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Revision of Mediterranean and NE Atlantic Raphitomidae (Gastropoda, Conoidea) 8: The genus *Leufroyia* Monterosato, 1884

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Couverture / *Cover* :
The raphitomid neogastropod *Leufroyia leufroyi* (Michaud, 1828). Two living specimens photographed in situ at Cap d'Antibes, France, 13-17 m depth. Photo courtesy: Dominique Horst.

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Revision of Mediterranean and NE Atlantic Raphitomidae (Gastropoda, Conoidea) 8: The genus *Leufroyia* Monterosato, 1884

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ABSTRACT
The four recent species of the genus *Leufroyia* Monterosato, 1884 are revised based on an integrative taxonomy approach: *L. leufroyi* (Michaud, 1828), *L. concinna* (Scacchi, 1836), *L. erronea* Monterosato, 1884 and *L. villaria* (Pusateri & Giannuzzi-Savelli, 2008).

KEY WORDS
Northeastern Atlantic, Mediterranean Sea, integrative taxonomy.

RÉSUMÉ
Révision des Raphitomidae de la Méditerranée et de l'Atlantique NE (Gastropoda, Conoidea) 8 : Le genre Leufroyia *Monterosato, 1884.*
Les quatre espèces actuelles du genre *Leufroyia* Monterosato, 1884 sont révisées sur la base d'une approche de taxonomie intégrative : *L. leufroyi* (Michaud, 1828), *L. concinna* (Scacchi, 1836), *L. erronea* Monterosato, 1884 et *L. villaria* (Pusateri & Giannuzzi-Savelli, 2008).

MOTS CLÉS
Atlantique Nord-Est, mer Méditerranée, taxonomie intégrative.

INTRODUCTION

The Raphitomidae Bellardi, 1875 are a well-supported clade of the Conoidea Fleming, 1822 (Bouchet *et al*. 2011) worthy of family ranking. It is probably the most diverse family of Conoidea, in terms of species richness, ecological range and anatomical disparity (Kantor & Taylor 2002). We are currently revising the Raphitomidae of the Mediterranean Sea and adjacent Atlantic coasts, which we provisionally estimated *ca*. 47 Mediterranean extant species, some of which still undescribed. The taxon Raphitomidae Bellardi, 1875 is based on the genus *Raphitoma* Bellardi, 1847 which was introduced as comprising 34 fossil and Recent species (Bellardi, 1847: 85), previously classified in various genera (such as *Pleurotoma* Lamarck, 1799 and *Clathurella* Carpenter, 1857).

The systematics of several Mediterranean and North-East Atlantic conoidean species, traditionally ascribed to the genus *Raphitoma* Bellardi, 1847, have been revised by Fassio *et al*. (2019) based on molecular data. Three major lineages have been identified, considered as worthy of genus ranking: *Raphitoma*, *Cyrillia* Kobelt, 1905 and *Leufroyia* Monterosato, 1884. Here we have revised the Recent species of the genus *Leufroyia* Monterosato, 1884.

MATERIAL AND METHODS

Specimens studied in this work are housed in private and public collections. Many of the specimens were found alive, attached to the underside of small and medium-sized stones at 0-40 m depth, where they were manually collected during snorkelling or scuba diving. Empty shells were found crabbed mostly under stones at 0-40 m depth during diving, sorted out of bioclastic sediment samples collected manually at 1-30 m depth, by dredging from soft and mixed bottoms at 20-400 m depth, or in the residuals of material collected during red coral fishing at 60-100 m depth by scuba divers.

SEM images were taken with a Hitachi TM400 Plus by Nanovision s.r.l. (Brugherio). Light photographs were taken by the authors if not otherwise stated.

Scheme of the shell parameters are given in Fig. 1. The number of protoconch whorls has been counted according to the method of Verduin (1977).

The number of spiral cords on the body whorl, reported in this work, includes both cords and cordlets, and also threads on the subsutural ramp.

We have used a standardised format for the citation of specimen data in Type Material and Other Material Examined sections, as described by Chester *et al*. (2019).

SPECIES DELIMITATION

Most ITS-2 and COI sequences used in the present work, have been derived after the works by Fassio *et al*. (2019) and Russini *et al*. (2020). We have added hereby the sequences from additional specimens. DNA was extracted from a small piece of foot tissue using a modified Proteinase k-Phenol-Cloroform protocol (Oliverio & Mariottini, 2001). We amplified one nuclear marker (the internal transcribed spacer 2 of the ribosomal cluster, ITS2, ~500 bp with primers ITS-3d and ITS-4r (Oliverio & Mariottini 2001)), and the mitochondrial cytochrome *c* oxidase subunit I (COI), with primers LCO1490 and HCO 2198 (Folmer *et al*. 1994), corresponding to the standard barcode fragment (658 bp) or with primers HCO2198 and mlCOIint-F (5'-GGWACWGGWTGAACWGTWTAYCCYCC-3') designed to amplify a shorter fragment (*ca.* 300 bp) and employed in meta-barcoding works (Leray *et al*. 2013). PCR product were purified using Exosap-IT (USB Corporation) and Sanger sequenced by Macrogen Inc. (Spain).

Sequences were aligned using Geneious 11 (Kearse *et al*. 2012) or the online version of MAFFT 7 (Katoh *et al*. 2017; Kuraku *et al*. 2013) with the Q-INS-I algorithm. Intraspecific genetic distance for each putative species were estimated with MEGA 7 (Kumar *et al*. 2016), with the Kimura-2 parameters (K2p) model for easier comparison with standard DNA-barcoding studies.

We have adopted here an Integrative Taxonomy approach: all shells and live collected specimens were preliminarily defined by using shell characters to identify putative species (Preliminary Species Hypotheses, PSH), based on the most recent taxonomy of the group (Giannuzzi-Savelli *et al*. 2017, 2018a, 2018b; Pusateri *et al*. 2012, 2013, 2016, 2018). The PSH were then tested by a multi-step molecular approach: 1) the distance-based Automatic Barcode Gap Discovery (ABGD, available at https://bioinfo.mnhn.fr/abi/public/abgd/), was used to group specimens after an analysis of the distribution of pairwise distances in a COI alignments (Puillandre *et al*. 2012); 2) the species hypotheses retained aftert the ABGD analyses were eventually tested for their reciprocal monophyly by performing Maximum Likelihood (ML) and Bayesian inference (BI) phylogenetic analyses on single-gene alignments and on a concatenated dataset (COI + ITS2), using *Conus consors* G.B. Sowerby I, 1833 and *C. bandanus* Hwass in Bruguière, 1792 as outgroup for the Raphitomidae (Nam *et al*. 2009); 3) diagnostic nucleotides were identified on the COI and the ITS2 alignments by the r-package SPIDER (Brown *et al*. 2012). Nodes with Bootstraps support (BS) of 70-90% and Posterior Probabilities (PP) of 0.90-0.95 have been considered as moderately supported; BS >90% and PP >0.95 have been considered as highly supported (Hillis & Bull 1993; Alfaro & Holder 2006).

