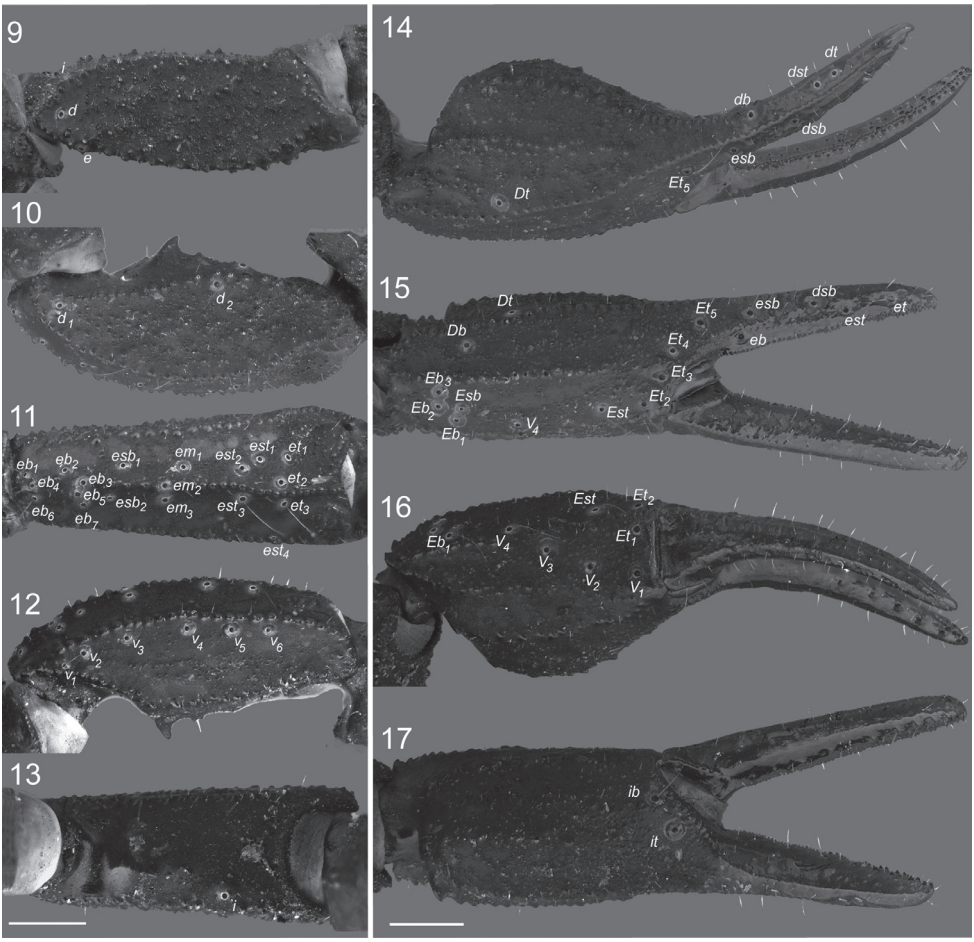


Figure 7, 8. *Megacormus granosus* (Gervais, 1844). **7** dextral chelicera, dorsal view **8** dorsal carapace. Scale bar: 0.5 mm (**7**), 1 mm (**8**).

Carapace: Length equal to 0.9 times the posterior width. Surface shagreened, with enlarge scattered granules covering entire surfaces (Figure 8). Distal margin with two pairs of macrosetae; emarginated, bilobed, with a shallow median notch, with extreme lateral sides curving placing lateral ocelli in a laterofrontal position. Two pairs of lateral ocelli of equal size, lateral ocular carinae strong, costate-granular. Median ocular tubercle raised, situated in anterior half of carapace. Superciliary carinae strongly (♀) or weakly (♂) granular, lower than median ocelli. Anteromedian sulcus deep and broad, with scattered granules; posteromedian, proximal half with a granular carina and distal half with a deep and broad depression; anterolateral, deep and narrow; posterior transverse shallow.

Coxosternal region: Sternum pentagonal, subequilateral, length equal to 0.8 times the width, with five to ten pairs of microsetae. Median sulcus of sternum with anterior and posterior margins broadened, moderately deep (♂), or very deep (♀). Coxa IV two and half times longer than coxa II. Coxae I–IV surfaces with scattered granules and margins densely granular; coxa II, prolateral subproximal margin with three oblique slit-like structures, adjacent to a moderate (♀) or low (♂) granular protuberance; coxae II–IV, prolateral carinae strongly granular (Figures 20, 21).

Pedipalps, Femur prolateral, dorsal and retrolateral intercarinal surfaces shagreened (Figure 9), ventral surface with a cluster of fine granules medially. Dorsal prolateral, dorsal retrolateral, ventral prolateral and dorsal prolateral carinae complete, irregularly granular; retrolateral dorsosubmedian complete, weak proximally, becoming strongly granular distally; retrolateral ventral and ventral median carinae vestigial, reduced to few granules proximally; ventral retrosubmedian partial, with a scattered enlarged granules on proximal half; prolateral ventral vestigial, one or two median granules;

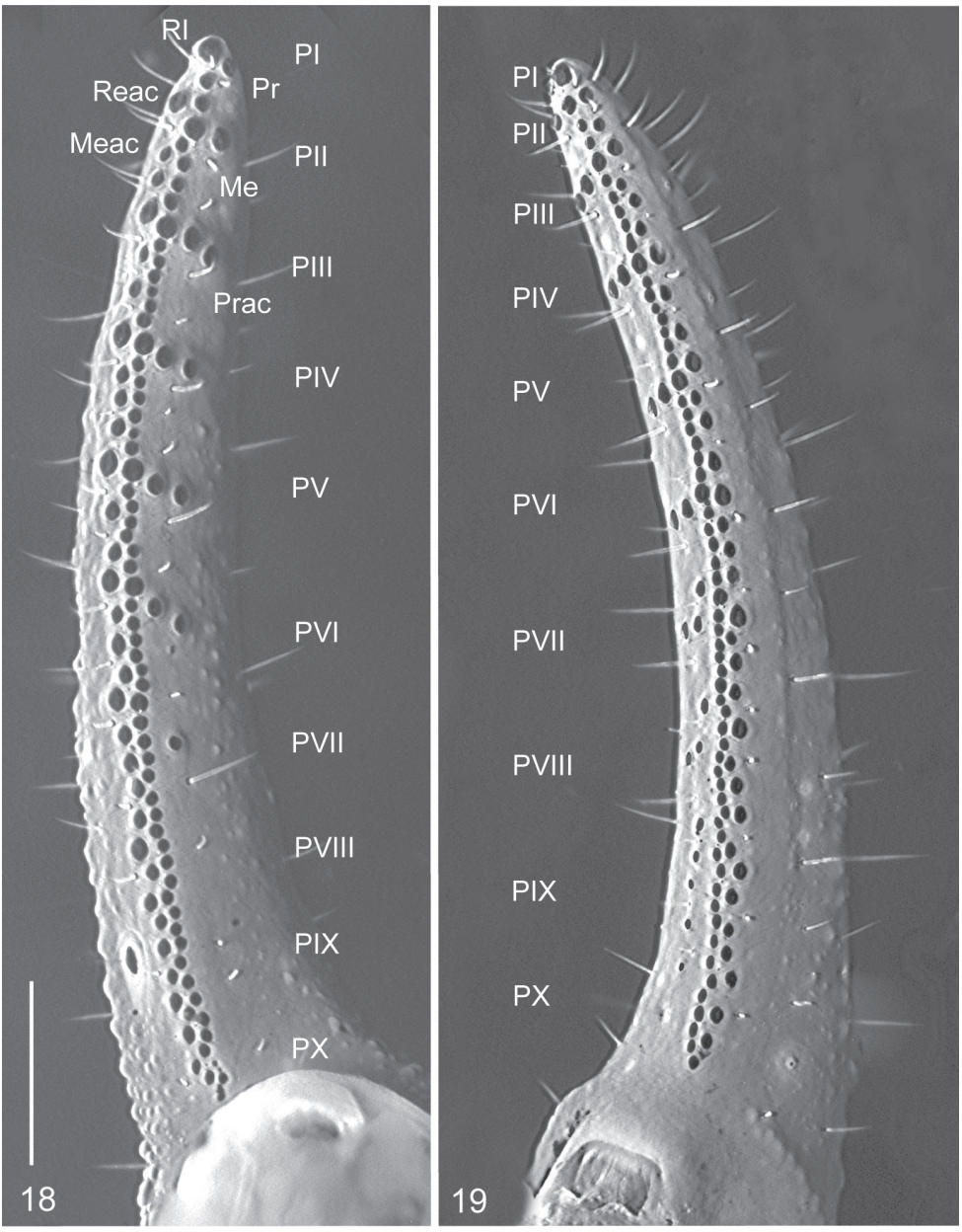


Figures 9–17. *Megacormus granosus* (Gervais, 1844). **9** dextral femur, dorsal view **10–13** dextral patella, dorsal, retrolateral, ventral and prolateral views **14–17** dextral chela, dorsal, retrolateral, ventral and prolateral views. Scale bars 0.5 mm.

prolateral ventrosubmedian partial, with enlarged granules on proximal fifth. Patella width 1.5 times greater than femur width. Dorsal intercarinal surfaces shagreened, prolateral, retrolateral, and dorsal sparsely finely granular. Dorsal prolateral, dorsal retrolateral, ventral prolateral, ventral retrosubmedian, and retrolateral median complete, granular; retrolateral dorsosubmedian absent; prolateral process reduced, expressed as a spiniform enlarged tubercle, prolateral median carina vestigial, expressed by one or two median granules (Figures 10–13). Chela length 1.9 times greater than femur and patella, width 1.6 times greater than patella and 1.1 than femur. Dorsal intercarinal surfaces shagreened, a dense field of minute and coarse granules subdistally, other surfaces with scattered minute and coarse granules. Dorsal retrolateral carina complete, strongly granular, extending to proximal four-fifths of the fixed finger, becoming weaker and smooth distally; dorsal retrosubmedian accessory vestigial, irregularly gran-

ular, restricted to trichobothrium *Dt*; dorsal median and dorsal retrosubmedian with an enlarged proximal tubercle, complete, irregular, granular forming two rows proximally, converging into a single row distally; prolateral dorsal, dorsal prosubmedian and dorsal prolateral, fused, irregular, with five to seven scattered granules proximally, minute and coarse granules medially, and coarse granules extending to fixed finger to the extent of trichobothrium *dsb*; retrolateral dorsal partial, minute granules on median two quarters; retrolateral dorsosubmedian vestigial, restricted to distal short row of coarse granules between trichobothria Et_4 and Et_5; retrolateral median complete, strongly granular, ending at the level of trichobothria Et_3 and Et_4; retrolateral subventral accessory and retrolateral subventral vestigial, restricted to a distal short row of coarse granules converging to trichobothrium Et_2, commonly merging to ventral retrolateral carinae; retrolateral ventral partial, irregular, with minute granules restricted by trichobothria *Esb* and *Est*; ventral retrolateral complete, strongly granular, in some specimens forming a ring of granules around trichobothrium V_4; ventral median partial, strongly granular proximally, becoming weak medially and merging with a field of granules distally, ventral retrolateral and ventral median forming an acute angle proximally, becoming parallel medially to distally; ventral prolateral and prolateral ventral complete, merging to a low tubercle proximally, multiple rows of granules curving to prolateral condyle distally; prolateral ventral accessory partial, restricted to midpoint of the manus as a multiple row of minute and coarse granules, prolateral median partial, irregular, coarse granules row restricted to proximal half (Figures 14–17). Pedipalp fixed and movable fingers: notches, lobes, and gap when fingers closed absent; dentate margin sublinear, compound, with multiple rows of prolateral, median and retrolateral denticles; prolateral, prolateral accessory, retrolateral and median denticles aligned in an oblique row angling retrolaterally in position III–VI. Fixed finger median row comprising six or seven denticle subrows with, commonly two, occasionally one denticle in position I, four to six in position II–VII; flanked by a two- or three-denticle retrolateral accessory median subrow, absent in position I; median subrows divided by six or seven retrolateral denticles, indistinguishable from median subrows' denticles in position VII/VIII–X; median accessory subrows divided by five or six subpaired retrolateral accessory denticles, absent on I and undistinguishable from median accessory denticles subrows on VII/VIII–X; flanked by six or seven prolateral denticles and a subpaired prolateral accessory denticles in position III–VI, absent on I and II, vestigial to absent on VII–X. Movable finger median denticle row comprising six or seven median denticle subrows, zero to one in position I, three to seven in positions II–IX, zero on X; flanked by a two- or three-denticle median accessory denticles subrows, absent in position I; median subrows divided by seven to eight retrolateral denticles, indistinguishable in position IX and X, and median accessory subrows divided by six to seven subparied retrolateral accessory denticles, absent in position I, undistinguishable in position VII–X; flanked by nine prolateral denticles, position III–X subparied by prolateral accessory denticles, lower and less defined in positions VIII–X (Figures 18, 19).

Trichobothrial pattern Type C, neobothriotaxic. Femur trichobothria *d*, *e*, and *i* positioned proximally, equidistant; *d* on dorsal surface, *e* on ventral prolateral carina,



Figures 18, 19. *Megacormus granosus* (Gervais, 1844). **18** dextral pedipalp movable finger **19** dextral pedipalp fixed fingers. Scale bars 0.5 mm.

i ventral to dorsal prolateral carina (Figure 9). Patella trichobothria d_1 and d_2 on dorsal surface proximal and medial respectively; *i* on prolateral distal half, ventral to dorsal prolateral carina; eb_1–eb_4, and eb_5–eb_6 dorsal to retrolateral median carina; esb_1, em_1, est_1, et_1, et_2 and eb_5–eb_7, esb_2, em_3, est_3, et_3 dorsal and ventral to retrolateral median cari-

na respectively, esb_2, petite, em_2 on retrolateral median carina, v_1–v_6 proximal to ventral retrosubmedian carina (Figures 10–13). Variation in trichobothrial counts as follow: series *v*, 2 specimens, 5 left/5 right; 14, 6/6; 1, 6/5; 1, 7/7; *et*, 16, 3/3; 1, 3/2; *est*, 13, 4/4; 2, 3/4; 1, 3/3; *em*, 15, 3/3; 1, 3/2; *esb*, 15, 2/2; 1, 2/1. Chela trichobothrium *Db* on retrolateral surface between dorsal retrolateral and retrolateral dorsal carinae; *Dt* on dorsal surface at distal end of dorsal retrosubmedian accessory carina; series *db–dt* on dorsal and *db* on retrolateral surface, between denticle positions VIII and IX; series *eb–et* on retrolateral surface, *eb* between position VIII and IX; *esb* between positions VI and VII; *est* between positions V and VI, *et* at position IV; Eb_1–Eb_3 on retrolateral surface, between retrolateral median and ventral retrolateral carinae; *Esb* petite, proximal to Eb_1; Et_1 on dorsal surface close to retrolateral condyle, Et_2–Et_5 on retrolateral surface, Eb_2–Eb_4 on distal margin of manus, Eb_4 not petite, Eb_5 on base of movable finger; V_1–V_3 on dorsal surface, equidistant, V_4 on ventral retrolateral carina; *ib* and *it* on distal margin of fixed finger (Figures 14–17).

Legs: Basitarsi, prolateral ventral and retrolateral ventral spinule rows partial, distal half with two or three sparse spinules on legs I–III, absent on leg IV; retrolateral and retrolateral dorsal rows absent on I–IV; macrosetal counts on legs I–IV, respectively: dorsal 2:2:2:2, retrolateral dorsal, 2:2:3:3; retrolateral ventral, 5:5:5:5; prolateral ventral, 4:4:4:4, all macrosetae not pigmented, translucent and shaped as tines; dorsal and retrolateral dorsal macrosetae arranged in two separate parallel rows on legs I–IV. Telotarsi I–IV, each with single irregular ventromedian row of scattered spinules and one ventrodistal spinule, flanked by prolateral and retrolateral rows of six macrosetae. Ungues short and curved.

Genital operculum: Wider than long, with four (♂) or six (♀) pairs of short and translucent macrosetae; sclerites free longitudinally, anterior margin fused on distal two thirds (♂) or fused longitudinally by a loose pleura folding into a valve covering the genital opening (♀). Genital papillae present, protruding posteriorly (♂) or absent (♀) (Figures 20, 21).

Hemispermatophore: Distal lamina 1.1 times the length of trunk; tapering distally, basal constriction well-developed (Figures 26–28). Capsule's dorsal and ventral troughs strongly sclerotized, merging into a complete, thick, transverse plate, dividing lamina and trunk (Figure 28). Marginal terminus of dorsal and ventral troughs with a spiculate processes with 25 and 24 irregular spines [in part Sissom's (1994) accessory lobes], respectively. Hemi-mating plug gelatinous. Sperm duct formed by a spicule-coated membrane (*sensu* Jacob et al. 2004) connected to the spiculate processes of the dorsal and ventral troughs and to the crown-like process (*sensu* Jacob et al. 2004). Trunk broad proximally, tapering distally; crown-like process relatively long, with row of six to eight irregular spinules on the margin; truncal flexure and dorsal axial carinae well-developed (Figures 26–28).

Pectines: Basal piece with three or five pairs of macrosetae, proximal surface granular, V-shaped (♂) or isosceles trapezoidal (♀). Marginal and median lamellae nearly fused into one piece with a fine, shallow furrow (♂), or completely fused, indistinguishable

Figures 20–25. *Megacormus granosus* (Gervais, 1844). **20** ♂ dorsal coxosternal region, genital operculum, pectines, and sternites III–VI **21** ♀ pectines and genital operculum **22** telson lateral view **23–25** metasomal segments I–V dorsal, lateral, and ventral view. Scale bars: 0.5 mm, except Figure **21**: 0.25 mm.

furrow (♀). Fulcra absent. Pectinal teeth: three to four (♂) or one to four (♀). Pectines relatively short, fused lamella aligned with midpoint of coxa IV (Figures 20, 21).

Tergites: I–VI, intercarinal surfaces shagreened, densely covered with minute and coarse granules, posterior margin with rows of irregular granules (Figures 1 and 2); dorsal median and dorsal lateral carinae partial, costate-granular, restricted to proximal half (♂) or vestigial (♀). VII, intercarinal surfaces shagreened; dorsal median carina partial, restricted to anterior half of segment, costate-granular; dorsal sublateral carinae vestigial, comprising few serrate granules restricted to anterior half of segment; dorsal lateral and lateral median carinae converging anteriorly, serrate, posterior granules enlarged.

