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Numerous new records of tropical non-indigenous species in the Eastern Mediterranean highlight the challenges of their recognition and identification

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Abstract

New data on 52 non-indigenous mollusks in the Eastern Mediterranean Sea is reported. *Fossarus* sp. (aff. *aptus* sensu Blatterer 2019), *Coriophora lessepsiana* Albano, Bakker & Sabelli, **sp. nov.**, *Cerithiopsis* sp. aff. *pulvis*, *Joculator problematicus* Albano & Steger, **sp. nov.**, *Cerithiopsis* sp., *Elachisina* sp., *Iravadia* aff. *elongata*, *Vitrinella* aff. *Vitrinella* sp. 1 (sensu Blatterer 2019), *Melanella orientalis*, *Parvioris* aff. *dilecta*, *Odostomia* cf. *dalli*, *Oscilla virginiae*, *Parthenina cossmanni*, *Parthenina typica*, *Pyrgulina craticulata*, *Turbonilla funiculata*, *Cylichna collyra*, *Musculus coenobitus*, *Musculus* aff. *viridulus*, *Chavania erythraea*,

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Scintilla cf. *violescens*, *Iacra seychellarum* and *Corbula erythraeensis* are new records for the Mediterranean. An unidentified gastropod, Skeneidae indet., *Triphora* sp., *Hypermastus* sp., *Sticteulima* sp., *Vitreolina* cf. *philippi*, *Odostomia* (s.l.) sp. 1, *Henrya* (?) sp., and Semelidae sp. are further potential new non-indigenous species although their status should be confirmed upon final taxonomic assessment. Additionally, the status of *Dikoleps micalii*, *Hemiliostraca clandestina* **comb. nov.** and *H. athenamariae* **comb. nov.** is changed to non-indigenous, range extensions for nine species and the occurrence of living individuals for species previously recorded from empty shells only are reported. *Opimaphora blattereri* Albano, Bakker & Sabelli, **sp. nov.** is described from the Red Sea for comparison with the morphologically similar *C. lessepsiana* Albano, Bakker & Sabelli, **sp. nov.** The taxonomic part is followed by a discussion on how intensive fieldwork and cooperation among institutions and individuals enabled such a massive report, and how the poor taxonomic knowledge of the Indo-Pacific fauna hampers non-indigenous species detection and identification. Finally, the hypothesis that the simultaneous analysis of quantitative benthic death assemblages can support the assignment of non-indigenous status to taxonomically undetermined species is discussed.

Keywords

Cerithiopsidae, invasion biology, Lessepsian invasion, Mollusca, new species, Red Sea, taxonomy, Triphoridae

Introduction

The Eastern Mediterranean Sea is a hotspot of non-indigenous species introductions. The opening of the Suez Canal in 1869 broke a long-standing biogeographic barrier and enabled hundreds of Red Sea species to enter the basin and establish populations (Por 1978; Galil 2009; Zenetos et al. 2010, 2017; Zenetos and Galanidi 2020). These so-called Lessepsian species are now recorded from all countries bordering this basin west to Greece (Katsanevakis et al. 2009; Çinar et al. 2011; Ammar 2018; Zenetos et al. 2018; Bariche and Fricke 2020; Crocetta et al. 2020) and some have already reached the central Mediterranean, e.g., Tunisia (Ounifi-Ben Amor et al. 2015), Italy (Occhipinti-Ambrogi et al. 2011), and even France (Daniel et al. 2009; Bodilis et al. 2011).

The introduction rate is an important metric to describe the invasion process. Genuine variation in this rate can result from changes in vector efficacy, connectivity between the native and introduced range, and environmental conditions in the recipient ecosystem. The introduction rate is often estimated from the discovery record (Solow and Costello 2004). However, even in well sampled and taxonomically well-known groups like mollusks, multi-decadal time lags between introduction and first detection have been quantified (Oliver 2015; Guy-Haim et al. 2017; Albano et al. 2018), suggesting that the detection rate is a poor proxy of the introduction rate. Indeed, although the discovery rate is increasing (Galil 2009; Raitsos et al. 2010), estimates of the introduction rate corrected for temporal variation in sampling effort for Lessepsian fishes showed that it was constant over ~ 1930–2010 (Belmaker et al. 2009). Still, the most recent enlargement of the Suez Canal has raised concerns that the improved connectivity could increase the introduction rate of Lessepsian species

(Galil et al. 2015). Additionally, rapid climate warming is particularly affecting the Eastern Mediterranean (Ozer et al. 2017), causing, on the one hand, the decline of native species and, on the other hand, more favourable conditions for the establishment of tropical species (Rilov 2016; Albano et al. 2021).

To monitor a dynamic process such as the Lessepsian invasion, intensive fieldwork is mandatory. We indeed show that an intensive sampling effort coupled with identification at high taxonomic resolution and collaborative research among individuals and institutions enabled the detection of 23 new Lessepsian mollusks, another nine species which, upon further inspection, may prove to be new Lessepsian species, nine new records for Eastern Mediterranean countries, and new data for eleven already recognized non-indigenous species. We here describe these new findings, providing detailed collecting data, taxonomic comments, and comparisons with similar species.

Materials and methods

Origin of samples

The studied material comes from three main sources. First, sampling on the Israeli Mediterranean shelf performed in the context of the project "Historical ecology of Lessepsian migration" (**HELM**), in progress at the University of Vienna. Second, benthic assemblage monitoring by the Israel Oceanographic and Limnological Research (**IOLR**). Third, smaller scale sampling by some of us, further detailed in the Results section.

Sampling in the framework of the HELM project was conducted on soft substrates between 10 and 40 m depth with a van Veen grab, and on hard substrates between 5 and 30 m by diver-operated airlift suction sampling, using 0.5 mm mesh-size net bags. Samples were sieved with a 0.5 mm mesh and the retained material fixed in 95% ethanol. Both living individuals and empty shells were identified and counted.

IOLR conducts regular monitoring of Israeli soft bottom benthic assemblages in the framework of the National Monitoring (NM) and focused sampling for environmental assessment (APM DAN, Shafdan, Via Maris). The NM, APM DAN and Via Maris projects sampled soft substrates with a 0.11 m^2 van Veen grab at depths between 6 and 12.5 m (NM), 22 and 26.5 m (APM DAN) and 18 and 26 m (Via Maris). Samples were sieved with a 250 μm mesh. During the Shafdan project, three replicate sediment samples were taken at each station from a different 0.062 m^2 box-corer launch (Ocean Instruments model 700 AL) twice a year in spring (May) and fall (October). The samples were sieved on board with a 0.5 mm mesh. All samples were preserved in 99% ethanol, stained with eosin solution (hence the pink hue that some specimens bear) and picked for living individuals.

Finally, we included serendipitous findings by some of us or by colleagues within our extended network, from multiple localities. For each species, we provide detailed collecting data following the guidelines by Chester et al. (2019).

Taxonomic assignment and non-indigenous status attribution

The depth of taxonomic assignment varies across taxa, mostly reflecting the available knowledge on these groups in the Indo-Pacific province (the source pool of most non-indigenous species in the Eastern Mediterranean). For families like the Triphoridae, some of us (PGA, PAJB, and BS) have been conducting taxonomic research for a long time and we have thus been able to describe new species as we have robust knowledge of inter- and intraspecific variability and of type specimens (Albano et al. 2011, 2017, 2019; Albano and Bakker 2016). For other families, like the Eulimidae, we focused our attention on highlighting differences from native species and similarities with Indo-Pacific species, because a more thorough coverage would have required revising the taxonomy of entire Indo-Pacific species-groups, a task well beyond our objectives. In all cases, we strove to provide detailed and high-quality images as a basis to foster further research and enable the scientific community to refine our identifications. The use of qualifiers for species left in open nomenclature follows the recommendations of Sigovini et al. (2016).

Acknowledging that an unsettled taxonomic status implies uncertainty in the assignment of non-indigenous status (Marchini et al. 2015), we here tagged as non-indigenous only the species which: i) unequivocally belong to Indo-Pacific species; ii) belong to clades (genera or families) that do not occur in the Mediterranean Sea, even if left in open nomenclature; iii) belong to species whose diagnostic characters did not enable a clear attribution to a non-Mediterranean clade but that were found alive while not, or only very rarely, in the death assemblage (see Discussion). In contrast, we tagged as "potential" non-indigenous species those whose morphological characters did not allow for an unambiguous attribution to a non-Mediterranean clade and that were found mostly, or exclusively, as empty shells.

Imaging and reporting

Small specimens were photographed with a Zeiss SteREO Discovery.V20 stereomicroscope, larger ones with a Nikon D7200 camera mounted on a stand, using a Nikon Micro-Nikkor 60 mm lens. Photographs were stacked with Helicon Focus 6. Scanning electron microscope (SEM) images were shot with a Fei Inspect S50 at low-vacuum mode without coating. The internal shell morphology of *Odostomia* (s.l.) sp. 1, with a particular focus on the intorted protoconch, was visualized using a Phoenix v|tome|x s research edition computer tomographic (CT) scanner. The 3D-reconstruction and virtual sections through the shell were produced with VGSTUDIO MAX 2.1 software. The X-ray image stack, mesh files, virtual sections, and a video showing the interior of the shell are available from the Figshare repository (https://doi.org/10.6084/m9.figshare.c.5215226). Plates were mounted with the image manipulation software GIMP 2.

For each new non-indigenous species record, we report the size of at least one specimen (usually the one figured, unless otherwise stated). The systematic arrangement follows Bouchet et al. (2010, 2017). Table 1 summarizes the species treated in this work.

Table 1. List of the taxa treated in this paper, with indication of the novelty of the records.

Family	Taxon	Novelty	Page	Figure
–	Unidentified gastropod	Potential new NIS for the Mediterranean Sea	6	Figure 1
Conradiidae	*Conradia eutornisca*	First record of living individuals in the Mediterranean Sea	7	–
Skeneidae	*Dikoleps micalii*	Declared NIS in the Mediterranean Sea. First record from Israel; first record of living individuals in the Mediterranean Sea	8	Figure 2
	Skeneidae indet.	Potential new NIS for the Mediterranean Sea	9	Figure 3
Planaxidae	*Fossarus* sp. (aff. *aptus* sensu Blatterer, 2019)	New NIS for the Mediterranean Sea	10	Figure 4
Epitoniidae	*Cycloscala hyalina*	First record of living individuals in the Mediterranean Sea	11	–
Naticidae	*Eunaticina papilla*	First record of living individuals in Israel	12	Figure 5
Triphoridae	*Coriophora lessepsiana* Albano, Bakker & Sabelli, sp. nov.	New NIS for the Mediterranean Sea	12	Figure 6
	Opimaphora blattereri Albano, Bakker & Sabelli, sp. nov.	New species from the Red Sea, for comparison with the non-indigenous *Coriophora lessepsiana* Albano, Bakker & Sabelli, sp. nov.	15	Figure 7
	Triphora sp.	Potential new NIS for the Mediterranean Sea	18	Figure 8
	Viriola cf. *bayani*	New reports of living individuals from Israel	19	–
Cerithiopsidae	*Cerithiopsis* sp. aff. *pulvis*	New NIS for the Mediterranean Sea	20	Figure 9
	Cerithiopsis sp.	New NIS for the Mediterranean Sea	20	Figure 10
	Joculator problematicus Albano & Steger, sp. nov.	New NIS for the Mediterranean Sea	23	Figure 11
Elachisinidae	*Elachisina* sp.	New NIS for the Mediterranean Sea	26	Figure 12
Iravadiidae	*Iravadia* aff. *elongata*	New NIS for the Mediterranean Sea	26	Figure 13
Vitrinellidae	*Vitrinella* aff. *Vitrinella* sp. 1 (sensu Blatterer 2019)	New NIS for the Mediterranean Sea	29	Figure 14
Eulimidae	*Hypermastus* sp.	Potential new NIS for the Mediterranean Sea	31	Figure 15
	Hemiliostraca clandestina comb. nov.	Declared NIS in the Mediterranean Sea. First record from Israel; first record of living individuals in the Mediterranean Sea	31	Figure 16
	Melanella orientalis	New NIS for the Mediterranean.	33	Figure 17
	Parvioris aff. *dilecta*	New NIS for the Mediterranean Sea	35	Figure 18
	Sticteulima sp.	Potential new NIS for the Mediterranean Sea	37	Figure 19
	Vitreolina cf. *philippi*	Potential new NIS for the Mediterranean Sea	37	Figure 16
Conidae	*Conus fumigatus*	First record from Israel	38	Figure 20
Murchisonellidae	*Henrya* (?) sp.	Potental new NIS for the Mediterranean Sea	39	Figure 21
Pyramidellidae	*Odostomia* cf. *dalli*	New NIS for the Mediterranean Sea	41	Figure 22
	Odostomia (s.l.) sp. 1	Potential new NIS for the Mediterranean Sea	41	Figure 23
	Odostomia (s.l.) sp. 2	First record of a living individual in the Mediterranean Sea	44	Figure 24
	Oscilla virginiae	New NIS for the Mediterranean Sea	45	Figure 25
	Parthenina cossmanni	New NIS for the Mediterranean Sea	47	Figure 26
	Parthenina typica	New NIS for the Mediterranean Sea	49	Figure 27
	Pyrgulina craticulata	New NIS for the Mediterranean Sea	49	Figure 28
	Pyrgulina nana	First record of living individuals in Israel	53	–
	Turbonilla funiculata	New NIS for the Mediterranean Sea	53	Figure 29
Cylichnidae	*Cylichna collyra*	New NIS for the Mediterranean Sea	55	Figure 30
Mnestiidae	*Mnestia girardi*	First record of living individuals in the Mediterranean Sea	57	–
Haminoeidae	*Atys angustatus*	First record from Greece	57	Figure 31
Mytilidae	*Arcuatula perfragilis*	Additional records of living individuals from Israel	58	Figure 32
	Lioberus ligneus	First record from Cyprus and Israel	58	Figure 33
	Musculus coenobitus	New NIS for the Mediterranean Sea	60	Figure 34, Figure 35
	Musculus aff. *viridulus*	New NIS for the Mediterranean Sea	61	Figure 36
Isognomonidae	*Isognomon* aff. *australica* (sensu Angelidis and Polyzoulis 2018)	New record from Cyprus	65	Figure 37
Lucinidae	*Pegophysema* cf. *philippiana*	First record of living individuals in the Mediterranean Sea	66	Figure 38
	Chavania erythraea	New NIS for the Mediterranean Sea	67	Figure 39
	Rugalucina angela	Additional records of living individuals from Israel	67	–

Family	Taxon	Novelty	Page	Figure
Galeommatidae	*Nudiscintilla* cf. *glabra* (sensu Mifsud and Ovalis 2012)	First record from Israel	68	Figure 40
Galeommatidae	*Scintilla* cf. *violescens*	New NIS for the Mediterranean Sea	69	Figure 41
Psammobiidae	*Gari pallida*	Additional records of living individuals from Israel	72	–
Semelidae	*Ervilia scaliola*	First record from Israel	72	Figure 42
	Iacra seychellarum	New NIS for the Mediterranean Sea	72	Figure 43
	Semelidae sp.	Potential new NIS for the Mediterranean Sea	74	Figure 44
Veneridae	*Clementia papyracea*	Additional records of living individuals from Israel	76	–
Corbulidae	*Corbula erythraeensis*	New NIS for the Mediterranean Sea	76	Figure 45

Abbreviations

BPBM	Bernice Pauahi Bishop Museum, Honolulu, Hawaii, USA;
H	height;
HELM	“Historical ecology of Lessepsian migration” project;
IOLR	Israel Oceanographic and Limnological Research;
L	length;
LACM	Natural History Museum of Los Angeles County, Los Angeles, California, United States;
MNHN	Museum national d’Histoire naturelle, Paris, France;
MSNG	Museo Civico di Storia Naturale di Genova “Giacomo Doria”, Genova, Italy;
MZUB	Museum of Zoology of the University of Bologna, Italy;
NHMW	Natural History Museum, Vienna, Austria;
NM	National Monitoring Israel;
OLML	Oberösterreichisches Landesmuseum Linz, Austria;
RMNH	Rijksmuseum van Natuurlijke Historie (now Naturalis Biodiversity Center), Leiden, The Netherlands;
SMF	Senckenberg Museum Frankfurt, Germany;
SMNH	Steinhardt Museum of Natural History, Tel Aviv, Israel;
sh/shs	empty shell/s;
spcm/spcms	live collected specimen/s;
v/vv	valve/s;
W	width.

Results

Class Gastropoda Cuvier, 1795
Family unassigned (Caenogastropoda)

Unidentified gastropod
Figure 1

New records. Israel • 1 spcm; Haifa Bay; 32.8211°N, 35.0196°E; depth 11 m; 2 Aug. 2015; soft substrate; grab; NM project (sample HM27(c)); size: H 2.5 mm, W 1.6 mm.

Remarks. We were not able to confidently assign this specimen to any family. The general characters suggest that it is a caenogastropod. This specimen has apparently

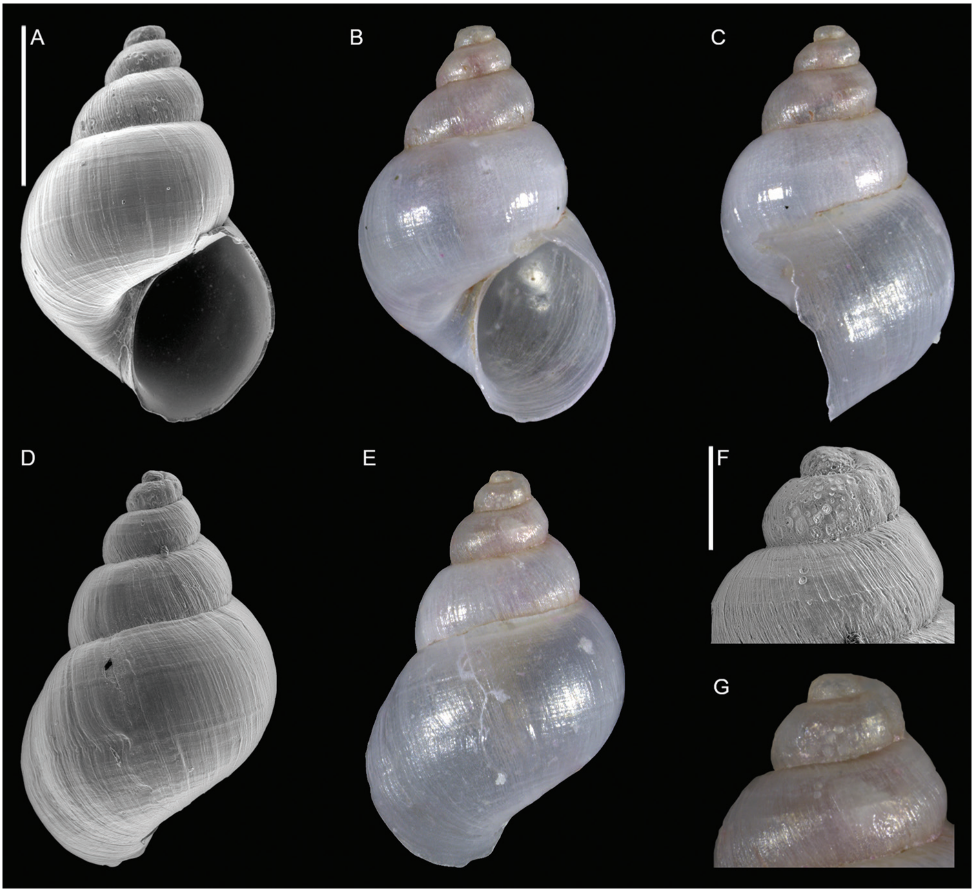

Figure 1. Unidentified gastropod (Caenogastropoda), Haifa Bay, Israel (sample HM27(c)): front (**A, B**), side (**C**) and back (**D, E**) views, protoconch (**F, G**). Scale bars: 1 mm (**A–E**); 0.3 mm (**F–G**).

traces of the animal inside and has thus been considered live collected. However, as it was found in Haifa Bay, we cannot exclude that it comes from freshwater or transitional ecosystems (the adjacent Kishon River and estuary) whose waters flow into the bay. An anatomical study of the soft parts, should another living specimen become available, will clarify the taxonomic placement of this intriguing species.

Family Conradiidae Golikov & Starobogatov, 1987

Conradia eutornisca (Melvill, 1918)

New records. Israel • 1 sh; Ashqelon; 31.7101°N, 34.5406°E; depth 31 m; 18 Sep. 2016; muddy-sand; grab; HELM project (sample SG30_5F) • 3 spcms; Ashqelon; 31.6868°N, 34.5516°E; depth 11 m; 31 Oct. 2018; offshore rocky reef; suction sampler; HELM project (samples S58_1M, S58_2F) • 3 spcms; Ashqelon; 31.6891°N, 34.5257°E; depth 25 m; 2 May 2018; offshore rocky reef; suction sampler; HELM project (sample S16_1M) • 1 spcm; same collecting data as for preceding; depth 28 m; 31 Oct. 2018; HELM project (sample S59_3F) • 1 spcm, 1 sh; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 1 May 2018; rocky substrate; suction sampler; HELM project (samples S14_1F, S14_3F) • 3 spcms; same collecting data as for preceding; 29 Oct. 2018; HELM project (samples S52_1M, S52_3F, S52_3M) • 12 spcms, 4 shs; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E; depth 20 m; 1 May 2018; rocky substrate; suction sampler; HELM project (samples S13_1F, S13_1M, S13_2F, S13_3F, S13_3M) • 14 spcms; same collecting data as for preceding; depth 19 m; 29 Oct. 2018; HELM project (samples S53_1F, S53_1M, S53_2F, S53_2M, S53_3F, S53_3M); size: H 2 mm, W 1.7 mm.

Remarks. The species has already been reported from Israel and Turkey (Bogi and Galil 1999; Buzzurro and Cecalupo 2006), but only from empty shells. To the best of our knowledge, this is the first record of living individuals from the Mediterranean Sea. Based on our observations, it occurs rather frequently on shallow subtidal rocky substrates. The samples from Turkey led to the description of *Parviturbo dibellai* Buzzurro & Cecalupo, 2006, at that time supposed to be a native species, but this name was later recognized to be a synonym of the Indo-Pacific *Fossarus eutorniscus* (Rubio et al. 2015), attributed to *Conradia* by Janssen et al. (2011). Janssen et al. (2011) highlighted, however, that the Red Sea specimens have seven spiral cords instead of the five cited in the original description based on material from Karachi (Pakistan). Specimens with five spiral cords occur also in the Persian (Arabian) Gulf and rarely in the Red Sea (H. Dekker, pers. comm., November 2020). Further research is required to ascertain if these two morphologies belong to two different taxa.

Family Skeneidae W. Clark, 1851

Dikoleps micalii Agamennone, Sbrana, Nardi, Siragusa & Germanà, 2020

Figure 2

New records. Israel • 4 spcms; Haifa Bay; 32.8211°N, 35.0196°E; depth 11 m; 2 Aug. 2015; soft substrate; grab; NM project (samples HM27(a) and HM27(c)); size of largest specimen: H 0.7 mm, W 0.7 mm.

Remarks. This species has been recently described from sediment collected in 2016 at 33–45 m depth at Karpathos and Samos islands in the eastern Aegean Sea (Agamennone et al. 2020b). The authors discussed but declined the possibility that this is a Lessepsian species, but one of us (BS) observed non-distinguishable specimens from the Red Sea and we received reports of further indistinguishable specimens from the Persian (Arabian) Gulf (H. Dekker, pers. comm., November 2020). This is the first record for Israel; all specimens were live collected.

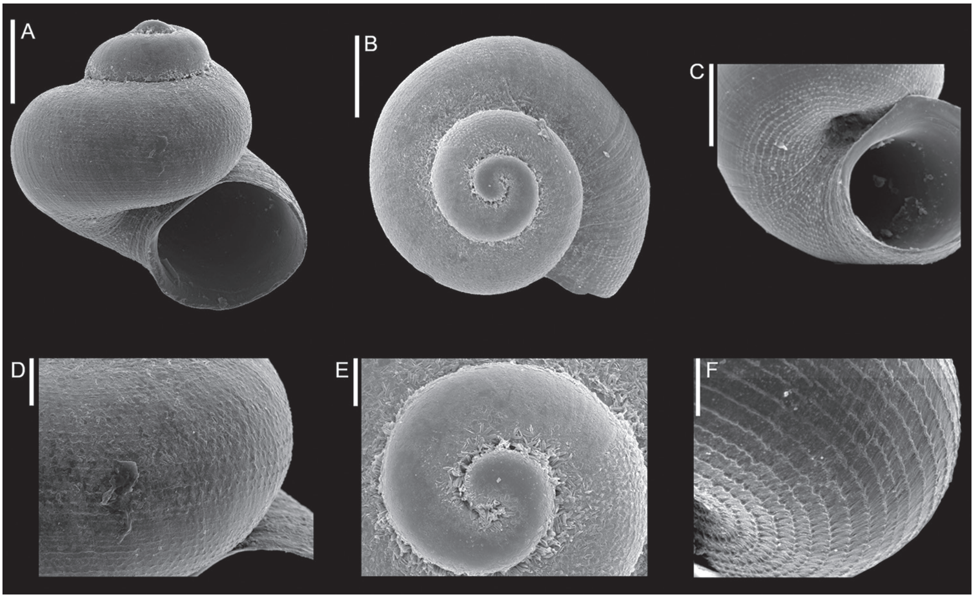

Figure 2. *Dikoleps micalii* Agamennone, Sbrana, Nardi, Siragusa & Germanà, 2020, Haifa Bay, Israel: front (**A**) and apical (**B**) views, umbilicus (**C**), microsculpture of body whorl (**D**), apical view of protoconch (**E**) and microsculpture of the base (**F**). Photograph courtesy A. Bonfitto. Scale bars: 0.2 mm (**A–C**); 0.05 mm (**D–F**).

Skeneidae indet.

Figure 3

New records. Israel • 1 sh; Akko; 32.92°N, 35.07°E; depth 4 m; 22 Oct. 1998; shell grit sample; size: H 0.6 mm, W 1.0 mm.

Remarks. This tiny gastropod (largest diameter 1 mm) is characterized by a small but solid shell, ~ 0.75 whorls of protoconch with axial costae visible near the proto-teleoconch transition (more costae closer to the nucleus may be abraded), and two teleoconch whorls with numerous regular spiral cords. The shoulder is slightly angulated near the lip. Umbilicus open, large. Shell white, slightly translucent. No native Mediterranean species shares these features. Only *Skenea catenoides* (Monterosato, 1877) has a similarly solid shell with numerous regular spiral cords, but it can be distinguished easily by the three nodulose thicker spiral cords on the base and the lack of angulation at the shoulder. Both Mediterranean (e.g., *Circulus striatus* (Philippi, 1836) and Red Sea *Circulus* (e.g., *C. novemcarinatus* (Melvill, 1906a)) and *C. octoliratus* (Carpenter, 1856)) can be distinguished by the multispiral protoconch and the much more prominent spiral cords. It is most likely a new, probably still unnamed, Indo-Pacific species in the Mediterranean.

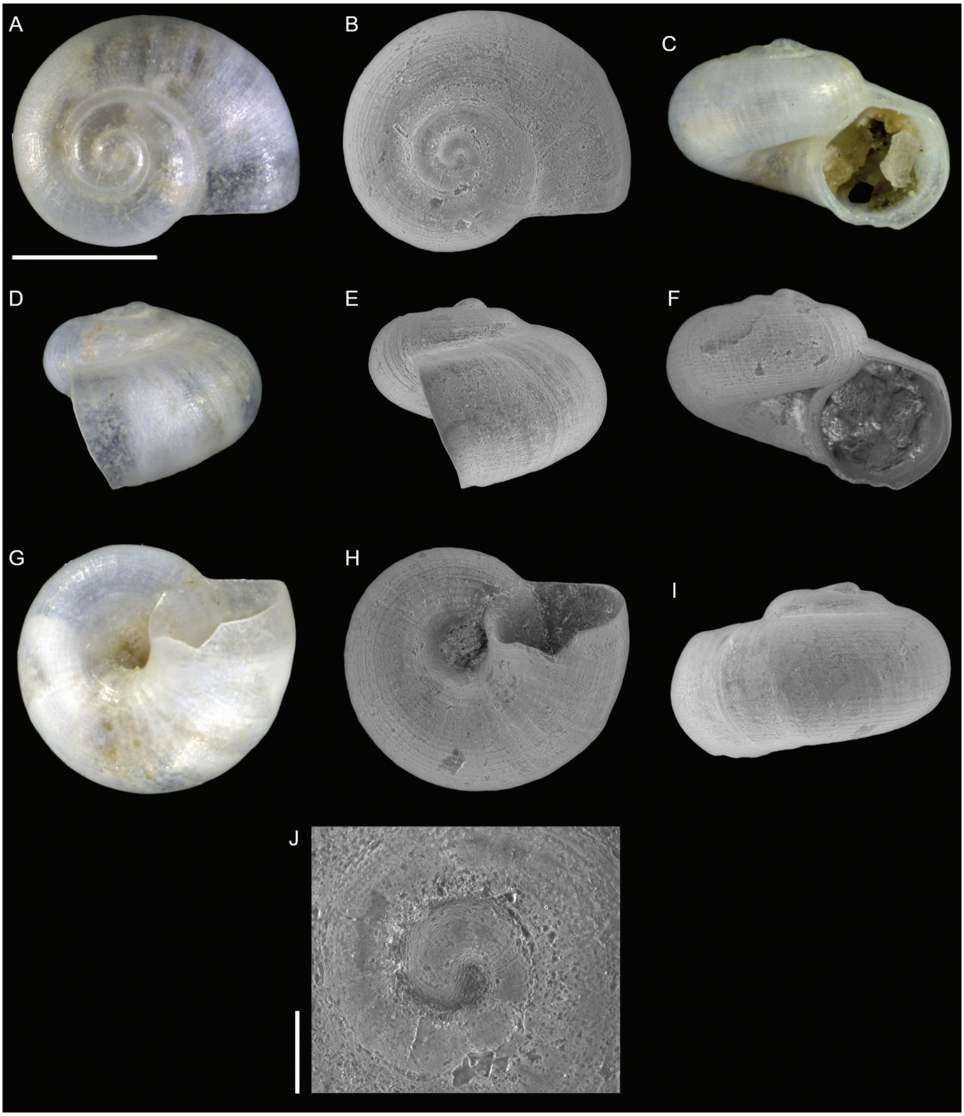

Figure 3. Skeneidae indet., Akko, Israel: apical (**A, B**), front (**C, F**), side (**D, E**), umbilical (**G, H**) and back (**I**) views, protoconch (**J**). Scale bars: 0.5 mm (**A–I**); 0.1 mm (**J**).

Family Planaxidae Gray, 1850

Fossarus sp. (aff. *aptus* sensu Blatterer 2019)

Figure 4

New records. Israel • 1 sh; Ashqelon; 31.6868°N, 34.5516°E; depth 11 m; 31 Oct. 2018; offshore rocky reef; suction sampler; HELM project (sample S58_3M); size: H 3.3 mm, W 2.7 mm.

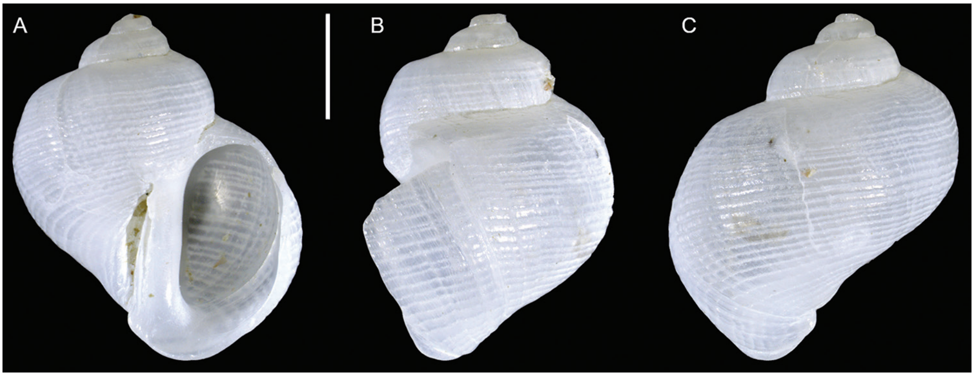

Figure 4. *Fossarus* sp. (aff. *aptus* sensu Blatterer, 2019), Ashqelon, Israel, HELM project (sample S58_3M): front (**A**), side (**B**) and back (**C**) views. Scale bar: 1 mm.

Remarks. We found a single empty shell of this *Fossarus* that can be readily distinguished from the Mediterranean *F. ambiguus* (Linnaeus, 1758), which bears prominent spiral ridges and has a depressed spire. In contrast, our shell bears numerous spiral cords and has a high spire. This shell is extremely similar to "*Fossarus* aff. *aptus* Melvill, 1912" illustrated by Blatterer (2019: plate 87, fig. 7a–f). Especially the largest specimen (plate 87, fig. 7a, b) bears a sculpture of similarly depressed and closely arranged spiral cords, has a very similar profile and a large elongated umbilical area. Blatterer's specimen shows, however, more regularly alternated thicker and finer cords, whereas in our specimen this feature is not so evident. Our specimen is almost the double in size and rather worn, which may explain the observed differences in sculpture. The extreme similarity with Blatterer's Red Sea specimens suggests that this is a new non-indigenous species in the Mediterranean Sea.

The name *aptus* is problematic. Originally introduced by Melvill (1912) for a species from the Persian (Arabian) Gulf, it is currently considered a synonym of the Atlanto-Mediterranean *F. ambiguus* (MolluscaBase 2020), but no revision of this genus is available. However, this name fits neither Blatterer's specimens nor ours because *F. aptus* is characterized by five strong spiral keels (indeed similar to *F. ambiguus*).

Family Epitoniidae Berry, 1910 (1812)

Cycloscala hyalina (G.B. Sowerby II, 1844)

New records. Israel • 2 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 29 Oct. 2018; rocky substrate; suction sampler; HELM project (samples S52_1M, S52_2F); size of largest specimen: H 3.7 mm, W 2.0 mm.

Remarks. The species has been recently recorded for the Mediterranean Israeli coastline based on empty shells collected off the Soreq desalination plant, ~ 15 km south of Tel Aviv (Scaperrotta et al. 2019). The species is also known from Cyprus (Cecalupo and Quadri 1994), Turkey (Giunchi et al. 2001), and Greece (Scaperrotta et al. 2019). To our knowledge, this is the first record of living individuals in the Mediterranean Sea.

Family Naticidae Guilding, 1834

Eunaticina papilla (Gmelin, 1791)
Figure 5

New records. Israel • 1 spcm; Ashdod; 31.8758°N, 34.6465°E; depth 27 m; 17 May 2017; soft substrate; grab; APM DAN project (sample 8C); size: H 1.1 mm, W 1.4 mm (illustrated specimen) • 1 sh; rocky reef off Sdot Yam; 32.5111°N, 34.8702°E; depth 28 m; 1 Nov. 2018; hard substrate; suction sampler; HELM project (sample S60_2M).

Remarks. We here report the finding of a living individual of *Eunaticina papilla* from the Israeli Mediterranean shelf. This juvenile specimen can be assigned to *E. papilla* because of its overall shape, the sculpture of fine spiral cords, the large umbilicus and the morphology of the thin corneus operculum (Figure 5D).The species has already been reported in the Mediterranean Sea from Iskenderun in eastern Turkey with a living individual (Öztürk and Bitlis Bakir 2013). An empty shell was collected near Shiqmona, Israel, in November 2019 and reported as *Eunaticina linneana* (Récluz, 1843) (Schechter and Mienis 2020), a name considered a junior synonym of *E. papilla* by Beu et al. (2004).

Family Triphoridae Gray, 1847

Coriophora lessepsiana Albano, Bakker & Sabelli, sp. nov.
http://zoobank.org/B6911508-20E6-43B2-A01C-694571AD60FE
Figure 6

Type material. *Holotype.* Egypt • sh; Sinai (Red Sea), Dahab, dive site "Blue Hole"; 28.572°N, 34.538°E; depth 4 m; 2017; H. Blatterer leg.; NHMW-MO-113282.

Paratypes. Egypt • sh; Sinai (Red Sea), Dahab, dive site "Tigerhouse"; 28.567°N, 34.533°E; depth 7 m; 2015; H. Blatterer leg.; OLML LIEV 2019/70/1 (paratype 1) • sh; Sinai (Red Sea), Dahab, dive site "Caves"; 28.416°N, 34.456°E; depth 20 m; 2017; H. Blatterer leg.; MNHN-IM-2014-7546 (paratype 2)

Sudan • sh; Arous, ca 30 km N of Port Sudan; 19.90°N, 37.23°E; depth 25–30 m; 2–8 Apr. 1975; G. Spada leg.; MZUB 60254 (paratype 3).

Additional material examined. Egypt • 1 sh; Sinai (Red Sea), Dahab, dive site "Caves"; 28.416°N, 34.456°E; depth unspecified; 2012; H. Blatterer leg. • 1 sh; same collecting data as for preceding; depth 15 m; 2015 • 1 sh; same collecting data as for preceding; depth 14 m; 2017 • 1 sh; same collecting data as for preceding; depth 18 m; 2017 • 1 sh (juv.); Sinai (Red Sea), Dahab, dive site "Blue Hole"; floor of cave in cliff face; 28.57°N, 34.54°E; depth 25 m; Oct. 1994; D. Korkos leg.; H. Dekker coll. reg. no. 22017.

Records from the Mediterranean Sea. Israel • 1 sh; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 29 Oct. 2018; HELM project (sample S52_2M); NHMW-MO-112930/LM/0169; size: H 3.1 mm, W 1.2 mm (illustrated shell, Figure 6N, O).

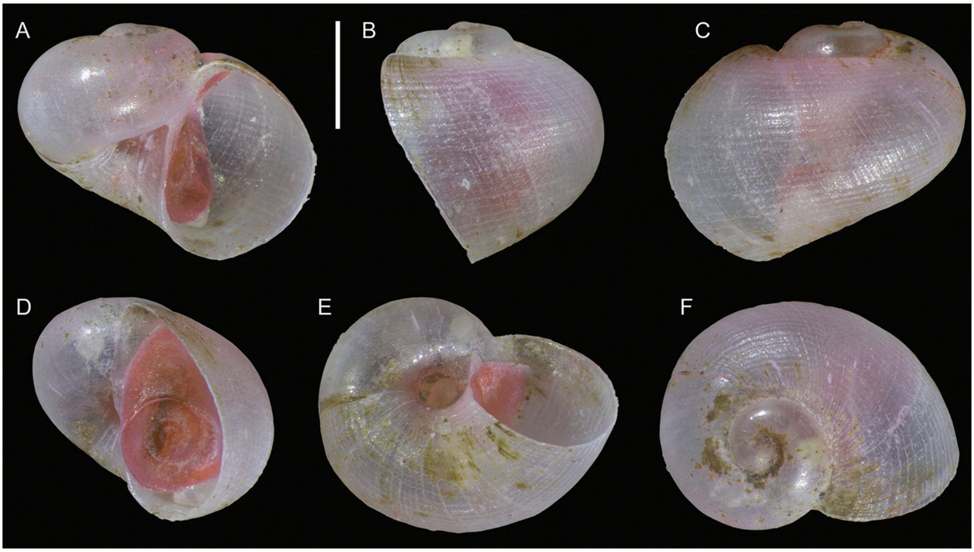

Figure 5. *Eunaticina papilla* (Gmelin, 1791), juvenile, Ashdod, Israel, APM DAN project (sample 8C): front (**A**), side (**B**) and back (**C**) views, operculum (**D**), base (**E**) and apical view (**F**). The pink hue is due to staining with eosin solution. Scale bar: 0.5 mm.

Diagnosis. Shell cyrtoconoid of ~ 3 mm with 11 whorls and multispiral protoconch. Nucleus with hemispherical granules. Sculpture of three spiral cords of which two with elevated tubercles larger than their interspaces; second cord appearing later. Peristome apparently without bifurcating spiral cords.

Description. ***Color*:** protoconch light brown; first teleoconch whorls whitish, with the first spiral cord becoming brown after one to three whorls. The second spiral cord acquires this brown color only on the dorsal part of the last whorl. The fourth cord, visible only on the last whorl, is brown. The base is light brown.

***Dimensions*:** H 2.6 mm, W 1.0 mm (holotype); H 2.4 mm, W 0.9 mm (paratype 1); H 2.7 mm, W 1.1 mm (paratype 2, without apex); H 3.1 mm, W 1.2 mm (Mediterranean specimen, without apex).

***Protoconch*:** multispiral with five whorls, H 530 µm (holotype), 553 µm (paratype 1).

Protoconch I: 1.5 whorls with hemispherical granules, nucleus height of 114 µm (holotype), 104 µm (paratype 1) and a maximum diameter of 154 µm (holotype), 145 µm (paratype 1).

Protoconch II: 3.5 monocarinated whorls with axial orthogonal riblets with a maximum diameter of 305 µm (holotype), 311 µm (paratype 1), 323 µm (paratype 2), 268 µm (Mediterranean specimen).

***Teleoconch*:** 6 (holotype, paratype 1 and 2), 7.5 (Mediterranean specimen) whorls, height: 2.04 mm (holotype), 1.83 mm (paratype 1), 2.43 mm (paratype 2) and 2.95 mm (Mediterranean specimen).

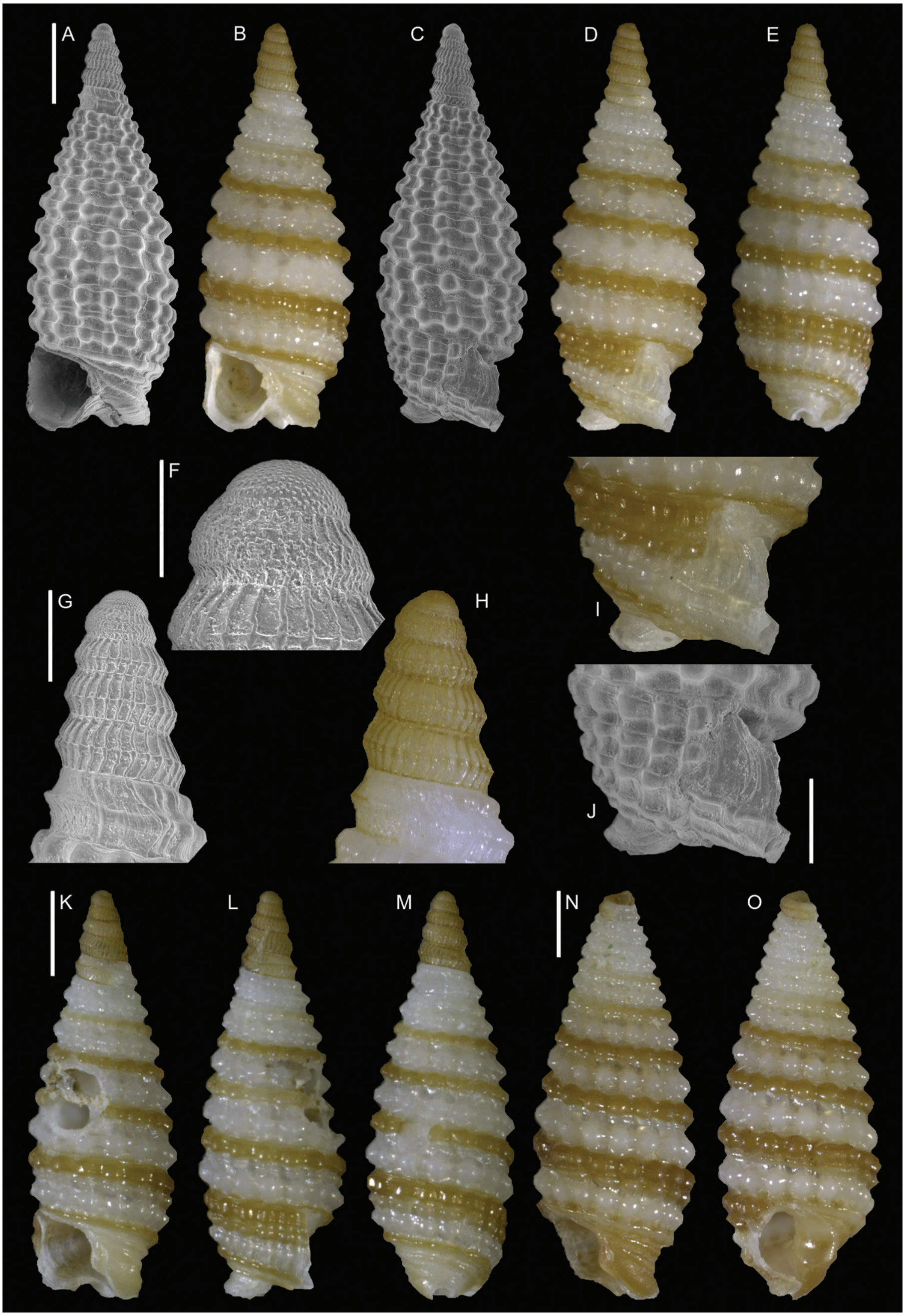

Figure 6. *Coriophora lessepsiana* Albano, Bakker & Sabelli, sp. nov. **A–J** holotype, NHMW-MO-113282, dive site "Blue Hole", Dahab, Sinai, Egypt: front (**A, B**), side (**C, D**) and back (**E**) views, nucleus (**F**), protoconch (**G, H**) and peristome (**I, J**) **K, M** paratype 1, OLML LIEV 2019/70/1, dive site "Tigerhouse", Dahab, Sinai, Egypt: front (**K**), side (**L**) and back (**M**) views. **N, O** NHMW-MO-112930/LM/0169, west of Rosh HaNikra Islands, Israel (Mediterranean), HELM project (sample S52_2M): front (**N**) and side (**O**) views. Scale bars: 0.5 mm (**A–E, K–O**); 0.1 mm (**F**); 0.2 mm (**G, H**); 0.3 mm (**I, J**).

The tuberculate first and third spiral cords start simultaneously after the protoconch with the same size, the third later becomes progressively larger and more acute. The second spiral cord appears only on the last whorl and is smaller than the others in front view, becoming of similar size to the first dorsally. In the second half of the last whorl, a very thin smooth suprasutural cord is visible. The base shows a fourth rather smooth cord of the same color as the first, followed by a fifth and sixth cord that are smooth and very pale in color. Anterior siphonal canal short, tubular, and oblique; posterior siphonal canal a simple notch. Peristome without microsculpture and apparently without bifurcating spiral cords.

The Mediterranean specimen is larger, has three white whorls after the protoconch and the second spiral cord appears on the seventh whorl, remaining still smaller than the others.

Etymology. Named after the Lessepsian invasion (Por 1978), because we first found this Red Sea species on the Mediterranean Israeli shelf. The species epithet is an adjective in nominative singular feminine.

Remarks. The Mediterranean specimen is larger and broader than the Red Sea ones. Triphorids do show a morphological dimorphism characterized by smaller and larger morphs and we think that we captured this dimorphism in our samples. See under *Opimaphora blattereri* Albano, Bakker & Sabelli, sp. nov. for a comparison with similar species.

Opimaphora blattereri **Albano, Bakker & Sabelli, sp. nov.**

http://zoobank.org/9133ECDF-5F41-4E68-80C2-D20A74549047

Figure 7

Type material. ***Holotype.*** EGYPT • sh; Sinai (Red Sea), Dahab, dive site "Islands"; 28.476°N, 34.513°E; depth 10 m; 2015; H. Blatterer leg.; NHMW-MO-113283.

Paratypes. EGYPT • sh; same collecting data as for holotype; OLML LIEV 2019/70/2 (paratype 1) • sh; Sinai (Red Sea), Dahab, dive site "Labyrinth"; 28.478°N, 34.514°E; depth unspecified; 2011; H. Blatterer leg.; MNHN-IM-2014-7547 (paratype 2).

Additional material examined. EGYPT • 3 shs (juv. and fragments); same collecting data as for holotype • 9 shs (juv. and fragments); same collecting data as paratype 2 • 1 sh; Sinai (Red Sea), Dahab, dive site "Rick's Reef"; 28.557°N, 34.524°E; 2012; H. Blatterer leg. • 1 sh; Sinai (Red Sea), Dahab, dive site "Caves"; 28.416°N, 34.456°E; depth 45 m; 2012; H. Blatterer leg. • 3 shs (juv.); Sinai (Red Sea), Dahab, dive site "Canyon"; 28.553°N, 34.522°E; depth 29 m; 2012; H. Blatterer leg. • 3 shs (juv.); Sinai (Red Sea), Dahab, Masbay Bay; 28.497°N, 34.518°E; depth 5 m; 2015; H. Blatterer leg. • 2 shs; Marsa Abu Makhadiq (Makadi Bay), SW side of bay, station 03; 26.9889°N, 33.9036°E; beached shell grit; 24 Sep. – 4 Oct. 1999; H. Dekker leg.; H. Dekker coll. reg. nos. 37192 and 37201).

Diagnosis. Shell cyrtoconoid of less than 3 mm with 11 (holotype) or 12 (paratype 2) whorls and multispiral protoconch. Nucleus with hemispherical granules. Sculpture

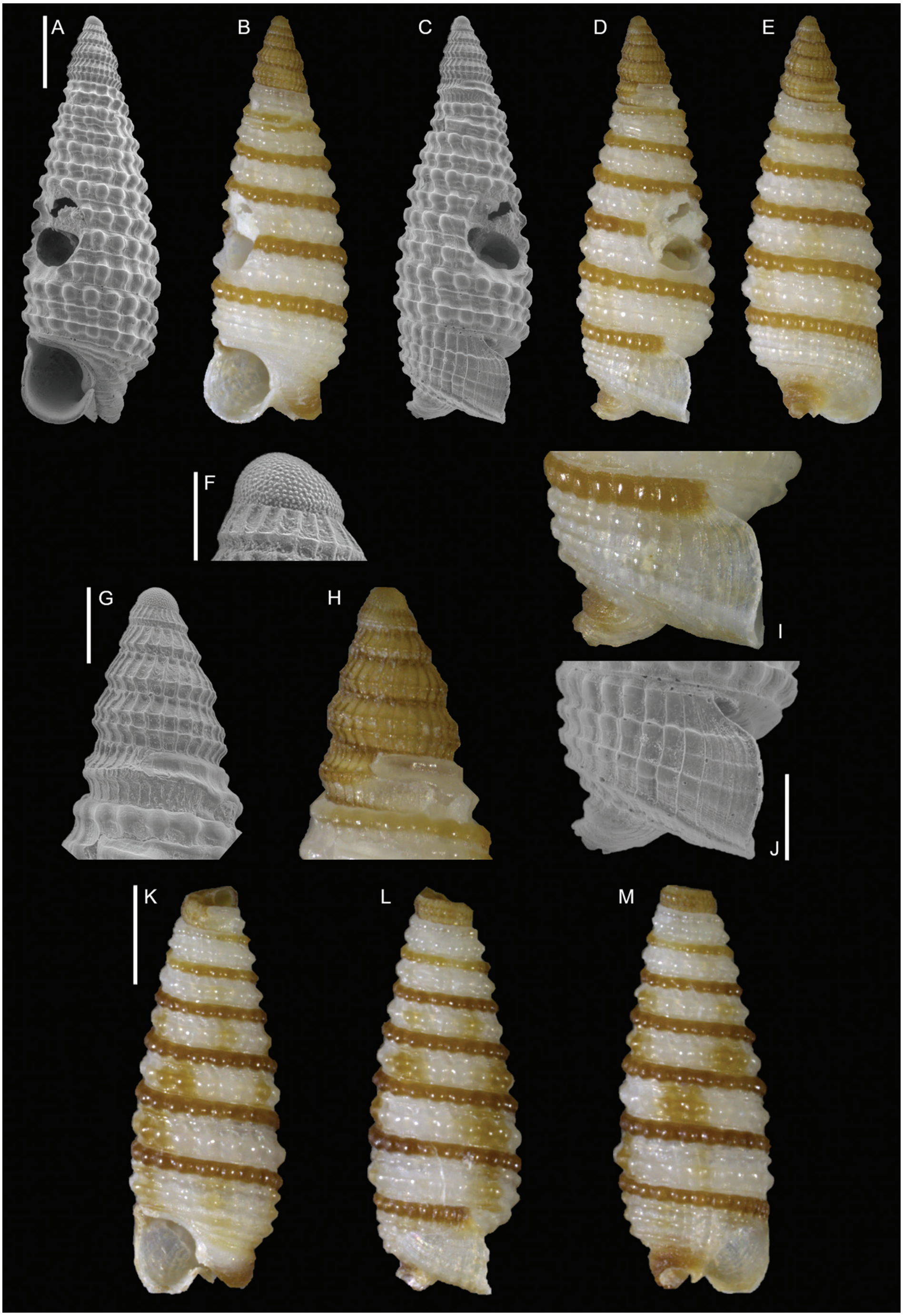

Figure 7. *Opimaphora blattereri* Albano, Bakker & Sabelli, sp. nov., dive site "Islands", Dahab, Sinai, Egypt **A–J** holotype, NHMW-MO-113283: front (**A, B**), side (**C, D**) and back (**E**) views, nucleus (**F**), protoconch (**G, H**) and peristome (**I, J**) **K–M** paratype 1, LIEV 2019/70/2: front (**K**), side (**L**) and back (**M**) views. Scale bars: 0.5 mm (**A–E, K–M**), 0.1 mm (**F**); 0.2 mm (**G, H**); 0.3 mm (**I, J**).

of three spiral cords with round tubercles larger than their interspaces; the second cord appears only on the fourth whorl, initially as a thin smooth thread. Microsculpture absent on the teleoconch whorls, present on the peristome, which bears bifurcating spiral cords.

Description. ***Color*****:** protoconch brown; whitish first teleoconch whorls with the first spiral cord becoming brown after two whorls. Light brown irregular patches are randomly distributed on the teleoconch, usually covering one or, more frequently, two tubercles. The base background is white, with the color patches of the last whorl extending onto it. The tip of the anterior siphon is brown.

Dimensions**:** H 2.7 mm, W 0.9 mm (holotype); H 2.6 mm, W 1.0 mm (paratype 1, without apex); H 3.0 mm, W 1.0 (paratype 2).

Protoconch**:** multispiral with 5.5 whorls (holotype), 5 (paratype 2, but first whorl worn); height: 566 µm (holotype), 644 µm (paratype 2).

Protoconch I: 1.5 whorls with hemispherical granules, nucleus with a height of 109 µm (holotype), 122 µm (paratype 2), and a maximum diameter of 371 µm (holotype), 380 µm (paratype 2).

Protoconch II: 3.5 whorls with axial orthogonal riblets with a maximum diameter of 371 µm (holotype), 380 µm (paratype 2). First two whorls monocarinated, then bicarinated.

Teleoconch**:** 6 (holotype), 7.5 (paratype 1), 7 (paratype 2) whorls, height: 2.24 mm (holotype), 2.43 mm (paratype 1), 2.50 mm (paratype 2).

The tuberculate first and third spiral cords start simultaneously after the protoconch with the same size, whereas the second cord appears from the fourth to the seventh teleoconch whorl, depending on shell size. This cord is initially thin and closer to the first one, it progressively increases its size until reaching that of the other two cords on the last whorl. On the second half of the shell, a very thin smooth suprasutural cord is visible. The second cord bifurcates on the peristome. The base shows a fourth rather smooth cord, and a fifth and sixth smooth ones; these cords become towards the peristome more granulated. On the peristome, below the third spiral thread, microsculpture is visible as fine spiral lines. Anterior siphonal canal tubular, short and oblique; posterior siphonal canal a simple notch.

Etymology. This species is named after Hubert Blatterer, Austrian conchologist, in recognition of his work on Red Sea mollusks. Moreover, he contributed to our work on Lessepsian species by granting us access to the material he collected in the Red Sea and by donating the type series of *O. blattereri* and *Coriophora lessepsiana*. The species epithet is a noun in the genitive case.

Remarks. We describe *O. blattereri* as new because of the similar color pattern to *C. lessepsiana* Albano, Bakker & Sabelli, sp. nov., even if it has not been reported from the Mediterranean Sea. The two species can be easily distinguished because *C. lessepsiana* has an monocarinated protoconch while *O. blattereri* has a bicarinated one; the second spiral cord of *O. blattereri* never becomes brownish as in *C. lessepsiana*; *O. blattereri* has a white background on the base and a distinct brown end of the anterior siphonal canal, whereas *C. lessepsiana* has a light brown base and the anterior siphon has not a colored end; the teleoconch of *O. blattereri* has irregular light brown patches, particularly evident on fresh specimens; this feature is totally absent in *C. lessepsiana*.

We have seen specimens very similar to *O. blattereri* collected in Madagascar, New Caledonia, and French Polynesia. A revision of the group in the Indo-Pacific province is beyond the scope of this paper; however, this species likely has a broad distribution.

Opimaphora blattereri and *C. lessepsiana* share their color pattern of brown to orange spiral cords on a white background with other Indo-Pacific species. *Litharium bilineatum* (Kosuge, 1962) (holotype illustrated by Higo et al. (2001)), *Costatophora iniqua* (Jousseaume 1898) (= *Notosinister kawamurai* Kosuge, 1962, type material illustrated by Higo et al. (2001) and Albano et al. (2019)) and *Aclophora albozonata* Laseron, 1958 can be easily distinguished by having three fully developed spiral cords since the early teleoconch. *Iniforis formosula* (Hervier, 1898) and *Mastonia peanites* Jousseaume, 1898 (= *Mastonia squamosa* Kosuge, 1962, type material again illustrated by Higo et al. (2001) and Albano et al. (2019)) have only two spiral cords, but the former has three or four dark brown lines on the last whorl, whereas the latter has a dark brown last whorl with lighter tubercles. *Triphora fulvescens* Hervier, 1898 also has a similar color pattern, but the second spiral cord remains a very fine thread even on the last whorl and the tubercles are whitish even on the first cord (on an orange background). Some species show a delayed appearance of the second spiral cord: *Nototriphora regina* (Hedley, 1903) has a brown tip of the anterior siphonal canal similarly to *O. blattereri*, but lacks the patches on the whorls and has an orange line on the third spiral cord on the last whorl; *Coriophora tigris* Laseron, 1958 has a paucispiral protoconch; *Cautor similis* (Pease, 1871) has larger and more densely arranged tubercles, a brown fourth spiral cord and white base. Last, a few species have a similar color pattern, but with an inverted pattern: the first spiral cord is white and the third orange to brown, like *Mastonia cingulifera* (Pease, 1861), which also has a dark yellow teleoconch, *Mastonia funebris* Jousseaume, 1884 and *Mastonia tulipa* Jousseaume, 1898 with a brown and white base, respectively.

***Triphora* sp.**

Figure 8

New records. Israel • 1 sh; north of Atlit; 32.7433°N, 34.9067°E; depth 40 m; 20 Sep. 2016; coarse biogenic sediment in a pool among rocks covered by coralligenous formations; grab; HELM project (sample NG40_2M); NHMW-MO-112930/LM/0170; size: H 4.5 mm, W 1.4 mm.

Remarks. We found a single, adult, empty shell. It likely possesses a large paucispiral protoconch, but it is incomplete in our shell. The second spiral cord starts at mid-shell height, the fourth and fifth spiral cords are smooth, and the posterior siphonal canal is shallow. It is brown in color with darker spiral cords. We have not been able to assign it to a species so far, but it is distinctly different from all known Mediterranean species and most likely belongs to the Indo-Pacific fauna.

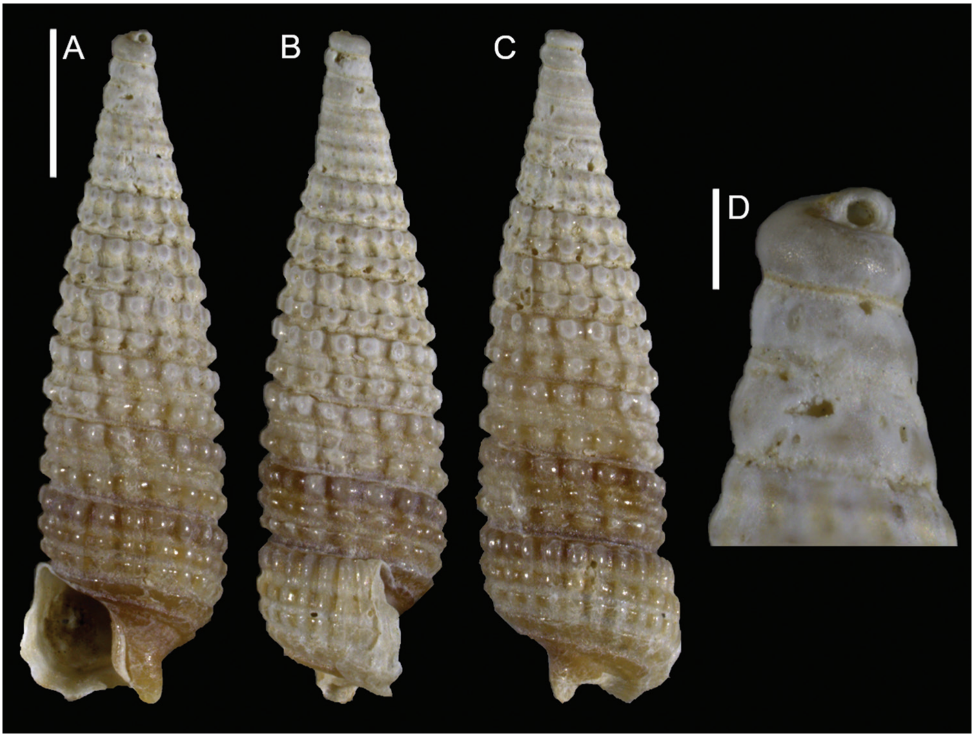

Figure 8. *Triphora* sp., NHMW-MO-112930/LM/0170, north of Atlit, Israel, HELM project (sample NG40_2M): front (**A**), side (**B**) and back (**C**) views, protoconch (**D**). Scale bars: 1 mm (**A–C**); 0.2 mm (**D**).

Viriola cf. *bayani* Jousseaume, 1884

New records. Israel • 3 spcms; Ashqelon; 31.6868°N, 34.5516°E; depth 11 m; 31 Oct. 2018; offshore rocky reef; suction sampler; HELM project (samples S58_1M, S58_2F, S58_2M) • 3 spcms; off Tel Aviv Marina; 32.0871°N, 34.7635°E; depth 7 m; 8 Nov. 2018; rocky reef, suction sampler; HELM project (sample S67_1M) • 7 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; rocky substrate; suction sampler; 29 Oct. 2018; HELM project (samples S52_1M, S52_3F) • 1 spcm; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E; depth 20 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S13_3M) • 9 spcms; same collecting data as for preceding; depth 19 m; 29 Oct. 2018; HELM project (samples S53_1M, S53_2F, S53_2M, S53_3F, S53_3M); size of largest specimen: H 11.6 mm, W 2.7 mm.

Remarks. This species was first recorded from Israel by Steger et al. (2018) based on three living individuals from Palmachim, southern Israel. We here report multiple living individuals all along the Israeli coast, confirming its establishment. The species shows a broad distribution in the Eastern Mediterranean ranging from Greece to Turkey and Cyprus (Micali et al. 2017; Stamouli et al. 2017; Angelidis and Polyzoulis 2018; Chartosia et al. 2018). Its final taxonomic assignment requires the clarification of the relation between several other *Viriola* such as *V. corrugata* (Hinds, 1843), *V. senafirensis* (Sturany, 1903), and *V. tricincta* (Dunker, 1882) (Albano and Bakker 2016; Albano et al. 2017, 2019).

Family Cerithiopsidae H. Adams & A. Adams, 1853

Cerithiopsis sp. aff. *pulvis* (Issel, 1869)

Figure 9D–F

New records. Israel • 1 sh; Ashqelon; 31.6868°N, 34.5516°E; depth 11 m; 31 Oct. 2018; offshore rocky reef; suction sampler; HELM project (sample S58_1F) • 1 spcm; Ashqelon; 31.6891°N, 34.5257°E; depth 28 m; 31 Oct. 2018; offshore rocky reef; suction sampler; HELM project (sample S59_3F); NHMW-MO-112930/LM/0174; size: H 1.8 mm, W 0.7 mm (illustrated specimen).

Additional material examined. *Cerithiopsis pulvis* (Issel, 1869): Israel • 2 spcms, 1 sh; Ashqelon; 31.6868°N, 34.5516°E; depth 12 m; 30 Apr. 2018; offshore rocky reef; suction sampler; HELM project (sample S12_1F) • 5 spcms; same collecting data as for preceding; depth 11 m; 31 Oct. 2018; HELM project (samples S58_1F, S58_1M, S58_2F) • 5 spcms, 2 shs; Ashqelon; 31.6891°N, 34.5257°E; depth 25 m; 2 May 2018; offshore rocky reef; suction sampler; HELM project (samples S16_1F, S16_2F, S16_2M) • 19 spcms; same collecting data as for preceding; depth 28 m; 31 Oct. 2018; HELM project (samples S59_1F, S59_1M, S59_2F, S59_3F) • 8 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 29 Oct. 2018; rocky substrate; suction sampler; HELM project (samples S52_2F, S52_2M, S52_3M) • 1 spcm; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E; depth 20 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S13_1M) • 6 spcms; same collecting data as for preceding; depth 19 m; 29 Oct. 2018; HELM project (samples S53_1F, S53_1M, S53_3F).

Remarks. This species superficially resembles the Lessepsian *Cerithiopsis pulvis* but has a more cyrtoconoid shape and a greater ratio between the height of the last whorl and that of the shell. The base is not concave as in *C. pulvis*, bears a fourth spiral cord which is more prominently tuberculate, and an additional fifth tuberculate cord that is not present in typical *C. pulvis*. Additionally, the siphonal canal bears numerous fine cords. The color pattern is similar to *C. pulvis* which has orange bands on white background; in contrast, in *C.* aff. *pulvis* these are brown and yellowish, respectively. It is distinct from any native Mediterranean species and clearly belongs to an Indo-Pacific clade. It is here considered a new non-indigenous species.

Cerithiopsis sp.

Figure 10

New records. Israel • 1 sh; Shiqmona Beach; 32.8259°N, 34.9555°E; beached; 4 Jan. 2008; size: H 3.5 mm, W 1.2 mm.

Figure 9. Comparison between *Cerithiopsis pulvis* (Issel, 1869) and *Cerithiopsis* sp. aff. *pulvis*. **A–C** *Cerithiopsis pulvis*, Ashqelon, Israel, HELM project (sample S16_1F): front (**A**), side (**B**) and back (**C**) views. **D–F** *Cerithiopsis* sp. aff. *pulvis*, NHMW-MO-112930/LM/0174, Ashqelon, Israel, HELM project (sample S59_3F): front (**D**), side (**E**) and back (**F**) views. Scale bars: 0.5 mm.

Remarks. This beautiful species has almost eight teleoconch whorls bearing two strong spiral cords with oblong tubercles at the intersection with prosocline axial ribs. Interspaces between spiral cords are approximately as large as the cords themselves, and interspaces between the axial ribs are double the size of the ribs. A third smooth thick cord delimits the rather flat base and is visible above the suture throughout most of the teleoconch. The protoconch is smooth with very fine and extremely short axial riblets

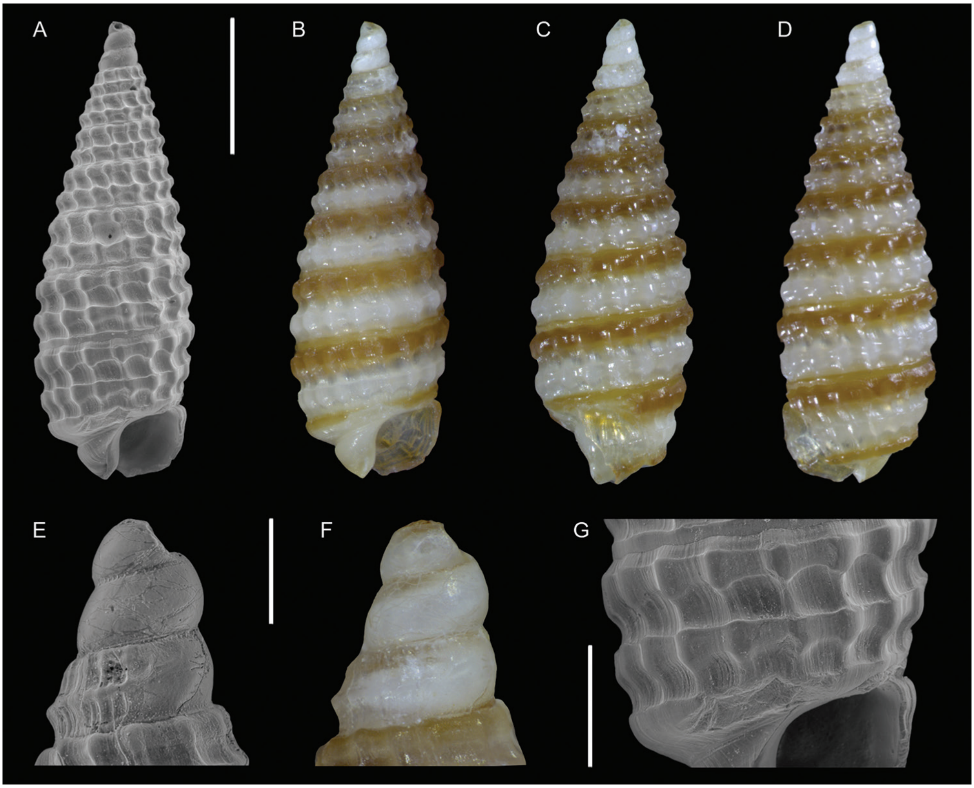

Figure 10. *Cerithiopsis* sp., Shiqmona Beach, Israel: front (**A, B**), side (**C**) and back (**D**) views, protoconch oriented to highlight the transition to the teleoconch (**E, F**), microsculpture (**G**). Scale bars: 1 mm (**A–D**); 0.2 mm (**E, F**); 0.4 mm (**G**).

just below the suture; it is multispiral but broken in our specimen in which only the last two whorls are preserved. The slender shape, the two strong spiral cords and the smooth flat base distinguish it at once from all native Mediterranean species suggesting it is a new non-indigenous species in the basin.

Among Indo-Pacific cerithiopsids, *Synthopsis lauta* Cecalupo & Perugia, 2013, described from Vanuatu, is among the few similar species we were able to trace. However, the interspace between the spiral cords is broader, the tubercles on the first spiral cord of the last whorl are larger than those on the second cord, and the teleoconch is shorter with just six whorls. Additionally, the color pattern with white tubercles, yellowish interspaces, deep brown suture and violet protoconch is strikingly different from the one of our shell. We have some reservations that *S. lauta*, as well as our specimen, belong to the genus *Synthopsis* Laseron, 1956 that was described as bearing three tuberculate spiral cords on the whole teleoconch (Laseron 1956). Pending a molecular phylogeny of the family, we consider this feature important at the genus level. Therefore, we assign our specimen to the nominotypical genus *Cerithiopsis*, in the wait of a better understanding of cerithiopsid systematics. The specimen identified as *Horologica gregaria*

Cecalupo & Perugia, 2012 and illustrated in the recent revision of Cerithiopsidae from South Madagascar (Cecalupo and Perugia 2014b: fig. 8G) is also similar to ours; that specimen, however, has a distinct basal spiral cord which is absent in our specimen. The latter character, the prominence of the tuberculate spiral cords and the evident but rather flat third cord also raise some doubts that the specimen from South Madagascar is conspecific with the *H. gregaria* originally described from the Central Philippines (Cecalupo and Perugia 2011). Last, the Sudanese specimen of *Horologica* cf. *taeniata* Cecalupo & Perugia, 2013 illustrated by Cecalupo and Perugia (2016: fig. 1P–S) shares the general features of our shell but can be distinguished by the first spiral cord that tends to split into two separate cords, and by the color pattern of white teleoconch and orange base.

Joculator problematicus **Albano & Steger, sp. nov.**

http://zoobank.org/1D9DDB2C-99D0-40A6-824A-93F4149B3550
Figure 11

Type material. ***Holotype.*** Israel • spcm; Ashqelon; 31.6868°N, 34.5516°E; depth 11 m; 31 Oct. 2018; offshore rocky reef; suction sampler; HELM project (sample S58_3F); NHMW-MO-113580.

Paratypes. Israel • spcm; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S14_2F); MNHN-IM-2012-25505 (paratype 1) • spcm; same collecting data as for paratype 1; HELM project (sample S14_4F); MZUB 60400 (paratype 2) • spcm; same collecting data as for paratype 1; 29 Oct. 2018; HELM project (sample S52_3F); SMF 360591 (paratype 3) • spcm; same collecting data as for paratype 1; HELM project (sample S14_2F); SMNH MO 99705 (paratype 4).

Additional material examined. Israel • 5 spcms; Ashqelon; 31.6868°N, 34.5516°E; depth 12 m; 30 Apr. 2018; offshore rocky reef; suction sampler; HELM project (samples S12_1F, S12_2F, S12_3F) • 6 spcms; same collecting data as for preceding; depth 11 m; 31 Oct. 2018; HELM project (samples S58_1F, S58_2F, S58_3F) • 1 spcm; Ashqelon; 31.6891°N, 34.5257°E; depth 25 m; 2 May 2018; offshore rocky reef; suction sampler; HELM project (sample S16_2F) • 2 spcms; same collecting data as for preceding; depth 28 m; 31 Oct. 2018; HELM project (samples S59_3F, S59_3M) • 1 sh; Sdot Yam; 32.5299°N, 34.8599°E; depth 24 m; 3 May 2018; rocky substrate; suction sampler; HELM project (sample S17_1F) • 3 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 1 May 2018; rocky substrate; suction sampler; HELM project (samples S14_2F, S14_4F) • 16 spcms; same collecting data as for preceding; 29 Oct. 2018; HELM project (samples S52_1F, S52_1M, S52_2F, S52_3F) • 2 spcms; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E; depth 20 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S13_1F) • 9 spcms; same collecting data as for preceding; depth 19 m; 29 Oct. 2018; HELM project (samples S53_1F, S53_2F, S53_3F, S53_3M).