ABBREVIATIONS

Institutions

BAU	Department of Biology and Biotechnologies, 'Sapienza' University, Rome;
CGS	Can Geyran Seashells Center, Istanbul;
HUJ	Hebrew University, Jerusalem;
MCZR	Museo Civico di Zoologia, Roma;
MNHN	Musée Nationale Histoire Naturelle, Paris;
MDCL	Musée des Confluences, Lyon;

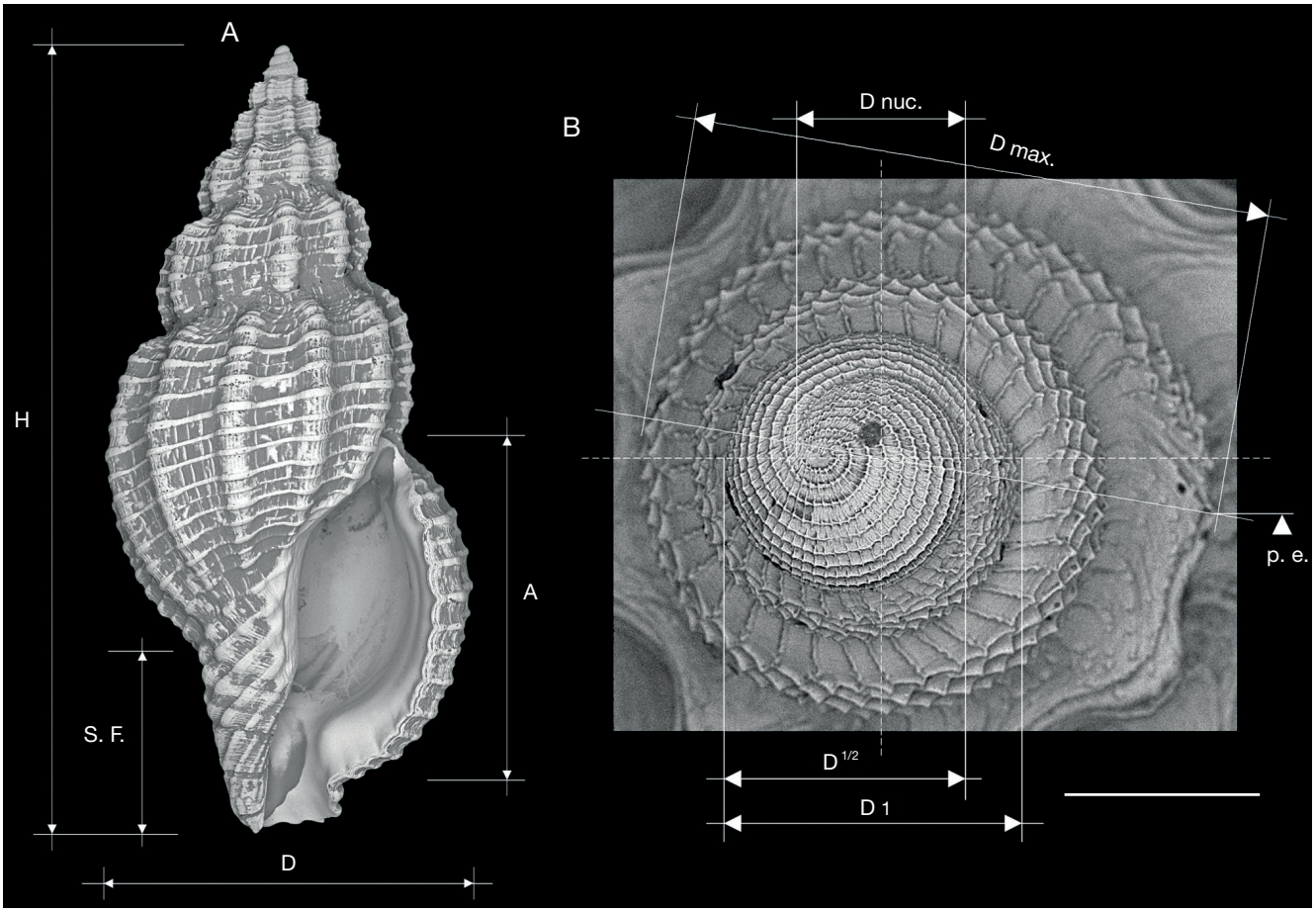

FIG. 1. — **A**, Scheme of the shell parameters. **B**, measurements taken on protoconch (according to Verduin 1977). Abbreviations: A, aperture; W, width; H, height; S. F., siphonal fasciole; Dnuc, diameter of nucleus; D½, diameter of first half-whorl; D1, diameter of first whorl; max. D, maximum diameter; p.e., protoconch end. Scale bar: 200 µm.

MHNG	Muséum d'histoire Naturelle de Genève, Genève;
MRSNT	Museo Regionale Storia Naturale, Terrasini, Palermo;
NMR	Natural History Museum, Rotterdam;
NMW	National Museum of Wales, Cardiff;
SMNH	Swedish Museum of Natural History, Stockholm;
USNM	United States National Museum (Smithsonian), Washington;
ZMBN	Zoological Museum, Bergen.