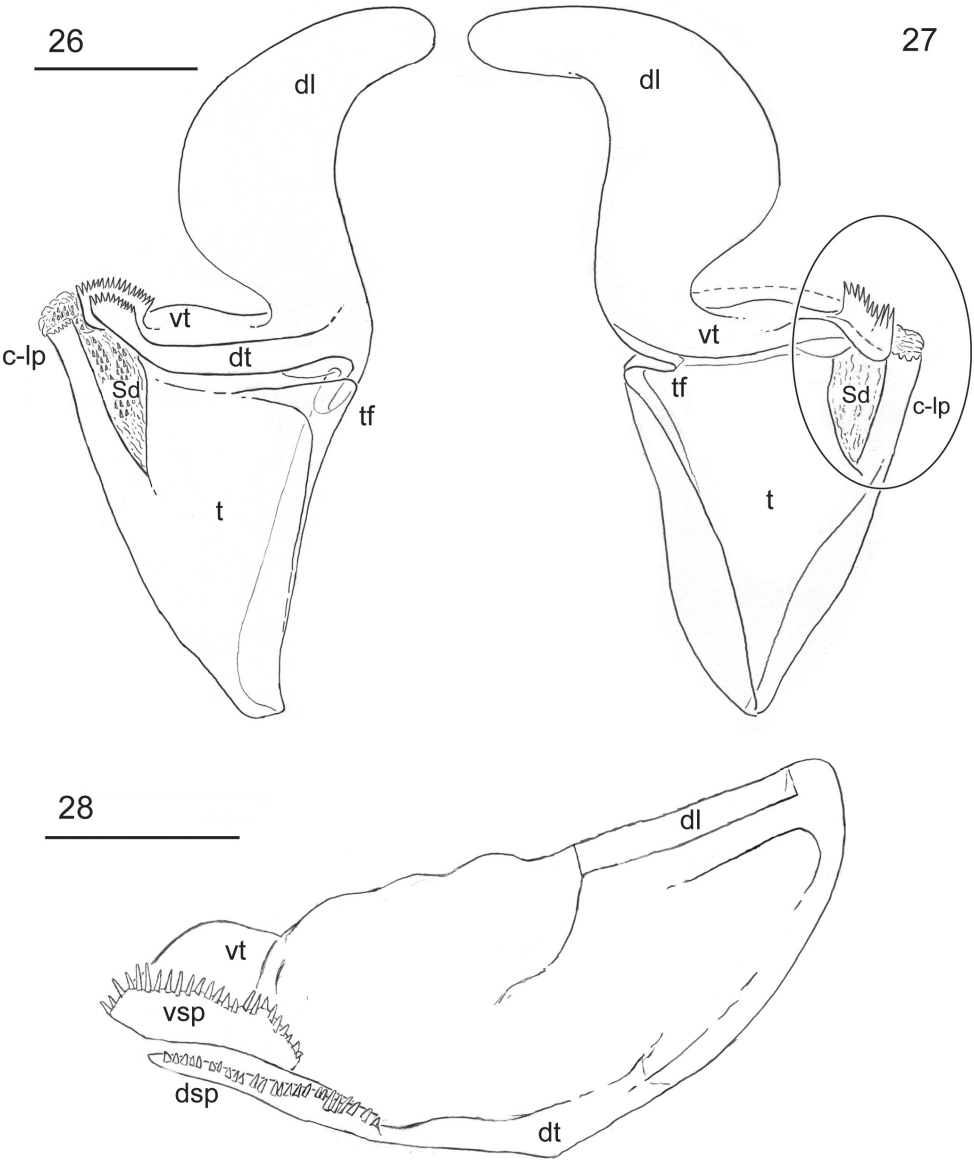


Figure 26–28. *Megacormus granosus* (Gervais, 1844). **26** ♂ dextral hemispermatophore dorsal view **27** hemispermatophore ventral view **28** transverse plate of dorsal and ventral troughs cross section view. Scale bars: 0.5 mm (**26, 27**); 0.2 mm (**28**).

Sternites: Sternite III, surface around pectines shagreened; sternites IV–VI, surfaces smooth to weakly granular medially, shagreened laterally; spiracles minute, ovoid, 2.0 times longer than wide; sternite V, ventral surface distinct hyaline glandular area posteromedially, densely cover with micropores (♂) or absent (♀) (Figure 20). Sternite

VII, intercarinal surfaces shagreened, without hyaline glandular area posteromedially; carinae obsolete, except ventral median, variable from a row of weak granules to coarse granules medially; ventrolateral with a row of coarse granules medially.

Metasoma: Length 0.9 times greater than mesosomal length (Table 1); segment I, 0.6; II, 0.7; III, 0.8; IV, 1.2; and V, 2.1 length greater than width; segment V width 0.9 times greater than telson width. Segments I–V, dorsal intercarinal surfaces scattered, finely granular, lateral and ventral shagreened. Dorsal lateral carinae complete, strongly serrate; lateral median carinae complete, serrate on I–III, weakly lobate posteriorly on IV, partial, reduced to anterior half, irregular scattered granules on V. Lateral inframedian carinae complete, with scattered, coarse granules on I, partial, granular, restricted to posterior half on II and III, vestigial and restricted to a posterior marginal tubercle on IV, absent on V. Ventral lateral carinae complete, serrate. Ventral submedian carinae vestigial, restricted to a marginal paired tubercle posteriorly on I–IV, absent on V. Ventral median carina complete, strongly serrate on I–V (Figures 23–25). Macrosetal counts on carinae of segments I–V, respectively: dorsal lateral, 4:4:4:5:7; lateral median, 4:4:5:5:3; lateral inframedian, 4:2:2:1:0; ventral lateral, 3:3:3:3:2; ventral sublateral, 0:0:0:0:1; ventral submedian, 3:3:3:3:4.

Telson: Vesicle globose, length 1.4 times greater than width (Table 1); dorsal surface with finely punctuated and scattered minute granules (♂) or smooth (♀); ventral surface scattered with minute and coarse granules, carinae obsolete, with four or five pairs of short translucent macrosetae, annular ring moderately developed (Figure 22). Aculeus, fairly elongated, laterobasal microserration and subaculear tubercle absent, venom delivery openings slit-like, paired.

Distribution. *Megacormus granosus* has been reported in the vicinities of the National Park Pico de Orizaba, on the slopes of the Trans-Mexican Volcanic Belt facing the Gulf of Mexico, and between Orizaba and Huatusco, Veracruz.

Ecology. All adult males were collected by pitfall traps, suggesting high motility within the leaf litter. They were particularly abundant in the May 2012 expedition. This behavior in males and the period of the year may be related to the mating season of the species. All adult females and immatures of both sexes were collected exclusively using Berlese funnels, suggesting these are comparatively less mobile. A total of 72 Berleses and 180 pitfalls were used to sample two hectares, of which 18 (25%) and 11 (5%), caught 18 and 9 specimens respectively. These yields are consistent with low population density of this species; adult males are particularly rare. The habitat of, and behavior exhibited by, this species as well as its cryptic morphology (color resembling substrate; relative small size) are congruent with a humiculous ecomorphotype (Prendini 2001).

Remarks. The catalog of the scorpions of the world (Fet et al. 2000) indicates that the location of *M. granosus* type material is either unknown or lost. It is important to investigate the whereabouts of Gervais' unique specimen to verify the holotype, or failing this, to designate a neotype. Workable keys to the species of *Megacormus* are provided in Sissom (1994). The genus *Megacormus* is under revision by O.F. Francke (per. comm.).

Table 1. Measurements (mm) of six adult males and three females of *Megacormus granosus* (Gervais, 1844).

		♂/♂/♂/♂/♂/♂/♀/♀/♀
Carapace	length	3.40/3.25/3.20/3.00/3.25/3.15/4.20/4.30/3.90
Anterior	width	2.00/1.80/1.80/1.60/1.80/1.75/2.40/2.50/2.35
Posterior	width	3.60/3.35/3.35/3.20/3.35/3.25/4.40/4.20/4.25
	length	2.70/2.65/2.70/2.45/2.60/2.55/3.30/3.60/3.05
Femul	width	1.10/1.00/0.95/0.90/1.00/1.00/1.30/1.30/1.30
	height	2.80/2.80/2.60/2.60/2.85/2.65/3.50/3.80/3.35
Patella	width	1.40/1.25/1.40/1.30/1.40/1.30/1.90/1.80/1.80
Chela	length	5.30/5.20/5.05/4.70/5.15/5.00/6.50/7.10/6.4
Manus	width	1.70/1.60/1.55/1.50/1.55/1.50/2.20/2.30/1.95
	height	1.40/1.20/1.35/1.05/1.45/1.15/1.70/1.70/1.75
Fixed finger	length	2.30/2.30/2.30/2.15/2.20/2.15/3.00/3.00/2.80
Movable Finger	length	3.00/2.95/3.00/2.70/2.85/2.85/3.90/4.10/3.75
Coxa II	length	1.30/1.35/1.25/1.20/1.40/1.25/1.50/1.70/1.75
Coxa IV	length	2.70/2.55/2.60/2.45/2.55/2.40/3.40/3.60/3.40
Sternum	length	0.80/0.70/0.70/0.65/0.75/0.85/1.00/0.90/1.05
Sternum	width	0.90/0.90/0.90/0.90/0.85/0.70/1.00/0.70/1.15
Mesosoma	length	5.20/4.70/5.35/4.35/5.30/4.90/7.00/7.70/6.80
Metasoma	length	8.50/4.48/4.60/4.23/4.30/4.10/8.60/9.10/4.25
	length	0.90/1.00/1.10/1.10/1.05/1.00/1.00/1.20/1.05
Segment I	width	2.00/1.95/1.95/1.65/1.95/1.80/2.10/2.20/2.10
	height	1.70/1.50/1.60/1.50/1.55/1.60/1.70/1.70/1.85
	length	1.20/1.20/1.25/1.25/1.15/1.10/1.20/1.20/1.30
Segment II	width	1.90/1.85/1.85/1.60/1.75/1.70/1.90/2.00/1.90
	height	1.70/1.35/1.55/1.40/1.35/1.45/1.50/1.70/1.65
	length	1.40/1.35/1.40/1.45/1.30/1.20/1.30/1.30/1.30
Segment III	width	1.80/1.75/1.75/1.60/1.70/1.65/1.80/1.90/1.80
	height	1.60/1.30/1.55/1.40/1.40/1.35/1.50/1.60/1.65
	length	1.80/1.90/1.95/1.65/1.80/1.80/1.90/1.90/1.75
Segment IV	width	1.70/1.60/1.65/1.50/1.55/1.50/1.60/1.70/1.60
	height	1.70/1.40/1.55/1.40/1.50/1.35/1.50/1.60/1.60
	length	3.20/3.50/3.50/3.00/3.30/3.10/3.20/3.50/3.10
Segment V	width	1.50/1.60/1.65/1.45/1.55/1.45/1.50/1.50/1.55
	height	1.60/1.25/1.50/1.35/1.45/1.25/1.40/1.50/1.55
Telson	length	4.20/3.90/4.25/3.80/4.00/3.80/4.50/4.50/4.30
	length	2.90/2.25/2.45/2.30/2.35/2.20/2.90/2.60/2.30
Vesicle	width	1.90/1.65/1.65/1.55/1.70/1.50/1.50/1.60/1.50
	height	1.30/1.30/1.45/1.35/1.35/1.30/1.30/1.30/1.25
Aculeus	length	1.30/1.65/1.80/1.50/1.65/1.60/1.60/1.90/2.00
Total	length	21.30/16.33/17.40/15.38/16.85/15.95/24.30/25.60/19.25

Discussion

The illustrations of the *M. granosus* hemispermatophore presented in Figures 26 and 27 are congruent with that of Stockwell (1989: p. 381, figure 217), but differ from that of Sissom (1994: p. 269, figures 8–10), who illustrate accessory lobes associated to the sperm duct (Sissom's *acc*, figure 8). According to our findings, the accessory lobes are the termini of both the dorsal and ventral trough margins with a spiculate process (Figures 26, 27) and are not independent lobes as suggested by Sissom's illustration (Figure 28). Furthermore, the basic conformation of the sperm duct, with the spicule-coated membrane and the crown-like process, appears to be uniform in these species. Although intra- and inter-specific comparative work is needed, we hypothesize that the capsular region of the hemispermatophore of *Megacormus* might carry little information to diagnose species of the genus, as demonstrated in other species complexes (Jacob et al. 2014, Santibañez-López and Francke 2010) and predicted by other studies (Song and Bucheli 2010, Peretti 2010).

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Thysanoptera of Bulgaria

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Abstract

The present checklist includes data on the species composition, geographic distribution and feeding preferences of thrips species in Bulgaria. In total, 155 species in 48 genera are listed. Of these, 125 species belong to suborder Terebrantia and include 103 species of 33 genera in family Thripidae, 14 species of two genera in Aeolothripidae, seven species of two genera in Melanthripidae and one species in Fauriellidae. In suborder Tubulifera, 30 species of 10 genera in the single family Phlaeothripidae are listed. Of the 155 Bulgarian thrips species, 87.7% are phytophagous, 4.5% are obligate predators, 5.8% are mycophagous and 1.9% are with unknown feeding preferences. Fourteen pest species are listed for Bulgaria, of which *Frankliniella occidentalis*, *Thrips tabaci* and *Haplothrips tritici* are of economic importance. The list provides detailed information on the horizontal and vertical distribution of Thysanoptera in 5 regions and 45 subregions of Bulgaria. The present paper also includes an evaluation of the biodiversity of Thysanoptera and the extent to which each region of the country has been studied.

Keywords

Thysanoptera, Bulgaria, checklist, geographic distribution, feeding preference

Introduction

Bulgaria is located on the Balkan Peninsula and extends from the western shore of the Black Sea to Serbia and Macedonia to the west. It lies in the transitional area between the contrasting continental and Mediterranean climatic zones. Its varied relief and the peculiar characteristics of its weather contribute to its biotope diversity. According to the

Palaearctic classification (Devillers et al. 2001), 977 distinct habitats from all hierarchical types occur in Bulgaria, 96 of which are unique to the country. This richness of habitats on a relatively small area is a prerequisite for a diverse thysanopteran fauna.

At present, the Bulgarian entomofauna is insufficiently studied and it has been estimated that about 51% of the insect species are known. More than 29 000 species of superclass Hexapoda have been established and it is expected that if rigorous research is performed, their number would increase to 56 000 (Hubenov 2005).

Thrips are small and slender insects that generally feed on plant sap, fungal spores and some on them are predators of small arthropods. Until now about 6000 species have been described worldwide (ThripsWiki 2015). Some are pests of agricultural crops and ornamentals, causing damage to plants either by feeding or via transmission of plant viruses, pathogenic bacteria and fungi.

The biodiversity of thrips on the Balkans has been studied more extensively in Romania (Vasiliu-Oromulu 1998) and Serbia (Andjus et al. 2008) with 215 and 155 reported species respectively. Information is scarce on the thysanopteran fauna in the other neighbours of Bulgaria: Greece, Macedonia and the European part of Turkey. After considering the climate and the number of described species of superclass Hexapoda in Bulgaria's neighbours and on the European continent as a whole, Hubenov (1996) claimed that there should be about 250 species of thrips in the country.

The thysanopterological activities in Bulgaria began at the end of the 19th century. The first thrips species recognised in the country, *Thrips urticae*, was recorded on tobacco (Manushev 1897). Malkov recorded *Limothrips cerealium* and a year later *Thrips tabaci* (Malkov 1902, 1903), and *Limothrips denticornis* was recorded on rye and barley (Dospevski 1910). Following these, *Haplothrips reuteri*, *Aeolothrips fasciatus*, *Haplothrips tritici*, *Heliothrips haemorrhoidalis* and *Thrips atratus* were recorded (Chorbadjiev 1929). In 1958, the Czech entomologist Pelikán conducted a study of the Bulgarian thrips fauna. He was the first to report 13 species of Aeolothripidae, described a new genus and species of Fauriellidae, *Ropotamothrips buresi*, and two years later recorded *Melanthrips paspalevi* and *Melanthrips titschacki* from Bulgaria (Pelikán 1960a, 1960b).

In the late 60's, thrips research became more active. Janev (1968 and 1973) reported 22 species. In 1967, Genov reported two *Haplothrips* species on alfalfa. Donchev (1968, 1972, 1976, 1984, 1993 and 1996) contributed to the Bulgarian thrips fauna with a series of publications, recording 33 species. Vesselinov (1968, 1976) recorded eight species; and. Popov (1973) recorded four thrips species found on medicinal plants which were new to the fauna of Bulgaria. Moreover, Popov (1976; 1982a, 1985; 1988) carried out extensive research on the diversity of thrips in Ograzhden mountain and reported 22 further species. He was also the first to document the Bulgarian tree-living thysanopteran fauna, reporting another 13 species from the country (Popov 1982b). Schliephake (1982) reported *Thrips fedorovi* from this country.

Trenchev (1991) reported *Frankliniella occidentalis* in Bulgaria, and Trenchev and Karadjova (1992) reported its distribution and host plants in Bulgarian greenhouses. In 1996, after revision of microscope slides, the record of *Anaphothrips armatus* was cancelled because the reference specimens turned out to represent *Rubiothrips*

ferrugineus (Zur Strassen 1996). *Echinothrips americanus* was first reported in 2003 by Karadjova and Krumov. A recent contribution to the arboreal thrips fauna of Bulgaria is the report of the mulberry thrips, *Pseudodendrothrips mori*, on the leaves of *Morus alba* (Trenchev and Trencheva 2007). Jenser and Krumov (2009) newly reported nine species. Krumov (2013) reported *Idolimothrips paradoxus* and *Iridothrips iridis* for the first time for the fauna of Bulgaria.

The main aim of this paper is to summarize all published data on thrips from Bulgaria in order to present a full list of known thrips taxa from the entire area of the country. Until now, no comprehensive review of the Bulgarian thrips fauna has been published. The present list includes 125 species of suborder Terebrantia and 30 species of suborder Tubulifera, and provides detailed information on the horizontal and vertical distribution of Thysanoptera in Bulgaria. It is complemented by an evaluation of the biodiversity and the extent to which each region of the country has been studied. The territorial distribution of thysanopteran species is crucial for the understanding of their biology and adaptations to different habitats. Such knowledge is of basic importance to explain the introduction and spread of exotic species, particularly pest species (Marullo and Grazia 2013). Another aim of the paper is to present information on the feeding preferences of thrips in Bulgaria: whether they are predatory, mycophagous or phytophagous and what plant species they have been collected from. This is important in order to understand the role of thrips in ecosystems, to ascertain which plants support phytophagous thrips (Mound and Marullo 1996), to evaluate their pest potential and to assess the impact of different thrips species on populations of other organisms within crops and natural non-cultivated areas

Material and methods

The list was prepared after a thorough review of all available publications and individual samples collected by the authors. The review includes all 37 scientific papers on the thysanopteran fauna in Bulgaria, published from 1897 to 2013. The list is arranged systematically and the nomenclature follows ThripsWiki (2015). Genera are listed alphabetically within each family or subfamily, and species are similarly listed within each genus. Each species account includes its taxonomic name, references, locality records within Bulgaria, altitudinal range (in m.a.s.l), plants on which adults have been found, and whether predatory, mycophagous or phytophagous. The geographic regions of Bulgaria and their abbreviations used in the text follow the division of Hubenov (1997), developed for the purposes of faunistic research. It does not consider the administrative territories but rather uses characteristics such as relief and local climatic conditions. The division includes five major territories, further split into subregions. The subheading "Distribution" for each species refers only to localities within Bulgaria.