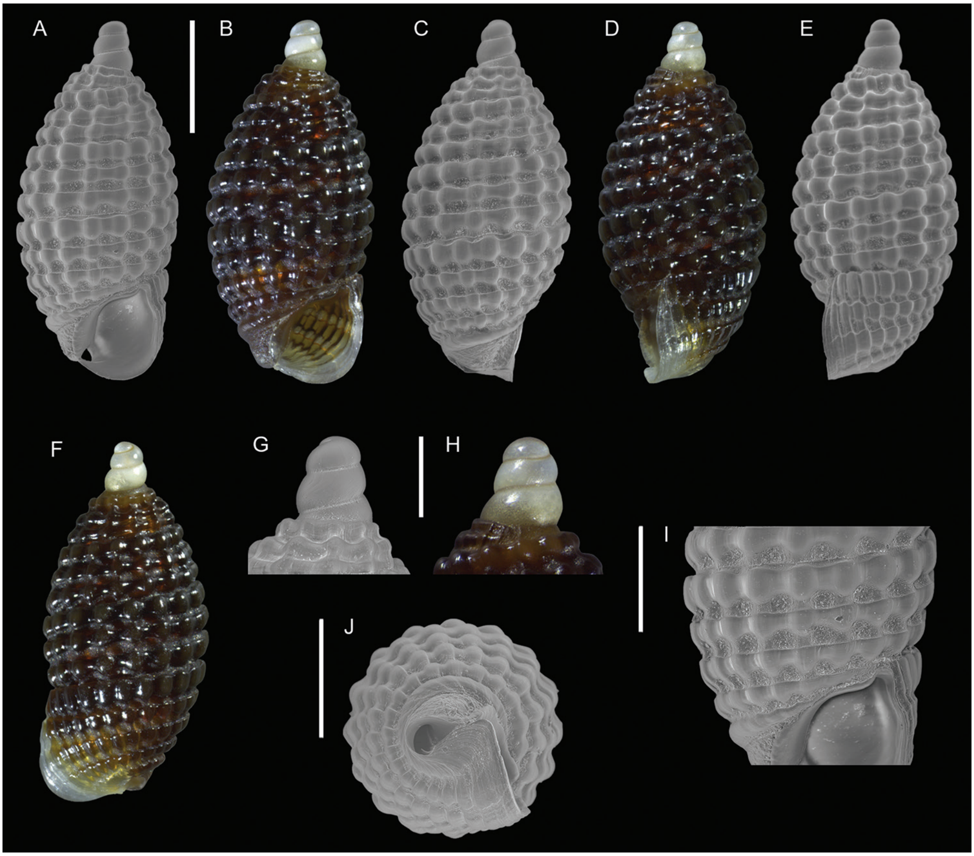

Figure 11. *Joculator problematicus* Albano & Steger, sp. nov., holotype, NHMW-MO-113580, Ashqelon, Israel, HELM project (sample S58_3F): front (**A, B**), left side (**C**), right side (**D, E**) and back (**F**) views, protoconch (**G, H**), microsculpture (**I**) and base and siphonal canal (**J**). Scale bars: 0.5 mm (**A–F**); 0.2 mm (**G, H**); 0.3 mm (**I**); 0.4 mm (**J**).

Diagnosis. Very small bulbous brown shell, of ~ 1.5 mm in height and < 1 mm in width, with a relatively short, almost smooth protoconch.

Description. ***Color*:** Protoconch white, teleoconch brown with white outer lip margin.

***Dimensions*:** H 1.6 mm, W 0.7 mm (holotype), H 1.4 mm, W 0.7 mm (paratype 1), H 1.5 mm, W 0.7 mm (paratype 2), H 1.5 mm, W 0.7 mm (paratype 3), H 1.6 mm, W 0.8 mm (paratype 4).

***Protoconch*:** composed of 3.5 whorls with no clear demarcation between protoconchs I and II, height: ~ 300 µm, width ~ 200 µm (holotype), but accurate measurement hampered by the last protoconch whorl being covered by the first teleoconch whorl. It appears smooth except for growth lines and fine pustules covering the lower half of the first whorl and sparsely present apically and abapically on the following whorls (only visible with scanning electron microscopy at high magnification).

***Teleoconch*:** 4 whorls (holotype), height: 1.4 mm (holotype). It bears three spiral cords of equal size, with tubercles at the intersection of orthocline axial ribs. The base is contracted and has two additional tuberculate spiral cords. Tubercles become oblong near the lip. Anterior siphonal canal short, reverted upwards, formed by a prong-like protrusion of the anterior outer lip (Figure 11A); posterior siphonal canal notch-like.

Etymology. The name *problematicus* refers to the difficult task of recognizing and identifying non-indigenous species belonging to groups whose taxonomy in the tropical seas is poorly known (see Discussion). The species epithet is an adjective in nominative singular masculine.

Remarks. This species is characterized by its bulbous contour and constricted last whorl which justify its inclusion in the genus *Joculator* Hedley, 1909 (Hedley 1909; Marshall 1978).

The Cerithiopsidae of the Indo-Pacific have been subject to numerous in-depth studies (Cecalupo and Perugia 2011, 2013, 2014a, b, 2016, 2017a, b, 2018, 2019a, b, c). Still, this species does not fit any of the known species. Among the most similar species in terms of shell shape and ornamentation, *Joculator itiensis* Cecalupo & Perugia, 2014 has one teleoconch whorl more and a different color pattern characterized by light brown first whorl and base, *J. olivoideus* Cecalupo & Perugia, 2018 can be distinguished by its clearly prosocline axial ribs and greyish tubercles, and *J. sekensis* Cecalupo & Perugia, 2018 has only two spiral cords and blunter axial ribs on the first teleoconch whorl, in addition to a blunter siphonal canal.

There are several more species of small brown bulbous *Joculator* often distinguishable only by subtle character differences. *Joculator priorai* Cecalupo & Perugia, 2012 is corneous in color and has a pointed protoconch with one additional whorl; moreover, in our specimens the interspaces between the spiral cords are smaller. *Joculator pupiformis* Cecalupo & Perugia, 2012 has one protoconch and one teleoconch whorl more, the tubercles are oblong, and the base lacks a clearly visible fifth tuberculate spiral cord. *Joculator fuscus* Cecalupo & Perugia, 2012 has much broader interspaces between cords and a wide subquadrangular aperture which is, in contrast, quite small in our specimens. *Joculator furvus* Cecalupo & Perugia, 2012 has a neat abapical smooth cord on the protoconch, one teleoconch whorl less and a broader aperture. *Joculator carpatinus* Cecalupo & Perugia, 2012 has one protoconch whorl more, one teleoconch whorl less, a broader aperture and a fine abapical thread on the protoconch. *Joculator caliginosus* Cecalupo & Perugia, 2012 has one protoconch whorl more and one teleoconch whorl less, the basal fourth and fifth cords are only weakly tuberculate whereas they are neatly tuberculate in our specimens. *Joculator coffeus* and *J. subglobosus*, both Cecalupo & Perugia, 2013, have one clear abapical thread on the protoconch, one teleoconch whorl less, the shell has a more roundish shape and the lip does not reach anteriorly the siphonal canal, almost covering it, like in our specimens. The other representatives of *Joculator* include also other more elongated species that can be easily distinguished from our specimens.

This species is superficially similar to the native Mediterranean *Cerithiopsis ladae* Prkić & Buzzurro, 2007, which, however, can be distinguished at once for not having the last protoconch whorl partially covered by the first teleoconch whorl and lacking the prong-like process of the anterior outer lip. Additionally, tubercles in *C. ladae* on the last whorl are more elongated, subrectangular, and the shell profile is less bulbous. *Cerithiopsis greppii* Buzzurro and Cecalupo, 2005, described from Turkey, has a rather oval profile, but not as bulbous as in our species; additionally, it has a paucispiral protoconch. *Cerithiopsis micalii* (Cecalupo and Villari, 1997), which also has a somewhat oval shell profile, can be quickly distinguished by its protoconch whose last two whorls bear strong axial ribs.

Unfortunately, a revision of Red Sea Cerithiopsidae is lacking, but given that *Joculator* is a broadly distributed genus in the Indo-Pacific province, we consider *J. problematicus* another previously undescribed Indo-Pacific species recently introduced to the Mediterranean Sea.

Family Elachisinidae Ponder, 1985

Elachisina sp.

Figure 12A–E

New records. Israel • 1 spcm; north of Atlit; 32.7417°N, 34.9177°E; depth 31 m; 25 Apr. 2017; sand; grab; HELM project (sample NG30_8M) • 14 spcms, 1 sh; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E; depth 20 m; 1 May 2018; rocky substrate; suction sampler; HELM project (samples S13_1F, S13_1M, S13_2F, S13_3L); size of largest specimen: H 1.6 mm, W 1.3 mm • 9 spcms; same collecting data as for preceding; depth 19 m; 29 Oct. 2018; HELM project (samples S53_1F, S53_2F, S53_3F).

Additional material examined. *Elachisina robertsoni* Kay, 1979: United States • 1 sh; Hawaii, Oahu, Maunalua Bay; BPBM 9754 (holotype).

Remarks. The morphology of this species is unique among the native mollusks of the Mediterranean, which does not host any shallow water Elachisinidae. Therefore, we consider it a new non-indigenous species in the basin.

The only Indo-Pacific *Elachisina* we are aware of is *E. robertsoni* Kay, 1979, which indeed shares the general characters of our species. However, it can be readily distinguished by the thicker and fewer spiral cords, less rounded whorls and sigmoid, rather than strongly prosocline, aperture profile. *Elachisina* sp. is more similar to the West-African *E. tenuisculpta* (Rolán and Gofas 2003), but the Israeli shells have more rounded whorls, a greater height/width ratio and smaller ratio between aperture and shell height.

Family Iravadiidae Thiele, 1928

Iravadia aff. *elongata* (Hornung & Mermod, 1928)

Figure 13

New records. Israel • 1 spcm; Ashqelon; 31.6868°N, 34.5516°E; depth 12 m; 30 Apr. 2018; offshore rocky reef; suction sampler; HELM project (sample S12_1F) • 5 shs; same collecting data as for preceding; depth 11 m; 31 Oct 2018; HELM project (sample S58_2F); size: H 2.8 mm, W 1.1 mm (largest (illustrated) shell).

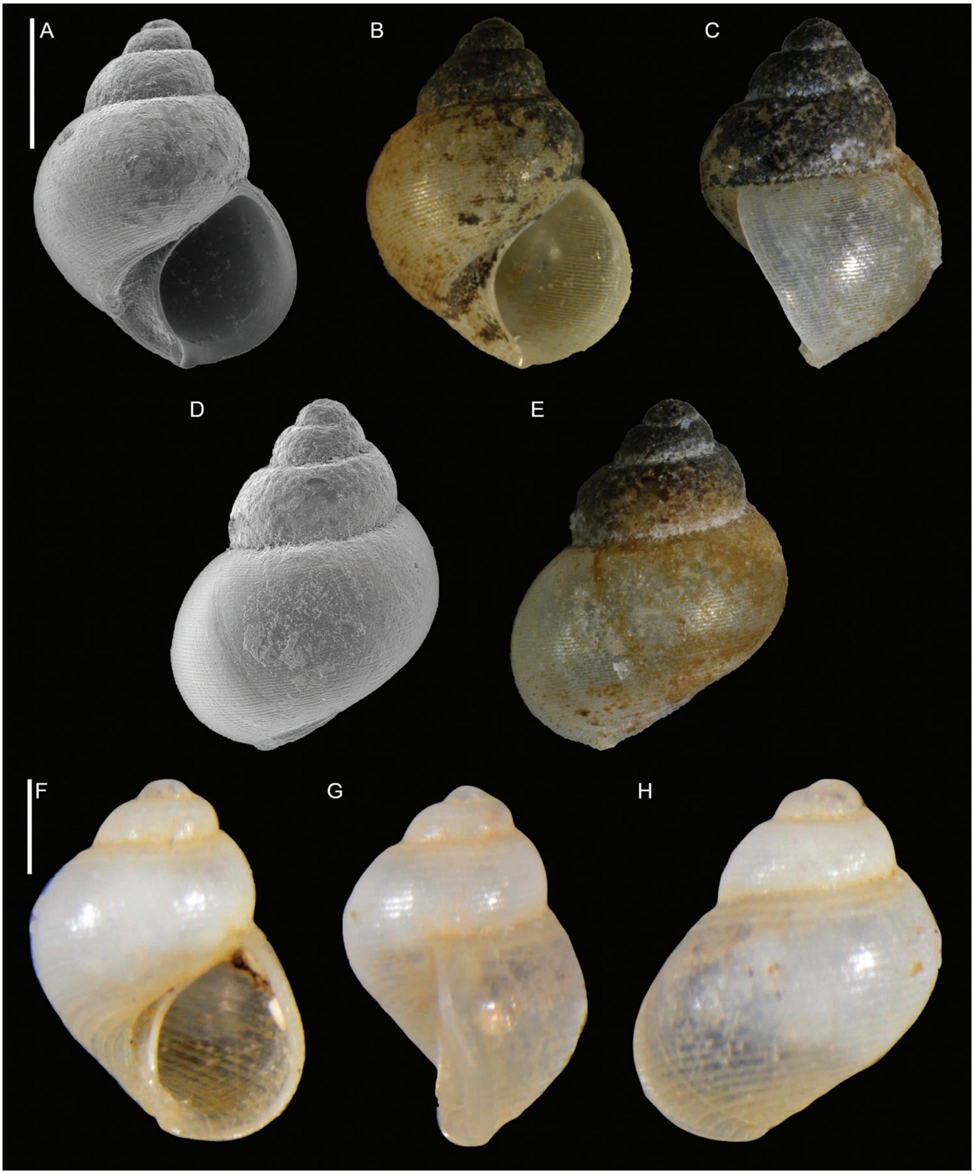

Figure 12. Comparison between *Elachisina* sp. and *Elachisina robertsoni* Kay, 1979 **A–E** *Elachisina* sp., west of Rosh HaNikra Islands, Israel, HELM project (sample S13_3L): front (**A, B**), side (**C**) and back (**D, E**) views **F–H** *Elachisina robertsoni*, BPBM 9754 (holotype), Maunalua Bay, Oahu, Hawaii: front (**F**), side (**G**) and back (**H**) views (photograph courtesy N. Young). Scale bars: 0.5 mm.

Additional material examined. *Iravadia* aff. *elongata*: SUDAN • 2 shs; Arusa (near Port Sudan); 19.90°N, 37.23°E; shallow water; 1975; shell-grit; G. Spada leg.; MZUB.

Iravadia elongata (Hornung & Mermod, 1928): ERITREA • 1 sh; Massawa; depth 30 m; 1870; A. Issel leg.; syntype in MSNG; size: H 3.9 mm, W 1.4 mm.

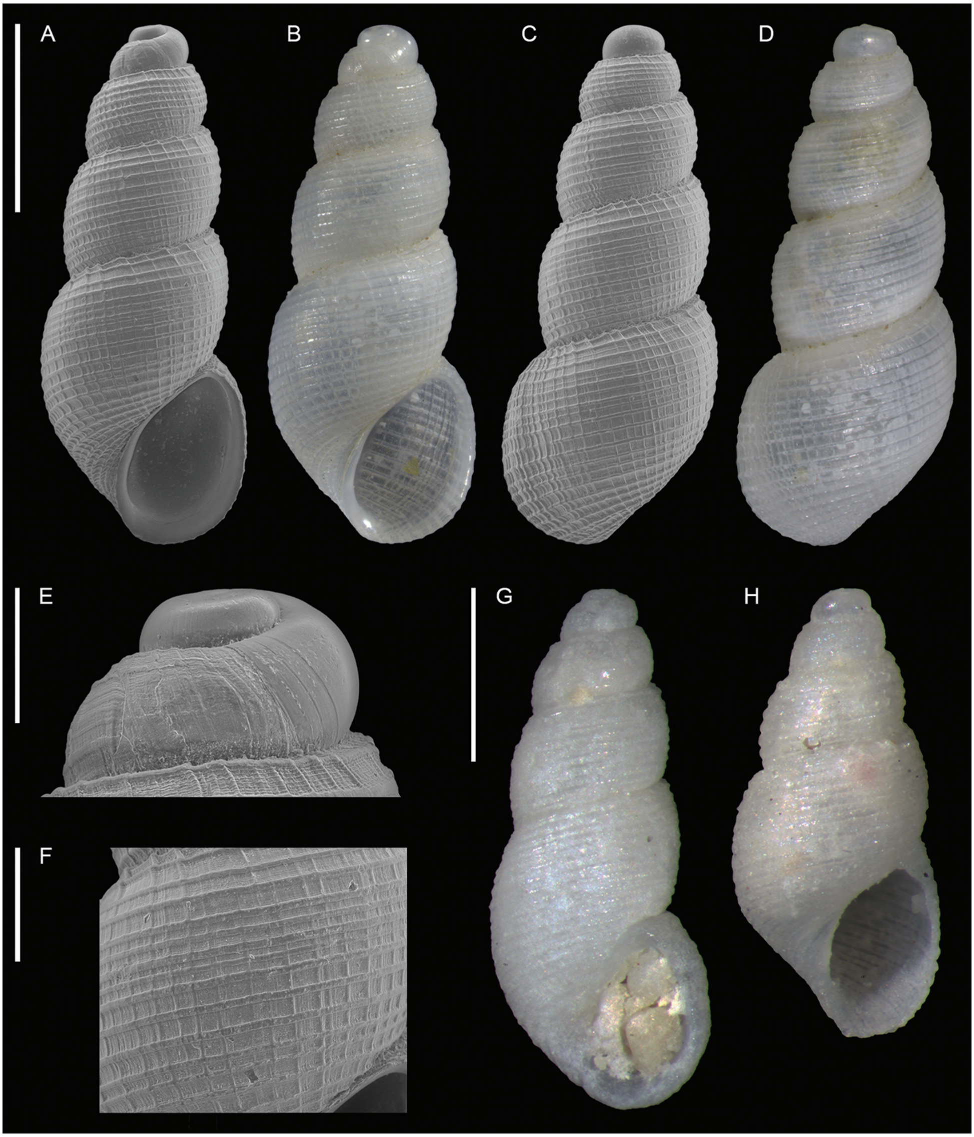

Figure 13. *Iravadia* aff. *elongata* (Hornung & Mermod, 1928) **A–F** Ashqelon, Israel, HELM project (sample S58_2F): front (**A, B**) and back (**C, D**) views, protoconch (**E**) and detail of sculpture on the body whorl (**F**) **G, H** Arusa (near Port Sudan), Sudan: front view of an adult (**G**) and juvenile (**H**) shell. Scale bars: 1 mm (**A–D, G, H**); 0.2 mm (**E**); 0.3 mm (**F**).

Remarks. This species is characterized by a turriform shell with up to five convex whorls, separated by a marked suture and a blunt, flat, and smooth protoconch. The sculpture consists of flat spiral ridges (12–14 on the penultimate whorl) that become more raised at both the adapical and abapical parts of the whorls, and which overlie numerous axial lines (Figure 13F), resulting in a reticulate surface.

The closest match to our specimens is *Iravadia elongata* (Hornung & Mermod, 1928) which was described from material collected by Arturo Issel in the Red Sea off Massawa, Eritrea, at 30 m depth (Hornung and Mermod 1928). Compared to our material, however, the syntype of *I. elongata* is larger (height 3.9 mm vs. 2.8 mm in our largest shell) and has seven less convex whorls. Further, the apical part of its spire has a slightly concave profile and thus appears more tapered. According to Issel's description, the sculpture of *I. elongata* consists of spiral ridges (12 on the penultimate and 22 on the last whorl) as well as growth lines, although the latter are not indicated in the accompanying line drawing. This suggests that the axial component might be less evident in *I. elongata* than in our specimens, however, the poor preservation of the shell surface of the syntype of *I. elongata* did not allow a reliable comparison with our material. Slightly eroded shells very similar to our specimens have been collected from the Sudanese Red Sea (Figure 13G, H), confirming that the material from Israel indeed represents an Indo-Pacific species rather than an undescribed Mediterranean taxon.

Among Mediterranean iravadiids, our specimens superficially resemble only *Ceratia proxima* (Forbes and Hanley, 1850). This species, however, lacks axial sculpture. Interestingly, Hornung and Mermod (1928) also mention the presence of this latter species at Assab (Eritrea) and "île Saldadin" (Zeila, northern Somalia). While obviously based on a misidentification – *C. proxima* has an Eastern Atlantic-Mediterranean distribution (Bouchet and Warén 1993; Høisæter 2009) – one might speculate that this record could be the result of a confusion of *C. proxima* with the *Iravadia* presented here.

Family Vitrinellidae Bush, 1897

***Vitrinella* aff. *Vitrinella* sp. 1 (sensu Blatterer 2019)**

Figure 14

New records. Israel • 1 sh; Ashdod; 31.8697°N, 34.6473°E; depth 24 m; Sep. 2019; soft substrate; grab; APM DAN project (sample 10B); size: H 0.4 mm, W 0.7 mm.

Remarks. This tiny gastropod defeated all our attempts to identify it. It consists of a protoconch and a teleoconch of ~ 1.5 whorls each. Sculpture is absent, except for two spiral ridges that run on the shoulder and on the base. A third ridge runs periumbilically (Figure 14E). Broad umbilicus, roundish aperture. Our shell closely resembles the *Vitrinella* sp. 1 illustrated by Blatterer (2019: plate 127, fig. 12a–j) from the Dahab region in the northern Red Sea, which, however, apparently bears fine spiral threads in the umbilicus (fig. 12e, and unpublished figures). SEM images of our shell show that its surface is taphonomically altered; additionally, Blatterer's specimens look slightly more mature, reaching 2 teleoconch whorls. The significance of these features should be re-assessed upon a satisfying revision of these tiny gastropods from the Indo-Pacific province. Another similar shell is illustrated by Janssen et al. (2011, plate 19, figs. 3a–b), which apparently has less conspicuous or absent spiral ridges as long as can be judged from the optical illustrations provided. It is worth mentioning that gastropods belonging to the family Clenchiellidae D.W. Taylor, 1966 share the

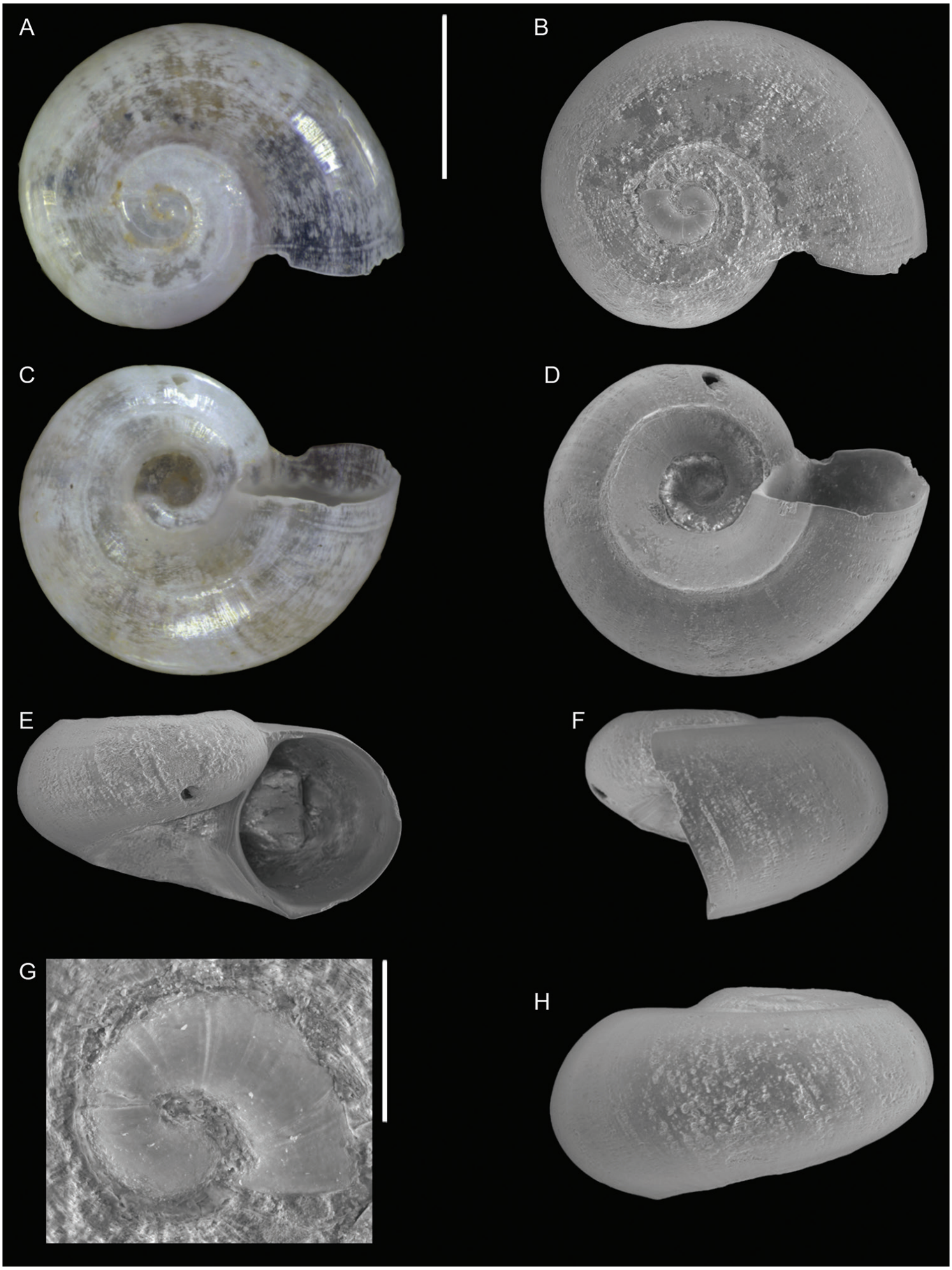

Figure 14. *Vitrinella* aff. *Vitrinella* sp. 1 (sensu Blatterer 2019), Ashdod, Israel, APM DAN project (sample 10B): apical (**A, B**), umbilical (**C, D**), front (**E**) and side (**F**) views, protoconch (**G**) and back view (**H**). Scale bars: 0.3 mm (**A–F, H**); 0.1 mm (**G**).

small size, low spire, wide umbilicus and presence of strong spiral keels we observed in our specimen (Ponder et al. 2014); the latter, however, lacks the numerous finer spiral cords that characterize clenchiellids. Additionally, these gastropods occur in mangrove swamps or adjacent habitats in tropical estuaries, a kind of habitat that does not occur in Israel. The shell shape and sculpture (in particular the strong spiral keels) distinguish it at once from native Mediterranean species. The extreme similarity with the shell illustrated in Blatterer's book suggests that the species belongs to a Red Sea clade and is here considered a new non-indigenous species in the Mediterranean Sea.

Family Eulimidae Philippi, 1853

***Hypermastus* sp.**

Figure 15

New records. Israel • 4 shs; off Tel Aviv Marina; 32.0871°N, 34.7635°E; depth 7 m; 8 Nov. 2018; rocky reef; suction sampler; HELM project (sample S67_3F); size: H 1.9 mm, L 0.5 mm (illustrated shell).

Remarks. This slender eulimid is characterized by a constriction at the transition between the protoconch and the teleoconch (Figure 15A, B, F). This feature distinguishes it at once from any native Mediterranean species. The protoconch is ~ 2.5 whorls, apparently without any ornamentation. The teleoconch is very slender, made of 6 translucent-white whorls, with flat sides, inconspicuous suture; the lip profile is arched. These characters fit the genus *Hypermastus* Pilsbry, 1899 to which we tentatively assign the species (Warén 1991b). We were not able to assign it to any Indo-Pacific species, but the family is among the most diverse and least known in that province (Bouchet et al. 2002), thus it could be another still undescribed species recently introduced into the Mediterranean Sea.

***Hemiliostraca clandestina* (Mifsud & Ovalis, 2019), comb. nov.**

Figure 16A–C

New records. Israel • 1 spcm; Ashqelon; 31.6868°N, 34.5516°E; depth 12 m; 30 Apr. 2018; offshore rocky reef; suction sampler; HELM project (sample S12_1F) • 38 spcms; Ashqelon; 31.6891°N, 34.5257°E; depth 25 m; 2 May 2018; offshore rocky reef; suction sampler; HELM project (samples S16_1F, S16_2F, S16_2M); size: H 2.7 mm, L 0.9 mm (illustrated shell) • 16 spcms; same collecting data as for preceding; depth 28 m; 31 Oct. 2018; HELM project (samples S59_1F, S59_2F, S59_3F) • 1 spcm; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E; depth 20 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S13_3F).

Remarks. *Sticteulima clandestina* and *S. athenamariae*, both Mifsud & Ovalis, 2019, were described on specimens collected in Turkey (Mifsud and Ovalis 2019). However, both belong to species present in the Red Sea and were illustrated by Blatterer (2019) for the Gulf of Aqaba on plate 131, fig. 8a–d and plate 131, fig. 9a–h, respectively. *Sticteulima clandestina* appears rather variable but our specimens clearly match Mifsud and Ovalis (2019: fig. 1B). Both *S. clandestina* and *S. athenamariae* look closely related to *Hemiliostraca* and thus we propose the new combinations *Hemiliostraca clandestina*

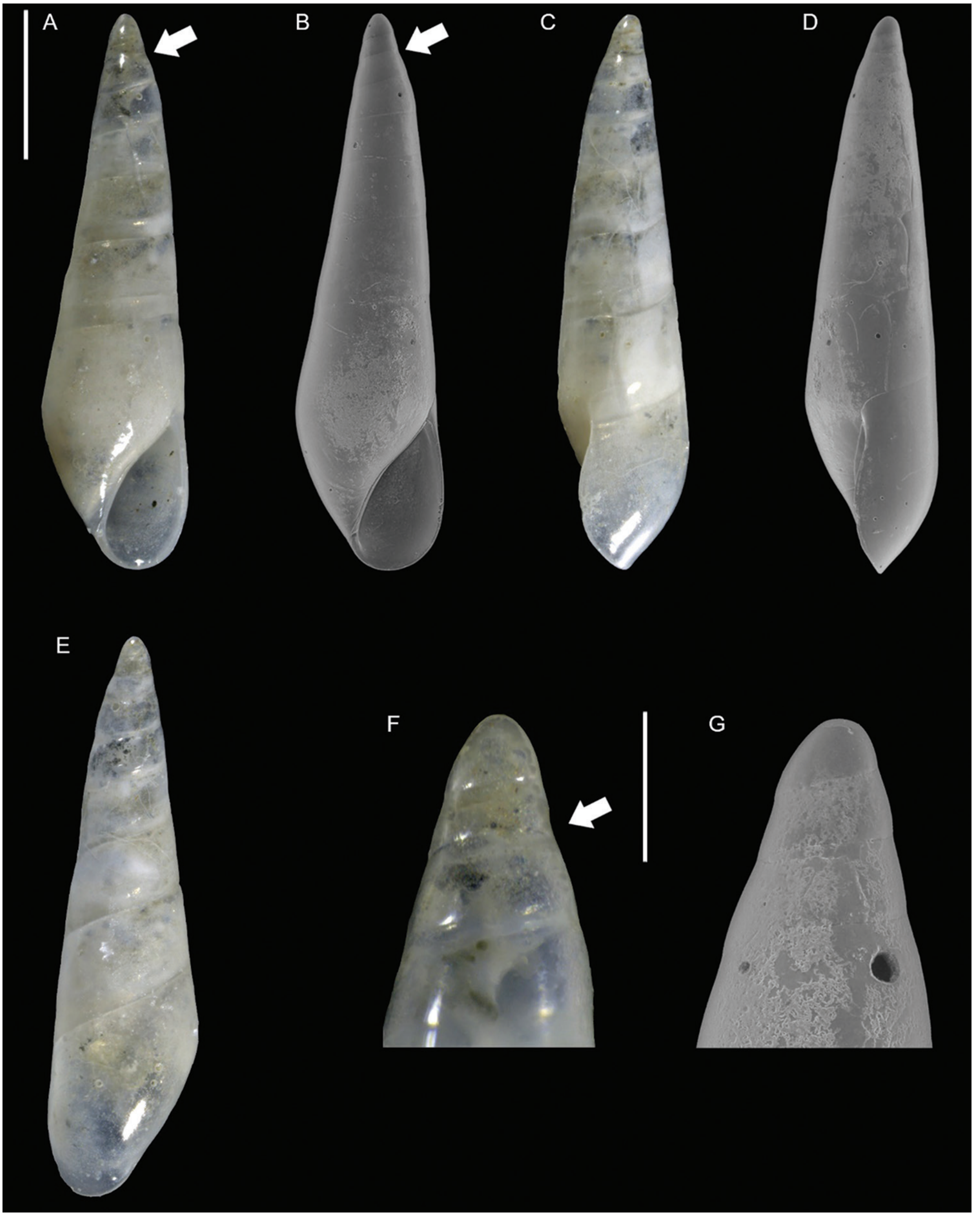

Figure 15. *Hypermastus* sp., Tel Aviv, Israel, HELM project (sample S67_3F): front (**A, B**), side (**C, D**) and back (**E**) views, apex with optical microscope (**F**) and SEM (**G**) showing the protoconch-teleoconch transition (the shell had a different orientation in images **F** and **G**). The arrow marks the constriction between protoconch and teleoconch that is a diagnostic character for this species. Scale bars: 0.5 mm (**A–E**); 0.2 mm (**F, G**).

and *Hemiliostraca athenamariae*. This is the first record of *H. clandestina* in Israel, but the species has been recorded for Lebanon based on empty shells collected in 1999 (Crocetta et al. 2020). Consequently, it is likely present here since at least 1999, with a ~ 20 year time-lag in first detection as quantified also for other non-indigenous species

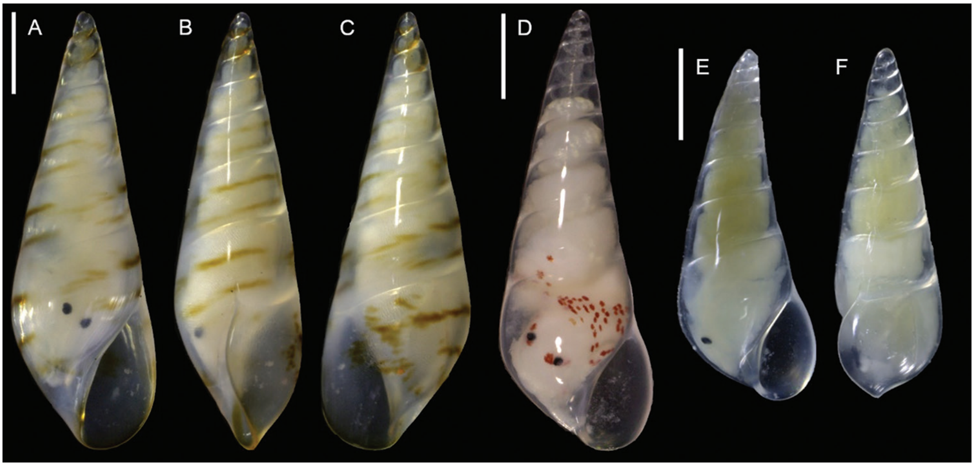

Figure 16. *Hemiliostraca clandestina* (Mifsud & Ovalis, 2019), and comparison between *Vitreolina philippi* (de Rayneval & Ponzi, 1854) and *Vitreolina* sp. **A–C** *Hemiliostraca clandestina*, Ashqelon, Israel, HELM project (sample S16_1F): front (**A**), side (**B**) and back (**C**) views. **D** *Vitreolina philippi* (de Rayneval & Ponzi, 1854), Plakias, Crete, Greece (sample Rh.05_5M): front view. **E, F** *Vitreolina* cf. *philippi*, Ashqelon, Israel, HELM project (S16_2F): front (**E**) and side (**F**) views. Scale bars: 0.5 mm.

in the Mediterranean Sea (Crooks 2005; Albano et al. 2018). This is also the first record of living individuals from the Mediterranean Sea. Despite the relatively large number of living individuals, we did not find any attached to an echinoderm host; this is consistent with the fact that some eulimids actively leave the host if disturbed (Warén 1984).

Melanella orientalis Agamennone, Micali & Siragusa, 2020
Figure 17

New records. Israel • 5 spcms; Ashqelon; 31.6868°N, 34.5516°E; depth 12 m; 30 Apr. 2018; offshore rocky reef; suction sampler; HELM project (samples S12_1F, S12_1M, S12_3F); size: H 2.7 mm, W 1.0 (illustrated specimen) • 1 spcm; same collecting data as for preceding; depth 11 m; 31 Oct. 2018; HELM project (sample S58_2F) • 3 spcms; Ashqelon; 31.6891°N, 34.5257°E; depth 25 m; 2 May 2018; offshore rocky reef; suction sampler; HELM project (samples S16_1F, S16_2F) • 1 spcm; same collecting data as for preceding; depth 28 m; 31 Oct. 2018; HELM project (sample S59_1F).

Remarks. This species can be distinguished from Mediterranean *Melanella* by its gently curved whorls, straight spire with fewer whorls and thinner shell than most species. It superficially resembles the Red Sea "*Eulima*" *orthophyes* Sturany, 1903 (type illustrated by Albano et al. (2017)), which can be distinguished because of its slightly bent apical whorls and the unusual pustulous sculpture of the protoconch. The species presented here is apparently already widespread in the Eastern Mediterranean (Agamennone et al. 2020a). We found only living individuals and no empty shells. Because of this, and the low likelihood that a so widespread species in shallow depths in the

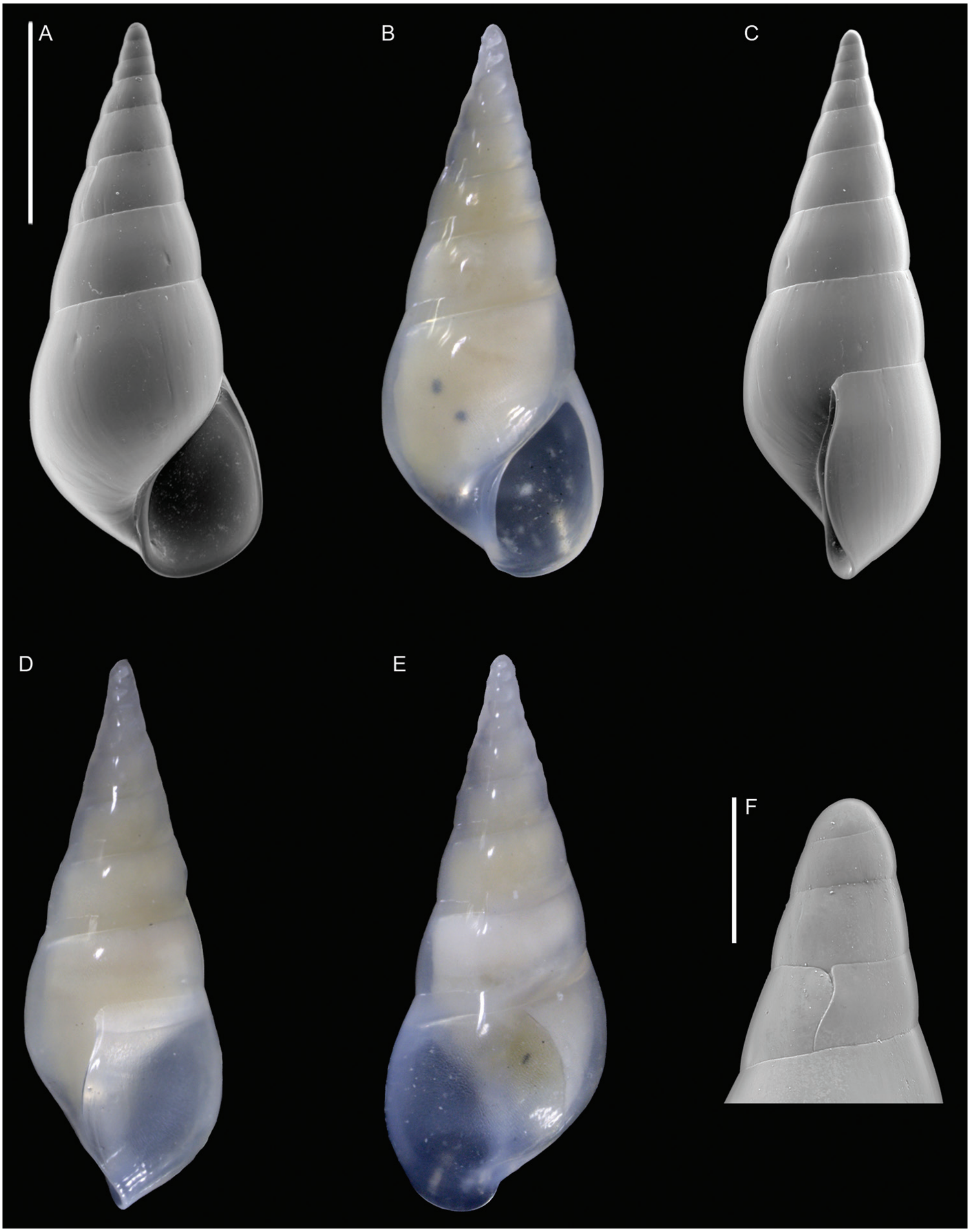

Figure 17. *Melanella orientalis* Agamennone, Micali & Siragusa, 2020, Ashqelon, Israel, HELM project (sample S12_1M): front (**A, B**), side (**C, D**) and back (**E**) views, apex (**F**). Scale bars: 1 mm (**A–E**); 0.2 mm (**F**).

Eastern Mediterranean would have escaped detection for long, we consider it a new non-indigenous species in the basin. The specimens reported as *Melanella* sp. by Albano et al. (2020) from mesophotic reefs off northern Israel belong to this species.

Parvioris aff. *dilecta* (E.A. Smith, 1899)

Figure 18E–M

New records. Israel • 1 sh; north of Atlit; 32.7433°N, 34.9067°E; depth 40 m; 20 Sep. 2016; coarse biogenic sediment in a pool among rocks covered by coralligenous formations; grab; HELM project (sample NG40_2M); size: H 4.9 mm, W 2.2 mm (illustrated shell, Figure 18E–H) • 3 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 29 Oct. 2018; rocky substrate; suction sampler; HELM project (samples S52_1F, S52_1M, S52_2F).

Additional material examined. *Parvioris ibizenca* (F. Nordsieck, 1968): Israel • 1 sh; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 29 Oct. 2018; rocky substrate; suction sampler; HELM project (sample S52_2F).

Remarks. The genus *Parvioris* Warén, 1981 was erected for a group of numerous conchologically very similar species of which many are still undescribed (Warén 1981). The species here reported is very similar in general shape and size to *P. dilecta* (Warén 1981: 146), especially the morphs illustrated here in Figure 18I–M. However, it has a multispiral protoconch of ~ 4.5 whorls (Figure 18H), whereas *P. dilecta* has a paucispiral protoconch of ~ 1.5 whorls. The type of protoconch is considered to be related to the developmental mode, which was regarded a diagnostic character at the species level for most molluscan lineages (Hoagland and Robertson 1988; Bouchet 1989). Because Warén (1984) suggested that the number of protoconch whorls is rather constant within species in Eulimidae, we currently do not consider our material conspecific with *P. dilecta*, but only closely related (thus the "aff." notation). However, there is increasing evidence that poecilogony, the intraspecific variation in developmental mode, occurs in Caenogastropoda (McDonald et al. 2014), Neogastropoda (Russini et al. 2020), and Sacoglossa (Krug 1998; Ellingson and Krug 2006; Vendetti et al. 2012).

Parvioris aff. *dilecta* can be easily distinguished from the native *P. ibizenca* because of a more arched apical part and because of the protoconch morphology: both have multispiral protoconchs, but *P. ibizenca* has shorter whorls and a distinct profile which inflates at the third whorl, in contrast with the more slender and regular profile of *P.* aff. *dilecta*. Our specimens are likely conspecific with those identified as *Melanella* sp. 1 by Blatterer (2019) from Dahab, Red Sea, suggesting that it is indeed a new Lessepsian species. An additional issue is whether the animal color is diagnostic at the species level like in other groups whose shells offer few diagnostic morphological characters, e.g., Mediterranean *Granulina* (Neogastropoda: Granulinidae) and *Gibberula* (Neogastropoda: Cystiscidae) (Gofas 1990, 1992). Some of our live collected specimens show a light yellow-white color (e.g., Figure 18I–K) whereas others have a brownish animal (e.g., Figure 18K–M). The final attribution of our findings to a species requires a thorough revision of *Parvioris*, which is beyond the scope of this paper. The specimens reported as *Parvioris* sp. by Albano et al. (2020) from mesophotic reefs off northern Israel belong to this species.

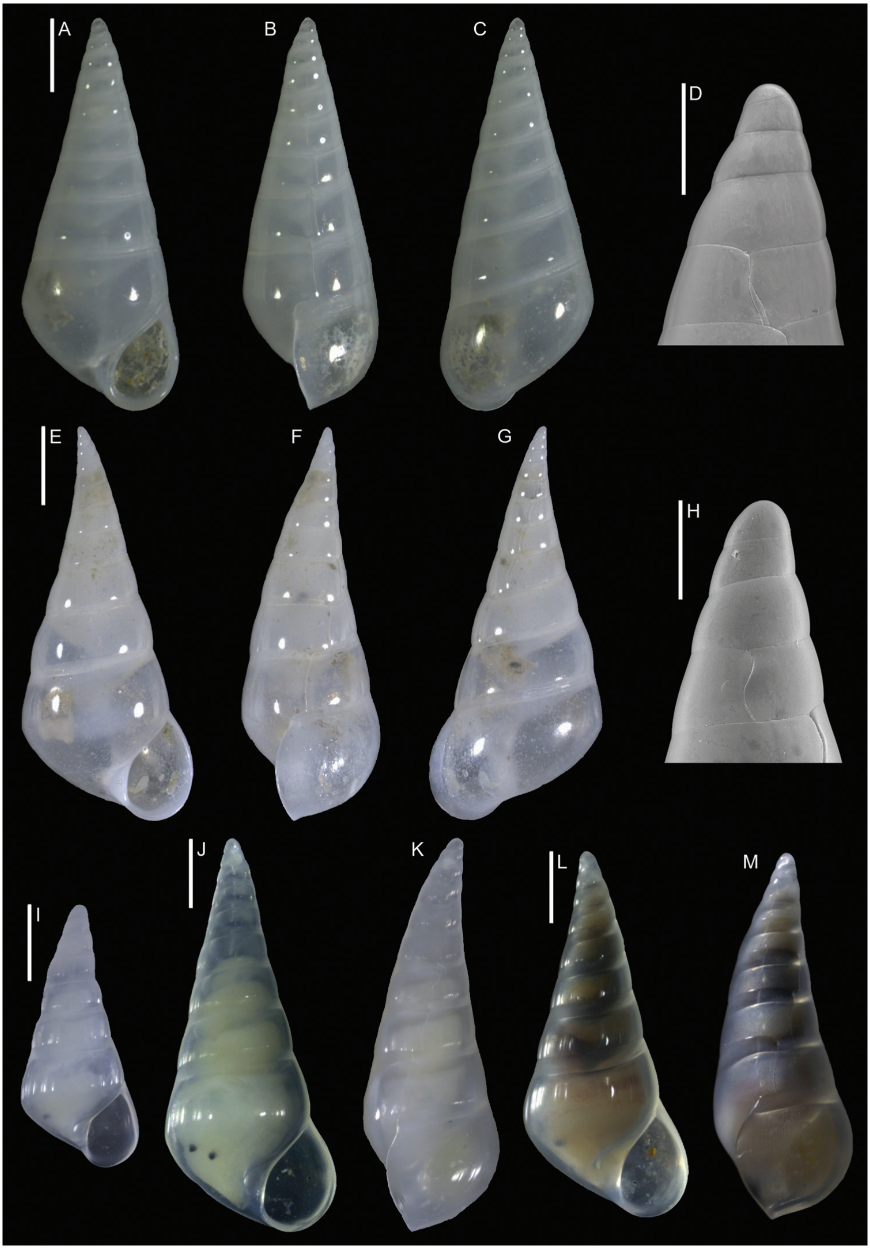

Figure 18. Comparison between *Parvioris* aff. *dilecta* (E.A. Smith, 1899) and *Parvioris ibizenca* (F. Nordsieck, 1968) **A–D** *Parvioris ibizenca*, west of Rosh HaNikra Islands, Israel, HELM project (sample S52_2F): front (**A**), side (**B**) and back (**C**) views, protoconch (**D**) **E–H** *Parvioris* aff. *dilecta*, north of Atlit, Israel, HELM project (sample NG40_2M): front (**E**), side (**F**) and back (**G**) views, protoconch (**H**) **I** *Parvioris* aff. *dilecta*, west of Rosh HaNikra Islands, Israel, HELM project (sample S52_1F): front view **J–K** *Parvioris* aff. *dilecta*, west of Rosh HaNikra Islands, Israel, HELM project (sample S52_1M): front (**J**) and side (**K**) views **L, M** *Parvioris* aff. *dilecta*, same collecting data as for preceding, HELM project (sample S52_2F): front (**L**) and side (**M**) views. Scale bars: 0.5 mm (**A–C, I–M**); 0.2 mm (**D, H**); 1 mm (**E–G**).

Sticteulima **sp.**

Figure 19

New records. Israel • 1 sh; north of Atlit; 32.7820° N, 34.9466° E; depth 10 m; 21 Sep. 2016; sand; grab; HELM project (sample NG10_1F); size: H 1.4 mm, W 0.6 mm (illustrated shell, Figure 19A–F) • 1 spcm; Ashqelon; 31.6891°N, 34.5257°E; depth 28 m; 31 Oct. 2018; offshore rocky reef; suction sampler; HELM project (sample S59_1F).

Remarks. We place this species in *Sticteulima* due to its small size, slender profile with high and rather flat whorls (Warén 1984). In contrast to the native *S. jeffreysiana* (Brusina, 1869) and the Lessepsian *S. lentiginosa* (A. Adams, 1861), it is colorless, also in live-collected specimens, and stouter. Further, this species does not match any of the known small-sized Mediterranean eulimids. It can be readily distinguished from *Vitreolina curva* (Monterosato, 1874) and *Melanella levantina* (Oliverio, Buzzurro & Villa, 1994) by the lack of the strongly arched apical whorls. This feature differentiates it at once also form other Red Sea small-sized eulimids (Blatterer 2019). *Melanella petitiana* (Brusina, 1869) is larger, has more numerous whorls (our *Sticteulima* has a fully thickened lip suggesting that it is an adult) and has a less prominent lip profile. *Nanobalcis nana* (Monterosato, 1878) (type illustrated by Appolloni et al. (2018)) has shorter whorls, especially the last one, which is also much broader than in this species. It can also be easily distinguished from *Hemiliostraca athenamariae* (Mifsud & Ovalis, 2019) by the lack of any color pattern, and the more inflated lip profile with a deeper posterior sinus. *Sticteulima* sp. may be a new non-indigenous species in the Mediterranean Sea.

Vitreolina **cf.** ***philippi*** **(de Rayneval & Ponzi, 1854)**

Figure 16E, F

New records. Israel • 4 spcms; Ashqelon; 31.6891°N, 34.5257°E; depth 25 m; 2 May 2018; offshore rocky reef; suction sampler; HELM project (samples S16_1F, S16_2F); size: H 2.6 mm, W 0.9 mm.

Additional material examined. *Vitreolina philippi* (de Rayneval & Ponzi, 1854): GREECE • Crete, Plakias; 35.1796°N, 24.3957°E; depth 5 m; 24 Sep. 2017; *Posidonia oceanica* rhizomes; suction sampler (sample Rh.05_5M).

Remarks. This *Vitreolina* is extremely similar to the native *V. philippi*, but the animal is whitish with a yellowish digestive gland (Figure 16E, F), in contrast to the peculiar color pattern of typical *V. philippi* with a white background and red dots (Figure 16D). *Vitreolina* is known to be gonochorous (Warén 1984) but it is unclear if this different color pattern, never reported from the Mediterranean, can be related to sex. We suspect that this could be another new Lessepsian species for the Mediterranean Sea, because we observed several Mediterranean-Red Sea species pairs that are morphologically extremely similar. If we are correct, the occurrence

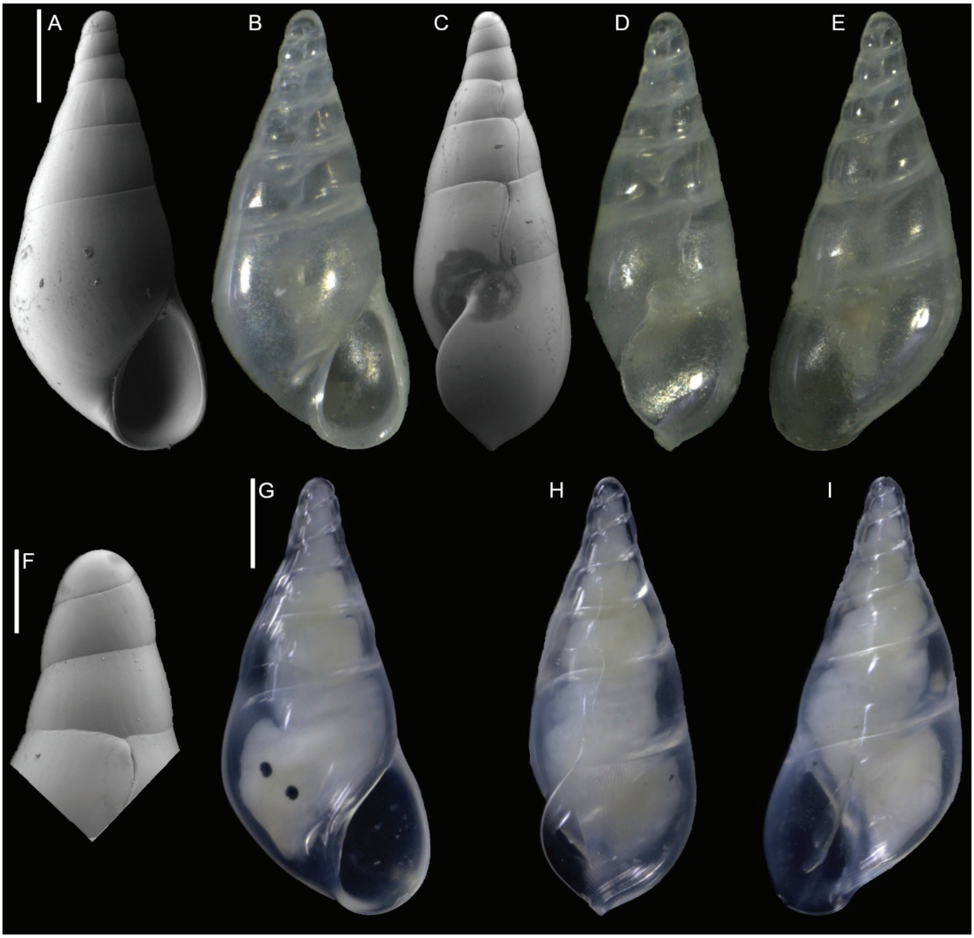

Figure 19. *Sticteulima* sp. **A–F** north of Atlit, Israel, HELM project (sample NG10_1F): front (**A, B**), side (**C, D**) and back (**E**) views, protoconch (**F**) **G–I** Ashqelon, Israel, HELM project (sample S59_1F): front (**G**), side (**H**) and back (**I**) views. Scale bars: 0.3 mm (**A–E, G–I**); 0.1 mm (**F**).

and distribution of this species in the Mediterranean may be difficult to trace, because empty shells, the most easily collected, are virtually indistinguishable from the native *V. philippi*.

Family Conidae J. Fleming, 1822

Conus fumigatus Hwass in Bruguière, 1792
Figure 20

New records. Israel • 3 shs; north of Atlit; 32.7433°N, 34.9067°E; depth 40 m; 20 Sep. 2016; coarse biogenic sediment in a pool among rocks covered by coralligenous formations; grab; HELM project (sample NG40_2M); NHMW-MO-112930/LM/0175; size of the largest shell (illustrated shell 2, Figure 20D–F): H 7.2 mm, W 4.0 mm.

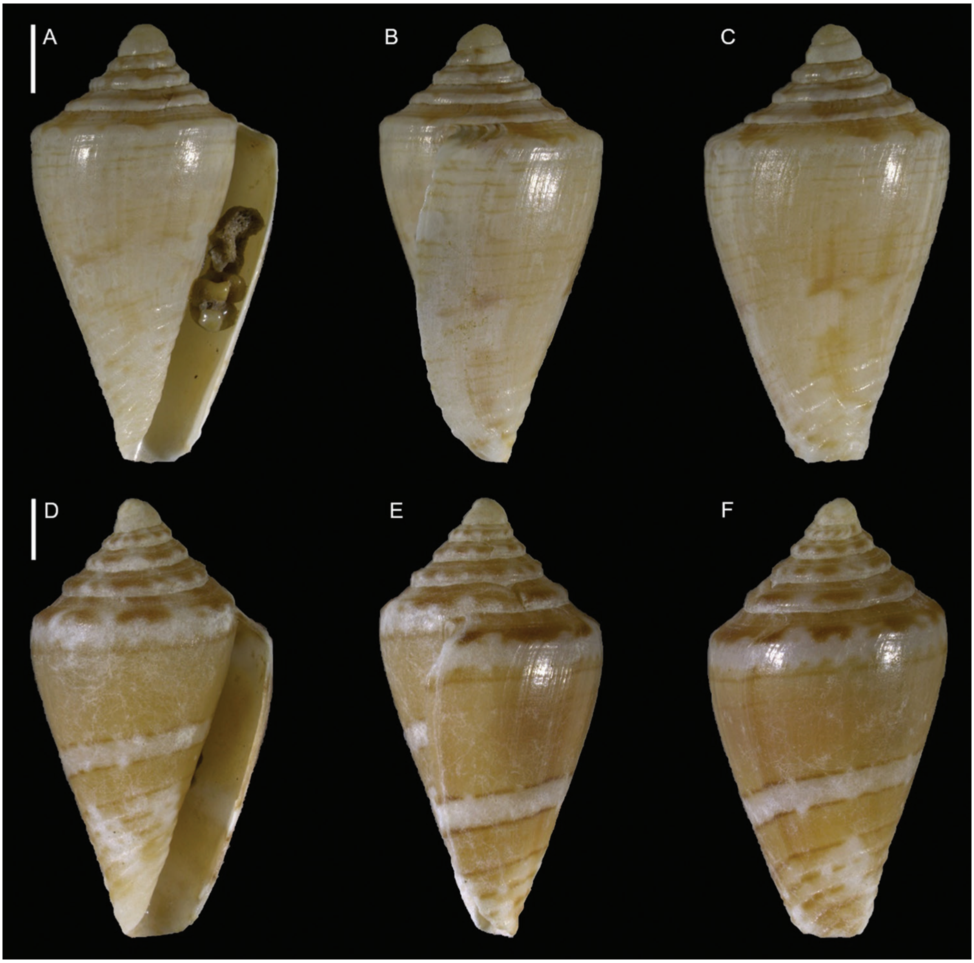

Figure 20. *Conus fumigatus* Hwass in Bruguière, 1792, NHMW-MO-112930/LM/0175, north of Atlit, Israel, HELM project (sample NG40_2M) **A–C** Shell 1: front (**A**), side (**B**) and back (**C**) views **D–F** Shell 2: front (**D**), side (**E**) and back (**F**) views. Scale bars: 1 mm.

Remarks. *Conus fumigatus* was first recorded from the Mediterranean Sea in Libya (Röckel 1986) but not recorded again for three decades until a recent report from Syria (Ammar 2018). This is the first finding in Israel, filling the distributional gap from the Suez Canal northward; only shells of juveniles have been found so far.

Family Murchisonellidae T.L. Casey, 1904

Henrya (?) sp.

Figure 21

New records. Israel • 1 spcm; Palmachim; 31.9574°N, 34.6645°E; depth 36.2 m; 24 May 2017; soft substrate; box-corer; Shafdan project (sample 24(B)); size: H 1.6 mm, W 0.8 mm.

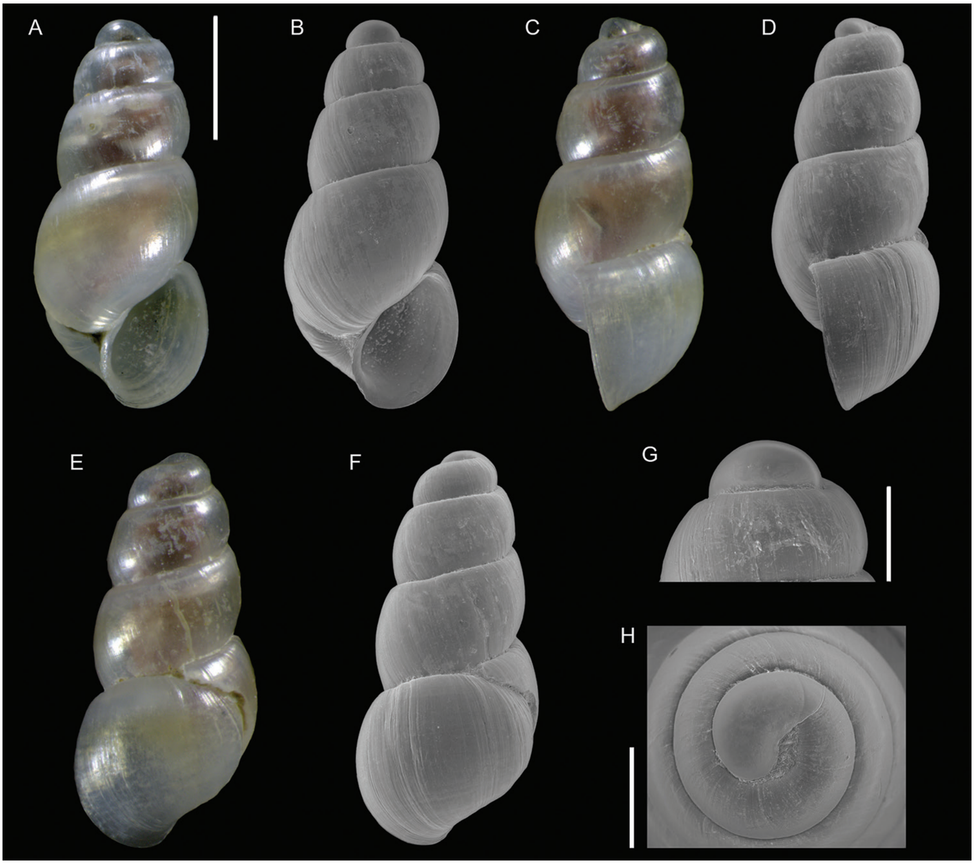

Figure 21. *Henrya* (?) sp., Palmachim, Israel, Shafdan project (sample 24(B)): front (**A, B**), side (**C, D**) and back (**E, F**) views, apex (**G**) and apical view of the protoconch (**H**). Scale bars: 0.5 mm (**A–F**); 0.2 mm (**G, H**).

Remarks. We were unable to assign this species to any Mediterranean or Indo-Pacific species, despite its conspicuous combination of shell characters. Our single specimen has an elongated, pupoid shell with convex whorls, a narrow but deeply incised suture, and a heterostrophic protoconch of type B (diameter: 250 µm). The surface is glossy and smooth except for densely spaced, very fine growth lines. The latter are straight, slightly prosocline on the spire, becoming orthocline near the aperture. The aperture is drop-shaped with a simple, thin lip that is slightly reflected at the columella. An umbilical chink is present. The shell is translucid-white, ornamented with a single, broad, light brown spiral color band. The shell morphology is similar to species of the murchisonellid genus *Henrya* Bartsch, 1947. However, the three currently known species of that genus were described form the tropical West Atlantic (Florida, Bahamas, and Yucatan) (Bartsch 1947), and none of them has a brown color band. For these reasons, the lack of anatomical and molecular data, and the fact that only a single specimen was available for study, we refrained from a definitive generic assignment. This species is potentially another non-indigenous one originating from the Indo-Pacific.

Among Mediterranean gastropods, the shell shape somewhat resembles the iravadiid *Hyala vitrea* (Montagu, 1803), however, the semi-immersed protoconch and brown color band of *Henrya* (?) sp. immediately set it apart. The heterobranch *Cima minima* (Jeffreys, 1858) is smaller, has a more concial shape, flexuous growth lines, and also lacks the brown band (van Aartsen 1981; Gofas et al. 2011; Scaperrotta et al. 2012; Giannuzzi-Savelli et al. 2014).

Family Pyramidellidae Gray, 1840

Odostomia cf. *dalli* (Hornung & Mermod, 1925)

Figure 22

New records. Israel • 4 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 29 Oct. 2018; rocky substrate; suction sampler; HELM project (samples S52_1F, S52_2F); size: H 2.1 mm, W 1.0 mm (illustrated specimen) • 1 spcm; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E; depth 19 m; 29 Oct. 2018; rocky substrate; suction sampler; HELM project (sample S53_1F).

Remarks. The shell of this species is white and rather solid, with convex, unkeeled whorls and a deep, narrow suture. The columellar tooth is visible in frontal view; there are no lirae inside the aperture. The outer surface appears smooth at first sight but bears numerous very fine spiral lines. The protoconch is of type A2, tending to type B. In ethanol-preserved specimens, the soft body is yellowish-white, with the eyes well visible through the shell (Figure 22A). *Odostomia* cf. *dalli* differs in its shell morphology from all known Mediterranean Odostomiinae, but bears close resemblance to the illustration of the type specimen of *Odostomia dalli* from Sarad Island ("Ile de Sarato"), Dahlak Archipelago, Eritrean Red Sea (Hornung and Mermod 1925). In contrast to our material, however, *O. dalli* was described as lacking both, spiral sculpture and a visible columellar fold, although a columellar tooth seems to be indicated in the line drawing accompanying the original description. A rigorous assessment of potential conspecificity between *O. dalli* and our material therefore awaits a thorough study of the type material of the former, but the close similarity suggests that this is a new non-indigenous species in the Mediterranean Sea. This interpretation is also supported by the lack of empty shells in death assemblages (see Discussion).

Odostomia (s.l.) sp. 1

Figure 23

New records. Israel • 1 spcm; Haifa Bay; 32.8211°N, 35.0196°E; depth 11 m; 2 Aug. 2015; soft substrate; grab; NM project (sample HM27(c)); size: H 1.4 mm, W 0.7 mm

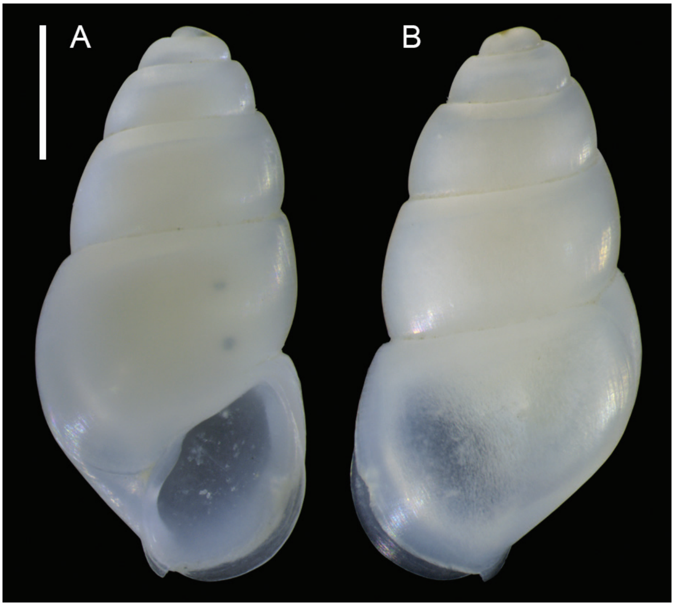

Figure 22. *Odostomia* cf. *dalli* (Hornung & Mermod, 1925), west of Rosh HaNikra Islands, Israel, HELM project (sample S52_2F): front (**A**) and back (**B**) views. Scale bar: 0.5 mm.

(illustrated specimen) • 8 spcms; 31.9364°N, 34.6846°E; depth 20.2 m; 11 Oct. 2012; sandy substrate; grab; Via Maris project (sample VM40).

Remarks. This species is characterized by a translucid-white, cylindrical shell with ~ 3 whorls, and an intorted protoconch of type C (Figure 23I) whose columella is oriented at an angle of ~ 160° relative to the teleoconch axis (revealed by µCT-imaging, Figure 23H and additional scans available at https://doi.org/10.6084/m9.figshare.c.5215226). The growth lines are slightly prosocline on the spire while becoming almost orthocline on the body whorl; an extremely faint spiral microsculpture is present on the apical part of the whorls, but only visible in high-magnification SEM images (Figure 23G). This species differs from *Odostomia* cf. *dalli* by its smaller size (height up to 1.4 mm), the more cylindrical shape, shallower suture, and the absence of a visible columellar tooth. Although this species, in terms of size and overall shape, somewhat resembles representatives of the fresh- and brackish water-dwelling family Hydrobiidae, the fact that numerous living specimens were found in a fully marine environment and its heterostrophic protoconch unambiguously identify it as member of the family Pyramidellidae.

Odostomia sp. 1 does not resemble any known Mediterranean pyramidellid; considering the great number of confirmed introductions of Indo-Pacific microgastropods to the eastern Mediterranean Sea, we therefore suspect that also this taxon might be a Lessepsian species. Among Indo-Pacific Odostomiinae, *O. bullula* Gould, 1861 (e.g., Johnson 1964; Robba et al. 2004) is similar to our specimens, but differs by its more conical shape and larger size (height to 2 mm, width to 1 mm). Another similar species, *O. decouxi* Saurin, 1959, was suggested to be a junior synonym of *O. bullula* (Robba et al. 2004).

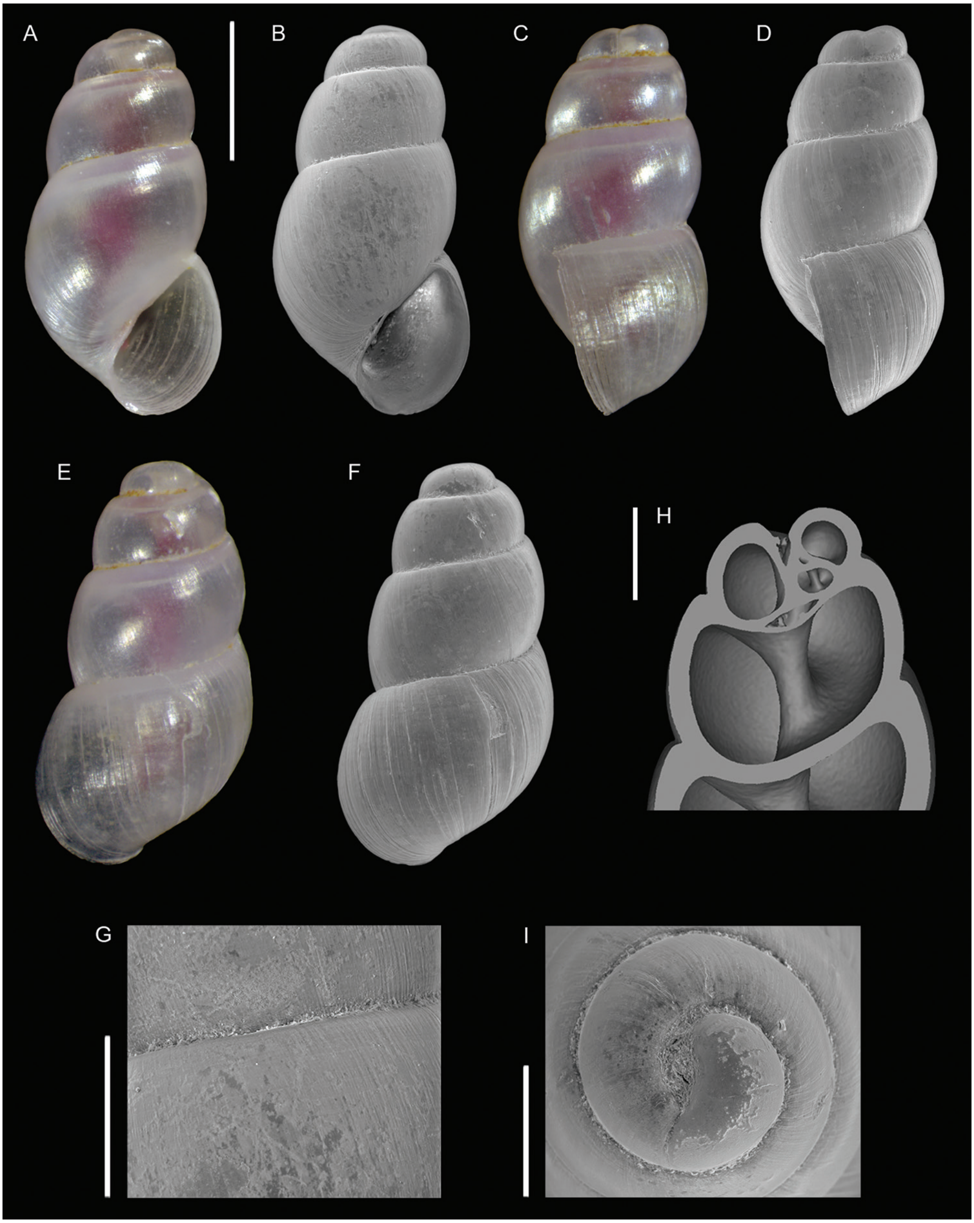

Figure 23. *Odostomia* (s.l.) sp. 1, Haifa Bay, Israel, NM project (sample HM27(c)): front (**A, B**), side (**C, D**) and back (**E, F**) views, detail of the adapical part of the body whorl showing the extremely faint spiral microsculpture (**G**), virtual section through the apical spire showing the columella of the intorted protoconch (**H**) and apical view of the protoconch (**I**; surface partly corroded). The pink hue is due to staining with eosin solution. Scale bars: 0.5 mm (**A–F**); 0.2 mm (**G–I**).