Private collections

coll. AGA	Franco Agamennone, Pescara;
coll. ARD	Roberto Ardovini, Roma;
coll. BAL	Giovanni Balena, Livorno;
coll. BAR	Stefano Bartolini, Firenze;
coll. BIN	Gianluigi Bini, Città di Castello;
coll. CAM	Enzo Campani, Livorno;
coll. CAR	Alberto Caruso, Sapri;
coll. CRO	Paolo Crovato, Napoli;
coll. DIN	Antonio Di Nisio, Pescara;
coll. DSC	Christiane Delongueville & Roland Scaillet, Bruxelles;
coll. DUR	Sergio Duraccio, Napoli;
coll. FEN	David Fenwick, Penzance;
coll. FIO	Angelo Fiorita, Porto Cesareo;
coll. FUM	Bruno Fumanti, Sabaudia;
coll. GER	Alfio Germanà, Pedara;
coll. GIR	Antonio Girgenti, Palermo;
coll. GON	César Fernandez Gonzàlez, Vigo;
coll. GOR	Sandro Gori, Livorno;
coll. GUB	Franco Gubbioli, Marbella;
coll. HOA	André Hoarau, Fréjus;
coll. HOU	Juan Horro, Vigo;
coll. KEL	Lars David Kellner, Munich;
coll. KON	Costas Kontadakis, Athens;
coll. LET	Neven Lete, Split;
coll. MAC	Gabriele Macrì, Scorrano;
coll. MAR	Alessandro Margelli, Santa Maria a Monte;
coll. MEL	Nicola Melone, Giovinazzo;
coll. MIF	Constantin Mifsud, Rabat, Malta;
coll. NAP	Andrea Nappo, Pomezia;
coll. NOT	Giuseppe Notaristefano, Milazzo;
coll. OCC	Rosario Occhipinti, Ragusa;
coll. OLI	Marco Oliverio, Roma;
coll. OZT	Bilal Oztürk, Izmir;
coll. PAG	Attilio Pagli, Sovigliana;
coll. PAO	Paolo Paolini, Livorno;
coll. PIE	Angela Pierullo, Anzio;
coll. PIS	Michele Pisanu, Cagliari;
coll. PRK	Jakov Prkić, Split;
coll. PUS	Francesco Pusateri, Palermo;
coll. REP	Gianni Repetto, Alba;
coll. RON	Francesco Roncone, Cosenza;
coll. SER	Gabriele Sercia, Roma;
coll. SMR	Carlo Smriglio, Roma;
coll. SPM	Maria Teresa Spanu, Alghero;

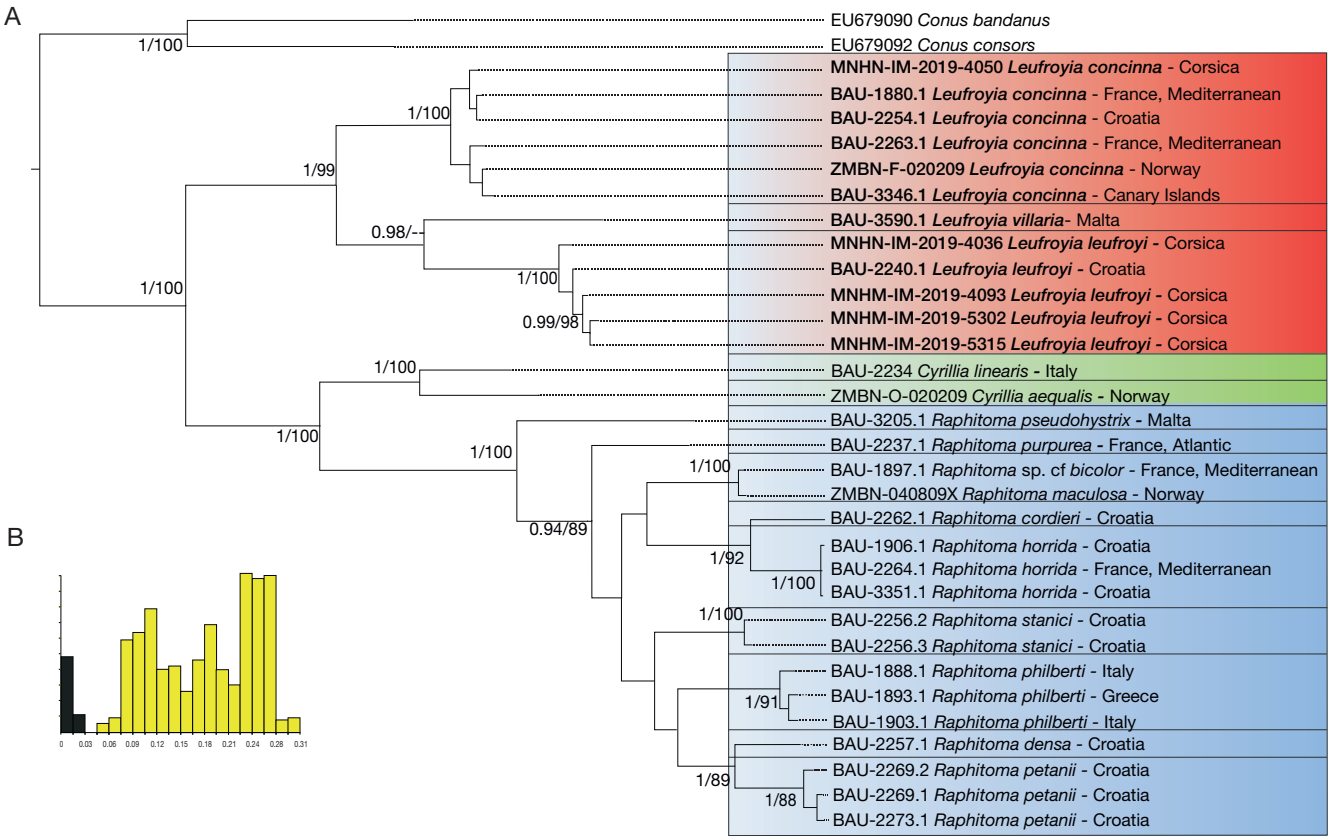

FIG. 2. — Relationships and genetic divergence among species of Raphitomidae Bellardi, 1875. **A**, Bayesian topology on the COI alignment. Numbers at nodes are posterior probabilities after a Bayesian analysis, and bootstrap supports after Maximum likelihood analysis on 1000 pseudoreplicates; only values higher than 75% bootstrap support and 95% posterior probability are reported. The boxes comprise the species hypotheses as defined by the ABGD analysis. **B**, Distribution of the pairwise genetic distances (K2p) among the COI sequences (black bars on the left, intraspecific comparisons; on the right, interspecific comparisons).

coll. STA Rino Stanić, Split;
coll. STH Peter Stahlschmidt, Rohrbach;
coll. TIS Morena Tisselli, San Zaccaria;
coll. TRI Lionello Tringali, Roma;
coll. UGA Pero Ugarković, Split;
coll. VAZ Angelo Vazzana, Reggio Calabria.

Morphometrics (Fig. 1)
H height;
H/W height/width ratio;
PW protoconch whorls;
SD Standard Deviation;
TW teleoconch whorls;
W width.

RESULTS

Species delimitation

For this work we obtained only the shorter COI barcode sequences (*ca*. 300 bp) from a specimen (BAU 3590.1) morphologically identified as *Leufroyia villaria* (Pusateri & Giannuzzi-Savelli, 2008) from Malta and from a specimen (BAU 3346.1) from Canary Islands of uncertain morphological identification. Furthermore, we obtained an ITS-2 sequence from the specimen BAU 3590.1. These sequences, along with 5 COI barcode sequences (658 bp) from Corsican specimens (provided by Nicolas Puillandre, MNHN), were eventually aligned with sequences from GenBank (after Fassio *et al*. 2019 and Russini *et al*. 2020), and used for a molecular phylogenetic analysis of all available *Leufroyia* sequences. The new sequences (seven COI and one ITS2) have been deposited in GenBank (acc. nos. MT611531, MT606166, MT606167, MT606161-MT606165).