B Black Sea Coast**:**
BN Northern Black Sea Coast,

BS Southern Black Sea Coast.
D Danubian Plain**:**
DE Eastern Danubian Plain:
DEL Ludogorie–Dobrudja District,
DEP Popovo–Provadiya District,
DM Middle Danubian Plain,
DW Western Danubian Plain,
P Transitional Region:
PB Tundja–Strandja Subregion:
PBB Bakadjik–Burgas District,
PBC Sakar Mts.,
PBD Strandja–Dervent District,
PBS Strandja Mts,
PBT Sakar–Tundja District
PK Kraishte–Konyavo District:
PKG Golo Bardo Mts.,
PKK Kraishte,
PKQ Konyavska Planina Mts.,
PKR Rui Mts.,
PKV Verila Mts.,
PKZ Zemenska Planina Mts.
PS Srednogorie–Podbalkan Subregion:
PSA Sredna Gora,
PSC Sashtinska Sredna Gora Mts.,
PSI Ihtimanska Sredna Gora Mts.,
PSL Lozenska Planina Mts.,
PSP Podbalkan Basins,
PSS Sredna Gora Mts.
PT Thracian Lowland
PV Vitosha District:
PVL Lyulin Mts.,
PVP Plana Mts.,
PVS Sofia Basin,
PVV Vitosha Mts.,
PVW Viskyar Mts.
R Rila–Rhodope Massif**:**
RO Osogovo–Belasitsa Group:
ROB Belasitsa Mts.,
ROG Ograzhden Mts.,
ROM Maleshevska Planina Mts,
ROO Osogovska Planina Mts.,
ROP Krupnik–Sandanski–Petrich Valley,
ROS Srednostrumska Valley,

ROT Boboshevo–Simitli Valley,
ROV Vlahina Planina Mts.
RP Rila–Pirin Group:
RPM Mesta Valley,
RPP Pirin Mts.,
RPR –Rila Mts.,
RPS Slavyanka Mts.,
RPT Stargach Mts.
RR Rhodope Mts.:
RRE Eastern Rhodope Mts.,
RRW Western Rhodope Mts.
S Stara Planina Range**:**
SP Predbalkan (Pre-Balkan or foothills north of Stara Planina Mts.):
SPW Western Predbalkan,
SPM Middle Predbalkan,
SPE Eastern Predbalkan
SB Stara Planina (Balkan) Mts:
SBW Western Stara Planina Mts.,
SBM Middle Stara Planina Mts.,
SBE Eastern Stara Planina Mts.

Suborder Terebrantia Haliday

Four families of this suborder are recorded from Bulgaria: Aeolothripidae, Melanthripidae, Fauriellidae and Thripidae. Thripidae is the largest family and includes the most economically important pest species.

Family Aeolothripidae Uzel

The family includes 190 extant species in 23 genera worldwide (ThripsWiki 2015). The adults and larvae of many representatives of this family appear to be facultative predators of small arthropods, although some species are almost certainly solely phytophagous (Tyagi et al. 2008). In the warmer parts of the world, a considerable number of species in family Aeolothripidae are obligate predators (Hoddle 2003). In Bulgaria, 14 species belonging to two genera have been recorded.

Aeolothrips albicinctus Haliday, 1836

Distribution. DM – Krushovitsa (160 m). Obligate predator residing at the collar of grasses, collected from *Festuca aerudinacea* (Donchev and Tomov 1996).

Aeolothrips astutus Priesner, 1926

Distribution. DM – Krushovitsa; **ROP** – Kresna, Parvomai, Petrich, Samuilova krepost; **RPR** – Rila Monastery (150–300 m). Phytophagous and facultative predator, collected from *Anchusa* sp., *Echium vulgare*, different grasses (Pelikán 1958, Donchev 1968, Popov 1982a).

Aeolothrips balati Pelikán, 1958

Distribution. RPP – Pirin (below Banderitsa) (1600 m). Predator, found in alpine meadows (Pelikán 1958).

Aeolothrips collaris Priesner, 1919

Distribution. BN – Obzor; **BS** – Primorsko, Rosen, Ropotamo; **DM** – Krushovitsa; **PVP** – Pancharevo; **ROB** – Belasitsa; **ROP** – Samuilova krepost; **ROT** – Simitli; **RPP** – Banderitsa; **RPR** – Rila Monastery; **SBE** – Sinite Kamani (0–1810 m). Phytophagous and facultative predator, collected from *Achillea compacta*, *Alyssum montanum*, *Brassicaceae* species, *Campanula* sp., *Castanea sativa*, *Clematis vitalba*, *Colutea arborescens*, *Coronilla varia*, *Euphorbia* sp., *Medicago sativa*, *Onobrychis sativa*, *Paliurus aculeatus*, *Senecio* sp., *Symphytum* sp., *Trifolium pratense* (Pelikán 1958, Donchev 1976, Popov 1976, 1982a).

Aeolothrips ericae Bagnall, 1920

Distribution. BS – Ropotamo; **PBC** – Topolovgrad; **PSP** – Sliven; **PVP** – Pancharevo; **ROG** – Karnalovo; **ROP** – Parvomai, Petrich; **ROT** – Blagoevgrad; **RPP** – Banderitsa; **RPR** – Partizanska poliana, Rila Monastery; **RRW** – Chaira, Smolyan lakes; **SBW** – Lakatnik (0–1810 m). Phytophagous and facultative predator, collected from *Astragalus* sp., *Coronilla emerus*, *C. varia*, *Daphne cneorum*, *D. oleoides*, *Fabaceae* species (flowers), *Lotus corniculatus*, *Syringa vulgaris*, *Tropaeolum majus*, grassy vegetation in forests (Pelikán 1958, Yanev 1973, Donchev 1976, Popov 1976, 1982a).

Aeolothrips fasciatus (Linnaeus, 1758)

Distribution. DEL – Ruse, Obrazov chiflic; **PVL** – Lyulin Monastery; **PVS** – Sofia basin; **ROG** – Karnalovo, Nikudin; **ROP** – Petrich, Samuilova krepost; **ROT** – Blagoevgrad; Rila; **RP** – Predela – Gradevo; **RPP** – Dolnoto breznichko ezero; **RPR** – Ribni ezera; **RRW** – Golyam Beglik dam (100–2230 m). Phytophagous and facultative

predator, collected from *Brassica napus*, *Cannabis sativa*, *Cytisus* sp., *Helianthus annuus*, *Nicotiana tabacum*, *Rosa* sp., *Trifolium pratense*, *Zea mays*, grasses and shrubs in forests (Chorbadzhiev 1929, Yanev 1973, Popov 1976, 1982a, 1982b).

Aeolothrips gloriosus Bagnall, 1919

Distribution. ROP – Kresna (170 m). Phytophagous and facultative predator, collected from *Clematis vitalba* (Jenser and Krumov 2009).

Aeolothrips intermedius Bagnall, 1934

Distribution. BS – Mandra lake, Primorsko; **DM** – Pleven – Chaira, Krushovitsa; **PBB** – Karnobat; **PT** – Stara Zagora; **PVP** – Pancharevo; **PSL** – Gorni Lozen; **PVS** – Kostinbrod, Opitsvet, Svetovrachane; **ROB** – Belasitsa Mts.; **ROP** – Petrich; **ROT** – Simitli; **RPP** – Banderits); **RPR** – Rila Monastery; **SBE** – Sinite kamani; **SBM** – Beklemeto, Troyan (0–1810 m). Phytophagous and facultative predator, collected from *Beta vulgaris*, *Campanula* sp., *Echium vulgare*, *Galium* sp., *cereals*, *Hordeum vulgare*, *Lathyrus sativus*, *Lotus corniculatus*, *Medicago sativa*, *Melilotus officinalis*, *Onobrychis sativa*, *Sinapis arvensis*, *Solanum dulcamara*, *Soja hispida*, *Trifolium incarnatum*, *T. repens*, vegetation of grasses and shrubs (Pelikán 1958, Genov 1967, Donchev 1968, 1972, Yanev 1973, Popov 1982a).

Aeolothrips melaleucus Haliday, 1852

Distribution. DM – Pleven-Chaira; **PVP** – Pancharevo; **PSP** – Sliven; **ROG** – Churicheni, Markovi Kladentsi (150–1530 m). Obligate predator, collected from leaves of *Castanea sativa*, *Crataegus* sp., *Fraxinus* sp, *Ligustrum* sp., *Quercuss* sp., *Sambucus* sp., *Solanum dulcamara*, *Sorbus* sp. (Pelikán 1958, Donchev 1968, Popov 1982a).

Aeolothrips priesneri Knechtel, 1923

Distribution. PVP – Pancharevo (600–800 m). Unknown feeding preferences, collected from *Euphorbia* sp. (flowers) (Pelikán 1958).

Aeolothrips propinquus Bagnall, 1924

Distribution. BS – Ropotamo; **ROP** – Petric); **ROT** – Simitli; **RPR** – Rila Monastery (0–1150 m). Phytophagous and facultative predator, collected from *Anchusa officinalis* (Pelikán 1958).

***Aeolothrips versicolor* Uzel, 1895**

Distribution. BS – Ropotamo; **ROB** – Belasitsa Mts.; **RPR** – Rila Monastery (0–1150 m). Obligate predator, collected from leaves of *Castanea sativa* (Pelikán 1958).

***Aeolothrips vittatus* Haliday, 1836**

Distribution. ROG – Ograzhden Mts. (100–1530 m). Predator of arthropods, collected from *Pinus* sp. (Popov 1985).

***Rhipidothrips gratiosus* Uzel, 1895**

Distribution. DM – Krushovitsa; **PBB** – Karnobat; **PK** – Breznik valley; **PVS** – Prolesha, Svetovrachane (170–760 m). Phytophagous (Marullo and Grazia 2013) and facultative predator (Bailey 1954), collected from *Avena sativa*, *Hordeum vulgare*, *Onobrychis sativa*, *Triticum aestivum* (Donchev 1968, 1972, 1976, Yanev 1973).

Family Melanthripidae Bagnall

This family includes 65 species of four genera. All representatives feed on flowers, but the distribution of the genera is remarkably fragmented (ThripsWiki 2015). In Bulgaria, 7 species of two genera have been recorded.

***Ankothrips niezabitowskii* (Schille, 1910)**

Distribution. PVV – Cherni vrah; **SBW** – Belidie han (735–2290 m). Phytophagous, collected from *Juniperus communis*, *J. procumbens* (Popov 1982b).

***Melanthrips acetosellae* John, 1927**

Distribution. BS – Ropotamo; **RPR** – Rila Monastery; **PSP** – Sliven (0–1150 m). Unknown feeding preferences (Pelikán 1958).

***Melanthrips fuscus* (Sulzer, 1776)**

Distribution. DEP – Makariopolsko; **DM** – Krushovitsa; **PVS** – Suhodol; **PVP** – Pancharevo; **ROG** – Churicheni; **ROP** – Petrich; **RPM** – Bany); **SBE** – Sinite kamani

(155–1000 m). Phytophagous, collected from *Onobrychis sativa*, *Rosa* sp., *Sinapis arvensis*, *Syringa vulgaris*, grassy vegetation (Pelikán 1958, Yanev 1973, Donchev 1976, Popov 1982a, 1982b).

Melanthrips knechteli Priesner, 1936

Distribution. BS – Ropotamo (0 m). Phytophagous, collected from forest and steppe vegetation (Pelikán 1958).

Melanthrips pallidior Priesner, 1919

Distribution. BS – Mandra lake, Primorsko, Rosen, Ropotamo; **DEP** – Makariopolsko; **DM** – Krushovitsa, Obnova, Pordim, Vulchi trun; **DW** – Vidin; **PVP** – Pancharevo; **PVS** – Opitsvet, Trebich; **ROG** – Churicheni; **ROP** – Petrich; **RPP** – Banderitsa; **RPR** – Borovec, Rila Monastery; **SBE** – Sinite kamani; **SBW** – Lakatnik; **SPW** – Botevgrad (0–1810 m). Phytophagous, collected from *Agrostemma githago*, *Campanula* sp., *Colutea arborescens*, *Coronilla varia*, *Cruciferous* species, *Echium vulgare*, *Latirus tuberosus*, *Lotus corniculatus*, *Medicago sativa*, *Onobrychis sativa*, *Symphytum* sp., *Trifolium incarnatum*, *T. repens*, *Veronica spicata*, blooming grasses (Pelikán 1958, Donchev 1968, 1972, 1976, Yanev 1973, Popov 1982a).

Melanthrips paspalevi Pelikán, 1960

Distribution. SBE – Sinite kamani; **SBW** – Lakatnik (550–950 m). Phytophagous, collected from steppe vegetation (Pelikán 1960b).

Melanthrips titschacki Pelikán, 1960

Distribution. BS – Ropotamo; **PVP** – Pancharevo; **ROB** – Belasitsa Mts.; **RPP** – Banderitsa; **SBE** – Sinite kamani (0-1810 m). Phytophagous, collected from steppe and forest vegetation, mixed populations with *Melanthrips pallidior* (Pelikán 1960a).

Family Fauriellidae Priesner

Five species belonging to four genera have been described worldwide but very little is known about them (ThripsWiki 2015). In Bulgaria, only one species has been reported.

***Ropotamothrips buresi* Pelikán, 1958**

Distribution. BS – Ropotamo (0 m). Unknown feeding preferences (Pelikán 1958) According to zur Strassen (2003) *R. buresi* is possibly associated with *Artemisia*.

Family Thripidae Stephens

This family includes 1970 species in 287 genera worldwide, systematized in four subfamilies: Dendrothripinae, Panchaetothripinae, Sericothripinae and Thripinae (ThripsWiki 2015). Most of the species are phytophagous (Mound 2002), but a few are obligate predators (Mound 2011). *F. occidentalis* and *T. tabaci* are polyphagous pests but also behave as facultative predators in some regions (Wilson et al. 1996), and the genus *Aulacothrips* includes five species that are ectoparasitic on Hemiptera (Cavalleri et al. 2013, Cavalleri and Kaminski 2014). In Bulgaria, 103 species from 33 genera have been recorded.

Subfamily Dendrothripinae Priesner

***Dendrothrips degeeri* Uzel, 1895**

Distribution. ROB – Belasitsa; **ROG** – Churicheni; **ROP** – Kulata, Petrich; **RPP** – Pirin Mts.; **RPR** – Rila Mts. (85–1490 m). Phytophagous, collected from *Abies alba*, *Corylus avellana*, *Fagus sylvatica*, *Morus alba*, *Ostrya carpinifolia* (Popov 1985, 1988).

***Dendrothrips ornatus* (Jablonowski, 1894)**

Distribution. PVS – Sofia; **ROB** – Belasitsa Mts.; **ROP** – Petrich; **ROT** – Blagoevgrad; **RPP** – Pirin Mts.; **RPR** – Rila Mts.; **SPW** – Belidie han (360–1490 m). Phytophagous, plant pest, collected from *Alnus alba*, *A. incana*, *Syringa* sp., *S. vulgaris*, *Tilia* sp. (Veselinov 1976, Popov 1982b, 1988).

***Dendrothrips phillireae* (Bagnall, 1927)**

Distribution. ROP – Damyanitsa (120 m). Phytophagous, found on *Phillyrea media* (Popov 1982b).

***Dendrothrips saltator* Uzel, 1895**

Distribution. ROG – Divechova polyana; ROP – Sandanski (270-1150m). Phytophagous, found on *Alnus alba*, *Tamarix* sp. (Popov 1982a, 1982b).

***Pseudodendrothrips mori* (Niwa, 1908)**

Distribution. DW – Butan (60 m). Phytophagous, pest species on leaves of *Morus alba* (Trenchev and Trencheva 2007).

Subfamily Panchaetothripinae Bagnall

***Heliothrips haemorrhoidalis* (Bouche, 1833)**

Distribution. glasshouses: **PT** – Plovdiv, Pazardjik; **PVS** – Sofia basin; **ROP** – Petrich; **ROT** – Blagoevgrad. Phytophagous, pest of *Cucumis sativus*, leaves of ornamentals – *Citrus* sp., *Cyclamen* sp., *Fuchsia* sp., *Orchis* sp., *Rhododendron* sp. (Chorbadzhiev 1929, Elenkov and Hristova 1974, Atanasov et al. 2005).

Subfamily Sericothripinae Karny

***Neohydatothrips abnormis* (Karny, 1910)**

Distribution. DM – Komudara, Krushovitsa; **DEL** – Obrazov chiflic; **PBB** – Yambol; **ROG** – widespread in Ograzhden Mts.; **RPR** – Borovets, Musala peak; **SPM** – Gorsko Slivovo (160 – 2925 m). Phytophagous, collected from *Lotus corniculatus*, *Medicago sativa*, *Trifolium* sp., *Vicia* sp. (Donchev 1976, Popov 1982a).

***Neohydatothrips gracilicornis* (Williams, 1916)**

Distribution. DM – Krushovitsa; **PBB** – Karnobat; **PT** – Plovdiv; **ROG** – widespread in Ograzhden Mts.; **ROB** – Drangovo; **ROP** – Kresna, Samuilovo; **RPM** – Banichan; **RPP** – Predela – Gradevo, Dobrinishte (130 – 845 m). Phytophagous, collected from flowers of *Medicago sativa*, *Onobrychis sativa*, *Prunus* sp., *P. mahaleb*, *P. spinosa*, *Quercus petraea*, *Quercus* sp., *Soja hispida*, *Vicia* sp. (Donchev 1968, 1976; Popov 1976, 1982a, 1982b).

***Sericothrips bicornis* (Karny, 1910)**

Distribution. ROG – widespread Ograzhden Mts. (200–1000 m). Phytophagous, collected from *Lotus corniculatus*, *Trifolium* sp., *Vicia* sp. (Popov 1982a).