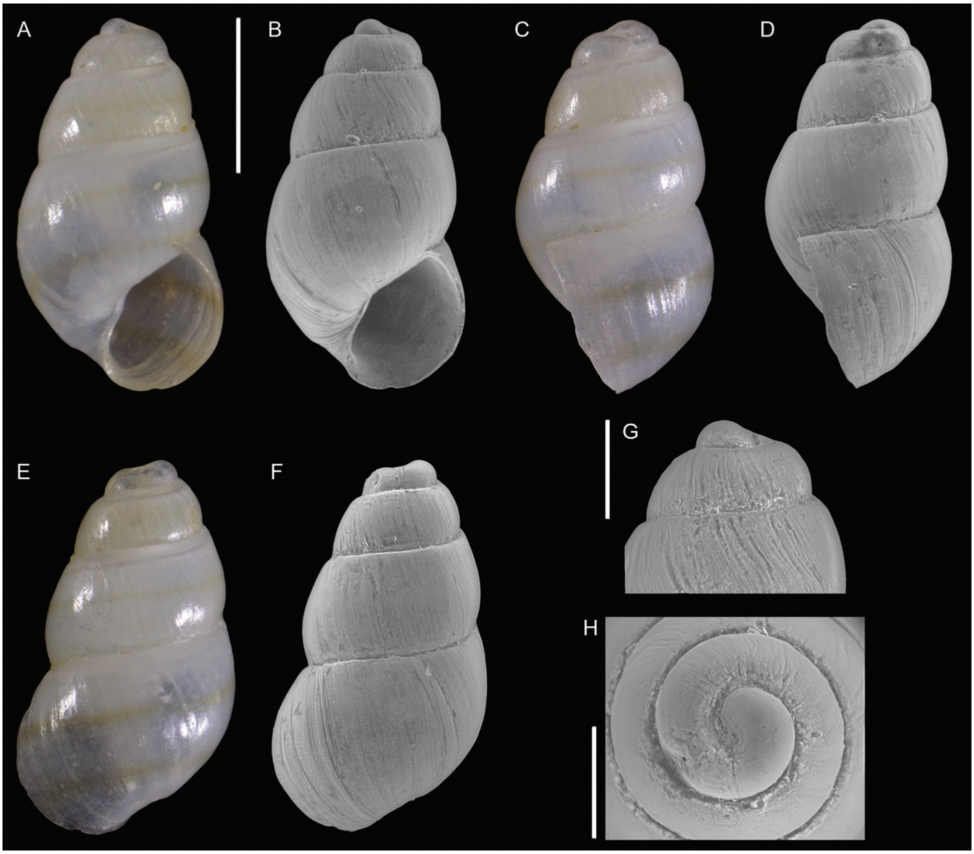

Figure 24. *Odostomia* (s.l.) sp. 2, Neve Yam, Atlit, Israel: front (**A, B**), side (**C, D**) and back (**E, F**) views, apex (**G**) and apical view of the protoconch (**H**). Scale bars: 0.5 mm (**A–F**); 0.2 mm (**G, H**).

Odostomia (s.l.) sp. 2

Figure 24

New records. Israel • 1 spcm; Soreq desalination plant; 31.9420°N, 34.6896°E; depth 17.4 m; 19 May 2015; soft substrate; grab; Soreq project (sample S027).

Additional material examined. Israel • 1 sh; Neve Yam, Atlit; 32.6785°N, 34.9289°E; 6 Feb. 2006; beached; size H 1.3 mm, W 0.7 mm (illustrated shell; previously figured by Bogi and Galil (2006)).

Remarks. The first record of this species is based on five well-preserved shells found in a shell grit sample taken in 1995 on the beach of Yumurtalik, Adana, Turkey (Giunchi et al. 2001). In 2006, another beached shell was found at Neve Yam, northern Israel (Bogi and Galil 2006, re-illustrated in Figure 24 herein) and, according to these authors, the species was also found in Israel by J.J. van Aartsen. A specimen of *Odostomia* sp. 2, from the original lot from Yumurtalik, was recently figured by Giannuzzi-Savelli et al. (2014). Here, we report the first finding of a living individual of *Odostomia* sp. 2 which was recovered from a sediment sample taken at the Soreq desalination plant, southern Israel.

Since the first finding in Turkey 25 years ago, the identity of this most likely non-indigenous species has remained unresolved. It differs from all known Mediterranean Odostomiinae at first glance by the presence of two brown spiral bands. We are unaware of any Indo-Pacific pyramidellid resembling this taxon, and it may well represent an undescribed species. To aid the further study of this taxon and raise awareness of its presence and apparent spread in the Mediterranean, we here re-illustrate the well-preserved shell from Neve Yam using light and scanning electron microscopy.

Oscilla virginiae Peñas, Rolán & Sabelli, 2020
Figure 25A, B

New records. Israel • 1 spcm; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 29 Oct. 2018; rocky substrate; suction sampler; HELM project (sample S52_1F) • 1 spcm; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E; depth 19 m; 29 Oct. 2018; rocky substrate; suction sampler; HELM project (sample S53_1F); size: H 1.6 mm, W 0.9 mm (illustrated specimen).

Additional material examined. *Oscilla appeliusi* (Hornung & Mermod, 1925): EGYPT • 1 sh; Sinai (Red Sea), south of Sharm-el-Sheik, Na'ama Bay; 27.8500°N, 34.2833°E; depth 0–6 m; 28 Sep. –4 Oct. 1978; rocky substrate; A.J. Ferreira leg.; LACM 1978-79.4 • 1 sh; Sinai (Red Sea), Gulf of Aqaba, Strait of Tiran, Jackson Reef; 28.0167°N, 34.4667°E; depth 2–3 m; 31 Oct. 1985; sand and coral substrate; T. Bratcher leg.; LACM 1985-111.5 • 2 shs; Sinai (Red Sea), Gulf of Aqaba, Strait of Tiran, east side Jackson Reef; 28.000°N, 34.4667°E; depth 10 m; 9 Jul. 1988; coral rubble; J. H. Golden leg.; LACM 1988-118.1 • 4 shs; Sinai (Red Sea), off Ras Umm Sid, "Amphoras" dive site; 27.8667°N, 34.333°E; depth 18 m; 24 Jul. 1988; coral rubble; J.H. Golden leg.; LACM 1988-119.2.

Indonesia • 7 shs; Papua Province, south-east of Biak Island, east side of Auki Islet; 1.2300° S, 136.3367°E; depth 0 m; 5 Apr. 1988; rock; J.H. McLean & E. Abbott leg.; LACM 1988-48.12.

Taiwan • 7 shs; Tai-Pei County, east of Chi-lung (= Keelung), south-east side of Pitou Chiao (= Pitou Nonkow); 25.1333°N, 121.9167°E; depth 0–3 m; 10 May 1988; rocky tide pool; C.C. Coney & P.F. Liu leg.; LACM 1988-80.13.

Miralda sp. (*Oscilla jocosa* sensu van Aartsen et al. (1989)): Israel • 1 spcm; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 29 Oct. 2018; rocky substrate; suction sampler; HELM project (sample S52_1F); size: H 2.0 mm, W 1.0 mm (illustrated specimen).

Remarks. *Oscilla virginiae* is characterized by a small-sized, white, conical shell with a type A protoconch. The sculpture consists of thick, smooth spiral cords: the first and second whorl bear two cords; the upper cord is broadest and bifurcates on the third whorl, forming three cords on the last whorl, with the newly formed pair remaining positioned very close one to each other (Figure 25A, B; Peñas et al., 2020).

This species has just been described from the infralittoral of Jordan and also occurs in the Egyptian Red Sea (Peñas et al. 2020). It superficially resembles the Indo-Pacific *O. appeliusi* (Hornung & Mermod, 1925), and indeed, a juvenile shell from Dahab (Egypt) was

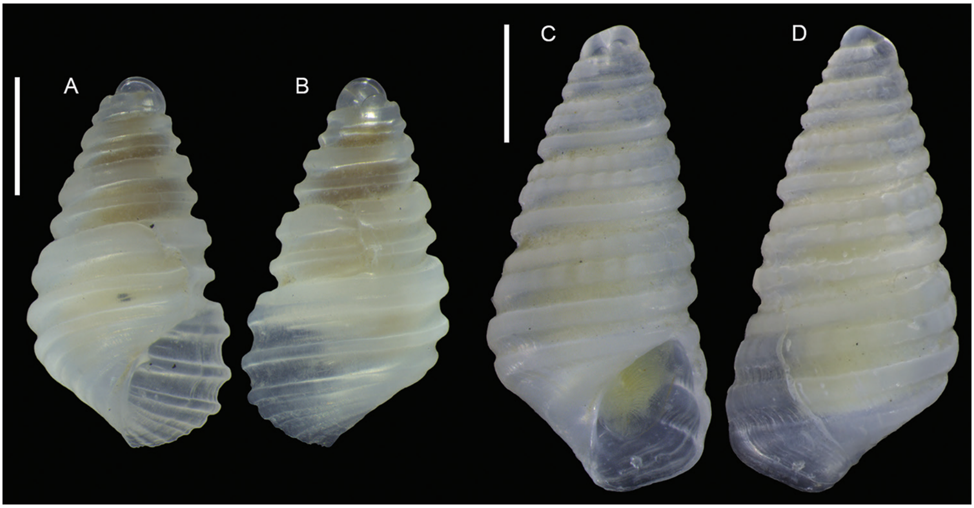

Figure 25. Comparison between *Oscilla virginiae* Peñas, Rolán & Sabelli, 2020 and *Miralda* sp. **A, B** *Oscilla virginiae*, west of Rosh HaNikra Islands, Israel, HELM project (sample S53_1F): front (**A**) and back (**B**) views **C, D** *Miralda* sp. (*Oscilla jocosa* sensu van Aartsen et al. (1989)), west of Rosh HaNikra Islands, Israel, HELM project (sample S52_1F): front (**C**) and back (**D**) views. Scale bars: 0.5 mm.

recently figured by Blatterer (2019: plate 212, fig. 17c, d) under this name. In contrast to *O. virginiae*, however, *O. appeliusi* bears spiral cords more similar in thickness which are spaced more equidistantly and closer to each other. Already on the second whorl, three cords are present, and the uppermost cord does not evidently bifurcate (Peñas et al. 2020). Lastly, the illustration of Hornung and Mermod (1925) suggests a greater number of spiral cords on the last whorl. To date, *O. appeliusi* has not been recorded from the Mediterranean Sea.

Within the Mediterranean, *O. virginiae* is superficially similar only to two other non-indigenous pyramidellids, *Cingulina isseli* (Tryon, 1886) and *Miralda* sp. (Figure 25C, D). The latter taxon has previously been reported under the name *Oscilla jocosa* Melvill, 1904, despite recent evidence by Peñas & Rolán (2017) that it is not conspecific with Melvill's (1904) type material. *Oscilla virginiae* differs from *C. isseli* by its broader, more conical shell, fewer whorls, smaller size (*C. isseli* reaches a height of ~ 3 mm), and the much less pronounced axial sculpture between the spiral cords. Compared to *Miralda* sp., *O. virginiae* differs by its smaller size (up to ~ 3 mm in *Miralda* sp.), the absence of beads on the two upper spiral cords (Figure 25C, D), and stronger spiral cords on the base of the shell. Another *Oscilla* present in the Mediterranean Sea is *O. galilae* Bogi, Kharan & Yokes, 2012, which can be easily distinguished from *O. virginiae* by the smaller size, the oval profile, the oblique spiral sculpture, the more prominent axial sculpture and a type C protoconch. Peñas et al. (2020) illustrated *O. galilae* (their Fig. 38A–E) under the name *O. cylindrica* (de Folin, 1879) suggesting synonymy between the two names. However, *O. cylindrica* can be easily distinguished from *O. galilae* because it bears spiral cords without interspaces, because it does not bear the fine axial lamellae typical of *O. galilae* and because of its more cylindrical profile. The Red Sea records of *O. virginiae* and *O. galilae* by Peñas et al. enable to assess that both species are non-indigenous in the Mediterranean Sea.

Parthenina cossmanni (Hornung & Mermod, 1924)
Figure 26A–H

New records. Israel • 1 sh; north of Atlit; 32.7422°N, 34.9181°E; depth 30 m; 20 Sep. 2016; sand; grab; HELM project (sample NG30_2F); size: H 1.9 mm, W 0.9 mm (illustrated shell, Figure 26A–F) • 9 spcms, 2 shs; Ashqelon; 31.7002°N, 34.5498°E; depth 21 m; 18 Sep. 2016; sand; grab; HELM project (samples SG20_1F, SG20_2F, SG20_4F, SG20_5F); size: H 2.0 mm, W 0.8 mm (illustrated specimen, Figure 26G, H) • 1 spcm; Ashqelon; 31.6868°N, 34.5516°E; depth 12 m; 30 Apr. 2018; offshore rocky reef; suction sampler; HELM project (sample S12_1F).

Additional material examined. *Parthenina indistincta* (Montagu, 1808): Israel • 2 shs; Ashqelon; 31.7002°N, 34.5498°E; depth 21 m; 18 Sep. 2016; sand; grab; HELM project (sample SG20_2F) • 1 sh; Ashqelon; 31.7101°N, 34.5406°E; depth 31 m; silty sand, 15 cm below sediment surface; gravity corer; HELM project (sample SC30_1_15L); size: H 1.7 mm, W 0.7 mm (illustrated shell).

Remarks. *Parthenina cossmanni* has an elongated-conical shell with flat-convex whorls and a protoconch of type C. The whorls of the spire have a subangular profile, whereas the body whorl in adult specimens is more convex and evenly rounded. The axial sculpture is made of strong orthocline ribs that become slightly flexuous on the body whorl in some specimens (Figure 26A–E). The spiral sculpture on the spire consists of a single, thin, suprasutural cord; a second cord emerges on the penultimate whorl, and three cords are present on the last whorl. The columellar tooth is weak and deeply inset, and in some of the studied specimens hardly visible inside the aperture. The soft body of ethanol-preserved specimens is yellowish, with the eyes visible through the shell (Figure 26G, H).

The type material of *P. cossmanni* was collected from the Red Sea of Massawa (Eritrea) at a depth of 30 m (Hornung and Mermod 1924); the species was recently recorded from Dahab (Gulf of Aqaba, northern Egypt) by Blatterer (2019), and from Jordan by Peñas et al. (2020). Outside the Red Sea, it is known from Vietnam (Saurin 1959) and Thailand (Robba et al. 2004).

Among native Mediterranean species, *P. cossmanni* superficially resembles *Parthenina interstincta* (J. Adams, 1797). The latter species, however, has only two spiral cords on the last whorl and a more developed columellar tooth. *P. cossmanni* is further similar to *P. indistincta* (Montagu 1808) (Figure 26I–L) which has a very weak, internal columellar fold (Warén 1991a: 96, fig. 29f) and three (rarely four) spiral cords on the last whorl. Compared to *P. cossmanni*, however, the shell of *P. indistincta* is more elongated and has two spiral cords on the spire whorls.

We suspect the two shells illustrated as *P. indistincta* in Öztürk et al. (2011: fig. 10A, B) might also be *P. cossmanni*, considering their broad shape and overall morphology. Öztürk et al.'s material was collected in 2009 from a mud bottom at 9 m depth in Mersin Bay (stn. 46, 36.7167°N, 34.8667°E), south-eastern Turkey; should our hypothesis be confirmed upon re-examination of these shells, this would suggest that *P. cossmanni* likely has a wider distribution in the southeastern Mediterranean Sea. Our finding of several

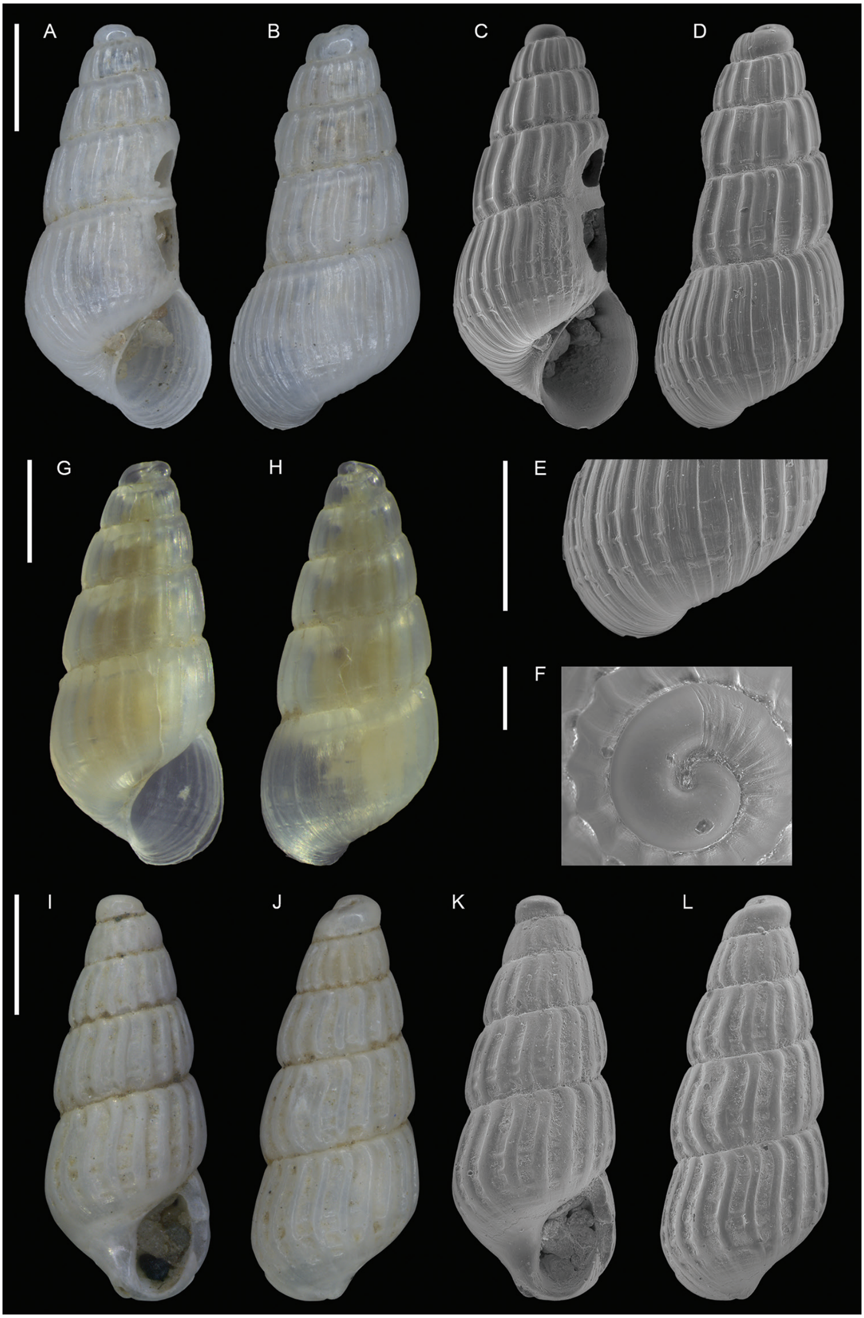

Figure 26. Comparison between *Parthenina cossmanni* (Hornung & Mermod, 1924) and *Parthenina indistincta* (Montagu, 1808) **A–F** *Parthenina cossmanni*, north of Atlit, Israel, HELM project (sample NG30_2F): front (**A, C**) and back (**B, D**) views, detail of the spiral sculpture on the body whorl (**E**) and apical view of the protoconch (**F**) **G, H** *Parthenina cossmanni*, Ashqelon, Israel, HELM project (sample SG20_4F): front (**G**) and back (**H**) views **I–L** *Parthenina indistincta*, Ashqelon, Israel, HELM project (sample SC30_1_15L): front (**I, K**) and back (**J, L**) views. Scale bars: 0.5 mm (**A–E, G–L**); 0.1 mm (**F**).

living specimens on the Israeli shelf, together with the relative rarity of empty shells in the samples, suggests that this species might have established locally only rather recently.

Parthenina typica (Laseron, 1959)

Figure 27

New records. Israel • 2 spcms; Palmachim; 31.9737°N, 34.6767°E; depth 35.4 m; 2 Sep. 2015; soft substrate; box-corer; Shafdan project (sample 29(C)) • 4 spcms; Palmachim; 31.9685°N, 34.6732°E; depth 35.6 m; 2 Sep. 2015; soft substrate; box-corer; Shafdan project (sample 26(B)); size: H 2.0 mm, W 0.8 mm (illustrated specimen) • 1 sh; north of Atlit; 32.7433°N, 34.9067°E; depth 40 m; 20 Sep. 2016; coarse biogenic sediment in a pool among rocks covered by coralligenous formations; grab; HELM project (sample NG40_2M) • 1 spcm; Ashqelon; 31.7487°N, 34.4960°E; depth 41 m; 18 Sep. 2016; sandy mud; grab; HELM project (sample SG40_1F).

Remarks. This species is characterized by a straight, conical profile with flat whorls, separated by a deep, canaliculate suture; the abapical part of the whorl is angulated. The sculpture consists of straight axial ribs and a prominent suprasutural spiral cord; the base is smooth except for faint continuations of the axial ribs; an internal columellar fold is present and visible inside the aperture when slightly turning the shell to the left side. The protoconch is of type C and in the illustrated specimen it has a diameter of ~ 240 µm, which is slightly smaller than 270–290 µm stated by Peñas and Rolán (2017) for this species.

Parthenina typica (Laseron, 1959) was described from eastern Australia (Laseron 1959) and subsequently recorded from the Solomon Islands, Fiji and the Philippines at infralittoral to bathyal depths (Peñas and Rolán 2017). To our knowledge, it has not been reported from the Indian Ocean nor from the Red Sea, however, its absence could well represent an artifact of the limited knowledge of the micromollusk fauna of these regions. Among native species, the conchologically highly variable *Parthenina interstincta* (J. Adams, 1797) and *P. monozona* (Brusina, 1869) are most similar, however, they differ by having more rounded whorls and a greater number of axial ribs.

Pyrgulina craticulata (Issel, 1869)

Figure 28A–I

New records. Israel • 1 sh; north of Atlit; 32.7820°N, 34.9466°E; depth 10 m; 21 Sep. 2016; sand; grab; HELM project (sample NG10_1F) • 3 spcms; Ashqelon; 31.6868°N, 34.5516°E; depth 12 m; 30 Apr. 2018; offshore rocky reef; suction sampler; HELM project (samples S12_2F, S12_3F) • 17 spcms, 1 sh; same collecting data as for preceding; depth 11 m; 31 Oct. 2018; HELM project (samples S58_1F, S58_1M, S58_2F, S58_3F); size: H 1.5 mm, W 0.7 mm (illustrated specimen) • 2 spcms; Ashqelon; 31.6891°N, 34.5257°E; depth 25 m; 2 May 2018; offshore rocky reef; suction sam-

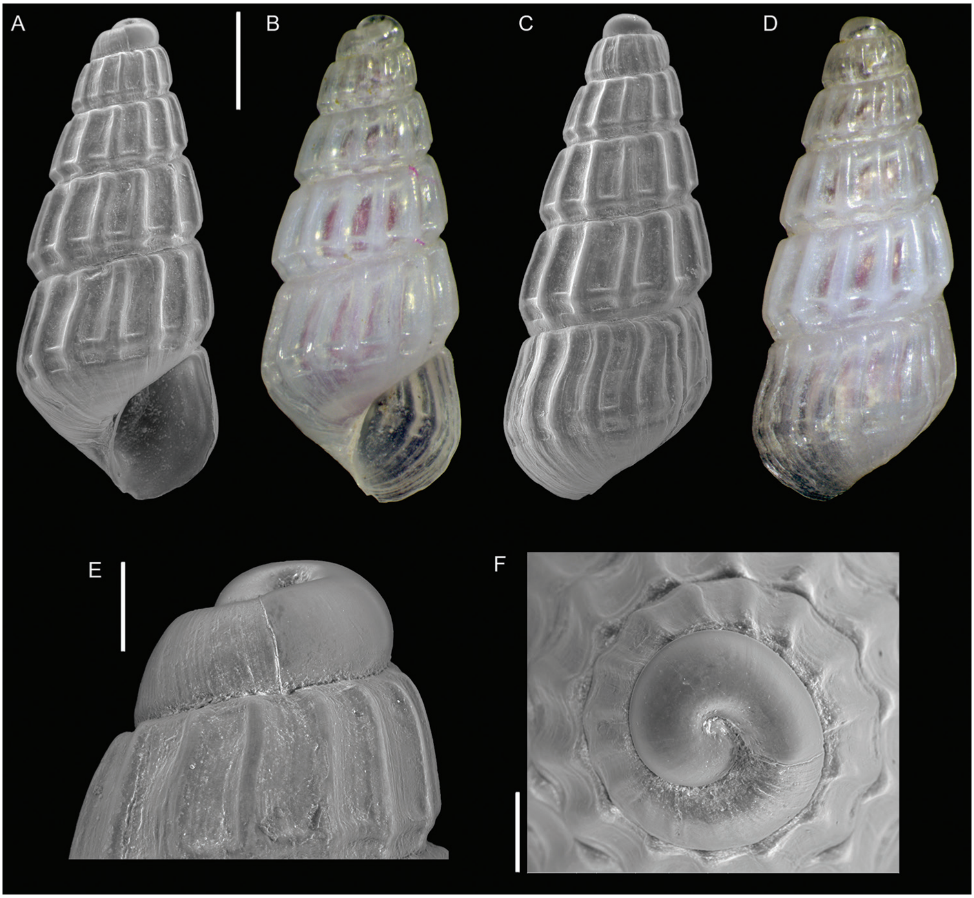

Figure 27. *Parthenina typica* (Laseron, 1959), Palmachim, Israel, Shafdan project: front (**A, B**) and back (**C, D**) views, apex (**E**) and apical view of the protoconch (**F**). Scale bars: 0.4 mm (**A–D**); 0.1 mm (**E, F**).

pler; HELM project (sample S16_2F) • 1 spcm; same collecting data as for preceding; depth 28 m; 31 Oct. 2018; HELM project (sample S59_2F) • 2 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 29 Oct. 2018; rocky substrate; suction sampler; HELM project (samples S52_2F, S52_3F) • 1 spcm; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E; depth 20 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S13_3F) • 2 spcms; same collecting data as for preceding; depth 19 m; 29 Oct. 2018; HELM project (sample S53_1F).

Additional material examined. *Pyrgulina craticulata*: EGYPT • 1 sh; Sinai (Red Sea), Gulf of Aqaba, Strait of Tiran, Jackson Reef; 28.0167°N, 34.4667°E; depth 2–3 m; 31 Oct. 1985; sand and coral substrate; T. Bratcher leg.; LACM 1985-111.4.

Madagascar • 3 shs; Antsiranana Province, south of Nosy Be, out from Hellville (= Andoany); 13.4500° S, 48.2500°E; depth 14 m; 5 Apr. 1989; coral heads and gorgonians; J.H. McLean leg.; LACM 1989-55.1.

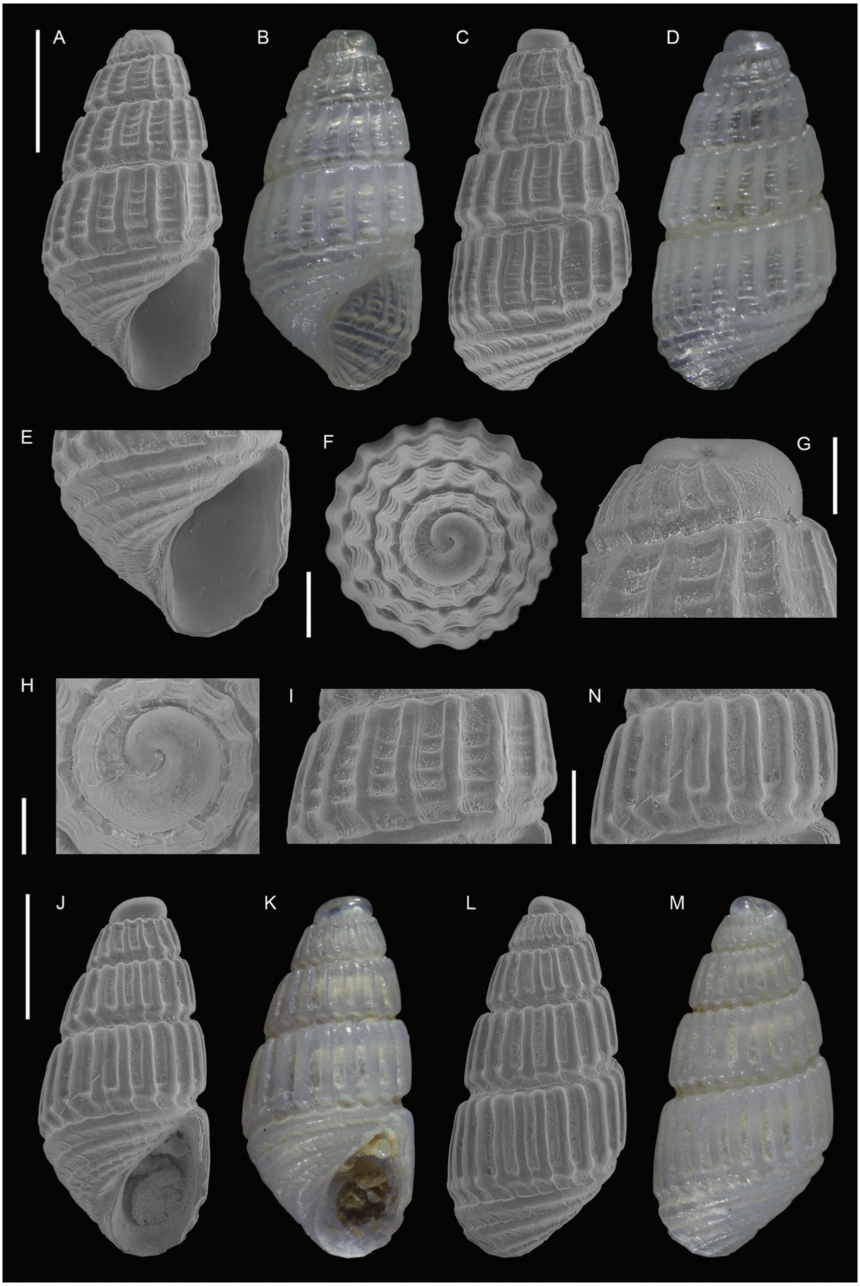

Figure 28. Comparison between *Pyrgulina craticulata* (Issel, 1869) and *Spiralinella incerta* (Milaschewitsch, 1916) **A–I** *Pyrgulina craticulata*, Ashqelon, Israel, HELM project (sample S58_3F): front (**A, B**) and back (**C, D**) views, aperture and details of the sculpture on the base (**E**), top view (**F**), detail of the protoconch-teleoconch transition (**G**), apical view of the protoconch (**H**) and detail of the sculpture of the body whorl (**I**) **J–N** *Spiralinella incerta*, west of Rosh HaNikra Islands, Israel, HELM project (sample S14_4F): front (**J, K**) and back (**L, M**) views, detail of the sculpture of the body whorl (**N**). Scale bars: 0.5 mm (**A–D, J–M**); 0.2 mm (**E, F, I, N**); 0.1 mm (**G, H**).

Maldives • 1 sh; North Male Atoll, 2 km north of Baros Island; 4.3167°N, 73.4167°E; depth 25–35 m; 10 Feb. 1983; gravel; leg. A.J. Ferreira; LACM 1983-9.7.

Thailand • 1 sh; Phuket Province, east side of Kaew Yai Island; 7.7450°N, 98.3083°E; depth 0–3 m; 24–26 Mar. 1985; coral; J.H. McLean leg.; LACM 1985-5.17 • 1 sh; same collecting data as for preceding; LACM 1985-5.18 • 6 shs; Phuket Province, southern tip of Phromthep Cape; 7.7583°N, 98.3217°E; depth 0 m; 24 Mar. 1985; boulder beach with coral; J.H. McLean leg.; LACM 1985-6.4 • 4 shs; Phuket Province, east of Phuket, near Pee-Pee (= Phi Phi) Island, Hin Hmusang Rock; 7.7917°N, 98.5500°E; depth 15 m; 15 Feb. 1985; sand; A.J. Ferreira leg.; LACM 1985-14.2.

Spiralinella incerta (Milaschewitsch, 1916): Israel • 1 sh; north of Atlit; 32.7820°N, 34.9466°E; depth 10 m; 21 Sep. 2016; sand; grab; HELM project (sample NG10_1F) • 1sh; north of Atlit; 32.7422°N, 34.9181°E; depth 30 m; 20 Sep. 2016; sand; grab; HELM project (sample NG30_2F) • 2 shs; Ashqelon; 31.7002°N, 34.5498°E; depth 21 m; 18 Sep. 2016; sand; grab; HELM project (sample SG20_2F) • 1 sh; Ashqelon; 31.7101°N, 34.5406°E; depth 31 m; silty sand, 90 cm below sediment surface; gravity corer; HELM project (sample SC30_1_90L) • 1 sh; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S14_4F); size: H 1.5 mm, W 0.7 mm (illustrated shell).

Remarks. Issel (1869) described *Odontostomia craticulata* based on an illustration of a shell from the Red Sea by Savigny (1817: pl. 3, fig. 39); the syntype from the Savigny collection (MNHN-IM-2000-34095) was later figured by Bouchet & Danrigal (1982) and is shown on the MNHN website (https://science.mnhn.fr/institution/mnhn/collection/im/item/2000-34095?listIndex=15&listCount=44; last accessed 26 July 2020). As *Odontostomia* is considered an unjustified emendation of *Odostomia* (MolluscaBase 2020), a genus with very different conchological characters from *P. craticulata*, we follow the opinion of Peñas et al. (2020) and use the combination *Pyrgulina craticulata* (Issel, 1869).

Pyrgulina craticulata has been reported only from the Red Sea so far, however, a search of previously uncatalogued lots of pyramidellid shells in the LACM collection by one of us (PILF) yielded specimens from Madagascar, the Maldives and Thailand, confirming that this species has a much wider distribution in the Indian Ocean. Shells of *P. craticulata* seem indistinguishable from the illustration of *Chrysallida tribulationis* (Hedley, 1909), a taxon recorded from Australia and the western Japan Sea (Hedley 1909; Higo et al. 2001). In the light of a possible distribution of *P. craticulata* also in the West Pacific, we recommend an assessment of potential synonymy between *C. tribulationis* and *P. craticulata*.

Here, we provide the first records of *P. craticulata* for the Mediterranean Sea. Several living specimens were found on hard substrates off southern and northern Israel, suggesting it is established in the region. In terms of shell size, shape and type of ornamentation, this species closely resembles the native *Spiralinella incerta* (Figure 28J–N), but has pronounced spiral cords in the interspaces of the axial ribs (Figure 28I vs. 28N) which enable a reliable segregation of these two species. In addition, the axial ribs are spaced more closely in *S. incerta* than in *P. craticulata*.

Pyrgulina nana Hornung & Mermod, 1924

New records. Israel • 2 spcms; Ashqelon; 31.6891°N, 34.5257°E; depth 28 m; 31 Oct 2018; offshore rocky reef; suction sampler; HELM project (sample S59_2F) • 1 spcm; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S14_4F) • 5 spcms; same collecting data as for preceding; 29 Oct. 2018; HELM project (samples S52_1F, S52_2F).

Remarks. Until now, the first record of this species from the Mediterranean was considered to be by Öztürk and van Aartsen (2006), who reported on material obtained from shallow-water sediment samples collected along the Turkish Levantine (Viransehir, Mersin Bay) and Aegean coasts (Güllük Bay) in 1997 and 2000, respectively. However, already van der Linden and Eikenboom (1992) described and illustrated *P. nana* from the Levantine Sea (page 60, Figure 41), referring to it as *Chrysallida* spec. C in the lack of a species-level identification. Their material consisted of a single individual, likely an empty shell, but not specified by the authors, from Mersin (south-eastern Turkey) with unknown collecting date, housed in the collection of J. van der Linden (The Hague, The Netherlands). Although we were unable to examine this material, the excellent and detailed line drawing provided enabled an unambiguous assignment of *Chrysallida* spec. C to *P. nana*; thus, van der Linden and Eikenboom (1992) should be regarded the first Mediterranean record. Today, the known Mediterranean distribution of *P. nana* includes Turkey, Lebanon, and Israel (Bogi and Galil 2006; Giannuzzi-Savelli et al. 2014). To our knowledge, this is the first record of living individuals of *P. nana* from Israel; here, the species occurs along both the southern (Ashqelon) and northern coasts (west of Rosh HaNikra Islands) on rocky bottoms at 12–28 m depth.

Turbonilla funiculata de Folin, 1868

Figure 29

New records. Israel • 2 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S14_4F) • 15 spcms; same collecting data as for preceding; 29 Oct. 2018; HELM project (samples S52_1F, S52_2F, S52_3F); size: H 1.8 mm, W 0.6 mm (illustrated specimen).

Additional material examined. China • 10 shs; Hong Kong, Tolo Channel, cove at Hoi Sing Wan; 22.430°N, 114.2467°E; depth 0 m; 6 Apr. 1985; sand, rock and oysters; J.H. McLean leg.; LACM 1985-12.2.

Pakistan • 4 shs; Sind Province, small cove 4.8 km west of atomic power plant and 7 km west-northwest of Bulegi Point; 24.8000°N, 66.7250°E; depth 0–4 m; 19 Jan. 1979; rock and clay; C.C. Swift leg.; LACM 1979-1.3.

Sri Lanka • 1 sh; Southern Province, Tangalla, cove at Tangalla Bay Hotel; 6.0250°N, 80.8000°E; depth 0–1 m; 30–31 Jan. 1983; rock and clay; A.J. Ferreira leg.; LACM 1983-5.2.

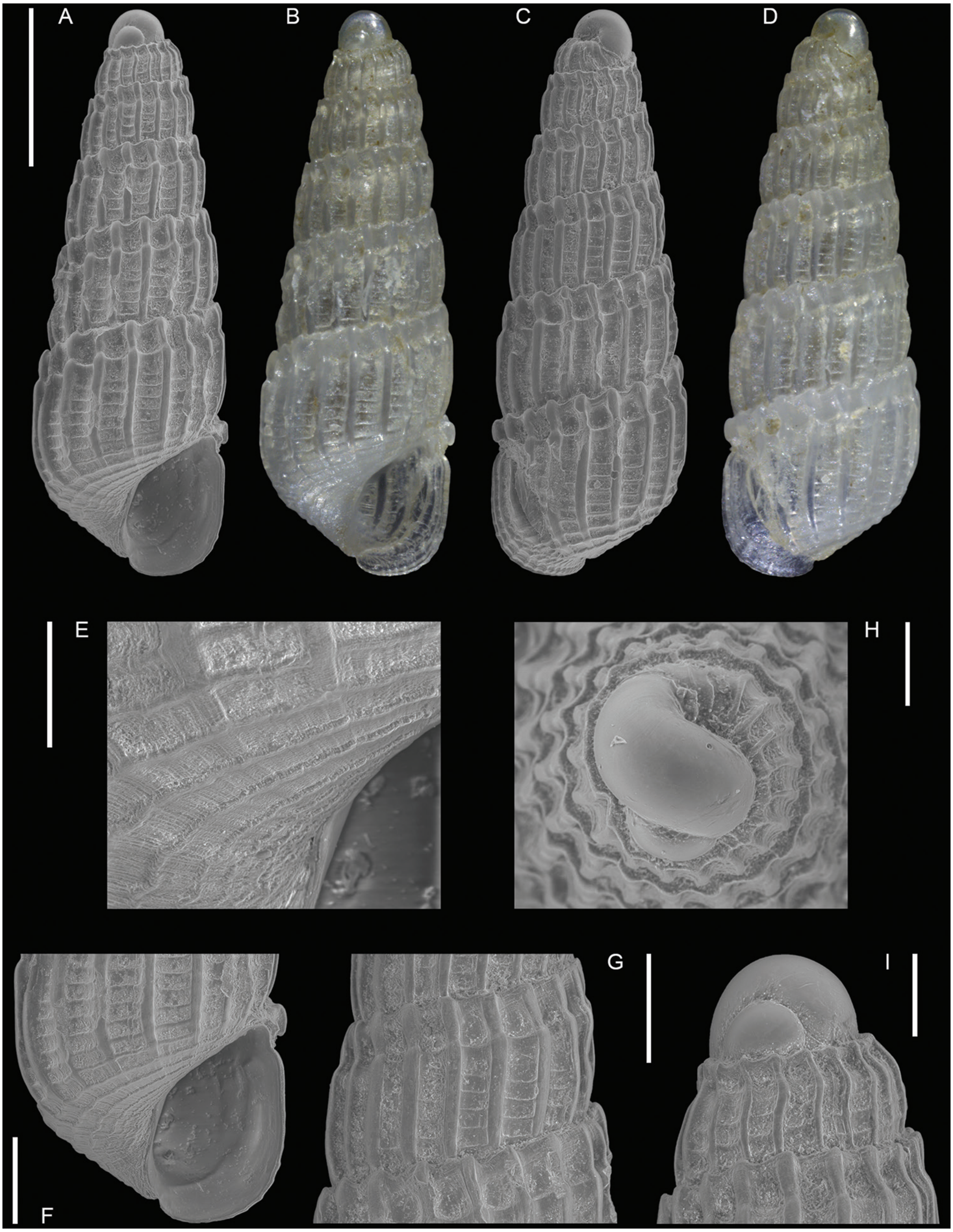

Figure 29. *Turbonilla funiculata* de Folin, 1868, west of Rosh HaNikra Islands, Israel, HELM project (sample S52_2F): front (**A, B**) and back (**C, D**) views, detail of the sculpture on the base (**E**), aperture (**F**), detail of the sculpture on the back of the third whorl (**G**), apical (**H**) and side (**I**) views of the protoconch. Scale bars: 0.5 mm (**A–D**); 0.1 mm (**E, H, I**); 0.2 mm (**F, G**).

Vietnam • 1 sh; station 1328 of the Nha-Trang Oceanography Institute: "Entre les îles des Pêcheurs, Hon-Mung, le banc du Castleragh et l'isobathe 50. (En dehors et au S. de la baie de Nha-Trang)" [between Îles des Pêcheurs, Hon-Mung, Banc du

Castleragh (= Castlereagh) and isobath 50. (outside of and to the south of the Bay of Nha-Trang)]; sediment sample; dredge; MNHN-IM-2000-21843 (holotype of *Pyrgiscus mirandus* Saurin, 1959).

Remarks. Shells of *Turbonilla funiculata* are polymorphic with respect to their shape (Peñas and Rolán 2010 and our own observations) but the species can be readily distinguished from all pyramidellids in the Mediterranean – the most similar being the non-indigenous *Turbonilla edgarii* (Melvill, 1896), *Turbonilla flaianoi* Mazziotti, Agamennone, Micali & Tisselli, 2006 and *Pyrgulina fischeri* Hornung & Mermod, 1925 – by the presence of a very marked subsutural constriction running along the whorls. This constriction separates the pronounced, almost orthocline axial ribs into a larger lower and a narrow upper, crown-like, portion. The ribs extend adapically beyond the suture of the preceding whorl, giving the transition zone between subsequent whorls a wavy appearance. The interspaces of the lower portion of the ribs bear several thin spiral lines, while those between the narrow upper parts of the ribs are smooth. The protoconch is helicoid and of type A.

Turbonilla funiculata has been previously reported from Fiji, Hong Kong, Indonesia, New Caledonia, Thailand, the Solomon Islands and Vietnam from shore to 396 m depth (Robba et al. 2004; Peñas and Rolán 2010). As Robba et al. (2004) already pointed out, the shell figured as *Pyrgiscus microscopica* (Laseron, 1959) by Okutani (2000: 712, fig. 68) is most likely *T. funiculata*, confirming that the species also occurs in Japan. This interpretation is re-affirmed by another illustration of the very same Japanese specimen in Mazziotti et al. (2005: 81, fig. 1m, n), showing the subsutural constriction characteristic of *T. funiculata*. Shells of *T. funiculata* were found by one of us (PILF) also among hitherto unidentified lots of shells from Pakistan and Sri Lanka housed in the LACM collection, demonstrating that this species also lives in the Indian Ocean. Here, we report the first records of *T. funiculata* for the Mediterranean, where several living specimens were collected in northern Israel on hard substrates at 12 m depth.

Family Cylichnidae H. Adams & A. Adams, 1854

Cylichna collyra Melvill, 1906

Figure 30

New records. Israel • 1 spcm; Palmachim; 31.9477°N, 34.6562°E; depth 37.5 m; 18 Oct. 2017; soft substrate; box-corer; Shafdan project (sample 22(A)); size: H 4.2 mm, W 1.5 mm (illustrated specimen) • 1 spcm; Palmachim; 31.9424°N, 34.6551°E; depth 36.3 m; 2 May 2018; soft substrate; box-corer; Shafdan project (sample 21(A)); size: H 7.2 mm, W 4.0 mm • 2 spcms; Palmachim; 31.9376°N, 34.6515°E; depth 36.7 m; 2 May 2018; soft substrate; box-corer; Shafdan project (sample 5(B)) • 1 spcm; Palmachim; 31.9685°N, 34.6732°E; depth 35.6 m; 2 May 2018; soft substrate; box-corer; Shafdan project (sample 26(A)) • 1 spcm; Palmachim; 31.9477°N, 34.6562°E; depth 37.5 m; 2 May 2018; soft substrate; box-corer; Shafdan project (sample 22(B)) • 3 spcms; Palmachim; 31.9424°N, 34.6551°E; depth 36.3 m; 2 May 2018; soft substrate; box-corer; Shafdan project (sample 21(C)) • 2 spcms; Palmachim; 31.9327°N, 34.6495°E; depth

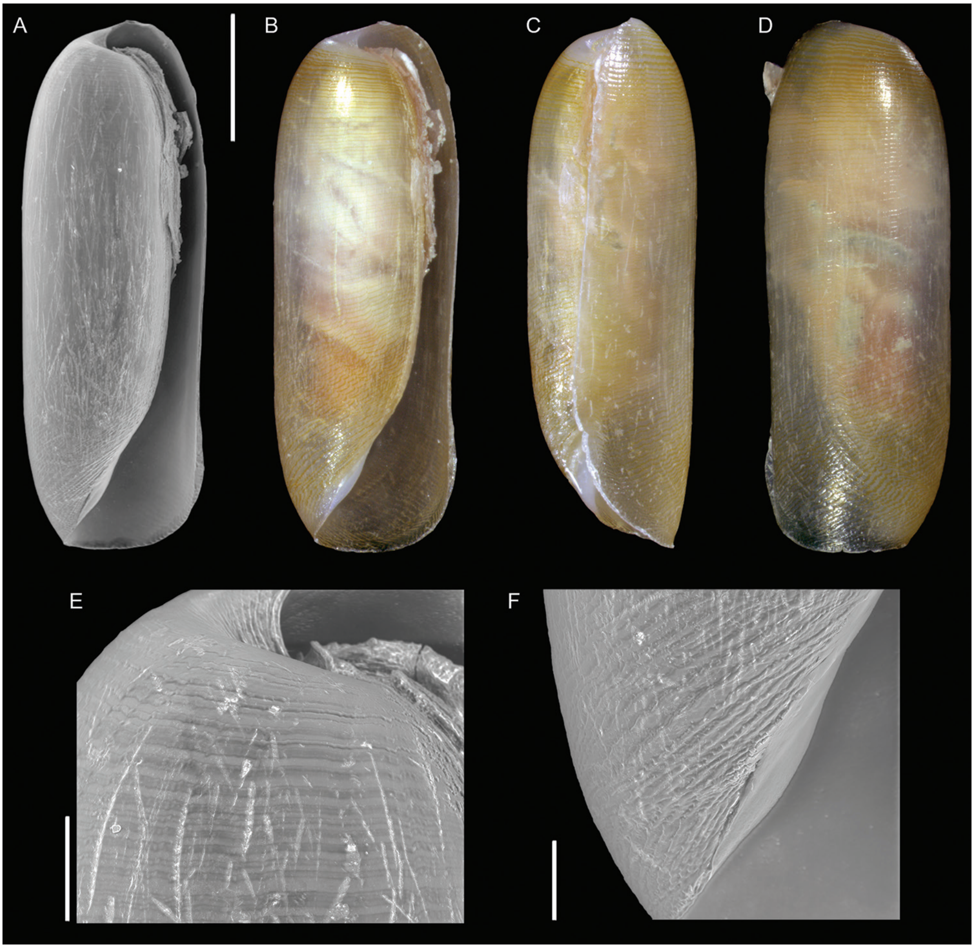

Figure 30. *Cylichna collyra* Melvill, 1906, Palmachim, Israel, Shafdan project (sample 22(A)): front (**A, B**), side (**C**) and back (**D**) views, and apical (**E**) and anterior (**F**) microsculpture. Scale bars: 1 mm (**A–D**); 0.2 mm (**E, F**).

36.2 m; 2 May 2018; soft substrate; box-corer; Shafdan project (sample 4(A)) • 1 spcm; Palmachim; 31.9574°N, 34.6645°E; depth 36.2 m; 2 May 2018; soft substrate; box-corer; Shafdan project (sample 24(C)) • 1 spcm; Palmachim; 31.9477°N, 34.6562°E; depth 37.5 m; 20 Oct. 2018; soft substrate; box-corer; Shafdan project (sample 22(A)).

Additional material examined. Oman • 13 shs; off Muscat; 24°58'N, 56°54'E; 156 fathoms (285 m) depth; NMW.1955.158.00578 (F.W. Townsend coll.).

Remarks. We record here for the first time in the Mediterranean 13 living individuals of *Cylichna collyra*, a cephalaspidean originally described from the Gulf of Oman (Melvill 1906b). *Cylichna collyra* can be distinguished from the native Mediterranean *C. cylindracea* (Pennant, 1777) by its more elongated and slender shell, the more tapering apical part, the color pattern characterized by fine brown spiral lines apically and abapically, and the smaller size (*C. cylindracea* commonly reaches 1 cm in height whereas *C. collyra* attains approximately half that size). *Cylichna villersii* (Audouin, 1826), another non-indigenous species of Red Sea origin recorded from the Mediterranean coast of Israel (Bogi and Galil 2013a), is smaller (less than 2 mm), less slender, has a more rounded base and stronger growth marks (not visible in *C. collyra*), and bears two brown bands apically and abapically instead of the fine brown lines. *Cylichna biplicata* (A. Adams in Sowerby, 1850), a species occurring on the continental platform in the Indo-West Pacific, shares with our specimens the cylindrical shape and the color pattern of reddish-brown spiral bands apically and abapically (Valdés 2008), but is larger, more elongated anteriorly, with a stronger columellar tooth, and the colored spiral bands become a compact larger band apically. *Cylichna collyra* has not been recorded from the Red Sea yet (Dekker and Orlin 2000).

Family Mnestiidae Oskars, Bouchet & Malaquias, 2015

Mnestia girardi (Audouin, 1826)

New records. Israel • 5 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 29 Oct. 2018; HELM project (samples S52_1F, S52_2F, S52_3F) • 1 spcm, 2 shs; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E; depth 20 m; 1 May 2018; rocky substrate; suction sampler; HELM project (samples S13_2M, S13_3F) • 12 spcms; same collecting data as for preceding; depth 19 m; 29 Oct. 2018; HELM project (samples S53_1F, S53_2F, S53_2M, S53_3F).

Remarks. This species was first recorded in the Mediterranean Sea in 1974 with the finding of few empty shells in the Bardawil Lagoons in Egypt (Mienis 1976). The species has since been recorded also in Greece (Crocetta et al. 2017), Turkey (Çinar et al. 2011), Cyprus (Katsanevakis et al. 2009), and Lebanon (Crocetta et al. 2020). A single record is available from Israel based on shells collected in 2004 off Palmachim (Bogi and Galil 2006). We here report living individuals from Israel for the first time. This is also the first finding of living individuals in the Mediterranean Sea.

Family Haminoeidae Pilsbry, 1895

Atys angustatus E.A. Smith, 1872

Figure 31

New records. Greece • 1 sh; Crete, Plakias; 35.1796°N, 24.3957°E; depth 15 m; 21 Sep. 2017; *Posidonia oceanica* rhizomes; suction sampler (sample Rh.15_5M); size: H 2.6 mm, W not available because of broken aperture.

Remarks. *Atys angustatus* was first recorded in the Mediterranean Sea in 1974, based on specimens collected at Haifa, Israel (Aartsen and Goud 2006). It has been reported from Mersin, Turkey, since 1986 (Aartsen and Goud 2006) and multiple records from Israel followed from several locations along its coast (Micali et al. 2016). To the best of our knowledge, this is the first record from Greece.

Figure 31. *Atys angustatus* E.A. Smith, 1872, Plakias, Crete, Greece (sample Rh.15_5M): front view. Scale bar: 0.5 mm.

Class Bivalvia Linnaeus, 1758
Family Mytilidae Rafinesque, 1815

Arcuatula perfragilis (Dunker, 1857)
Figure 32

New records. Israel • 1 spcm; Palmachim; 31.9574°N, 34.6645°E; depth 36.2 m; 2 May 2018; soft substrate; box-corer; Shafdan project (sample 24(C)); size: L 13 mm, H 5.3 mm • 1 spcm; Palmachim; 31.9737°N, 34.6767°E; depth 35.4 m; 2 May 2018; soft substrate; box-corer; Shafdan project (sample 29(A)).

Remarks. This species was first recorded in Israel in 1960 from Bat Yam with living individuals (Barash and Danin 1973). Further living individuals were recorded in the 1960s and early 1970s from Israel and Egypt (Bardawil Lagoons) (Barash and Danin 1971, 1973, 1977). Since then, however, no further living individuals were found, questioning the persistence of its populations in the Mediterranean. We report here the recent finding of two living individuals, suggesting that the species indeed still occurs in Israel.

Lioberus ligneus (Reeve, 1858)
Figure 33A–D

New records. Cyprus • 2 shs; Turkish Republic of Northern Cyprus, southern tip of Karpaz Peninsula; 35.6809°N, 34.5785°E; depth 1 m; 29 Jul. 2019; mixed sub-

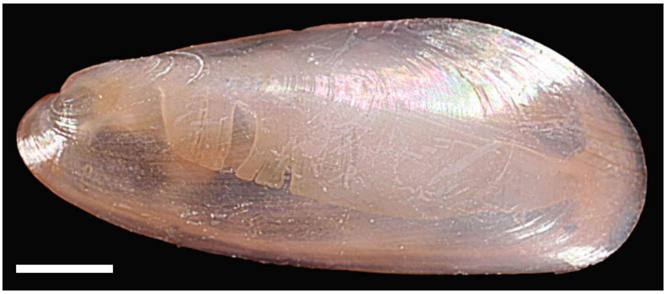

Figure 32. *Arcuatula perfragilis* (Dunker, 1857), Palmachim, Israel, Shafdan project. Left valve outer view. The pink hue is due to staining with eosin solution. Photograph courtesy S. Bartolini. Scale bar: 2 mm.

strate with sand, rocks and *Cystoseira*; P.G. Albano leg. (sample NCY7H); NHMW-MO-112930/LM/0173; size of the largest shell: L 30.2 mm, H 15.0 mm.

Israel • 1 spcm; Carmel Head; 32.8232°N, 34.9431°E; depth 12 m; 21 Apr. 2020; in a small patch of *Galaxaura rugosa* and *Cystoseira* sp.; M. Mulas leg. (sample SK2); SMNH MO83605; size: L 17.6 mm, H 10.0 mm.

Additional material examined. *Lioberus ligneus*: Egypt • 19 vv; Red Sea, Suez; Jousseaume coll.; MNHN • 1 sh; Sinai (Red Sea), Dahab, dive site "Islands"; 28.4789°N, 34.5126°E; beached; Nov. 2007; H. Blatterer leg. • 1 v; same collecting data as for preceding; 2012 • 1 v; Sinai (Red Sea), Dahab, dive site "Lagoon"; depth unspecified; 2008; H. Blatterer leg. • 1 v; same collecting data as for preceding; 2009.

Lioberus agglutinans (Cantraine, 1835): Portugal • 1 v; Algarve, Canal of Olhão; depth 3–7m, MNHN • 2 vv; Algarve, Tavira, Pedra do Barril; depth 25 m; MNHN • 1 sh, 1 v; Algarve, Sagres, Ponta da Baleeira; depth 17–23 m; MNHN • 1 spcm; Algarve, Tavira, off Cabanas; depth 14 m; MNHN • 2 shs; Algarve, Olhão, Ilha da Barretta; depth unspecified; MNHN.

Tunisia • 1 sh, 8 vv; Gulf of Gabès, NW Boughrara Gulf; depth 10–15 m; MNHN • 11 spcms, 42 vv; Gulf of Gabès, Djerba, Ajim Canal; depth 10–32 m; MNHN.

Remarks. We here report *Lioberus ligneus* for the first time from Israel and Cyprus. The Israeli live-collected specimen comes from a patch of *Galaxaura rugosa* and *Cystoseira* sp. whereas the two empty but fresh shells from Cyprus were found attached vertically to *Cystoseira* shoots. These findings suggest that this species indeed prefers vegetated habitats in the shallow subtidal. This species has been previously reported from Lebanon based on shells collected in 1999–2000 (Crocetta et al. 2013), suggesting that it has likely occurred undetected throughout the Levantine Basin for long. The distinction of *L. ligneus* from the native Mediterranean *Lioberus agglutinans* (Cantraine, 1835) is not straightforward because both species share the elongated appearance, sculpture limited to concentric striae, and brown color. Moreover, they are morphologically variable. A fairly consistent character of *L. ligneus* in the samples we inspected from the Red Sea is the darker internal color, often shading into violet. The group would deserve a taxonomic revision to unambiguously distinguish its species.

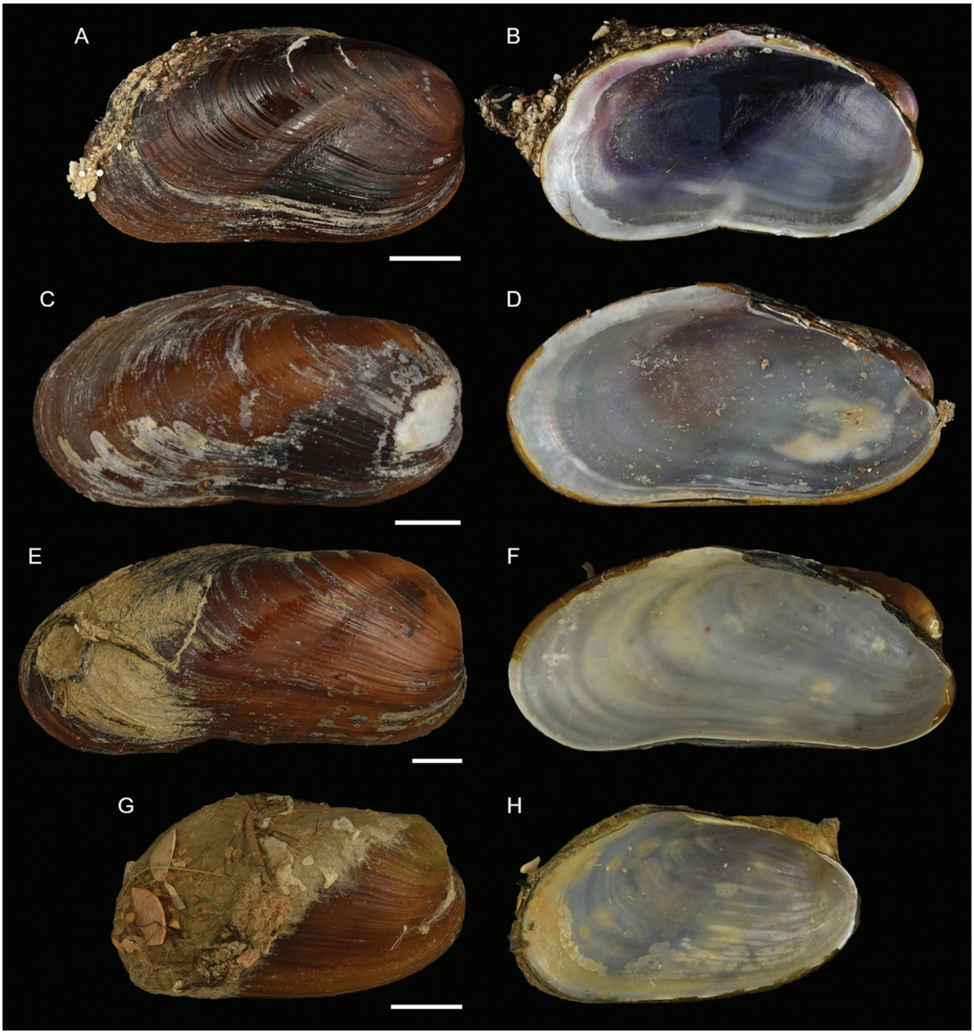

Figure 33. Comparison between *Lioberus ligneus* (Reeve, 1858) and *Lioberus agglutinans* (Cantraine, 1835). **A, B** *Lioberus ligneus*, NHMW–MO-112930/LM/0173, Karpaz Peninsula, Turkish Republic of Northern Cyprus, Cyprus: right valve outer (**A**) and left valve inner (**B**) views **C, D** *L. ligneus*, Dahab, Egypt (H. Blatterer coll.): right valve outer (**C**) and left valve inner (**D**) views **E, F** *Lioberus agglutinans*, Olhão, Ilha da Barretta, Algarve, Portugal: right valve outer (**E**) and left valve inner (**F**) views **G, H** *L. agglutinans*, Tavira, off Cabanas, Algarve, Portugal: right valve outer (**G**) and left valve inner (**H**) views. Scale bars: 5 mm.

Musculus coenobitus **(Vaillant, 1865)**

Figures 34A–D, 35A–F

New records. Israel • 2 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S14_4M) • 4 spcms; same collecting data as for preceding; 29 Oct. 2018; HELM project (samples S52_1M, S52_2L, S52_3M, S52_3L) • 1 sh; north of Nahariyya port;

33.0127°N, 35.0896°E; beached; 29 Oct. 2018; HELM project (sample H3); size: L 10.2 mm, H 6.0 mm (illustrated shell, Figure 34A–D).

Additional material examined. *Musculus subpictus* (Cantraine, 1835): Croatia • 14 spcms; Istria, off Rovinj, western shore of Sveta Katarina; 45.0760°N, 13.6276°E; 3 Jul. 2008; dried-out fouling community collected from the surface of buoy-like floating objects dumped on the shore (J. Steger coll.).

Israel • 10 spcms, 3 vv; Ashqelon; 31.6868°N, 34.5516°E; depth 12 m; 30 Apr. 2018; offshore rocky reef; suction sampler; HELM project (samples S12_1F, S12_1M, S12_1L, S12_2F, S12_2M) • 111 spcms, 2 vv; Ashqelon; 31.6891°N, 34.5257°E; depth 25 m; 2 May 2018; offshore rocky reef; suction sampler; HELM project (samples S16_1F, S16_1M, S16_1L, S16_2F, S16_2M, S16_2L) • 13 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 1 May 2018; rocky substrate; suction sampler; HELM project (samples S14_2F, S14_2M, S14_3F, S14_4F) • 1 v; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E; depth 20 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S13_3M) • 1 spcm; same collecting data as for preceding; depth 19 m; 29 Oct. 2018; HELM project (sample S53_2L).

Malta • 9 spcms; off Filfla Island; on a rafting fisherman's net; 1981 (P.G. Albano coll. ID 557).

Remarks. We found several living individuals of *Musculus coenobitus* in northern Israel. It is the first record of this Red Sea species for the Mediterranean Sea. *Musculus coenobitus* is very similar to the native *M. subpictus*, which can occur sympatrically, but can be distinguished at once because of its reddish rather than greenish hue (Figure 34). It is also more elongated with a more pointed posterior margin. Juvenile specimens are bright red (Figure 35C), have interspaces between the radial riblets in the posterior part of the shell almost as large as the riblets themselves, while in *M. subpictus* the riblets are closely arranged with very narrow interspaces (Figure 35E, J). *Musculus coenobitus* also shows a fine but distinct lamellar concentric sculpture in such interspaces, whereas *M. subpictus* shows more sparse fine concentric ridges (Figure 35E and J, respectively). The relation of *M. coenobitus* with other Indo-Pacific species like *M. cumingianus* (Reeve, 1857) and *M. cuneatus* (Gould, 1861) deserves a revision (Oliver 1992).

Musculus aff. *viridulus* (H. Adams, 1871)

Figure 36A–E

New records. Israel • 1 spcm; Ashqelon; 31.6891°N, 34.5257°E; depth 25 m; 2 May 2018; offshore rocky reef; suction sampler; HELM project (sample S16_2F) • 15 spcms; same collecting data as for preceding; depth 28 m; 31 Oct. 2018; HELM project (samples S59_1F, S59_1M, S59_2F, S59_2M) • 2 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 1 May 2018; rocky substrate; suction sampler; HELM project (samples S14_3F, S14_4M) • 25 spcms; same collecting data as for preceding; 29 Oct. 2018; HELM project (samples S52_1F, S52_2F, S52_2M, S52_2L, S52_3F, S52_3M, S52_3L); size: L 3.6 mm, H 2.1 mm (illustrated specimen, Figure 36A–E) • 1 spcm; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E;

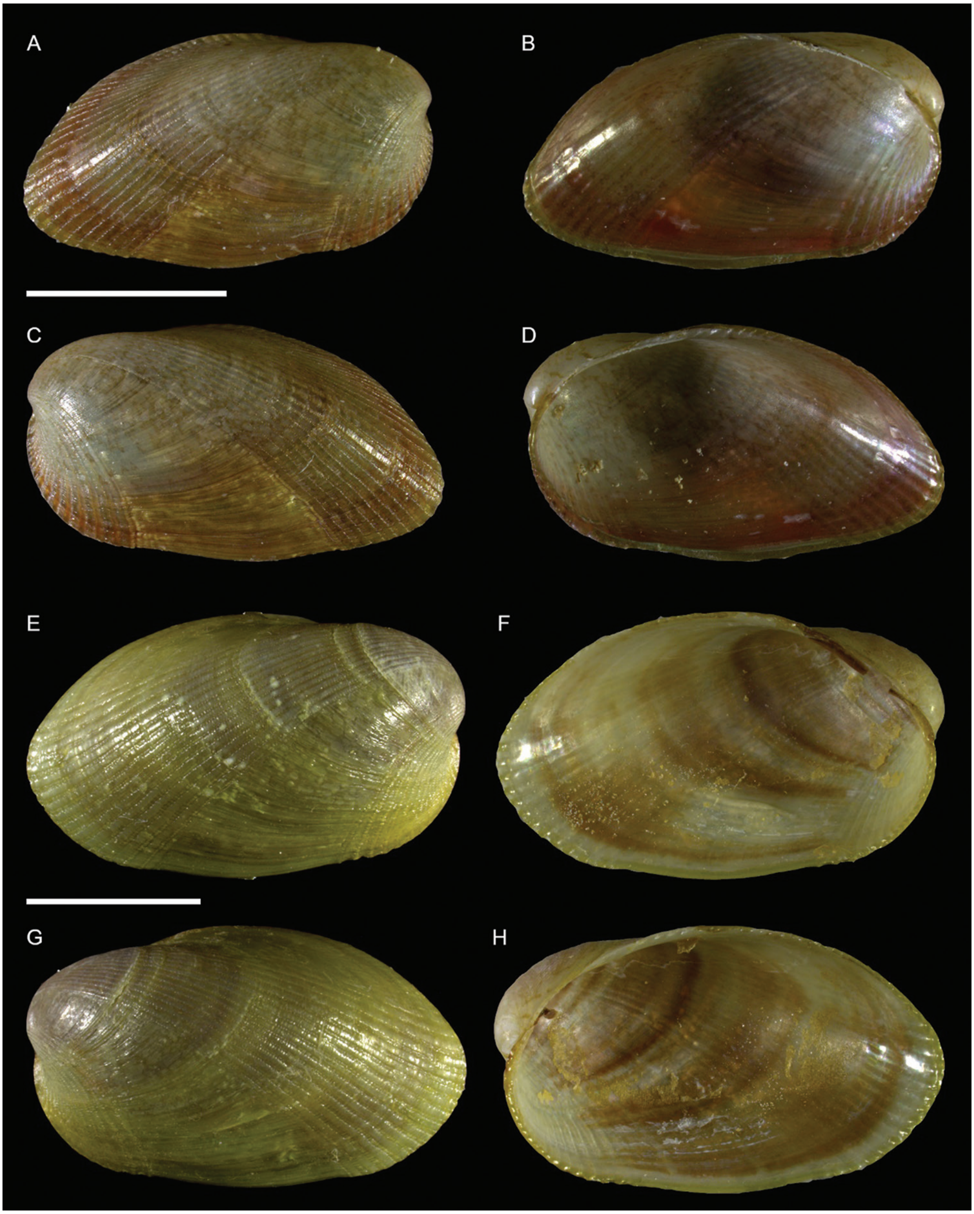

Figure 34. Comparison between *Musculus coenobitus* (Vaillant, 1865) and *Musculus subpictus* (Cantraine, 1835) **A–D** *Musculus coenobitus*, north of Nahariyya port, Israel, HELM project (sample H3): right valve outer (**A**) and inner (**D**) views, left valve inner (**B**) and outer (**C**) views **E–H** *Musculus subpictus*, off Filfla, Malta: right valve outer (**E**) and inner (**H**) views, left valve inner (**F**) and outer (**G**) views. Scale bars: 5 mm.

depth 20 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S13_3M) • 9 spcms; same collecting data as for preceding; depth 19 m; 29 Oct. 2018; HELM project (samples S53_1F, S53_2F, S53_2M, S53_3F, S53_3M).

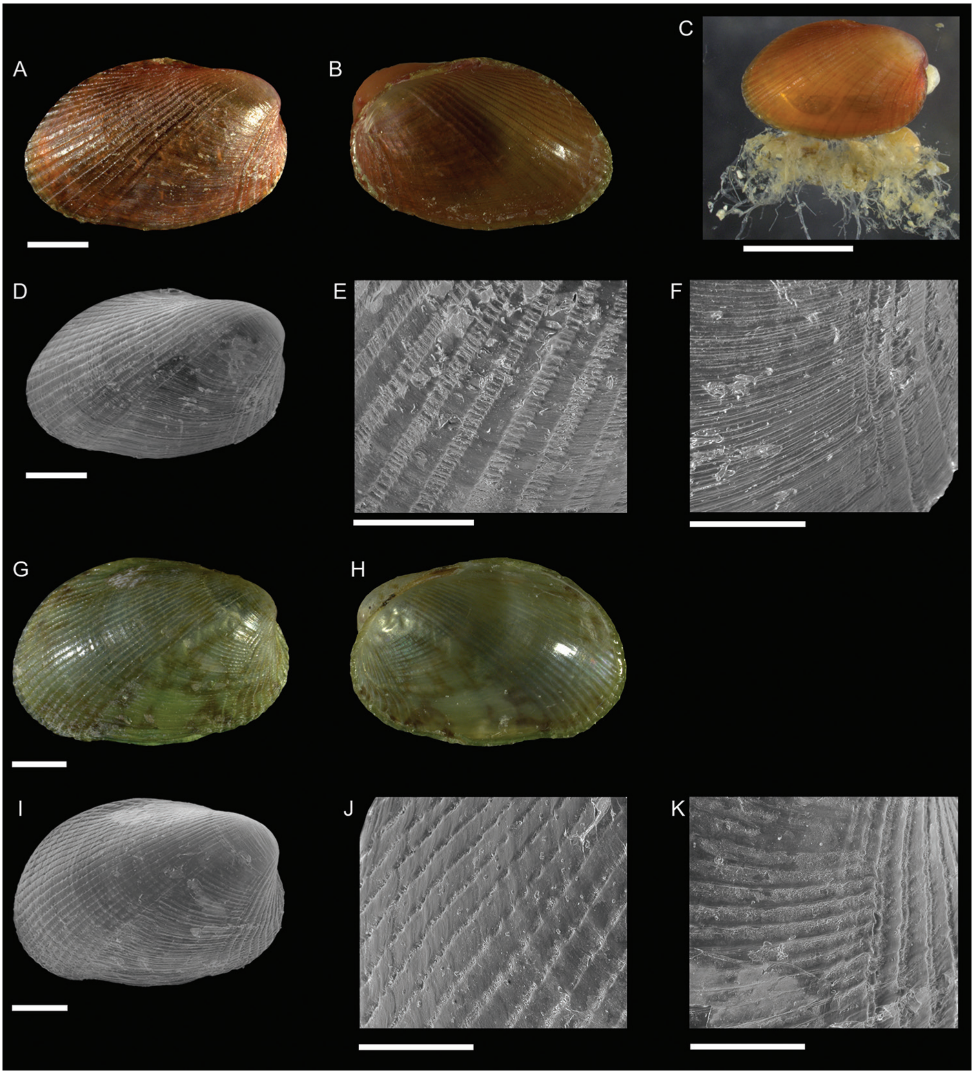

Figure 35. Comparison between *Musculus coenobitus* (Vaillant, 1865) and *Musculus subpictus* (Cantraine, 1835) **A–F** *Musculus coenobitus*, west of Rosh HaNikra Islands, Israel, HELM project (sample S52_2L): right valve outer (**A, D**) and inner (**B**) views, living specimen with byssus (**C**), sculpture of the posterior (**E**) and anterior (**F**) area of the right valve **G–K** *Musculus subpictus*, Ashqelon, Israel, HELM project (sample S12_1L): right valve outer (**G, I**) and inner (**H**) views, sculpture of the posterior (**J**) and anterior (**K**) area. Scale bars: 1 mm (**A, B, D, G–I**), 2.5 mm (**C**); 0.5 mm (**E, F, J, K**).

Additional material examined. *Musculus* aff. *viridulus*: Egypt • 1 v; Sinai (Red Sea), Dahab, dive site "Caves"; 28.416°N, 34.456°E; depth 15 m; 2015; H. Blatterer leg. • 4 vv; same collecting data as for preceding; depth 17–19 m; 2016; H. Blatterer leg. • 2 vv; same collecting data as for preceding; depth 18 m; 2017; H. Blatterer leg. • 1 v; Sinai (Red Sea), Dahab, dive site "Golden Blocks"; 28.436°N, 34.459°E; depth 18 m; 2018; H. Blatterer leg.