The recursive ABGD analysis on the COI alignment identified 3 putative species (Fig. 2) among the assayed *Leufroyia* specimens. In particular, the specimen BAU 3590.1 morphologically identified as *L. villaria* was consistently regarded as distinct from Mediterranean specimens identified as *L. leufroyi* (Michaud, 1828) (BAU 1742.1, BAU 2240.1, MNHN-IM-2019-4036, MNHN-IM-2019-4093, MNHN-IM-2019-5302, MNHN-IM-2019-5315) and from Mediterranean and Atlantic specimens identified as *L. concinna* (Scacchi, 1836) (Mediterranean: BAU 2237.1, BAU 2254.1, MNHN-IM-2019-4050; Atlantic: ZMBN 020209-F, ZMBN E-23-67, ZMBN H-3-69a). The last group included also the specimen BAU 3346.1 from Canary Islands, of uncertain morphological identification

In the phylogenetic analyses, the single-gene and combined-dataset trees showed broadly similar topologies (Figs 2, 3), with only lower node support values in the single-gene trees. *Leufroyia* was consistently monophyletic, including also

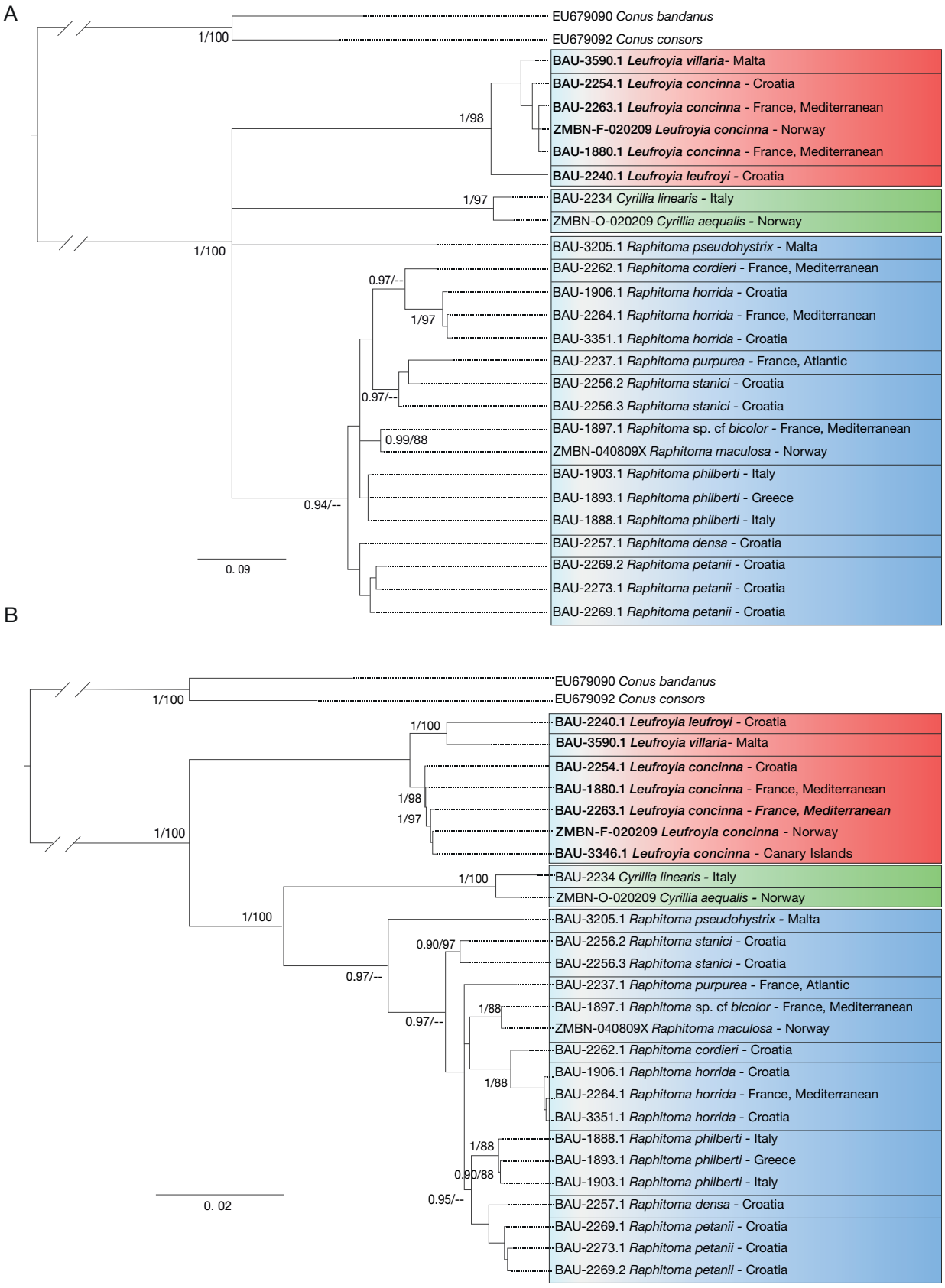

FIG. 3. — Phylogenetic relationships among species of Raphitomidae Bellardi, 1875. **A**, Bayesian analysis on the ITS2 alignment. **B**, Bayesian analysis on the combined (COI+ITS2) alignment. Numbers at nodes are posterior probabilities after a Bayesian analysis, and bootstrap supports after Maximum Likelihood analysis on 1000 pseudoreplicates; only values higher than 75% bootstrap support and 95% posterior probability are reported. The boxes comprise the species hypotheses as defined by the ABGD analysis.

L. villaria (Pusateri & Giannuzzi-Savelli, 2008) with very high support. *L. concinna* was always supported as monophyletic, positioned as the sister to the pair *L. leufroyi*-*L. villaria* in the trees from the COI and the combined (COI+ITS2) datasets.

SYSTEMATICS

(Citation of unpublished names is not intended for taxonomic purposes).

Based on an extensive morphological study and largely supported by the genetic analyses, the systematics of the recent species of the genus *Leufroyia* is revised and four extant species are here recognised in the Northeastern Atlantic and the Mediterranean Sea: *L. leufroyi* (Michaud, 1828), *L. concinna* (Scacchi, 1836), *L. erronea* Monterosato, 1884, and *L. villaria* (Pusateri & Giannuzzi-Savelli, 2008).