***Sericothrips staphylinus* Haliday, 1836**

Distribution. PVV – Bistritsa, Ostrica, Shevovitsa, Zheleznitsa; **ROG** – Karnalovo, Nikudin, Dolene (150–1640 m). Phytophagous, collected from *Bromus arvensis*, *Corylus avellana*, *Festuka elatior*, *Oxalis* sp., *Prunus cerasus*, *P. communis*, *P. domestica*, *P. persica*, *P. sativa*, *P. spinosa* (Yanev 1968, Popov 1982a, 1982b).

Subfamily Thripinae Stephens

***Anaphothrips euphorbiae* Uzel, 1895**

Distribution. ROG – Churicheni, Divechova polyana; **SBM** – Beklemeto, Troyan (300–1360 m). Phytophagous, collected from *Euphorbia rupestris*, *E. myrsinites*, *Galium* sp. (Donchev 1968, Popov 1982a).

***Anaphothrips obscurus* (Muller, 1776)**

Distribution. DM – (Krushovitsa); **PVP** – Pancharevo; **PT** – Pazardzhik; **PVV** – Simeonovo; **ROG** – widespread in Ograzhden Mts.; **ROT** – Blagoevgrad; RPP – Predela) (160–1000 m). Phytophagous, collected from *Avena sativa*, *Holcus lanatus*, *Hordeum* sp., *Medicago* sp., *Onobrychis sativa*, *Trifolium pratense*, *Triticum aestivum*, mixed Poaceae (Veselinov 1968, Donchev 1976, Popov 1976, 1982a).

***Aptinothrips elegans* Priesner, 1924**

Distribution. PVS – Obelya (500 m). Phytophagous, collected from *Triticum aestivum* (Veselinov 1968).

***Aptinothrips rufus* Haliday, 1836**

Distribution. PVV – Dragalevci; **PVP** – Pancharevo; **ROG** – Churicheni, Divechova polyana; **ROP** – Samuilova krepost (150–1150 m). Phytophagous, collected from *Avena sativa*, *Bromus* sp., *Hordeum* sp. (Veselinov 1968, Popov 1982a).

***Aptinothrips stylifer* Trybom, 1894**

Distribution. RRW – Studenets, Rock bridges (1450–1735 m). Phytophagous, collected from *Agrostis* sp., *Alopecurus* sp., *Dactylis glomerata* (Donchev 1993).

***Asphodelothrips croceicollis* (Karny, 1914)**

Distribution. ROG – Divechova polyana, Dolene, Markovi kladentsi (400–1535 m). Phytophagous, collected from mixed grass vegetation (Popov 1982a).

***Belothrips morio* O. M. Reuter, 1899**

Distribution. PVV – Kumata, Sredec, Selimitsa; **SBW** – Kom, Vezhen (100–1650 m). Phytophagous, collected from *Gnaphalium* sp., *Pinus montana*, *Rubus idaeus*, *Thymus* sp. (Yanev 1968, Popov 1982b).

***Bregmatothrips dimorphus* (Priesner, 1919)**

Distribution. ROG – Ograzhden Mts. (400–1000 m). Phytophagous, collected from mixed herbaceous vegetation (Jenser and Krumov 2009).

***Chirothrips aculeatus* Bagnall, 1927**

Distribution. PVS – Gorublyane (550 m). Phytophagous, collected from *Avena sativa* (Veselinov 1968).

***Chirothrips manicatus* Haliday, 1836**

Distribution. DM – Krushovitsa; **DEL** – Obraztsov chiflik; **PT** – Plovdiv; **PVP** – Pancharevo; **PVS** – Sofia; **PVV** – Dragalevci, Selimitsa; **ROG** – Nikudin; **SBM** – Beklemeto (130–1360 m). Phytophagous, collected from *Dactylis glomerata*, *Galium* sp., *Lotus corniculatus*, *Medicago sativa*, *Onobrychis sativa*, *Secale cereale*, *Solanum tuberosum*, mixed herbaceous vegetation (Veselinov 1968, Donchev 1968, 1976, Yanev 1973, Popov 1982a, 1982b).

***Chirothrips pallidicornis* Priesner, 1925**

Distribution. RRW – Rock bridges (1450 m). Phytophagous, collected from *Dactylis glomerata*, *Silene* sp. (Donchev 1993).

***Dictyothrips betae* Uzel, 1895**

Distribution. PVV – Aleko, Bistritsa, Dragalevci, Kupena, Rodina, Zheleznitsa; **ROG** – Nikudin; **ROP** – Purvomai, Samuilova krepost (150–1840 m). Phytophagous, collected from *Gnaphalium supinum*, *Juniperus* sp., *Melissa officinalis*, *Rosa* sp., *Salvia glutinosa*, *Silene juvenalis*, *Verbascum blattaria*, mixed herbaceous vegetation (Yanev 1968, Popov 1982a).

***Drepanothrips reuteri* Uzel, 1895**

Distribution. SBW – Berkovitsa; **SPM** – Dryanovo Monastery (410–620 m). Phytophagous, collected from *Parthenocissus* sp. (Popov 1982b).

***Echinothrips americanus* Morgan, 1913**

Distribution. Greenhouses in **BS** – Burgas; **PT** – Plovdiv; **PVS** – Sofia. Phytophagous, plant pest of *Chrysanthemum* sp., *Euphorbia* sp., *Hibiscus* sp., *Impatiens* sp., *Syngonium* sp. (Karadjova and Krumov 2003).

***Frankliniella intonsa* (Trybom, 1895)**

Distribution. DM – Krushovitsa; **PVL** – Lyulin Monastery; **PVP** – Gorni Lozen; **PVS** – Kostinbrod, Svetovrachane; **PVV** – Boyana, Aleko; **ROG** – widespread in Ograzhden Mts.; **RRW** – Trigrad, Smolyan (155–1840 m). Phytophagous, plant pest collected from *Avena sativa*, *Campanula* sp., *Lotus corniculatus*, *Medicago sativa*, *Onobrychis sativa*, *Ranunculus arvensis*, *Trifolium pratense*, *Verbascum* sp., mixed herbaceous vegetation (Genov 1967, Donchev 1968, 1972, Yanev 1968, Yanev 1973, Popov 1982a).

***Frankliniella occidentalis* (Pergande, 1895)**

Distribution. Greenhouses in **BS** – Burgas; **PT** – Plovdiv; **PVS** – Sofia; **ROP** – Petrich; **ROT** – Blagoevgrad; **RPM** – Banya. Phytophagous, plant pest of *Alstromeria* sp., *Calla* sp., *Chrysanthemum* sp., *Cucumis sativus*, *Dianthus* sp., *Gerbera jamesonii*, *Gladiolus* sp., *Petunia hybrida*, *Primula* sp., *Rosa* sp., *Saintpaulia ionantha*, *Solanum lycopersicum* (Trenchev 1991, Trenchev and Karadjova 1992).

***Frankliniella pallida* (Uzel, 1895)**

Distribution. DM – Krushovitsa; **PK** – Breznik valley; **PVV** – Boyana, Dragalevci Simeonovo; ROG – widespread in Ograzhden Mts.; **ROP** – Petrich; **ROT** – Blagoevgrad; **RPR** – Partizanska poliana; **SPM** – Zlatna Panega (155–1500 m). Phytophagous, collected from *Chrysanthemum leucanthemum*, *Coronilla emerus*, *Hypericum perforatum*, *Rumex* sp., *Silene juvenalis*, *Trifolium pratense*, *Xeranthemum* sp., *Viola* sp. mixed herbaceous vegetation (Yanev 1968, Donchev 1976, Popov 1982a).

***Frankliniella tenuicornis* (Uzel, 1895)**

Distribution. DM – Krushovitsa; **PT** – Pazardzhik; **PVS** – Gorublyane; **PVV** – Dragalevtsi; **RPP** – Delchevo; **ROO** – Kyustendil valley – Bagrentsi (155–1025 m). Phytophagous, collected from *Antirrhinum* sp., *Avena sativa*, *Delphinium* sp., *Hordeum vulgare*, *Medicago sativa*, *Triticum aestivum* (Veselinov 1968, Donchev 1968, 1976).

***Idolimothrips paradoxus* Priesner, 1920**

Distribution. PKG – Debeli Lag (600 m). Phytophagous, collected from *Bellis perennis* (Krumov 2013).

***Iridothrips mariae* Pelikán, 1961**

Distribution. PVP – Plana Mts.; **ROG** – valley of river Lebnitsa; **SBW** – Katina (585–1200 m). Phytophagous, collected from *Typha latifolia* (Jenser and Krumov 2009).

***Iridothrips iridis* (Watson, 1924)**

Distribution. DEL – Kalimok-Brushlen Protected Site (25 m). Hygrophilous and phytophagous, found in the leaf sheaths of *Iris pseudacorus* (Krumov 2013).

***Kakothrips dentatus* Knechtel, 1938**

Distribution. DM – Krushovitsa; **ROG** – Churicheni, Dolene (155–1000 m). Phytophagous, collected from *Carduus* sp., *Trifolium* sp. mixed herbaceous vegetation (Donchev 1968, Popov 1982a).

***Kakothrips pisivorus* (Westwood, 1880)**

Distribution. DM – Krushovitsa; **PSL** – Gorni Lozen; **PVV** – Boyana, Cherni vruh, Momina skala, Selimitsa; **ROG** – Divechova polyana (150–2290 m). Phytophagous, collected from *Coronilla varia*, *Lathyrus sativus*, *L. tuberosus*, *Lepidium draba*, *Lotus corniculatus*, *Medicago sativa*, *Onobrychis sativa*, *Pisum sativum*, *Secale cereale*, *Taraxacum officinale*, *T. incarnate*, *Trifolium pratense*, *T. repens*, *Vicia faba*, *V. sativa* (Genov 1967, Donchev 1968, Yanev1968, Popov 1982a).

***Krokeothrips innocens* (Priesner, 1922)**

Distribution. ROG – Karnalovo (150–300 m). Phytophagous, collected from mixed grasses (Popov 1982a).

***Limothrips angulicornis* Jablonowski, 1894**

Distribution. ROG – Churicheni, Karnalovo (150–1000 m). Phytophagous, collected from *Hordeum murinum*, *H. maritimum* (Popov 1982a).

***Limothrips cerealium* Haliday, 1836**

Distribution. PT – Sadovo; **DEL** – Obrazov Chiflic; **DEP** – Popovo, Tutrakan, Preslav; **DM** – Gorna Oryahovitsa, Veliko Tarnovo); **PVS** – Sofia; **ROG** – Churicheni, Dolene Karnalovo (150–1000 m). Phytophagous, plant pest of *Bromus* sp., *Hordeum* sp., *Hordeum vulgare*, *Pisum sativum*, *Triticum aestivum* (Malkov 1902, Dospevski 1910, Popov 1982a).

***Limothrips consimilis* Priesner, 1926**

Distribution. ROP – Samuilova krepost (150–300 m). Phytophagous, collected from *Poa* sp. (Popov 1982a).

***Limothrips denticornis* Haliday, 1836**

Distribution. DEP – Razgrad; **DM** – Chaira, Krushovitsa; **PT** – Sadovo; **PVS** – Sofia,, Kostinbrod, Lokorsko; **PVV** – Aleko, Boyana, Kumata, Malak rezen, Momina skala, Ostrica, Selimitsa, Simeonovo, Trite kladentsi; **ROG** – Karnalovo; RPP – Predela – Gradevo; **RRW** – Smolyan Lakes; **SBM** – Ribaritsa (155–2400 m). Phytophagous, plant pest, collected from *Alopecurus* sp., *Avena sativa*, *Dactylis glomerata*, *Dian-*

thus sp., *Eriophorum gracile*, *Festuca* sp., *Hordeum vulgare*, *Lotus corniculatus*, *Medicago sativa*, *Pinus montana*, *Poa* sp., *P. alpina*, *Rubus* sp., *Secale cereale*, *Solanum dulcamara*, *Triticum aestivum*, *Trifolium pratense*, *Vaccinium vitis idea*, mixed herbaceous vegetation (Dospevski 1910, Donchev 1968, 1976, Veselinov 1968, Yanev 1968, 1973, Popov 1982a, 1982b, Krasteva et al. 2013).

***Limothrips schmutzi* Priesner, 1919**

Distribution. PVV – Boyana, Dragalevtsi, Kaleto, Vladaya, Rudartsi; **RPM** – Banya; **SBW** – Berkovitsa (750–1050 m). Phytophagous, collected from *Alopecurus* sp., *A. montanum*, *Avena* sp., *Avena sativa*, *Crataegus montania*, *Phleum* sp., *Plantago* sp., *Poa alpina*, *Rosa* sp., *Rubus* sp, *Vaccinium vitis-idaea* (Yanev 1968, Popov 1982b).

***Mycterothrips albidicornis* (Knechtel, 1923)**

Distribution. ROG – Markovi Kladentsi (1200–1535 m). Phytophagous, collected from leaves of *Fagus sylvatica* (Popov 1982a).

***Mycterothrips consociatus* (Targioni-Tozzetti, 1886)**

Distribution. ROB – Belasitsa Mts. (600 m). Phytophagous, collected from leaves of *Quercus coccifera* (Popov 1988).

***Mycterothrips latus* (Bagnall, 1912)**

Distribution. ROP – Struma valley – Kresna; **SPM** – Reselets (165–210 m). Phytophagous, collected from leaves of *Sambucus* sp. (Popov 1982b).

***Mycterothrips salicis* (O. M. Reuter, 1879)**

Distribution. PVS – Sofia (500–700 m). Phytophagous, collected from leaves of *Tilia* sp. (Popov 1982b).

***Odontothrips confusus* Priesner, 1926**

Distribution. BN – Obzor; **DEL** – Obrazcov chiflic, Hursovo, Rujitsa; **DM** – Krushovitsa; **PT** – Pazardjik, Plovdiv, Opan; **ROG** – Churicheni; **SPW** – Lilyache (130–300 m). Phytophagous, collected from *Lotus corniculatus*, *Medicago lupulina*, *M. sativa*,

Melilotus albus, *Onobrychis caput-galli*, mixed herbaceous vegetation (Donchev 1968, 1976, Popov 1982a).

Odontothrips cytisi Morison, 1928

Distribution. RPS – Slavyanka Mts. (720–1170 m). Phytophagous, collected from *Cytisus* sp. (Popov 1988).

Odontothrips dorycnii Priesner, 1951

Distribution. ROP – Melnik (437 m). Phytophagous, collected from *Dorycnium germanicum* (Jenser and Krumov 2009).

Odontothrips intermedius (Uzel, 1895)

Distribution. PVV – Momina scala, Planinets (1365–1485 m). Phytophagous, collected from mixed herbaceous vegetation (Yanev 1968).

Odontothrips loti (Haliday, 1852)

Distribution. DM – Valchitran; **PT** – Stara Zagora; **ROG** – Ograzhden Mts., **RPR** – Borovec, Partizanska poliana; **SBM** – Glozhene; **SPM** – Gorsko Slivovo; **SPW** – Botevgrad (155–1350 m). Phytophagous, collected from *Coronilla emerus*, *Fabaceae* species, *Lathyrus* sp., *Lotus corniculatus*, *Medicago sativa*, mixed herbaceous vegetation (Donchev 1972, 1976, Popov 1982a).

Odontothrips meliloti Priesner, 1951

Distribution. DM – Krushovitsa; **ROG** – Churicheni, Karnalovo (150–1000 m). Phytophagous, collected from *Melilotus officinalis*, *Melilotus* sp. (Donchev 1968, Popov 1982a).

Odontothrips meridionalis Priesner, 1919

Distribution. ROG – Churicheni (300–1000 m). Phytophagous, collected from mixed herbaceous vegetation (Popov 1982a).

***Odontothrips phaleratus* (Haliday, 1836)**

Distribution. RPR – Borovets (1350 m). Phytophagous, collected from *Lathyrus* sp., *Lotus corniculatus*, *Medicago sativa*, *Trifolium* sp. (Donchev 1976).

***Oxythrips ajugae* Uzel, 1895**

Distribution. PVV – Kumata, Sredec, Zlatnite mostove; **ROG** – Churicheni, Gorski Dom; **RPP** – Dolno Kornichko ezero; **SBW** – Kom peak, Vezhen peak (300–1650 m). Phytophagous, collected from *Campanula alpina*, *Eriophorum gracile*, *Juniperus communis*, *Pinus montana*, *P. sylvestris*, *Ranunculus montanum*, *Verbascum pannosum* (Yanev 1968, 1973, Popov 1982a, 1982b).

***Oxythrips bicolor* (O. M. Reuter, 1879)**

Distribution. ROG – Divechova polyana, Gorski Dom (1000–1250 m). Phytophagous, collected from *P. sylvestris* (Popov 1982a).

***Oxythrips ulmifoliorum* (Haliday, 1836)**

Distribution. SBW – Belidie Han (735 m). Phytophagous, collected from *Syringa vulgaris* (Popov 1982b).

***Prosopothrips vejdovskyi* Uzel, 1895**

Distribution. SBW – Gintsi (1000 m). Phytophagous, collected from Poaceae (Jenser and Krumov 2009).

***Rhaphidothrips longistylosus* Uzel, 1895**

Distribution. ROG – Nikudin, Gorski Dom (712–1250 m). Phytophagous, collected from *Bromus mollis* (Popov 1982a).

***Rubiothrips ferrugineus* (Uzel, 1895)**

Distribution. SBM – Beklemeto (1360 m). Phytophagous, collected from *Galium* sp. (zur Strassen 1996).

***Rubiothrips silvarum* (Priesner, 1920)**

Distribution. ROG – Churicheni, Divechova polyana (300–1150 m). Phytophagous, collected from mixed vegetation (Popov 1982a).

***Rubiothrips validus* (Karny, 1910)**

Distribution. ROP – Kresna; **SBW** – Gintsi; (165–1000 m). Phytophagous, collected from Rubiaceae and mixed vegetation (Jenser and Krumov 2009).

***Rubiothrips vitalbae* (Bagnall, 1926)**

Distribution. ROP – Kresna (165 m). Phytophagous, collected from *Clematis vitalba* (Jenser and Krumov 2009).

***Scolothrips longicornis* Priesner, 1926**

Distribution. RPR – Yastrebets (2230 m). Predator of mites, collected from leaves of *Genista rumelica* (Donchev 1976).

***Scolothrips uzeli* (Schille, 1910)**

Distribution. ROB – Belasitsa Mts.; **RPR** – Rila Mts.; (800–1490 m). Predator of mites, collected from *Juniperus communis* (Popov 1988).