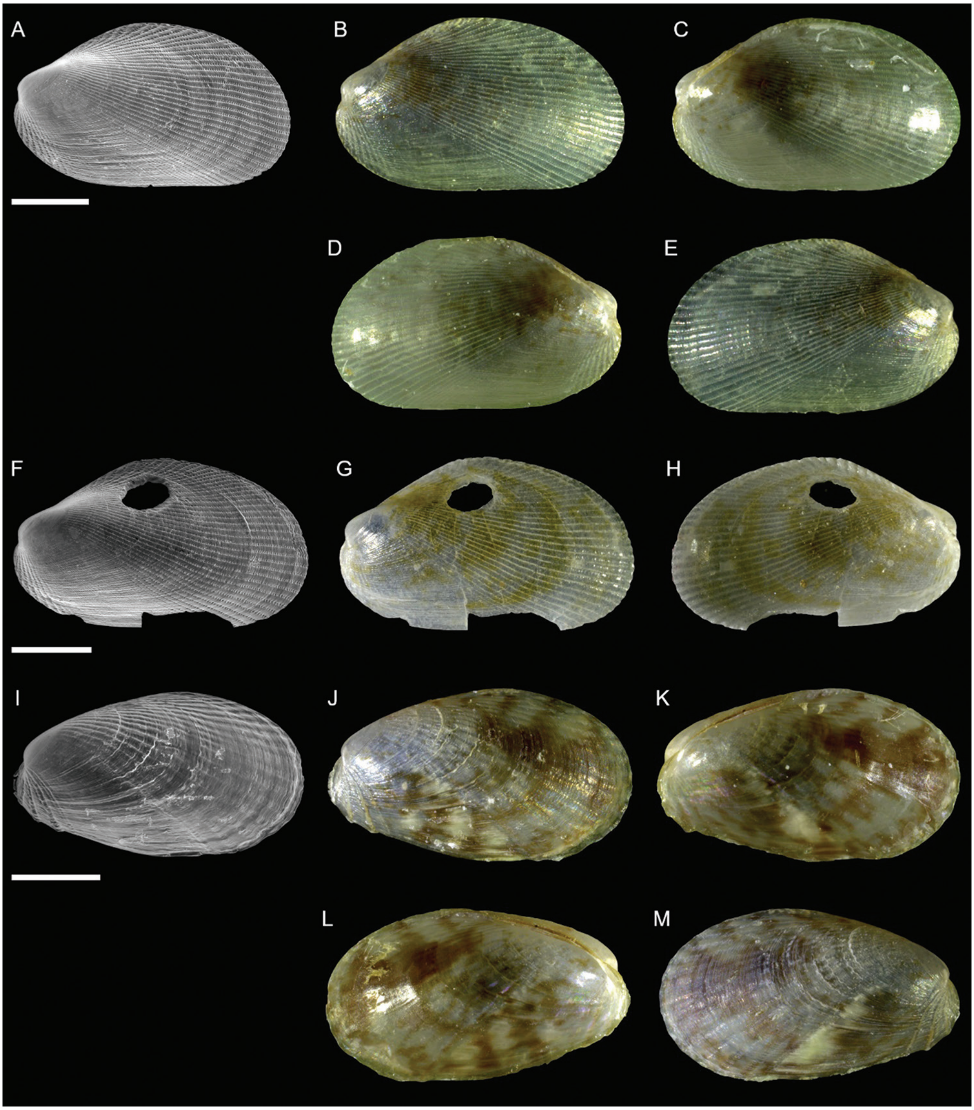

Figure 36. Comparison between *Musculus* aff. *viridulus* (H. Adams, 1871) and *Musculus costulatus* (Risso, 1826) **A–E** *Musculus* aff. *viridulus*, west of Rosh HaNikra Islands, Israel, HELM project (sample S52_3L): left valve outer (**A, B**) and inner (**D**) views, right valve inner (**C**) and outer (**E**) views **F–H** *Musculus* aff. *viridulus*, dive site "Caves", Dahab, Sinai, Egypt: left valve outer (**F, G**) and inner (**H**) views **I–M** *Musculus costulatus,* west of Rosh HaNikra Islands, Israel, HELM project (sample S53_2L): left valve outer (**I, J**) and inner (**L**) views, right valve inner (**K**) and outer (**M**) views. Scale bars: 1 mm.

Musculus costulatus (Risso, 1826): Israel • 9 spcms, 4 vv; Ashqelon; 31.6868°N, 34.5516°E; depth 12 m; 30 Apr. 2018; offshore rocky reef; suction sampler; HELM project (samples S12_1F, S12_1M, S12_1L, S12_2F, S12_2M) • 3 spcms; Ashqelon; 31.6891°N, 34.5257°E; depth 25 m; 2 May 2018; offshore rocky reef; suction sampler; HELM project (samples S16_1F, S16_2F) • 1 spcm; same collecting data as for preceding;

depth 28 m; 31 Oct. 2018; HELM project (sample S59_1M) • 5 spcms; west of Rosh HaNikra Islands; 33.0704°N, 35.0926°E; depth 12 m; 1 May 2018; rocky substrate; suction sampler; HELM project (samples S14_1L, S14_3F, S14_3L, S14_4F) • 56 spcms; same collecting data as for preceding; 29 Oct. 2018; HELM project (samples S52_1F, S52_1M, S52_1L, S52_2F, S52_2M, S52_2L, S52_3F, S52_3M, S52_3L) • 1 v; west of Rosh HaNikra Islands; 33.0725°N, 35.0923°E; depth 20 m; 1 May 2018; rocky substrate; suction sampler; HELM project (sample S13_3F) • 20 spcms; same collecting data as for preceding; depth 19 m; 29 Oct. 2018; HELM project (sample S53_2L).

Remarks. We report numerous living individuals of *Musculus* aff. *viridulus* from the Mediterranean Israeli coastline. It is the first record of this Indo-Pacific species in the Mediterranean Sea. This species can be readily distinguished from the native *M. costulatus* because the latter has a more oval outline and a much smaller number of riblets at the same overall shell size (Figure 36). These riblets are also much larger compared to *M.* aff. *viridulus*. The Atlanto-Mediterranean *M. discors* (Linnaeus, 1767) has a similarly fine posterior sculpture but at the same size is much higher and at all sizes bears much more prominent riblets anteriorly. The taxonomy of *Musculus* in the Indo-Pacific province is not settled and the available images of Red Sea *M. viridulus* (Oliver 1992; Zuschin and Oliver 2003) show a more oval species, hence our dubitative identification. Still, we are confident that this is a Red Sea species because we examined indistinguishable specimens from the northern Red Sea (Figure 36F–H). Blatterer (2019) illustrated these and other similar specimens (plate 10, fig. 18a, b) as *Gregariella ehrenbergi* (Issel, 1869). We recorded a morphologically distinct species as *G. ehrenbergi* from a buoy stranded on the Israeli coastline (Steger et al. 2018; Ivkić et al. 2019). *Gregariella ehrenbergi* type material is corroded by Byne's disease and the original description likely refers to a juvenile specimen; the identity of this species deserves further scrutiny.

Family Isognomonidae Woodring, 1925 (1828)

Isognomon aff. *australica* (Reeve, 1858) (sensu Angelidis and Polyzoulis 2018)

Figure 37

New records. Cyprus • 1 sh; Turkish Republic of Northern Cyprus, Esentepe; 35.3589°N, 33.6078°E; depth 2 m; 28 Jul. 2019; rocky substrate; P.G. Albano leg. (sample NCY3H); size: L 11.8 mm, H 10.1 mm (Figure 37A, B, D, E).

Greece • 1 spcm; Crete, Plakias; 35.1796°N, 24.3957°E; depth 5 m; 24 Sep. 2017; *Posidonia oceanica* rhizomes; suction sampler (sample Rh.05_4M); size: L 4.4 mm, H 4.4 mm (Figure 37C, F).

Remarks. The discrimination and identification of the species of *Isognomon* Lightfoot, 1786 is difficult due to their morphological plasticity that is related to their cryptic way of life. Still, the specimens recently reported from Astypalaia, in the Eastern Aegean Sea (Lipej et al. 2017; Angelidis and Polyzoulis 2018), show clear morphological differences from *I. legumen* (Gmelin, 1791), the established non-indigenous species in the Mediterranean Sea: the main features of the sculpture are radial rather than concentric and the shape of the shell can be very elongated rather than subquadrate.

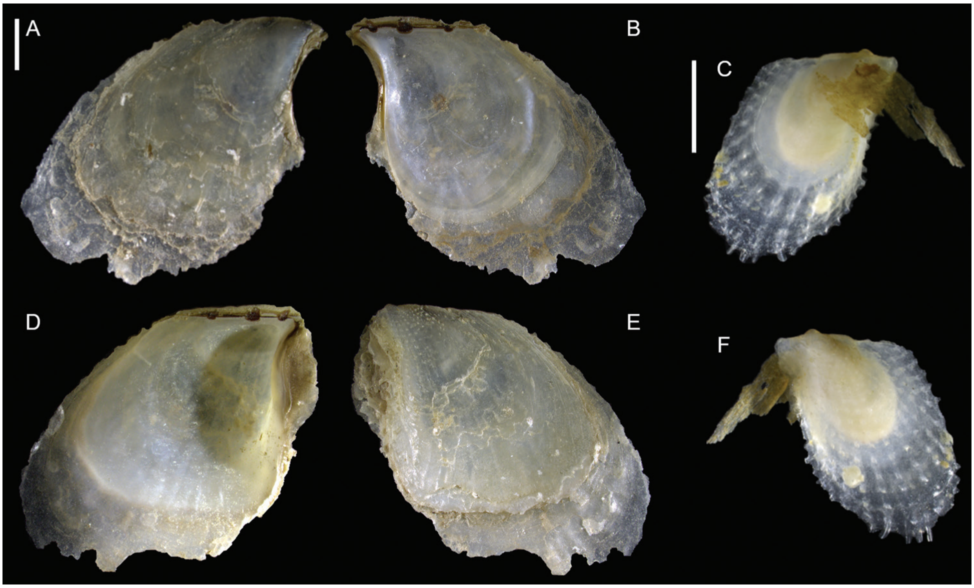

Figure 37. *Isognomon* aff. *australica* (Reeve, 1858) (sensu Angelidis and Polyzoulis 2018) **A, B, D, E** Esentepe, Cyprus (sample NCY3H): left valve outer (**A**) and inner (**B**) views, right valve inner (**D**) and outer (**E**) views **C, F** Plakias, Crete (sample Rh.05_4M): left (**C**) and right (**F**) valve outer views. Scale bars: 2 mm.

We here report a juvenile living individual and an empty shell from Greece and Cyprus (for which this is a new record), respectively, which are not distinguishable from those previously reported from Astypalaia. Juvenile shells (up to a size of ~ 5 mm) bear a sculpture of radial ribs adorned by tubular spines. We do not comment upon the choice of the *australica* name for this taxonomic entity by previous authors, lamenting the lack of a thorough revision of this genus in the Indo-Pacific province.

Family Lucinidae J. Fleming, 1828

Pegophysema cf. *philippiana* (Reeve, 1850)

Figure 38

New records. Israel • 1 spcm; Palmachim; 31.9574°N, 34.6645°E; depth 36.2 m; 2 May 2018; soft substrate; box-corer; Shafdan project (sample 24(B)); size: L 15 mm, H 13.5 mm.

Remarks. *Pegophysema philippiana* was first found in the Mediterranean Sea in 2018 as a single valve from south of Tel Aviv (Mienis 2019). The specimen here reported is much smaller, and we acknowledge that the identification of juvenile individuals of this genus can only be tentative. We do not consider it conspecific to native species such as *Loripinus fragilis* (Philippi, 1836) because this latter species is much more inflated at this size, nor *Loripes orbiculatus* Poli, 1795 which has a different valve profile. If the identification is confirmed, this would be the first live collected specimen of *P. philippiana* in the Mediterranean Sea.

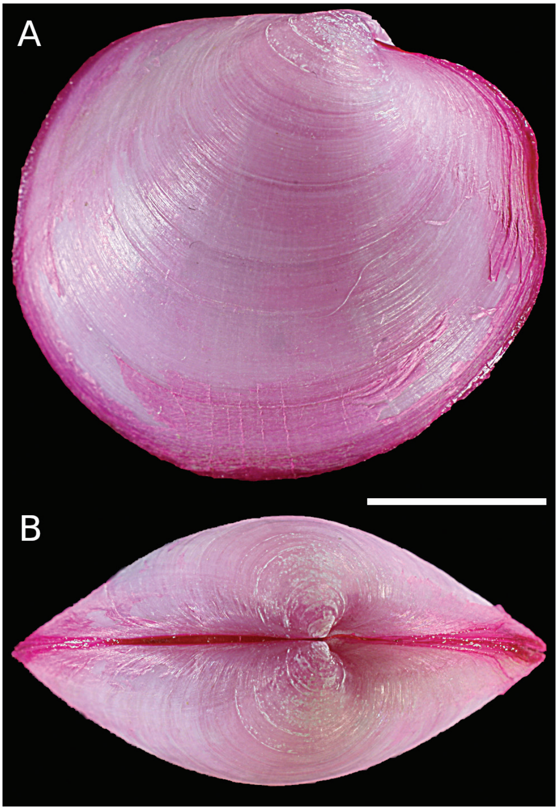

Figure 38. *Pegophysema* cf. *philippiana* (Reeve, 1850), Palmachim, Israel, Shafdan project (sample 24(B)): right valve outer (**A**) and dorsal (**B**) views. The pink hue is due to staining with eosin solution. Photograph courtesy S. Bartolini. Scale bar: 5 mm.

Chavania erythraea (Issel, 1869)
Figure 39

New records. Israel • 1 spcm; Palmachim; 31.9292°N, 34.6405°E; depth 36.9 m; 29 May 2004; soft substrate; grab; NM project (station 19); size: L 3.2 mm, H 3.2 mm.

Remarks. We report a juvenile but living individual of *Chavania erythraea*, a lucinid occurring in the Red Sea, the Persian (Arabian) Gulf and the Arabian Sea (Glover and Taylor 2001). This is the first record of this species from the Mediterranean Sea. Adults develop a commarginal lamellar sculpture.

Rugalucina angela (Melvill, 1899)

New records. Israel • 1 spcm, 1 v; Ashqelon; 31.6868°N, 34.5516°E; depth 11 m; 31 Oct. 2018; offshore rocky reef; suction sampler; HELM project (samples S58_2M, S58_3M).

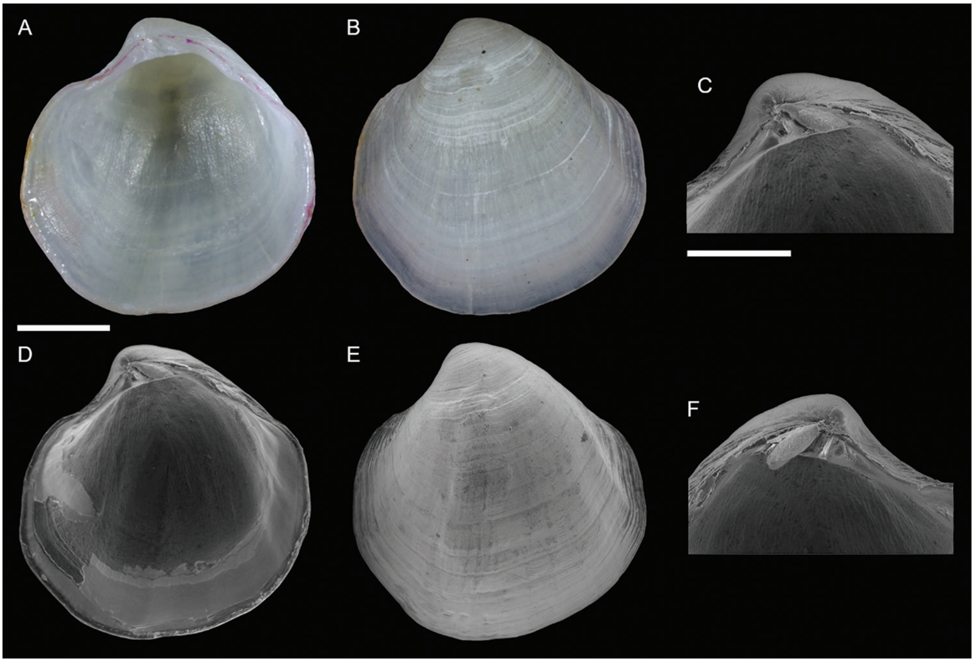

Figure 39. *Chavania erythraea* (Issel, 1869), Palmachim, Israel, NM project (station 19): right valve inner (**A, D**) and left valve outer (**B, E**) views, hinge of right (**C**) and left (**F**) valve. The pink hue is due to staining with eosin solution. Scale bars: 1 mm (**A, B, D, E**); 0.5 mm (**C, F**).

Remarks. This species was first recorded as *Pillucina vietnamica* Zorina, 1978 (now in *Rugalucina* too) from the Mediterranean coast of Israel by Steger et al. (2018), who also illustrated it. A recent molecular phylogeny showed that *R. vietnamica* is distinct from *R. angela* and that the non-indigenous species in the Mediterranean belongs to this latter species, which occurs in the Red Sea and northwest Indian Ocean (Taylor and Glover 2019).

Family Galeommatidae Gray, 1840

Nudiscintilla cf. *glabra* Lützen & Nielsen, 2005 (sensu Mifsud and Ovalis 2012)
Figure 40

New records. Israel • 1 v; Nahariyya, 200 m north of the entrance to the marina; 33.0149°N, 35.0890°E; depth 3–4 m; 6 Nov. 2018; pools with bioclastic sand in rocky bottom; snorkelled; J. Steger leg.; HELM project (sample D7); size: L 10.0 mm, H 6.4 mm (Figure 40A–E) • 1 spcm; Palmachim; 31.9285°N, 34.6947°E; depth 3 m; 7 Nov. 2018; attached to the lower valve of a living Lessepsian *Spondylus*; scuba diving; hand-picked; J. Steger & A. Ivkić leg.; HELM project (sample H17); size: L 4.2 mm, H 2.8 mm (Figure 40F, G).

Remarks. This non-indigenous species has first been recorded in the Mediterranean Sea by Mifsud and Ovalis (2012) as *Nudiscintilla* cf. *glabra* Lützen and Nielsen, 2005, based on five living specimens collected at Yumurtalik, Adana (Turkey) in shallow water. Their tentative identification was primarily guided by the external morphology of the living animals, which had a smooth mantle surface. This feature is characteristic for the monotypic genus *Nudiscintilla* (hence the genus name), but unusual among scintilloid galeommatids in general. Although no observations on living individuals could be made by us, the shell morphology of our material well matches that of the specimen illustrated in Mifsud and Ovalis (2012: fig. 1), suggesting conspecificity. Our findings represent the first records of this species from Israel. However, the dentition of the right valve as seen in SEM images (Figure 40C–E) clearly differs from that described by Lützen and Nielsen (2005) for *Nudiscintilla*: the latter has a single cardinal tooth in each valve and no lateral teeth. However, the studied right valve – the hinge of the single live-collected specimen was not examined to avoid damage – bears what appears to be two cardinal teeth (Figure 40C) that are fused at their base (Figure 40D, E), as well as a ridge posterior to the internal ligament which most likely is a lateral tooth. This ridge seems to correspond to the left of the two swellings indicated by a pair of arrows on the right hand side of Mifsud and Ovalis (2012: fig. 1e), while the right swelling might correspond to a narrow ridge visible also on the dorsal margin of our valve. Mifsud and Ovalis (2012) interpreted these features as aberrant shell growth, however, the presence of such ridges also in our right valve (Figure 40D) speaks against this hypothesis. Furthermore, their living individuals had a small tentacle situated above the widely gaping anterior inhalant region (cf. Mifsud and Ovalis (2012: 8, fig. 2a), however, the illustration of *N. glabra* in Lützen and Nielsen (2005: 292, fig. 38a) shows a small tentacle in the posterior exhalant region of the reflected mantle. In the light of the poorly developed taxonomy and great species diversity of galeommatid bivalves in the Indo-Pacific, further observations on living specimens, thorough comparisons with the type material from Thailand and molecular analyses are required to definitely clarify the relationship of Mediterranean specimens with *N. glabra*.

Scintilla cf. *violescens* Kuroda & Taki, 1961
Figure 41

New records. Israel • 1 spcm; Haifa; depth 15 m; May 1999; biogenic sediment; B.S. Galil leg.; size: L 6.9 mm, H 5.2 mm.

Remarks. The single shell found is trapezoid-oval (L:H ratio = 1.33), slightly higher posteriorly than anteriorly, translucid-white, and has a glossy external surface. The valves are narrowly gaping, more widely in their posterior part. The umbones are prosogyrate, pointed and submedian. The commarginal sculpture consists of fine growth lines that are slightly wavy posteriorly, as well as irregular growth marks. Flat radial ribs are present in the posterior part of the shell; they are visible, upon close examination, also on the inside of the valves in the form of shallow markings. The inner surface,

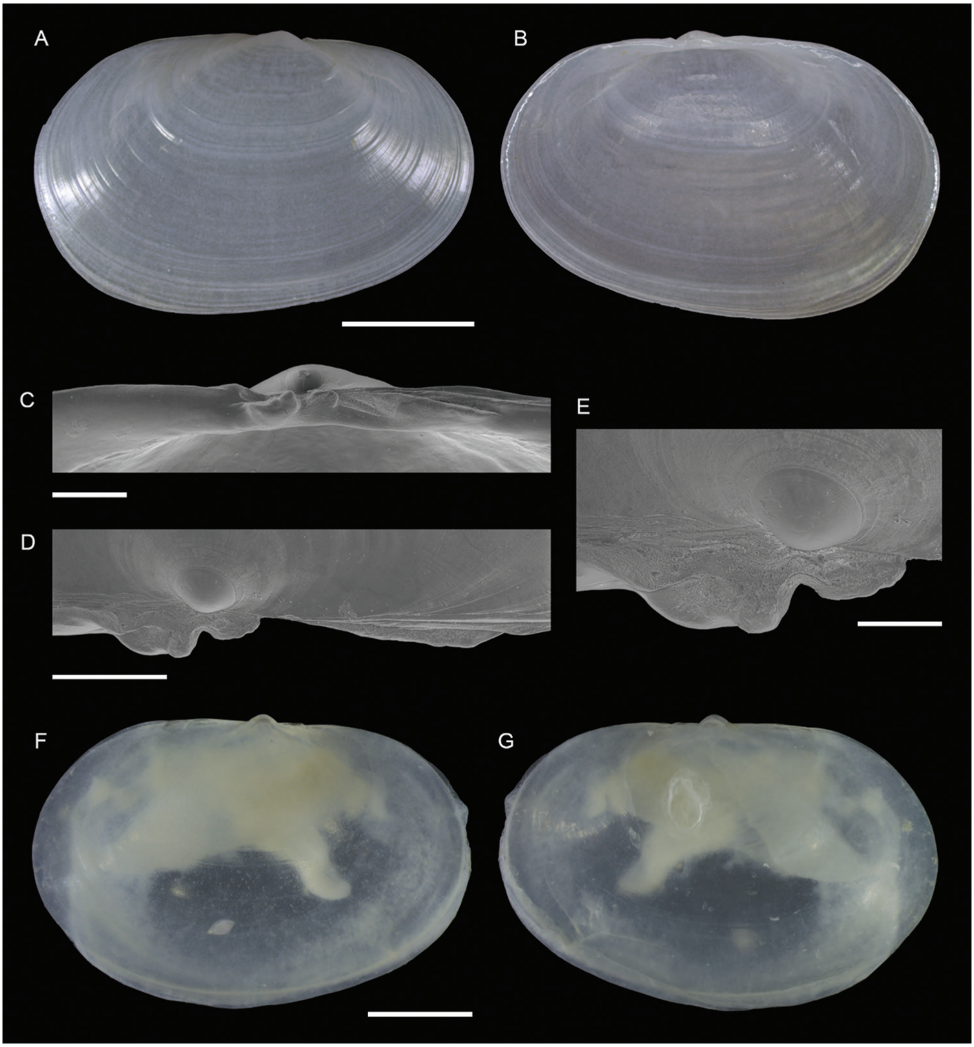

Figure 40. *Nudiscintilla* cf. *glabra* Lützen & Nielsen, 2005 (sensu Mifsud and Ovalis 2012) **A–E** Nahariyya, Israel, HELM project (sample D7): outer (**A**) and inner (**B**) views, detail of hinge (**C**) and hinge in dorsal view (**D, E**) of right valve **F, G** Palmachim, Israel, HELM project (sample H17): right (**F**) and left (**G**) valve outer views. Scale bars: 3 mm (**A, B**); 0.5 mm (**C, D**); 0.2 mm (**E**); 1 mm (**F, G**).

particularly of the right valve, is spotted by blister-like markings (Figure 41C, D). The hinge of the right valve bears a single cardinal tooth, bent towards the anterior, and an elongated posterior lateral tooth. The left valve has two cardinals, but the anterior one is broken off (Figure 41G); a posterior lateral is present.

Lacking further material and observations on living individuals, which are of great diagnostic importance in galeommatids, we refrained from assigning a definitive specific name to our shell. However, the overall shape, hinge dentition and the presence of radial sculpture match well descriptions of *Scintilla violescens* Kuroda & Taki, 1961 (Arakawa 1961; Kuroda and Taki 1961), a species recorded from the intertidal and

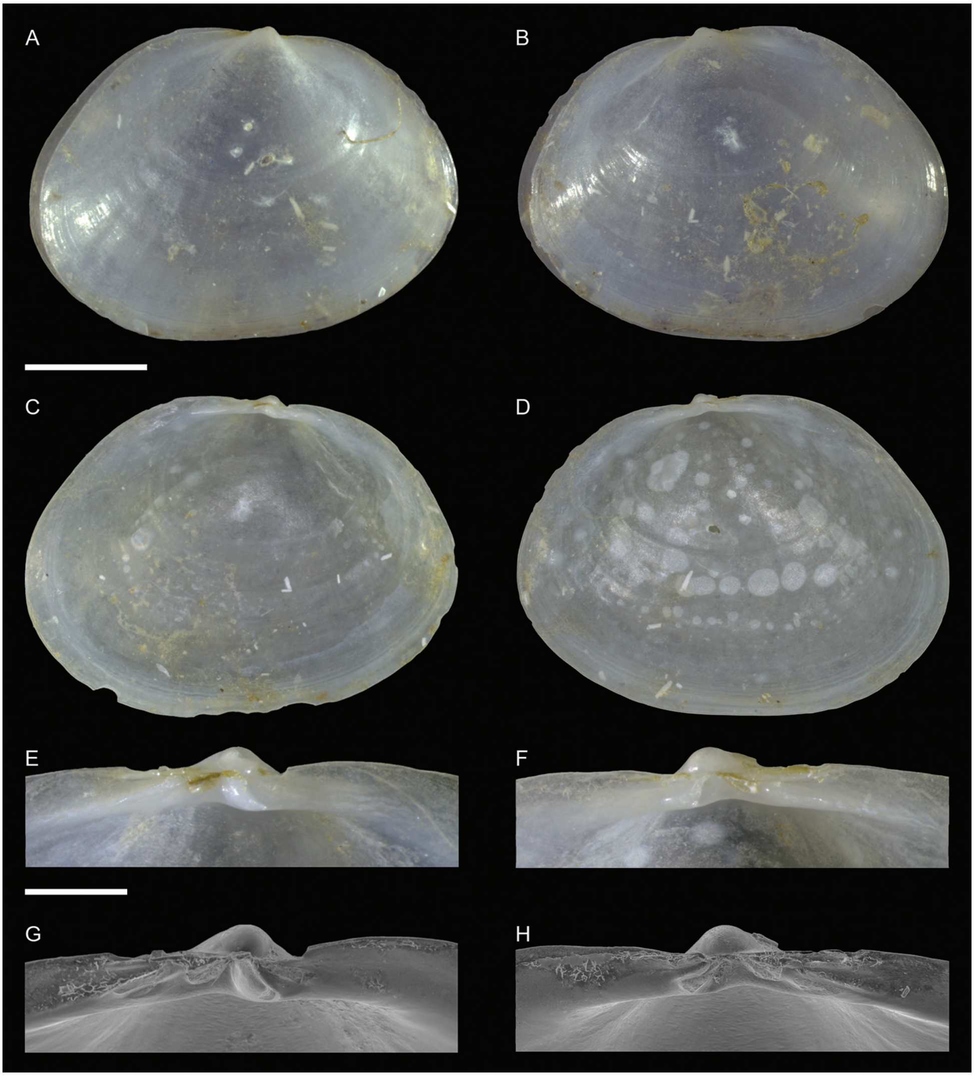

Figure 41. *Scintilla* cf. *violescens* Kuroda & Taki, 1961, Haifa, Israel: right (**A**) and left (**B**) valve outer views, left (**C**) and right (**D**) valve inner views, hinge of left (**E, G**) and right (**F, H**) valve. Scale bars: 2 mm (**A–D**); 0.5 mm (**E–H**).

shallow subtidal of Thailand and Japan (Huber 2015). In contrast to our shell, however, Kuroda and Taki (1961) mention the presence of radial sculpture on the entire surface of the valves of their type material. While our Mediterranean shell is less elongated than the specimens of *S. violescens* illustrated by Okutani (2000), Lützen and Nielsen (2005), and Huber (2015), it is very similar in outline to the shell shown by Arakawa (1961: fig. 5B) (which was identified by T. Kuroda and I. Taki). *Scintilla violescens* appears to be variable also with respect to shell size and coloration: specimens from Thailand (maximum length = 10.5 mm, n = 12 spcms) all were considerably smaller than the > 15 mm-long Japanese type (Kuroda and Taki 1961) and had a whitish instead of pale violet color (Lützen and Nielsen 2005), like the Israeli shell. Considering this great plasticity in shell characters, and the differences in living animal morphology observed for Thai vs. Japanese specimens of *S. violescens* by Lützen and Nielsen (2005), the question arises whether more than one biological entity might be involved.

Irrespective of its unresolved specific affinity, the shell presented here clearly differs from all native Mediterranean galeommatids and thus cannot be confused; it can be easily distinguished from the non-indigneous *Nudiscintilla* cf. *glabra* (see above) by its less elongated shell, smaller L:H-ratio and, most notably, the presence of radial sculpture on the valves. Apart from the present shell, which was found in 1999 in Haifa Bay, we know of no other material.

Family Psammobiidae J. Fleming, 1828

Gari pallida (Deshayes, 1855)

New records. Israel • 6 spcms; Ashqelon; 31.7002° N, 34.5498° E; depth 21 m; 18 Sep. 2016; sand; grab; HELM project (samples SG20_1F, SG20_3F, SG20_3M).

Remarks. A single living individual of this species has been recently reported from Palmachim, along the southern Mediterranean coast of Israel, representing the first record from the Mediterranean Sea (Lubinevsky et al. 2018). We here confirm the establishment of this species by reporting six further living individuals, again from southern Israel.

Family Semelidae Stoliczka, 1870 (1825)

Ervilia scaliola Issel, 1869

Figure 42

New records. Israel • 2 vv; Ashqelon; 31.7002° N, 34.5498° E; depth 21 m; 18 Sep. 2016; sand; grab; HELM project (sample SG20_2F) • 1 sh; Ashqelon; 31.6868°N, 34.5516°E; depth 11 m; 31 Oct. 2018; offshore rocky reef; suction sampler; HELM project (sample S58_3M); NHMW-MO-112930/LM/0176; size: L 3.1 mm, H 2.2 mm (illustrated shell).

Remarks. *Ervilia scaliola* was first recorded from Turkey based on material collected in 2013 by Zenetos and Ovalis (2014) who correctly described the complex taxonomic status of this genus in the Indo-Pacific. We here record the species from Israel for the first time. The complete shell from Ashqelon (Figure 42) is very fresh, and thus probably originates from an extant population.

Iacra seychellarum (A. Adams, 1856)

Figure 43

New records. GREECE • 3 vv; Kos Island; 2005–2010; A. Storm leg.; RMNH. MOL.342632; size: L 12.1 mm, H 9.8 mm.

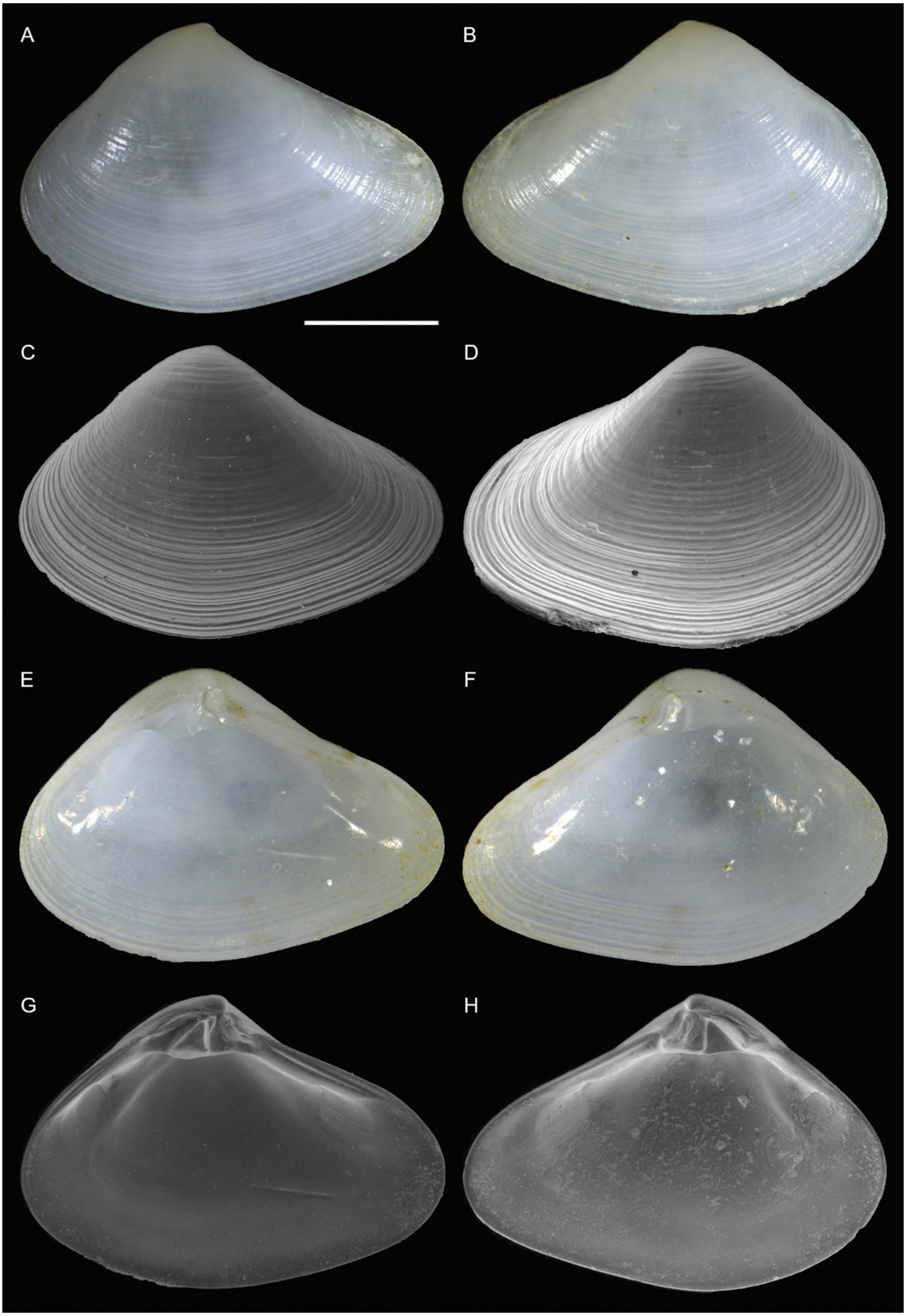

Figure 42. *Ervilia scaliola* Issel, 1869, NHMW-MO-112930/LM/0176, Ashqelon, Israel, HELM project (sample S58_3M): right (**A, C**) and left (**B, D**) valve outer views, left (**E, G**) and right (**F, H**) valve inner views. Scale bar: 1 mm.

Figure 43. *Iacra seychellarum* (A. Adams, 1856), Kos Island, Greece, RMNH.MOL.342632: left valve outer (**A**) and inner (**B**) views, hinge (**C**). Photograph courtesy T. van Haaren. Scale bar: 2 mm (**A, B**); 1 mm (**C**).

Remarks. We here report the finding of three beached valves of *Iacra seychellarum* in Kos, Greece. *Iacra seychellarum* can be readily distinguished from any Mediterranean semelid by its thick valves, large chondrophore and different sculpture in three zones: anterior with fine incised concentric lirations, median to posterior slope of fine incised oblique lines becoming strongly divaricate over the posterior slope, posterior area with closely spaced concentric incised lirations (Oliver 1992; Zuschin and Oliver 2003). It has been recorded from the northern Red Sea by Blatterer (2019) but has a broader distribution in the Indian Ocean (Oliver 1992). Because to our knowledge the finding has not been followed by others, we suggest that living individuals are needed to confirm the introduction and establishment of this species in the Mediterranean Sea.

Semelidae sp.
Figure 44

New records. Israel • 1 spcm; Palmachim; 31.9737°N, 34.6767°E; depth 35.4 m; 24 May 2017; soft substrate; box-corer; Shafdan project (sample 29(A)); size: L 2.4 mm, H 2.0 mm.

Additional material examined. *Abra alba* (W. Wood, 1802): Israel • 1 v; north of Atlit; 32.7422°N, 34.9181°E; depth 30 m; 20 Sep. 2016; sand; grab; HELM project (sample NG30_2M) • 2 vv; Ashqelon; 31.7101°N, 34.5406°E; depth 31 m; 18 Sep. 2016; sand; grab; HELM project (sample SG30_5M).

Remarks. We were unable to identify this peculiar bivalve beyond family level, despite a thorough search in the literature on Mediterranean and Indo-Pacific mollusks. The shell of the single specimen found is roundly subtrigonal, fragile, with a rounded, steeply sloping anterior and a subacute to subtruncate posterior part; the ventral margin is slightly concave, the umbo submedian. The outer surface is smooth, glossy, and only sculptured by very fine growth lines. Although the small size and outline are reminiscent of certain galeommatoid genera such as *Bornia* Philippi, 1836, which is also represented in the Mediterranean Sea, the presence of both an external and an internal ligament, the latter situated on a well-developed resilifer, is typical for the family Semelidae (Oliver 1992; Beesley and Ross 1998; Huber 2010). The hinge of both valves bears two cardinals; the posterior cardinal of the left valve is becoming obsolete

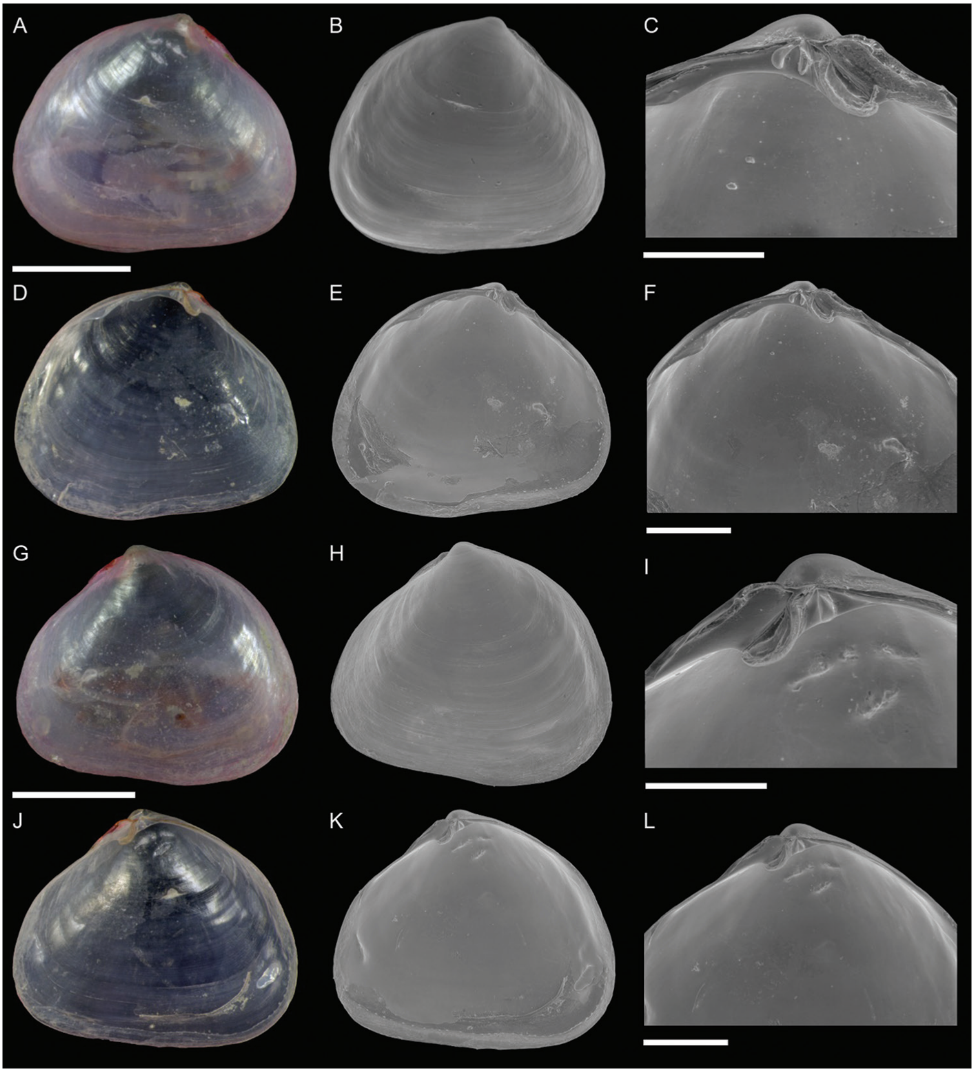

Figure 44. Semelidae sp., Palmachim, Israel, Shafdan project (sample 29(A)): left valve outer view (**A, B**), right valve inner view (**D, E**), hinge (**C, F**) and outer view (**G, H**), left valve inner view (**J–K**) and hinge (**I, L**). The pink hue is due to staining with eosin solution. Scale bars: 1 mm (**A, B, D, E, G, H, J, K**); 0.5 mm (**F, L**); 0.3 mm (**C, I**).

by encroachment of the internal ligament portion which also extends vertically beyond the hinge line. Two well-developed laterals are present in the right valve, while in the left valve, only a weak tooth-like ridge is present anteriorly, formed by the dorsal shell margin. Due to the extremely smooth and glossy interior of the valves that renders hardly visible even the adductor muscle scars, it remains unclear whether a deep pallial sinus, another feature typical of semelids, is present in the studied specimen.

Lonoa katoi Habe, 1976, a semelid from Japan, shares with our species the small size and irregular outline with an often concave ventral margin (related to its attached lifestyle); however, the outer shell surface of *L. katoi* bears rough lamellae and fine radial threads (Habe 1976; Okutani 2017), while that of the Israeli specimen is almost smooth. The most similar confamilial species from the Red Sea probably is *Abra aegyptiaca* Oliver and Zuschin, 2000, however, it differs from the specimen described here in shell shape, sculpture, the prosogyrate umbo, and features of the hinge such as the shape of the anterior lateral tooth of the right valve. Similar-sized juveniles of Mediterranean *Abra* spp., including *A. alba*, the most common species on the shallow Israeli shelf, have a hinge morphology comparable to our specimen, but differ in their outline and by having more protruding umbos (Scaperrotta et al. 2013). *Abra tenuis* is most similar in shape, and a teratological specimen might approach the outline of our shell; however, such a specimen would still differ from Semelidae sp. by the presence of commarginal lines on the early dissoconch (Scaperrotta et al. 2013; Oliver et al. 2020).

Until the finding of further specimens, it remains open whether the present individual is a juvenile or an adult of a small-sized species. Considering that only a single specimen was found so far, the lack of known native Mediterranean species with a similar morphology, and the geographical proximity of the Israeli coast to the Suez Canal, we suspect that this species might be another Indo-Pacific taxon introduced to the southeastern Mediterranean.

Family Veneridae Rafinesque, 1815

Clementia papyracea (Gmelin, 1791)

New records. Israel • 1 spcm; Haifa Bay; 32.8211°N, 35.0196°E; depth 11 m; 2 Aug. 2015; soft substrate; grab; NM project (station HM27).

Remarks. *Clementia papyracea* has been recorded in the Mediterranean Sea since 1937, but findings of living individuals are very scarce and limited to samples collected in 1968 in El Arish, Egypt (Barash and Danin 1973), in 1975 in Haifa, Israel (Barash and Danin 1977) and in 2012 in Ashqelon, Israel (Crocetta et al. 2016). We here report a further living juvenile individual.

Family Corbulidae Lamarck, 1818

Corbula erythraeensis H. Adams, 1871

Figure 45A–K

New records. Israel • 1 spcm; Ashqelon; 31.7002°N, 34.5498°E; depth 21 m; 18 Sep. 2016; sand; grab; HELM project (sample SG20_4F) • 3 spcms; Ashqelon; 31.7487°N, 34.4960°E; depth 41 m; 27 Apr. 2017; sandy mud; grab; HELM project (sample SG40_8M); sizes: L 2.9 mm, H 2.5 mm (illustrated specimen 1, Figure 45A–C); L 3.8 mm, H 3.1 mm (illustrated specimen 2, Figure 45D, E) • 2 spcms; Soreq desalination plant; 31.94°N, 34.69°E; depth 17–22 m; 10 May 2009; soft substrate; grab; Soreq project; size: L 1.9 mm, H 1.5 mm (Figure 45J, K).

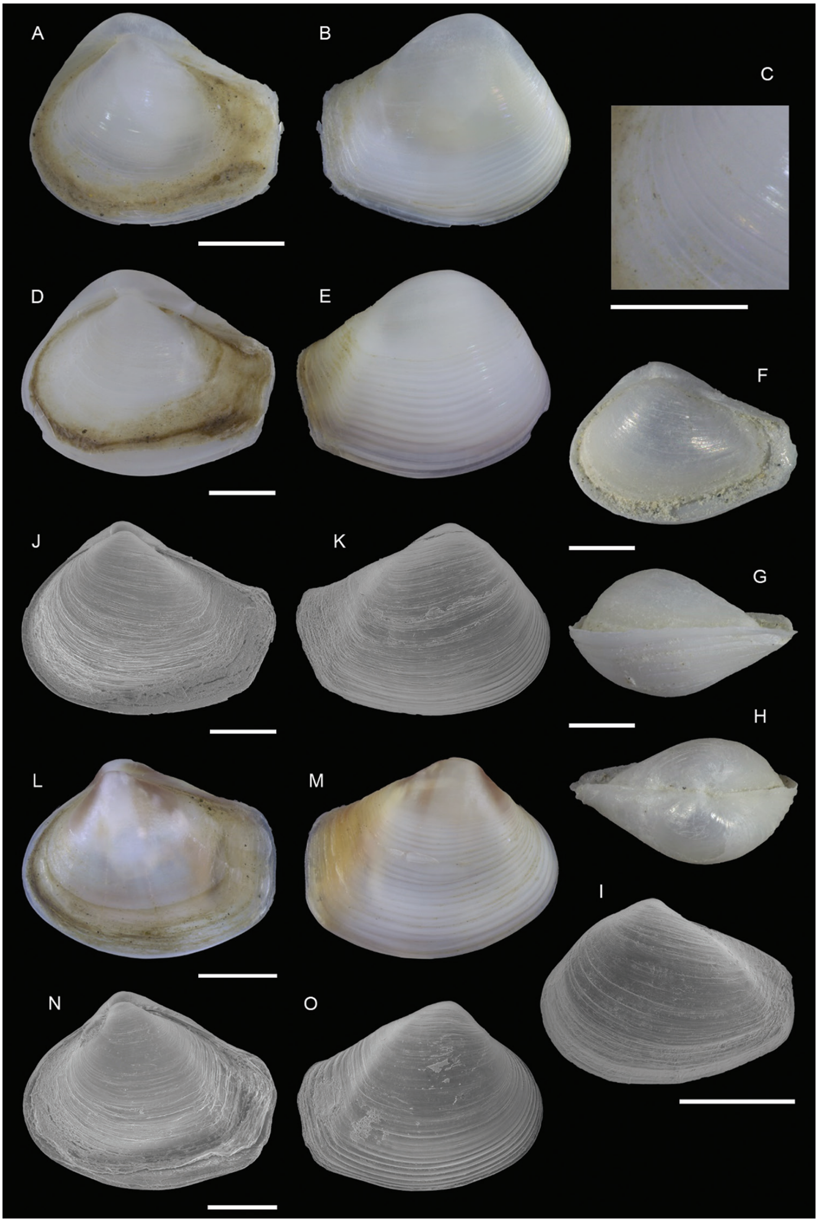

Figure 45. Comparison between *Corbula erythraeensis* H. Adams, 1871 and *Corbula gibba* (Olivi, 1792). **A–E** *Corbula erythraeensis*, Ashqelon, Israel, HELM project (sample SG40_8M): **A–C** Specimen 1: left (**A**) and right (**B**) valve outer views, sculpture of the anterior left valve (**C**) **D, E** Specimen 2: left (**D**) and right (**E**) valve outer views. **F–H** *Corbula erythraeensis*, Bay of Safaga, Egypt, NHMW-MO-106107: left valve outer (**F**), ventral (**G**) and dorsal (**H**) views. **I** *Corbula erythraeensis*, same collecting data as for preceding, NHMW-MO-106100: left valve outer view **J, K** *Corbula erythraeensis,* Soreq desalination plant, Israel, Soreq project: left (**J**) and right (**K**) valve outer views **L, M** *Corbula gibba*, same collecting data as for **A–E**: left (**L**) and right (**M**) valve outer views **N, O** *Corbula gibba*, same collecting data as for **J–K**: left (**N**) and right (**O**) valve outer views. Scale bars: 1 mm (**A, B, D, E, F–I, L, M**); 0.5 mm (**C, J, K, N, O**).

Additional material examined. *Corbula erythraeensis*: Egypt • 1 sh; Bay of Safaga; 26.8142°N, 33.9653°E; depth 39 m; 31 Oct. 1994; mud; scuba diving; M. Zuschin leg.; ref. Oliver and Zuschin (2000), sample 94/4/b; NHMW-MO-106107; size: L 3.5 mm, H 2.5 mm (illustrated shell, Figure 45F–H) • 1 v; same collecting data as for preceding; NHMW-MO-106100; size: L: 2.3 mm, H: 1.6 mm (illustrated valve, Figure 45I).

Corbula gibba (Olivi, 1792): Israel • 271 spcms; Ashqelon; 31.7492°N, 34.4964°E; depth 41 m; 27 Apr. 2017; sandy mud; grab; HELM project (sample SG40_8M) • 300 spcms, 11 shs, 10 vv (5 right, 5 left); Soreq desalination plant; 31.94°N, 34.69°E; depth 17–22 m; 10 May 2009; soft substrate; grab; Soreq project.

Remarks. *Corbula erythraeensis* is widespread in the northern Red Sea where it has been recorded from the gulfs of Suez (MacAndrew 1870; Oliver 1992) and Aqaba at Eilat (Edelman-Furstenberg and Faershtein 2010), as well as the northern Bay of Safaga (Egypt) (Zuschin and Oliver 2003); outside the Red Sea, its distribution ranges eastward to Pakistan (Huber 2010). Here we report the first findings of this species from the Mediterranean. *Corbula erythraeensis* was found sympatrically with the common native Mediterranean *Corbula gibba* but was always present in very low numbers. No empty shells have been found so far. While being similar in appearance to the morphologically variable *C. gibba*, *C. erythraeensis* has a convex anterior dorsal margin of the right valve (usually concave in *C. gibba*, particularly in smaller specimens), a more inflated umbonal region, a regular concentric sculpture on the left valve (Oliver 1992), and its color always is whitish-yellowish (*C. gibba* frequently has a rosy pattern). Juvenile individuals are more wedge-shaped than those of *C. gibba*.

Discussion

Massive reporting follows intensive fieldwork and broad cooperation

We have covered 52 species, reporting the finding of 23 new Lessepsian mollusks, nine additional species that, upon final identification, may turn out to be further new Lessepsian species, nine new records for Eastern Mediterranean countries and new data for eleven already recognized non-indigenous species. Such a massive report is derived from three characteristics of this study which translate into recommendations for an effective approach to non-indigenous species detection and monitoring. First, the intensive sampling effort and the effective sampling techniques of the "Historical ecology of Lessepsian migration" (HELM) project and of the IOLR monitoring programs. The HELM project in particular targeted also hard substrates, poorly explored at this taxonomic resolution in the Eastern Mediterranean, by suction sampling. This technique has repeatedly proved to be a very effective method on compact (e.g., coral rubble, pebbles (Bouchet et al. 2002; Linnane et al. 2003; Ringvold et al. 2015; Evans et al. 2018)), seagrass (Bonfitto et al. 1998; Albano and Sabelli 2012; Albano and Stockinger 2019) or hard substrates (Templado et al. 2010) and has enabled here the collection of vast amounts of living micromollusks and their shells. Indeed, 26 out of the 52 (50%) species treated here and 17 out of 32 (53%) new and potentially new NIS came from suction samples on hard substrates. The IOLR surveys covered soft substrates along the whole Israeli Mediterranean coastline with a dense station network and multi-seasonal sampling that led to the detection of 16 out of 52 (31%) treated species, notwithstanding several findings had already been published (e.g., Bogi and Galil 2013b, Aartsen et al. 2015; Lubinevsky et al. 2018). Second, the use of fine mesh sizes. The HELM samples were sieved with a 0.5 mm mesh and those of the IOLR monitoring programs were sieved with either a 0.5 mm or even a 250 µm mesh. Such small sizes enabled retaining the large majority of invertebrates, including mollusks, even those with very small and elongated shells, such as many Pyramidellidae. However, this approach requires an enormous effort when picking and sorting the samples and the availability of high-level taxonomic expertise, since most small-sized species belong to taxonomically challenging groups or represent juvenile individuals. Third, and importantly, cooperation among institutions and individuals. Despite new records of non-indigenous species are often scattered into short papers in the literature and may become difficult to trace in the long term, recent efforts have demonstrated the value of cooperation to build up large datasets (e.g., Katsanevakis et al. 2020). It is also important to highlight the role that citizen scientists had in the detection of the new non-indigenous species treated here by contributing to sample sorting, species identification and their taxonomic study.

The challenge of recognizing and identifying tropical non-indigenous species

Taxonomic uncertainty is recognized as a major impediment to the reliable inventorying of non-indigenous species (McGeoch et al. 2012; Marchini et al. 2015; Katsanevakis and Moustakas 2018). Species whose identification is uncertain or whose taxonomic status is unresolved were suggested to be excluded from inventories (Marchini et al. 2015). Taxonomic uncertainty may also imply an uncertain non-indigenous status: a species morphologically distinct from the native species pool can either be a yet undescribed native species or a newly introduced species (which may be undescribed too). If the new species belongs to a clade not occurring in the sampled range, then the attribution of the non-indigenous status is well supported. Still, only the finding of clearly conspecific individuals from the source pool would provide final evidence of the non-indigenous status. We exemplified these cases with two new taxa described here: *Coriophora lessepsiana* Albano, Bakker & Sabelli, sp. nov. clearly belongs to a tropical clade of Triphoridae and the availability of material from the Red Sea enabled the unambiguous attribution of the species to the Red Sea pool (hence the species name *lessepsiana*). *Joculator problematicus* Albano & Steger, sp. nov. belongs to a genus absent from the Mediterranean Sea. Despite multiple similar species have been recorded in the Indo-Pacific province, we have not been able to find conspecific Red Sea material (hence the species name *problematicus*, to highlight the uncertainty in attributing the non-indigenous status when solid taxonomic and faunistic knowledge is lacking).

A more complex case is represented by species that have few diagnostic characters, hampering the unequivocal attribution to a tropical clade (e.g., within Eulimidae and Pyramidellidae). We here propose to exploit the properties of death assemblages to deliver a solid hypothesis of non-indigenous status. Death assemblages, the taxonomically identifiable, dead or discarded organic remains encountered in a landscape or seabed such as molluscan shells, accumulate species richness over time (Kidwell 2013). This property implies that death assemblages are good archives of local species diversity and that species which have long occurred in a study site (like native ones) are likely to be found in a death assemblage even if they are too rare to be regularly detected in living censuses. Indeed, the inclusion of empty shells in field surveys increased the estimations of occupancy and detectability of native land snails (Albano et al. 2015). In contrast, a species which has recently established a population in a new area would be expected to be poorly detectable in the death assemblage because not enough time has elapsed to contribute a significant number of skeletal parts to it. Consequently, newly reported non-indigenous species found alive but not, or very rarely, in the death assemblage may represent newly introduced species. This approach can be applied when living and death assemblages are sampled simultaneously with quantitative methods. The main limitation of this approach is that it is applicable only to organisms with hard skeletal parts like foraminiferans, ostracods and fishes (e.g. Agiadi and Albano 2020).

With biological invasions constituting a major element of global change, there is understandable concern on the accuracy of non-indigenous species inventories (Marchini et al. 2015; Katsanevakis and Moustakas 2018). However, also the risk of underestimating the magnitude of biological invasions must be considered. In this respect, the Lessepsian invasion is a special case. The salinity reduction of the Bitter Lakes (Galil 2006), the containment by dams of the annual Nile flood which used to modulate salinity off its delta (Rilov and Galil 2009), and the multiple enlargements of the Suez Canal (Galil et al. 2015) have certainly enhanced connectivity between the Mediterranean Sea and the Indo-Pacific province during the 20th century. Additionally, in the most recent decades, rising seawater temperatures in the Mediterranean Sea (Ozer et al. 2017) make it increasingly suitable for the establishment of inherently thermophilic Red Sea species. These factors combined render very likely that an increasing number of Red Sea species manages to cross the Canal and to settle in the Mediterranean Sea. The proper understanding of this phenomenon and of its drivers requires a timely and detailed census of assemblages as well as a broad toolkit to overcome the limitations of the taxonomic challenges associated with tropical species.

Authors' contributions

PGA and JS conceived the study. PGA, JS, CB, MB, TGH, MFH, HL, MM, and MS contributed to fieldwork, sample sorting and data acquisition. PGA, JS, PAJB, CB, PILF, and BS identified the specimens and contributed to the taxonomic discussion. PGA, JS, and TGH contributed to the discussion. PGA, JS, PAJB, and MA prepared the figures. PGA and JS wrote the first draft of the manuscript, which then received contributions by all co-authors.

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References

Aartsen JJ van (1981) European marine Mollusca: notes on less well-known species. II. The genus *Cima* Chaster, 1896. Basteria 45: 117–119.

Aartsen JJ van, Goud J (2006) Indo-Pacific migrants into the Mediterranean. 3. *Atys angustatus* Smith, 1872 (Gastropoda, Opisthobranchia). Basteria 70: 29–31.

Aartsen JJ van, Barash A, Carrozza F (1989) Addition to the knowledge of the Mediterranean Mollusca of Israel and Sinai. Bollettino Malacologico 25: 63–76.

Aartsen JJ van, Galil B, Bogi C (2015) Two alien venerid bivalves from the Eastern Mediterranean. Marine Biodiversity Records 8: e83. https://doi.org/10.1017/S1755267215000573

Adams A (1856) Descriptions of thirty four new species of bivalve Mollusca (*Leda*, *Nucula*, and *Pythina*) from the Cumingian collection. Proceedings of the Zoological Society of London 24: 47–53.

Adams A (1861) On some new genera and species of Mollusca from the North of China and Japan. Annals and Magazine of Natural History ser. 3, 8: 239–246. https://doi.org/10.1080/00222936108697411

Adams H (1871) Descriptions of twenty-six new species of shells collected by Robert M'Andrew, Esq., in the Red Sea. Proceedings of the Zoological Society of London 1870: 788–793.

Adams J (1797) The specific characters of some minute shells discovered on the coast of Pembrokeshire, with an account of a new marine animal. Transactions of the Linnean Society of London 3: 64–69. https://doi.org/10.1111/j.1096-3642.1797.tb00559.x

Agamennone F, Micali P, Siragusa F (2020a) *Melanella orientalis* n. sp. (Gastropoda: Eulimidae) from the Eastern Mediterranean. Bollettino Malacologico 56: 172–175.

Agamennone F, Sbrana C, Nardi N, Siragusa F, Germanà A (2020b) *Dikoleps micalii* n. sp. (Gastropoda: Skeneidae) from the Eastern Aegean Sea. Bollettino Malacologico 56: 91–95.

Agiadi K, Albano PG (2020) Holocene fish assemblages provide baseline data for the rapidly changing eastern Mediterranean. The Holocene 30: 1438–1450. https://doi.org/10.1177/0959683620932969

Albano PG, Sabelli B (2012) The molluscan assemblages inhabiting the leaves and rhizomes of a deep water *Posidonia oceanica* settlement in the central Tyrrhenian Sea. Scientia Marina 76: 721–732. https://doi.org/10.3989/scimar.03396.02C

Albano PG, Bakker PAJ (2016) Annotated catalogue of the types of Triphoridae (Mollusca, Gastropoda) in the Museum für Naturkunde, Berlin, with lectotype designations. Zoosystematics and Evolution 92: 33–78. https://doi.org/10.3897/zse.92.5936

Albano PG, Stockinger M (2019) The rhizome layer of *Posidonia oceanica*: an important habitat for Mediterranean brachiopods. Marine Biodiversity 49: 2467–2472. https://doi.org/10.1007/s12526-019-00968-6

Albano PG, Sabelli B, Bouchet P (2011) The challenge of small and rare species in marine biodiversity surveys: microgastropod diversity in a complex tropical coastal environment. Biodiversity and Conservation 20: 3223–3237. https://doi.org/10.1007/s10531-011-0117-x

Albano PG, Bakker PAJ, Sabelli B (2019) Annotated catalogue of the types of Triphoridae (Mollusca, Gastropoda) in the Natural History Museum of the United Kingdom, London. Zoosystematics and Evolution 95: 161–308. https://doi.org/10.3897/zse.95.32803

Albano PG, Strazzari G, D'Occhio P, Succetti F (2015) Field estimates of detectability and site occupancy show that northern Italy forest molluscs are spatially rare and poorly detectable. Italian Journal of Zoology 82: 592–608. https://doi.org/10.1080/11250003.2015.1040084

Albano PG, Bakker PAJ, Janssen R, Eschner A (2017) An illustrated catalogue of Rudolf Sturany's type specimens in the Naturhistorisches Museum Wien, Austria (NHMW): Red Sea gastropods. Zoosystematics and Evolution 93: 45–94. https://doi.org/10.3897/zse.93.10039

Albano PG, Gallmetzer I, Haselmair A, Tomašových A, Stachowitsch M, Zuschin M (2018) Historical ecology of a biological invasion: the interplay of eutrophication and pollution determines time lags in establishment and detection. Biological Invasions 20: 1417–1430. https://doi.org/10.1007/s10530-017-1634-7

Albano PG, Azzarone M, Amati B, Bogi C, Sabelli B, Rilov G (2020) Low diversity or poorly explored? Mesophotic molluscs highlight undersampling in the Eastern Mediterranean. Biodiversity and Conservation 29: 4059–4072. https://doi.org/10.1007/s10531-020-02063-w

Albano PG, Steger J, Bošnjak M, Dunne B, Guifarro Z, Turapova E, Hua Q, Kaufman DS, Rilov G, Zuschin M (2021) Native biodiversity collapse in the Eastern Mediterranean. Proceedings of the Royal Society B: Biological Sciences 288. https://doi.org/10.1098/rspb.2020.2469

Ammar I (2018) New record of alien species of gastropods in Syrian coast. Damascus University Journal of Basic Science 34: 95–122.

Angelidis A, Polyzoulis G (2018) New distributional records of four Indo-Pacific species from Astypalaia Island, South Aegean Sea, Greece. Xenophora Taxonomy 21: 3–10.

Appolloni M, Smriglio C, Amati B, Lugliè L, Nofroni I, Tringali LP, Mariottini P, Oliverio M (2018) Catalogue of the primary types of marine molluscan taxa described by Tommaso Allery Di Maria, Marquis of Monterosato, deposited in the Museo Civico di Zoologia, Roma. Zootaxa 4477: 1–138. https://doi.org/10.11646/zootaxa.4477.1.1

Arakawa KY (1961) A note on the animal of *Scintilla violescens* collected in Genkai Sea. Venus 21: 143–146.

Audouin V (1826) Explication sommaire des planches de Mollusques de l'Egypte et de la Syrie publiées par J.C. Savigny. In: Description de l'Egypte ou recueil des observations et des recherches qui ont été faites en Egypte pendant l'expédition de l'armée française, publié par les ordres de sa majesté l'empereur Napoléon le grand. Histoire Naturelle, Animaux invertébrés. Imprimerie impériale, Paris, 7–56.

Barash A, Danin Z (1971) Opisthobranchia (Mollusca) from the Mediterranean waters of Israel. Israel Journal of Zoology 20: 151–200.

Barash A, Danin Z (1973) Contributions to the knowledge of Suez Canal migration. The Indo-Pacific species of Mollusca in the Mediterranean and notes on a collection from the Suez Canal. Israel Journal of Zoology 21: 301–374.

Barash A, Danin Z (1977) Additions to the knowledge of Indo-Pacific Mollusca in the Mediterranean. Conchiglie 13: 85–116.

Bariche M, Fricke R (2020) The marine ichthyofauna of Lebanon: an annotated checklist, history, biogeography, and conservation status. Zootaxa 4775: 1–157. https://doi.org/10.11646/zootaxa.4775.1.1

Bartsch P (1947) A monograph of the west Atlantic mollusks of the family Aclididae. Smithsonian Miscellaneous Collections 106: 1–29.

Beesley PL, Ross GJB (Eds) (1998) Mollusca: the southern synthesis. Fauna of Australia. Volume 5. CSIRO Publishing, Melbourne, part A XVI + 563 pp, part B VIII + 565 pp.

Belmaker J, Brokovich E, China V, Golani D, Kiflawi M (2009) Estimating the rate of biological introductions: Lessepsian fishes in the Mediterranean. Ecology 90: 1134–1141. https://doi.org/10.1890/07-1904.1

Beu AG, Alloway BV, Pillans BJ, Naish TR, Westgate JA (2004) Marine Mollusca of oxygen isotope stages of the last 2 million years in New Zealand. Part 1: Revised generic positions and recognition of warm-water and cool-water migrants. Journal of the Royal Society of New Zealand 34: 111–265. https://doi.org/10.1080/03014223.2004.9517766

Blatterer H (2019) Mollusca of the Dahab region (Gulf of Aqaba, Red Sea). Denisia 43: 1–480.

Bodilis P, Arceo H, Francour P (2011) Further evidence of the establishment of *Fistularia commersonii* (Osteichthyes: Fistulariidae) in the north-western Mediterranean Sea. Marine Biodiversity Records 4: E18. https://doi.org/10.1017/S1755267211000194

Bogi C, Galil BS (1999) Nuovi ritrovamenti di immigranti lessepsiani lungo le coste israeliane. La Conchiglia 31: 29–32.

Bogi C, Galil BS (2006) Nuovi ritrovamenti lungo le coste israeliane. Notiziario S.I.M. 24: 16–18.

Bogi C, Galil BS (2013a) *Cylichna villersii*, an Erythraean cephalaspideid snail (Mollusca: Gastropoda: Opisthobranchia) in the eastern Mediterranean. Marine Biodiversity Records 6: e92. https://doi.org/10.1017/S1755267213000687

Bogi C, Galil BS (2013b) *Finella pupoides* Adams A., 1860 (Gastropoda, Scaliolidae) – a population explosion underway, Mediterranean Sea. BioInvasions Records 2: 43–45. https://doi.org/10.3391/bir.2013.2.1.07

Bogi C, Karhan SU, Yokes MB (2012) Oscilla galilae, a new species of Pyramidellidae (Mollusca, Gastropoda, Heterobranchia) from the Eastern Mediterranean. Iberus 30: 1–6.

Bonfitto A, Fellagara I, Gillone G (1998) Sampling techniques and structure of the malacofauna associated to the rhizome zone in *Posidonia oceanica* (L.) Delile. Bollettino Malacologico 33: 83–88.

Bouchet P (1989) A review of poecilogony in gastropods. Journal of Molluscan Studies 55: 67–78. https://doi.org/10.1093/mollus/55.1.67

Bouchet P, Danrigal F (1982) Napoleon's Egyptian campaign (1798–1801) and the Savigny collection of shells. The Nautilus 96: 9–24.

Bouchet P, Warén A (1993) Revision of the northeast Atlantic bathyal and abyssal Mesogastropoda. Bollettino Malacologico Suppl. 3: 579–840. https://doi.org/10.5962/bhl.title.140732

Bouchet P, Lozouet P, Maestrati P, Heros V (2002) Assessing the magnitude of species richness in tropical marine environments: exceptionally high numbers of molluscs at a New Caledonia site. Biological Journal of the Linnean Society 75: 421–436. https://doi.org/10.1046/j.1095-8312.2002.00052.x

Bouchet P, Rocroi J-P, Bieler R, Carter JG, Coan EV (2010) Nomenclator of bivalve families with a classification of bivalve families. Malacologia 52: 1–184. https://doi.org/10.4002/040.052.0201

Bouchet P, Rocroi J-P, Hausdorf B, Kaim A, Kano Y, Nützel A, Parkhaev P, Schrödl M, Strong EE (2017) Revised classification, nomenclator and typification of gastropod and monoplacophoran families. Malacologia 61: 1–526. https://doi.org/10.4002/040.061.0201

Bruguière JG (1792) Encyclopédie méthodique ou par ordre de matières. Histoire naturelle des vers, volume 1. Pancoucke, Paris, 345–757. [Livraison 48] https://doi.org/10.5962/bhl.title.49857

Brusina S (1869) Gasteropodes nouveaux de l'Adriatique. Journal de Conchyliologie 17: 230–249.

Buzzurro G, Cecalupo A (2005) Descrizione di una nuova specie di Cerithiopsidae per le coste turche. Bollettino Malacologico 40: 77–79.

Buzzurro G, Cecalupo A (2006) I molluschi lessepsiani di Taşucu (Turchia sud-orientale): descrizione di *Parviturbo dibellai* n. sp. (Gastropoda: Trochoidea: Skeneidae). Bollettino Malacologico 42: 27–32.

Cantraine FJ (1835) Diagnoses ou descriptiones succinctes de quelques espèces nouvelles de mollusques. Bulletin de l'Académie Royale des Sciences et Belles-lettres de Bruxelles 2: 380–401.

Carpenter PP (1856) Description of new species and varieties of Calyptraeidae, Trochidae, and Pyramidellidae, principally in the collection of Hugh Cuming, Esq. Proceedings of the Zoological Society of London 24: 166–171.

Cecalupo A, Quadri P (1994) Contributo alla conoscenza malacologica per il nord dell'Isola di Cipro (parte I). Bollettino Malacologico 30: 5–16.

Cecalupo A, Villari A (1997) *Dizoniopsis micalii*. Una nuova specie per il Mediterraneo (Mesogastropoda: Cerithiopsidae). Bollettino Malacologico 32: 41–44.

Cecalupo A, Perugia I (2011) The family Cerithiopsidae H. Adams & A. Adams, 1853 in the Central Philippines (Caenogastropoda: Triphoroidea). Quaderni della Civica Stazione Idrobiologica di Milano 30: 5–262.

Cecalupo A, Perugia I (2013) The Cerithiopsidae (Caenogastropoda: Triphoroidea) of Espiritu Santo - Vanuatu (South Pacific Ocean). Published by the Authors, 253 pp.

Cecalupo A, Perugia I (2014a) Cerithiopsidae and Newtoniellidae (Gastropoda: Triphoroidea Gray) from French Polynesia area (South Pacific Ocean). Novapex 15: 1–22.

Cecalupo A, Perugia I (2014b) The Cerithiopsidae (Caenogastropoda: Triphoroidea) of South Madagascar (Indian Ocean). Bollettino Malacologico 50: 75–126.

Cecalupo A, Perugia I (2016) Report on some Cerithiopsidae from Indo-Pacific area (Caenogastropoda: Triphoroidea). Bollettino Malacologico 52: 98–109.

Cecalupo A, Perugia I (2017a) A new species of Cerithiopsidae (Gastropoda: Triphoroidea) from the East China Sea. Bollettino Malacologico 53: 30–32.

Cecalupo A, Perugia I (2017b) Cerithiopsidae and Newtoniellidae (Gastropoda: Triphoroidea) from New Caledonia, Western Pacific. Visaya Suppl. 7: 5–175.

Cecalupo A, Perugia I (2018) New species of Cerithiopsidae (Gastropoda: Triphoroidea) from Papua New Guinea (Pacific Ocean). Visaya Suppl. 11: 4–187.

Cecalupo A, Perugia I (2019a) New species of Cerithiopsidae and Newtoniellidae from Okinawa (Japan - Pacific Ocean). Visaya Suppl. 12: 4–84.

Cecalupo A, Perugia I (2019b) New species of Cerithiopsidae the Philippines and Samoa Islands (Caenogastropoda: Triphoroidea). Visaya 5: 19–34.

Cecalupo A, Perugia I (2019c) Report from Bangka Pulau (Indonesia): Cerithiopsidae. Bollettino Malacologico 55: 11–22.

Chartosia N, Anastasiadis D, Bazairi H, Crocetta F, Deidun A, Despalatović M, Martino VD, Dimitriou N, Dragičević B, Dulčić J, Durucan F, Hasbek D, Ketsilis-Rinis V, Kleitou P, Lipej L, Macali A, Marchini A, Ousselam M, Piraino S, Stancanelli B, Theodosiou M, Tiralongo F, Todorova V, Trkov D, Yapici S (2018) New Mediterranean Biodiversity Records (July 2018). Mediterranean Marine Science 19: 398–415. https://doi.org/10.12681/mms.18099

Chester C, Agosti D, Sautter G, Catapano T, Martens K, Gérard I, Bénichou L (2019) EJT editorial standard for the semantic enhancement of specimen data in taxonomy literature. European Journal of Taxonomy 586: 1–22. https://doi.org/10.5852/ejt.2019.586

Çinar ME, Bilecenoglu M, Oztürk B, Katagan T, Yokes MB, Aysel V, Dagli E, Acik S, Ozcan T, Erdogan H (2011) An updated review of alien species on the coasts of Turkey. Mediterranean Marine Science 12: 257–315. https://doi.org/10.12681/mms.34

Crocetta F, Bitar G, Zibrowius H, Oliverio M (2013) Biogeographical homogeneity in the eastern Mediterranean Sea. II. Temporal variation in Lebanese bivalve biota. Aquatic Biology 19: 75–84. https://doi.org/10.3354/ab00521

Crocetta F, Tringali LP, Mienis HK, Zenetos A (2016) *Clementia papyracea* (Gmelin, 1791) (Mollusca: Bivalvia: Veneridae): its established status in the Mediterranean Sea and the first record from Greece. Cahiers de Biologie Marine 57: 271–275.

Crocetta F, Bitar G, Zibrowius H, Oliverio M (2020) Increase in knowledge of the marine gastropod fauna of Lebanon since the 19th century. Bulletin of Marine Science 96: 22. https://doi.org/10.5343/bms.2019.0012

Crocetta F, Gofas S, Salas C, Tringali LP, Zenetos A (2017) Local ecological knowledge versus published literature: a review of non-indigenous Mollusca in Greek marine waters. Aquatic Invasions 12: 415–434. https://doi.org/10.3391/ai.2017.12.4.01

Crooks JA (2005) Lag times and exotic species: The ecology and management of biological invasions in slow-motion. Ecoscience 12: 316–329. https://doi.org/10.2980/i1195-6860-12-3-316.1

Daniel B, Piro S, Charbonnel E, Francour P, Letourneur Y (2009) Lessepsian rabbitfish *Siganus luridus* reached the French Mediterranean coasts. Cybium 33: 163–164.

Dekker H, Orlin Z (2000) Checklist of Red Sea Mollusca. Spirula 47: 1–46.

Deshayes GP (1855) Descriptions of new shells from the collection of H. Cuming. Esq. Proceedings of the Zoological Society of London 22: 317–371. https://doi.org/10.1111/j.1469-7998.1854.tb07284.x

Dunker WR (1857) Mytilacea nova collectione Cumingianae. Proceedings of the Zoological Society of London 24: 358–366.