Family RAPHITOMIDAE Bellardi, 1875

Genus *Leufroyia* Monterosato, 1884

Leufroyia Monterosato, 1884: 134.

TYPE SPECIES. — *Pleurotoma leufroyi* Michaud, 1828, by subsequent designation (Crosse 1885).

ORIGINAL DESCRIPTION. — "Gruppo ben distinto ad anfratti rigonfi, costati, spiralmente striati; bocca ingrossata internamente, levigata, senza denti nè solchi" (Monterosato 1884: 134).

DIAGNOSIS. — Shell of medium to large size for the family, from 16 mm (*L. concinna*) to 27 mm (*L. erronea* Monterosato, 1884) length, outline from suboval (*L. erronea*) to fusiform (*L. leufroyi*).
Protoconch of 2.4-3.25 whorls when multispiral, with protoconch I (embryonic shell) of 0.9-1.15 whorls, with reticulate sculpture of spirals and orthocline axial threads, and protoconch II (larval shell) of 1.4-2.2 whorls, with diagonally cancellate sculpture, sometime with weakly keeled last whorl; when paucispiral (only fossils), protoconch II (larval shell) of 1.4-2.2 whorls, with reticulate sculpture of spirals and orthocline axial threads.
Teleoconch slender, of 7 (*L. concinna*) to 8 (*L. leufroyi, L. villaria*) uniformly convex whorls, wavy axial ribs much broader than thin and numerous spiral cords. Microsculpture of dense, rather conspicuous growth lines, and extremely fine and dense microgranules, less dense, scattered or absent (*L. leufroyi*) on 1-2 adapical whorls. Whole external surface covered with relatively thick (*L. concinna*, *L. leufroyi*) or thin and not persistent (*L. erronea, L. villaria*) periostracum.
Inner side of outer lip smooth with no denticles. Columella simple, slightly sinuous anteriorly.
Siphonal canal from short (*L. erronea*) to moderately long (*L. leufroyi*). Siphonal notch wide, plain.

REMARKS. — The protoconch is broader (*c.* 500-600 µm diameter) than in the 'multispiral' species of *Raphitoma* Bellardi, 1847 and *Cyrillia* Kobelt, 1905. Several Miocene and Pliocene species have a paucispiral protoconch: *L. pseudoleufroyi* (Marquet, 1998: 278), *L. pseudoconcinna* (Ceulemans, Van Dingenen & Landau, 2018:113) and other still undescribed species (Landau *et al.* 2020). *Leufroyia* differs from *Raphitoma* and *Cyrillia* also by the absence of denticles on the outer lip and by its much thinner and more numerous spiral cords.

DISTRIBUTION. — Stratigraphic distribution: the genus appears in the Middle Miocene with records from the Langhian of the Loire Basin (France) (Peyrot 1938; Glibert 1954). Then it is known from the Langhian-Serravallian of the Paratethys, with records from the Vienna Basin, Austria (Hörnes 1854), Poland (Bałuk 2003), Ukraine (Friedberg 1912), the Karaman Basin (Serravallian Proto-Mediterranean), Turkey (Landau *et al.* 2003). In the Late Miocene it has been revised in the Tortonian of the nothwestern France (Landau *et al.* 2020), and it is known from the Messinian of the Loire Basin (France) (Brébion 1964). Then, it is continuously present throughout the Pliocene (e.g. Sacco 1904; Cipolla 1914), and the Pleistocene (e.g. Cerulli-Irelli 1910). Based on the current knowledge, the extant species of the genus are restricted to the North-East Atlantic, from the North Sea (Norway) south to Angola, and the Mediterranean Sea.

Leufroyia leufroyi (Michaud, 1828)
(Figs 4-8)

Pleurotoma leufroyi Michaud, 1828: 121, pl. 1, figs 5, 6.

Pleurotoma zonalis Delle Chiaje, 1831: pl. 84, fig. 1.

Pleurotoma cyrilli O.G. Costa, 1844: 54.

Murex caudicula Nardo, 1847: 59 ex Chiereghini ms – Brusina 1870: 158.

Clathurella leufroyi var. *albida* Bucquoy, Dautzenberg & Dollfus, 1883: 96.

Clathurella mirabilis Locard, 1891: 68.

Clathrurella [sic] *concina* [sic] – sensu Ostroumoff 1896: 59 non Scacchi, 1836.

Clathurella leufroyi – Bucquoy *et al.* 1883: 95, pl. 14, figs 3, 4 – Carus 1893: 427, no. 16 – Claudon 1902: 189 – Kobelt 1905: 365, pl. 96, figs 4, 5 – Coen 1933: 74, no. 482 – Dautzenberg 1889: 28 – G.O. Sars 1878: 361 – Gignoux 1913: 93 – J.T. Marshall 1912: 297 – Locard & Caziot 1899: 62 – Locard 1886: 115; 1892: 68, fig. 54; 1899: 49 – Nobre 1936: 52, pl. 32, fig. 4; 1938: 133, pl. 19, fig. 8 – Norman 1899: 137 – Paulus & Mars 1942: 76 – Sykes 1906: 186 – Tryon 1890: 276, pl. 18, fig. 33 – Watson 1886: 350.

Defrancia leufroyi – Appelius 1869: 138 – Caruana-Gatto & Despott 1919: 25 – Cocconi 1873: 59 – Coppi 1869: 165 – Despott 1919: 181 – Foresti 1874: 71 – H. Adams & A. Adams 1853: 96 – Jeffreys 1870: 82 – Monterosato 1872: 51 – Seguenza 1873: 298; 1875: 208 – Weinkauff 1868: 132 sp. 4; 1873: 11.

Homotoma leufroyi – Bellardi 1877: 274, no. 13.

Leufroyia leufroyi – Monterosato 1884: 134 – Di Stefano 1889: 101 – Pallary 1900: 257 – Bellini 1929: 31 – Montefameglio *et al.* 1979: 191 – Nordsieck & Garcia Talavera 1979: 165, pl. 41, fig. 33 – Orlando & Palazzi 1985: 44, no. 344 – Öztürk, Buzzurro & Benli 2004: 59 – Brunetti & Vecchi 2005: 3 – Brunetti & Della Bella 2006: 118, 121 – Trono 2006: 65 – Mazziotti *et al.* 2008: 78 – Cecalupo *et al.* 2008: pl. 70, no. 19 – Vazzana 2010: 71; 2011: 60.