***Stenothrips graminum* Uzel, 1895**

Distribution. DM – Krushovitsa; **PK** – Breznik valley; **PT** – Pazardzhik; **PVS** – Sofia; **ROG** – Ograzhden Mts.; **RPR** – Yastrebets (155–2230 m). Phytophagous, collected from *Avena sativa*, *Medicago sativa*, *Melilotus officinalis*, *Hordeum vulgare*, *Galium* sp., *Onobrychis sativa*, *Phleum pratense*, mixed Poaceae (Donchev 1968, 1976, Popov 1982a).

***Taeniothrips inconsequens* (Uzel, 1895)**

Distribution. PVV – Aleko, Boerica, Boyana, Konyarnika, Planinets, Selimitsa, Trendafila, Zlatnite mostove; **ROP** – Petrich, Samuilovo; **RPP** – Predela – Gradevo (300–1840 m). Phytophagous, collected from *Ficaria verna*, *Malus sylvestris*, *Mentha*

sp., *Pinus montana*, *Pyrus communis*, *Primula* sp., *Prunus dulcis*, *P. persica*, *P. spinosa*, *Ranunculus aquaticus* (Yanev 1968, Popov 1982, Staneva 1991).

***Taeniothrips picipes* (Zetterstedt, 1828)**

Distribution. DM – Krushovitsa; **ROG** – Divechova polyana, Nikudin; **ROP** – Samuilova krepost; **RPR** – Partizanska polyana; **SBM** – Beklemeto, Troyan (150–1500 m). Phytophagous, collected from *Coronilla emerus*, *Lotus corniculatus*, *Primula* sp., *Trifolium pratense*, *Verbascum* sp. (Donchev 1972, 1976, Popov 1982a).

***Tamaricothrips tamaricis* (Bagnall, 1926)**

Distribution. ROP – Kresna Gorge (300–500 m). Phytophagous, collected from *Tamarix* sp. (Popov 1982b).

***Tenothrips croceicollis* (Priesner, 1919)**

Distribution. DM – Krushovitsa; **RRW** – Studenets (160–1735 m). Phytophagous, collected from *Cichorium intybus*, *Erigeron canadensis*, *Geranium macrorrhizum*, *Hypochaeris radicata*, *Leontodon* sp. *Sonchus arvensis*, *Verbascum* sp. (Donchev 1993).

***Tenothrips discolor* (Karny, 1907)**

Distribution. DM – Krushovitsa (160 m). Phytophagous, collected from *Lotus corniculatus* (Donchev 1976).

***Tenothrips frici* (Uzel, 1895)**

Distribution. DM – Krushovitsa; **PSP** – Tazha; **PVS** – Kostinbrod; **RPR** – Musala peak; **SBM** – Teteven; **SBW** – Botevgrad; **SPW** – Lilyache (160–2925 m). Phytophagous, collected from *Carduus* sp., *Dactylis glomerata*, *Lotus corniculatus*, *Medicago sativa*, *Senecio* sp., *Trifolium pratense* (Donchev 1972, 1976).

***Theilopedothrips pilosus* (Uzel, 1895)**

Distribution. ROG – Dolene, Markovi kladentsi, Divechova polyana (400–1535 m). Phytophagous, collected from mixed herbaceous vegetation (Popov 1982a).

Thrips albopilosus Uzel, 1895

Distribution. RPP – Yavorov; Predela (1050–1740 m). Phytophagous, collected from *Juniperus communis*, *Juniperus* sp. (Popov 1988).

Thrips alni Uzel, 1895

Distribution. ROP – Melnik, Kresna Gorge; RPP – Predela – Gradevo (300–500 m). Phytophagous, collected from *Alnus glutinosa*, *Coylus* sp. (Popov 1988).

Thrips angusticeps Uzel, 1895

Distribution. DM – Krushovitsa, Valchi Tran; **PVV** – Simeonovo; **ROG** – Karnalovo (150–550 m). Phytophagous, collected from *Hordeum vulgare*, *Lotus corniculatus*, *Medicago sativa*, *Onobrychis sativa*, *Sinapis arvensis*, *Triticum aestivum*, mixed herbaceous vegetation (Donchev 1968, 1972, 1976, Veselinov 1968, Popov 1982a).

Thrips atratus (Haliday, 1836)

Distribution. DM – Krushovitsa; **PBC** – Topolovgrad – Hlyabovo; **ROG** – Ograzhden Mts.; **ROT** – Bobochevo); **SPW** (Botevgrad); **RPR** – (Borovec, Musala peak, Partizanska poliana, Rila); **SPM** – (Zlatna Panega) (155–2925 m). Phytophagous, collected from *Centaurium erythraea*, *Genista tinctoria*, *Haberlea rhodopensis*, *Lotus corniculatus*, *Matricaria chamomilla*, *Medicago sativa*, *Nicotiana tabacum*, *Onobrychis sativa*, *Sorghum halepense*, *Thymus* sp., *Trifolium pratense*, *T. repens*, mixed herbaceous vegetation of *Poaceae*, *Fabaceae* (Chorbadzhiev 1929, Donchev 1976, Popov 1982a).

Thrips calcaratus Uzel, 1895

Distribution. PVS – Sofia (500 m). Phytophagous, collected from *Tilia* sp. (Popov 1982b).

Thrips dificilis Priesner, 1920

Distribution. PVP – Kokalyane; **PVS** – Opicvet; **SBM** – Teteven (410–685 m). Phytophagous, collected from *Salix* sp., *S.babylonica*, *S. purpurea* (Popov 1982b).

***Thrips dilatatus* Uzel, 1895**

Distribution. ROG – Divechova polyana, Nikudin (300–1150 m). Phytophagous, collected from mixed herbaceous vegetation (Popov 1982a).

***Thrips discolor* Haliday, 1836**

Distribution. ROG – widespread in Ograzhden Mts. (100–700 m). Phytophagous, collected from mixed herbaceous vegetation (Popov 1982a).

***Thrips euphorbiae* Knechtel, 1923**

Distribution. ROG – Karnalovo (150–300 m). Phytophagous, collected from *Euphorbia* sp. (Popov 1982a).

***Thrips fedorovi* (Priesner, 1933)**

Distribution. no specific location is mentioned. Phytophagous, collected from *Rosa canina*, *Salvia sclarea* (Schliephake 1983).

***Thrips flavus* Schrank, 1776**

Distribution. PT – Sadovo; **RPR** – Borovets, Granchar, Partizanska polyana (155–2185 m). Phytophagous, collected from *Lathyrus aureus*, *Hypericum perforatum*, *Verbascum phlomoides* (Manushev 1897, Donchev 1976).

***Thrips fuscipennis* Haliday, 1836**

Distribution. ROG – valley of river Lebnitsa (700 m). Phytophagous, collected from *Platanus acerifolia*, *P. orientalis* (Jenser and Krumov 2009).

***Thrips italicus* (Bagnall, 1926)**

Distribution. ROG – Nikudin; **ROP** – Samuilova krepost (150–1000 m). Phytophagous, collected from *Bellis* sp., *Chrysanthemum* sp., *Euphorbia* sp., *Matricaria* sp. (Popov 1982a).

***Thrips juniperinus* Linnaeus, 1758**

Distribution. RPP – Yavorov, Popina luka; (1250–1740 m). Phytophagous, collected from *Juniperus communis*, *Juniperus* sp. (Popov 1988).

***Thrips linariae* (Priesner, 1928)**

Distribution. RPR – Partizanska poliana (1500 m). Phytophagous, collected from *Hypericum perforatum*, *Lotus corniculatus*, *Verbascum phlomoides* (Donchev 1976).

***Thrips linarius* Uzel, 1895**

Distribution. DEL – Dobrudja (230 m). Phytophagous, plant pest, collected from *Agrostemma githago*, *Euphorbia* sp., *Linum usitatissimum*, *Sinapis* sp. (Kirkov 1954).

***Thrips major* Uzel, 1895**

Distribution. ROG – Churicheni; **ROP** – Samuilova krepost; **RPM** – Banya; **RPR** – Partizanska polyana; **SBW** – Berkovitsa (150–1500 m). Phytophagous, collected from *Alopecurus agrestis*, *Lotus corniculatus*, *Rosa* sp. (Donchev 1976, Popov 1982a, 1982b).

***Thrips mareoticus* (Priesner, 1932)**

Distribution. ROP – Samuilova krepost (150–300 m). Phytophagous, collected from *Lepidium* sp. (Popov 1982a).

***Thrips meridionalis* (Priesner, 1926)**

Distribution. ROG – Nikudin; **ROP** – Petrich, Samuilova krepost; **ROT** – Blagoevgrad; **SBM** – Beklemeto, Troyan; **RPR** – Granchar, Smradlivoto ezero, Partizanska polyana (150–2295 m). Phytophagous, plant pest, collected from *Asteraceae*, *Campanula* sp., *Cornus sanguinea*, *Coronilla emerus*, *Euphorbia* sp., *Hieracium* sp., *Lotus corniculatus*, *Genista tinctoria*, *Malus domestica*, *Prunus dulcis*, *Prunus persica*, *Prunus spinosa*, *Ranunculus* sp., *Trifolium repens*, *Verbascum phlomoides* (Donchev 1968, 1976, Popov 1976, 1982a, Staneva 1991).

***Thrips minutissimus* Linnaeus, 1758**

Distribution. ROG – Markovi kladentsi (1532 m). Phytophagous, collected from mixed herbaceous vegetation (Popov 1985).

***Thrips nigropilosus* Uzel, 1895**

Distribution. PVS – Gorublyane; **DM** – Komudara (150–550 m) Phytophagous, collected from *Avena sativa*, *Medicago sativa*, *Sorghum halepense* (Veselinov 1968, Donchev 1976).

***Thrips physapus* Linnaeus, 1758**

Distribution. DM – Krushovitsa; **ROP** – Parvomai; **RPR** – Yastrebetz, Grunchar, Smradlivo ezero, Partizanska poliana; **PSP** – Tazha (150–2295 m). Phytophagous, collected from *Cardus* sp., *Euphorbia* sp., *Genista tinctoria*, *Hypericum perforatum*, *Medicago sativa*, *Senecio* sp., *Solanum tuberosum*, *Viola* sp. (Donchev 1968, 1972, 1976; Popov 1982a).

***Thrips pini* (Uzel, 1895)**

Distribution. ROG – Churicheni, Divechova polyana; **RPP** – Predela – Gradevo; **SBM** – Vasilyovo (300–1150 m). Phytophagous, collected from *Asteraceae* plants *Pinus* sp., *P. sylvestris*, *Picea* sp., *Verbascum* sp. (Popov 1976, 1982a, 1985b).

***Thrips sambuci* Heeger, 1854**

Distribution. ROP – Kresna Gorge; **SPM** – Reselets (205–500 m). *Picea* sp., *Sambucus* sp. (Popov 1982b).

***Thrips simplex* (Morison, 1930)**

Distribution. Greenhoses and open field **PVS** – Negovan (500 m). Phytophagous, collected from Iridaceae (*Gladiolus* sp.) (Donchev 1984).

Thrips tabaci Lindeman, 1889

Distribution. widespread in the country, **DEP** – Isperih; **DM** – Chaira, Krushovitsa, Lovech, Pleven; **PVS** – Kostinbrod; **PVV** – Dragalevtsi, Kumata, Malinazha, Selimitsa, Tintyava, Rodina; **ROP** – Melnik, Petrich; ROT – Bobochevo; **RPR** – Rila; **RPM** – Gotce Delchev; **SBM** – Beklemeto, Troyan, Vasilyovo; **PT** – Pazardzhik, Plovdiv, Sadovo, Haskovo (50–2200 m). Phytophagous, plant pest, collected from *Beta vulgaris*, *Dianthus* sp., *Galium* sp., *Hypericum perforatum*, *Ligustrum vulgare*, *Lotus corniculatus*, *Medicago sativa*, *Melilotus officinalis*, *Nicotiana tabacum*, *Onobrychis sativa*, *Poa pratensis*, *Primula elatior*, *Sinapis arvensis*, *Solanum dulcamara*, *Trifolium pratense*, *Vaccinium* sp., *V. myrtillus*, *Verbascum* sp. (Malkov 1903, Yanev 1968, Donchev 1968, 1972, Popov 1982a, 1982b).

Thrips trehernei Priesner, 1927

Distribution. RPR – Granchar (2185 m). Phytophagous, collected from *Trifolium repens* (Donchev 1976).

Thrips urticae Fabricius, 1781

Distribution. PT – Sadovo; **ROP** – Samuilova krepost (150–300 m). Phytophagous, collected from *Nicotiana tabacum*, *Urtica dioica*, *Ranunculus* sp. (Manushev 1897, Popov 1982a).

Thrips validus Uzel, 1895

Distribution. ROG – widespread in Ograzhden Mts.; **RPR** – Borovets (150–1350 m); Phytophagous, collected from mixed *Asteraceae* plants, *Lathyrus* sp. (Donchev 1976, Popov 1982a).

Thrips verbasci (Priesner, 1920)

Distribution. DM – Krushovitsa; **PSP** – Tazha; **ROG** – widespread in Ograzhden Mts.; **SBM** – Beklemeto, Troyan; **SBW** – Vezhen (155–1650 m). Phytophagous, collected from *Galium* sp., *Lotus corniculatus*, *Verbascum* sp. (Donchev 1968, 1976, Popov 1982a).

Thrips viminalis Uzel, 1895

Distribution. SPM – Reselets (210 m). Phytophagous, collected from *Salix* sp. (Popov 1982b).

***Thrips vuiletti* (Bagnall, 1933)**

Distribution. ROG – Divechova polyana (1000 m). Phytophagous, collected from mixed grasses (Popov 1982a).

***Thrips vulgatissimus* Haliday, 1836**

Distribution. DM – Komudara; **PVV** – Kikish, Ostrec, Ostritsa, Planinets; **ROG** – widespread in Ograzhden Mts.; **RPR** – Granchar, Musala peak, Partizanska polyana; **RRW** – Chaira, Smolyan; **SBM** – Beklemeto, Troyan (300–2925 m). Phytophagous, collected from *Campanula* sp., *Hypericum perforatum*, *Medicago sativa*, *Sorghum halepense*, *Trifolium repens*, *Verbascum* sp., mixed herbaceous vegetation from Brassicaceae, Rosaceae (Yanev 1968, 1973, Donchev 1968, 1976, Popov 1982a).

Suborder Tubulifera Haliday

Suborder Tubulifera consists of about 3500 species and 450 genera, placed in the single family Phlaeothripidae and two subfamilies- Idolothripinae and Phlaeothripinae (ThripsWiki 2015). Species in Idolothripinae are considered to feed on fungal spores (Mound and Palmer 1983), while the Phlaeothripidae are considerably diverse with three recognized "lineages": *Haplothrips*, *Liothrips* and *Phlaeothrips* (Mound and Marullo 1996). The *Haplothrips* lineage is well defined as the tribe Haplothripini (Mound and Minaei 2007). Species in this tribe are often phytophagous but some are predatory on other small arthropods. Although flower-living is relatively unusual among Phlaeothripidae, in the genus *Haplothrips* a large number of species live in the flowers of Asteraceae, Poaceae and Cyperaceae (Mound and Minaei 2007). Members of the *Liothrips* lineage are leaf-feeding, and many of these are associated with the induction of leaf galls. Species in the *Phlaeothrips* lineage are essentially mycophagous, presumably hyphae feeders, and are often associated with dead leaves and branches (ThripsWiki 2015). Some Phlaeothripidae are associated with mosses, and others are predators on mites or on coccids (Mound 2004). Thirty species of 10 genera have been recorded from Bulgaria.

Family Phlaeothripidae

Subfamily Idolothripinae Bagnall

***Bolothrips bicolor* (Heeger, 1852)**

Distribution. ROG – Gorski Dom (1250 m). Mycophagous-spore feeder, collected from fallen leaves (Popov 1982a).

***Bolothrips dentipes* (O. M. Reuter, 1880)**

Distribution. ROG – Churicheni (300–1000 m). Mycophagous-spore feeder, found in soil from a field with *Hordeum vulgare* (Popov 1982a).

***Compsothrips albosignatus* (Reuter, 1884)**

Distribution. ROG – Markovi kladentsi (1520 m). Mycophagous-spore feeder, collected from *Fagus* sp. (Popov 1982a).

***Cryptothrips nigripes* (Reuter, 1880)**

Distribution. PVL – Lyulin Monastery; **RRW** – Trigrad; **PVV** – Selimitsa (1000–1300 m). Mycophagous-spore feeder, collected from *Corylus avellana* leaves, and on mixed herbaceous vegetation in oak forests (Yanev 1973).

Subfamily Phlaeothripinae Uzel

***Amphibolothrips knechteli* (Priesner, 1936)**

Distribution. BN – Cape Kaliakra (70 m). Mycophagous -hyphae feeder, found in leaf litter (Vasiliu-Oromulu 1981).

***Cephalothrips monilicornis* (O. M. Reuter, 1880)**

Distribution. BS – Dyuni (50 m). Unknown feeding preferences, collected from mixed herbaceous vegetation (Jenser and Krumov 2009).

***Haplothrips acanthoscelis* (Karny, 1910)**

Distribution. DM – Krushovitsa; **PVS** – Kostinbrod; **SPW** – Botevgrad (155–400 m). Phytophagous, collected from *Lotus corniculatus*, *Onobrychis sativa*, *Zea mays* (Popov 1973, Donchev 1976).

***Haplothrips aculeatus* (Fabricius, 1803)**

Distribution. DM – Krushovitsa; **PBC** – Topolovgrad; **PBB** – Yambol; **PT** – Pazardzhik; **PSL** – Gorni Lozen; **PVS** – Negovan; **PVV** – Simeonovo; **SBM** –

Beklemeto, Troyan (155–1360 m). Phytophagous, collected from *Avena sativa*, *Dactylis glomerata*, *Lotus corniculatus*, *Medicago sativa*, *Onobrychis sativa*, *Secale cereale*, *Trifolium repens*, *T. pratense*, *Triticum aestivum* (Genov 1967, Veselinov 1968, Donchev 1976).

***Haplothrips angusticornis* Priesner, 1921**

Distribution. DM – Krushovitsa; **PBC** – Topolovgrad – Hlyabovo; **PVS** – Negovan; **ROG** – Ograzhden Mts.; **SPM** – Draganovo; **SPW** – Botevgrad (150–700 m). Phytophagous, collected from *Berberis vulgaris*, *Dactylis glomerata*, *Lotus corniculatus*, *Matricaria chamomilla*, *Medicago sativa*, *Onobrychis sativa*, *Secale cereale*, *Trifolium pratense* mixed grasses (Genov 1967; Veselinov 1968; Donchev 1976; Popov 1982a).