Dunker WR (1882) Index molluscorum maris Japonici. Conscriptus et tabulis iconum XVI illustratus. Cassellis Cattorum. Sumptibus Theodori Fischer, 390 pp. https://doi.org/10.5962/bhl.title.10277

Edelman-Furstenberg Y, Faershtein G (2010) Molluscan fauna of the Gulf of Elat: indicators of ecological change. Jerusalem, 132 pp.

Ellingson RA, Krug PJ (2006) Evolution of poecilogony from planktotrophy: cryptic speciation, phylogeography, and larval development in the gastropod genus *Alderia*. Evolution 60: 2293–2310. https://doi.org/10.1111/j.0014-3820.2006.tb01866.x

Evans J, Attrill MJ, Borg JA, Cotton PA, Schembri PJ (2018) Hidden in plain sight: species richness and habitat characterisation of sublittoral pebble beds. Marine Biology 165: 35. https://doi.org/10.1007/s00227-018-3292-4

Folin AGL de (1868) Quelques points de la côte septentrionale de Java (Tome 1, 1er Partie, Chapitre 14). In: Folin AGL de, Périer JPL (Eds), Les Fonds de la Mer. Étude internationale sur les particularités nouvelles des régions sous-marines. Savy, Libraire-Editeur, Paris, 54–108.

Folin AGL de (1879) Mers de Chine. Mollusques. Les Fonds de la Mer. Paris [1878], 263–267.

Forbes E, Hanley SC (1850) A history of British Mollusca and their shells. Vol. 2. van Voorst., London, 481–557.

Galil BS (2006) The marine caravan – The Suez Canal and the Erythrean invasion. In: Gollasch S, Galil BS, Cohen AN (Eds) Bridging divides. Maritime canals as invasion corridors. Monographiae Biologicae. Springer, Dordrecht, 207–301. https://doi.org/10.1007/978-1-4020-5047-3_6

Galil BS (2009) Taking stock: inventory of alien species in the Mediterranean Sea. Biological Invasions 11: 359–372. https://doi.org/10.1007/s10530-008-9253-y

Galil BS, Boero F, Campbell ML, Carlton JT, Cook E, Fraschetti S, Gollasch S, Hewitt CL, Jelmert A, Macpherson E, Marchini A, McKenzie C, Minchin D, Occhipinti-Ambrogi A, Ojaveer H, Olenin S, Piraino S, Ruiz GM (2015) 'Double trouble': the expansion of the Suez Canal and marine bioinva https://doi.org/10.1007/s10530-014-0778-y sions in the Mediterranean Sea. Biological Invasions 17: 973–976.

Giannuzzi-Savelli R, Pusateri F, Micali P, Nofroni I, Bartolini S (2014) Atlante delle conchiglie marine del Mediterraneo Vol. 5 (Heterobranchia). Edizioni Danaus, Palermo, 111 + 191 pp.

Giunchi L, Micali P, Tisselli M (2001) Report of two lessepsian migrants from Turkey. La Conchiglia 33: 47–48. https://doi.org/10.2307/25304703

Glover EA, Taylor JD (2001) Systematic revision of Australian and Indo-Pacific Lucinidae (Mollusca: Bivalvia): *Pillucina*, *Wallucina* and descriptions of two new genera and four new species. Records of the Australian Museum 53: 263–292. https://doi.org/10.3853/j.0067-1975.53.2001.1349

Gmelin JF (1791) Vermes. In: Gmelin JF (Ed.) Caroli a Linnaei Systema Naturae per Regna Tria Naturae. G.E. Beer, Lipsiae [Leipzig], 3021–3910.

Gofas S (1990) Le genre *Gibberula* (Marginellidae) en Mediterranee. Lavori della Società Italiana di Malacologia 23: 113–140.

Gofas S (1992) Le genre *Granulina* (Marginellidae) en Mediterranee et dans l'Atlantique Oriental. Bollettino Malacologico 28: 1–26.

Gofas S, Moreno D, Salas C (2011) Moluscos marinos de Andalucía. Volumen II - Clase Gastropoda (Heterobranchia), clase Bivalvia, clase Scaphopoda, clase Cephalopoda, glosario e índices. Universidad de Málaga, Servicio de Publicaciones e Intercambio Científico, Málaga, 343–798.

Gould AA (1861) Description of new shells collected by the United States North Pacific Exploring Expedition. Proceedings of the Boston Society of Natural History: 7: 385–389 [January 1861], 401–409 [February 1861]; 8: 14–32 [March 1861], 33–40 [April 1861].

Guy-Haim T, Hyams-Kaphzan O, Yeruham E, Almogi-Labin A, Carlton JT (2017) A novel marine bioinvasion vector: Ichthyochory, live passage through fish. Limnology and Oceanography Letters 2: 81–90. https://doi.org/10.1002/lol2.10039

Habe T (1976) Eight new bivalves from Japan. Venus 35: 37–46.

Hedley C (1903) Studies on Australian Mollusca. Part. 7. Proceedings of the Linnean Society of New South Wales 27: 596–619.

Hedley C (1909) Mollusca from the Hope Islands, north Queensland. Proceedings of the Linnean Society of New South Wales 34: 420–466.

Hervier J (1898) Diagnoses d'espèces nouvelles de *Triforis*, provenant de l'archipel de la Nouvelle-Calédonie (suite). Journal de Conchyliologie 45: 249–266.

Higo S, Callomon P, Goto Y (2001) Catalogue and bibliography of the marine shell-bearing Mollusca of Japan. Gastropoda. Bivalvia. Polyplacophora. Scaphopoda. Type figures. Elle Scientific Publications, Osaka, 196 pp.

Hinds RB (1843) Descriptions of new shells from the collection of Captain Belcher, R.N., C.B. The Annals and Magazine of Natural History 11: 16–21. https://doi.org/10.1080/03745484309445254

Hoagland KE, Robertson R (1988) An assessment of poecilogony in marine invertebrates: phenomenon or fantasy? The Biological Bulletin 174: 109–125. https://doi.org/10.2307/1541778

Høisæter T (2009). Distribution of marine, benthic, shell bearing gastropods along the Norwegian coast. Fauna norvegica, 28, 5-106. https://doi.org/10.5324/fn.v28i0.563

Hornung A, Mermod G (1924) Mollusques de la Mer Rouge recueillis par A. Issel faisant partie des collections du Musée Civique d'Histoire Naturelle de Gênes. Première partie, Pyramidellides. Annali del Museo Civico di Storia Naturale "G. Doria" 51: 283–311.

Hornung A, Mermod G (1925) Mollusques de la Mer Rouge recueillis par A. Issel faisant partie des collections du Musée Civique d'Histoire Naturelle de Gênes. Deuxième partie, Pyramidellides (fin) - Rissoinides. Annali del Museo Civico di Storia Naturale "G. Doria" 52: 20–33.

Hornung A, Mermod G (1928) Mollusques de la Mer Rouge recueillis par A. Issel faisant partie des collections du Musée Civique d'Histoire Naturelle de Gênes. Quatrième partie, Rissoidés. Annali del Museo Civico di Storia Naturale "G. Doria" 52: 363–372.

Huber M (2010) Compendium of bivalves. ConchBooks, Hackenheim, 901 pp.

Huber M (2015) Compendium of bivalves 2. ConchBooks, Harxheim, 907 pp.

Issel A (1869) Malacologia del Mar Rosso. Ricerche zoologiche e paleontologiche. Biblioteca Malacologica, xi–387 pp.

Ivkić A, Steger J, Galil BS, Albano PG (2019) The potential of large rafting objects to spread Lessepsian invaders: the case of a detached buoy. Biological Invasions 21: 1887–1893. https://doi.org/10.1007/s10530-019-01972-4

Janssen R, Zuschin M, Baal C (2011) Gastropods and their habitats from the northern Red Sea (Egypt: Safaga) Part 2: Caenogastropoda: Sorbeoconcha and Littorinimorpha. Annalen des Naturhistorischen Museums in Wien 113: 373–509.

Jeffreys JG (1858) Gleanings in British Conchology. Annals and Magazine of Natural History: (3)1: 39–48, pl. 2; (3)2: 117–133, 5. https://doi.org/10.1080/00222935808696993

Johnson RI (1964) The Recent Mollusca of Augustus Addison Gould. Illustrations of the types described by Gould with a bibliography and catalog of his species. United States National Museum Bulletin 239: 1–182. https://doi.org/10.5479/si.03629236.239

Jousseaume FP (1884) Monographie des Triforidae. Bulletins de la Société Malacologique de France 1: 217–270.

Jousseaume FP (1898) Triphoridae de la Mer Rouge. Bulletin de la Société Philomathique ser. 8, 9: 71–77.

Katsanevakis S, Moustakas A (2018) Uncertainty in Marine Invasion Science. Frontiers in Marine Science 5: 38. https://doi.org/10.3389/fmars.2018.00038

Katsanevakis S, Tsiamis K, Ioannou G, Michailidis N, Zenetos A (2009) Inventory of alien marine species of Cyprus (2009). Mediterranean Marine Science 10: 109–134. https://doi.org/10.12681/mms.113

Katsanevakis S, Poursanidis D, Hoffman R, Rizgalla J, Bat-Sheva Rothman S, Levitt-Barmats Y, Hadjioannou L, Trkov D, Garmendia JM, Rizzo M, Bartolo AG, Bariche M, Tomas F, Kleitou P, Schembri PJ, Kletou D, Tiralongo D, Pergent C, Pergent G (2020) Unpublished

Mediterranean records of marine alien and cryptogenic species. BioInvasions Records 9: 165–182. https://doi.org/10.3391/bir.2020.9.2.01

Kay EA (1979) Hawaiian marine shells. Reef and shore fauna of Hawaii. Section 4: Mollusca. 64xviii + 1–653.

Kidwell SM (2013) Time-averaging and fidelity of modern death assemblages: building a taphonomic foundation for conservation palaeobiology. Palaeontology 56: 487–522. https://doi.org/10.1111/pala.12042

Kosuge S (1962) Descriptions of 10 new species and 1 new subspecies of the family Triphoridae (Mollusca) from Shiono-misaki, Kii Peninsula, Central Japan with a list of hitherto known species. Bulletin of the National Science Museum (Tokyo) 6: 78–89.

Krug PJ (1998) Poecilogony in an estuarine opisthobranch: planktotrophy, lecithotrophy, and mixed clutches in a population of the ascoglossan *Alderia modesta*. Marine Biology 132: 483–494. https://doi.org/10.1007/s002270050414

Kuroda T, Taki I (1961) On a new species of *Scintilla* (Galeommatidae) from Japan. Venus 21: 141–142.

Laseron CF (1956) The family Cerithiopsidae (Mollusca) from the Solanderian and Dampierian zoogeographical provinces. Australian Journal of Marine and Freshwater Research 7: 151–182. https://doi.org/10.1071/MF9560151

Laseron CF (1958) The family Triphoridae (Mollusca) from northern Australia; also Triphoridae from Christmas Island (Indian Ocean). Australian Journal of Marine and Freshwater Research 9: 569–658. https://doi.org/10.1071/MF9580569

Laseron CF (1959) The family Pyramidellidae from Northern Australia. Australian Journal of Marine and Freshwater Research 10: 177–267. https://doi.org/10.1071/MF9590177

van der Linden J, Eikenboom JCA (1992) On the taxonomy of the Recent species of the genus *Chrysallida* Carpenter from Europe, the Canary Islands and the Azores (Gastropoda, Pyramidellidae). Basteria 56: 3–63.

Linnaeus C (1758) Systema Naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Editio decima, reformata [10th revised edition]. Laurentius Salvius, Holmiae, 824 pp.

Linnaeus C (1767) Systema naturae per regna tria naturae: secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Ed. 12. 1., Regnum Animale. 1 & 2. Laurentii Salvii, Holmiae, 1327 pp. https://doi.org/10.5962/bhl.title.156772

Linnane A, Ball B, Munday B, Browne R, Mercer JP (2003) Faunal description of an Irish cobble site using airlift suction sampling. Biology and Environment: Proceedings of the Royal Irish Academy 103B: 41–48. https://doi.org/10.3318/BIOE.2003.103.1.41

Lipej L, Acevedo I, Akel EHK, Anastasopoulou A, Angelidis A, Azzurro E, Castriota L, Çelik M, Cilenti L, Crocetta F, Deidun A, Dogrammatzi A, Falautano M, Fernández-Álvarez FÁ, Gennaio R, Insacco G, Katsanevakis S, Langeneck J, Lombardo BM, Mancinelli G, Mytilineou C, Papa L, Pitacco V, Pontes M, Poursanidis D, Prato E, Rizkalla SI, Rodríguez-Flores PC, Stamouli C, Tempesti J, Tiralongo F, Tirnetta S, Tsirintanis K, Turan C, Yaglioglu D, Zaminos G, Zava B (2017) New Mediterranean biodiversity records (March 2017). Mediterranean Marine Science 18: 179–201. https://doi.org/10.12681/mms.2068

Lubinevsky H, Galil B, Bogi C (2018) First record of *Gari pallida* (Deshayes, 1855) (Mollusca: Bivalvia: Psammobiidae) in the Mediterranean Sea. BioInvasions Records 7: 415–419. https://doi.org/10.3391/bir.2018.7.4.10

Lützen J, Nielsen C (2005) Galeommatid bivalves from Phuket, Thailand. Zoological Journal of the Linnean Society 144: 261–308. https://doi.org/10.1111/j.1096-3642.2005.00168.x

MacAndrew R (1870) Report on the testaceous Mollusca obtained during a dredging-excursion in the Gulf of Suez in the months of February and March 1869. Annals and Magazine of Natural History (Fourth Series) 6: 429–450. https://doi.org/10.1080/00222937008696289

Marchini A, Galil BS, Occhipinti-Ambrogi A (2015) Recommendations on standardizing lists of marine alien species: Lessons from the Mediterranean Sea. Marine Pollution Bulletin 101: 267–273. https://doi.org/10.1016/j.marpolbul.2015.09.054

Marshall BA (1978) Cerithiopsidae (Mollusca: Gastropoda) of New Zealand, and a provisional classification of the family. New Zealand Journal of Zoology 5: 47–120. https://doi.org/10.1080/03014223.1978.10423744

Mazziotti C, Agamennone F, Micali P, Tisselli M (2005) Descrizione di *Turbonilla flaianoi* n. sp. per il Mare Adriatico. Bollettino Malacologico 41: 79–84.

McDonald KA, Collin R, Lesoway MP (2014) Poecilogony in the caenogastropod *Calyptraea lichen* (Mollusca: Gastropoda). Invertebrate Biology 133: 213–220. https://doi.org/10.1111/ivb.12057

McGeoch MA, Spear D, Kleynhans EJ, Marais E (2012) Uncertainty in invasive alien species listing. Ecological Applications 22: 959–971. https://doi.org/10.1890/11-1252.1

Melvill JC (1896) Descriptions of new species of minute marine shells from Bombay. Proceedings of the Malacological Society of London 2: 108–116.

Melvill JC (1899) Notes on the Mollusca of the Arabian Sea, Persian Gulf, and Gulf of Oman, mostly dredged by Mr. F. W. Townsend, with descriptions of twenty-seven species. Annals and Magazine of Natural History ser. 7, 4: 81–101. https://doi.org/10.1080/00222939908678167

Melvill JC (1904) Descriptions of twelve new species and one variety of marine Gastropoda from the Persian Gulf, Gulf of Oman and Arabian sea, collected by Mr. F. W. Townsend, 1902–1904. Journal of Malacology 11: 79–85.

Melvill JC (1906a) A revision of the species of Cyclostrematidae and Liotiidae occurring in the Persian Gulf and North Arabian Sea. Proceedings of the Malacological Society of London 7: 20–30. https://doi.org/10.1093/oxfordjournals.mollus.a066121

Melvill JC (1906b) Descriptions of thirty-one Gastropoda and one scaphopod from the Persian Gulf and Gulf of Oman, dredged by Mr. F.W. Townsend, 1902–1904. Proceedings of the Malacological Society of London 7: 69–80. https://doi.org/10.1093/oxfordjournals.mollus.a066148

Melvill JC (1912) Descriptions of thirty-three new species of Gastropoda from the Persian Gulf, Gulf of Oman, and North Arabian Sea. Proceedings of the Malacological Society of London 10: 240–254.

Melvill JC (1918) Descriptions of thirty-four species of marine Mollusca from the Persian Gulf, Gulf of Oman and Arabian Sea, collected by Mr. F. W. Townsend. Annals and Magazine of Natural History Ser. 9, 1: 137–158. https://doi.org/10.1080/00222931808562296

Micali P, Bogi C, Galil BS (2016) On the occurrence of *Atys angustatus* E. A. Smith, 1872 and *Atys macandrewii* E. A. Smith, 1872 (Cephalaspidea: Haminoeidae) in the Mediterranen Sea. Iberus 34: 1–5.

Micali P, Siragusa F, Agamennone F, Germanà A, Sbrana C (2017) Karpathos Island (Greece) and its Indo-Pacific alien species, Part 1. Bollettino Malacologico 53: 40–49.

Mienis HK (1976) *Ventomnestia girardi* (Audouin, 1827) from the Mediterranean. Conchiglie 12: 209–210.

Mienis HK (2019) A first record of *Anodontia philippiana* from the Mediterranean Sea off Israel. Triton 38: 4–5.

Mifsud C, Ovalis P (2012) A galeommatid bivalve new to the Mediterranean Sea. Triton 26: 6–8.

Mifsud C, Ovalis P (2019) Two new species of *Sticteulima* Laseron, 1955 (Gastropoda: Eulimidae) from Turkey, eastern Mediterranean. Bollettino Malacologico 55: 68–71.

Milaschewitsch KO (1916) Mollyuski Russkikh Morey. Tom 1. Mollyuski Chernago i Azovskago Morey. Imperatorskaya Akademiya Nauk, Zoologicheskiy Muzey, Petrograd, 312 pp.

MolluscaBase (2020) MolluscaBase. http://www.molluscabase.org [March 7, 2020]

Montagu G (1803) Testacea Britannica or natural history of British shells, marine, land, and fresh-water, including the most minute: Systematically arranged and embellished with figures. J. White, London, Vol. 1: xxxvii + 291 pp.; Vol. 2: 293–606 + 16 pls. https://doi.org/10.5962/bhl.title.33927

Montagu G (1808) Supplement to Testacea Britannica with Additional Plates. Woolmer, Exeter, v + 183 pp.

Monterosato TA di (1874) Recherches conchyliologiques, effectuées au Cap Santo Vito, en Sicile. Journal de Conchyliologie 22: 243–282.

Monterosato TA di (1877) Notizie sulle conchiglie della rada di Civitavecchia. Annali del Museo Civico di Storia Naturale "G. Doria" 9: 407–428.

Monterosato TA di (1878) Note sur quelques coquilles draguées dans les eaux de Palerme. Journal de Conchyliologie 26: 143–160.

Occhipinti-Ambrogi A, Marchini A, Cantone G, Castelli A, Chimenz C, Cormaci M, Froglia C, Furnari G, Gambi MC, Giaccone G, Giangrande A, Gravili C, Mastrototaro F, Mazziotti C, Orsi-Relini L, Piraino S (2011) Alien species along the Italian coasts: an overview. Biological Invasions 13: 215–237. https://doi.org/10.1007/s10530-010-9803-y

Okutani T (2000) Marine mollusks in Japan. Tokai University Press, Tokyo, 1173 pp.

Okutani T (2017) Marine mollusks in Japan. 2nd edition. Tokai University Press, Tokyo, 1375 pp.

Oliver PG (1992) Bivalved seashells of the Red Sea. Verlag Christa Hemmen, 330 pp.

Oliver PG (2015) Old shell collection casts new light on an alien species. The dark false mussel (*Mytilopsis leucophaeata*) may have been in Britain as early as 1800! Journal of Conchology 42: 1.

Oliver PG, Zuschin M (2000) Addition to the bivalve fauna of the Red Sea with descriptions of new species of Limopsidae, Tellinidae and Semelidae. Journal of Conchology 37: 17–37.

Oliver PG, Holmes AM, Killeen IJ, Turner JA (2020) Marine bivalve shells of the British Isles. https://naturalhistory.museumwales.ac.uk/BritishBivalves/home.php

Oliverio M, Buzzurro G, Villa R (1994) A new Eulimid Gastropod from the Eastern Mediterranean sea (Caenogastropoda, Ptenoglossa). Bollettino Malacologico 30: 211–215.

Olivi G (1792) Zoologia Adriatica, ossia catalogo ragionato degli animali del golfo e delle lagune di Venezia. G. Remondini e fl., Bassano, 334 pp. https://doi.org/10.5962/bhl.title.60887

Ounifi-Ben Amor K, Rifi M, Ghanem R, Draeif I, Zaouali J, Ben Souissi J (2015) Update of alien fauna and new records from Tunisian marine waters. Mediterranean Marine Science 17: 124. https://doi.org/10.12681/mms.1371

Ozer T, Gertman I, Kress N, Silverman J, Herut B (2017) Interannual thermohaline (1979–2014) and nutrient (2002–2014) dynamics in the Levantine surface and intermediate water masses, SE Mediterranean Sea. Global and Planetary Change 151: 60–67. https://doi.org/10.1016/j.gloplacha.2016.04.001

Özturk B, Aartsen JJ van (2006) Indo-Pacific migrants into the Mediterranean. 5 *Chrysallida micronana* nom. nov. for *Chrysallida nana* (Hornung and Mermod, 1924) (Gastropoda:Pyramidellidae). Aquatic Invasions 1: 241–244. https://doi.org/10.3391/ai.2006.1.4.7

Öztürk B, Bitlis Bakir B (2013) *Eunaticina papilla* Gmelin, 1791) (Naticidae, Gastropoda) a new alien in the eastern Mediterranean. Triton 28: 7–8.

Öztürk B, Bitlis B, Filiz ME (2011) The genus *Chrysallida* Carpenter, 1856 on the Turkish coasts (Gastropoda: Heterostropha). Zoology in the Middle East 54: 53–78. https://doi.org/10.1080/09397140.2011.10648880

Pease WH (1861) Descriptions of forty-seven new species of shells from the Sandwich Islands, in the collection of Hugh Cuming. Proceedings of the Zoological Society of London 28: 431–438.

Pease WH (1871) Remarks on the genus *Triphoris* (Desh.), with descriptions of new species. Proceedings of the Zoological Society of London 1870: 773–777.

Peñas A, Rolán E (2010) 26 Deep water Pyramidelloidea from the Central and South Pacific: *Turbonilla* and related genera. Mémoires du Muséum national d'Histoire naturelle, Paris, 436 pp.

Peñas A, Rolán E (2017) Deep water Pyramidelloidea from the Central and South Pacific: the tribe Chrysallidini.

Peñas A, Rolán E, Sabelli B (2020) The family Pyramidellidae in the Red Sea. I. The tribe Chrysallidini. Iberus 39: 1–93.

Pennant T (1777) British Zoology, vol. IV. Crustacea. Mollusca. Testacea. London, i–viii, 1–154 pp.

Philippi RA (1836) Enumeratio molluscorum Siciliae cum viventium tum in tellure tertiaria fossilium, quae in itinere suo observavit. Schropp, Berlin, Vol. 1. I-XIV, 1–303. [Tab. XIII-XXVIII pp] https://doi.org/10.5962/bhl.title.100735

Ponder WF, Fukuda H, Hallan A (2014) A review of the family Clenchiellidae (Mollusca: Caenogastropoda: Truncatelloidea). Zootaxa 3872: 101–153. https://doi.org/10.11646/zootaxa.3872.2.1

Por FD (1978) Lessepsian migration: the influx of Red Sea biota into the Mediterranean by way of the Suez Canal. Springer-Verlag, Berlin Heidelberg, VIII + 228 pp.

Prkić J, Buzzurro G (2007) A new species of *Cerithiopsis* (Gastropoda Cerithiopsidae) from Croatian coasts. Triton 15: 1–4.

Raitsos DE, Beaugrand G, Georgopoulos D, Zenetos A, Pancucci-Papadopoulou AM, Theocharis A, Papathanassiou E (2010) Global climate change amplifies the entry of tropical species into the eastern Mediterranean Sea. Limnology and Oceanography 55: 1478–1484. https://doi.org/10.4319/lo.2010.55.4.1478

Rayneval AG de, van den Hecke EBG, Ponzi G (1854) Catalogue des fossiles du Monte Mario (près Rome), recueillis par M. le Cte de Rayneval, Mgr Vanden Hecke et M. le professeur Ponzi. impr. Beau jeune, Versailles, 17 pp. https://doi.org/10.5962/bhl.title.112311

Reeve LA (1850) Monograph of the genus *Lucina*. In: Conchologia Iconica. L. Reeve & Co., London, pl. 1–11 and unpaginated text.

Reeve LA (1858a) Monograph of the genus *Modiola*. In: Conchologia Iconica. L. Reeve & Co., London, pl. 1–11 and unpaginated text.

Reeve LA (1858b) Monograph of the genus *Perna*. In: Conchologia Iconica, or illustrations of the shells of molluscous animals. Vol. 11. L. Reeve & Co., London, 8.

Rilov G (2016) Multi-species collapses at the warm edge of a warming sea. Scientific Reports 6: 36897. https://doi.org/10.1038/srep36897

Rilov G, Galil B (2009) Marine bioinvasions in the Mediterranean Sea – History, distribution and ecology. In: Rilov G, Crooks JA (Eds) Biological Invasions in Marine Ecosystems. Ecological Studies. Springer Berlin Heidelberg, Berlin, Heidelberg, 549–575. https://doi.org/10.1007/978-3-540-79236-9_31

Ringvold H, Grytnes J-A, van der Meeren GI (2015) Diver-operated suction sampling in Norwegian cobble grounds: technique and associated fauna. Crustaceana 88: 184–202. https://doi.org/10.1163/15685403-00003406

Risso A (1826) Histoire naturelle des principales productions de l'Europe Méridionale et particulièrement de celles des environs de Nice et des Alpes Maritimes. Tome quatrième. F.-G. Levrault, Paris, vii–439 pp. https://doi.org/10.5962/bhl.title.58984

Robba E, Di Geronimo I, Chaimanee N, Negri MP, Sanfilippo R (2004) Holocene and Recent shallow soft-bottom mollusks from the northern Gulf of Thailand area: Scaphopoda, Gastropoda, additions to Bivalvia. La Conchiglia 35: 5–288.

Röckel D (1986) Sensational find in the Mediterranean. La Conchiglia 18: 12.

Rolán E, Gofas S (2003) The family Elachisinidae (Mollusca, Rissooidea) in the temperate and tropical Atlantic. Iberus 21: 67–90.

Rubio F, Rolán E, Fernández-Garcés R (2015) Revision of the genera *Parviturbo* and *Pseudorbis* (Gastropoda, Skeneidae). Iberus 33: 167–259.

Russini V, Giannuzzi-Savelli R, Pusateri F, Prkic J, Fassio G, Modica MV, Oliverio M (2020) Candidate cases of poecilogony in Neogastropoda: implications for the systematics of the genus *Raphitoma* Bellardi, 1847. Invertebrate Systematics 34(3): 293–318.

Saurin E (1959) Pyramidellidae de Nhatrang (Vietnam). Annales de la Faculté des Sciences (Saigon) 1959: 223–283.

Savigny JC (1817) Description de l'Egypte ou recueil des observations et des recherches qui ont été faites en Egypte pendant l'expédition de l'armée française, publié par ordre du Gouvernement. Histoire Naturelle, Planches, Tome Deuxième. Imprimerie Royale, Paris, Coquilles, pl. 1–14.

Scaperrotta M, Bartolini S, Bogi C (2012) Accrescimenti. Stadi di accrescimento dei molluschi marini del Mediterraneo. Volume IV. L'Informatore Piceno, 184 pp.

Scaperrotta M, Bartolini S, Bogi C (2013) Accrescimenti. Stadi di accrescimento dei molluschi marini del Mediterraneo. Volume V. L'Informatore Piceno, 192 pp.

Scaperrotta M, Bartolini S, Bogi C (2019) Accrescimenti. Stadi di accrescimento dei molluschi marini del Mediterraneo. Volume X. L'Informatore Piceno, 212 pp.

Schechter HC, Mienis HK (2020) A first record of *Eunaticina linneana* from the Mediterranean Coast of Israel (Gastropoda, Naticidae). Triton 40: 4–5.

Sigovini M, Keppel E, Tagliapietra D (2016) Open Nomenclature in the biodiversity era. Methods in Ecology and Evolution 7: 1217–1225. https://doi.org/10.1111/2041-210X.12594

Smith EA (1872) Remarks on several species of Bullidae, with descriptions of some hitherto undescribed forms, and of a new species of *Planaxis*. Annals and Magazine of Natural History 4: 344–355. https://doi.org/10.1080/00222937208696599

Smith EA (1899) Descriptions of new species of South African marine shells. Journal of Conchology 9: 247–252.

Solow AR, Costello CJ (2004) Estimating the Rate of Species Introductions from the Discovery Record. Ecology 85: 1822–1825. https://doi.org/10.1890/03-3102

Sowerby GBI (1844) Monograph of the genus *Scalaria*. In: Sowerby GBI (Ed.), Thesaurus Conchyliorum. Privately published, London, 83bis–108bis.

Stamouli C, Akel EHK, Azzurro E, Bakiu R, Bas AA, Bitar G, Boyaci Y, Cakalli M, Corsini-Foka M, Crocetta F, Dragičević B, Dulčić J, Durucan F, El Z, Erguden D, Filiz H, Giardina F, Giovos I, Gönülal O, Hemida F, Kassar A, Kondylatos G, Macali A, Mancini E, Ovalis P, De M, Pavičić M, Rabaoui L, Rizkalla SI, Tiralongo F, Turan C, Vrdoljak D, Yapici S, Zenetos A (2017) New Mediterranean biodiversity records (December 2017). Mediterranean Marine Science 18: 534–556.

Steger J, Stockinger M, Ivkić A, Galil B, Albano PG (2018) New records of non-indigenous molluscs from the eastern Mediterranean Sea. BioInvasions Records 7: 245–257. https://doi.org/10.3391/bir.2018.7.3.05

Sturany R (1903) Expeditionen S.M. Schiff "Pola" in das Rothe Meer, nördliche und südliche Hälfte, 1895/96 – 1897/98. Zoologische Ergebnisse XXIII. Gastropoden des Rothen Meeres. Denkschriften der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe 74: 210–283. [Preprint 1–75 pp.]

Taylor JD, Glover EA (2019) Unloved, paraphyletic or misplaced: new genera and species of small to minute lucinid bivalves and their relationships (Bivalvia, Lucinidae). ZooKeys 899: 109–140. https://doi.org/10.3897/zookeys.899.47070

Templado J, Paulay G, Gittenberger A, Meyer C (2010) Sampling the marine realm. In: Eymann J, Degreef J, Häuser C, Monje JC, Samyn Y, VandenSpiegel D (Eds) Manual on field recording techniques and protocols for all taxa biodiversity inventories. ABC Taxa, 273–302.

Tryon GW (1886) Manual of conchology, structural and systematic, with illustrations of the species. (1)8: Naticidae, Calyptraeidae, Turritellidae, Vermetidae, Caecidae, Eulimidae, Turbonillidae, Pyramidellidae. Published by the Author, Philadelphia, 461 pp.

Vaillant L (1865) Recherches sur la faune malacologique de la baie de Suez. Journal de Conchyliologie 13: 97–127.

Valdés Á (2008) Deep-sea "cephalaspidean" heterobranchs (Gastropoda) from the tropical southwest Pacific. In: Héros V, Cowie RH, Bouchet P (Eds), Tropical Deep-Sea Benthos 25. Mémoires du Muséum national d'Histoire naturelle. 587–792.

Vendetti JE, Trowbridge CD, Krug PJ (2012) Poecilogony and population genetic structure in *Elysia pusilla* (Heterobranchia: Sacoglossa), and reproductive data for five sacoglossans that express dimorphisms in larval development. Integrative and Comparative Biology 52: 138–150. https://doi.org/10.1093/icb/ics077

Warén A (1981) Revision of the genera *Apicalia* A. Adams and *Stilapex* lredale and description of two new genera (Mollusca, Prosobranchia, Eulimidae). Zoologica Scripta 10: 133–154. https://doi.org/10.1111/j.1463-6409.1981.tb00491.x

Warén A (1984) A generic revision of the family Eulimidae (Gastropoda, Prosobranchia). Journal of Molluscan Studies suppl. 13: 1–96. https://doi.org/10.1093/mollus/49.Supplement_13.1

Warén A (1991a) New and little known Mollusca from Iceland and Scandinavia. Sarsia 76: 53–124. https://doi.org/10.1080/00364827.1991.10413466

Warén A (1991b) Revision of *Hypermastus* Pilsbry, 1899 and *Turveria* Berry, 1956 (Gastropoda: Prosobranchia: Eulimidae), two genera parasitic on sand dollars. Records of the Australian Museum 43: 85–112. https://doi.org/10.3853/j.0067-1975.43.1991.42

Zenetos A, Ovalis P (2014) Alien Mollusca in the Levantine Sea: an update. Occurrence of *Ervilia scaliola* Issel, 1869 along the Levantine coast of Turkey. Cahiers de Biologie Marine 55: 507–512. https://dx.doi.org/10.21411/CBM.A.67AC08A4

Zenetos A, Galanidi M (2020) Mediterranean non indigenous species at the start of the 2020s: recent changes. Marine Biodiversity Records 13: 10. https://doi.org/10.1186/s41200-020-00191-4

Zenetos A, Corsini-Foka M, Crocetta F, Gerovasileiou V, Simboura N, Tsiamis K, Pancucci-Papadopoulou M-A (2018) Deep cleaning of alien and cryptogenic species records in the Greek Seas (2018 update). Management of Biological Invasions 9: 209–226. https://doi.org/10.3391/mbi.2018.9.3.04

Zenetos A, Çinar ME, Crocetta F, Golani D, Rosso A, Servello G, Shenkar N, Turon X, Verlaque M (2017) Uncertainties and validation of alien species catalogues: The Mediterranean as an example. Estuarine, Coastal and Shelf Science 191: 171–187. https://doi.org/10.1016/j.ecss.2017.03.031

Zenetos A, Gofas S, Verlaque M, Cinar ME, Raso JEG, Bianchi CN, Morri C, Azzurro E, Bilecenoglu M, Froglia C, Siokou I, Violanti D, Sfriso A, Martin GS, Giangrande A, Katagan T, Ballesteros E, Ramos-Espla AA, Mastrototaro F, Ocana O, Zingone A, Gambi MC, Streftaris N (2010) Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. Mediterranean Marine Science 11: 381. https://doi.org/10.12681/mms.87

Zorina IP (1978) New species of clams (Bivalvia) from the Tonkin Bay (South China sea). Trudy Zoologicheskogo Instituta AN SSSR 61: 193–203.

Zuschin M, Oliver PG (2003) Bivalves and bivalve habitats in the northern Red Sea. The Northern Bay of Safaga (Red Sea, Egypt): An actuopalaeontological approach. VI. Bivalvia. Naturhistorisches Museum Wien, 304 pp.

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RESEARCH ARTICLE

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Five new species of the genera *Falcileptoneta* and *Longileptoneta* (Araneae, Leptonetidae) from South Korea

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Abstract

Five new leptonetid species belonging to *Falcileptoneta* Komatsu, 1970 and *Longileptoneta* Seo, 2015 are newly described from South Korea: *F. dolsan* **sp. nov.** (Jeollanam-do), *F. naejangsan* **sp. nov.** (Jeollabuk-do), *L. buyongsan* **sp. nov.** (Chungcheongbuk-do), *L. byeonsanbando* **sp. nov.** (Jeollabuk-do) and *L. jirisan* **sp. nov.** (Gyeongsangnam-do). All new species are found in leaf litter and described from both male and female specimens.

Keywords

Biodiversity, litter-dwelling fauna, morphology, spider, taxonomy

Introduction

The spider family Leptonetidae Simon, 1890 includes 22 genera and 363 species from North America, the Mediterranean region and Asia (Li 2020; Wang et al. 2020; WSC 2020). Members of the family are tiny (1–3 mm) and typically have six eyes, with the anterior four eyes in a recurved row, and the posterior two contiguous; some species have only four or two eyes or are eyeless (Seo 2016b). Most species live in secluded environments, such as irregular sheet webs in leaf litter, caves, or mines (Xu et al. 2019). In South Korea, there are 47 described species in four genera: *Falcileptoneta* Komatsu, 1970; *Leptoneta* Simon, 1872; *Longileptoneta* Seo, 2015 and *Masirana* Kishida, 1942 (WSC 2020). *Falcileptoneta* is a species-rich genus in the family Leptonetidae with 59 described species. The genus was erected by Komatsu (1970), with *Leptoneta striata* Oi, 1952 as the type species. Species of *Falcileptoneta* are mainly distributed in South Korea and Japan (Irie and Ono 2007). Among these, 23 species are found in South Korea (WSC 2020). *Longileptoneta* is a small genus in the family Leptonetidae with only 11 described species; 5 species are distributed in South Korea (WSC 2020). *Longileptoneta* was established by Seo (2015a) for a new species, *L. songniensis* Seo, 2015, and can be easily recognized by the strong spines restricted to the male palpal femur, the prolaterodistal spur and the prolateral curvature of the palpal tarsus (Seo 2016b). The aim of this paper is to describe two new species of the genus *Falcileptoneta* and three new species of the genus *Longileptoneta* from South Korea.

Materials and methods

All specimens were collected by hand from the litter layers of mixed forest in South Korea. Type material is deposited in the National Institute of Biological Resources (**NIBR**) in Incheon, South Korea. All specimens were preserved in 75% ethanol and examined under a Leica M205C stereomicroscope. Images were captured with an Olympus C7070 wide zoom digital camera (7.1 megapixels) mounted on a Leica M205C stereomicroscope and assembled using Helicon Focus 3.10.3 image stacking software (Khmelik et al. 2006). All measurements are in millimeters (mm). The left male palps are illustrated. Internal genitalia of females were removed and treated in lactic acid before illustration. Leg measurements are shown as: Total length (femur, patella, tibia, metatarsus, tarsus). The distribution map was generated with ArcView GIS 3.2 (ESRI 2002). Adobe Photoshop CC (Adobe Systems Incorporated) was used for digital editing of photos and maps. Terminology and taxonomic descriptions follow Wang et al. (2017) and Xu et al. (2019).

Taxonomy

Family Leptonetidae Simon, 1890

Genus *Falcileptoneta* Komatsu, 1970

Falcileptoneta Komatsu, 1970: 1

Type species. *Leptoneta striata* Oi, 1952 from Japan.

Diagnosis. The genus *Falcileptoneta* is similar to *Leptoneta* and *Longileptoneta* in having few sclerites on the male palpal bulb and absenting cribellum but can be distinguished by the following combination of male palpal characters: femur lacking strong spines, tibia usually with complex apophyses on the retrolateroapical end (Figs 1D, 3D), tarsus with shallow, transverse depression (Figs 1D, 3D) and the bulb usually with sickle-like or membranous embolus and complex laminae (Figs 1B–D, 3B–D).

Falcileptoneta dolsan **sp. nov.**

http://zoobank.org/6C63FFC6-5990-40F9-8507-E718FE257F26
Figures 1, 2, 12

Type material. ***Holotype.*** Male (NIBR), South Korea, Jeollanam-do, Yeosu-si, Dolsan-eup, Seodeok-ri (34.641085°N, 127.760978°E, elevation ca 93 m), 13 August 2019, ZG. Chen, Z. Zhao & YY. Hu leg. ***Paratypes.*** 1 male and 1 female (NIBR), same data as holotype.

Diagnosis. *Falcileptoneta dolsan* sp. nov. is similar to *F. digitalis* Seo, 2015 and *F. geumsanensis* Seo, 2016 but can be distinguished by the presence of three palpal tibial distal apophyses, dorsal apophysis sickle-shaped, middle apophysis black, triangular and ventral apophysis narrow and leaf-like (Fig. 1D) (vs. dorsal apophysis long and spur-like, middle apophysis black and rugulose, and ventral apophysis finger-like in *F. digitalis*; dorsal apophysis beak-like, middle apophysis leaf-like and ventral apophysis spur-like in *F. geumsanensis*); and by the bulb with a spine-like prolateral sclerite (Fig. 1C) (vs. narrow, leaf-like prolateral sclerite in *F. digitalis* and *F. geumsanensis*).

Description. Male (holotype). Total length 1.67. Prosoma 0.75 long, 0.62 wide. Opisthosoma 0.92 long, 0.66 wide. Clypeus 0.10 high. Leg measurements: I 4.39 (1.21, 0.24, 1.20, 1.03, 0.71); II 3.42 (0.90, 0.22, 0.89, 0.77, 0.64); III 2.84 (0.83, 0.22, 0.71, 0.70, 0.38); IV 4.05 (1.15, 0.24, 1.09, 0.93, 0.64). Habitus as in Fig. 1A. Prosoma brown. Eyes six (Fig. 1A). Median groove, cervical grooves and radial furrows distinct. Opisthosoma brown, ovoid. Palp (Fig. 1C, D): femur without strong spine; tibia with three distal apophyses and one spine retrolaterally, dorsal apophysis sickle-shaped, middle apophysis black, triangular, ventral apophysis narrow, leaf-like (Fig. 1D), and with one strong dorsal spur (Fig. 1C, D); tarsus with transverse depression (Fig. 1D). Bulb with embolus bearing sickle-like tip and three types of sclerites: prolateral sclerite spine-like; median sclerite shoehorn-like; retrolateral sclerite transparent and membranous (Fig. 1B–D).

Female (paratype). Similar to male in color and general features, habitus as in Fig. 2A, B. Total length 2.09. Prosoma 0.74 long, 0.62 wide. Opisthosoma 1.35 long, 1.06 wide. Clypeus 0.12 high. Leg measurements: I 3.89 (1.05, 0.25, 1.03, 0.92, 0.64); II 3.24 (0.89, 0.24, 0.86, 0.67, 0.58); III 2.81 (0.79, 0.23, 0.69, 0.64, 0.46); IV 3.72 (1.03, 0.24, 1.01, 0.85, 0.59). Internal genitalia (Fig. 2C) with atrium rectangular, genital duct coiled apically, and spermathecae pear-shaped.

Etymology. The specific name refers to the type locality and is a noun in apposition.

Habitat. Litter layers in mixed forest.

Distribution. South Korea (Jeollanam-do; Fig. 12).

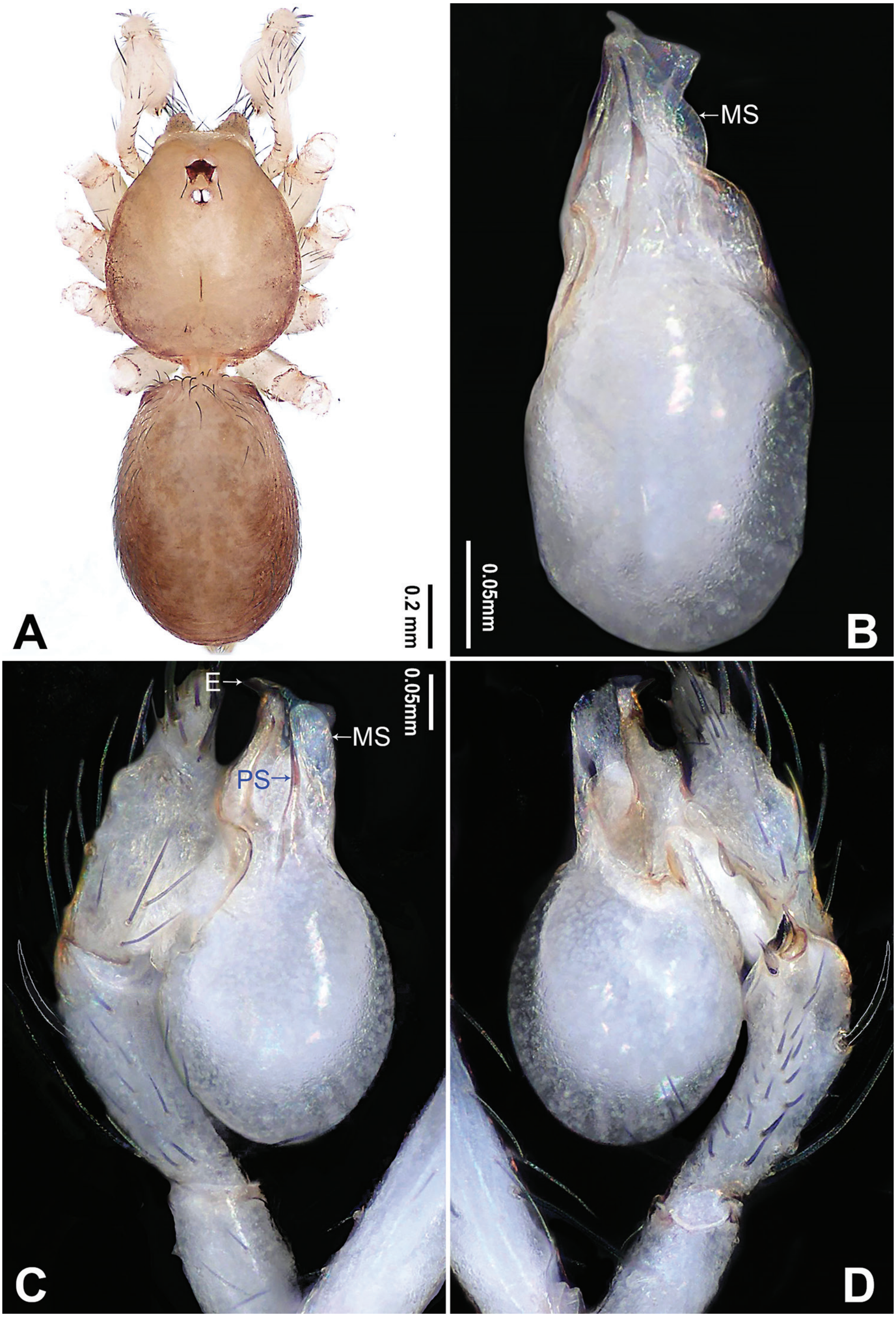

Figure 1. *Falcileptoneta dolsan* sp. nov., holotype male **A** habitus, dorsal view **B** palpal bulb, ventral view **C** palp, prolateral view **D** palp, retrolateral view. Abbreviations: **E** embolus **MS** median sclerite **PS** prolateral sclerite. Scale bars: equal for **C, D**.

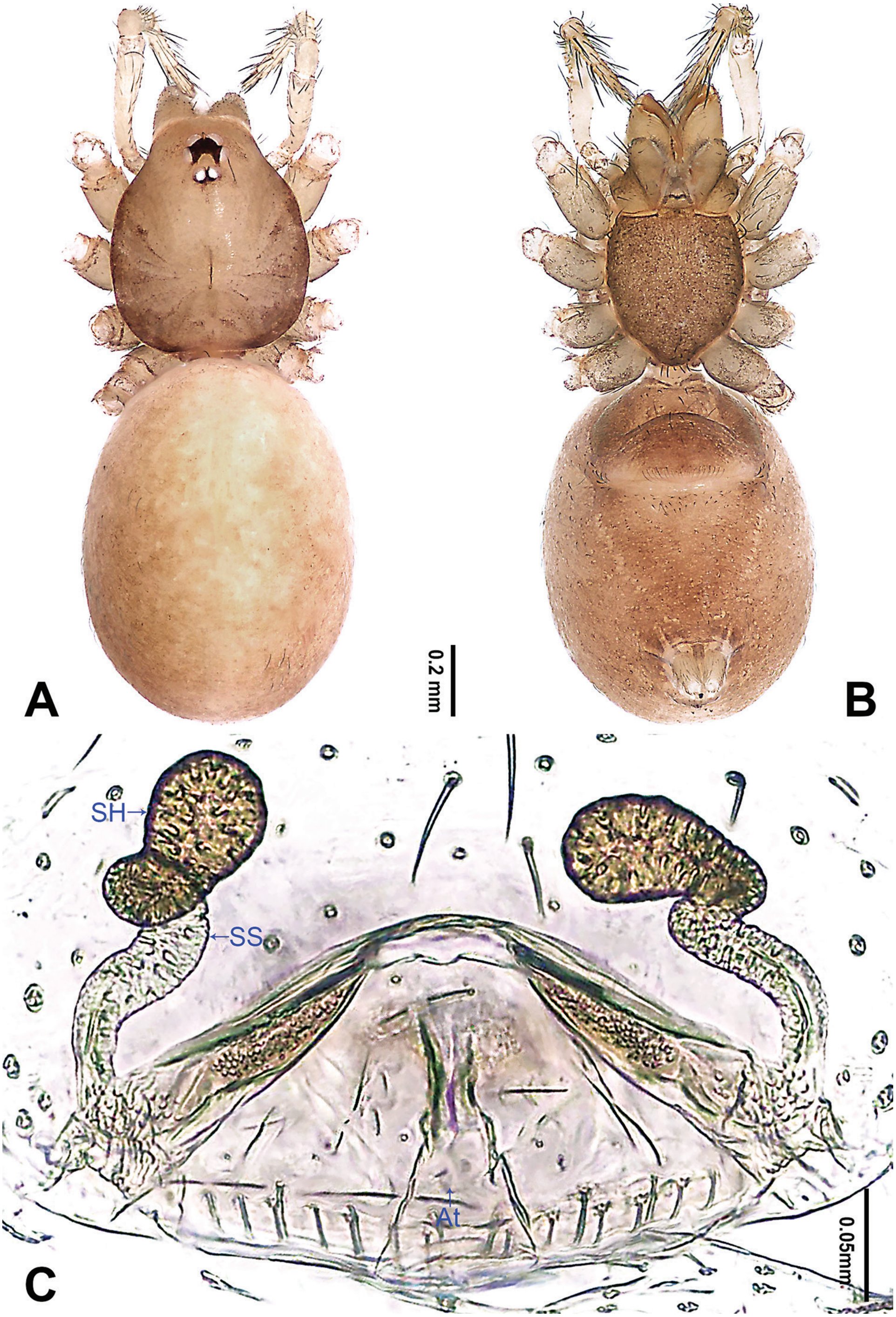

Figure 2. *Falcileptoneta dolsan* sp. nov., female paratype **A** habitus, dorsal view **B** habitus, ventral view **C** internal genitalia, dorsal view. Abbreviations: **At** atrium **SH** spermathecae **SS** spermathecae stalk. Scale bars: equal for **A, B**.

Falcileptoneta naejangsan sp. nov.

http://zoobank.org/A6EE1759-E916-42CC-9A0C-50D0E169169F
Figures 3, 4, 12

Type material. ***Holotype.*** Male (NIBR), South Korea, Jeollabuk-do, Jeongeup-si, Naejang-dong, Mt. Naejangsan National Park (35.491727°N, 126.900469°E, elevation ca 237 m), 9 August 2019, ZG. Chen, Z. Zhao & YY. Hu leg. ***Paratype.*** 1 female (NIBR), same data as holotype.

Diagnosis. *Falcileptoneta naejangsan* sp. nov. is similar to *F. naejangensis* Seo, 2015 and *F. sunchangensis* Seo, 2016 but can be distinguished by the shape of the two palpal tibial retrolaterodistal apophyses, with the dorsal apophysis beak-like and the ventral apophysis spine-like (Fig. 3D) (vs. dorsal one curved and ventral one triangular, and with one spine in *F. naejangensis*; dorsal apophysis thick and spur-like, and ventral apophysis spine-like in *F. sunchangensis*); and by the male palpal bulb with a spine-like prolateral sclerite and narrow leaf-like median sclerite (Fig. 3B–D) (vs. needle-shaped prolateral sclerite and longish, shoehorn-like median sclerite in *F. naejangensis*; narrow, leaf-like prolateral sclerite and leaf-like median sclerite in *F. sunchangensis*).

Description. Male (holotype). Total length 1.68. Prosoma 0.69 long, 0.58 wide. Opisthosoma 0.99 long, 0.58 wide. Clypeus 0.10 high. Leg measurements: I 4.43 (1.15, 0.32, 1.22, 1.03, 0.71); II 3.41 (0.90, 0.26, 0.90, 0.77, 0.58); III 2.76 (0.83, 0.26, 0.65, 0.64, 0.38); IV 3.97 (1.15, 0.26, 1.15, 0.83, 0.58). Habitus as in Fig. 3A. Prosoma dark brown. Eyes six (Fig. 3A). Median groove, cervical grooves and radial furrows distinct. Opisthosoma dark brown, ovoid. Palp (Fig. 3C, D): femur lacking strong spine; tibia with two retrolaterodistal apophyses, dorsal apophysis beak-like and ventral apophysis spine-like (Fig. 3D); tarsus with transverse depression (Fig. 3D). Bulb with embolus bearing sickle-like tip and three types of sclerites: prolateral sclerite spine-like; median sclerite narrow, leaf-like; retrolateral sclerite transparent and membranous (Fig. 3B–D).

Female (paratype). Similar to male in color and general features, habitus as in Fig. 4A, B. Total length 1.80. Prosoma 0.68 long, 0.61 wide. Opisthosoma 1.12 long, 0.63 wide. Clypeus 0.11 high. Leg measurements: I 4.16 (1.15, 0.38, 1.15, 0.90, 0.58); II 3.15 (0.90, 0.26, 0.83, 0.71, 0.45); III 2.68 (0.77, 0.19, 0.64, 0.63, 0.45); IV 3.78 (1.15, 0.26, 1.09, 0.77, 0.51). Internal genitalia (Fig. 4C) with atrium rectangular, genital duct coiled apically, and spermathecae round.

Etymology. The specific name refers to the type locality and is a noun in apposition.

Habitat. Litter layers in mixed forest.

Distribution. South Korea (Jeollabuk-do; Fig. 12).

Genus *Longileptoneta* Seo, 2015

Longileptoneta Seo, 2015a: 306

Type species. *Longileptoneta songniensis* Seo, 2015 from South Korea.

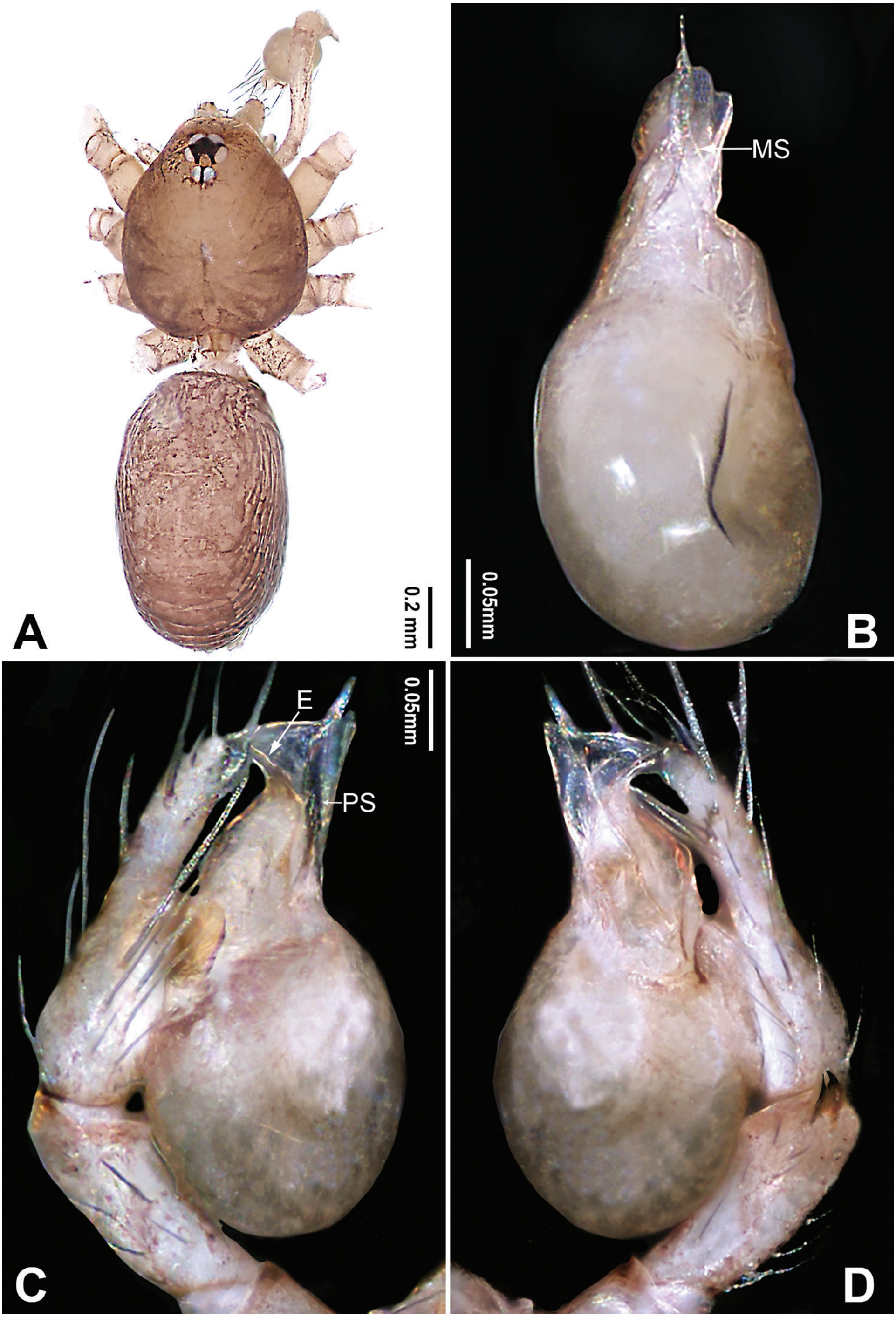

Figure 3. *Falcileptoneta naejangsan* sp. nov., holotype male **A** habitus, dorsal view **B** palpal bulb, ventral view **C** palp, prolateral view **D** palp, retrolateral view. Abbreviations: **E** embolus **MS** median sclerite **PS** prolateral sclerite. Scale bars: equal for **C, D**.

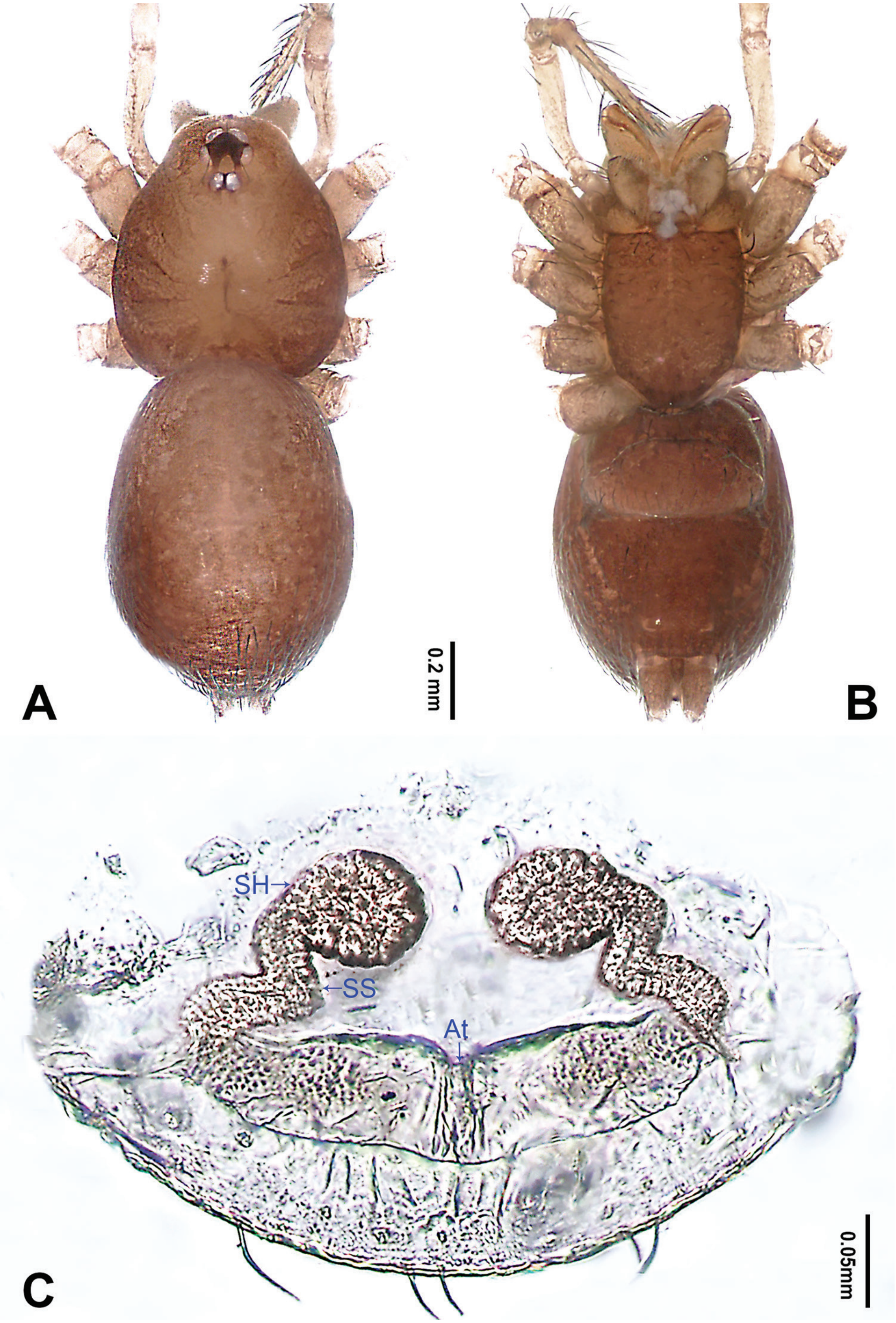

Figure 4. *Falcileptoneta naejangsan* sp. nov., female paratype **A** habitus, dorsal view **B** habitus, ventral view **C** internal genitalia, dorsal view. Abbreviations: **At** atrium **SH** spermathecae **SS** spermathecae stalk. Scale bars: equal for **A, B**.

Diagnosis. The genus *Longileptoneta* is similar to *Falcileptoneta* and *Leptoneta* in having few sclerites on the bulb and absenting cribellum but can be distinguished by the following combination of male palpal characters: femur with many strong spines (Figs 5C, D, 8A, B, 10C, D); tibia without apophyses or with simple apophyses (Figs 5D, 7D, 8B, 10D); tarsus usually with the prolateral curvature bearing prolaterodistal spurs (Figs 5C, D, 8A, B, 10C, D); bulb usually with leaf-like embolus, narrow and nearly ribbon-like prolateromesal sclerites, serrated tip, transparent and tongue-like retrolateral sclerite (Figs 5B–D, 7B–D, 10B–D).

Longileptoneta buyongsan **sp. nov.**

http://zoobank.org/B2B9B136-76D5-49DA-B56E-11127DF24DA5

Figures 5, 6, 12

Type material. ***Holotype.*** Male (NIBR), South Korea, Chungcheongbuk-do, Eumseong-gun, Eumseong-eup, Sajeong-ri, Mt. Buyongsan (36.970236°N, 127.619596°E, elevation ca 167 m), 6 August 2019, ZG. Chen, Z. Zhao & YY. Hu leg. ***Paratypes.*** 1 male and 1 female (NIBR), same data as holotype.

Diagnosis. *Longileptoneta buyongsan* sp. nov. is similar to *L. gayaensis* Seo, 2016 and *L. songniensis* Seo, 2015 but can be distinguished by the palpal tibia with one small retrolaterodistal apophysis (Fig. 5D) (vs. tibia without apophysis in *L. gayaensis* and *L. songniensis*); by the palpal tarsus without spur at tip (Fig. 5C, D) (vs. tarsus with one spur at tip in *L. gayaensis*; tarsus with one spur at tip and one prolateroproximal spur, branched retrolaterally in *L. songniensis*); also distinguished from *L. songniensis* by the palpal bulb with needle-shaped prolateral sclerite and shoehorn-like median sclerite (Fig. 5B–D) (vs. without prolateral sclerite and finger-like median sclerite in *L. songniensis*).

Description. Male (holotype). Total length 1.86. Prosoma 0.82 long, 0.76 wide. Opisthosoma 1.04 long, 0.74 wide. Clypeus 0.11 high. Leg measurements: I 5.56 (1.60, 0.30, 1.67, 1.28, 0.71); II 4.50 (1.28, 0.26, 1.29, 1.03, 0.64); III 3.56 (1.03, 0.19, 0.89, 0.83, 0.62); IV 4.96 (1.41, 0.24, 1.47, 1.15, 0.69). Habitus as in Fig. 5A. Prosoma brownish. Eyes six (Fig. 5A). Median groove, cervical grooves and radial furrows distinct. Opisthosoma yellowish, ovoid. Palp (Fig. 5C, D): femur with many strong spines (Fig. 5C, D); tibia with one small retrolaterodistal apophysis (Fig. 5D); tarsus with many spines and prolateral curvature (Fig. 5C, D). Bulb with leaf-like embolus and three types of sclerites: prolateral sclerite needle-shaped; median sclerite shoehorn-like; retrolateral sclerite transparent and triangular (Fig. 5B–D).

Female (one of the paratypes). Similar to male in color and general features, habitus as in Fig. 6A, B. Total length 1.77. Prosoma 0.71 long, 0.61 wide. Opisthosoma 1.06 long, 0.70 wide. Clypeus 0.10 high. Leg measurements: I 3.95 (1.09, 0.25, 1.14, 0.89, 0.58); II 3.13 (0.88, 0.20, 0.87, 0.63, 0.55); III – (0.71, -, -, -, -); IV 3.79 (1.08, 0.24, 1.07, 0.83, 0.57). Internal genitalia (Fig. 6C) with atrium rectangular, spermatheca and genital duct tube-shaped, loosely coiled.

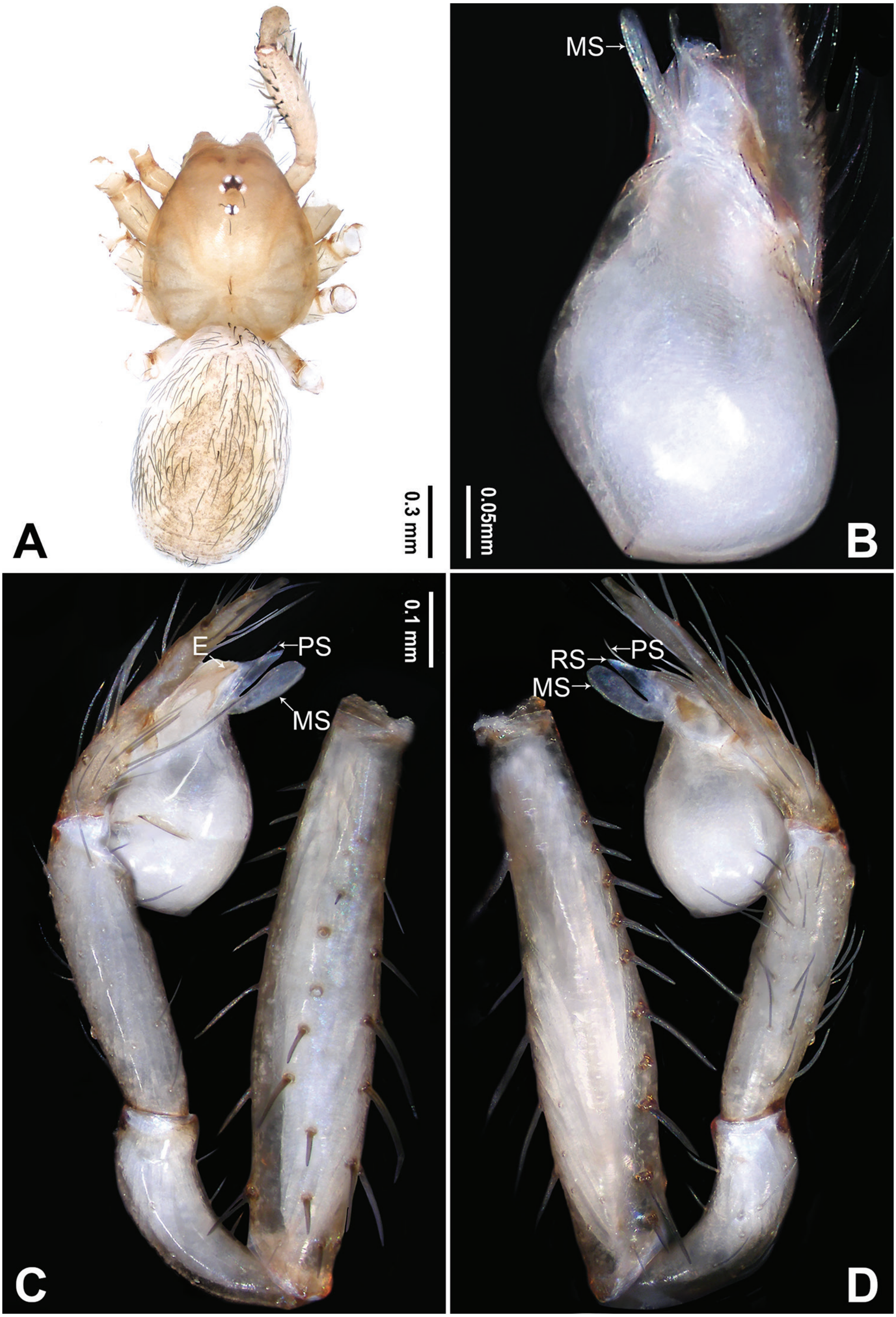

Figure 5. *Longileptoneta buyongsan* sp. nov., holotype male **A** habitus, dorsal view **B** palpal bulb, ventral view **C** palp, prolateral view **D** palp, retrolateral view. Abbreviations: **E** embolus **MS** median sclerite **PS** prolateral sclerite **RS** retrolateral sclerite. Scale bars: equal for **C, D**.

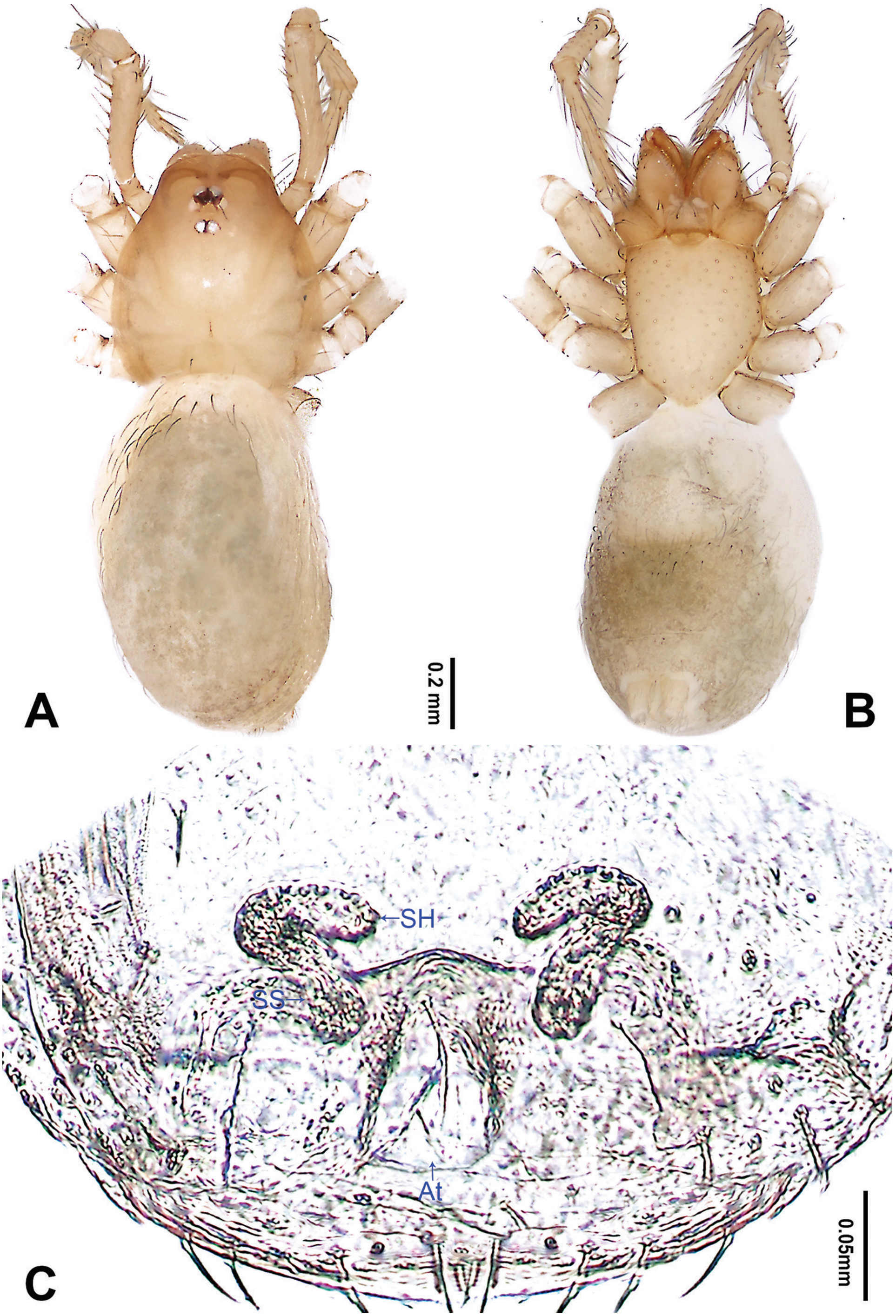

Figure 6. *Longileptoneta buyongsan* sp. nov., female paratype **A** habitus, dorsal view **B** habitus, ventral view **C** internal genitalia, dorsal view. Abbreviations: **At** atrium **SH** spermathecae **SS** spermathecae stalk. Scale bar: equal for **A, B**.

Etymology. The specific name refers to the type locality and is a noun in apposition.

Habitat. Litter layers in mixed forest.

Distribution. South Korea (Chungcheongbuk-do; Fig. 12).

Longileptoneta sp. nov.

http://zoobank.org/77E95657-EE0D-40ED-A697-8CC89B6C4B7D

Figures 7–9, 12

Type material. ***Holotype.*** Male (NIBR), South Korea, Jeollabuk-do, Buan-gun, Sangseo-myeon, Cheongrim-ri, Byeonsanbando National Park (35.670146°N, 126.629253°E, elevation ca 135 m), 8 August 2019, ZG. Chen, Z. Zhao & YY. Hu leg. ***Paratypes.*** 1 male and 1 female (NIBR), same data as holotype.

Diagnosis. *Longileptoneta byeonsanbando* sp. nov. is similar to *L. gayaensis* Seo, 2016 and *L. jangseongensis* Seo, 2016 but can be distinguished by the palpal tibia with one distal columnar apophysis, with apophysis tip armed with one long spine retrolaterally (Figs 7D, 8B) (vs. tibia without apophysis in *L. gayaensis*; tibia with one small apophysis armed with one spine in *L. jangseongensis*); by the palpal bulb with narrow, leaf-like prolateral sclerite and ribbon-like median sclerite (Fig. 7B–D) (vs. needle-like prolateral sclerite and shoehorn-like median sclerite in *L. gayaensis*; without prolateral sclerite and leaf-like median sclerite in *L. jangseongensis*); and can be further distinguished from *L. gayaensis* by the presence of two spurs at tarsal tip (Fig. 8A, B) (vs. one spur in *L. gayaensis*).