Mangelia leufroyi – Forbes & Hanley 1853: 468 pl. CXIII, figs 6, 7; pl. RR, fig. 1 – Malm 1855: 41 – Jeffreys 1856: 187; 1859: 199 – G. B. Sowerby II 1859: pl. 19, fig. 11 – Capellini 1860: 48 – Doderlein 1864: 102 – P. Fischer 1878: 189, no. 500 – Scalia 1900: 25; 1907: 37 – Zelinskaya *et al.* 1968: 224, pl. 50, figs 40, 41.

Mangilia (*Clathurella*) *leufroyi* – Cossmann 1896: 124.

Mangilia (*Leufroyia*) *leufroyi* – Dollfus & Dautzenberg 1886: 102.

Mangilia leufroyi – Friedberg 1912: pl. 14, fig. 8 – Meznerics 1933: 320 – Friedberg 1951: 222, pl. 14, fig. 8.

FIG. 4. — *Leufroyia leufroyi* (Michaud, 1828): **A**, original engravings; **B**, potential syntypes, MDCL ('Méditerranée') 13.1 and 15 mm; **C**, potential syntype, 13.1 mm; **D**, original label by Locard; **E**, Murter Island (Croatia), 15.4 mm (H/D = 2.54); **F**, Murter Island (Croatia), 15.2 mm (H/D = 2.10); **G**, Gulf of Termini Imerese (Palermo - Italy), h. 22.71 mm (with 19 ribs); **H**, Isola delle Femmine (Palermo - Italy), h. 14 mm (specimen with 10 axial ribs on last whorl). Photo courtesy: B-D, Cédric Audibert; G-H, Ignazio Sparacio.

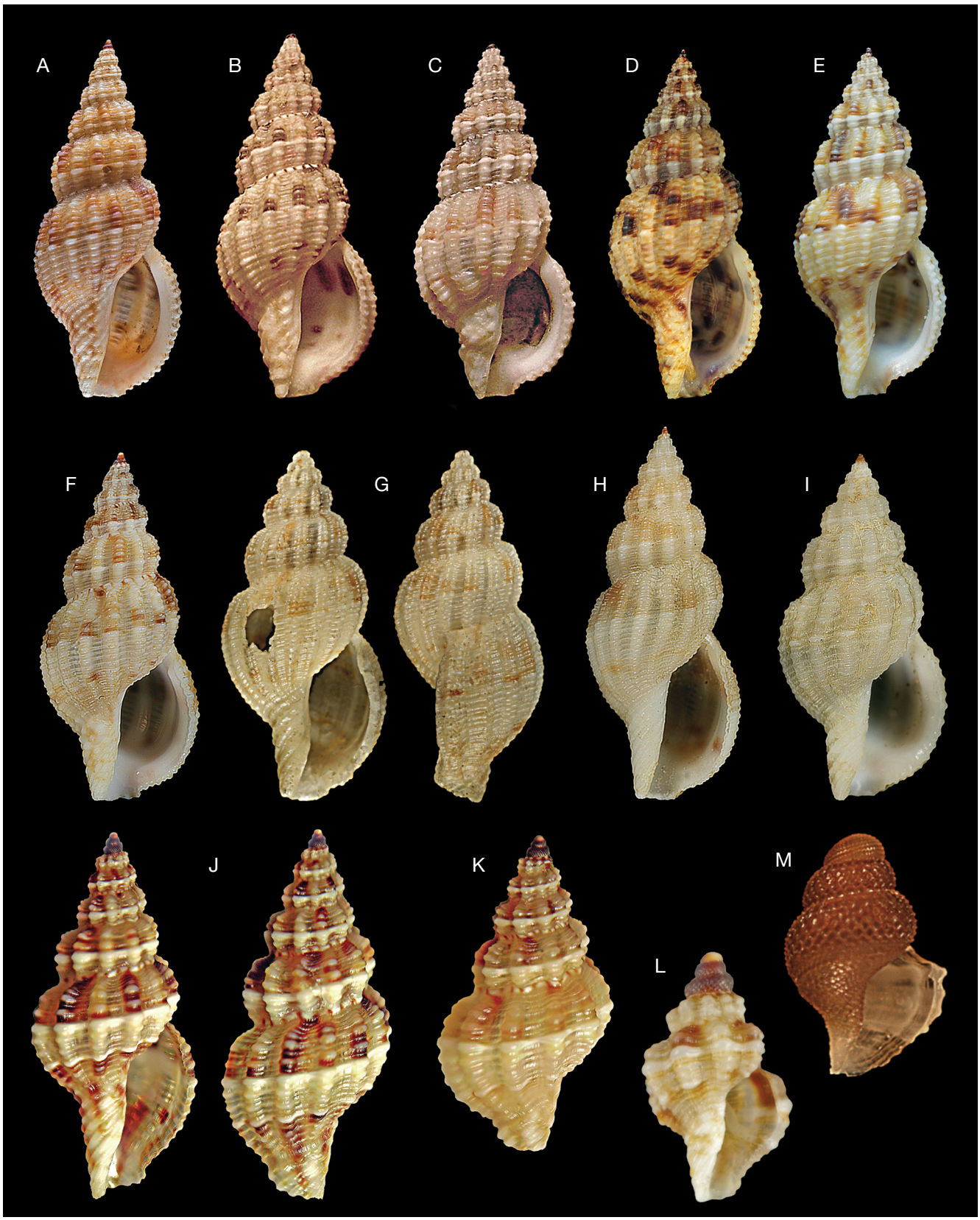

FIG. 5. — *Leufroyia leufroyi* (Michaud, 1828): **A**, Sevid (Croatia) 18 m, h. 17 mm; **B**, Murter Island (Croatia) 3 m, h. 18.2 mm; **C**, Murter Island (Croatia) 3 m, h. 15.5 mm; **D**, Saronic Gulf (Greece), h. 15.8 mm; **E**, Le Dramont (Saint Raphael, France), h. 15.8 mm; **F**, Secca del Frate, Palmaiola Island (Tuscan Archipelago), h. 15.2 mm; **G**, *Clathurella mirabilis* Locard, 1891, syntype (MNHN), Belle Isle (Brittany, France), h. 18.6 mm; **H**, Tuscan Archipelago, h. 20 mm; **I**, Tuscan Archipelago, h. 15.5 mm; **J**, Split (Croatia) 3 m, h. 9 mm; **K**, Mljet Island (Croatia), 60-100 m h. 6.1 mm; **L**, Ponta Delgada (São Miguel Island, Açores), h: 2.3 mm; **M**, Elba Island (Italy), h. 0.8 mm. Photo courtesy: A. Pero Ugarković; D. Costas Kontadakis; E. Dominique Horst.