***Haplothrips biroi* (Priesner, 1928)**

Distribution. DM – Krushovitsa (160 m). Phytophagous, collected from *Lamium purpureum* (Donchev 1993).

***Haplothrips dianthinus* Priesner, 1924**

Distribution. RRW – Smolyan Lakes (1525 m). Phytophagous, collected from *Dianthus* sp. (Donchev 1993).

***Haplothrips distinguendus* (Uzel, 1895)**

Distribution. ROG – Nikudin; **ROP** – Samuilova krepost (150–1000 m). Phytophagous, collected from mixed herbaceous vegetation of Asteraceae (Popov 1982a).

***Haplothrips flavicinctus* (Karny, 1910)**

Distribution. DEP – Makariopolsko; **DM** – Krushovitsa (160–250 m). Phytophagous, collected from *Beta vulgaris*, *Medicago sativa*, *Onobrychis sativa* (Donchev 1968, 1976).

***Haplothrips hispanicus* Priesner, 1924**

Distribution. PBC – Topolovgrad – Hlyabovo (400 m). Phytophagous, collected from *Haberlea rhodopensis* (Donchev 1976).

***Haplothrips leucanthemi* (Schrank, 1781)**

Distribution. DM – Krushovitsa; **PBS** – Kosti; **PVS** – Chepintsi, Filipovtsi, Trebich; **ROG** – widespread in Ograzhden Mts.; **RPP** – Dolnoto breznichko ezero **SBM** – Beklemeto, Teteven, Troyan (50–1965 m). Phytophagous, collected from mixed herbaceous of *Asteraceae*, *Medicago sativa*, *Trifolium pratense*, *T. repens* (Donchev 1968, 1976, Yanev 1973, Popov 1982a).

***Haplothrips marrubiicola* Bagnall, 1932**

Distribution. DM – Krushovitsa (160 m). Phytophagous, collected from *Onobrychis sativa* (Donchev 1976).

***Haplothrips minutus* (Uzel, 1895)**

Distribution. RPR – Vada hut (1410 m). Phytophagous, collected from shrubby vegetation (Yanev 1973).

***Haplothrips phyllophilus* Priesner, 1914**

Distribution. SBM – Ribarica (600 m). Phytophagous, collected from *F. sylvatica* (Popov 1982b)

***Haplothrips propinquus* Bagnall, 1933**

Distribution. RPR – Partizanska polyana (1500 m). Phytophagous, collected from *Achilea millefolium*, *Onobrychis sativa* (Donchev 1976).

***Haplothrips reuteri* (Karny, 1907)**

Distribution. DEL – Obrazov chiflic; **DEP** – Razgrad; **DM** – Krushovitsa; **DW** – Boychinovci; **PBC** – Topolovgrad – Hlyabovo; **PSL** – Gorni Lozen; **PSP** – Sliven; **SPM** – Pravec, Zlatna Panega; **PVS** – Suchodol, Kazichene, Gorna Banya; **RPR** – Granchar (155–2200 m). Phytophagous, collected from *Centaurea cyanus*, *Dactylis glomerata*, *Haberlea rhodopensis*, *Helianthus annuus*, *Medicago sativa*, *Onobrychis sativa*, *Secale cereale*, *Senecio* sp., *Sorghum* sp., *Trifolium repens*, *Triticum aestivum*, *Zea mays* (Chorbadzhiev 1929, Donchev 1968, 1976, Yanev 1973).

***Haplothrips scythicus* Knechtel, 1961**

Distribution. DM – Krushovitsa (160 m). Phytophagous, collected from *Medicago sativa* (Donchev 1976).

***Haplothrips setiger* Priesner, 1921**

Distribution. DM – Krushovitsa; **SPW** – Botevgrad; **PBC** – Topolovgrad – Hlyabovo; **ROG** – Nikudin; **ROP** – Parvomai; **RPR** – Borovets, Granchar, Musala peak, Yastrebetz (150–2925 m). Phytophagous, collected from *Aster junceus*, *Ch. cinerariifolium*, *Euphorbia* sp., *Genista tinctoria*, *Haberlea rhodopensis*, *Inula helenium*, *Lathyrus* sp., *Lotus corniculatus*, *Melilotus albus*, *Trifolium pratense*, *T. repens*, *Thymus* sp., *Viola* sp., mixed herbaceous vegetation (Donchev 1976, Popov 1973, 1982a).

***Haplothrips subtilissimus* (Haliday, 1852)**

Distribution. SPM – Pravec (405 m). Phytophagous and facultative predator, collected from *Haberlea rhodopensis* (Donchev 1976).

***Haplothrips tritici* (Kurdjumov, 1912)**

Distribution. DM – Pavlikeni, Gorna Oryahovitsa; **DW** – Boychinovci; **PSP** – Sliven; **PVS** – Kazichene, Kostinbrod, Prolesha, Svetovrachane; **ROG** – widespread in Ograzhden Mts. (300–1000 m). Phytophagous, pest of cereals, collected from *Hordeum vulgare*, *Secale cereale*, *Triticum aestivum*, mixed grasses (Chorbadzhiev 1929, Yanev 1973, Popov 1982a, Krasteva et al. 2013).

***Haplothrips verbasci* (Osborn, 1896)**

Distribution. PVS – Vrana; **ROG** – widespread in Ograzhden Mts.; (200–1000 m). Phytophagous, collected from *Verbascum* sp., *V. thapsus* (Popov 1973, 1982a).

***Hoplothrips semicaecus* (Uzel, 1895)**

Distribution. PKQ – Blateshnitsa (800 m). Mycophagous- hyphae feeder on dead tree branches, collected from the leaves of *Clematis vitalba* (Yanev 1973).

***Hoplothrips ulmi* (Fabricius, 1781)**

Distribution. PVS – Bankia, Suhodol, Lokorsko (585–695 m). Mycophagous -hyphae feeder on dead parts, large branches, found in the field with *Avena sativa*, mixed herbaceous vegetation in pine forests (Yanev 1973).

***Liothrips pragensis* Uzel, 1895**

Distribution. RPP – Predela – Gradevo (500 m). Phytophagous, collected from *Quercus sessile* leaves (Popov 1976).

***Phlaeothrips coriaceus* Haliday, 1836**

Distribution. RPR – Vada hut; **RRW** – Chaira dam (1300–1450 m). Mycophagous-hyphae feeder on dead branches, collected from shrubs in beech forests and meadow vegetation in pine forests (Yanev 1973).

***Xylaplothrips fuliginosus* (Schille, 1911)**

Distribution. RRW – Smolyan Lakes, Golyam Beglik reservoar; **SBM** – Ribarica; **SPM** – Reselets (210–1600 m). Predator of mites and hyphae feeder, collected from *Populus* sp., shrubs and herbaceous vegetation (Yanev 1973, Popov 1982b).

Discussion

In total, 155 species of thrips have been recorded in Bulgaria, in the altitudinal range from 0 to 2925 m a.s.l. Considering the assumption of Hubenov (1996) that there should be about 250 species in the country, order Thysanoptera has been insufficiently studied and research has uncovered merely 60% of its diversity. Currently thrips account for 0.53% of the total number of hexapods reported for Bulgaria.

Two species, *Rubiothrips vitis* and *Hoplothrips pallicornis*, have been reported for Bulgaria in Fauna Europea but there is no actual evidence of their presence in the country and they have not been included in the list. The inconsistency of the information on *R. vitis* probably stems from the fact that Bournier (1976) lists *R. vitis* as a pest of vines in Bulgaria, quoting Zinca (1964). However, the paper of Zinca does not give any information on the presence of this species in the country. No information on the presence of *H. pallicornis* in Bulgaria was found in the literature. The only reference for this species from Europe is the redescription of Priesner (1964) resulting from its interception by New York harbour quarantine. The author

explains that *H. pallicornis* is found in New York under bark of *Juglans regia* but originally comes from former Yugoslavia, suggesting that it may have a wider distribution at its origin. The authors of the present paper sent an informal request to Fauna Europea to ask for the source of the information leading to the inclusion of *H. pallicornis* in the list. The reply was that the only written reference of the species' presence in Europe is Preisner (1964) but it may be in the extensive collection of Pelikan (pers. comm., Bert Vierbergen, Andrea Hastenpflug-Vesmanis, 4 March, 2015) without ever having been published.

As regards the feeding preferences, 136 (87.7%) of the thrips species present in Bulgaria are phytophagous. The majority of them belong to the largest thysanopteran family, Thripidae (101). All seven reported species from family Melanthripidae are plant feeders. In family Aeolothripidae, there are eight phytophagous species which are also facultative predators. Family Phlaeothripidae includes 21 phytophagous species: 1 from genus *Liothrips* and 20 from genus *Haplothrips*. *H. subtilissimus* is also a facultative predator. Seven obligate predators from two families, Aeolothripidae (5) and Thripidae (2), have been reported. All 9 mycophagous thrips species present in Bulgaria belong to the Phlaeothripidae. Four of them are spore feeders (Idolothripinae) and 5 are hyphae feeders, of which *Xylaplothrips fuliginosus* is also a predator on mites. Three thrips species are with unknown feeding preferences.

Fourteen members of the phytophagous group are considered pests on agricultural crops. Among them, *Frankliniella occidentalis* and *Thrips tabaci* have economic importance as pests and vectors of Tomato spotted wilt virus (TSWV) (Karadjova and Krumov 2008), while *Haplothrips tritici* can cause significant damage to cereal crops (Krasteva et al. 2013).

On Figure 1 the geographical regions and subregions of Bulgaria are presented following the division of Hubenov (1997) and the numbers of thrips species found in each subregion.

Thirteen thrips species have been reported for the region of the Black Sea Coast (B). On the territory of Bulgaria, *Amphibolothrips knechteli* has been found only in the Northern Black Sea Coast subregion (BN), while *Cephalothrips monilicornis*, *Melanthrips knechteli* and *Ropotamothrips buresi* have been recorded only in the Southern subregion (BS) at altitudes close to 0 m a.s.l.

Forty nine species have been reported from the region of the Danubian Plain (D). A single species, *Pseudodendrothrips mori*, has been reported in Bulgaria only from its Western subregion (DW). The Middle subregion (DM) is well studied compared to the rest of the Danubian Plain due to the extensive research of the Bulgarian thysanopterologist Donchev during the period 1968–1996. Four species, *Aeolothrips albicinctus*, *Haplothrips biroi*, *H. marrubiicola* and *Tenothrips discolor*, have only been reported from there, at an altitude of 155 m a.s.l. *Iridothrips iridis* and *Thrips linarius* have been reported in Bulgaria only from the Eastern subregion (DE).

The large subregion of the Predbalkan (SP) is scarcely investigated with a total of 18 reported species. In Bulgaria, *Haplothrips subtilissimus* and *Thrips viminalis* are only found in the middle part of the Predbalkan (SPM).

Figure 1. Number of Thysanoptera species found in zoogeographical regions and subregions of Bulgaria.

Thirty nine species are found in the region of Stara Planina (Balkan) Mts (SB). *Oxythrips ulmifoliorum* and *Prosopothrips vejdovskyi* have been reported in Bulgaria only for its Western subregion (SBW), while *Haplothrips phyllophilus* and *Rubiothrips ferrugineus* have only been reported from its Middle subregion (SBM).

The parts of the Transitional Region (P) have been investigated to different degrees and are considered separately.

Twelve species have been reported from the Tundja–Strandja Subregion (PB). Currently, only *Haplothrips hispanicus*, found in the Sakar Mts (PBC), is reported in Bulgaria only from this subregion.

The diversity of thrips in the Thracian Lowland (PT) includes 14 species, none of which are found only in this subregion.

A total of nine species have been established in the vast Srednogorie–Podbalkan Subregion (PS) with no records which are unique for the country. Therefore its thysanopteran fauna is almost unknown.

The investigations in Kraishte–Konyavo District (PK) have led to the report of 5 thrips species. *Hoplothrips semicaecus* and *Idolimothrips paradoxus* are only found in Konyavska Planina Mts. (PKQ) and Golo Bardo (PKG), respectively.

The thrips of Vitosha District (PV) are better studied with 52 established species. The following have not been found elsewhere on the territory of Bulgaria: *Aeolothrips priesneri* in the Plana Mts. (PVP); *Aptinothrips elegans*, *Chirothrips aculeatus*, *Hoplothrips ulmi*, *Mycterothrips salicis*, *Thrips calcaratus* and *T. simplex* in the Sofia Basin (PVS); *Belothrips morio* and *Odontothrips intermedius* in the Vitosha Mts (PVV).

The Osogovo–Belasitsa region (RO) is the best studied area of Bulgaria, mainly due to the extensive research of T. Popov in Ograzhden during the period 1982–1988. A total of 89 thrips species have been reported, 27 of which have been recorded in Bulgaria only from this region: *Mycterothrips consociatus* in Belasitsa Mts (ROB); *Aeolothrips vittatus*, *Asphodelothrips croceicollis*, *Bolothrips bicolor*, *B. dentipes*, *Bregmatothrips dimorphus*, *Compsothrips albosignatus*, *Krokeothrips innocens*, *Limothrips angulicornis*, *Mycterothrips albidicornis*, *Odontothrips meridionalis*, *Rubiothrips silvarum*, *Sericothrips bicornis*, *Theilopedothrips pilosus*, *Thrips dilatatus*, *T. discolor*, *T. euphorbiae*, *T. fuscipennis* and *T. vuiletti* in Ograzhden Mts (ROG); *Aeolothrips gloriosus*, *Dendrothrips phillireae*, *Odontothrips dorycnii*, *Oxythrips bicolor*, *Rubiothrips validus*, *R. vitalbae*, *Tamaricothrips tamaricis*, *Thrips minutissimus* in Krupnik–Sandanski–Petrich Valley (ROP).

Fifty-four species are known from the mountanous Rila–Pirin region (RP). The following are specific only for this region: *Aeolothrips balati*, *Thrips juniperinus*, *Liothrips pragensis* in Pirin Mts. (RPP) with altitudinal range from 400 to 1700 m a.s.l.; *Haplothrips minutus*, *H. propinquus*, *Odontothrips phaleratus*, *Scolothrips longicornis*, *Thrips linariae*, *T. trehernei* in Rila Mts. (RPR) at altitudes ranging from 1350–2230 m a.s.l.; *Odontothrips cytisi* is in Slavyanka Mts. (RPS).

The other large southern mountaineous area of the Rhodope Mts. (RR) is poorly studied with 12 recorded thrips species. *Aptinothrips stylifer*, *Chirothrips pallidicornis* and *Haplothrips dianthinus* are currently known only from the Western Rhodope Mts (RRW).

Three of the species in the list, *Frankliniella occidentalis*, *Echinothrips americanus* and *Heliothrips haemorrhoidalis*, have been reported only from greenhouses.

The number of Thysanoptera species recognized from Bulgaria demonstrates that they constitute one of the not very well studied orders of insects. The Bulgarian Thysanoptera represents less than 1% (0.53%) of the Hexapoda living in Bulgaria.

The reported thysanopteran species from Bulgaria are distributed in the altitudinal range from 0 to 2925 m a s l.

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RESEARCH ARTICLE

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Two new species of the genus *Comidoblemmus* Storozhenko & Paik from China (Orthoptera, Gryllidae)

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Abstract

Two new species of *Comidoblemmus* Storozhenko & Paik, 2009 are described and illustrated, *C. sororius* **sp. n.** (CHINA, Zhejiang) and *C. excavatus* **sp. n.** (CHINA, Guizhou). A key and a distribution map of all species in the world are presented.

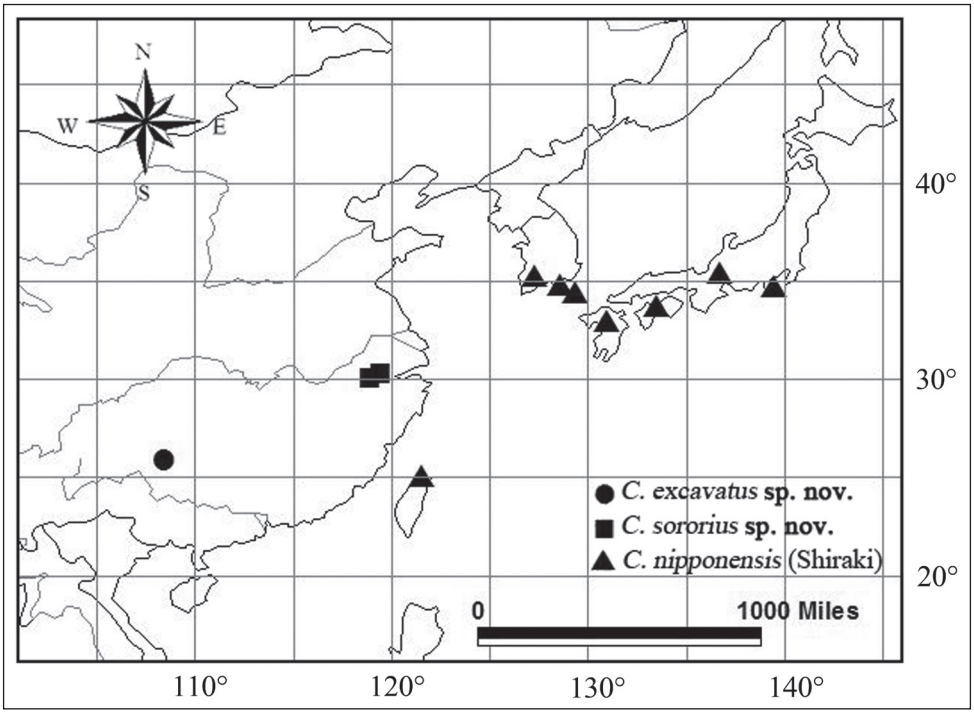
Keywords

Orthoptera, Gryllidae, *Comidoblemmus*, new species, China

Introduction

The genus *Comidoblemmus* was established by Storozhenko and Paik (2009) for *Gryllus nipponensis* Shiraki, 1911, by monotypy and original designation. Except for the type species, which is widely distributed in Japan, Korea and China (Taiwan), none has been added to this genus until now (Eades et al. 2014).

During our study, two new species of *Comidoblemmus* from China were recently discovered and are described here under the names of *C. sororius* sp. n. and *C. excavatus* sp. n. They match the generic diagnosis well and are characterized by having four pairs of dorsal spines on each hind tibia and similar shapes of male genitalia as the type



Map 1. Distribution map of the genus *Comidoblemmus* Storozhenko & Paik.

species, epiphallus with posterior margin between lateral lobes rounded, not sinuate. But they are different from *C. nipponensis* (Shiraki, 1911) by the distinctly oblique head, whose shape could be more or less variable owing to the agonistic behavior character (Storozhenko and Paik 2009) within one genus, such as *Loxoblemmus* Saussure, 1877 (sensu Gorochov 2001). Thus, we confirm the two new species belong to the genus *Comidoblemmus*, which currently includes three species. A key for their identification and a distribution map (Map 1) are presented.