Description. Male (holotype). Total length 2.39. Prosoma 0.98 long, 0.86 wide. Opisthosoma 1.41 long, 0.90 wide. Clypeus 0.13 high. Leg measurements: I 6.81 (1.79, 0.33, 1.99, 1.67, 1.03); II 5.51 (1.56, 0.32, 1.54, 1.26, 0.83); III 4.43 (1.29, 0.26, 1.15, 1.02, 0.71); IV 6.15 (1.67, 0.32, 1.78, 1.47, 0.91). Habitus as in Fig. 7A. Prosoma brown. Eyes six (Fig. 7A). Median groove, cervical grooves and radial furrows distinct. Opisthosoma brown, ovoid. Palp (Figs 7C, D, 8A, B): femur with many strong spines and very long (Fig. 8A, B); patella very long (Fig. 8A, B); tibia with one distal columnar apophysis, with apophysis tip armed with one long spine retrolaterally (Figs 7D, 8B); tarsus with two spurs at tip and many spines, and with prolateral curvature (Fig. 8A, B). Bulb with leaf-like embolus and three types of sclerites: prolateral sclerite narrow, leaf-like; median sclerite ribbon-like; retrolateral sclerite with serrated tip, transparent and tongue-like (Fig. 7B–D).

Female (one of the paratypes). Similar to male in color and general features, habitus as in Fig. 9A, B. Total length 2.02. Prosoma 0.78 long, 0.68 wide. Opisthosoma 1.24 long, 0.86 wide. Clypeus 0.12 high. Leg measurements: I 5.23 (1.41, 0.31, 1.47, 1.14, 0.90); II 4.13 (1.16, 0.21, 1.15, 0.90, 0.71); III 3.33 (0.96, 0.19, 0.83, 0.77, 0.58); IV 4.61 (1.28, 0.32, 1.27, 1.03, 0.71). Internal genitalia (Fig. 9C): atrium trapezoidal, spermathecae and genital duct slender, tube-shaped, loosely coiled.

Etymology. The specific name refers to the type locality and is a noun in apposition.

Habitat. Litter layers in mixed forest.

Distribution. South Korea (Jeollabuk-do; Fig. 12).

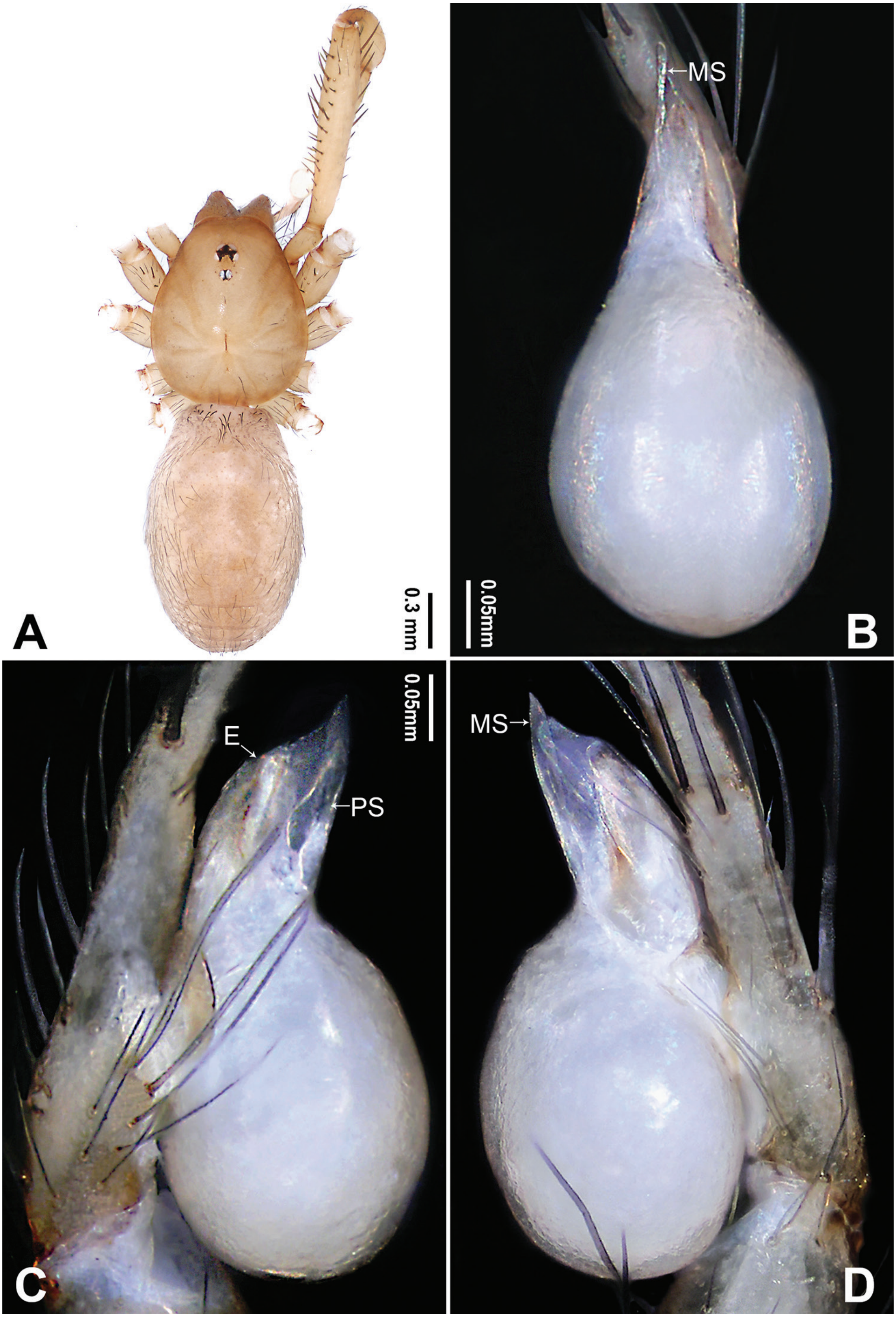

Figure 7. *Longileptoneta byeonsanbando* sp. nov., holotype male **A** habitus, dorsal view **B** palpal bulb, ventral view **C** palpal bulb, prolateral view **D** palpal bulb, retrolateral view. Abbreviations: **E** embolus **MS** median sclerite **PS** prolateral sclerite. Scale bars: equal for **C, D**.

Figure 8. *Longileptoneta byeonsanbando* sp. nov., holotype male **A** palp, prolateral view **B** palp, retrolateral view. Scale bars: equal for **A, B**.

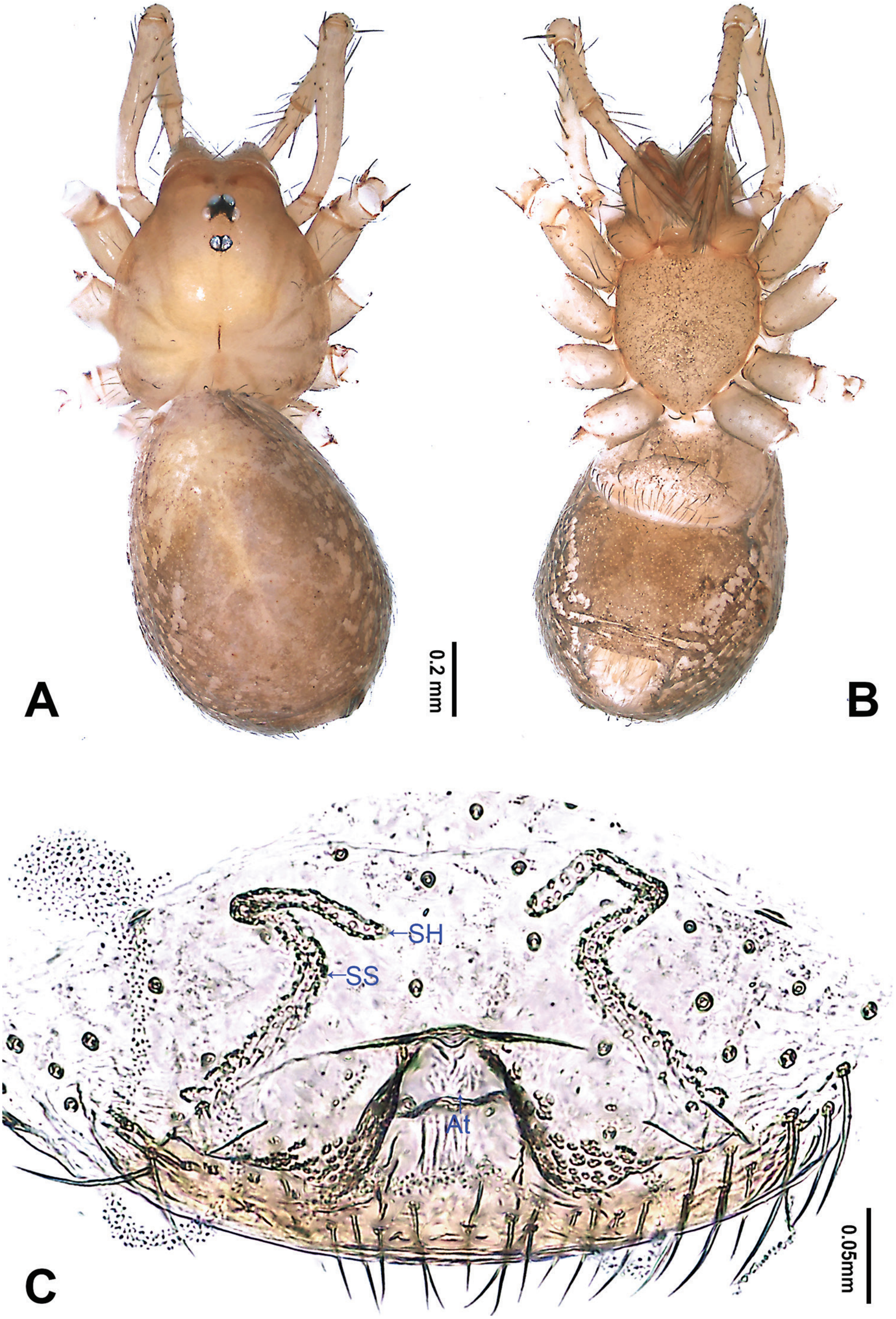

Figure 9. *Longileptoneta byeonsanbando* sp. nov., female paratype **A** habitus, dorsal view **B** habitus, ventral view **C** internal genitalia, dorsal view. Abbreviations: **At** atrium **SH** spermathecae **SS** spermathecae stalk. Scale bars: equal for **A, B**.

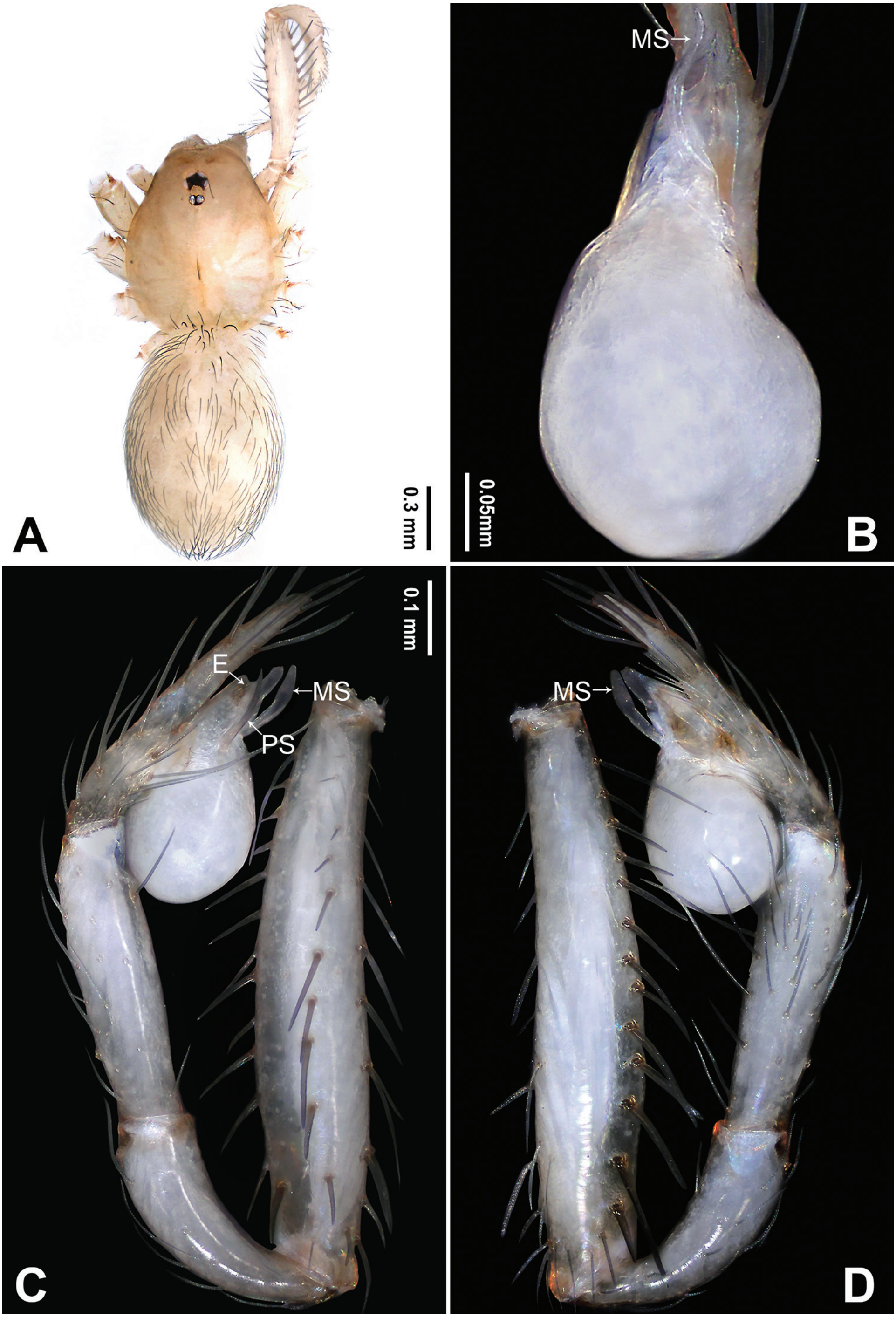

Figure 10. *Longileptoneta jirisan* sp. nov., holotype male **A** habitus, dorsal view **B** palpal bulb, ventral view **C** palp, prolateral view **D** palp, retrolateral view. Abbreviations: **E** embolus **MS** median sclerite **PS** prolateral sclerite. Scale bars: equal for **C, D**.

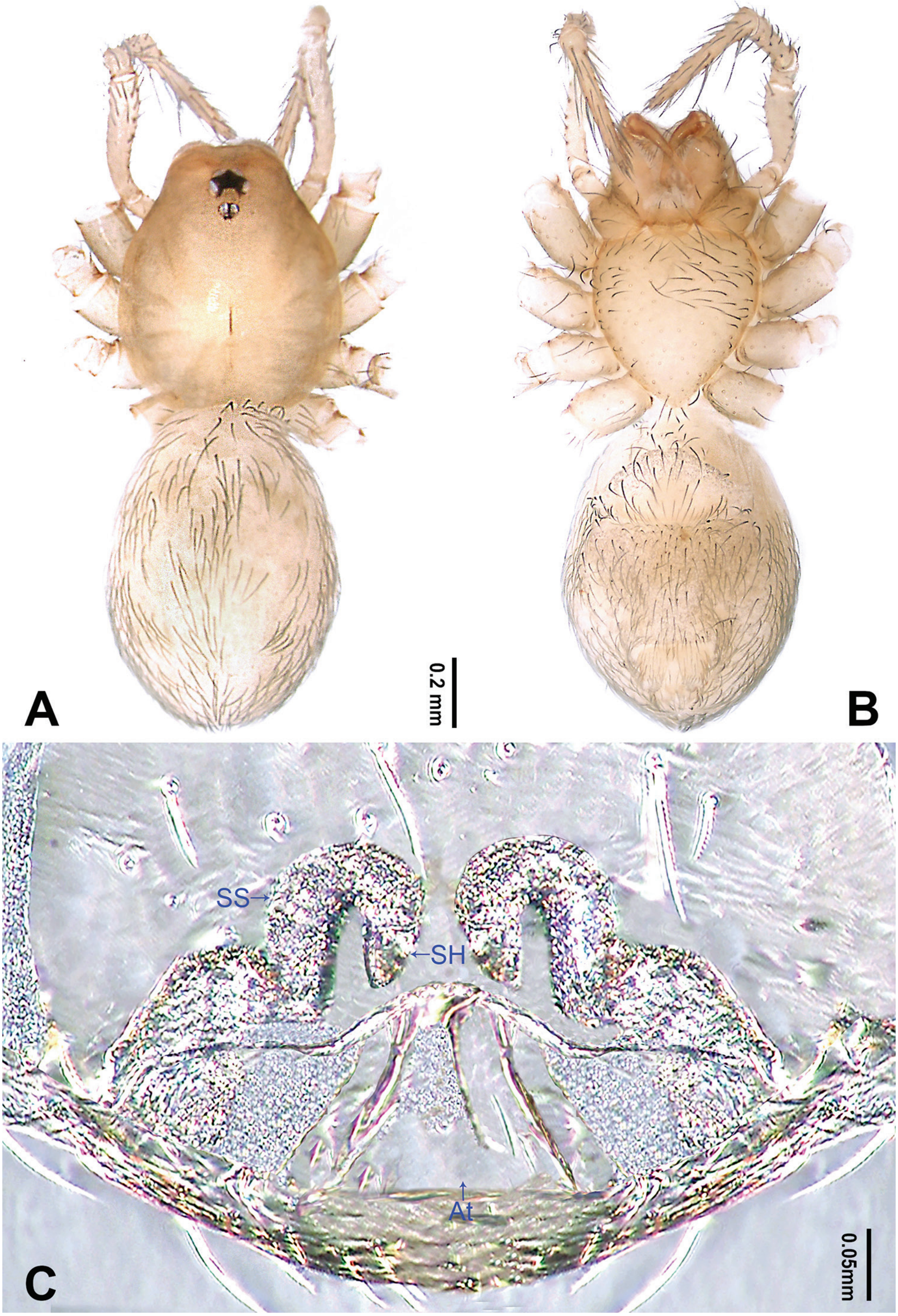

Figure 11. *Longileptoneta jirisan* sp. nov., female paratype **A** habitus, dorsal view **B** habitus, ventral view **C** internal genitalia, dorsal view. Abbreviations: **At** atrium **SH** spermathecae **SS** spermathecae stalk. Scale bars: equal for **A, B**.

Figure 12. Known distribution records of new leptonetid species from Korea **1** *Falcileptoneta dolsan* sp. nov. **2** *Falcileptoneta naejangsan* sp. nov. **3** *Longileptoneta buyongsan* sp. nov. **4** *Longileptoneta byeonsanbando* sp. nov. **5** *Longileptoneta jirisan* sp. nov.

Longileptoneta jirisan sp. nov.

http://zoobank.org/9BF96C1B-55D4-402C-8A33-1E0B9FAA1101

Figures 10–12

Type material. ***Holotype.*** Male (NIBR), South Korea, Gyeongsangnam-do, Hadong-gun, Hwagye-myeon, Daeseong-ri, Mt. Jirisan National Park (35.273974°N, 127.657439°E, elevation ca 357 m), 15 August 2019, ZG. Chen, Z. Zhao & YY. Hu leg. ***Paratype.*** 1 female (NIBR), same data as holotype.

Diagnosis. *Longileptoneta jirisan* sp. nov. is similar to *L. gachangensis* Seo, 2016 and *L. weolakensis* Seo, 2016 but can be distinguished by the palpal tibia with one retrolaterodistal spur (Fig. 10D) (vs. tibia without apophysis in *L. gachangensis* and *L. weolakensis*); and by the palpal bulb with spur-like prolateral sclerite and tongue-like retrolateral sclerite (Fig. 10C, D) (vs. blade-like prolateral sclerite and skinny and triangular retrolateral sclerite in *L. gachangensis*; without prolateral sclerite and triangular retrolateral sclerite in *L. weolakensis*).

Description. Male (holotype). Total length 1.85. Prosoma 0.78 long, 0.72 wide. Opisthosoma 1.07 long, 0.76 wide. Clypeus 0.10 high. Leg measurements: I 5.52 (1.60, 0.27, 1.67, 1.35, 0.63); II 4.50 (1.35, 0.25, 1.28, 1.03, 0.59); III 3.68 (1.04, 0.19, 0.96, 0.91, 0.58); IV 5.04 (1.47, 0.26, 1.53, 1.16, 0.62). Habitus as in Fig. 10A. Prosoma brownish. Eyes six (Fig. 10A). Median groove, cervical grooves and radial furrows distinct. Opisthosoma yellowish, ovoid. Palp (Fig. 10C, D): femur with many strong spines (Fig. 10C, D); tibia with one retrolaterodistal spur (Fig. 10D); tarsus with two spurs at tip and many spines, and with prolateral curvature (Fig. 10C, D). Bulb with leaf-like embolus and three types of sclerites: prolateral sclerite spur-like; median sclerite leaf-like; retrolateral sclerite with serrated tip, transparent and tongue-like (Fig. 10B–D).

Female (paratype). Similar to male in color and general features, habitus as in Fig. 11A, B. Total length 1.76. Prosoma 0.74 long, 0.62 wide. Opisthosoma 1.02 long, 0.68 wide. Clypeus 0.10 high. Leg measurements: I 4.43 (1.28, 0.26, 1.34, 0.97, 0.58); II 3.44 (0.96, 0.22, 0.94, 0.76, 0.56); III 2.92 (0.83, 0.19, 0.74, 0.66, 0.50); IV 4.10 (1.17, 0.24, 1.16, 0.97, 0.56). Internal genitalia (Fig. 11C) with atrium trapezoidal, spermatheca and genital duct tube-shaped, loosely coiled.

Etymology. The specific name refers to the type locality and is a noun in apposition.

Habitat. Litter layers in mixed forest.

Distribution. South Korea (Gyeongsangnam-do; Fig. 12).

Acknowledgements

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References

ESRI (2002) ArcView GIS. Version 3.2. Environmental Systems Research Institute, Redlands, California. http://www.esri.com/software/arcgis/arcview/ [accessed 25 September 2020]

Irie T, Ono H (2007) Two new species of the genus *Falcileptoneta* (Arachnida, Araneae, Leptonetidae) collected from Chûbu District, Honshu. Bulletin of the National Museum of Nature and Science, Tokyo (A) 33: 175–180.

Khmelik VV, Kozub D, Glazunov A (2006) Helicon Focus. Version 3.10.3. http://www.heliconsoft.com/heliconfocus.html [accessed 25 September 2020]

Komatsu T (1970) A new genus and a new species of Japanese spiders (*Falcileptoneta* n. g. and *Sarutana kawasawai* n. sp., Leptonetidae). Acta Arachnologica 23: 1–12. https://doi.org/10.2476/asjaa.23.1

Li S (2020) Spider taxonomy for an advanced China. Zoological Systematics 45(2): 73–77. https://doi.org/10.11865/zs.202011

Seo BK (2015a) Four new species of the genera *Masirana* and *Longileptoneta* (Araneae, Leptonetidae) from Korea. Korean Journal of Environmental Biology 33(3): 306–313. https://doi.org/10.11626/KJEB.2015.33.3.306

Seo BK (2015b) Ten new species of the genus *Falcileptoneta* (Araneae, Leptonetidae) from Korea. Korean Journal of Environmental Biology 33(3): 290–305. https://doi.org/10.11626/KJEB.2015.33.3.290

Seo BK (2016a) Four new species of the genus *Falcileptoneta* (Araneae, Leptonetidae) from Korea. Journal of Species Research 5(3): 590–595. https://doi.org/10.12651/JSR.2016.5.3.590

Seo BK (2016b) Four new species of the genus *Longileptoneta* (Araneae, Leptonetidae) from Korea. Journal of Species Research 5(3): 584–589. https://doi.org/10.12651/JSR.2016.5.3.584

Wang C, Xu X, Li S (2017) Integrative taxonomy of *Leptonetela* spiders (Araneae, Leptonetidae), with descriptions of 46 new species. Zoological Research 38(6): 321–448. https://doi.org/10.24272/j.issn.2095-8137.2017.076

Wang C, Li S, Zhu W (2020) Taxonomic notes on Leptonetidae (Arachnida, Araneae) from China, with descriptions of one new genus and eight new species. Zoological Research 41(6): 684–704. https://doi.org/10.24272/j.issn.2095-8137.2020.214

WSC (2020) World Spider Catalog. Version 21.0. Natural History Museum Bern. http://wsc.nmbe.ch [accessed 8 December 2020] https://doi.org/10.24436/2

Xu M, Kim ST, Yoo JS, Nam EJ, Li S (2019) Three new species of the genus *Falcileptoneta* Komatsu, 1970 (Araneae, Leptonetidae) from Korea. ZooKeys 872: 1–12. https://doi.org/10.3897/zookeys.872.34594

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RESEARCH ARTICLE

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Taxonomic review of the *Cataglyphis livida* complex (Hymenoptera, Formicidae), with a description of a new species from Iran

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Abstract

Cataglyphis fici **sp. nov.**, a member of the *Cataglyphis livida* complex, is described from the Estahban county of south-western Iran. The species is characterized by small body size and yellow to yellowish red body coloration with distinctly infuscated legs. Additionally, the taxonomic status of all known members of the *Cataglyphis livida* complex is updated. *Cataglyphis lutea* Pisarski, 1967, **stat. rev.** is raised to the species level and *Cataglyphis viaticoides* (André, 1881) is proposed as a senior synonym of *Cataglyphis livida bulgarica* Atanassov, 1982, **syn. nov.** and *Cataglyphis albicans mixtus* (Forel, 1895), **syn. nov.** Finally, a provisional key to members of the *livida* complex is provided.

Keywords

Cataglyphis, eastern Mediterranean, key to species, south-western Iran, taxonomy

Introduction

The ant genus *Cataglyphis* Foerster, 1850 currently includes 112 valid species and subspecies (Bolton 2020) distributed mostly in the semideserts and deserts of the Palearctic Region and the sub-Saharan area, India, and Pakistan. *Cataglyphis* species are among the most common ants occurring in arid and open, Mediterranean-type habitats of North Africa, the Arabian Peninsula, and Central Asia. Less frequently, *Cataglyphis* was recorded from the high altitude, mountain steppes, or forest steppes (Agosti 1990; Radchenko 1997; Brown 2000). Members of the genus are thermophilous, nest in ground and feed mainly on dead insects and other invertebrates. They are characterized by a strictly diurnal activity and are recognized for their superior navigating abilities (Lenoir et al. 2009; Wehner 2020).

The very first worldwide revision of the genus (Santschi 1929) is outdated. The only modern and comprehensive revision of *Cataglyphis* was presented by Agosti (1990) who provided, among others, its redefined species group division. Unfortunately, most of the groups recognized by Agosti remain unrevised and consist of taxa of uncertain status. On the regional level *Cataglyphis* was revised in the following countries: Armenia (Arakelian 1994), Bulgaria (Atanassov and Dlussky 1992), China (Chang and He 2002), Iraq (Pisarski 1965), Kingdom of Saudi Arabia (Collingwood and Agosti 1996), Morocco (Cagniant 2009), Portugal (Collingwood and Prince 1998), and Turkmenistan (Dlussky et al. 1992). There are also available revisions or checklists covering the former European U.S.S.R. (Arnol'di and Dlussky 1978), Iberian Peninsula (Collingwood 1978), Asia (Radchenko 1997, 1998), Central and North Europe (Seifert 2018), and Arabian Peninsula (Collingwood et al. 2011; Sharaf et al. 2015).

Recent publications, presenting descriptions of new species and changes in taxonomic statuses of these already described, proved that the diversity of *Cataglyphis* is underestimated and requires further studies (Radchenko and Paknia 2010; Amor and Ortega 2014; Sharaf et al. 2015; Ionescu and Eyer 2016; Salata and Borowiec 2018). Iran, due to its location and predominance of open and arid habitats, hosts one of the highest numbers of *Cataglyphis* species. So far, there are 35 *Cataglyphis* taxa recorded for this country, but some records need confirmation or correction (Paknia et al. 2008, 2009; Moradloo et al. 2015; Janicki et al. 2016; Rad et al. 2018; Khalili-Moghadam et al. 2021).

Cataglyphis fici, a new species collected in Fars Province of Iran, is a member of the *Cataglyphis albicans* species group sensu Agosti (1990). Its members are characterized by small body size (WL < 3.5 mm), monomorphic workers and colonies lacking distinct major or soldier castes, nodiform petiole with angled dorsal outline and short peduncle, subtly microsculptured and shiny body, and uniformly yellow to black mesosoma. Within the *albicans* species group, *C. fici* is most similar to species listed within the *livida* complex. Agosti (1990) characterized this complex based on uniform, yellow body coloration and included there three species: *C. argentata* (Radoszkowsky), *C. livida* (André), and *C. viaticoides* (André), four subspecies: *C. albicans aurata* Menozzi, *C. albicans fezzanensis* Bernard, *C. albicans mixtus* (Forel), and *C. livida lutea* Pisarski, and four quadrinominal unavailable names: *C. livida lutea agnata* Santschi, *C. livida lutea ambigua* Santschi, *C. livida lutea arabica* (Emery), and *C. livida lutea arenaria* Finzi. Members of the *livida* complex are distributed from Morocco to Indus river including the Arabian Peninsula, and inhabit semi-deserts, deserts, and rocky open areas such as dry hills or coastal cliffs.

The work presented here is a contribution to studies on members of the *C. livida* complex. We list an updated synopsis of members of this complex and provide a provisional key to their identification. Additionally, we describe *Cataglyphis fici* sp. nov., a new member of the *C. livida* complex, based on material recently collected from Iran.

Materials and methods

Investigated specimens were collected in fig orchards located in Estahban city, Fars Province, Iran and are part of the material gathered for a scientific project conducted by the second author. The city is placed 1730 m a.s.l and is characterized by a dry climate, with a yearly precipitation amount of 224 millimeters and summer temperatures frequently exceeding 25.0 °C.

The dominant method was direct sampling (hand collecting). Individual specimens were collected on the ground and preserved in 75% EtOH. Photographs were taken using a Nikon SMZ 1500 stereomicroscope, Nikon D5200 photo camera, and Helicon Focus software. All given label data are in the original spelling, presented in square brackets; a vertical bar (|) separates data on different rows and double vertical bars (||) separate labels. Type specimens' photographs are available online on AntWeb (www.AntWeb.org) and are accessible using the unique CASENT identifying specimen code.

Examined specimens are housed in the following collections:

MNHW	Museum of Natural History, University of Wrocław, Poland, in temporary deposit by Department of Biodiversity and Evolutionary Taxonomy, University of Wrocław, Poland;
MHNG	Muséum d'Historie Naturelle, Genève, Switzerland.

Measurements:

HL	head length; measured in a straight line from mid-point of anterior clypeal margin to mid-point of posterior margin in full-face view;
HW	head width; measured in full-face view at the center of the eyes;
SL	scape length; maximum straight-line length of scape excluding the basal condylar bulb;
PW	pronotum width; maximum width of pronotum in dorsal view;
PRL	propodeum length; measured in lateral view, from metanotal groove to posterior-most point of propodeum;
PRW	propodeum width; maximum width of propodeum in dorsal view;
PTH	petiole height; the chord of ventral petiolar profile at node level is the reference line perpendicular to which the maximum height of petiole is measured, measured in lateral view;
PTW	petiole width; maximum width of the petiolar node in lateral view;

WL	Weber's length; measured as diagonal length from the anterior end of the neck shield to the posterior margin of the propodeal lobe;
HFL	hind femur length; measured on dorsal side from trochanter to apex of femur.

All measurements are given in mm.
Ratios

CI	cephalic index, HL/HW;
SI	scape index, SL/HL;
PI	petiole index, PTH/PTW;
FI	femur index, HFL/WL.

Synopsis of species of the *Cataglyphis livida* complex

Cataglyphis arenaria Finzi, 1940
Cataglyphis argentata (Radoszkowsky, 1876)*
Cataglyphis aurata Menozzi, 1932
Cataglyphis fici sp. nov.
Cataglyphis livida (André, 1881)
Cataglyphis lutea Pisarski, 1967, stat. rev.
Cataglyphis viaticoides (André, 1881)
= *Cataglyphis livida bulgarica* Atanassov, 1982, syn. nov.
= *Cataglyphis albicans mixtus* (Forel, 1895), syn. nov.

Taxonomy

Diagnosis of workers of the *Cataglyphis livida* complex

Small body size (WL < 3.0 mm); colonies with monomorphic workers, lacking distinct major or soldier castes; petiole nodiform with angled dorsal outline and short peduncle; body subtly microsculptured and shiny; body uniformly yellow to red (never brown to black) or bicolored with entirely to partially black gaster.

Distribution: from Morocco to Asia Minor and the Middle East, in semideserts, deserts and rocky open areas such as dry hills or coastal cliffs.

Note 1. Agosti (1990), as the first one, noticed that the data from labels of type specimens of *C. viaticoides* did not correspond with the original description of the species. This problem was later investigated and clarified by Bračko et al. (2016). Based on evidence gathered and discussed by the authors, the definition of the *livida* complex proposed by Agosti (1990) was modified to accommodate *C. viaticoides*.

Note 2. Based on its description, *C. albicans fezzanensis* Bernard is characterized by the presence of polymorphic worker caste, and additional study on the type specimen

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* Due to ambiguous description of this species it is tentatively assigned to the *livida* complex.

indicated that its body sculpture is stronger and less shiny than in other members of the *livida* complex. Based on this data, we decided not to list this species as a member of this complex.

Provisional key to the *Cataglyphis livida* complex

1 At least mid and hind legs infuscated. Iran.. ***C. fici***
– Legs in the same coloration as mesosoma...**2**
2 Head and mesosoma uniformly yellowish red to reddish yellow, gaster entirely or mostly black, Balkans to Asia Minor......................... ***C. viaticoides***
– Gaster in the same coloration as the rest of body (yellow to red) or its apex slightly infuscated **3**
3 Mesosoma and head without layer of silvery hair, northeastern Mediterranean to Middle East .... ***C. lutea***
– At least mesosoma with a layer of silvery hair, Morocco to Asia Minor........**4**
4 Mesosoma and posterior head with thick layer of silvery hair, North Africa.... .... ***C. arenaria*, *C. argentata*, *C. aurata***[*]
– A layer of silvery hair limited to mesosoma, Asia Minor................. ***C. livida***

Review of species

Cataglyphis fici **sp. nov.**
http://zoobank.org/81413366-4DA0-44D9-BF48-3ACD395E86F4
Figs 1–6

Type material. ***Holotype*****:** Iran •worker, Fars, Estahban, 29.1331/54.389, 1730 m a.s.l., 16 Aug. 2019, H. Kiyani leg., LBC-IR00179, CASENT6006519 (MNHW); ***paratypes*****:** 5 workers, the same data as holotype, CASENT6006520–CASENT6006524 (MNHW, MHNG); ***paratype*****:** worker: the same data as holotype except LBC-IR00180, CASENT6006525 (MNHW); ***paratype*****:** worker, the same data as holotype except 6 Sep. 2018 and LBC-IR00182, CASENT6006526 (MNHW).

Holotype worker labels**:** Iran, Fars, 1730 m | Estahban | 29.1331 / 54.389 | 16 VIII 2019, H. Kiyani || Collection L. Borowiec | Formicidae | LBC-IR00179 || CASENT6006519.

Diagnosis. *Cataglyphis fici* is a member of the *Cataglyphis albicans* group and can be separated from all species clustered in the *cinnamomea* and *fortis* complexes and most of members of the *albicans* complex by yellow to yellowish red body coloration; while other species have body completely brown to black. From bicolored species of the *albicans* complex it differs in smaller body size (WL < 3 mm) and presence of infuscated to

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[*] Note. The taxonomic status of *C. arenaria*, *C. argentata*, and *C. aurata* is unclear and requires further studies. Due to the lack of distinct morphological differences between types of these taxa and their ambiguous descriptions, we decided to list all three species in one couplet. For more details, see comments in the species accounts.

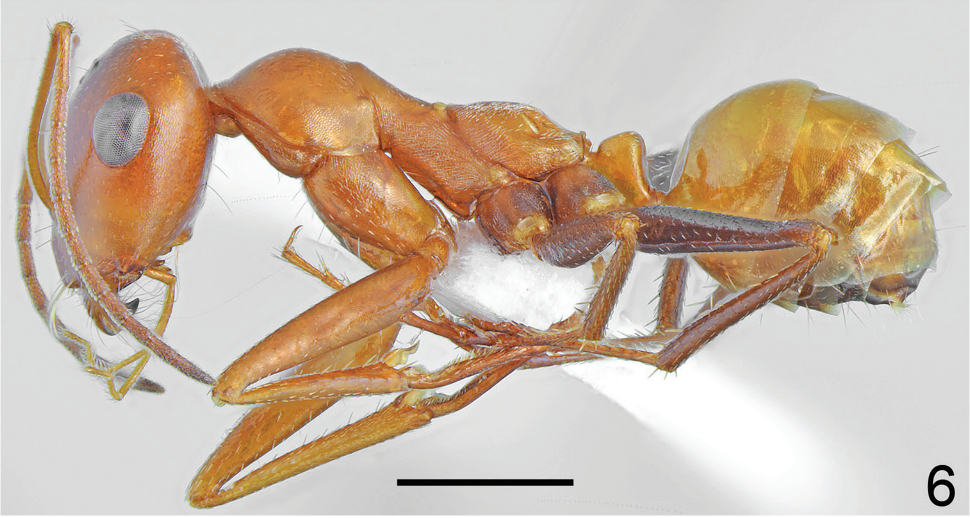
Figures 1, 2. Holotype worker of *Cataglyphis fici* sp. nov. **1** dorsal **2** lateral. Scale bars: 1 mm.

yellowish brown mid and hind legs. However, *C. fici* is most similar to species included in the *C. livida* complex and can be easily separated based on at least mid and hind legs partly to mostly infuscated to yellowish brown. In contrast, all remaining members of the *C. livida* complex have legs uniformly colored and always in the same shade as mesosoma and head. Additionally, *C. fici* differs from *C. lutea*, *C. arenaria*, *C. argentata*, *C. aurata*, and *C. livida* in gaster darker than head and mesosoma sometimes infuscated.

Description. Worker (n = 8): ***Measurements.*** HL: 1.405 (1.29–1.54); HW: 1.325 (1.23–1.43); SL: 1.483 (1.36–1.59); PW: 0.897 (0.84–0.97); PRL: 0.737

Figures 3, 4. Holotype worker of *Cataglyphis fici* sp. nov. **3** head **4** petiole Scale bars: 0.5 mm (**4**), 1 mm (**3**).

(0.68–0.79); PRW: 0.595 (0.56–0.65); PTH: 0.383 (0.32–0.654); PTW: 0.360 (0.34–0.38); WL: 1.933 (1.81–2.09); HFL: 2.038 (1.83–2.24); CI: 1.060 (1.038–1.077); SI: 1.056 (1.032–1.072); PI: 1.065 (0.889–1.158); FI: 1.054 (1.036–1.111). ***Color.*** Head, mesosoma and petiolar scale from yellow to yellowish red, in the darkest specimens sides of mesonotum and propodeum indistinctly infuscated, gaster in the palest specimens mostly yellow with infuscated two apical sternites (Fig. 6), in dark specimens yellowish at base then gradually infuscated apically, with dark brown apical tergites and sternites (Fig. 5). Forelegs in the palest specimens completely yellow, mid and hind legs with brown femora and tibiae and yellowish tarsi, in dark specimens all legs at least partly infuscated. Usually fore coxa mostly brown with reddish spots of



Figures 5, 6. Paratype workers of *Cataglyphis fici* sp. nov. **5** the darkest form **6** the palest form Scale bar: 1 mm.

diffused borders laterally, fore femora mostly brown with yellowish apices, fore tibiae yellowish brown and fore tarsi yellowish; mid and hind femora dark brown, tibiae yellowish brown to brown, tarsi yellowish to yellowish brown (Figs 2, 5). Antennal scape yellow, funicles in the palest specimens slightly darker than scape, yellowish basally and yellowish brown apically, in dark specimens only first segment of funiculus yellowish, remaining segments gradually yellowish brown to dark brown. ***Head.*** Subrectangular, approximately 1.05 × as long as wide, sides below eyes almost parallel, above eyes gently convex, occipital margin convex (Fig. 3). Anterior margin of the clypeus convex, with small median emargination, clypeal anterior margin with a row of short, white setae and additional six long, white setae, the longest as long as 0.7 × length of clypeus. Whole surface of clypeus densely microreticulate with shiny background, covered with very sparse and short, adpressed hairs. Eyes large, oval, approximately 1.4 × as long as wide. Frontal carinae short, not extending beyond frontal lobes, interocular area without shiny line or carina and with a pair of long white setae. Antennal fossa shallow, microreticulate with shiny background. Whole head surface finely microreticulate with shiny background, occipital part of the head and are behind eyes with reduced sculpture and shinier, covered with extremely sparse, indistinct, adpressed hairs. Ocellar region with a pair of moderately long white setae, occipital part of head with 2–6 long, white erect setae, underside only with a pair of long, white setae close to lateral margin of head. Antennal scape moderately long, in frontal view almost straight, approximately 1.1 × as long as length of the head; thin, in apex only slightly and gradually widened; its base without tooth. Funiculus long, first funicle segment elongated, approximately 0.8 × as long as segments II and III combined, and 1.7 × as long as segment II (Fig. 3). Surface of scape densely microsculptured; shiny to indistinctly opalescent; covered with strong, moderately dense, decumbent setae. Mandibles rounded, only in basal part smooth and shiny, apical ¾ with deep grooves, surface shiny with several long yellow setae, masticatory margin with four4 large teeth. ***Mesosoma.*** Long, 2.1 × as long as wide; metanotal groove shallow (Fig. 2). Pronotum convex on sides (Fig. 1). In lateral view promesonotum slightly arched in profile; propodeum positioned lower than promesonotum, moderately convex in lateral view; propodeal spiracle strongly elongated and slit-shaped, approximately 4.2 × as long as wide (Fig. 2). Whole mesosoma opalescent, with dense, fine microreticulation and shiny background; covered with extremely sparse and short adpressed microsetae, on sides of pro- and mesonotum appears almost hairless, only anterior part of pronotum, posterior angles of mesonotum and propodeum with sparse setosity. Pro- and mesonotum without erect setae, propodeum without erect setae or in its posterior part with one or two short, white, erect setae. ***Scale.*** In form of a short cuneiform node, in lateral view almost trapezoidal with very short peduncle. Anterior face close to base distinctly convex, posterior face slightly concave, top of scale in lateral view obtusely rounded, without erect setae (Fig. 4). In anterior and posterior view top margin of scale without emargination. Surface of petiole distinctly microreticulate and shiny. ***Gaster.*** With fine transverse microreticulation and striation and very shiny background. Whole surface of gaster with hardly visible, extremely short, sparse, adpressed microsetae, tergites I and II without erect setae, tergites III and IV with a pair of long white setae centrally, each gastral sternite with 2–4 long, white, erect setae. ***Legs.*** Dorsal and lateral surface of femora and tibiae covered with sparse, white adpressed setae. Ventral surface of femora and tibiae with rows of elongate, white, erect spiniform setae.

Biology. Little known, workers were collected on the ground in fig orchard at altitude 1730 m.

Etymology. The species name *fici* is a noun in the genitive case named after the generic name of the fig tree, *Ficus* sp., the dominant plant in the type locality of this ant species.

Cataglyphis arenaria Finzi, 1940

Cataglyphis (*Cataglyphis*) *albicans* var. *arenaria* Finzi, 1940: 164 [first available use of *Myrmecocystus albicans lividus arenaria* Forel, 1909: 384].
Status as species: Collingwood and Agosti (1996): 378.
Syntype worker, Biskra, Algeria (MHNG) [Syntype worker images examined, AntWeb, CASENT0911101, photographs by Alexandra Westrich, available on AntWeb.org].

Diagnosis. Whole body yellow, only gaster sometimes with indistinctly infuscated apex; mesosoma, posterior part of the head and coxae covered with a layer of silvery hair.

Distribution. North Africa region, from Mauritania to Jordan. Based on photographs available on AntWeb specimens from Arabian Peninsula probably refer to *C. lutea*.

Note. *Cataglyphis arenaria* was separated from *C. livida* and *C. viaticoides* based on the presence of a thick layer of silvery hair on mesosoma and posterior part of the head. Two years after the original description of *C. arenaria*, Karavaiev (1911) described *Myrmecocystus albicans* ssp. *lividus* var. *aurata*, which was later validated by Menozzi (1932) as trinominal. The latter species also was separated from *C. livida* based on presence of silvery hair on its body. Probably, Karavaiev was unaware of the existence of *C. arenaria* during his work on *C. aurata*. Study of type specimens and descriptions of both *C. arenaria* and *C. aurata* did not provide any characters useful in separating these two species. Thus, we conclude that both taxa could be conspecific (see also note in *Cataglyphis argentata* (Radoszkowsky, 1876) and *C. aurata* Menozzi, 1932). However, this hypothesis requires verification based on larger material collected from the whole area of their distribution, supported with studies on male genitalia, and genetic analyses.

Cataglyphis argentata (Radoszkowsky, 1876)

Camponotus argentata Radoszkowsky, 1876: 140.
Cataglyphis argentata: Dalla Torre (1893): 217.
Type specimens. Unavailable.

Diagnosis. Whole body yellow, only gaster sometimes with indistinctly infuscated apex; mesosoma, body covered with a layer of silvery hair.

Distribution. Egypt.

Note. Type specimens of this species are considered lost and, as suggested by Agosti (1990), due to ambiguous description of this species, its assignation to the *livida* complex is tentative. The silvery hair mentioned in the description can suggest an affiliation of *C. argentata* with the *bombycina* or *laevior* complexes. If *C. argentata* is a member of the *livida* complex, then its description could indicate that it is probably conspecific with two other North African taxa: *C. arenaria* and *C. aurata*. If this assumption is correct, then the name *C. argentata* has priority over *C. arenaria* and *C. aurata*.

Cataglyphis aurata Menozzi, 1932

Cataglyphis (*Cataglyphis*) *albicans aurata* Menozzi, 1932: 95 [first available use of *Myrmecocystus albicans* ssp. *lividus* var. *auratus* Karavaiev, 1911: 10].
Syntype worker, Assuan, Egypt (MHNG) [syntype worker images examined, AntWeb, CASENT0911100, photos by Zach Lieberman, available on AntWeb.org].

Diagnosis. Whole body yellow, only gaster sometimes with indistinctly infuscated apex; mesosoma, posterior head and coxa covered with a layer of silvery hair.

Distribution. North Africa. Probably records from Asia Minor refer to *Cataglyphis lutea*.

Note. *Cataglyphis aurata* was separated from *C. livida* based on the presence of a thick layer of silvery hair on its body. Probably, Karavaiev, during his work on *C. aurata*, was unaware of the existence of *C. arenaria*, another species described from the North African region characterized by the same feature. Study on type specimens and descriptions of both *C. arenaria* and *C. aurata* did not provide any characters useful separating these two species. Thus, we conclude that they could be conspecific. However, this hypothesis requires verification based on larger material collected from the whole area of their distribution, supported with studies on male genitalia, and genetic analyses. See also note in *C. argentata*.

Cataglyphis livida (André, 1881)

Myrmecocystus albicans var. *lividus* André, 1881: 58.
Status as species: Arnol'di (1964): 1810.
Syntype workers, Jaffa, Israel (MHNG) [syntype workers images examined, AntWeb, CASENT0911099 and CASENT0912207, photographs by Zach Lieberman and Will Ericson, available on AntWeb.org].

Diagnosis. Whole body yellow, only gaster sometimes with indistinctly infuscated apex; mesosoma and coxa covered with a layer of silvery hair.

Distribution. Unknown. Due to mislabeling of type specimens of *C. livida* and *C. viaticoides*, both species were wrongly interpreted, and most of their historic records require verification. Based on available material, we can confirm its presence in Egypt, coastal parts of Israel, Syria, and Antalya Province in Turkey.

Note. A study on type specimens of *C. livida* revealed that this species could be easily separated from most members of the *livida* complex based on the presence of a layer of silvery hair on propodeum and katepisternum, and lack of these on posterior head. Lack of comment on this feature in the original description combined with mislabeling of type specimens (see Bračko et al. 2016) caused confusion, leading to the long-lasting misinterpretation of *C. livida*.

Cataglyphis lutea Pisarski, 1967, stat. rev.

Cataglyphis livida subsp. *lutea* Pisarski, 1967: 418 [first available use of *Myrmecocystus albicans viaticoides lutea* Emery, 1906: 53].
Junior synonym of *Cataglyphis livida*: Radchenko, 1997: 428.
Syntype worker, Shiraz, Iran (MSNG) [Syntype worker images examined, AntWeb, CASENT0905718, photographs by Will Ericson, available on AntWeb.org].

Diagnosis. Whole body yellow, only gaster sometimes with indistinctly infuscated apex; body never with a layer of silvery hair.

Distribution. Species known from Arabian Peninsula east to Afghanistan.

Note. *Cataglyphis lutea* was described from Shiraz, Fars Province in Iran as an unavailable quadrinominal name (Emery 1906), later validated by Pisarski (1967) as a subspecies of *C. livida*, and finally considered as its junior synonym (Radchenko 1997). A study on type specimen revealed that *C. lutea* distinctly differs from *C. livida* in lack of a layer of silvery hair on mesosoma, and its distribution does not overlap with confirmed records of *C. livida*. Thus, we decided to raise it to the species status. AntCat resources indicated that, except type locality, *C. lutea* is also known from Aran va Bidgol, Maranjab, Iran (CDA000106) and Saudi Arabia (CASENT0906455).

Cataglyphis viaticoides (André, 1881)

Myrmecocystus albicans var. *viaticoides* André, 1881: 57.
Syntype worker, Beirut, Lebanon (MNHN) [syntype worker images examined, AntWeb, CASENT0912236, photographs by Zach Lieberman, available on AntWeb.org].
= *Cataglyphis livida bulgarica* subsp. *bulgarica* Atanassov, 1982: 213, syn. nov.
Type specimens unavailable.
= *Myrmecocystus albicans* var. *mixtus* Forel, 1895: 229, syn. nov.
Syntype worker, Edirne, Turkey (MHNG) [syntype worker images examined, AntWeb, CASENT0911104, photographs by Zach Lieberman, available on AntWeb.org].

Diagnosis. Head and mesosoma uniformly yellowish red to reddish yellow, gaster entirely or mostly dark; thin layer of silvery hair limited to propodeum.

Distribution. Balkans and Asia Minor.

Note. Radchenko (1997), based on confusion related to the type labels of *C. livida* and *C. viaticoides* (see Bračko et al. 2016), considered *C. livida bulgarica* and *C. albicans mixtus* as junior synonyms of *C. livida*. Results presented by Bračko et al. (2016) clarified that the only member of the *livida* complex with entirely or mostly black gaster is *C. viaticoides* and thus *Cataglyphis livida bulgarica* Atanassov, 1982 and *Cataglyphis albicans mixtus* (Forel, 1895) should be considered as its junior synonyms.

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References

Agosti D (1990) Review and reclassification of *Cataglyphis* (Hymenoptera, Formicidae). Journal of Natural History 24: 1457–1506. https://doi.org/10.1080/00222939000770851

Amor F, Ortega P (2014) *Cataglyphis tartessica* sp. n., a new ant species (Hymenoptera: Formicidae) in south-western Spain. Myrmecologican News 19: 125–132. https://doi.org/10.5281/zenodo.16346

André E (1881) Catalogue raisonné des Formicides provenant du voyage en Orient de M. Abeille de Perrin et description des espèces nouvelles. Annales de la Société Entomologique de France (6)1: 53–78. https://doi.org/10.5281/zenodo.27096

Arakelian GR (1994) Fauna of The Republic of Armenia. Hymenopterous insects. Ants (Formicidae). Erevan: Gitutium, 153 pp. [In Russian]

Arnol'di KV (1964) Higher and specialized representatives of the ant genus *Cataglyphis* (Hymenoptera, Formicidae) in the fauna of the USSR. Zoologicheskii Zhurnal 43: 1800–1815. [In Russian.] https://antcat.org/references/122339

Arnol'di KV, Dlussky GM (1978) Superfam. Formicoidea. 1. Fam. Formicidae – ants. In: Medvedev GS (Ed.) Keys to the insects of the European part of the USSR (Vol. 3). Hymenoptera. Part 1. Opredeliteli Faune SSSR 119: 519–556. [In Russian]

Atanassov N, Dlussky GM (1992) Fauna of Bulgaria. Hymenoptera, Formicidae. Fauna of Bulgaria 22: 1–310.

Bolton B (2020) An online catalog of the ants of the world. https://antcat.org. [accessed 25 August 2020]

Bračko G, Kiran K, Karaman C, Salata S, Borowiec L (2016) Survey of the ants (Hymenoptera: Formicidae) of the Greek Thrace. Biodiversity Data Journal 4: e7945. https://doi.org/10.3897/BDJ.4.e7945

Brown Jr WL (2000) Diversity of ants. In: Agosti D, Majer J, Alonso E, Schultz TR (Eds) Ants: Standard Methods for Measuring and Monitoring Biodiversity. Biological diversity hand book series. Smithsonian Institution Press, Washington, 280 pp.

Cagniant H (2009) Le genre *Cataglyphis* Foerster, 1850 au Maroc (Hyménoptères Formicidae). Orsis 24: 41–71. https://ddd.uab.cat/record/54485

Chang YD, He DH (2002) Three new species of the genus *Cataglyphis* Foerster from Northwest China (Hymenoptera: Formicidae: Formicinae). Zoological Research 23: 61–64. [In Chinese] http://www.zoores.ac.cn/en/article/id/826

Collingwood CA (1978) A provisional list of Iberian Formicidae with a key to the worker caste (Hym. Aculeata). EOS. Revista Española de Entomología 52: 65–95. https://doi.org/10.5281/zenodo.26690

Collingwood CA, Agosti D (1996) Formicidae (Insecta: Hymenoptera) of Saudi Arabia (Part 2). Fauna of Saudi Arabia 15: 300–385. https://antcat.org/references/130931

Collingwood C, Prince A (1998) A guide to ants of continental Portugal (Hymenoptera: Formicidae). Boletim da Sociedade Portuguesa de Entomologia. Suplemento 5: 1–49. https://doi.org/10.5281/zenodo.1244612

Collingwood C, Agosti D, Sharaf MR, van Harten A (2011) Order Hymenoptera, family Formicidae. Arthropod fauna of the UAE 4: 405–474. https://doi.org/10.5281/zenodo.1168586

Dalla Torre KW (1893) Catalogus Hymenopterorum Hucusque Descriptorum Systematicus et Synonymicus (Vol. 7). Formicidae (Heterogyna). W. Engelmann, Leipzig, 289 pp. https://www.biodiversitylibrary.org/page/10937376

Dlussky GM, Soyunov OS, Zabelin SI (1990) Ants of Turkmenistan. Ylym Press, Ashkabad, 273 pp. [In Russian]

Emery C (1906) Rassegna critica delle specie paleartiche del genere *Myrmecocystus*. Memorie della Reale Accademia delle Scienze dell'Istituto di Bologna (6)3: 47–61. https://doi.org/10.5281/zenodo.25506

Finzi B (1940) Formiche della Libia. Memorie della Società Entomologica Italiana 18 (1939): 155–166. https://doi.org/10.5281/zenodo.26322

Forel A (1895) Südpalaearctische Ameisen. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 9: 227–234. https://doi.org/10.5281/zenodo.14245

Forel A (1909) Études myrmécologiques en 1909. Fourmis de Barbarie et de Ceylan. Nidification des Polyrhachis. Bulletin de la Société Vaudoise des Sciences Naturelles 45: 369–407. https://doi.org/10.5281/zenodo.14425

Ionescu A, Eyer P-A (2015) Notes on *Cataglyphis* Foerster, 1850 of the *bicolor* species-group in Israel, with description of a new species (Hymenoptera: Formicidae). Israel Journal of Entomology 46: 109–131. https://doi.org/10.5281/zenodo.221456

Janicki J, Narula N, Ziegler M, Guénard B, Economo EP (2016) Visualizing and interacting with large-volume biodiversity data using client-server web-mapping applications: The design and implementation of antmaps.org. Ecological Informatics 32: 185–193. https://doi.org/10.1016/j.ecoinf.2016.02.006

Karavaiev V (1911) Ameisen aus Aegypten und dem Sudan. Russkoe Entomologicheskoe Obozrenie 11: 1–12. https://doi.org/10.5281/zenodo.25954

Khalili-Moghadam A, Salata S, Borowiec L (2021) Three new species of *Cataglyphis* (Hymenoptera: Formicidae) from Chaharmahal va Bakhtiari Province of Iran. ZooKeys 1009: 1–28. https://doi.org/10.3897/zookeys.1009.59205

Lenoir A, Aron S, Cerda X, Hefetz A (2009) *Cataglyphis* desert ants: a good model for evolutionary biology in Darwin's anniversary year–a review. Israel Journal of Entomology 39: 1–32. http://digital.csic.es/bitstream/10261/65135/1/israel.pdf

Menozzi C (1932) Missione scientifica del Prof. E. Zavattari nel Fezzan (1931). Hymenoptera-Formicidae. Bollettino della Società Entomologica Italiana 64: 93–95. https://doi.org/10.5281/zenodo.25776

Moradloo S, Fard RN, Rad SP, Taylor B (2015) Records of ants (Hymenoptera: Formicidae) from Northern Iran. Zoology in the Middle East 2015: 1–6. https://doi.org/10.1080/09397140.2015.1020611

Paknia O, Radchenko A, Alipanah H, Pfeiffer M (2008) A preliminary check list of the ants (Hymenoptera: Formicidae) of Iran. Myrmecological News 151–159. https://myrmecologicalnews.org/cms/index.php?option=com_content&view=category&id=254&Itemid=355

Paknia O, Radchenko A, Pfeiffer M (2009) New records of ants (Hymenoptera, Formicidae) from Iran. Asian Myrmecology 3: 29–38. http://doi.org/10.20362/am.003005

Pisarski B (1965) Les fourmis du genre *Cataglyphis* Foerst. en Irak (Hymenoptera, Formicidae). Bulletin de l'Académie Polonaise des Sciences. Série des Sciences Biologiques 13: 417–422. https://antcat.org/references/127818

Pisarski B (1967) Fourmis (Hymenoptera: Formicidae) d'Afghanistan récoltées par M. Dr. K. Lindberg. Annales Zoologici (Warsaw) 24: 375–425. https://doi.org/10.5281/zenodo.25692

Rad SP, Taylor B, Torabi R, Aram E, Abolfathi, Afshari, Borjali F, Ghatei M, Hediary F, Jazini F, Kiah VH, Mahmoudi Z, Sararyan F, Seiri M (2018) Further records of ants (Hymenoptera: Formicidae) from Iran. Zoology in the Middle East 2015: 1–15. https://doi.org/10.1080/09397140.2018.1442301

Radchenko AG (1997) Review of ants of the genus *Cataglyphis* Foerster (Hymenoptera, Formicidae) of Asia. Entomologicheskoe Obozrenie 76: 424–442. [In Russian.]

Radchenko AG (1998) A key to the ants of the genus *Cataglyphis* Foerster (Hymenoptera, Formicidae) of Asia. Entomologicheskoe Obozrenie 77: 502–508. [In Russian]

Radchenko AG, Paknia O (2010) Two new species of the genus *Cataglyphis* Foerster, 1850 (Hymenoptera: Formicidae) from Iran. Annales Zoologici 60: 69–76. https://doi.org/10.3161/000345410X499533

Radoszkowsky O (1876) Comte-rendu des hyménoptères recueillis en Égypte et Abyssinie en 1873. Trudy Russkago Entomologicheskago Obshchestva 12: 111–150. https://rcin.org.pl/ibd/dlibra/publication/142800/edition/114697

Salata S, Borowiec L (2018) Taxonomic and faunistic notes on Greek ants (Hymenoptera: Formicidae). Annals of the Upper Silesian Museum in Bytom Entomology 27(online 008): 1–51. http://doi.org/10.5281/zenodo.2199191

Santschi F (1929) Étude sur les *Cataglyphis*. Revue Suisse de Zoologie 36: 25–70. https://www.biodiversitylibrary.org/page/43721762

Seifert B (2018) The Ants of Central and North Europe. lutra Verlags- und Vertriebsgesellschaft, Tauer, 407 pp.

Sharaf MR, Collingwood CA, Aldawood AS (2015) Notes on the ant genus *Cataglyphis* Foerster, 1850 (Hymenoptera, Formicidae) in the Arabian Peninsula with description of a new species and a key to species of the *C. pallida*-group. ZooKeys 545: 101–117. https://doi.org/10.3897/zookeys.545.6308

Wehner R (2020) Desert Navigator. The Journey of an Ant. The Belkamp Press of Harvard University Press, Cambridge, Massachusetts and London, 392 pp. https://doi.org/10.4159/9780674247918

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RESEARCH ARTICLE

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Four new species of isopods (Crustacea, Isopoda) from South Korea

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Abstract

Four new isopods, *Amakusanthura intermedia* **sp. nov.**, *Apanthura laevipedata* **sp. nov.**, *Idarcturus trispinosus* **sp. nov.**, and *Neastacilla paralongipectus* **sp. nov.**, are reported from the sublittoral zones in Korean waters. *Amakusanthura intermedia* **sp. nov.** differs from its congeners by the following features: the uropodal exopod is sinuous distally and with pointed apex; the maxillipedal endite is present and reaching to the distal end of fused palp articles I and II; and the propodal palm of pereopod I is stepped. *Apanthura laevipedata* **sp. nov.** can be distinguishable from its related species by the following characteristics: the eye is lacking; the propodal palm of pereopod I is not stepped; and the uropodal exopod is not sinuous. *Idarcturus trispinosus* **sp. nov.** is diagnosed by the following features: the cephalon has three dorsal spines and a pair of lateral spines; pereonite IV has two pairs of small dorsolateral spines, four pairs of dorsal spines, and one posterior spine; and the pleotelson has three pairs of wings laterally. *Neastacilla paralongipectus* **sp. nov.** can be distinguished by the following characteristics: the body is smooth and lacking dorsal spines or tubercles; pereonite IV is approximately 5.4× longer than pereonites II and III together; and the pleotelson has two pairs of lateral wings. In this paper, detailed descriptions and illustrations of the four species are presented. A key to the genera of the family Arcturidae and keys to the species of the four genera are also provided.

Keywords

Amakusanthura, *Apanthura*, *Idarcturus*, Korea, *Neastacilla*, new species, sublittoral zone

Introduction

The Anthuridae Leach, 1814, characterized by having an elongate cylindrical body and the exopod of uropod attaching to the protopod dorsally, is a large family of marine isopods that dominated in the tropical regions (Poore 2001a; Poore and Bruce 2012; Chew et al 2014). Anthurids usually live in sediment burrows as abundant and important components of the offshore soft-sediment marine environment, also commonly occurring in algal mats on hard substrates in both littoral and sublittoral habitats (Brusca and Iverson 1985). Among the 26 anthurid genera, *Amakusanthura* Nunomura, 1977 and *Apanthura* Stebbing, 1900 each contain 43 species and are the largest genera in the family (Boyko et al. 2008a, b). It is known that the *Amakusanthura* is more common in the tropical regions and the *Apanthura* is more abundant in the temperate regions (Poore 2001a). In the Far East of the temperate region, four *Amakusanthura* species have been reported only from Japan (Nunomura 2016) and six *Apanthura* species from Russia (the Kuril Islands), Japan, and Korea (Mezhov 1976; Wägele 1984; Nunomura 1993; Song and Min 2015).

The Arcturidae Dana, 1849 is another large family of marine isopods that dominated in the Arctic region (Poore and Bruce 2012). Arcturids inhabit the sea floor from the subtidal region to the deep sea, feeding by filtration using setose pereopods I–IV (King 2003a; Castelló et al. 2016). Among the 14 arcturid genera, the *Idarcturus* Barnard, 1914 is a small genus comprising only three species with limited distribution: *I. platysoma* Barnard, 1914, from Cape Town, South Africa (Barnard 1914); *I. hedgpethi* Menzies, 1951 and *I. allelomorphus* Menzies & Barnard, 1959, both from California, USA (Menzies 1951; Menzies and Barnard 1959). On the other hand, the *Neastacilla* Tattersall, 1921 comprises 49 species reported worldwide, including 18 species from the Far Eastern Russia and Japan (Richardson 1909; Gurjaova 1936; Kussakin 1971, 1974, 1982; Kussakin and Vasina 1990; Nunomura 2004, 2006, 2008; Boyko et al. 2008c; Golovan et al. 2018). The *Neastacilla* has not yet been reported from Korea.

In this study, we describe two new anthurids, *Amakusanthura intermedia* sp. nov. and *Apanthura laevipedata* sp. nov., and two new arcturids, *Idarcturus trispinosus* sp. nov. and *Neastacilla paralongipectus* sp. nov., from the sublittoral zones in Korean waters. We also provide a key to the genera of the family Arcturidae and keys to the species of these four genera. This is the first reports of *Amakusanthura*, *Idarcturus*, and *Neastacilla* from Korea.

Materials and methods

The materials of the present study were collected from 13 sampling stations of the sublittoral zones in Korean waters by SCUBA diving and using a Smith-McIntyre grab (Fig. 1; Table 1). The collected materials were sorted using a sieve with a 1 mm mesh and immediately fixed in 94% ethyl alcohol. The observation and dissection of materials were conducted under a dissecting microscope (Nikon SMZ 1500) and a compound microscope (Olympus BX 50). Measurements and drawings of the specimens

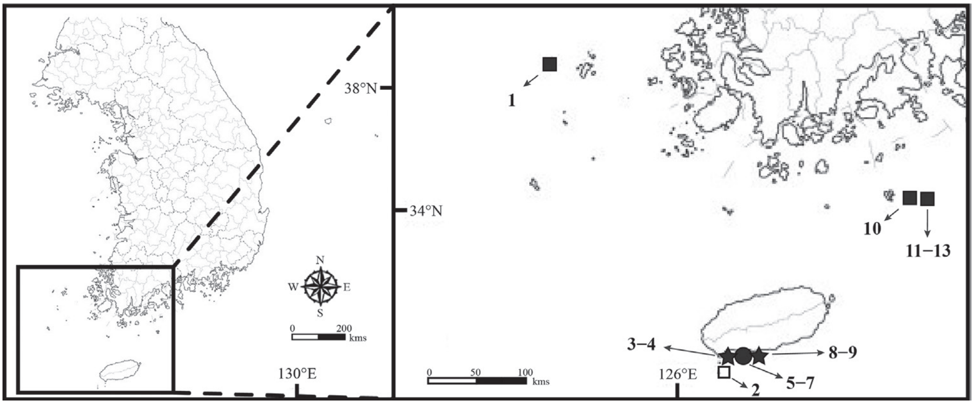

Figure 1. Map of the sampling stations where the isopod specimens collected (station numbers and localities are listed in Table 1). Key: □ *Amakusanthura intermedia* sp. nov. ★ *Apanthura laevipedata* sp. nov. ■ *Idarcturus trispinosus* sp. nov. ● *Neastacilla paralongipectus* sp. nov.

were performed with the aid of a drawing tube. The drawings were scanned, inked, and arranged digitally using the methods described by Coleman (2003, 2009). The examined materials in this study were deposited at the National Institute of Biological Resource (**NIBR**) and Chosun University in Korea (**CUK**).

Taxonomy

Order Isopoda Latreille, 1817
Suborder Cymothoida Wägele, 1989
Family Anthuridae Leach, 1814
Genus *Amakusanthura* Nunomura, 1977

***Amakusanthura intermedia* sp. nov.**
http://zoobank.org/740A3A8C-3C00-4E4B-AC7D-409FA2A8A7F2
Figures 2–4

Material examined. ***Holotype.*** South Korea • 1 non-ovigerous ♀ (5.4 mm); Jeju-do, Seogwipo-si, Daejeong-eup, Gapa-ri; 33°06'54"N, 126°16'42"E; 71 m; 31 Jan. 2018; Smith-McIntyre grab; NIBRIV0000862806.

Paratypes. 2 ♀♀, same data as for holotype; NIBRIV0000880420.

Etymology. The specific name, *intermedia*, originates from the Latin word *intermedius*, meaning “that is between”. This name refers to the length of maxillipedal endite comparing to the related species.

Description of holotype female. *Body* (Fig. 2A, B) 5.4 mm, 13× longer than wide, smooth and slender. Cephalon square to globular, 0.8× as long as pereonite I; rostrum as long as anterolateral lobes; eye very small; color not pigmented, white. Pereonites

Table 1. Sampling stations of the marine isopods in Korean waters.

No.	Locality	Geographical coordinates	Depth (m)	Collecting method	Date of collection
1	Jeollanam-do, Sinan-gun, Heyksan-myeon, Hondo-ri, Hongdo Island	34°40'09"N, 125°10'59"E	10 m	SCUBA diving	19 Jun 2018
2	Jeju-do, Seogwipo-si, Daejeong-eup, Gapa-ri	33°06'54"N, 126°16'42"E	71 m	Smith-McIntyre grab	31 Jan 2018
3	Jeju-do, Seogwipo-si	33°13'00"N, 126°19'30"E	30 m		31 Jan 2018
4		33°11'24"N, 126°18'18"E	30 m		28 Apr 2018
5	Jeju-do, Seogwipo-si, Beophwan-dong	33°13'36"N, 126°32'12"E	33 m		01 Feb 2018 26 Apr 2018
6	Jeju-do, Seogwipo-si, Seohong-dong	33°13'48"N, 126°33'06"E	51 m	Smith-McIntyre grab	26 Apr 2018
7	Jeju-do, Seogwipo-si, Donghong-dong	33°13'48"N, 126°34'36"E	59 m		26 Apr 2018
8	Jeju-do, Seogwipo-si	33°13'12"N, 126°32'12"E	33 m		01 Feb 2018
9		33°13'54"N, 126°36'24"E	38 m		26 Apr 2018
10	Jeollanam-do, Yeosu-si, Samsan-myeon, Geomun-ri, Sosambudo Island	34°02'23"N, 127°21'43"E	15 m	SCUBA diving	27 Jun 2017
11		34°03'04"N, 127°35'13"E	15 m		28 Jun 2017
12		34°03'15"N, 127°35'00"E	15 m		28 Jun 2017
13		34°03'38"N, 127°35'01"E	15 m		28 Jun 2017

rectangular; pereonites I–VI similar to each other in length; pereonite VII ~ 0.7× as long as pereonite VI; coxal plates of pereonites IV–VI visible dorsally. Pleonites 1.2× longer than pereonite VII; pleonites I–V separated by folds except dorsally between pleonites IV and V; pleonites IV and V visible partial sutures laterally; pleonite VI visible dorsally, with dorsal notch posteriorly.

Antennule (Fig. 2C) composed of three peduncular and three flagellar articles, sequentially slender distally in width. Peduncular article I rectangular, with one simple and a single penicillate seta distally; article II oblong, 0.6× as long as article I, with three simple and four penicillate setae distally; article III rectangular, 1.2× longer than article II, with three simple setae distally. Flagellar article I 0.4× as long as wide, with one simple and one penicillate seta; article II elongated, ~ 4× longer than article I, without seta; article III minute, square, with seven simple setae distally.

Antenna (Fig. 2D) consisting of five peduncular and four flagellar articles. Peduncular article I ~ 0.4× as long as article II, with two simple setae laterally; article II 1.8× longer than article I, with one short simple seta laterally and one simple seta distally; article III 0.7× as long as article II, with three simple setae distally; article IV square, subequal to article III, with six simple setae and one penicillate seta distally; article V elongate, 1.4× longer than article IV, with 13 simple setae on both lateral margin and one penicillate seta on distal end. Flagellar articles much shorter than peduncular article V, consecutively shortened; article I with four simple setae distally; article II with one simple seta; article III without setae; article IV with seven simple setae; articles III and IV minute.

Mandible (Fig. 2E), incisor with one prominent cusp and serrated margin; molar process bluntly rounded; palp article II 1.5× longer than article I, slightly stouter than other articles, with two simple setae distally; article III shortest in length, with four serrated setae and a row of spines laterally, one serrated seta distally.

Maxilla (Fig. 2F) with five teeth distally and several fine setae laterally.

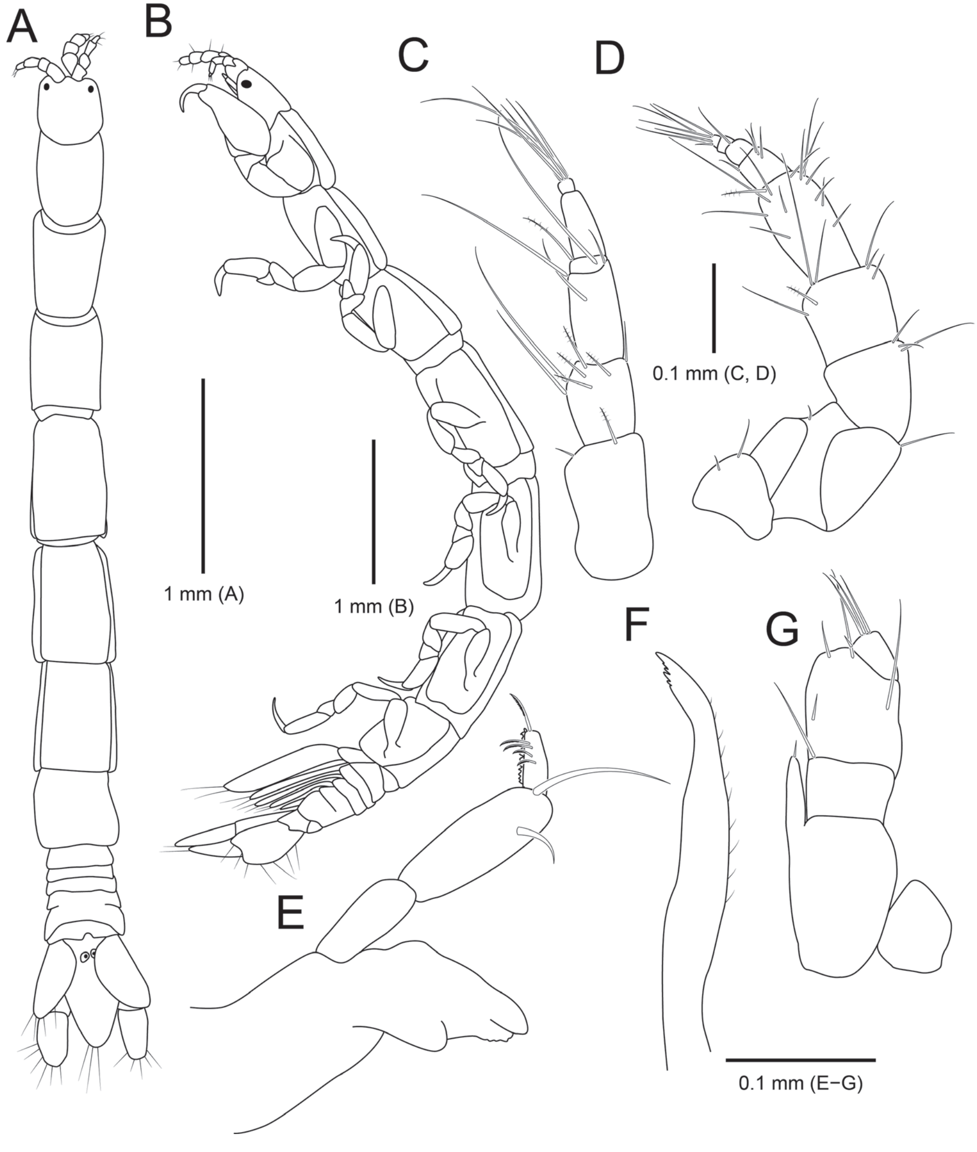

Figure 2. *Amakusanthura intermedia* sp. nov., holotype, female **A** habitus, dorsal view **B** habitus, lateral view **C** antennule **D** antenna **E** mandible **F** maxilla **G** maxilliped.