Fig. 6. — Photographs of two living animals of *Leufroyia leufroyi* (Michaud, 1828). **A-D**, Split, Croatia, 3 m, h. 10 mm; **E-F**, Čiovo Island, Croatia, 5 m, h. 6 mm. Photo courtesy: E-F, Pero Ugarković.

Peratotoma (*Leufroyia*) *leufroyi* – Sacco 1904: 53, pl. 13, figs 52, 53 – Cerulli-Irelli 1910: 59 (251), pl. 5 (36), fig. 46 – Cipolla 1914: 70 (174), pl. 3 (14), Fig. 24A, B.

Peratotoma leufroyi – Bałuk 2003: 73, pl. 29, fig. 12.

Philbertia (*Leufroya*) *leufroyi* – Thiele 1929: 370 – Steuer 1939: 44, fig. 18 – Devidts 1959: 104 – Priolo 1967: 702.

Philbertia (*Leufroyia*) *leufroyi* f. praecedens – Glibert, 1954: 60, pl. 7, fig. 8.

Philbertia leufroyi – Odhner 1931: 21 – Mars 1956: 44 – Pasteur-Humbert 1962: 104, pl. 39, fig. 169 – Powell 1966: 16, fig. 155F – Cadée 1968: 115 – Thiriot-Quiévreux 1972: 558, pl. 4, figs A-F – McMillan 1973: 56 – Spada *et al.*, 1973: 55.

Pleurotoma (*Clathurella*) *leufroyi* – Watson 1897: 304, no. 249.

Pleurotoma inflata – sensu Philippi 1836: 197, pl. XI, fig. 24 non De Cristofori & Jan, 1832.

Pleurotoma lefroyi [sic] – Deshayes 1835: 275 – Forbes 1844: 157 – Aradas & Benoit 1876: 251, no. 665.

Pleurotoma leufroyi – Potiez & Michaud 1838: 445 – Kiener 1839: 70, pl. 24, fig. 3 – Reeve 1843: pl. 16, sp. 131 – Philippi 1844:165, pl. 11, fig. 24 – Requien 1848: 73, no. 522 – D'Orbigny 1852: 172 – Petit de la Saussaye 1852: 187; 1869: 153 – Hörnes 1854: 373, pl. 40, Fig. 16A-C – Danilo & Sandri 1856: 137, no. 140s – Tallack 1861: 314 – Brusina 1866: 64 – Caruana 1867: 49 – Klećak 1873: 36 – Monterosato 1874: 277; 1875: 44, no. 744; 1878: 46; 1880: 230 – Nyst 1878:50 (1); 1881: pl. 3, Fig. 14A, B – Dewalque 1880: 478 – Locard 1891b: 11 – Tesch 1912: 90 – Nobre 1931: 79, pl. 32, fig. 4.

Raphitoma (*Leufroyia*) *leufroyi* – Wenz 1943: 1453, fig. 4114 – Shikama & Horikoshi 1963: 123, pl. 101, fig. 5 – Brébion 1964: 611, pl. 15, fig. 5 – Nordsieck 1968: 179, pl. 30, fig. 94.70; 1977: 60, pl. 20, fig. 157 – De Casa & Hallgass 1979: 6 pl. 1 – Montefameglio *et al*. 1979: 191 – Piani 1980: 156 – Templado & Llanso 1981: 36 – Van Aartsen *et al*. 1984: 45, fig. 219 – Sabelli *et al*. 1990: 44, 216 – Cavallo & Repetto 1992: 26, 146, fig. 404 (WI) – Cossignani *et al*. 1992: 26, fig. 179 – Mifsud 1993: 6 – Vera-Peláez *et al*. 1999: 13.

Raphitoma concinna – Manousis 2012: 178 [top and low figures], non Scacchi, 1836.

Raphitoma erronea – Arduino *et al*. 1995: 94 (figured) non Monterosato, 1884.

Raphitoma leufroyi – Bellardi 1847: 89 – Sismonda 1847: 36 – Ruggieri 1967: 314 – Albergoni & Spada 1969: 158, 161 – Parenzan 1970: 210, pl. 45, fig. 853 – Spada 1971: 131 – Ghisotti 1972: 85 – Lozet J.-B. & Dejean-Arrecgros 1977:112, fig. 163 – D'Angelo & Gargiullo 1978: 153 (figured) – Biagi & Corselli 1978: 11 – Bogi, Coppini & Margelli 1980: 14, fig. 2 – Terreni 1981: 41, no. 336 – Corselli, 1981: 16 – Berardelli *et al*. 1982:330 – Idato, Fresi & Russo 1983: 112 – Poppe & Goto 1991: 44,167, pl. 35, fig. 22, pl. 1, fig. 25 – Barash & Danin 1992: 161, fig. 184 – Cachia, Mifsud & Sammut 1993: 34 – Delamotte & Vardala-Theodorou 1994: 137, fig. 7 – Arduino *et al*. 1995: 94 (figured) – Hayward, Wigham & Yonow 1995: 536, fig. 10.17 – Giribet & Peñas 1997: 53 – Oliverio 1997: 86 – Bogi & Cauli 1998: 134 – Cachia 1999: 90 – Olabarria, Urgorri & Troncoso 1999: 89 – Avila *et al*. 2000: 154 – Borja & Muxika 2001: 76 – Cachia, Mifsud & Sammut 2001: 67, pl. 10, fig. 5; 2004: 254 – Martini *et al*. 2001: 193 – Landau *et al*. 2003: 271, pls. 45, fig. 8 – Rolán 2005: 172, fig. 789 – Repetto *et al*. 2005: 39, 218, fig. 900 – Peñas *et al*. 2006: 43 – Oliver Baldoví 2007: 39 – Vardala-Theodorou & Nicolaidou 2007: 65 – Soppelsa *et al*. 2007: 27 – Cecalupo *et al*. 2008: 32 – Pusateri & Giannuzzi-Savelli 2008: 124, figs 5, 7, 9, 14 – Robin 2008: 454, fig. 16 – Scaperrotta *et al*. 2010: 96 (figured) – Cossignani & Ardovini 2011: 31, 326 (figured) – Gofas, Moreno & Salas 2011: 339 (figured) – Rolán 2011: 230, fig. 76L, M – Manousis 2012: 179 [only upper figure, lower one is *L. concinna*] – Oliver *et al*. 2012: 55; 2015: 109 – Trono & Macrì 2013: 35 – Ceulemans *et al*. 2018: 113 – Manousis *et al*. 2018: 21, fig. 14A-C – Trigo *et al*. 2018: 355 – Muñoz Ferrera de Castro *et al*. 2019: 162-163 (figured).