Material and methods

The type specimens of the new species are deposited in the Museum, Hebei University, Baoding, China (MHBU).

The male genitalia were dissected and cleared in 10% KOH solution. All morphological structures were photographed using a Leica M205A microscope. Images of multiple layers were stacked using Combine ZM. Distribution maps were prepared using the geographic information system software ArcView 3.2 (ESRI, Redlands, CA, USA), based on localities of the specimens examined for this study and those mentioned in the literature (Shiraki 1911, 1930, Chopard 1961, Randell 1964, Ichikawa et al. 2000, Ichikawa et al. 2006, Storozhenko and Paik 2007, 2009).

Taxonomy

Key to the species of *Comidoblemmus* Storozhenko & Paik

1 Head with both genae nearly parallel in frontal view (Storozhenko and Paik 2009: Fig. 1); posterior margin between lateral lobes of epiphallus almost straight (Storozhenko and Paik 2009: Figs 10–12) ..... ***C. nipponensis* (Shiraki, 1911)**

– Head with genae distinctly converging downwards in frontal view (Figs 3, 4, 7); posterior margin between lateral lobes of epiphallus distinctly rounded **2**

2 Male tegmina reaching abdominal apex (Fig. 1); male supra anal plate slightly narrowed posteriorly, posterior margin narrowly rounded (Figs 9–11) ..... ***C. sororius* sp. n.**

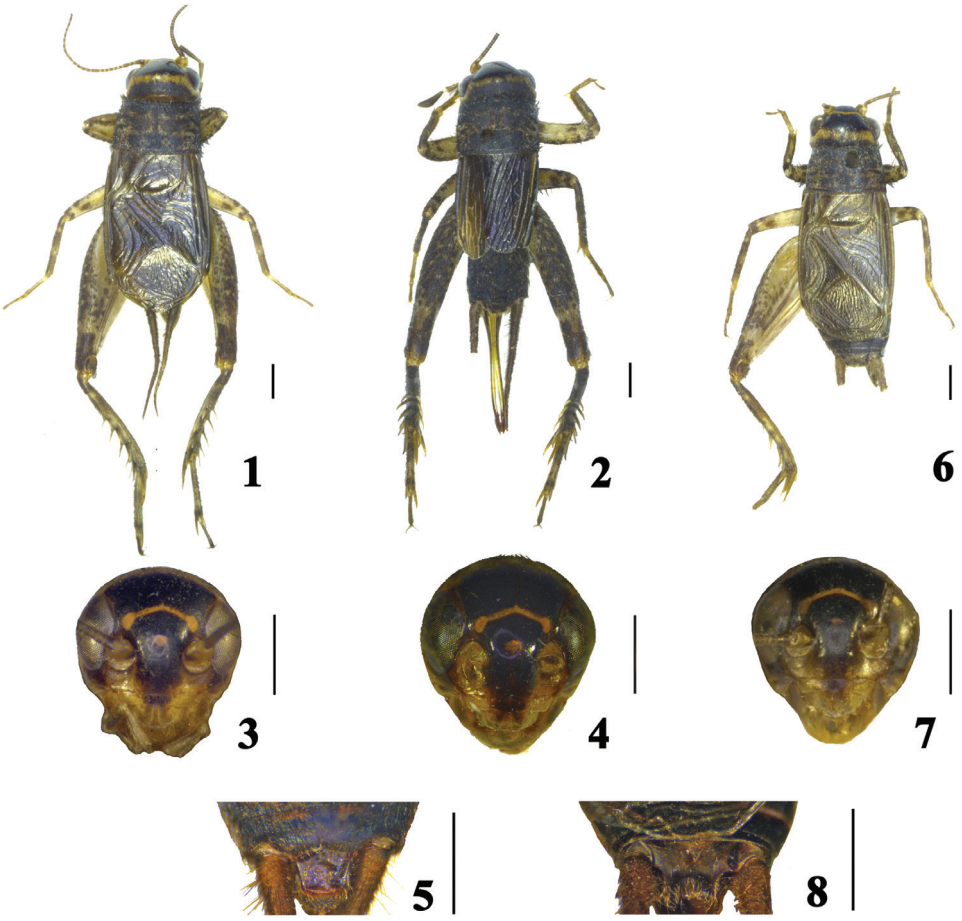
– Male tegmina reaching 8th abdominal tergite (Fig. 6); male supra anal plate distinctly narrowed posteriorly, posterior margin slightly emarginated in middle (Figs 12–14) ..... ***C. excavatus* sp. n.**

***Comidoblemmus sororius* sp. n.**
http://zoobank.org/ABF68F2D-C329-440F-BA69-755D1163146F
Figs 1–5, 9–11

Type material. Holotype ♂: CHINA: Zhejiang, Lin'an, Tianmushan, Qianmutian, 14.–15.IX.2012, leg. Y.Y. Lu. Paratypes: 9♂♂, 1♀: same data as the holotype; 2♀♀: Zhejiang, Lin'an, Qingliangfeng, Shunxiwu, 17.–19. IX.2012, leg. Y.Y. Lu.

Description. Male (Fig. 1). Body small-sized. Head nearly globular (Fig. 3), slightly wider than anterior margin of pronotum, frontal rostrum short and about 1.8 times as wide as scapus; eyes large, oval; last joint of maxillary palpus slightly longer than 4th joint, distinctly widened apicad. Pronotum transverse, slightly widened posterioly, about 0.6 times as long as width of posterior margin, anterior and posterior margins straight. Tegmina reaching abdominal apex, present with 3 oblique veins, mirror large, about 1.2 times as long as wide, apical field very short; wings absent. Fore tibia with two tympana, outer tympanum large and oblong, about 2.8 times as long as wide, inner tympanum small and nearly round. Hind femur slender, about 2.9 times as long as maximal width; hind tibia with 4 pairs of dorsal spines and 3 pairs of apical spurs, of which middle one longest while lower one shortest among the inner spurs, lower and upper ones equal in length and distinctly shorter than middle one among outer spurs; first hind tarsal segment each side with 4–5 small spines in a line on dorsal surface.

Supra anal plate (Fig. 5) slightly narrowed posteriorly, with posterior margin narrow and rounded at apex. Subgenital plate rather long, narrowed posteriorly, nearly coniform. Genitalia (Figs 9–11): epiphallus with two lateral lobes on posterior margin, and posterior margin between lateral lobes of epiphallus distinctly widely rounded; lateral lobes acute at apex and bent upwards apicad in lateral view; ectoparamers small.



Figures 1–8. *Comidoblemmus* spp. **1–5** *C. sororius* sp. n. (**1, 3, 5** male; **2, 4** female) **6–8** *C. excavatus* sp. n. (male): **1, 2, 6** habitus, dorsal view **3, 4, 7** head, frontal view; **5, 8** supra anal plate, dorsal view. Scale bars: 1.0 mm.

Female (Fig. 2). Head very similar to that of male (Fig. 4). Lateral margins of pronotum nearly parallel. Tegmina reaching 5th abdominal tergite, present with several parallel veins. Ovipositor straight, spear-shaped, 1.2 times shorter than hind femur.

Coloration. Body black brown. Head black, with a narrow transverse yellow stripe in middle of dorsum and between lateral ocelli respectively, mouthparts light yellow. Pronotum black, disc with light yellow markings. Legs yellowish brown mixed with irregular dark brown markings, hind femur with numerous oblique black markings on outer surface. Ovipositor brown.

Measurements (mm). Male: body 7.0–8.1, pronotum 1.4–1.5, tegmen 4.6–5.0, hind femur 5.2–5.7; female: body 6.9–8.0, pronotum 1.4–1.5, tegmen 3.2–3.5, hind femur 5.4–5.9, ovipositor 4.2–4.5.

Diagnosis. This new species is similar to *C. nipponensis* (Shiraki), but differs from the latter by the male tegmina reaching abdominal apex; head with genae distinctly converging downwards in frontal view; posterior margin of supra anal plate narrowly rounded; posterior margin between lateral lobes of epiphallus distinctly widely rounded.

Distribution. China (Zhejiang).

Etymology. The specific name is derived from Latin *soror* (sisters), referring to this species is similar to *C. nipponensis* (Shiraki).

***Comidoblemmus excavatus* sp. n.**

http://zoobank.org/5A43343F-DAF4-492C-9056-B653A8D24EE1

Figs 6–8, 12–14

Type material. Holotype ♂: CHINA: Guizhou, Leishan, Fangxiang, 15.IX.2005, leg. H.Y. Liu.

Description. Male (Fig. 6). Body small-sized. Head nearly globular (Fig. 7), slightly wider than anterior margin of pronotum, frontal rostrum short and about 1.4 times as wide as scapus; eyes large, oval; last joint of maxillary palpus slightly longer than 4th joint, distinctly widened apicad. Pronotum transverse, slightly widened posterioly, about 0.6 times as long as width of posterior margin, anterior and posterior margins straight. Tegmina reaching 8th abdominal tergite, present with 3 oblique veins, mirror large, about 1.4 times as long as wide, apical field short; wings absent. Fore tibia with two tympana, outer tympanum large and oblong, about 2.9 times as long as wide, inner tympanum small and nearly round. Hind femur slender, about 2.8 times as long as maximal width; hind tibia with 4 pairs of dorsal spines and 3 pairs of apical spurs, of which middle one longest while lower one shortest among the inner spurs, lower and upper ones equal in length and distinctly shorter than middle one among outer spurs; hind first tarsal segment each side with 5 small spines in a line on dorsal surface.

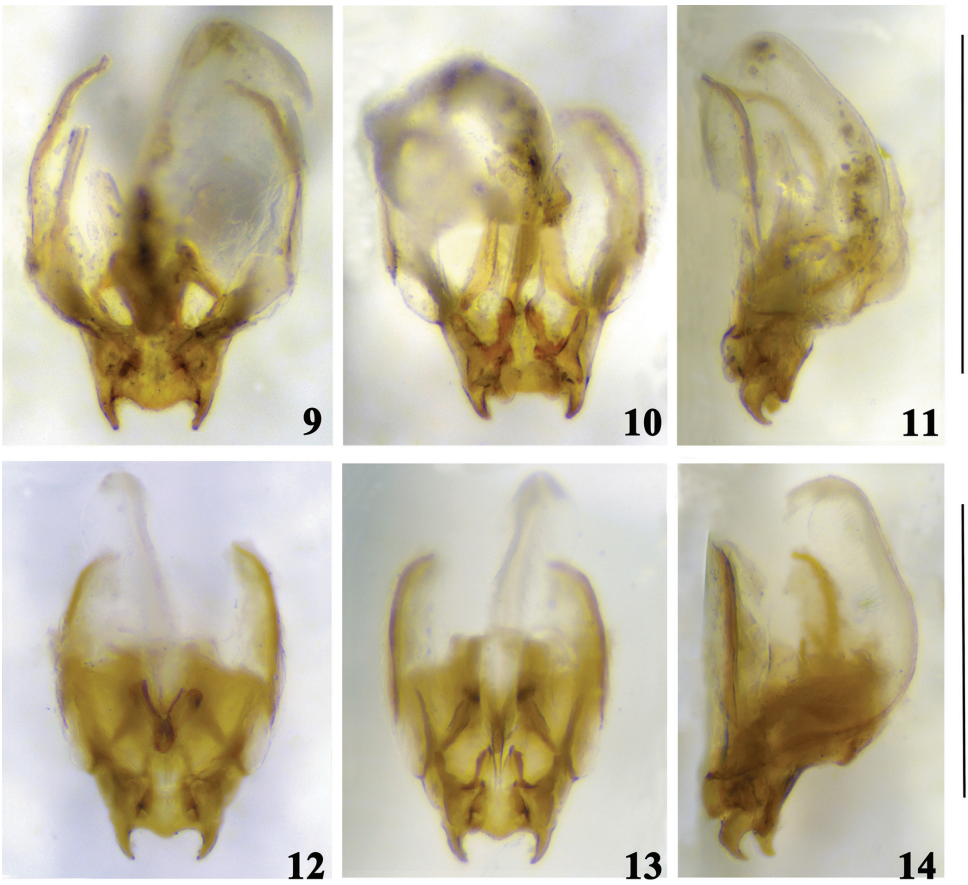
Supra anal plate (Fig. 8) distinctly narrowed posteriorly, with posterior margin slightly emarginated in middle. Subgenital plate rather long, narrowed posteriorly, nearly coniform. Genitalia (Figs 12–14): epiphallus with two lateral lobes on posterior margin, and posterior margin between lateral lobes of epiphallus distinctly narrowly rounded; lateral lobes acute at apex and bent upwards apicad in lateral view; ectoparamers small.

Female. Unknown.

Coloration. Body black brown. Head black, with a narrow transverse yellow stripe in middle of dorsum and between lateral ocelli respectively, mouthparts light yellow. Pronotum black, disc with light yellow markings. Tegmina brown. Legs yellowish brown with irregular dark brown markings, and hind femur with numerous oblique black markings on outer surface.

Measurements (mm). Male: body 8.8, pronotum 1.7, tegmen 6.0, hind femur 5.8.

Diagnosis. This new species is similar to *C. nipponensis* (Shiraki), but differs from the latter by the head with checks distinctly converging downwards in frontal view; posterior



Figures 9–14. Male genitalia of *Comidoblemmus* spp. **9–11** *C. sororius* sp. n. **12–14** *C. excavatus* sp. n.: **9, 12** dorsal view **10, 13** ventral view **11, 14** lateral view. Scale bars: 1.0 mm.

margin of supra anal plate slightly emarginated in middle; posterior margin between lateral lobes of epiphallus distinctly narrowly rounded. It also resembles *C. sororius* sp. n., but can be distinguished by the posterior margin of supra anal plate slightly emarginated in middle; posterior margin between lateral lobes of epiphallus distinctly narrowly rounded; tegmina reaching 8th abdominal tergite, mirror distinctly longer than wide.

Distribution. China (Guizhou).

Etymology. The specific name is derived from Latin *ex-* (out) + *cavare* (cave), referring to its posterior margin of supra anal plate slightly emarginated in middle.

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RESEARCH ARTICLE

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A new species of the genus *Anteon* Jurine (Hymenoptera, Dryinidae) from Thailand

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Abstract

A new species of *Anteon* Jurine, 1807 is described from Thailand, Nan Province: *A. huettingeri* **sp. n**. Morphologically the new species is similar to *A. borneanum* Olmi, 1984, *A. jurineanum* Latreille, 1809, *A. insertum* Olmi, 1991, *A. yasumatsui* Olmi, 1984, *A. sarawaki* Olmi, 1984, *A. thai* Olmi, 1984 and *A. krombeini* Olmi, 1984, but it is clearly different for the numerous sensorial processes present on the inner side of the paramere; these processes are absent in the other above species. Published identification keys to the Oriental species of *Anteon* are modified to include the new species.

Keywords

Taxonomy, *Anteon huettingeri*, Oriental region, key, Nan Province, Anteoninae

Introduction

Dryinidae (Hymenoptera, Chrysidoidea) are parasitoids of leafhoppers, planthoppers and treehoppers (Hemiptera, Auchenorrhyncha) (Guglielmino and Bückle 2003, 2010; Guglielmino et al. 2006, 2013; Guglielmino and Olmi 2013; Guglielmino and Virla 1998). *Anteon* Jurine, 1807 is a genus that is present in all zoogeographical regions (Olmi 1984; Xu et al. 2013; Olmi and Virla 2014). In total 423 species have been described from all continents (Olmi and Virla 2014) and the genus was revised at world

level by Olmi (1984, 1991) and in the Oriental and Neotropical regions by Xu et al. (2013) and Olmi and Virla (2014) respectively.

The species of *Anteon* inhabiting the Oriental region have been recently studied by Xu et al. (2013). In total 149 species have been described from the Oriental region (Guglielmino and Olmi 2013; Xu et al. 2013).

Anteon species are parasitoids of leafhoppers belonging to Cicadellidae (Guglielmino et al. 2013). As in almost all dryinids, females of *Anteon* have a chelate protarsus. Chelae are used to capture and restrain the host during oviposition and host-feeding (Olmi 1984, 1994).

In 2014 we examined additional specimens of *Anteon* from Thailand and discovered a new species described in this paper.

Material and methods

The descriptions follow the terminology used by Olmi (1984) and Xu et al. (2013). The measurements reported are relative, except for the total length (head to abdominal tip, without antennae), which is expressed in millimetres. The following abbreviations are used in the descriptions: POL is the distance between the inner edges of the two lateral ocelli; OL is the distance between the inner edges of a lateral ocellus and the median ocellus; OOL is the distance from the outer edge of a lateral ocellus to the compound eye; OPL is the distance from the posterior edge of a lateral ocellus to the occipital carina; TL is the distance from the posterior edge of an eye to the occipital carina.

The types of all Oriental species of *Anteon* have been previously examined by the authors.

The type specimen described in this paper is deposited in the collection of the Oberösterreichisches Landesmuseum, Linz, Austria (OLL).

The description of the new species is based on the study of only a single specimen. The authors are aware that descriptions of new taxa should normally be based on more individuals. However, Dryinidae are so rare that it is uncommon to collect more than one specimen of each species. In addition, on the basis of the experience and knowledge of the authors, the new species is sufficiently delimited by unique characters to justify its description.

Results

Genus *Anteon* Jurine, 1807

Anteon Jurine, 1807: 302. Type species: *Anteon jurineanum* Latreille, 1809, by subsequent monotypy.

Diagnosis. Female: Fully winged; rarely brachypterous; occipital carina complete; palpal formula 6/3; antenna without rhinaria; forewing with three cells enclosed by

pigmented veins (costal, median and submedian); forewing with stigmal vein and pterostigma; distal part of stigmal vein much shorter than proximal part, occasionally slightly shorter, as long as, or longer than proximal part; propodeum usually with transverse keel between dorsal and posterior surface; protarsus chelate; inner side of enlarged claw with proximal prominence bearing one long bristle; tibial spurs 1/1/2. Male: Fully winged; rarely brachypterous; occipital carina complete; vertex of head usually without two oblique keels connecting posterior ocelli to occipital carina; palpal formula 6/3; forewing with three cells enclosed by pigmented veins (costal, median and submedian); forewing with stigmal vein and pterostigma; distal part of stigmal vein much shorter than proximal part, occasionally slightly shorter, as long as, or longer than proximal part; pterostigma less than four times as long as broad; propodeum usually with transverse keel between dorsal and posterior surface; paramere without inner branch wrapping penis; tibial spurs 1/1/2.