Maxilliped (Fig. 2G), endite extending to proximal region of palp article III, with one short simple seta apically; palp articles I and II fused, with one simple seta distally; article III free, with two simple setae laterally and two simple setae distally; articles IV and V fused, oblique, smaller than other articles, with four simple setae laterally.

Pereopod I (Fig. 3A), basis continuously stouter distally, with three simple setae and three penicillate setae on superior margin; ischium slender than basis, rectangular, with one simple seta on inferodistal end; merus much shorter than ischium, wider

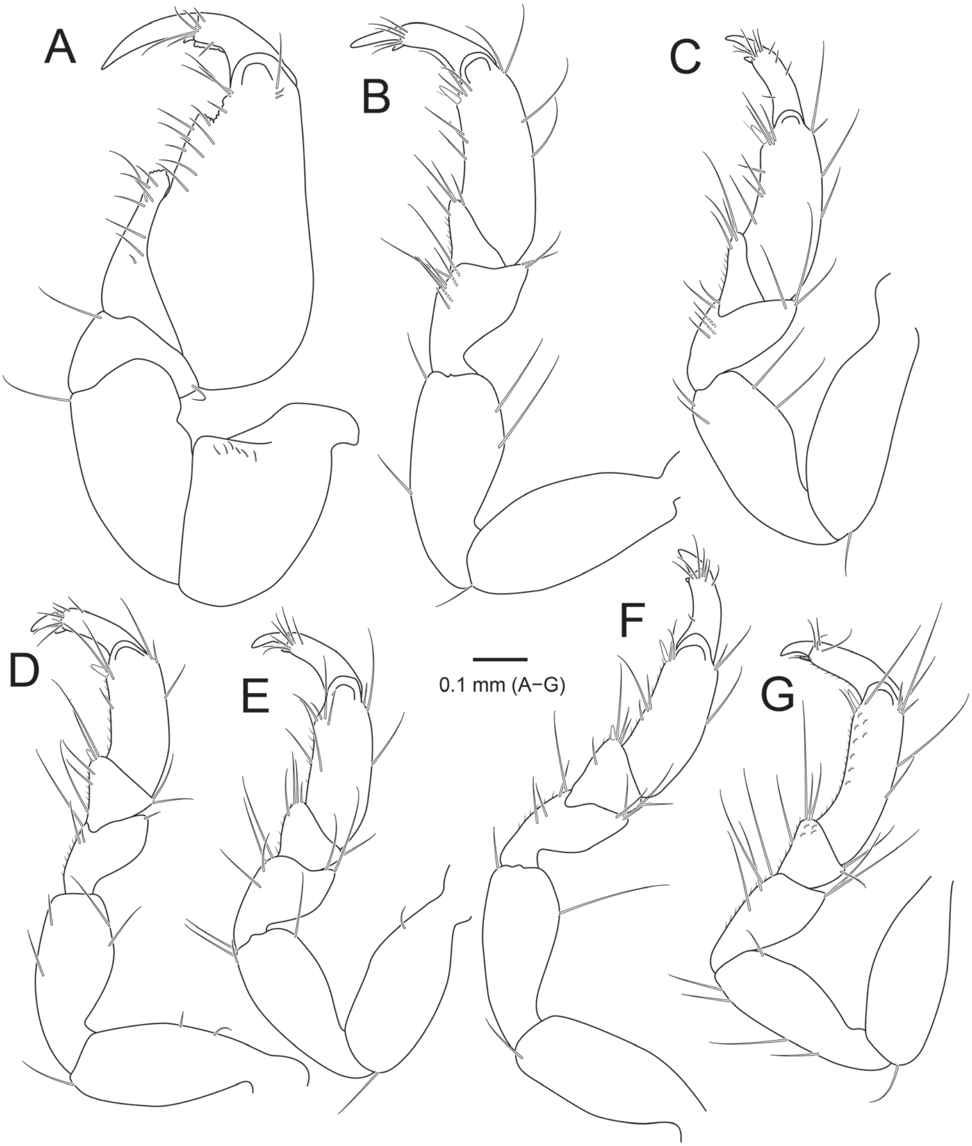

Figure 3. *Amakusanthura intermedia* sp. nov., holotype, female **A** pereopod 1 **B** pereopod 2 **C** pereopod 3 **D** pereopod 4 **E** pereopod 5 **F** pereopod 6 **G** pereopod 7.

than long, with one simple seta on superior and inferior distal end, respectively; carpus triangular, protruding inferodistally, with rough margin inferodistally and eight simple setae along with inferior margin; propodus stepped on palm, with twelve simple setae on inferior margin and three simple setae on distal end; dactylus with five simple setae distally, a row of spines and one simple seta laterally; unguis as long as dactylus, much longer than those of other pereopods, with small accessory unguis. *Pereopods II and III* (Fig. 3B, C), basis elongate, oval, with one simple seta on inferodistally; ischium

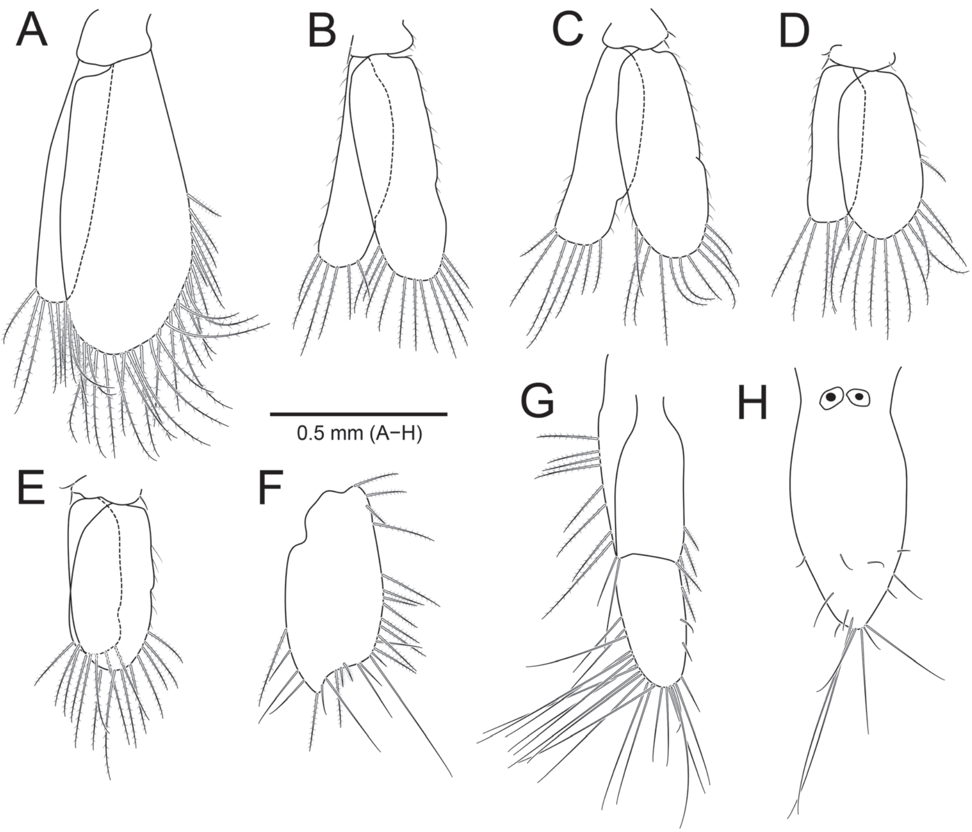

Figure 4. *Amakusanthura intermedia* sp. nov., holotype, female **A** pleopod 1 **B** pleopod 2 **C** pleopod 3 **D** pleopod 4 **E** pleopod 5 **F** uropodal exopod **G** uropodal endopod **H** pleotelson.

slightly shorter than basis, with two simple setae on both lateral margins; merus ~ 0.5× as long as ischium, tapering proximally, with several simple setae on superior and inferior margins; carpus triangular, with several simple setae on inferodistal angle and fine setae along inferior margin; propodus elongate and oval, with simple setae on both lateral margins and one stout seta on inferodistal angle; dactylus with simple setae distally; unguis 0.5× as long as dactylus, with small accessory unguis. *Pereopods IV-VI* (Fig. 3D–F), carpus more or less rectangular, with one stout seta on inferodistal angle (absent in pereopod V); propodus with several fine setae along both lateral margins and one stout seta on inferodistal angle. *Pereopod VII* (Fig. 3G), carpus and propodus with dentate margin baring simple setae along inferior margin.

Pleopods (Fig. 4A–E), exopod slightly longer than endopod. *Pleopod I* (Fig. 4A), exopod ~ 2× as long as wide; endopod 0.4× wider than exopod. *Pleopods II–V* (Fig. 4B–E), protopod with one or two simple setae on inner or outer margin.

Uropod (Fig. 4F, G), protopod rectangular, 2.4× longer than wide, with plumose setae both lateral margins; exopod oval, almost 2× longer than wide, surrounded by plumose and simple setae, with pointed apex, sinuous distally; endopod with plumose and simple setae along both lateral margins.

Pleotelson (Fig. 4H) 2.2× longer than wide, concave proximally, convex medially, tapering distally, with two statocysts on dorsal surface proximally; apex with five simple setae; distal region with several simple setae on dorsal surface and lateral margins.

Distribution. Southern coast of Jeju-do in South Korea.

Habitat. Sublittoral zone of sandy bottom.

Remarks. *Amakusanthura intermedia* sp. nov. is most similar to four species, *A. magnifica* (Menzies & Frankenberg, 1966), *A. pimelia* (Poore & Lew Ton, 1985), *A. paramagnifica* Müller, 1992, and *A. tengo* Müller, 1992, in having the following characteristics: (1) pleonites I–III are visible by folds dorsally and laterally, while pleonites IV and V are visible laterally; (2) the uropodal exopod has sinuous and acute distal region; (3) the pleotelson is concave laterally and tapering distally; (4) the maxillipedal endite is present; and (5) the propodal palm of pereopod I is stepped (Schultz 1969; Poore and Lew Ton 1985; Kensley and Schotte 1989; Müller 1992). However, the new species can be distinguished from the latter species by having the maxillipedal endite (vs. lacking in *A. tengo*), the carpus of pereopod I protruding inferodistally (vs. not protruding in *A. pimelia*), the maxillipedal endite reaching to the distal end of fused articles I and II (vs. over in *A. magnifica* and not reaching in *A. paramagnifica*) (Schultz 1969; Poore and Lew Ton 1985; Kensley and Schotte 1989; Müller 1992).

Key to known species of the genus *Amakusanthura* in the Far East

1	Pleonites IV and V distinguished by dorsal fold	***A. aokii* Nunomura, 2004**
–	Pleonites IV and V not distinguished by dorsal fold	**2**
2	Pleonites I–III not indicated by dorsal folds	**3**
–	Pleonites I–III indicated by dorsal folds	**4**
3	All pereonites without dorsal pits	***A. azumai* Nunomura, 2016**
–	Pereonites IV–VII with dorsal pits	***A. longiantennata* Nunomura, 1977**
4	Propodal palm of pereopod I not stepped	***A. aokii* Nunomura, 2004**
–	Propodal palm of pereopod I stepped	***A. intermedia* sp. nov.**

Genus *Apanthura* Stebbing, 1900

Apanthura laevipedata sp. nov.

http://zoobank.org/748471B2-B1F1-4E58-8AB1-72F3D81164FC
Figures 5–7

Material examined. ***Holotype.*** South Korea • 1 non-ovigerous ♀ (5.5 mm); Jeju-do, Seogwipo-si, Beophwan-dong; 33°13'36"N, 126°32'12"E; 33 m; 26 Apr. 2018; Smith-McIntyre grab; NIBRIV0000862805.

Paratypes. 4 ♀♀, same data as for holotype; 2 ♀♀, same locality as for holotype; 1 Feb. 2018; 2 ♀♀; Jeju-do, Seogwipo-si, Seohong-dong; 33°13'48"N, 126°33'06"E; 51 m; 26 Apr. 2018; Smith-McIntyre grab • 1 juvenile ♀; Jeju-do, Seogwipo-si, Donghong-dong; 33°13'48"N, 126°34'36"E; 59 m; 26 Apr. 2018; Smith-McIntyre grab; NIBRIV0000880421.

Etymology. The specific name, *laevipedata*, originates from the combination of the Latin words *laevis*, meaning smooth and *pedis*, meaning foot. This name refers to having the propodus of pereopod that is smooth, not stepped.

Description of holotype female. *Body* (Fig. 5A, B) smooth and slender, 5.5 mm in length, 11× longer than wide. Cephalon square, 0.7× as long as pereonite I; rostrum extending as long as anterolateral lobes; eye absent. Pereonites oblong; pereonites I–III similar in length; pereonites IV–VI longer than previous three pereonites, subequal each other in length; pereonite VII ~ 0.7× as long as pereonite VI; coxal plates of pereonites V–VII visible dorsally. Pleonites I–V not separated by folds dorsally and laterally; pleonite VI with middorsal notch posteriorly.

Antennule (Fig. 5C) consisting of three peduncular and three flagellar articles. Peduncular article I oblong, longer than wide, with three penicillate setae and one simple seta along lateral margin; article II square, ~ 0.5× as long as article I, with three penicillate setae on distal end; article III similar to article II in length, slender than article II, with one penicillate seta and three simple setae distally. Flagellar article I much shorter than other articles, 0.1× as long as peduncular article III; article II oblong to oval, tapering distally, 0.8× as long as peduncular article III; article III square to globular, 0.3× as long as article II, with two simple setae and two aesthetascs distally.

Antenna (Fig. 5D) longer than antennule, composed of five peduncular and three flagellar articles. Peduncular article I rectangular to globular, with one simple seta distally; article II 1.5× longer than article I; article III oblong, 0.4× as long as article II, with three simple setae distally; article IV similar to article III in shape, 0.7× as long as article III, with four simple setae distally; article V elongated oblong, 2.3× longer than article IV, with three penicillate and four simple setae on distal end. Flagellar article I elongated rectangular, ~ 0.5× as long as peduncular article V; articles II and III minute, with several simple setae on distal end.

Mandible (Fig. 5E), incisor with one cusp; molar process blunt; palp article I elongated oblong, with two simple setae distally; article II 1.4× longer than article I, slightly thicker than other articles; article III slander, slightly tapering distally, 0.4× as long as article II, with two short simple setae distally.

Maxilla (Fig. 5F) with six irregular teeth distally and fine setae laterally.

Maxilliped (Fig. 5G), epipods globular; endite slightly exceeding distal end of fused palp articles I and II, tapering distally, with one simple seta distally; palp articles I and II fused, rectangular, with one simple seta distally and one simple seta laterally; article III free, almost square, with three simple setae on distal end; articles IV and V fused, triangular, much smaller than other palp articles, with five simple setae along inner margin.

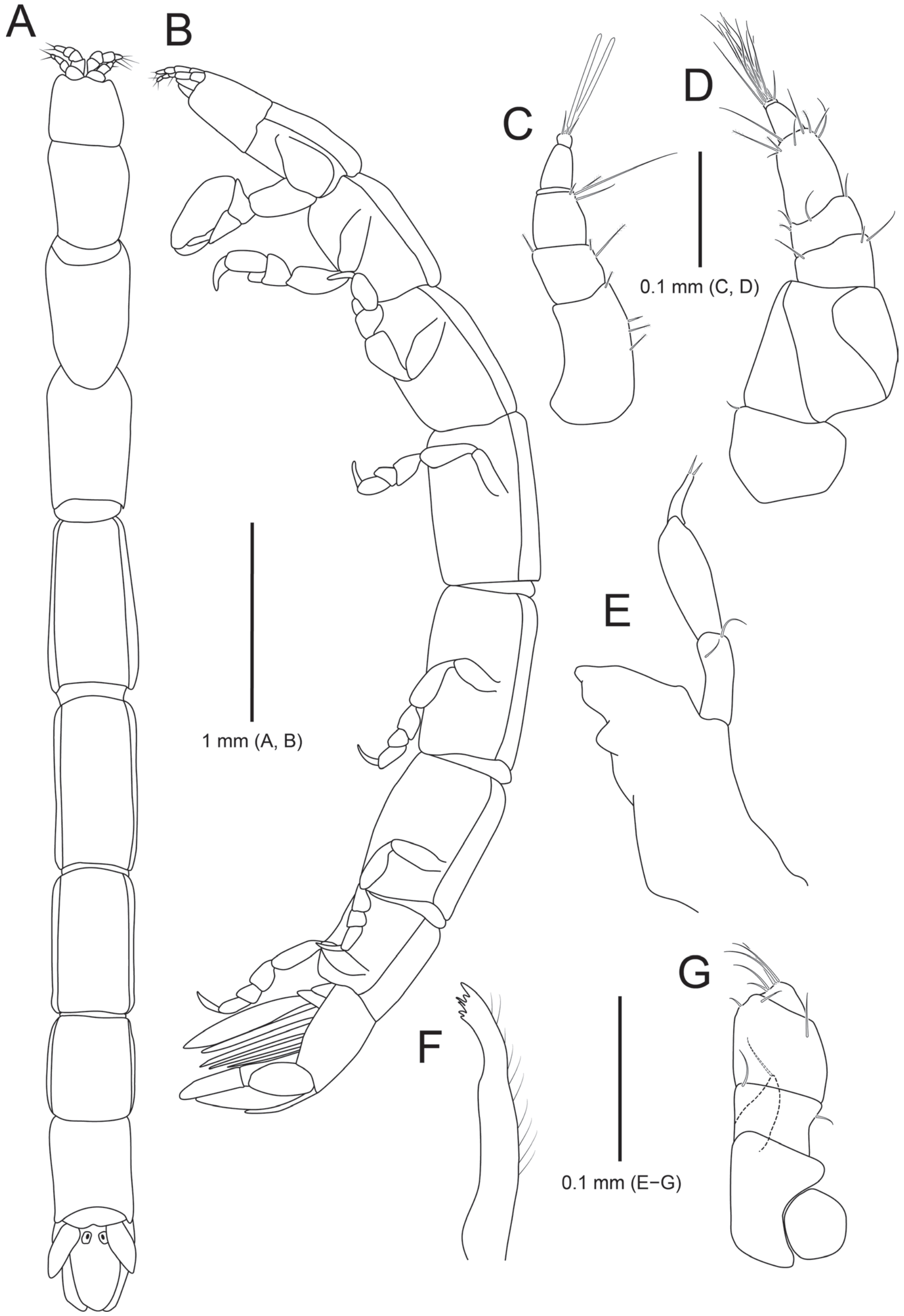

Figure 5. *Apanthura laevipedata* sp. nov., holotype, female **A** habitus, dorsal view **B** habitus, lateral view **C** antennule **D** antenna **E** mandible **F** maxilla **G** maxilliped.

Pereopod I (Fig. 6A) basis as long as ischium, gradually tapering proximally; ischium rectangular, with one simple seta on inferodistal angle; merus 0.4× as long as ischium; superior margin of merus extending upwardly, with five simple setae on inferior margin, one short simple seta on superior margin, and one simple seta on mesial margin; carpus triangular, with five simple setae along inferior margin; propodus not stepped on palm, with two rows of simple setae along inferior margin and several fine setae on superior margin; dactylus oblique, with five simple setae; unguis slightly longer than dactylus; much longer than other pereopods, with accessory unguis distally. *Pereopods II–VII* (Fig. 6B–G) basis oblong to oval, with several simple setae and penicillate setae on superior margin and one simple seta on inferodistal angle; ischium subequal in length, gradually tapering proximally, with several simple setae along with inferior margin and none or one simple seta on superodistal angle; merus tapering proximally, with several simple setae on inferior margin and 1–3 simple setae on superior margin; carpus of pereopods II and III triangular, with several simple setae on inferior margin without stout seta on inferodistal angle; carpus of pereopods IV–VII subsquare to globular or trapezoidal, with one stout seta on inferodistal angle, several simple setae on both lateral margins, none or one penicillate seta on superior margin; propodus slightly elongate and oval, with several simple setae on both lateral margins and one stout seta on inferodistal angle; dactylus slender, with several simple setae distally, unguis, much shorter than dactylus, with minute accessory unguis on distal end.

Pleopods (Fig. 7A–E), protopod square to rectangular; rami subequal in length, rounded distally. *Pleopod I* (Fig. 7A), protopod with three coupling hooks on inner margin; exopod 2× wider than endopod. *Pleopods II–V* (Fig. 7B–E), exopod with one simple seta on outer margin; pleopods III–V with notch on outer margin.

Uropod (Fig. 7F, G), protopod oblong, 1.7× longer than wide, with three plumose setae on each lateral margin; endopod triangular to oval, with one penicillate seta and 16 simple setae along outer margin; exopod oval, with numerous plumose and several simple setae along outer margin, not sinuous distally.

Pleotelson (Fig. 7H) 2.6× longer than wide, with two statocysts dorsally; lateral margins parallel; apex rounded, tapering distally, with two simple setae distally.

Distribution. Southern coast of Jeju-do in South Korea.

Habitat. Sublittoral zone of sandy bottom.

Remarks. *Apanthura laevipedata* sp. nov. differs from its congeners by the following features combined: (1) the integument is not pigmented; (2) the eyes are lacking; (3) pleonites I–V are not separated by folds dorsally and laterally; (4) the propodal palm of pereopod I is not stepped; and (5) the uropodal exopod is not sinuous.

Besides the new species, four species that have no eyes are known in the genus *Apanthura* Stebbing, 1900: *A. insignifica* Kensley, 1978; *A. tyrrhenica* Wägele, 1980; *A. drosera* Poore & Lew Ton, 1985; and *A. fusei* Nunomura, 1993 (Kensley 1978; Wägele 1980; Poore and Lew Ton 1985; Nunomura 1993). Among these species, *Apanthura laevipedata* sp. nov. is most similar to *A. fusei* in terms of dorsally fused pleonites I–V and not sinuous uropodal exopods. However, the new species is easily distinguished from the latter by not stepped propodal palm of pereopod I (vs.

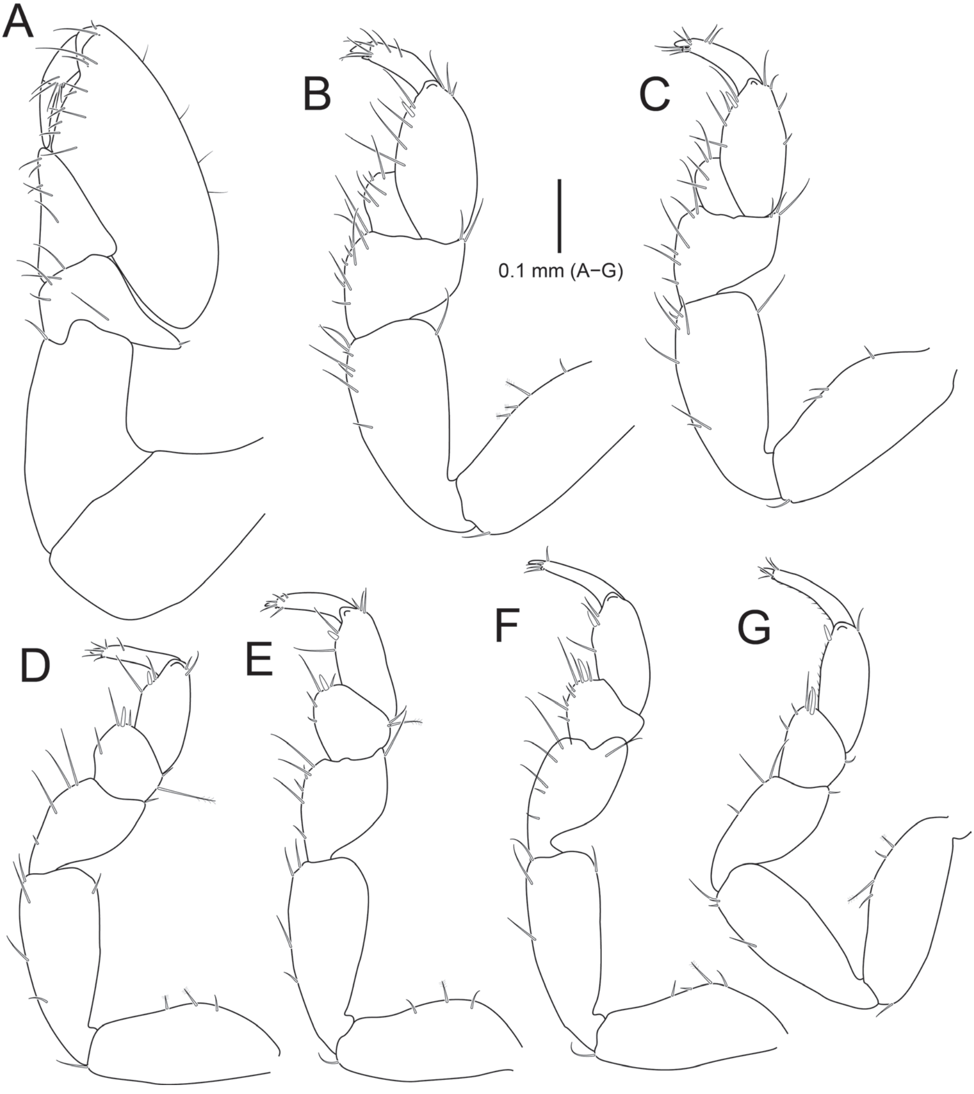

Figure 6. *Apanthura laevipedata* sp. nov., holotype, female **A** pereopod 1 **B** pereopod 2 **C** pereopod 3 **D** pereopod 4 **E** pereopod 5 **F** pereopod 6 **G** pereopod 7.

stepped in the latter), upwardly extending carpus (vs. not extending in the latter), laterally invisible suture in pleonites I–V (vs. visible in the latter), and parallel lateral margins of the pleotelson (vs. proximally concave lateral margins in the latter) (Nunomura 1993). The new species also differs from *A. drosera* in having not stepped propodal palm of pereopod I (vs. stepped in the latter) (Poore and Lew Ton 1985), while can be distinguished from *A. insignifica* and *A. tyrrhenica* in that all pleonites are not separated by folds (vs. separated in the latter species) (Kensley 1978; Wägele 1980).

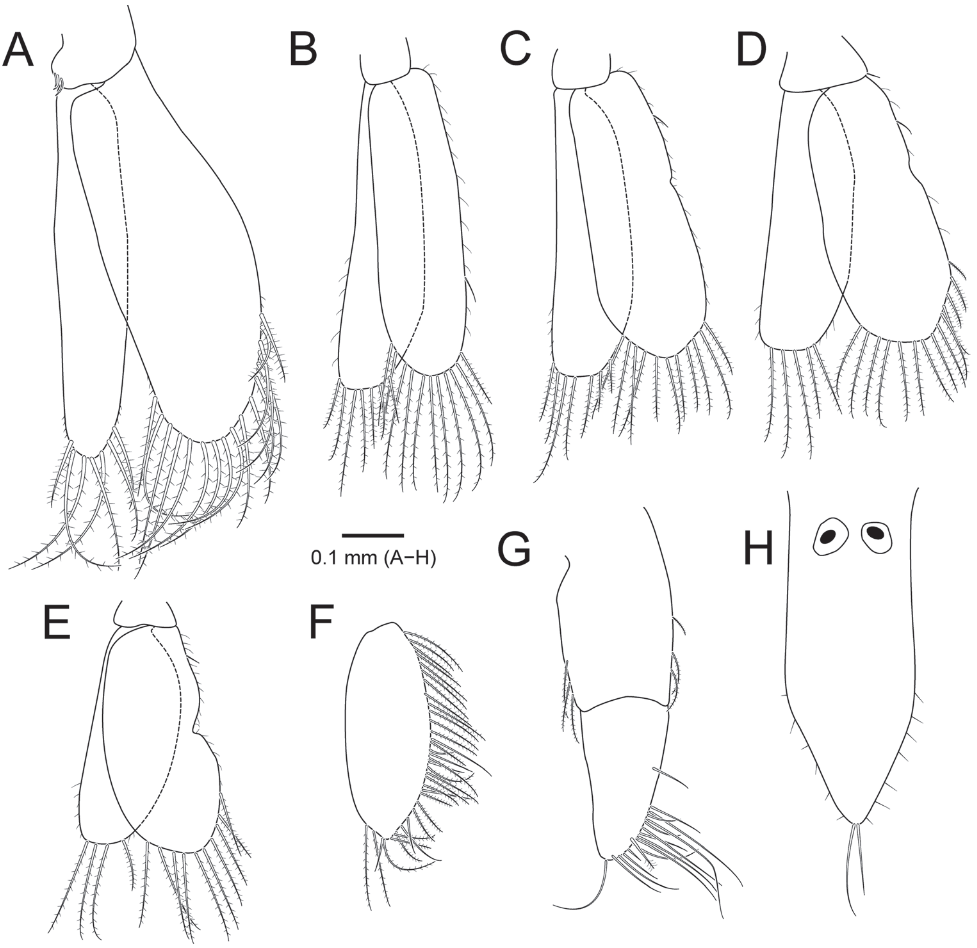

Figure 7. *Apanthura laevipedata* sp. nov., holotype, female **A** pleopod 1 **B** pleopod 2 **C** pleopod 3 **D** pleopod 4 **E** pleopod 5 **F** uropodal exopod **G** uropodal endopod **H** pleotelson.

Key to known species of the genus *Apanthura* in the Far East

1	Eye present	**2**
–	Eye absent	**6**
2	Propodal palm of pereopod I stepped	***A. honshuensis* Wägele, 1984**
–	Propodal palm of pereopod I not stepped	**3**
3	Statocysts absent	***A. shikokuensis* Nunomura, 1993**
–	Statocysts present	**4**
4	Uropodal exopod not sinuous distally	***A. trioculata* Nunomura, 1993**
–	Uropodal exopod sinuous distally	**5**
5	Distal end of uropodal exopod deeply notched	***A. excavate* Mezhov, 1976**
–	Distal end of uropodal exopod not notched	***A. koreaensis* Song & Min, 2016**

6 Lateral margins of pleotelson concave proximally; propodal palm of pereopod I stepped...***A. fusei* Nunomura, 1993**
– Lateral margins of pleotelson parallel; propodal palm of pereopod I not stepped ....***A. laevipedata* sp. nov.**

Suborder Valvifera Sars, 1883

Family Arcturidae Dana, 1849

Diagnosis (modified after Poore 2001b). Body moderately cylindrical, geniculate between pereonites IV and V, occasionally straight; cephalon and fused pereonite I expanded ventrolaterally; pereonite IV at least 1.5× longer than pereonite III; pleonites and pleotelson fused. Pereopod I gnathopod-like, immersed in lateral view by lateral plates of cephalon and pereonite I; pereopods II–IV slender, setose, directed anteriorly; pereopods V–VII ambulatory. Pleopod I, protopod elongated, much longer than wide; exopod of male with lateral excavation, and either a tuft of fine setae, long plumose setae, or both. Uropod biramous; endopod much smaller than exopod.

Remarks. Classification of the genera of Arcturidae had difficult because many genera were inadequately and ambiguously described (Kussakin 1972; King 2003b). To resolve this problem, Kussakin (1972) suggested using the structure of pereopods I–IV to diagnose genera and presented a key based on these features to eight Arctic and boreal genera. Since then Poore (2001b) transferred *Antarcturus* zur Strassen, 1903 and related genera Antarcturidae Poore, 2001. *Parapleuroprion* Kussakin, 1972 is now synonym of *Arcturus* Latreille, 1829 (Boyko et al. 2008d). *Arcturella* G. O. Sars, 1897 is synonym of *Astacilla* Cordiner, 1793 (Kensley et al. 2007; Rincón et al. 2018). Here we submit the key to all genera of Arcturidae.

Key to genera of the family Arcturidae

1 Pereopod I with unguis..**2**
– Pereopod I without unguis...**7**
2 Pereopod IV absent.......................................***Arcturinoides* Kensley, 1977**
– Pereopod IV present **3**
3 Pereopods II–IV with flexion between carpus and propodus.......................**4**
– Pereopods II–IV without flexion between carpus and propodus..................**6**
4 Pereonites without ventral process in both sex.......***Astacilla* Cordiner, 1793**
– Pereonites III or V with ventral process in male **5**
5 Pereonite III with ventral process in male...........***Arcturopsis* Koehler, 1911**
– Pereonite V with ventral process in male................***Arctopsis* Barnard, 1920**
6 Pereopods II–IV with unguis ....***Arcturus* Latreille, 1829**
– Pereopods II–IV without unguis..........................***Arcturina* Koehler, 1911**
7 Pereopods III and IV absent...**8**
– Pereopods III and IV present **9**

8 Last flagellar article of antenna with rounded tubercle at midlength; maxillipedal palp 5-articled; uropod biramous........... ***Amesopous* Stebbing, 1905**

– Last flagellar article of antenna without rounded tubercle at midlength; maxillipedal palp 4-articled; uropod uniramous .... ***Edwinjoycea* Menzies & Kruczynski, 1983**

9 Pereopod IV vestigial .... ***Arcturinella* Poisson & Maury, 1931**

– Pereopod IV not vestigial **10**

10 Pereopods II–IV with flexion between carpus and propodus .... ***Agularcturus* Kensley, 1984**

– Pereopods II–IV without flexion between carpus and propodus **11**

11 Pereopod II with dactylus, while pereopods III and IV without dactylus....... .... ***Parastacilla* Hale, 1924**

– Pereopods II–IV with dactylus (lacking in few *Neastacilla* species) **12**

12 Pereopod II with short ungius........................ ***Spectrarcturus* Schultz, 1981**

– Pereopods II–IV without ungius **13**

13 Body moderately flattened dorsoventrally; propodus of pereopod I with serrated setae on palmar surface; carpus with serrated setae on ventral margin; exopod of pleopod I with simple setae subbasally in male .... ***Idarcturus* Barnard, 1914**

– Body almost cylindrical; propodus of pereopod I without serrated setae on palmar surface; carpus without serrated setae on ventral margin; exopod of pleopod I with plumose setae subbasally .... ***Neastacilla* Tattersall, 1921**

Genus *Idarcturus* Barnard, 1914

Type species. *Idarcturus platysoma* Barnard, 1914, by monotype.

Diagnosis. Body not or slightly geniculate, moderately flattened dorsoventrally in female, whereas cylindrical in male; pereonite IV longer than other pereonites, but not markedly elongate in both sexes, < 2× longer than pereonites II and III combined. Pereopod I carpus with serrated setae on inferior margin; propodus with serrated setae and comb setae on palmar surface and inferior margin; dactylus with comb setae distally; unguis lacking. Pereopods II–IV lacking flexion between carpus and propodus; dactylus claw-like. Pleopod I, exopod with fine setae subbasally or mesally.

Idarcturus trispinosus sp. nov.

http://zoobank.org/35DABEAB-C655-4756-805E-6EF4CED60CC5

Figures 8–11

Material examined. ***Holotype.*** South Korea • 1 ♀ ovigerous (4.5 mm); Jeollanam-do, Yeosu-si, Samsan-myeon, Geomun-ri, Sangbackdo Island; 34°03'4"N, 127°35'13"E; 15 m, 28 Jun. 2017; SCUBA diving; NIBRIV0000813025.

Paratypes. South Korea • 1 ♂ (3.3 mm); Sangbackdo Island; 34°03'15"N, 127°35'00"E; 15 m; 28 Jun. 2017; SCUBA diving • 1 ♀; Sangbackdo Island; 34°03'38"N, 127°35'01"E; 15 m; 28 Jun. 2017; SCUBA diving • 1 ♂, Sosambudo Island; 34°02'23"N, 127°21'43"E; 15 m, 27 Jun. 2017; SCUBA diving; NIBRIV0000880423.

Additional material. South Korea • 1 ♂, 2 ♀♀; Sinan-gun, Heyksan-myeon, Hondo-ri, Hongdo Island, 34°40'09"N, 125°10'59"E; 10 m; 19 Jun. 2018; SCUBA diving.

Description of holotype female. *Body* (Fig. 8A, B) moderately flattened dorsoventrally, slightly geniculated between pereonites IV and V; length 4.5 mm, 4.5× longer than wide. *Cephalon* with three dorsal spines, one pair of lateral spines; anterior margin deeply concave, with small median process; anterolateral lobe expended anteriorly, concave distally; eye large, round, positioned laterally. *Pereonites* with dorsal spines; pereonite I with one pair of dorsal spines; pereonites II and III similar to each other in length, with one pair of dorsal spines, two pairs of lateral spines; dorsal spines of pereonite III bigger than dorsal spines of pereonite II; pereonite IV widest, ~ 1.5× longer than pereonites II and III together, with two pairs of small dorsolateral spines, four pairs of dorsal spines, one middorsal spine on posterior margin; posterior dorsal spines larger than other dorsal spines; anterolateral angle expanded laterally; oostegite IV with suture line posteriorly; pereonites V–VII similar to each other in length, with one pair of small dorsal spines, two or three tuberculate elevations. *Pleon* ~ 1.3× longer than pereonites V–VII, with two pairs of dorsal spines; anterior spines smaller than posterior spines; pleotelson gradually tapering posteriorly, with three pairs of wings laterally; proximal wing smaller than proceeding wings; apex round.

Antennule (Fig. 9A) exceeding peduncular article II of antenna, consisting of three peduncular articles and single-articled flagellum; peduncular article I globular, with one projection dorsally and two penicillate setae; article II cylindrical, with five penicillate setae; article III smaller than article II; flagellum with three aesthetascs on anterodistal end and three simple setae on distal end. *Antenna* (Fig. 9B–D) almost half of body length, slender, consisting of five peduncular articles and three flagellar articles; peduncular article I small; article II ×longer than article I; article III ×longer than article II, with two short simple setae distally; articles IV and V similar to each other, almost 3× longer than article III, with numerous minute simple setae along with lateral margin; article IV with one penicillate seta laterally; flagellar article I longer than flagellar articles II and III; articles II and III with one low of spines resembling saw-teeth on ventral margin; article III with one large claw apically.

Left mandible (Fig. 9E), incisor weakly 4-toothed; lacinia mobilis 3-toothed, with three serrated setae; molar process broad, rough distally. *Right mandible* (Fig. 9F), incisor 3-toothed; lacinia mobilis 4-toothed, with two serrated setae; molar process broad, strongly serrated. *Maxillule* (Fig. 9G) with fine setae laterally; inner lobe with three trifurcated setae; outer lobe with ten robust setae distally. *Maxilla* (Fig. 9H) with fine setae on lateral margin; inner lobe with seven stout circum-plumose setae on subapical region, nine simple setae on apical margin; mesial lobe with four plumose setae api-

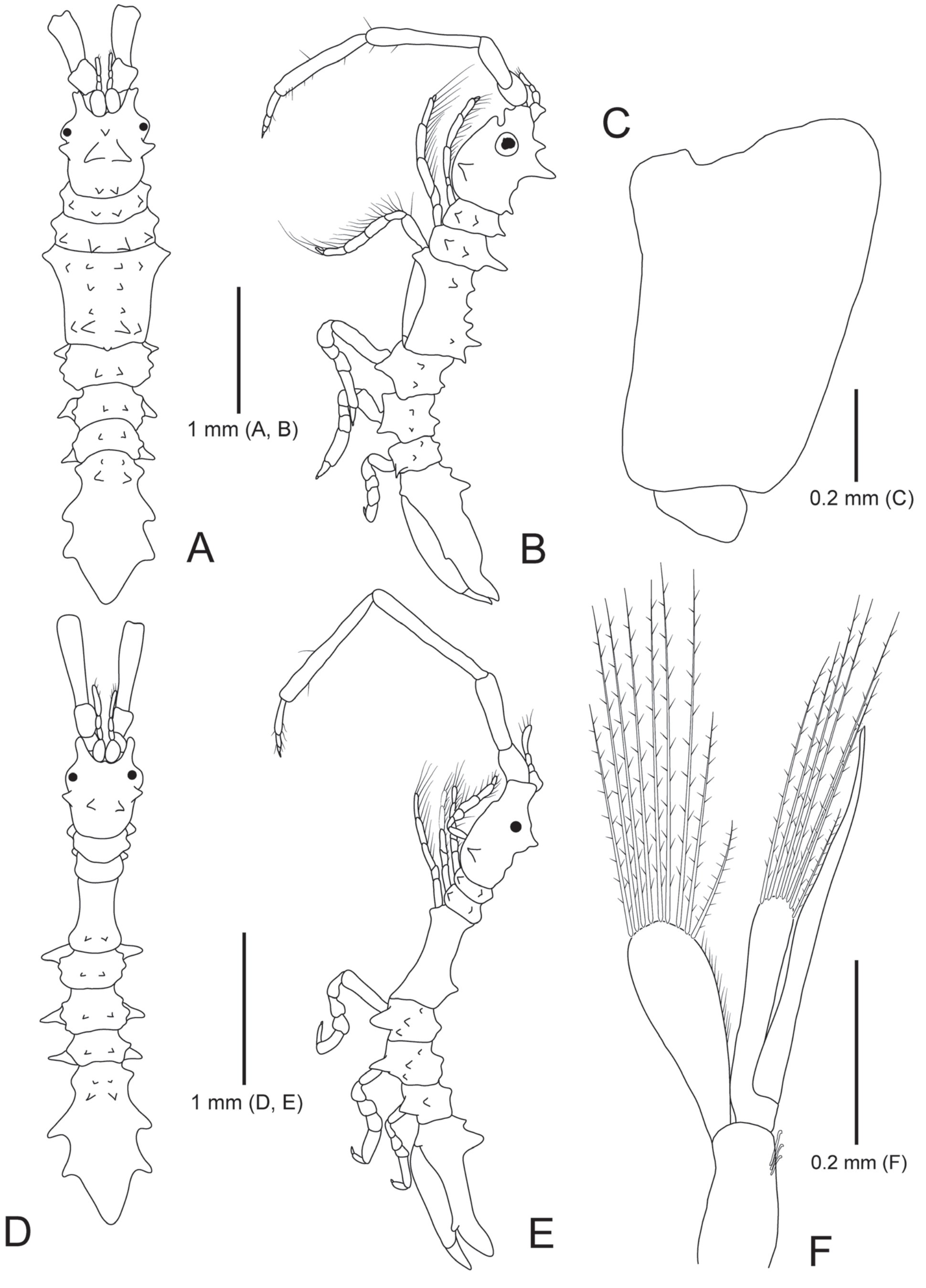

Figure 8. *Idarcturus trispinosus* sp. nov., holotype, female **A** habitus, dorsal view **B** habitus, lateral view **C** oostegite 4. Paratype, male **D** habitus, dorsal view **E** habitus, lateral view **F** pleopod 2.

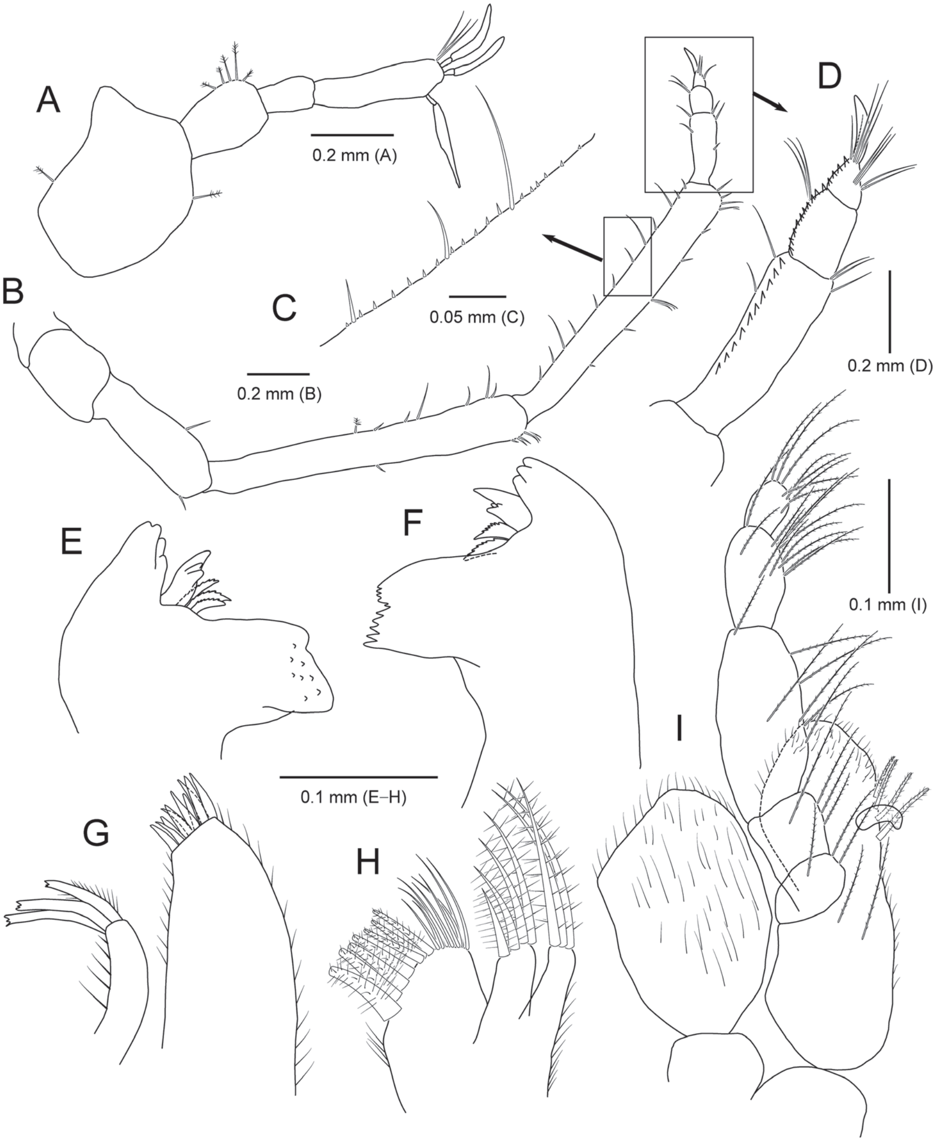

Figure 9. *Idarcturus trispinosus* sp. nov., holotype, female **A** antennule **B** antenna **C** detail of peduncular articles of antenna **D** flagellum of antenna **E** left mandible **F** right mandible **G** maxillule **H** maxilla **I** maxilliped.

cally; outer lobe with three plumose setae distally. *Maxilliped* (Fig. 9I), palp article I oval, with three plumose setae; article II square, with four plumose setae; article III cylindrical, with seven plumose setae; article IV oval, shorter than article III, with twelve plumose setae; article V square to globular, with eight plumose setae; endite round, with one coupling hook and four circum-plumose setae laterally, with short bristles apically; epipod globular to oval, with fine setae on distal and mesial margin.

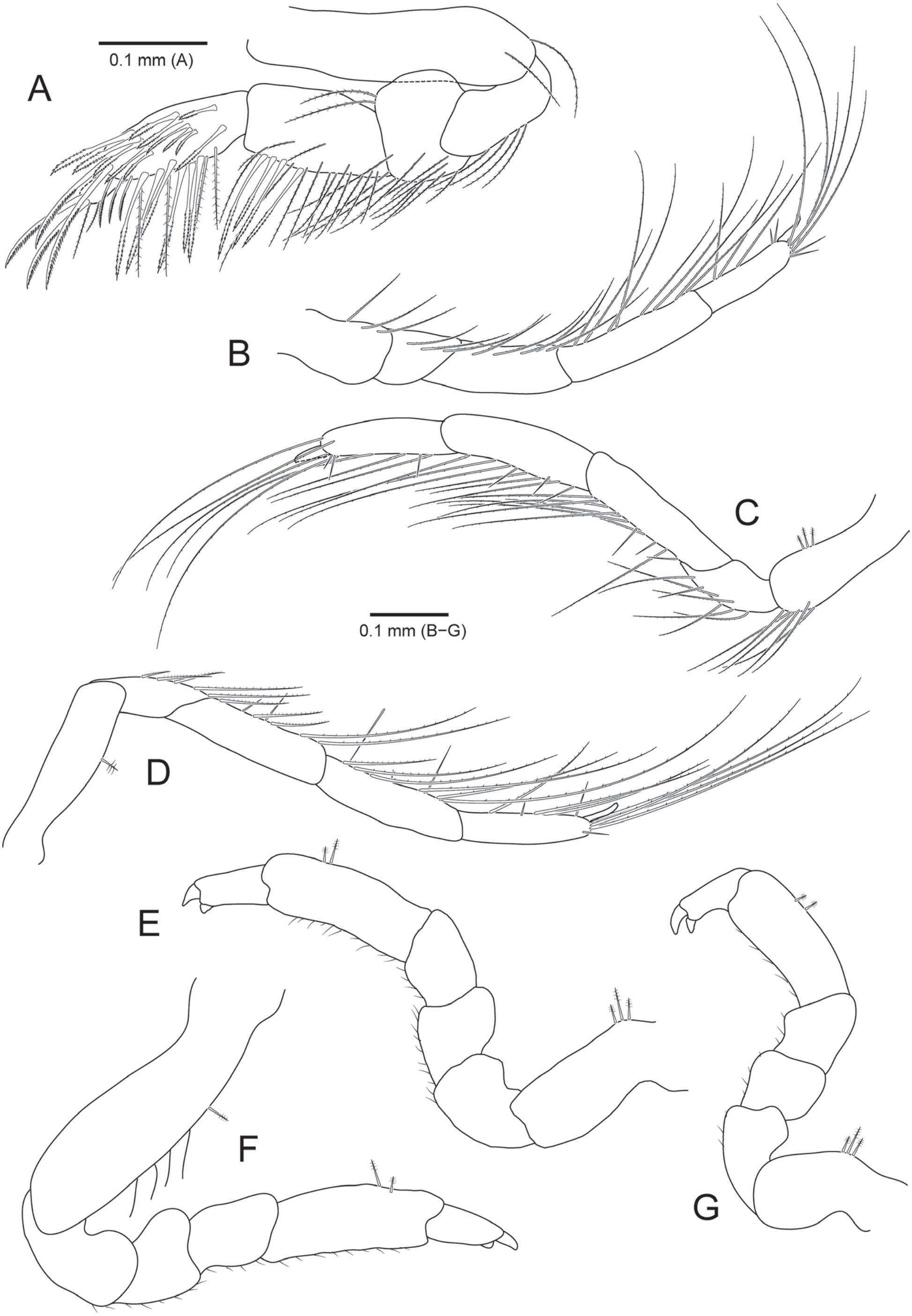

Figure 10. *Idarcturus trispinosus* sp. nov., holotype, female **A** pereopod 1 **B** pereopod 2 **C** pereopod 3 **D** pereopod 4 **E** pereopod 5 **F** pereopod 6 **G** pereopod 7.

Pereopods I–IV (Fig. 10A–D) slender, without unguis, consecutively longer. *Pereopods V–VII* (Fig. 10E–G) consecutively shorter. *Pereopod I* (Fig. 10A), basis longest, with two plumose setae on distal end; ischium 0.3× as long as basis, with four plumose setae on inferior margin; merus globular to square, with numerous plumose setae inferiorly and two plumose setae on superodistal angle; carpus rectangular, with numerous plumose and serrated setae on inferior margin; propodus elongated oval, subequal in length to carpus, with numerous plumose setae on inferior margin, serrated setae on palmar surface and inferior margin, comb setae on distal end; dactylus small, with two comb setae, two plumose setae distally. *Pereopods II–IV* (Fig. 10B–D) similar to each other; basis to propodus with numerous plumose setae on inferior margin; merus to propodus with several simple setae; basis longer than ischium; merus similar to basis in length; carpus and merus subequal in length; propodus slightly shorter than carpus, with several simple setae on distal end; dactylus claw-like. *Pereopods V–VII* (Fig. 10E–G) resembling each other; basis with one or three penicillate setae on superior margin; ischium to carpus subequal in length; propodus with two penicillate setae on superior margin; dactylus bi-unguiculate, half of propodus.

Pleopod I (Fig. 11A), protopod rectangular, with three coupling hooks on inner margin; rami subequal, longer than protopod, with numerous plumose apical setae. *Pleopod II* (Fig. 11B) similar to pleopod I; protopod rectangular, with three coupling hooks on inner margin; rami subequal each other, wider than rami of pleopod I, longer than plumose setae, with numerous setae on distal end. *Pleopods III–V* (Fig. 11C–E) similar to each other; protopod short; endopod with rounded apex, with 0–2 plumose setae subapically; exopod gradually tapering distal end, almost 1.3× longer than endopod.

Uropod (Fig. 11F) elongated oval to rectangular; protopod ~ 3× longer than wide, with numerous fine setae on border; endopod oval to rectangular, with two plumose setae apically; exopod elongated triangular, with numerous fine setae on border.

Description of paratype male. *Body* (Fig. 8D, E) cylindrical; length 3.3 mm; dorsal spines smaller than those of female. *Cephalon* (Fig. 8D, E) with two middorsal spines; anterolateral lobe rounded. *Pereonites* (Fig. 8D, E), pereonite I–III without dorsal spines; pereonite IV slender, narrower than that of female, with only one pair of dorsal spines posteriorly. *Pleopod I* (Fig. 11G), protopod rectangular, ~ 3.3× longer than wide, with four coupling hooks medially; rami similar in length, with plumose setae distally; exopod with fine setae subbasally; lateral notch of exopod present, but obscure. *Pleopod II* (Fig. 8F), protopod rectangular, with three coupling hooks on inner margin; plumose setae shorter than rami; endopod slightly longer than exopod, with seven plumose setae; exopod ~ 1.6× longer than protopod, with nine plumose setae; appendix masculine almost 1.8× longer than endopod, curved outwardly, acute distally.

Distribution. Southern coast of South Korea.

Habitat. Sublittoral zone of the rocky substrate.

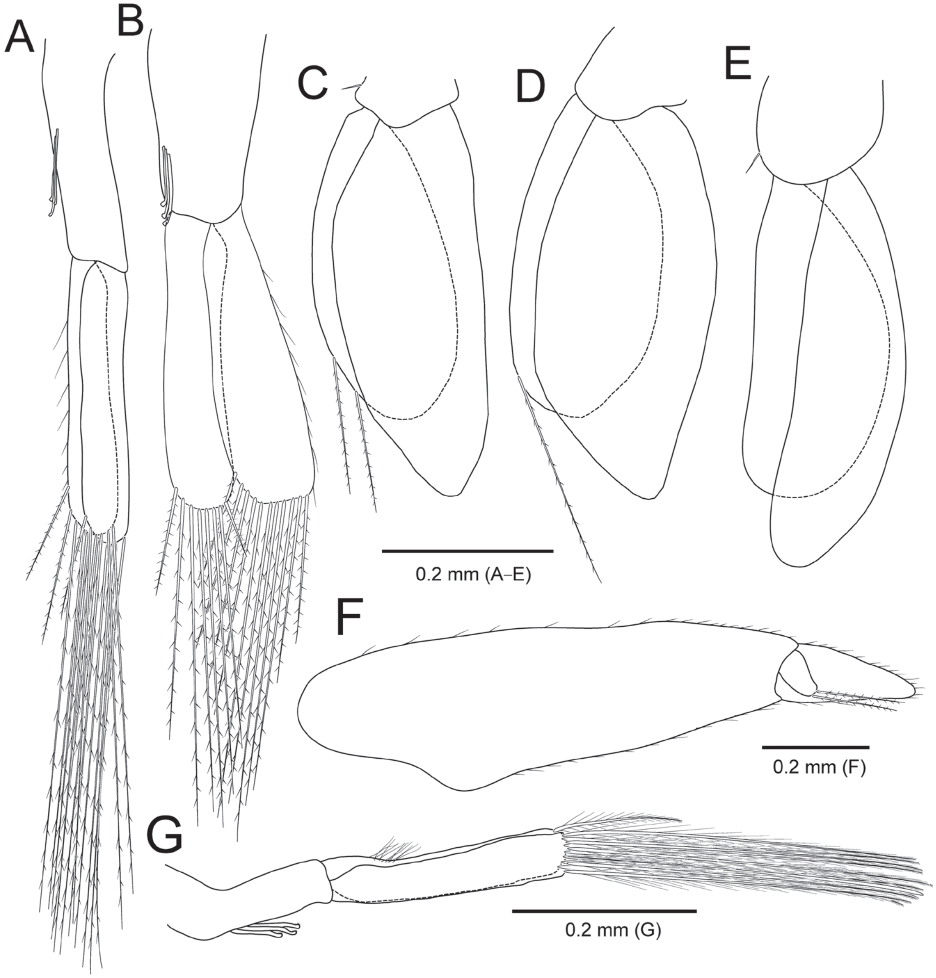

Figure 11. *Idarcturus trispinosus* sp. nov., holotype, female **A** pleopod 1 **B** pleopod 2 **C** pleopod 3 **D** pleopod 4 **E** pleopod 5 **F** uropod. Paratype, male **G** pleopod 1.

Etymology. The composite epithet of the specific name *trispinosus* is a combination of the Latin *tres*, meaning three, and *spinosus*, meaning thorny. This name refers to having three spines on the dorsal surface of the cephalon.

Remarks. Within the genus, *Idarcturus trispinosus* sp. nov. is distinguished from *I. platysoma*, the type species of the genus, by having dorsal spines in both sexes (lacking the dorsal spines in *I. platysoma*) and the pleotelson bearing lateral wings (lacking in the latter) (Barnard 1914).

Idarcturus trispinosus sp. nov. is similar to *I. allelomorphus* in having dorsal spines, but the former differs by having three dorsal spines on the cephalon (vs. two in the latter) and six pairs of dorsal spines on pereonite IV (vs. one pair in the latter) (Menzies and Barnard 1959).

Idarcturus trispinosus sp. nov. most resembles *I. hedgpethi* in having anterolaterally expanded pereonite IV and dorsal spines. However, they could be distinguished by the anterolateral lobe of the cephalon (concave distally in the former vs. truncated in the latter) and the numbers of dorsal spines on the cephalon (three in the former vs. two in the latter), on pereonite IV (six pairs in the former vs. one pair in the latter), and on the pleon (two pairs in the former vs. one pair in the latter) (Menzies 1951).

Key to females of the species of *Idarcturus*

1 Pereonites without dorsal spines........................***I. platysoma* Barnard, 1914**
– Pereonites with dorsal spines..**2**
2 Pereonites without spines dorsolaterally .... ***I. allelomorphus* Menzies & Barnard, 1959**
– Pereonites with spines dorsolaterally **3**
3 Cephalon with two middorsal spines; pereonite IV with one pair of dorsal spines; pleotelson with one pair of spines and two pairs of wings ....***I. hedgpethi* Menzies, 1951**
– Cephalon with three middorsal spines; pereonite IV with four pairs of dorsal spines; pleotelson with two pairs of spines and three pairs of wings.............. ....***I. trispinosus* sp. nov.**

Genus *Neastacilla* Tattersall, 1921

Type species. *Astacilla falclandica* Ohlin, 1901, by subsequent designation.

Diagnosis (modified after King 2003b). Body cylindrical; pereonite I fused to cephalon, occasionally indicated by groove dorsally or slit ventrally; pereonite IV ~ 3–10× longer than other pereonites; pereonites IV and V strongly geniculated. Antenna with one row of spines on each flagellar article. Pereopod I lacking an unguis; pereopods II–IV with claw-like dactylus, not flexible between carpus and propodus; pereopods V–VII with two claws on distal end of dactylus.

***Neastacilla paralongipectus* sp. nov.**

http://zoobank.org/10892AFB-E914-4D4D-A466-DDFB880EA0A5
Figures 12–15

Material examined. ***Holotype.*** South Korea • 1 ♂ (10.2 mm); Jeju-do, Seogwipo-si; 33°13'00"N, 126°19'30"E; 30 m; 31 Jan. 2018; Smith-McIntyre grab; NIBRIV0000862799.

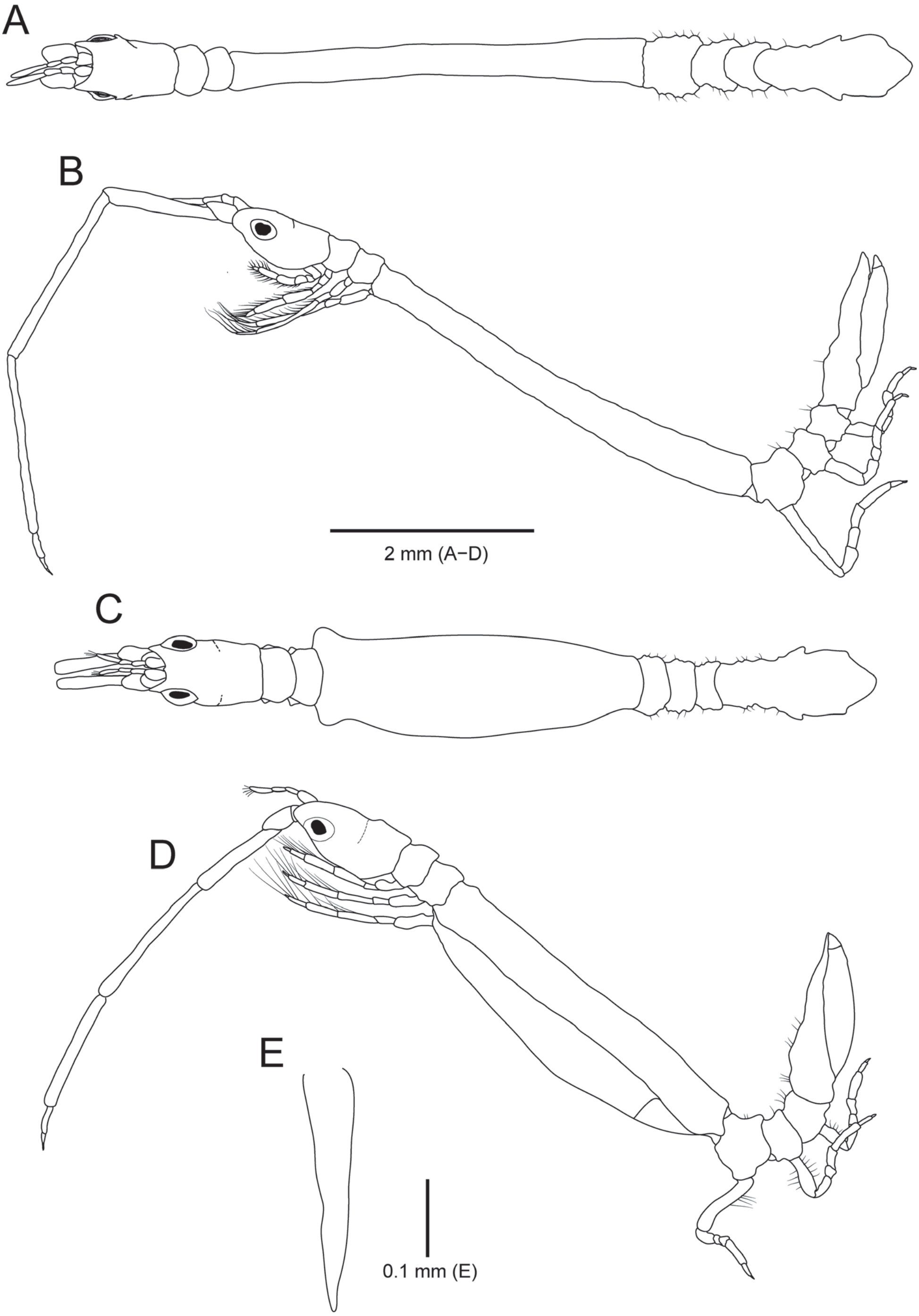

Figure 12. *Neastacilla paralongipectus* sp. nov., holotype, male **A** habitus, dorsal view **B** habitus, lateral view **E** penes. Paratype, female **C** habitus, dorsal view **D** habitus, lateral view.

Paratypes. South Korea • 1 ovigerous ♀ (3.3 mm); Jeju-do, Seogwipo-si; 33°13'12"N, 126°32'12"E; 33 m; 1 Feb. 2018; Smith-McIntyre grab • 1 ovigerous ♀; Jeju-do, Seogwipo-si; 33°11'24"N, 126°18'18"E; 30 m; 28 Apr. 2018; Smith-McIntyre grab • 1 ♂; Jeju-do, Seogwipo-si; 33°13'54"N, 126°36'24"E; 38 m; 26 Apr. 2018; Smith-McIntyre grab; NIBRIV0000880422.

Description of holotype male. *Body* (Fig. 12A, B) 10.2 mm, smooth, 12× as long as wide. *Cephalon* (Fig. 12A, B) with deeply concaved anterior margin possessing small median process; anterolateral lobe expended anteriorly; eye large, round, positioned on lateral margin. Pereonites II and III subequal in length; pereonite IV elongated, ~ 7× longer than pereonites II and III together; pereonites V–VII ~ 1.9× longer than pereonites II and III, surface of pereonites with small tuberculate elevations possessing setae. *Pleon* 1.3× longer than pereonites V–VII; pleotelson gradually tapering posterior region; apex rounded; lateral margin with two pairs of wings; proximal wing indistinct, but distal wing distinct.

Antennule (Fig. 13A) over second peduncular article of antenna, consisting of three peduncular articles and single-articled flagellum; peduncular article I square to globular, articles II and III cylindrical; article II slightly longer than article III; flagellum elongated oval, with five aesthetascs along with anterodistal region and three simple setae on distal end.

Antenna (Fig. 13B, C) slender, exceeding half of body length, composed of five peduncular articles and 3-articled flagellum; peduncular articles I and II subequal to each other; article IV longest; article V slightly shorter than article IV; articles IV and V with I–III pairs of simple setae; flagellar articles I and II with one row of spines resembling saw-teeth, article II with five simple setae on distal end.

Left mandible (Fig. 13D), incisor 3-toothed; lacinia mobilis 2-toothed, with three serrated setae; molar process broad, rough distally. *Right mandible* (Fig. 13E), incisor 3-toothed; lacinia mobilis 3-toothed, with one serrated seta; molar process, strongly serrated distally. *Maxillule* (Fig. 13F) with fine setae on lateral margin; inner lobe with one plumose seta and two distally bifid simple setae on distal end; outer lobe with four serrated robust setae and five robust simple setae on distal end. *Maxilla* (Fig. 13G) with fine setae laterally, consisting of three lobes; inner lobe with six stout circum-plumose setae, three plumose setae, four simple setae; mesial lobe with three comb setae; outer lobe with three plumose setae. *Maxilliped* (Fig. 13H), endite rounded distally, almost 1.2× wider than palp article III, with two coupling hooks medially, seven circum-plumose setae distally, one plumose seta mesially; palp article I with one plumose seta on mesial margin; article II with three plumose setae on medial margin; article III with 15 plumose on medial margin; article IV with five plumose setae medially and three simple setae distally; article V with six simple setae apically.

Pereopods I–IV (Fig. 14A–D) slender, sequentially longer, without unguis and flexion between carpus and propodus. *Pereopods V–VII* (Fig. 14E–G), sequentially shorter. *Pereopod I* (Fig. 14A) shorter than pereopods II–IV; basis longest, with one penicillate seta and four simple setae on superior margin, one simple seta on superodistal angle; ischium to dactylus with numerous plumose setae on inferior margin, 0–4 plumose setae on distal

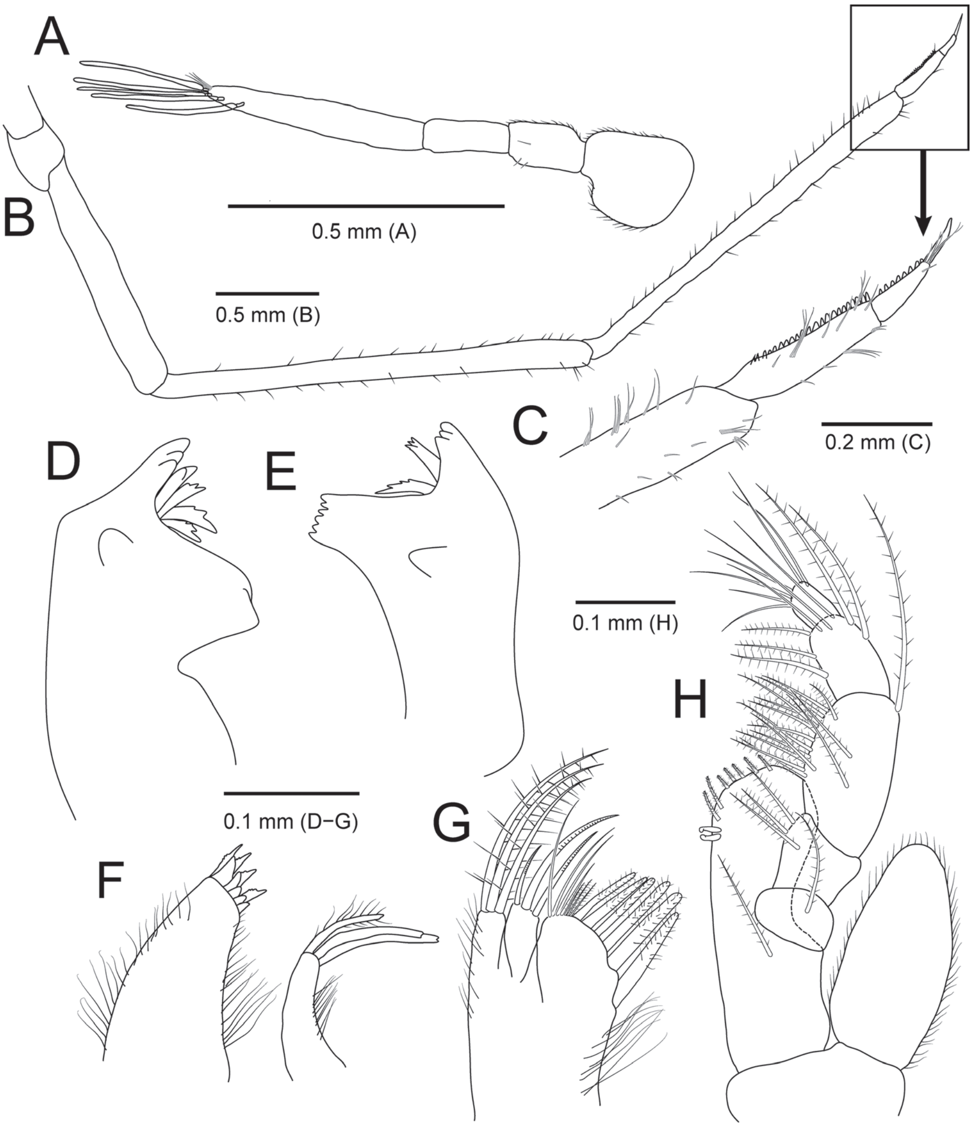

Figure 13. *Neastacilla paralongipectus* sp. nov., holotype, male **A** antennule **B** antenna **C** distal end of antenna **D** left mandible **E** right mandible **F** maxillule **G** maxilla **H** maxilliped.

end; carpus and propodus subequal in length; propodus with ten comb setae on dorsal margin; dactylus as long as wide. *Pereopods II–IV* (Fig. 14B–D), basis to propodus with numerous plumose setae along with inferior margin; merus to propodus with several short simple setae on inferior margin; basis ~ 1.2× longer than ischium; ischium with oblique end distally; merus and carpus similar in length; dactylus reduced and claw-like. *Pereopods V–VII* (Fig. 14E–G) similar to each other; basis, with 3–7 penicillate setae on superior margin; ischium almost 1.7× longer than merus; merus and carpus subequal in length,

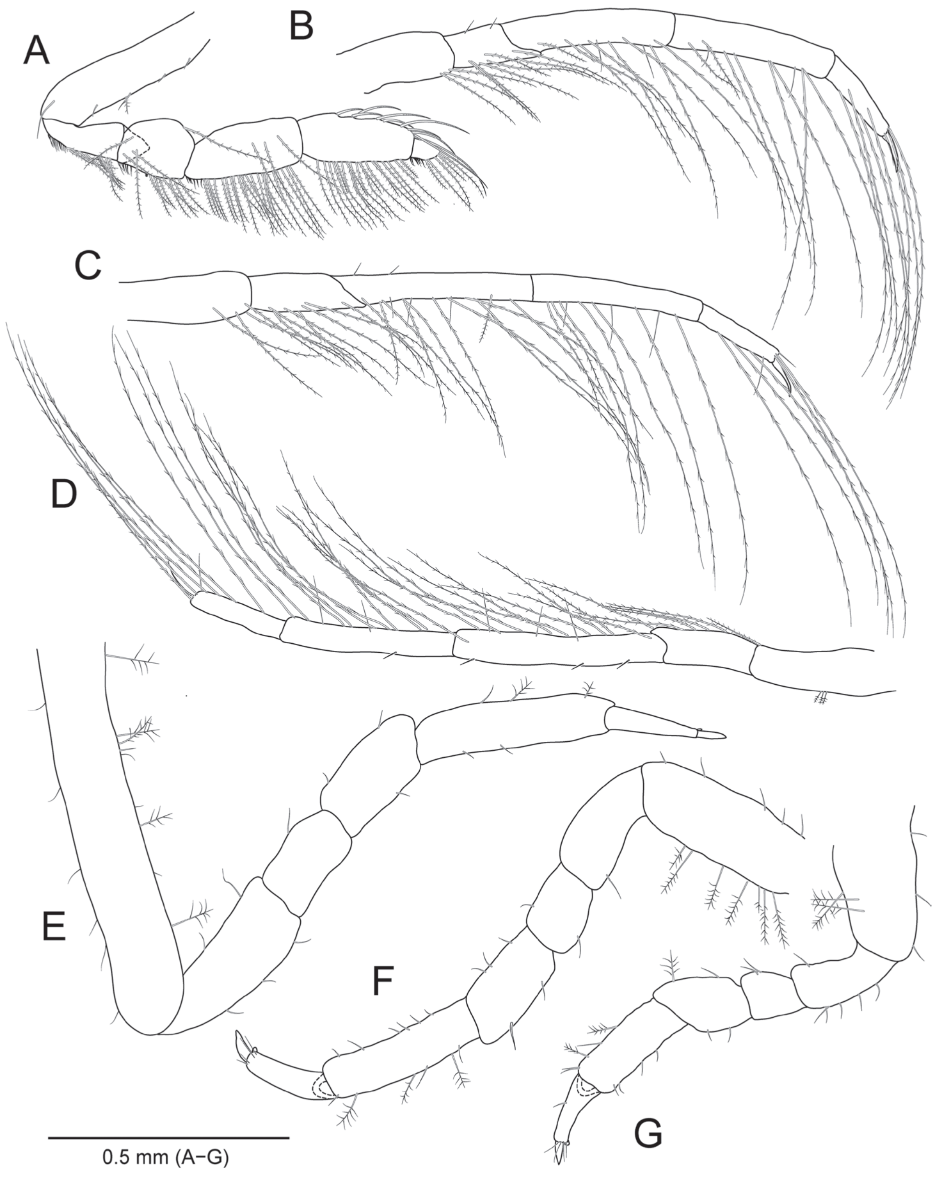

Figure 14. *Neastacilla paralongipectus* sp. nov., holotype, male **A** pereopod 1 **B** pereopod 2 **C** pereopod 3 **D** pereopod 4 **E** pereopod 5 **F** pereopod 6 **G** pereopod 7.

with one penicillate seta on superior margin in pereopod VI; propodus with two or three penicillate setae on superior margin; dactylus bi-unguiculate, secondary unguis tiny.

Penes (Fig. 12E) simple, fused, with acute apex.

Pleopod I (Fig. 15A), protopod rectangular, with four coupling hooks medially; rami subequal, plumose setae longer than rami; exopod with six long plumose setae apically and two plumose setae subbasally, slightly notched subbasally; endopod with

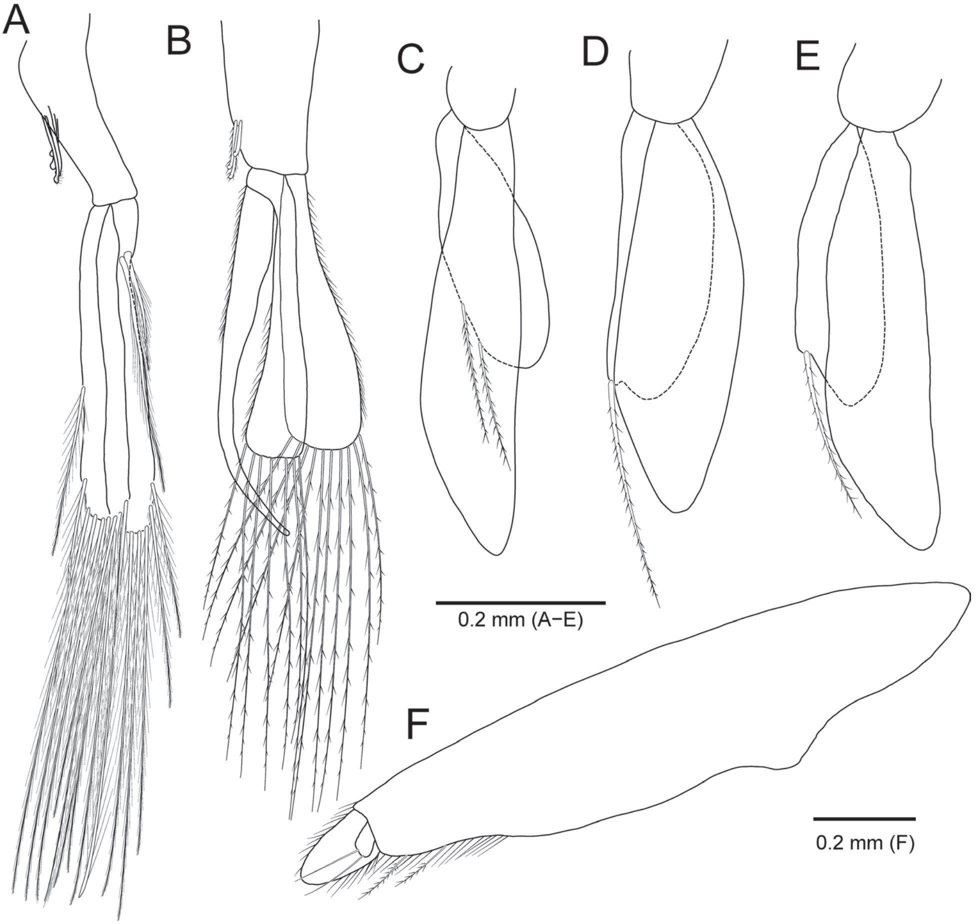

Figure 15. *Neastacilla paralongipectus* sp. nov., holotype, male **A** pleopod 1 **B** pleopod 2 **C** pleopod 3 **D** pleopod 4 **E** pleopod 5 **F** uropod.

eight long plumose setae distally. *Pleopod II* (Fig. 15B) resembling pleopod I; protopod rectangular, ~ 0.8× shorter than protopod of pleopod I, with three coupling hooks on medial margin; exopod with ten long plumose setae on distal end, endopod with seven long plumose setae on apical end; appendix masculina 1.2× longer than endopod, tapering distally. *Pleopod III* (Fig. 15C), protopod square to globular; rami rounded distally; exopod 1.6× longer than endopod, without plumose setae, tapering distally; endopod with two plumose setae medially. *Pleopods IV and V* (Fig. 15D, E) resembling each other; protopod square to globular; rami with rounded distal margin; exopod almost 1.5× longer than endopod, without plumose setae; endopod with one plumose seta subapically.

Uropod (Fig. 15F) elongated oval; protopod ~ 4× longer than wide, with two plumose setae and several fine setae on subapical margin; exopod triangular, with numerous fine setae; endopod square to rectangular, with two simple setae on distal end.

Description of paratype female. *Body* (Fig. 12C, D) ~ 10× as long as wide, length 7.5 mm. *Pereonite IV* (Fig. 12C, D) ~ 5.4× longer than pereonites II and III, shorter than male; anterolateral margins extended laterally. *Oostegite IV* (Fig. 12D) with suture line on posterior region.

Distribution. Southern coast of Jeju-do in South Korea.

Habitats. Sublittoral zone of sandy bottom.

Etymology. The composite epithet of the specific name *paralongipectus* is a combination of the Greek prefix *para-* and the specific name of *Neastacilla longipectus* Nunomura, 2008, which means near *longipectus*, refering to the close resemblance to *N. longipectus*.

Remarks. Seven species of *Neastacilla* have pereonite IV at least 5× as long as pereonites II and III together in female as in the new species: *N. algensis* Hale, 1924, *N. deducta* Hale, 1925, *N. kanowna* King, 2003, *N. lawadi* King, 2003, *N. longipectus* Nunomura, 2008, *N. monoseta* (Guiler, 1949), and *N. soelae* King, 2003 (Hale 1924, 1946; King 2003b; Nunomura 2008). Among these species, *Neastacilla paralongipectus* sp. nov. is easily distinguishable from *N. algensis*, *N. lawadi*, and *N. soelae* in terms of the absence of dorsal tubercles on the cephalon in female (vs. presence in the latter species) (Hale 1924; King 2003b). *Neastacilla paralongipectus* sp. nov. is similar to *N. deducta*, *N. kanowna*, and *N. monoseta* in having a smooth body lacking dorsal elevations (King 2003b). However, *Neastacilla paralongipectus* sp. nov. differs from *N. deducta*, *N. kanowna*, and *N. monoseta* in that oostegite IV has suture posteriorly (vs. mesially in *N. deducta* and *N. monoseta*) and the pleotelson has rounded apex (vs. truncated in *N. kanowna*) (King 2003b). *Neastacilla paralongipectus* sp. nov. is easily distinguishable from *N. longipectus* in terms of the shape of the anterior margin of the cephalon (deeply concave in the former vs. slightly concave in the latter), the shape of the penes (elongated triangle in the former vs. rectangle in the later), and the structure of pereonite I and pleonite I (fused to cephalon and pleotelson, respectively, in the former vs. not fused in the latter) (Nunomura 2008).

Key to known species of the genus *Neastacilla* in the northwest Pacific

1	Eye absent	**2**
–	Eye present	**4**
2	Body with bosses	***N. ochroleuca* Kussakin & Vasina, 1990**
–	Body without bosses	**3**
3	Carpus 3.2× longer than wide in pereopod	***N. birsteini* Golovan, Malyutina & Brandt, 2018**
–	Carpus ~ 6× longer than wide in pereopod I	***N. anophthalma* (Birstein, 1963)**
4	Pereonite IV ~ 0.5–3× longer than pereonites II and III together	**5**
–	Pereonite IV at least 7× longer than pereonites II and III together	**15**
5	Pleotelson without lateral wings	**6**
–	Pleotelson with lateral wings	**8**

6 Pereonite IV similar with other pereonites in length.. ***N. tritaeniata*** **(Richardson, 1909)**

– Pereonite IV ~ 2× longer than pereonites II and III together....................... **7**

7 Eye small and without pigment............. ***N. leucophthalma*** **Kussakin, 1971**

– Eye large and black .... ***N. tzvetkowae*** **Kussakin, 1974**

8 Body covered by tubercles... **9**

– Body covered by spines **11**

– Body smooth **14**

9 Tubercles small and granule size...................... ***N. scabra*** **Nunomura, 2006**

– Tubercles large and prominent **10**

10 Eye small and without pigment...................... ***N. nodulosa*** **Kussakin, 1982**

– Eye large and with pigment......... ***N. pallidocula*** **Kussakin & Vasina, 1990**

11 Spines large and prominent... **12**

– Spines minute and granule size **13**

12 Pereonite IV 1.5× longer than pereonites II and III together.. ***N. exilis*** **Kussakin, 1971**

– Pereonite IV similar to pereonites II and III together .... ***N. spinifera*** **Nunomura, 2006**

13 Pleotelson with rounded apex .... ***N. littoralis*** **Kussakin, 1974**

– Pleotelson with acute apex .... ***N. richardsonae*** **Kussakin, 1982**

14 Lateral wings of pleotelson small and indistinct.... ***N. kurilensis*** **Kussakin, 1974**

– Lateral wings of pleotelson large and distinct .... ***N. polita*** **(Gurjaova, 1936)**

15 Pleotelson without lateral wings.................... ***N. tanakai*** **Nunomura, 2004**

– Pleotelson with lateral wings **15**

16 Pereonite I separated from cephalon; pleon 2-segmented; anterior margin of cephalon deeply concave.......................... ***N. longipectus*** **Nunomura, 2008**

– Pereonite I fused to cephalon; pleon single-segmented; anterior margin of cephalon slightly concave................................ ***N. paralongipectus*** **sp. nov.**

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References

Barnard KH (1914) Contributions to the crustacean fauna of South Africa.3. Additions to the marine Isopoda, with notes on some previously incompletely known species. Annals of the South African Museum 10: 325a–358a, 359–442. https://doi.org/10.5962/bhl.part.9319

Boyko CB, Bruce NL, Hadfield KA, Merrin KL, Ota Y, Poore GCB, Taiti S, Schotte M, Wilson GDF [Eds] (2008a) World Marine, Freshwater and Terrestrial Isopod Crustaceans database. *Amakusanthura* Nunomura, 1977. Accessed through: World Register of Marine Species. http://www.marinespecies.org/isopoda/aphia.php?p=taxdetails&id=118287 [accessed 15 Oct 2020]

Boyko CB, Bruce NL, Hadfield KA, Merrin KL, Ota Y, Poore GCB, Taiti S, Schotte M, Wilson GDF [Eds] (2008b) World Marine, Freshwater and Terrestrial Isopod Crustaceans database. *Apanthura* Stebbing, 1900. Accessed through: World Register of Marine Species. http://www.marinespecies.org/isopoda/aphia.php?p=taxdetails&id=118289 [accessed 15 Oct 2020]

Boyko CB, Bruce NL, Hadfield KA, Merrin KL, Ota Y, Poore GCB, Taiti S, Schotte M, Wilson GDF [Eds] (2008c onwards). World Marine, Freshwater and Terrestrial Isopod Crustaceans database. *Neastacilla* Tattersall, 1921. Accessed through: World Register of Marine Species. http://www.marinespecies.org/isopoda/aphia.php?p=taxdetails&id=249016 [accessed 04 June 2020]

Boyko CB, Bruce NL, Hadfield KA, Merrin KL, Ota Y, Poore GCB, Taiti S, Schotte, M, Wilson GDF [Eds] (2008d onwards). World Marine, Freshwater and Terrestrial Isopod Crustaceans database. *Parapleuroprion* Kussakin, 1972. Accessed through: World Register of Marine Species. http://www.marinespecies.org/Isopoda/aphia.php?p=taxdetails&id=249128 [accessed 27 November 2020]

Brusca RC, Iverson EW (1985) A guide to the marine isopod Crustacea of Pacific Costa Rica. Revista de Biologia Tropical 33(Supplement): 1–77.

Chew M, Rahim AA, bin Haji Ross O (2014) *Tinggianthura alba*: A new genus and species of Anthuridae (Isopoda, Cymothoida, Anthuroidea) from Pulau Tinggi, Johor, Malaysia with an updated key to the genera of Anthuridae. PLoS ONE 9(6): e99072. https://doi.org/10.1371/journal.pone.0099072

Coleman CO (2003) "Digital inking": How to make perfect line drawings on computers. Organisms Diversity and Evolution 3(4): 1–14. https://doi.org/10.1078/1439-6092-00081

Coleman CO (2009) Drawing setae the digital way. Zoosystematics and Evolution 85(2): 305–310. https://doi.org/10.1002/zoos.200900008

Castelló J, Molina C, Constenla M, Soler-Membrives A (2016) Description of *Arcturinella deltensis* sp. nov. (Crustacea, Isopoda, Arcturidae) from the Ebro Delta (Western Mediterranean Sea), with remarks on the status of the genus *Arcturinella* Poisson & Maury, 1931. Marine Biodiversity 48(11): 1–8. https://doi.org/10.1007/s12526-016-0624-9

Gurjanova E (1936) Beitrage zur Kenntnis der Isopodenfauna des Pazifischen Ozeans. IV. Neue Isopodenarten aus dem Japanischen und Beringmeer. Zoologischer Anzeiger 114: 250–265.

Golovan OA, Malyutina MV, Brandt A (2018) Arcturoid isopods (Isopoda: Valvifera) from the SokhoBio expedition: first records from the abyss of the Sea of Okhotsk with description of *Neastacilla birsteini* sp. nov. Deep Sea Research Part II: Topical Studies in Oceanography 154: 308–319. https://doi.org/10.1016/j.dsr2.2017.11.004

Hale HM (1924) Notes on Australian Crustacea. No III. Transactions of the Royal Society of South Australia 48: 209–225.

Hale HM (1946) Isopoda -Valvifera. British, Australian and New Zealand Antarctic Research Expedition, 1929–1931. Reports–Series B (Zoology and Botany) 5(3): 161–212.

Kensley BF (1978) The South African Museum's Meiring Naude cruises. Part 8. Isopoda Anthuridea. Annals of the South African Museum 77(1): 1–25.

Kensley BF, Schotte M, Poore GCB (2007) New species and records of valviferan isopods (Crustacea: Isopoda: Valvifera) from the Indian Ocean. Proceedings of the Biological Society of Washington 120: 429–445. https://doi.org/10.2988/0006-324X(2007)120[429:NSAROV]2.0.CO;2

Kensley BF, Schotte M (1989) Guide to the Marine Isopod Crustaceans of the Caribbean. Smithonian Institution Press, Washington DC, 308 pp. https://doi.org/10.5962/bhl.title.10375

King RA (2003a) First valid record of *Astacilla* Cordiner, 1793 in Australia, with description of a new species (Crustacea: Isopoda: Arcturidae). Records of the Western Australian Museum 21(4): 359–366. https://doi.org/10.18195/issn.0312-3162.21(4).2003.359-366

King RA (2003b) *Neastacilla* Tattersall, 1921 redefined, with eight new species from Australia (Crustacea: Isopoda: Arcturidae). Memoirs of Museum Victoria 60(2): 371–416. https://doi.org/10.24199/j.mmv.2003.60.29

Kussakin OG (1971) Additions to the fauna of isopods (Crustacea, Isopoda) of the Kurile-Kamchatka Trench. Part III. Flabellifera and Valvifera. Trudy Instituta Okeaonogiya, Akademiya Nauk SSSR, Moscow 92: 239–273.

Kussakin OG (1972) Isopoda from the coastal zone of the Kurile Islands. III. Three new arcturids from the Middle Kuriles with taxonomic remarks on the family Arcturidae. Crustaceana Supplement 3: 178–189.

Kussakin OG (1974) Fauna and ecology of isopods (Crustacea) from the intertidal zone of the Kurile Islands. Flora and fauna of the intertidal zone of the Kurile Islands: 227–275.

Kussakin OG (1982) Marine and brackish-water Crustacea (Isopoda) of cold and temperate waters of the Northern Hemisphere. Suborders Anthuridea, Microcerberidea, Valvifera, Tyloidea. National Academy of Sciences, USSR, Zoology (Opredeliteli po Faune SSR, Akademiya Nauk, SSSR) 131: 1–461.

Kussakin OG, Vasina GS (1990) Isopod crustaceans of the suborders Flabellifera and Valvifera from the bathyal region of the Kurile Islands. Akademiya Nauk, SSSR, Dalnevostochroe Otdelenie, Institut Biologii Morya: 43–63.

Mezhov B (1976) New species of Anthuridea from the upper part of the sublittoral zone of the Middle Kuril Islands. Biologiya Morya, Vladivostok 5: 19–27.

Menzies RJ (1951) New marine isopods, chiefly from northern California, with notes on related forms. Proceedings of the United States National Museum 101(3273): 105–156. https://doi.org/10.5479/si.00963801.101-3273.105

Menzies RJ, Barnard JL (1959) Marine Isopoda on coastal shelf bottoms of southern California: systematics and ecology. Pacific Naturalist 1(11–12): 1–35.

Müller HG (1992) Anthuridae of the genera *Amakusanthura*, *Cortezura* and *Mesanthura* from the Caribbean Sea of Colombia (Crustacea: Isopoda). Revue suisse de Zoologie 99(1): 31–79. https://doi.org/10.5962/bhl.part.79820

Nunomura N (1993) Marine isopod crustaceans of Seto Inland Sea deposited at the Toyama Science Museum 1. Suborder Anthuridea-1. Bulletin of the Toyama Science Museum 16: 15–30.

Nunomura N (2004) Marine isopod crustaceans collected from Izu Peninsula, Middle Japan. Bulletin of the Toyama Science Museum 293: 1–14.

Nunomura N (2006) Marine isopod crustaceans in the Sagami Sea, central Japan. Memoirs of the National Science Museum 41: 1–42.

Nunomura N (2008) Marine isopod crustaceans collected from Shijiki Bay, western Japan (1) Valvifera, Cymothoida, Sphaeromatidea, Limnoriidea and Oniscidea. Bulletin of the Toyama Science Museum 31: 13–43.

Nunomura N (2016) A New Species of the Genus *Amakusanthura* (Crustacea: Isopoda: Anthuridae) Collected from Yuya Bay, on the Sea of Japan Side of Yamaguchi Prefecture, Western Japan. Japan Sea Research 47: 1–8.

Poore GCB (2001a) Families and genera of Isopoda Anthuridea. Crustacean Issues 13: 63–173.

Poore GCB (2001b) Isopoda Valvifera: diagnoses and relationships of the families. Journal of Crustacean Biology 21(1): 205–230. https://doi.org/10.1163/20021975-99990118

Poore GCB, Lew Ton HM (1985) *Apanthura*, *Apanthuretta* and *Apanthuropsis* gen. nov. (Crustacea: Isopoda: Anthuridae) from south-eastern Australia. Memoirs of the Museum of Victoria 46: 103–151. https://doi.org/10.24199/j.mmv.1985.46.05

Poore GCB, Bruce NL (2012) Global diversity of marine isopods (except Asellota and crustacean symbionts). PLoS ONE 7: e43529. https://doi.org/10.1371/journal.pone.0043529

Schultz GA (1969) How to Know the Marine Isopod Crustaceans. William C. Brown Company Publishers, Dubuque, Illinois, 359 pp.

Song JH, Min GS (2015) Two new species, *Caenanthura koreana* sp. nov. and *Apanthura koreaensis* sp. nov. (Crustacea: Isopoda: Anthuridae) from South Korea. Zootaxa 3937(2): 362–376. https://doi.org/10.11646/zootaxa.3937.2.7

Richardson H (1909) Isopods collected in the northwest Pacific by the US Bureau of Fisheries Steamer "Albatross" in 1906. Proceedings of the United States National Museum 37: 75–129. https://doi.org/10.5479/si.00963801.37-1701.75

Rincón B, Arranz S, Junoy J (2018) Isopods of the genus *Astacilla* (Valvifera, Arcturidae) from the LIFE + INDEMARES project off Alborán Island (S Spain), with the description of a rare species *A. carlosoteroi* (Reboreda, Wägele & Garmendia, 1994). Mediterranean marine science 19: 504–512. https://doi.org/10.12681/mms.15594

Wägele JW (1980) Anthuridea (Crustacea, Isopoda) aus dem Tyrrhenischen Meer. Zoologica Scripta 9: 53–66. https://doi.org/10.1111/j.1463-6409.1980.tb00650.x

Wägele J (1984) On a small collection of littoral Crustacea Isopoda Anthuridea (family Anthuridae) from the Far East. Journal of natural history 18: 739–757. https://doi.org/10.1080/00222938400770621

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Two new species of *Ooceraea* (Hymenoptera, Formicidae, Dorylinae) from India with ten-segmented antennae

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Abstract

Two new species, *O. decamera* **sp. nov.** and *O. joshii* **sp. nov.**, of the ant genus *Ooceraea* are described from India. These species differ from other known congeners on the basis of number of antennal segments. An illustrated key to the known species based on the worker caste is also provided.

Keywords

Cerapachys, distribution, illustrated key, *O. decamera* sp. nov., *O. joshii* sp. nov., systematics, taxonomy

Introduction

The taxonomic history of the ant genus *Ooceraea* Roger, 1862 has been challenging, since its inception based on the type species *O. fragosa*. The taxonomic ambiguity has led to its uncertain placements in different subfamilies: in Myrmicinae (Mayr 1865; Emery 1877), in Ponerinae (Dalla Torre 1893; Forel 1893) and in Dorylinae (Emery 1895). *Ooceraea* was treated as a subgenus of *Cerapachys* (Emery 1902; Wheeler W.M. 1902; Emery 1911), and as a junior synonym of *Cerapachys* (Brown 1975). This dilemma has lately been resolved with a comprehensive revision of generic-level classification of the subfamily Dorylinae. *Ooceraea* was resurrected as a valid genus in Dorylinae with a distinctive combination of characters, by which it can be distinguished from other Dorylinae genera. These include: propodeal spiracle positioned low on the sclerite; pygidium armed with modified setae; antennae with 11 or fewer segments; pronotomesopleural suture developed; abdominal segment III strongly tubulated (forming "postpetiole") and no constrictions between abdominal segments IV, V and VI. *Ooceraea* can be distinguished from the closely allied *Syscia* Roger, 1861 on the basis of abdominal segment III relatively narrow in dorsal view and similar in size to the preceding abdominal segment II (petiole); in lateral view, abdominal tergite IV not folding over sternite and the anterior portion of the sternite visible; hind basitarsi not dilating distally, circular in cross-section and metabasitarsal glands absent (Borowiec 2016).

The genus is currently represented by 14 species (Bolton 2020). Six of these are reported from the Australian and Oceanian regions, five from the Oriental region and two species from the Palearctic region (Holt et al. 2013; Janicki et al. 2016; Guénard et al. 2017; Yamada et al. 2018; Zhou et al. 2020); while the 14th species *O. biroi* (Forel, 1907) is probably native to the Asian continent, and has been introduced to Southeast Asia, the Pacific islands, Madagascar and the Caribbean islands (Borowiec 2016; Janicki et al. 2016; Guénard et al. 2017) (Fig. 10). The antennal count has been found to be one of the significant species-level diagnostic characters in the genus. Eight of the known *Ooceraea* species possess nine-segmented antennae, while five possess eleven-segmented antennae and one species has recently been reported with eight-segmented antennae (Zhou et al. 2020). In India, the genus is represented by two species viz. *Ooceraea alii* (Bharti & Akbar, 2013) and *Ooceraea besucheti* (Brown, 1975) with nine- and eleven-segmented antennae respectively (Bharti et al. 2016). Here in, we describe two new species with ten-segmented antennae from India, thus adding to the known diversity of this considered rare genus. A key to the known species based on the worker caste is also provided.

Materials and methods

Taxonomic analysis was conducted on a Nikon SMZ 1500 stereo zoom microscope with maximum magnification of 112.5×. Digital images of the specimens were prepared using a Nikon SMZ 1500 stereomicroscope fitted with a Micro Publisher digital camera (Figs 1–4) and Leica MZ 16 stereomicroscope with a JVC digital video camera (Figs 5–9). All the images were cleaned with Adobe Photoshop CS5 and Helicon Filter 5. Morphological measurements were recorded in millimeters on a Nikon SMZ 1500 stereomicroscope. Morphological terminology and standard measurements follow Borowiec (2016) and Yamada et al. (2018).

HL	Head length: maximum length of head capsule in full-face view, measured from transverse line spanning the anterior most point of clypeus to that of posterior most point of head capsule;
HW	Head width: maximum width of head capsule in full-face view (excluding eyes);

SL	Scape length: maximum length of antennal scape excluding basal condylar bulb;
MW	Mesosomal width: maximum width of promesonotum in dorsal view;
ML	Mesosomal length: maximum diagonal length of mesosoma in lateral view, measured from posterodorsal border of pronotal flange to posterior basal angle of metapleuron;
PL	Petiolar length: maximum length of petiole in lateral view;
PH	Petiolar height: maximum height of petiole in lateral view (including subpetiolar process);
PW	Petiolar width: maximum width of petiole in dorsal view;
PPL	Postpetiolar length: maximum length of postpetiole in lateral view;
PPH	Postpetiolar height: maximum height of postpetiole in lateral view;
PPW	Postpetiolar width: maximum width of postpetiole in dorsal view;
CI	Cephalic index: HW/HL × 100;
SI	Scape index: SL/HW × 100;
PI1	Petiolar index 1: PL/PH × 100;
PI2	Petiolar index 2: PW/PL × 100;
PPI1	Postpetiolar index 1: PPL/PPH × 100;
PPI2	Postpetiolar index 2: PPW/PPL × 100;
WI	Waist index: PPW/PW × 100.

Depositories

PUAC	Punjabi University Patiala Ant Collection at Department of Zoology and Environmental Sciences, Punjabi University, Patiala, Punjab, India;
MCZC	Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, United States.

Results

Ooceraea joshii sp. nov.

http://zoobank.org/182F8A89-653B-4604-8337-F7A5F258080B
Figs 1–4

Type locality. India, Kerala, Periyar Tiger Reserve 9.5627°N, 77.2348°E, 780 m.

Type material. ***Holotype*** worker and one ***paratype*** worker, both India, Kerala, Periyar Tiger Reserve 9.5627°N, 77.2348°E, 780 m, leaf litter, Winkler, 21 January 2017, Tarun Dhadwal leg. [PUAC].

Measurements. Holotype: HL 0.57; HW 0.56; SL 0.34; MW 0.39; ML 0.68; PL 0.29; PH 0.34; PW 0.27; PPL 0.32; PPH 0.34; PPW 0.30; CI 98; SI, 61; PI1 85; PI2 93; PPI1 94; PPI2 88; WI 111. Paratype: HL 0.57; HW 0.56; SL 0.33; MW 0.39; ML 0.68; PL 0.29; PH 0.33; PW 0.26; PPL 0.32; PPH 0.34; PPW 0.30; CI 98; SI, 59; PI1 88; PI2 89; PPI1 94; PPI2 88; WI 111.

Worker description. Head in full-face view, almost as long as broad, with lateral margin weakly convex and converging anteriorly, with posterior margin concave medially and posterior lateral corners rounded. Anterior clypeal margin reduced and slightly concave in the middle. Eyes present, small in size, with two ommatidia, parafrontal ridge prominently produced. Mandibles edentate, sub-triangular. Antenna 10-segmented; scape short and clavate, reaching almost mid-length of the head; apical funicular segment fusiform. Frontal lobes reduced. Antennal sockets fully exposed from above.

Mesosoma in lateral view weakly convex; promesonotal suture and metanotal groove absent. Pronotum in dorsal view anteriorly marginate. Propodeum in dorsal view with posterior margin concave; propodeal declivity in lateral view slightly concave, with lateral margin slightly marginate; propodeal lobe reduced. Petiolar node in dorsal view as long as broad, rounded anteriorly, in lateral view hemiglobular; subpetiolar process well-developed, with sickle-shaped anteroventral apex. Postpetiole in dorsal view subtrapezoidal, with anterior margin transverse and posterior margin convex, in lateral view with anteroventral corner angulate. Gastral segment I (abdominal segment IV) large, occupying the most part of gaster, in lateral view with dorsal margin weakly and roundly convex.

Sculpture. Head foveolate-reticulate; mesosoma, petiole and postpetiole foveolate-reticulate; gaster foveolate, with foveae smaller than those of head and mesosoma.

Pilosity and Pubescence. Body covered with erect or sub-erect hairs; sides of head and legs covered with shorter hairs; scape and funicular segments covered with short decumbent or subdecumbent hairs.

Body coloration. Head and gaster light brown; mesosoma, petiole and postpetiole darker than the head; legs yellowish brown.

Queen. Unknown.

Male. Unknown.

Recognition. *Ooceraea joshii* sp. nov. and *O. decamera* sp. nov. (described below) are distinctly separated from the other valid congeners by having 10-segmented antennae. Furthermore, the two new species are well distinguished from each other by a combination of the following characters: head shape (almost as long as broad in *O. joshii* sp. nov., rectangular, distinctly longer than broad in *O. decamera* sp. nov.); presence of ommatidia (present in *O. joshii* sp. nov. and absent in *O. decamera* sp. nov.); propodeal lobes (reduced versus roundly produced); petiolar node in lateral view (hemiglobular versus rectangular); subpetiolar process (anteroventral part sickle-shaped versus forming a rectangular and semitransparent lobe); pilosity (head and body comparatively more pilose in *O. joshii* sp. nov.); and sculpturation (head, mesosoma, petiolar, postpetiolar node, and gaster with more pronounced foveolate sculpture in *O. joshii* sp. nov.).

Bionomics. The type series was found in leaf litter samples collected from the Medaganam region of the Periyar Tiger Reserve situated at an elevation of 780 meters. The region is composed of an undisturbed tropical moist evergreen forest with low light penetration, with a mean average daytime temperature of 30 °C.

Figure 1. *Ooceraea joshii* sp. nov. Head in full-face view.

Figure 2. *Ooceraea joshii* sp. nov. Body in profile view.

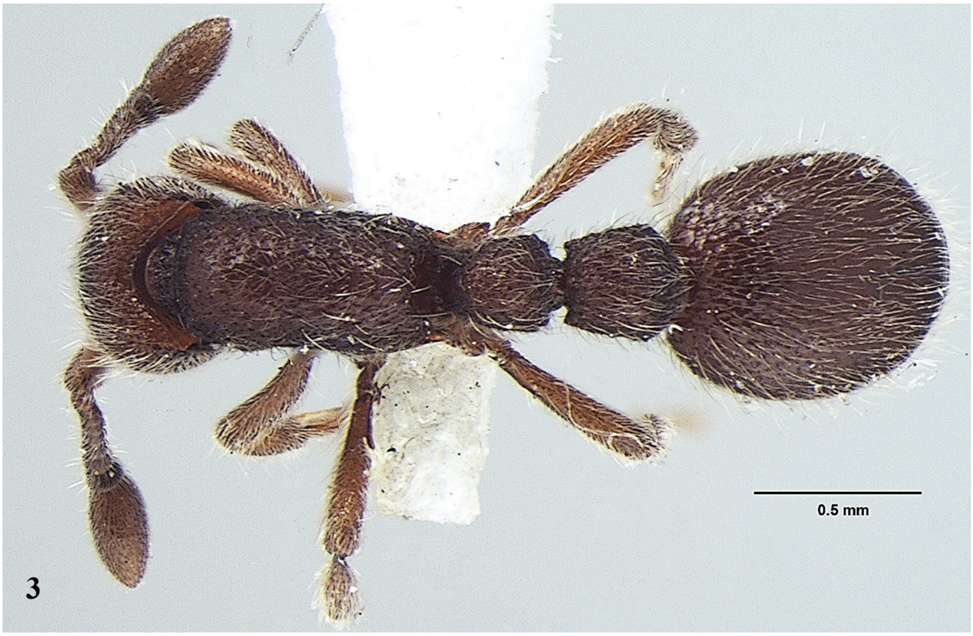


Figure 3. *Ooceraea joshii* sp. nov. Body in dorsal view.

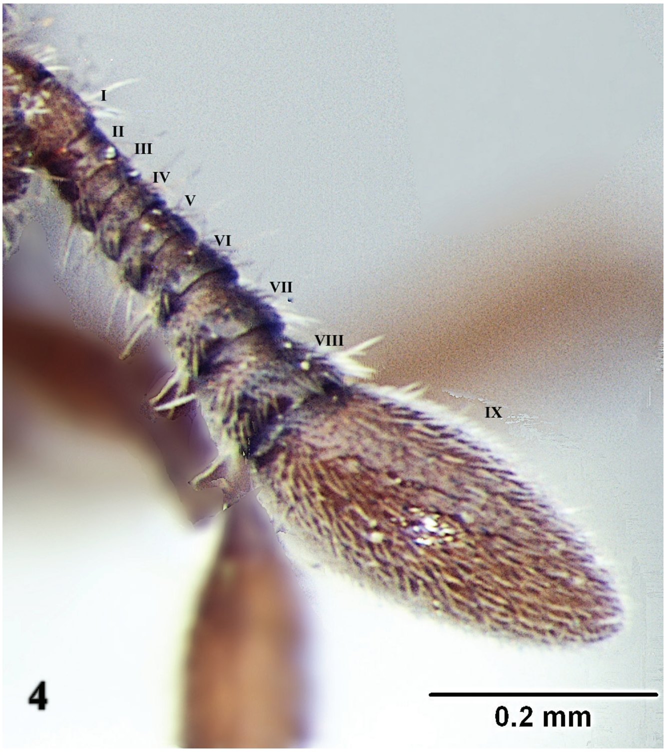


Figure 4. *Ooceraea joshii* sp. nov. Funicular segments.

Distribution. Known only from the type locality.

Etymology. The species has been named in honor of Professor Amitabh Joshi, a distinguished evolutionary biologist based at Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru, India.

Ooceraea decamera **sp. nov.**

http://zoobank.org/D8C9E609-7416-4081-A54A-83CAA01CEAD6

Figs 5–9

Type locality. India: Madras, Alagarkovil, 21 km. N Madurai, 10.02308°N, 77.833333°E, 250–350 m alt.

Type material. ***Holotype*** worker, India, Madras, Alagarkovil, 21 km N Madurai, 10.02308°N, 77.833333°E, 250–350 m alt.; 2 November 1972; Besuchet Lobt Mussard leg. (Specimen number/barcode: MCZ-ENT00649398) [MCZC].

Holotype measurements. HL 0.62; HW 0.46; SL 0.26; MW 0.38; ML 0.78; PL 0.26; PH 0.42; PW 0.30; PPL 0.34; PPH 0.41; PPW 0.40; CI 74; SI 57; PI1 62; PI2 93; PPI1 81; PPI2 118; WI 133.

Worker description. Head in full-face view rectangular, distinctly longer than broad (CI 74), with lateral sides weakly convex, with posterior margin concave medially, with occipital lobes/corners angulate. Anterior clypeal margin slightly projecting forward. Eyes absent. Parafrontal ridge prominent and elevated. Mandibles edentate but weakly serrate. Antennae with 10 segments; scape short, clavate, slightly surpassing the mid-length of head. Frontal lobes reduced. Antennal sockets fully exposed from above.

Mesosoma in lateral view almost flat; promesonotal suture and metanotal groove absent. Pronotum in dorsal view with anterior margin weakly and roundly convex, with humeral corner rounded. Propodeum in dorsal view with posterior margin concave; propodeal declivity in lateral view almost straight, with lateral margin marginate; propodeal lobe roundly produced. Petiolar node in dorsal view subtrapezoidal, distinctly broader than long, in lateral view rectangular with anterior and posterior margins almost straight and dorsal margin weakly convex. Subpetiolar process well-developed, with anteroventral part forming a rectangular and semitransparent lobe. Postpetiole broader than long, anterior margin weakly concave and posterior margin weakly convex, in lateral view with anteroventral part broadly and roundly produced. Gastral segment I (abdominal segment IV) large occupying the most part of gaster, in lateral view with dorsal margin almost straight, base of cinctus of first gastral tergite cross-ribbed.

Sculpture. Head, mesosoma, petiole and postpetiole shallowly foveolate-reticulate; mandibles and dorsal surface of gaster sparsely foveolate, foveae somewhat smaller as compared to those present on head, mesosoma, petiole, and postpetiole.

Pilosity and pubescence. Whole body covered with pale yellow erect and sub-erect hairs; appressed pubescence abundant on antennae and legs.

Body coloration. Mandibles, antennae, legs, subpetiolar process and gaster light brown; head, mesosoma and gaster dark brown.

Figure 5. *Ooceraea decamera* sp. nov. Head in full-face view.

Figure 6. *Ooceraea decamera* sp. nov. Body in profile view.

Queen. Unknown.

Male. Unknown.

Recognition. The two species significantly differ from each other on the basis of dimensions of head capsule and shape of subpetiolar process.

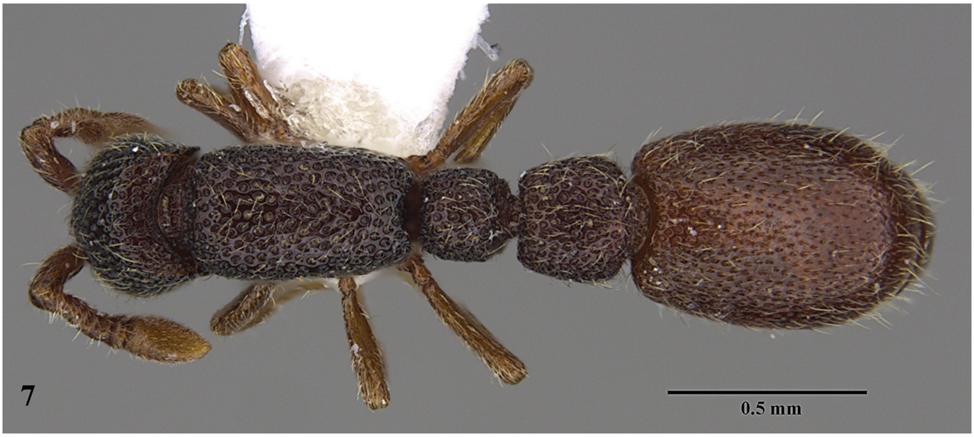


Figure 7. *Ooceraea decamera* sp. nov. Body in dorsal view.

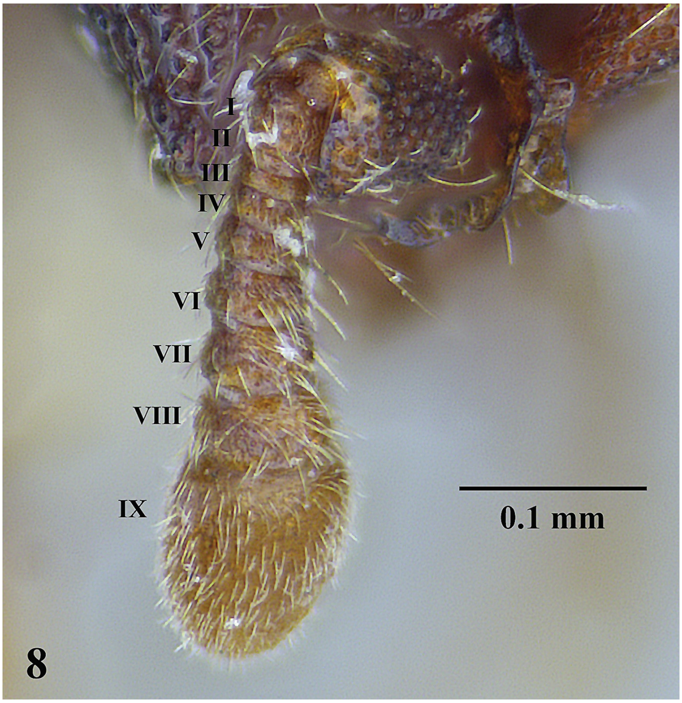


Figure 8. *Ooceraea decamera* sp. nov. Funicular segments.

Bionomics. Unknown.

Distribution. Known only from the type locality. The place has been transformed into agricultural land and is prone to anthropogenic activities. Thus, this reinforces the concept that important biodiversity components, which are already rare, are imperiled due to local extinctions.

Etymology. The species epithet *decamera* refers to the ten-segmented antennal count.

INDIA #5 Madras
Alagarkovil, 21
km. N. Madurai
250-350M. 2·XI·72
Besuchet Löbl Mussard

MCZ-ENT
00649398

HOLOTYPE
Cerapachys decamerus
des. M.L. BOROWIEC

Figure 9. Label of *Ooceraea decamera* sp. nov.

Figure 10. Map showing the current distribution of *Ooceraea* species.

Illustrated key to the known species of *Ooceraea* based on worker caste

1 Whole body variously sculptured **2**
– Whole body not sculptured, mesosoma smooth and shiny (Fig. A) .... ***O. australis***

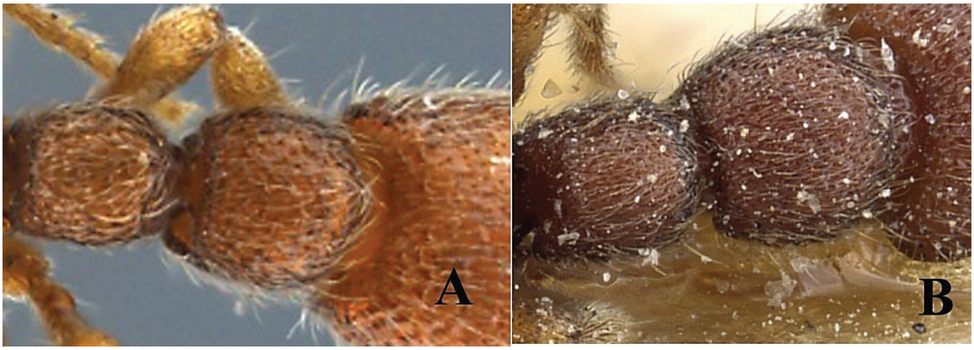
2 Body predominantly punctate (Fig. A) **3**
– Body predominantly foveate (Fig. B) **6**

3 Anterolateral shoulders of the first gastric segment as seen from above broadly rounded and gradually widening caudad (Fig. A) .... ***O. biroi***

– Anterolateral shoulders of the first gastric segment abruptly rounded, accentuating the medium concavity that receives the postpetiole (Fig. B) **4**

4 Postpetiole distinctly longer than broad (Fig. A) **5**

– Postpetiole broader than long (New Guinea) (Fig. B)................ ***O. papuana***



5 Head coarsely and irregularly rugose and punctuate (Solomon Islands)......... .... ***O. pawa***

– Head regularly punctate (New Guinea) (Fig. A)............................ ***O. pusilla***

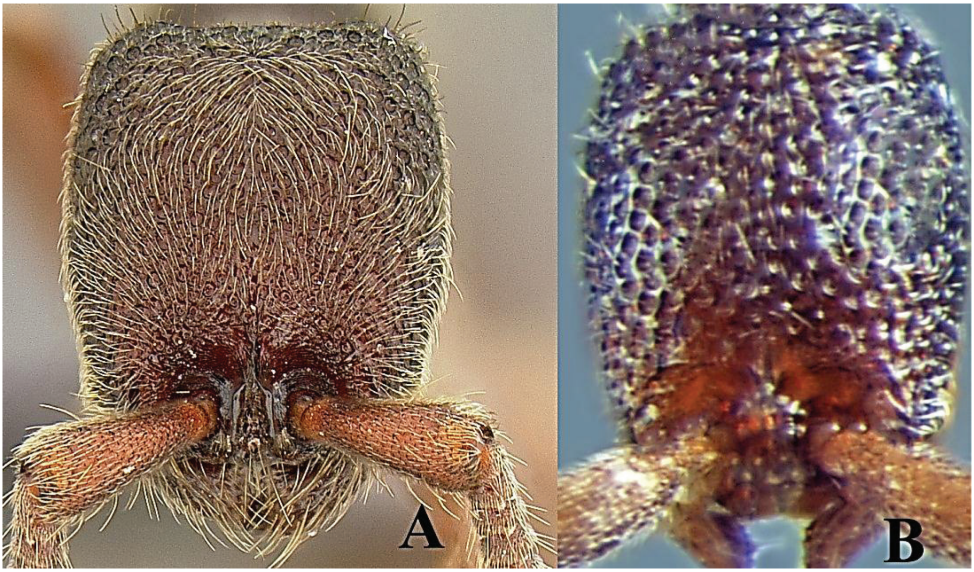
6 Lateral ridge of posterior face of propodeum armed with two pairs of denticles (Vietnam) (Fig. A)... ***O. quadridentata***

– Lateral ridge of posterior face of propodeum without denticles (Fig. B) **7**

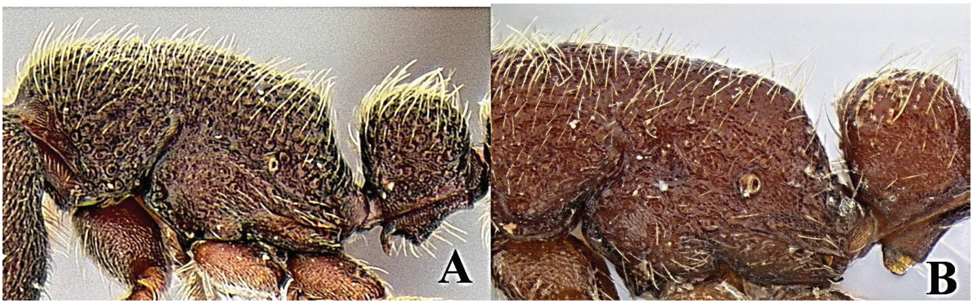
7 Spaces between foveolae shagreen-like, giving the integument a rough appearance (Fig. A)..**8**

– Spaces between foveolae smooth, giving the integument a shiny appearance (Fig. B) **10**

8 Species large in size (HW> 70mm); posterior margin of head almost straight (Fig. A) **9**
– Species small in size (HW< 40 mm); posterior margin of head distinctly concave in the middle (Fig. B) .... ***O. alii***



9 Sides of propodeum and sides of petiole with dense, deeply impressed foveae that are discernibly wider in diameter than propodeal spiracle or foveae on head. Dark species (Fiji) (Fig. A) .... ***O. fuscior***
– Sides of propodeum and sides of petiole with sparse, lightly impressed foveae that are not discernibly wider in diameter than propodeal spiracle or foveae on head. Pale species (Fiji) (Fig. B) .... ***O. crypta***



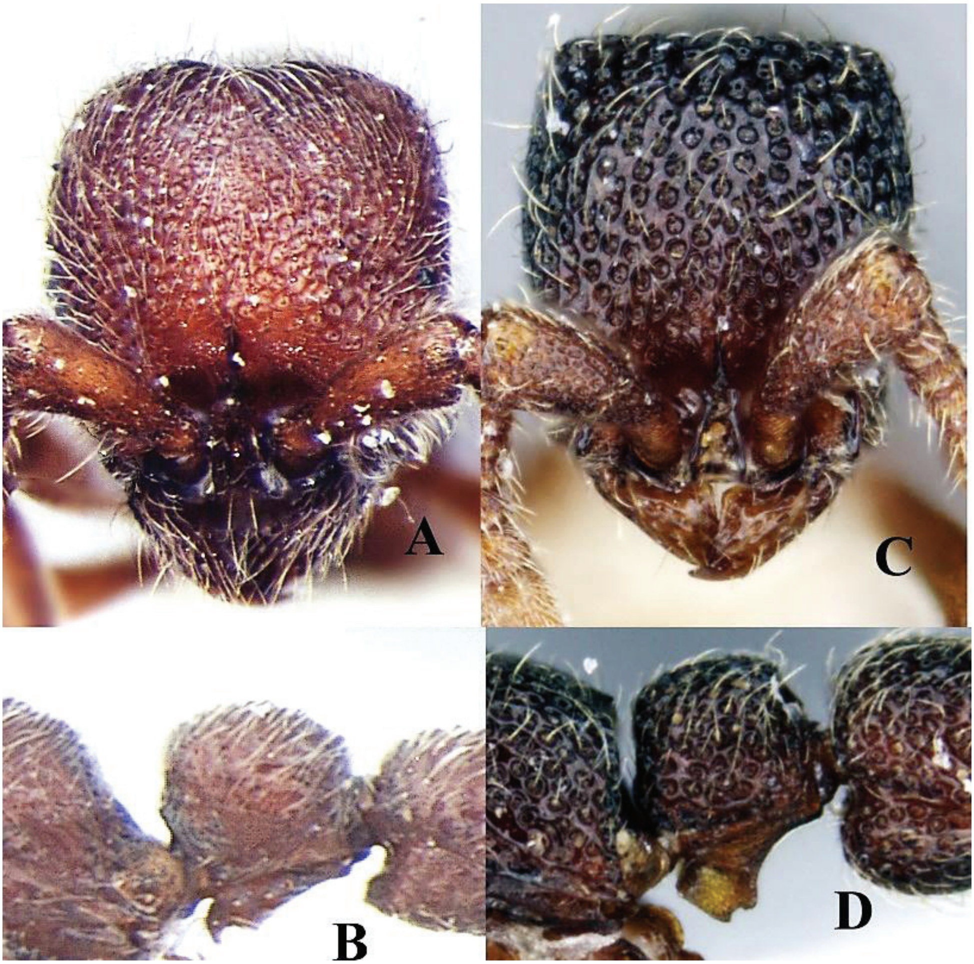
10 Antenna 8-segmented (China) .... ***O. octoantenna***
– Antenna more than 8-segmented **11**

11 Antenna 10-segmented **12**

– Antenna 11-segmented **13**

12 Head as long as broad; eyes present; propodeal lobes reduced; petiolar node in lateral view hemiglobular; anteroventral part of subpetiolar process sickle-shaped; head and body comparatively more pilose (India) (Fig. A, B) .... ***O. joshii*** **sp. nov.**

– Head distinctly longer than broad; eyes absent; propodeal lobes roundly produced; petiole node in lateral view rectangular; anteroventral part of subpetiolar process forming a rectangular and semitransparent lobe (India) (Fig. C, D) .... ***O. decamera*** **sp. nov.**



13 Body shallowly and coarsely foveolate; eye present with multiple ommatidia (India) (Fig. A) .... ***O. besucheti***

– Body conspicuously foveolate; eye absent or vestigial (Fig. B) **14**

14 Anterior portion of pronotum with distinct ridge; petiole and postpetiole in dorsal view broader than long (Sri Lanka) (Fig. A) .... ***O. coeca***

– Anterior portion of pronotum without distinct ridge; petiole and postpetiole in dorsal view longer than broad (Sri Lanka) (Fig. B) .... ***O. fragosa***[*]

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[*] Note: Comprehensive morphological diagnosis and image of *O. guizhouensis* (Zhou, 2006) is not available, so this species has been not included in the key. However, as cited in the comparative diagnosis, *O. guizhouensis* is close to *O. besucheti* and *O. fragosa*, but differs in having coarse pilose punctures on the surface of the mandibles, petiolar node distinctly longer than broad and is without eyes.

Table 1. Antennal count and distribution of *Ooceraea* species in different biogeographical regions.

Sr. No.	Species	Antennal count	Biogeographical region
1.	*Ooceraea octoantenna* Zhou et al., 2020	8	Palearctic
2.	*Ooceraea alii* (Bharti & Akbar, 2013)	9	Oriental
3.	*Ooceraea australis* (Forel, 1900)	9	Australasia
4.	*Ooceraea biroi* (Forel, 1907)	9	Malagasy, Neotropical, Oceania, Oriental, Palearctic
5.	*Ooceraea crypta* (Mann, 1921)	9	Oceania
6.	*Ooceraea fuscior* (Mann, 1921)	9	Oceania
7.	*Ooceraea papuana* Emery, 1897	9	Australasia
8.	*Ooceraea pawa* (Mann, 1919)	9	Australasia
9.	*Ooceraea pusilla* Emery, 1897	9	Australasia
10.	*Ooceraea quadridentata* Yamada et al., 2018	11	Oriental
11.	*Ooceraea besucheti* (Brown, 1975)	11	Oriental
12.	*Ooceraea coeca* Mayr, 1897	11	Oriental
13.	*Ooceraea fragosa* Roger, 1862	11	Oriental
14.	*Ooceraea guizhouensis* (Zhou, 2006)	11	Palearctic

Acknowledgments

We sincerely thank Dr Marek Borowiec for significant input on *Ooceraea decamera* sp. nov., Dr David Lubbertazi for providing access to the type material, Dr Eli Sarnat for providing images of *Ooceraea crypta* and *Ooceraea fuscior*, Dr Katsuyuki Eguchi for valuable comments on the manuscript and Mr Patrick McCormack for photography. We acknowledge the use of images from Antweb (CASENT0249322_D, CASENT0055090_D, ANTWEB1041156_P, D, CASENT0903779_D, CASENT0171152_P, D, H, CASENT0911143_D, CASENT0922424_D, CASENT0106215_D), from Museum of Comparative Zoology, Harvard University (MCZ-ENT00649398_H,P,D) Antwiki (*Ooceraea pusilla* Emery, 1897) and map from antmaps.org. Financial assistance rendered by the Ministry of Environment, Forest and Climate Change (Grant No. 22018/41/2010-CS (Tax)), Govt. of India, New Delhi is gratefully acknowledged. We also thank Forest and Wildlife Department, Govt. of Kerala for granting the permission to collect the research material vide Order No. WL 10-55389/2014 dated 07.01.2016.

References

Bharti H, Akbar SA (2013) Taxonomic studies on the ant genus *Cerapachys* Smith (Hymenoptera, Formicidae) from India. ZooKeys 336: 79–103. https://doi.org/10.3897/zookeys.336.5719

Bharti H, Guénard B, Bharti M, Economo EP (2016) An updated checklist of the ants of India with their specific distributions in Indian states (Hymenoptera, Formicidae). ZooKeys 551: 1–83. https://doi.org/10.3897/zookeys.551.6767

Bolton B (2020) An online catalog of the ants of the world. http://antcat.org/ [Accessed 19th July, 2020]

Borowiec ML (2016) Generic revision of the ant subfamily Dorylinae (Hymenoptera, Formicidae). ZooKeys 608: 1–280. https://doi.org/10.3897/zookeys.608.9427

Brown Jr WL (1973) A comparison of the Hylean and Congo-West African rain forest ant faunas. In: Meggers BJ, Ayensu ES, Duckworth WD (Eds) Tropical forest ecosystems in Africa and South America: a comparative review. Smithsonian Institution Press, Washington, 161–185.

Brown WL (1975) Contributions toward a reclassification of the Formicidae. V. Ponerinae, tribes Platythyreini, Cerapachyini, Cylindromyrmecini, Acanthostichini and Aenictogitini. Search Agriculture (Ithaca, New York) 5(1): 1–115.

Dalla Torre KW (1893) Catalogus Hymenopterorum hucusque descriptorum systematicus et synonymicus (Vol. 7). Formicidae (Heterogyna). W. Engelmann, Leipzig, 289 pp. https://doi.org/10.5962/bhl.title.10348

Emery C (1877) Saggio di un ordinamento naturale dei Mirmicidei, e considerazioni sulla filogenesi delle formiche. Bullettino della Società Entomologica Italiana 9: 67–83.

Emery C (1895) Die Gattung Dorylus Fab. und die systematische Eintheilung der Formiciden. Zoologische Jahrbücher. Abteilung für Systematik, Geographie und Biologie der Tiere 8: 685–778.

Emery C (1897) Formicidarum species novae vel minus cognitae in collectione Musaei Nationalis Hungarici quas in Nova-Guinea, colonia germanica, collegit L. Biró. Természetrajzi Füzetek 20: 571–599.

Emery C (1902) Note mirmecologiche. Rendiconti delle Sessioni della Reale Accademia delle Scienze dell'Istituto di Bologna (n.s.) 6: 22–34.

Emery C (1911) Hymenoptera. Fam. Formicidae. Subfam. Ponerinae. Genera Insectorum 118: 1–125.

Forel A (1893) Sur la classification de la famille des Formicides, avec remarques synonymiques. Annales de la Société Entomologique de Belgique 37: 161–167.

Forel A (1900) Ponerinae et Dorylinae d'Australie récoltés par MM. Turner, Froggatt, Nugent, Chase, Rothney, J.- J. Walker, etc. Annales de la Société Entomologique de Belgique 44: 54–77.

Forel A (1907) Formicides du Musée National Hongrois. Annales Historico-Naturales Musei Nationalis Hungarici 5: 1–42.

Guénard B, Weiser M, Gomez K, Narula N, Economo EP (2017) The Global Ant Biodiversity Informatics (GABI) database: a synthesis of ant species geographic distributions. Myrmecological News 24: 83–89.

Holt B, Lessard JP, Borregaard MK, Fritz SA, Araujo MB, Dimitrov D, Fabre PH, Graham CH, Graves GR, Jonsson KA, Nogues-Bravo D, Wang ZH, Whittaker RJ, Fjeldsa J, Rahbek C (2013) An update of Wallace's zoogeographic regions of the world. Science 339 (6115): 74–78. https://doi.org/10.1126/science.1228282

Janicki JH, Narula N, Ziegler M, Guénard B, Economo EP (2016) Visualizing and interacting with large-volume biodiversity data using client-server web mapping applications: the design and implementation of antmaps.org. Ecological Informatics 32: 185–193. https://doi.org/10.1016/j.ecoinf.2016.02.006

Mayr G (1865) Formicidae. In: Novara Expedition (1865) Reise der Österreichischen Fregatte 'Novara' um die Erde in den Jahren 1857, 1858, 1859. Zoologischer theil. Bd. II. Abt.1. K. Gerold's Sohn, Wien, 119 pp.

Mayr G (1897) Formiciden aus Ceylon und Singapur. Természetrajzi Füzetek 20: 420–436.

Mann WM (1921) The ants of the Fiji Islands. Bulletin of the Museum of Comparative Zoology 64: 401–499.

Roger J (1862) Einige neue exotische Ameisen-Gattungen und Arten. Berliner Entomologische Zeitschrift 6: 233–254. https://doi.org/10.1002/mmnd.47918620118

Wheeler WM (1902) An American *Cerapachys*, with remarks on the affinities of the Cerapachyinae. Biological Bulletin (Woods Hole) 3: 181–191. https://doi.org/10.2307/1535872

Yamada A, Phung THL, Eguchi K (2018) Description of a new species of the ant genus *Ooceraea* Roger, 1862 (Hymenoptera: Formicidae; Dorylinae) from the Vietnam's Central Highlands. Journal of Insect Biodiversity 7(1): 17–23. https://doi.org/10.12976/jib/2018.07.1.2

Zhou SY, Chen DN, Chen ZL (2020) Discovery of novel *Ooceraea* (Hymenoptera: Formicidae: Dorylinae) species with 8-segmented antennae from China. Sociobiology 67: 139–143. https://doi.org/10.13102/sociobiology.v67i2.3740

ZooKeys 1010: 185–190 (2021)
doi: 10.3897/zookeys.1010.59530
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RESEARCH ARTICLE

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A new species of *Coomaniella* (Coleoptera, Buprestidae, Coomaniellini) from Guangxi, China, with new distributional records and biological observations

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Abstract

A new species *Coomaniella* (*Coomaniella*) *dentata* **sp. nov.** from Guangxi Province, China, is described and placed in the *C.* (*C.*) *chinensis* species-group. The variability is discussed, and a new adult host plant is recorded. New distributional records are given for *C. biformissima* Jendek & Kalashian, 1999 and *C. lingafelteri* Jendek & Pham, 2013.

Keywords

Host plant, new distributional records, new species, taxonomy

Introduction

Bourgoin (1924) proposed the genus *Coomaniella* for two species. Years later, Bílý (1974) established a new tribe, Coomaniellini, for it and discussed its systematic position in the subfamily Buprestinae. Jendek and Kalashian (1999) revised the genus, dividing it into two new subgenera and eight species-groups, described new species, and provided keys. More new species were found, species-groups were redefined, and the distribution and biology were summarized in the last couple of decades (Jendek 2002, 2005; Jendek and Pham 2013). Currently, the genus contains three subgenera and 31 species. Bílý and Volkovitsh (2015) discussed the status of the tribe Coomaniellini and described the larval stage of *Coomaniella* (*Coomaniella*) *purpurascens* Baudon, 1966.

In this paper, a new species belonging to the *C.* (*C.*) *chinensis* species-group is described. New distributional records for two species from Guangxi province, China, are given, and a new adult host plant is recorded.

Materials and methods

Abbreviations for collections in this study are:

CHTS	Collection of Hai-Tian Song, Fuzhou, China;
FAFS	Fujian Academy of Forestry Sciences, Fuzhou, China.

Whole specimens were photographed using a Keyence VHX-5000 digital microscope with the Keyence VH-Z20R zoom lens (20–200×). The feeding behavior was photographed using Canon 5D4 digital camera with the Canon 100 mm f/2.8 macro USM. The host plant and photographs in nature were taken using a Huawei smartphone. The images were processed and combined into figures using Adobe Photoshop CC 2019.

Taxonomy

Coomaniella dentata sp. nov.

http://zoobank.org/E98B9837-24F7-489B-BC60-CD0C3E3F2D47
Figures 1, 2

Type specimens. ***Holotype*** ♂ (FAFS): China • Wuzhi Mountains, Yao Autonomous County of Jinxiu, Laibin City, Guangxi; 23°54'N, 110°9'E, alt. 700 m; 14–15.V.2020; Chun-Fu Feng leg. ***Paratypes*** 12 ♂♂, 17 ♀♀ (CHTS): China • same collection data as for holotype • 3 ♂♂, 4 ♀♀ (CHTS); same collection data as for preceding; 25–26.V.2020 • 1 ♂ (CHTS); same collection data as for preceding; 11.IV.2020.

Description of the holotype. ***Size*:** body length 6.55 mm, width 2.14 mm.

***Body*:** suboval, elongate; head, pronotum, legs, ventral side, appendices, and antenna golden-green; elytra color horizontal gradient, golden-blue near suture, golden-green in central and golden-orange outsides (Fig. 1A). Dorsal side with short, sparse, pale pubescence. ***Head*:** vertex roughly punctate, in narrowest part between the eyes reduced to six rows of punctures (Fig. 1B); antennae short, scarcely reaching to anterior pronotal corners, markedly shorter than length of pronotum. ***Pronotum*:** strongly transverse, 1.92× as wide as long, widest in the middle, sides deeply arcuate; anterior lobe existing, anterior margin narrower than posterior; disk with obvious, deep impressions (Fig. 1A). ***Scutellum*:** very small, subpentagonal with corners very obtuse; im-

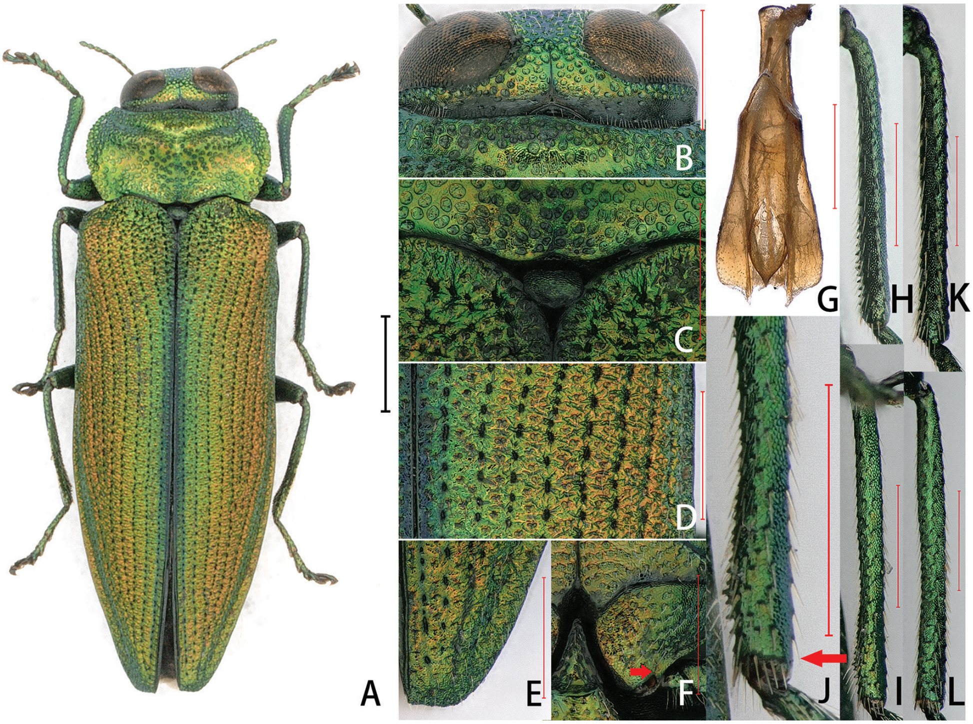

Figure 1. *Coomaniella* (*Coomaniella*) *dentata* sp. nov. **A–J** holotype: **A** habitus **B** head **C** scutellum **D** elytral surface **E** elytral apex **F** metacoxal plate with spine **G** aedeagus **H** male mesotibia, dorsal view **I** male metatibia, ventral view **J** denticles on male metatibia, ventral view **K, L** paratype: **K** female mesotibia, dorsal view **L** female metatibia, ventral view. Scale bars: 1 mm (**A**); 0. 5 mm (**B–L**).

pressed on disk (Fig. 1C). ***Elytra*:** about 2.43× as long as wide; rugoso-punctate, striae well marked; covered with asperate, dense sculptures and obvious longitudinal sequential punctures (Fig. 1D); elytral apices simplex, subtruncate with subangulate angle at sutural margin and without spines (Fig. 1E). ***Ventral side*:** inner posterior angle of metacoxal plates subangulate, with a big spine beside (Fig. 1F). Sternal carina flanked with groove. ***Legs*:** tibia with apical spur and many hairs. Mesotibia and metatibia in distal half of inner margin with denticles (Fig. 1H–J); tarsal shapes unchanged; tarsus distinctly longer than half of corresponding tibia; tarsomere 1 shorted than next three tarsomeres combined. ***Aedeagus*:** membranous, with much wider parameres (Fig. 1G).

Sexual dimorphism. Male eyes separated on vertex in narrowest part by six to eight rows of punctures, while female by nine or 10. Protarsomere 1 obviously lengthened in male; mesotibia and metatibia with denticles in distal half of inner margin in male (Fig. 1H–J) but no denticles in female (Fig. 1K, L). Antennal length similar in both sexes.

Variability. Body 3.05–3.40 × as long as wide. Pronotum sometimes variable in shape (Fig. 2A). Color variable and both sexes have green (Fig. 2B) and orange

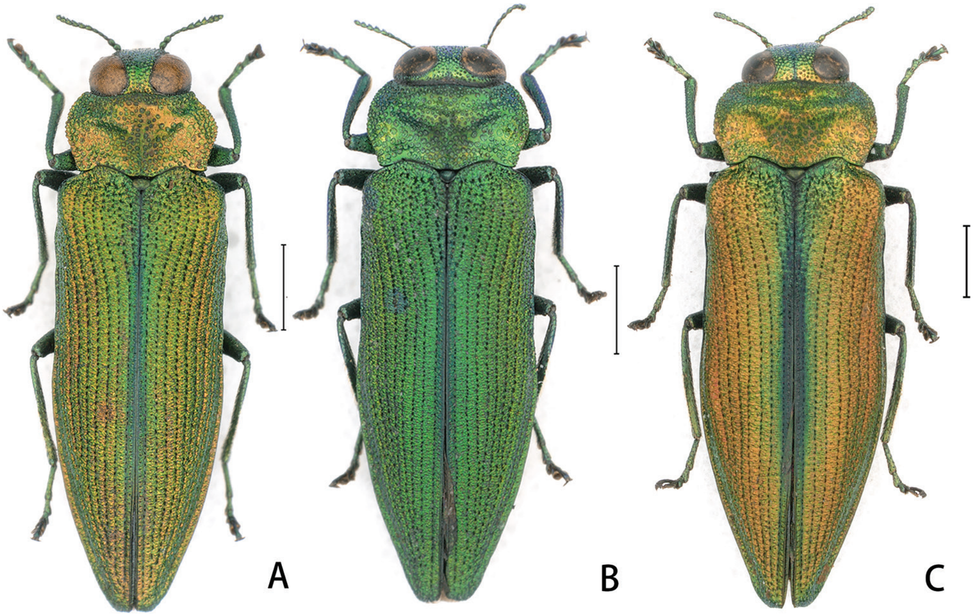

Figure 2. Variability of *Coomaniella* (*Coomaniella*) *dentata* sp. nov. **A** male, pronotal variety **B** male, green variety **C** female, orange variety. Scale bar: 1 mm.

forms (Fig. 2C). Aspect ratio of scutellum variable. Elytral apices from subarcuate to subtruncate, subangulate angle at sutural margin sometimes weakened or even absent (Fig. 2A–C). Body length of sexes overlap: male 5.78–7.53 mm and female 6.80–8.46 mm.

Discussion. This new species presents several diagnostic characters which allow it to be easily separated from other species: 1) mesotibia and metatibia in males with denticles, 2) elytral apices without spines, 3) metacoxal plates with a big spine beside the inner posterior angle in both sexes, 4) elytral surface with obvious longitudinal punctures, and 5) the narrowest part between the eyes on each sex with more rows of punctures. The first two characters are reported for the first time in genus *Coomaniella*, adding to the structural diversity of the genus. The new species is classified in the subgenus *Coomaniella* and belongs to *C.* (*C.*) *chinensis* species-group.

Etymology. The name *dentata* is for the denticles on male tibia.

Host plant. *Toona* sp. (Fig. 3A, B), determined by Prof. Xin-Hua Li (Nanjing Agricultural University), is a newly reported genus of adult host plant for the genus *Coomaniella*. *Toona* sp. belongs to the family Meliaceae, of which another species, *Chukrasia tabularis*, has been recorded as a host plant by Jendek (2002).

Remarks. All specimens of *C. dentata* sp. nov. were collected during hot sunny days on both the top and bottom surfaces of the leaves of *Toona* sp. (Fig. 3A). Margin feeding on the leaves was observed and was sometimes quite obvious (Fig. 3B). Laboratory breeding showed that *C. dentata* sp. nov. could indeed feed on this plant (Fig. 3C). No larval galleries were found.

Figure 3. Host plant and habits of *Coomaniella* (*Coomaniella*) *dentata* sp. nov. **A** *Toona* sp. in the wild **B** marginal feeding of the leaf of *Toona* sp. by *C. dentata* **C** feeding habits.

From the same host plant, two other species were collected

Coomaniella (*Coomaniella*) *biformissima* Jendek & Kalashian, 1999

Material examined. 7 ♂♂, 5 ♀♀(CHTS): China Wuzhi Mountains, Yao Autonomous County of Jinxiu, Laibin City, Guangxi; 23°54'N, 110°9'E, alt. 700 m; 14–29.V.2020; Chun-Fu Feng leg. New country record.

Coomaniella (*Coomaniella*) *lingafelteri* Jendek & Pham, 2013

Material examined. 8 ♂♂, 7 ♀♀(CHTS): China, Wuzhi Mountains, Yao Autonomous County of Jinxiu, Laibin City, Guangxi; 23°54'N, 110°9'E, alt. 700 m; 14–29.V.2020; Chun-Fu Feng leg. New country record.

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References

Bourgoin A (1924) Diagnoses préliminaires de buprestides nouveaux de l'Indochine française. Bulletin de la Société Entomologique de France 1924: 178–179. https://www.persee.fr/doc/bsef_0037-928x_1924_num_29_17_27378?pageid=t1_178

Bílý S (1974) A revision of the genus *Coomaniella* Bourgoin of the Coomaniellini tribe nov. (Coleoptera, Buprestidae). Acta Entomologica Bohemoslovaca 71: 30–41.

Bílý S, Volkovitsh MG (2015) A description of the larva of *Coomaniella* (*Coomaniella*) *purpurascens* Baudon, 1966 and a discussion on the tribal placement of Coomaniellini Bílý, 1974 (Coleoptera: Buprestidae). Zootaxa 3915(1): 123–131. https://doi.org/10.11646/zootaxa.3915.1.6

Jendek E (2002) New synonymy in the genus *Coomaniella* (Coleoptera: Buprestidae), with remarks on another species. Acta Societatis Zoologicae Bohemicae 66: 241–242. http://www.zoospol.cz/ixadmin/app/webroot/uploads/3-2017/2002_4_celek.pdf

Jendek E (2005) *Coomaniella* (*Coomaniella*) *janka* sp. n. from China (Coleoptera: Buprestidae). Zootaxa 850: 1–4. https://doi.org/10.11646/zootaxa.850.1.1

Jendek E, Kalashian MJ (1999) Revision of the genus *Coomaniella* (Coleoptera: Buprestidae). Entomological Problems, Bratislava 30: 9–36. http://www.entomologicalproblems.sav.sk/archiv/1999_2.html#4

Jendek E, Pham H (2013) Seven new species of *Coomaniella* Bourgoin, 1924 (Coleoptera: Buprestidae) with redefinition of species-groups and remarks on distribution and biology. Bonn zoological Bulletin 62(1): 111–123. https://www.zoologicalbulletin.de/BzB_Volumes/Volume_62_1/111_123_BzB62_1_Jendek_E_and_Pham_HT.pdf