***Anteon huettingeri* Olmi, Xu & Guglielmino, sp. n.**
http://zoobank.org/9DAA0C1A-15FE-40C1-9C9F-19C9A6676F8F

Diagnosis. Male with antenna filiform; scutum very slightly granulated and finely punctate; posterior surface of propodeum without longitudinal keels; paramere without distal inner process, with inner side provided with many sensorial processes (Fig. 1).

Description. Male. Fully winged (Fig. 2A). Length 2.2 mm. Head black, except mandible testaceous. Antenna testaceous. Mesosoma black. Metasoma brown. Legs testaceous, except metacoxa partly black. Antenna filiform. Antennal segments in following proportions: 11:6:6:5:5:6:5:5:5:7. Head dull, granulated and reticulate rugose. Face with two lateral keels around orbits directed towards antennal toruli. Vertex with two short oblique keels from posterior ocelli to occipital carina. Occipital carina complete. Frontal line complete. Vertex with POL = 6; OL = 3; OOL = 4; OPL = 3; TL = 4; greatest breadth of posterior ocelli as long as OPL. Scutum shiny, very slightly granulated, finely punctate, unsculptured among punctures. Notauli incomplete, reaching approximately 0.4 × length of scutum. Scutellum and metanotum unsculptured, shiny. Propodeum with strong transverse keel between dorsal and posterior surface. Dorsal surface of propodeum reticulate rugose. Posterior surface of propodeum without longitudinal keels, with median area granulated and lateral areas reticulate rugose. Forewing (Fig. 2B) hyaline, without dark transverse bands. Distal part of stigmal vein much shorter than proximal part (2:5). Paramere (Fig. 1) without distal inner process, with inner side provided with many small sensorial processes. Tibial spurs 1/1/2.

Female. Unknown.

Material examined. Holotype: male, Thailand, Nan Province, outside Mae Charim National Park gate, 18°36.00'N, 100°58.34'E, 260 m, 13.v.2012, E. & J. Hüttinger leg. (OLL).

Distribution. Thailand.

Hosts. Unknown.

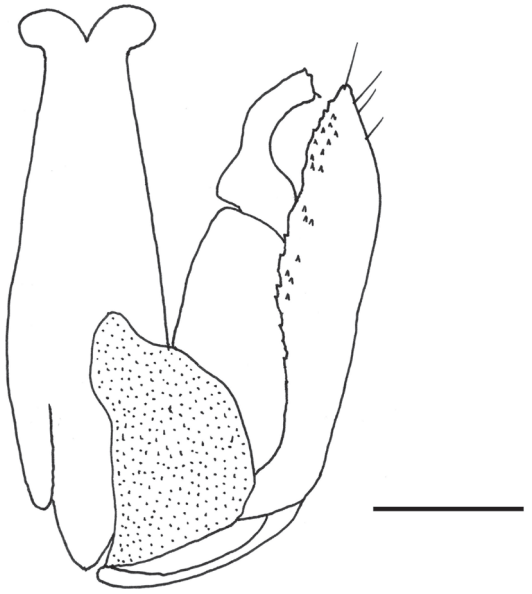

Figure 1. *Anteon huettingeri* Olmi, Xu & Guglielmino, sp. n.: male genitalia (left half removed). Scale bar = 0.06 mm.

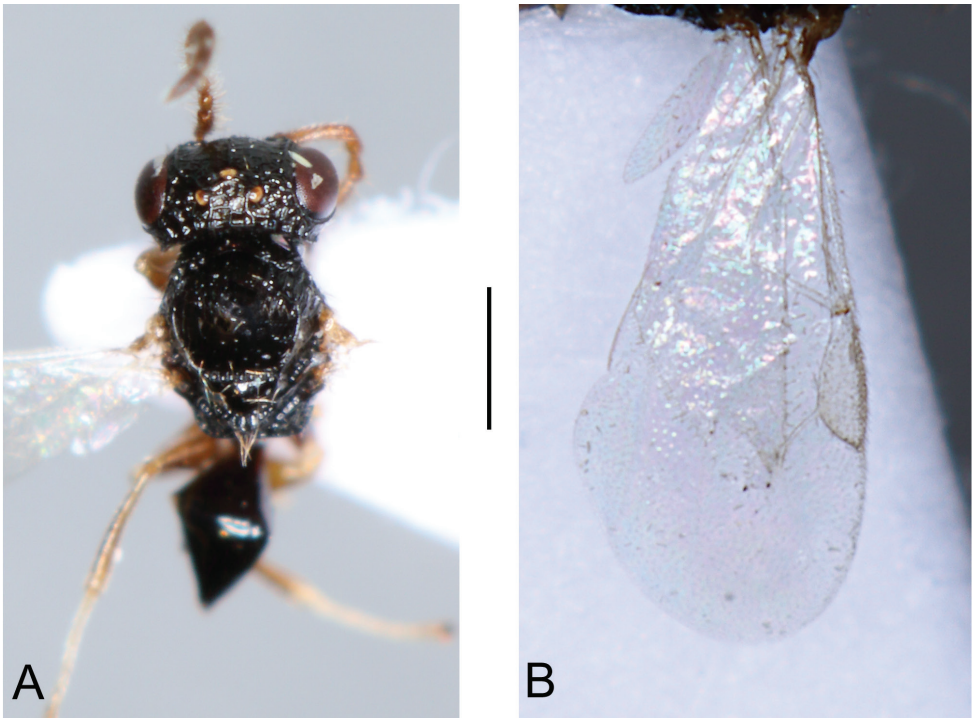

Figure 2. *Anteon huettingeri* Olmi, Xu & Guglielmino, sp. n.: **A** dorsal side **B** forewing. Scale bar = 0.67 mm (**A**), 0.41 mm (**B**).

Etymology. The species is named after the collector, Dr Ernst Hüttinger.

Remarks. Because of the antenna filiform, the scutum neither rugose nor sculptured by irregular keels, the posterior surface of the propodeum without longitudinal keels, the paramere without distal inner process, the new species is similar to *A. borneanum* Olmi, 1984, *A. insertum* Olmi, 1991, *A. jurineanum* Latreille, 1809, *A. krombeini* Olmi, 1984, *A. sarawaki* Olmi, 1984, *A. thai* Olmi, 1984 and *A. yasumatsui* Olmi, 1984. The main difference between *A. huettingeri* and all other species is centered on the structure of the inner side of the paramere (with many sensorial processes in *A. huettingeri* (Fig. 1); without sensorial processes in the other species (Plates 20 C, 30 D, 31 C, 31 D, 32 C, 43 B, 48 A, 50 E in Xu et al. 2013)). In the key to the males of Oriental *Anteon* published by Xu et al. (2013), the new species can be included by replacing couplet 9 as follows:

9	Inner side of paramere with many small sensorial processes (Fig. 1)	
	.....	***A. huettingeri* Olmi, Xu & Guglielmino, sp. n.**
–	Inner side of paramere without sensorial processes (Plates 20 C, 30 D, 31 C, 31 D, 32 C, 43 B, 48 A, 50 E in Xu et al. 2013)	**9'**
9'	Scutum granulated.....	**10**
–	Scutum punctate, or unsculptured, not granulated; occasionally scutum partly reticulate rugose	**11**
10	Paramere much shorter than penis (Plate 20C in Xu et al. 2013).....	
	.....	***A. borneanum* Olmi**
–	Paramere about as long as penis (Plate 31C, D in Xu et al. 2013).....	
	.....	***A. jurineanum* Latreille**
11	Head punctate, unsculptured among punctures.....	***A. insertum* Olmi**
–	Head granulated, or rugose, or with irregular keels	**12**
12	Head dull, smooth, granulated.....	***A. yasumatsui* Olmi**
–	Head shiny, rugose, with areolae and irregular keels	**13**
13	Notauli almost reaching posterior margin of scutum	***A. sarawaki* Olmi**
–	Notauli reaching at most 0.5 length of scutum	**14**

Conclusion

Xu et al. (2013) recorded 71 species of Dryinidae from Thailand. They belong to the following genera: *Aphelopus* Dalman, 1823 (seven species), *Crovettia* Olmi, 1984 (one species), *Anteon* Jurine, 1807 (26 species), *Deinodryinus* Perkins, 1907 (two species), *Bocchus* Ashmead, 1893 (three species), *Thaumatodryinus* Perkins, 1905 (two species), *Dryinus* Latreille, 1804 (13 species), *Pseudodryinus* Olmi, 1991 (one species), *Neodryinus* Perkins, 1905 (five species), *Echthrodelphax* Perkins, 1903 (three species), *Haplogonatopus* Perkins, 1905 (one species) and *Gonatopus* Ljungh, 1810 (seven species). With the description of the above new species the number of species now known in Thailand is 72.

In comparison with the 193 species recorded in China by He and Xu (2002) and the 62 and 40 listed respectively in India and Laos (Xu et al. 2013), the dryinid fauna of Thailand is poorly known. Some genera such as *Gonatopus* (with only seven species listed) are clearly under studied.

Acknowledgements

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SHORT COMMUNICATION

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First record of *Closterocerus chamaeleon*, parasitoid of the Eucalyptus Gall Wasp *Ophelimus maskelli* (Hymenoptera, Chalcidoidea, Eulophidae), in the New World

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Abstract

The uniparental parasitoid *Closterocerus chamaeleon* (Girault) is discovered to be fortuitously present on a population of the invasive Eucalyptus Gall Wasp *Ophelimus maskelli* (Ashmead) in Riverside, California. This is the first report from the New World of *C. chamaeleon*, which has proven to be a highly effective natural enemy of *O. maskelli* in the Mediterranean Basin. The taxonomy and identification of *C. chamaeleon* is discussed.

Keywords

Natural enemy, exotic pest, biological control

Introduction

Ophelimus maskelli (Ashmead) (Hymenoptera: Eulophidae) is a uniparental pest, originally from Australia, which forms leaf galls on *Eucalyptus* in the Exsertaria, Latoangulata, and Maidenaria sections, causing premature leaf drop. When uncontrolled, it reached high enough populations in the Mediterranean Basin to become a major nuisance in addition to the damage inflicted on *Eucalyptus* (Protasov et al. 2007a). It was recently found in multiple localities in southern California (Burks et al. 2015), and efforts have since been underway to explore biological control possibilities.

Closterocerus chamaeleon (Girault) (Hymenoptera: Eulophidae), also originally from Australia, has been the most effective natural enemy of *O. maskelli* released in the Mediterranean Basin, showing strong potential for spreading to populations of the pest in distant locations, and proving able to successfully attack overwintering hosts (Laudonia et al. 2006; Rizzo et al. 2006; Mendel et al. 2007; Protasov et al. 2007b; Caleca 2010; Caleca et al. 2011).

Both *O. maskelli* and *C. chamaeleon* are in the family Eulophidae, but are distantly related, in the subfamilies Opheliminae and Entedoninae, respectively. Opheliminae is composed entirely of gall makers and associates, while Entedoninae contains parasitoids of a wide variety of arthropods (Bouček 1988).

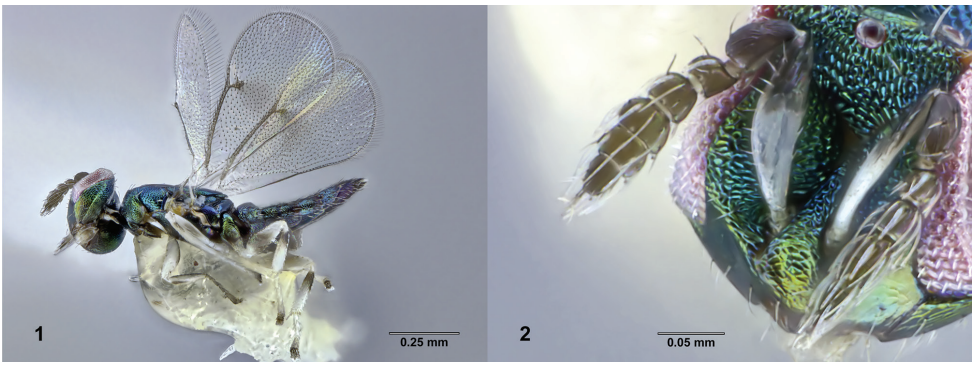
The morphology of *C. chamaeleon* was recently reviewed by Protasov et al. (2007b), who also discussed the recent taxonomic history of the genus *Closterocerus* Westwood. Since then, Burks et al. (2011) discovered that 28S D2 and COI DNA data supported *Closterocerus* as distinct from the morphologically similar genera *Chrysonotomyia* Ashmead and *Neochrysocharis* Kurdjumov. Placement of *C. chamaeleon* in *Closterocerus* is based on the strongly curved transepimeral sulcus and the presence of a bare area on the fore wing anterior to the uncus, which are reasonably reliable features of the genus (Hansson 1990, 1994). The number of spines on the volsellar digitus of the male genitalia has more recently been used to distinguish *Chrysonotomyia* (Hansson 2004) from all similar genera, but males of *C. chamaeleon* are unknown. The morphological features separating *C. chamaeleon* (Fig. 1) from species in all of these genera remain as initially reported (Protasov et al. 2007b: figs 1–12): antennal scape brown in apical third and with ventral margin convex, F3 (1st funicular) shorter than next flagellomere and strongly narrowed asymmetrically basally (Fig. 2), mesosoma dorsally with uniformly reticulate surface sculpture, fore wing with faint infuscation near stigmal vein, legs white except usually with brown areas on femora and laterally on metatibia, and gaster with first tergite smooth and all others reticulate.

Methods

Eucalyptus leaves with *O. maskelli* galls were placed in sealed containers awaiting emergence. A small amount of honey was placed on the inside of each container using a minutien pin probe. Photographs were taken using a Leica Imaging System with a Z16 APO A microscope, and stacked using Zerene Stacker (version 1.04). Terminology follows that of Gibson (1997).

Results and discussion

Several individuals of *Closterocerus chamaeleon* were reared from overwintering galls of *O. maskelli* on *Eucalyptus* leaves collected from the University of California, Riverside (UCR) campus on March 20, 2015. This suggests that *C. chamaeleon* was also present in the area in 2014. This is the first report of *C. chamaeleon* from the New World.



Figures 1–2. 1 *Closterocerus chamaeleon* reared from *Ophelimus maskelli* gall collected on UCR campus; body, lateral view. UCRCENT00412686 **2** Antennae and head of the same specimen, oblique antero-medial view.

While we have found *O. maskelli* in multiple locations in Orange, Riverside, and San Diego counties in California (Burks et al. 2015), we have found *C. chamaeleon* only in Riverside. No individuals of *C. chamaeleon* have been intentionally imported or released in California, and therefore it was most likely accidentally introduced through the same avenue that established *O. maskelli* in the area. This is therefore a case of fortuitous accidental introduction of a beneficial parasitoid.

Some native Californian species of *Neochrysocharis* are similar to *C. chamaeleon*, but they are parasitoids of leaf-miners and differ from *C. chamaeleon* in one or more details of surface sculpture, coloration, or flagellomere shape, and are not associates of *Eucalyptus*. Our specimens of *C. chamaeleon* were reared from *O. maskelli* galls on leaves of *Eucalyptus* isolated in sealed plastic containers and lacking leaf mines. In Hansson's (1994) key to Nearctic *Closterocerus*, *C. chamaeleon* keys to *Closterocerus ruforum* (Krausse), but these two species differ in antennal coloration especially, and in the dorsally carinate pedicel of *C. ruforum*. The pedicel in *C. chamaeleon* is rounded dorsally and lacks a carina (Fig. 2), and the scape is apically brown in *C. chamaeleon* but uniformly brownish in *C. ruforum*. Part of the 28S D2 rDNA of *C. chamaeleon* has already been sequenced (Adachi-Hagimori et al. 2011), and we are also in the process of sequencing another section of its 28S rDNA and the DNA barcoding region of its mtDNA, which will be uploaded to GenBank to facilitate identification of this species.

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It has come to our attention that in the work referenced above Figures 3A and 3E are incorrect. The published figures showed two chaetae in all lateral preclitellar bundles of *Chamaedrilus varisetosus* sp. n., instead of three chaetae in segments III-V (which is the most common occurrence), and an incomplete nephridial efferent duct.

The correct, whole Figure 3 is reproduced here below.

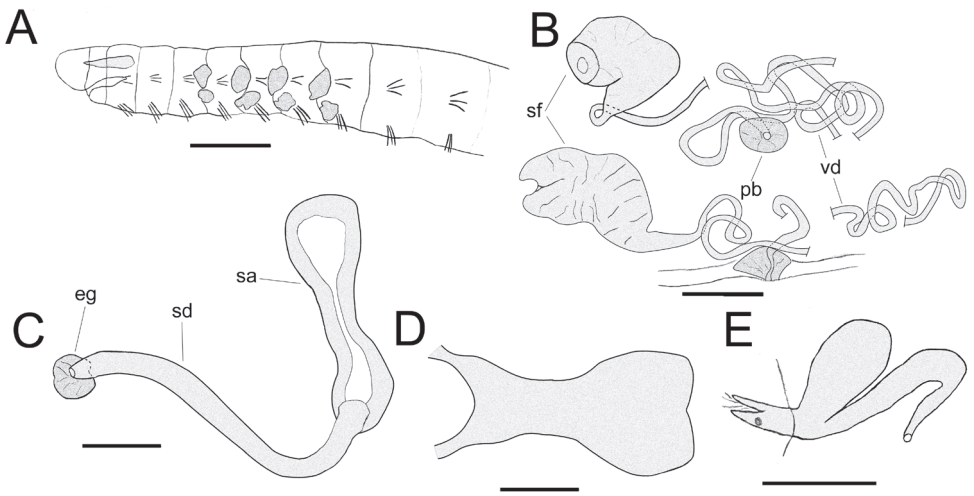

Figure 3. *Chamaedrilus varisetosus* sp. n. **A** Anterior part of body (immature specimen) in lateral view, indicating chaetal distribution and the size, shape and number of pharyngeal glands **B** Male genitalia of a mature worm with male pores in segment VIII **C** Spermatheca **D** Brain, dorsal view **E** Nephridium at septum 10/11, lateral view. Abbreviations: eg = ectal gland; pb = penial bulb; sa = spermathecal ampulla; sd = spermathecal duct; sf = sperm funnel; vd = vas deferens. Scale bars: 200 μm (**A**); 50 μm (**B–E**).

Furthermore, at the end of Material and methods, the University Museum Bergen should have been abbreviated ZMBN instead of UMB. We would like to thank Mark J. Wetzel (IHNS, University of Illinois) for bringing the incorrect abbreviation to our attention.