TYPE MATERIAL. — *Pleurotoma leufroyi* Michaud: **Potential syntypes. Mediterranean Sea** • 2 sh; Lyon Museum 45018065; Mediterranean; 13.1 and 15 mm long, glued with the apex pointing downward, on a cardboard labelled by Michaud ("PleuR. leufroyi Mich./Médit.") and by Locard ("Defrancia Leufroyi Mich/méditerranée/coll. Michaud") (Boyer & D'Audibert 2007: 151).

Pleurotoma zonalis Delle Chiaje*:* not found, it should be searched in the general collection at Museo Zoologico di Napoli, currently not revised (Sergio Duraccio pers. comm.).
Pleurotoma cyrilli O.G. Costa*:* not found, it should be searched in the general collection at Museo Zoologico di Napoli, currently not revised (Sergio Duraccio pers. comm.).
Murex caudicula Nardo: not available; it should be in the Stefano Chiereghini collections (Museo di Storia Naturale, Torino), currently not accessible (Paolo Russo pers. comm.).
Clathurella mirabilis Locard, 1891*:*
Syntype. France • 1 sh; MNHN-IM-2000-3104; Belle Isle; 18.6 mm.

TYPE LOCALITY. — *Pleurotoma leufroyi* Michaud: Mediterranean, "Habite la Méditerranée, côte d'Agde (Hérault)" [Lives in the Mediterranean, coast of Agde (Hérault): Michaud 1828].
Pleurotoma zonalis Delle Chiaje: Napoli.
Pleurotoma cyrilli O.G. Costa: Taranto.
Murex caudicula Nardo: Venezia.
Clathurella leufroyi var. *albida* Bucquoy, Dautzenberg & Dollfus: côtes de Barbarie.
Clathurella mirabilis Locard: l'Océan.

MATERIAL EXAMINED. — NE Atlantic. **Portugal** • 1 sh; Algarve, Marinha Portimão; 16-18 m; coll. PUS.
Canary Islands • 1 sh; Gran Canaria, La Luz; 109 m; coll. PUS.
Açores • 1 sh; São Miguel Island, Ponta Delgada; coll. DSC.
Mediterranean. **Spain** • 2 sh; Alboran Sea; coll. OLI • 1 sh; Cabo de Gata, coll. CRO • 1 sh; Malaga; coll. TRI • 1 sh; La Herradura; 10 m; coll. AGA • 3 sh; Baleares; unprecised locality; SMNH 73167 • 2 sh; Formentera I., El Calo; leg. Alf Josefson; SMNH 73166D.
France • 2 sh; Antibes; coll. HOA • 6 sh; Provence; HUJ coll. Coen 8092B • 1 sh; St. Raphael; labelled by Monts. "*leufroyi* var. *parva*"; MCZR-M-17111 • 1 sh; St. Raphael; coll. HOA • 2 sh; St. Raphael, Le Dramont; coll. HOA • 1 sh; Cassis; MNHN coll. Locard.
Corsica • 8 sh; Baie de Calvi; legit A. Warén, SMNH 73171L • 1 sh; Ile Rouge; 40 m; coll. BAR • 1 sh; Alistro; coll. MAR • 1 sh; Ajaccio; coll. CRO • 4 lv; Corsica2019; Cap Corse; MNHN-IM-2019-4036, MNHN-IM-2019-4093, MNHN-IM-2019-5302, MNHN-IM-2019-5315.
Sardinia • 3 sh; no. 8092A; no precise locality; HUJ coll. Coen • 3 sh; no precise locality; MCZR-M-17111 • 2 sh; S. Teresa di Gallura; 6 m; coll. CRO • 1 sh; Olbia; coll. CRO • 1 sh; Porto Conte; coll. OLI • 2 sh; Porto Conte, Nettuno cave; 15 m; coll. OLI • 14 sh; Poetto; coll. PIS • 1 lv; Villasimius; 39°07'43"N, 9°32'17"E; BAU-1742.
Sicily • 1 sh; Porticello; coll. GIR • 1 sh; Ustica I., Punta Gavazzi; 50 m; coll. AGA • 3 sh; Palermo; sub nomine *leufroyi* var. *minor;* MCZR-M-17111 • 3 sh; Palermo; sub nomine *"Leufroyia malatina"* Monts. ms; MCZR-M-17111 • 2 sh; Palermo; *"var. albescens"* Monts; MCZR-M-17111 • 1 h; Palermo Gulf; coll. GIR • 8 sh; Palermo Gulf; coll. PUS • 4 sh; Isola delle Femmine; coll. PUS • 5 sh; Isola delle Femmine; coll. SER • 2 sh; Isola delle Femmine; coll. GIR • 2 sh; Isola delle Femmine; coll. CRO • 1 sh; Trapani; coll. OCC • 2 sh; Favignana I.; coll. PUS • 1 sh; Sicily Channel; coll. TRI • 1 h; Lampedusa I., Punta Cappellone; 45 m; coll. CRO • 1 sh; SE Sicily; coll. ARD • 1 sh; unprecised locality; MRSNT no. 45335 • 2 sh; Punta Braccetto; coll. OCC • 3 sh; Porto Palo di Siracusa • 1 sh; coll. GER • Brucoli; coll. CRO • 2 sh; Isola delle Correnti; 15 m; coll. PIE • 4 sh; Cannizzaro; 45 m; coll. GER • 3 sh; Cannizzaro; 45 m; coll. CRO • 2 sh; Catania, Acireale; 15 m; coll. PAG • 18 sh; Acitrezza; coll. GER • 4 sh; Acitrezza; coll. CRO • 1 sh; Acitrezza; coll. PAG.
Italy • 1 sh; Gallinara I.; 40 m; coll. REP • 5 sh; Bergeggi; 38 m; coll. REP • 1 sh; Capo Noli; 2 m; coll. REP • 1 sh; Camogli, S. Fruttuoso; 42 m; coll. REP • 1 sh; Sestri Levante, Riva Trigoso; 20 m; coll. REP • 6 sh; Gorgona I.; 80 m; coll. BAL • 1 sh; Capraia I.; 80 m; coll. MAR • 8 sh; Capraia I.; 40 m; coll. PAO • 1 sh; Elba I.; coll. MAR • 1 sh; Elba I.; coll. GOR • 1 sh; Elba I.; coll. BAR • 1 sh; Elba I., Buccale; coll. PAG • 1 sh; Elba I., Manaregno; coll. TRI • 6 sh; Grosseto, Punta Ala; 5 m; coll. REP • 1 sh; Grosseto; coll. OCC • 5 sh;

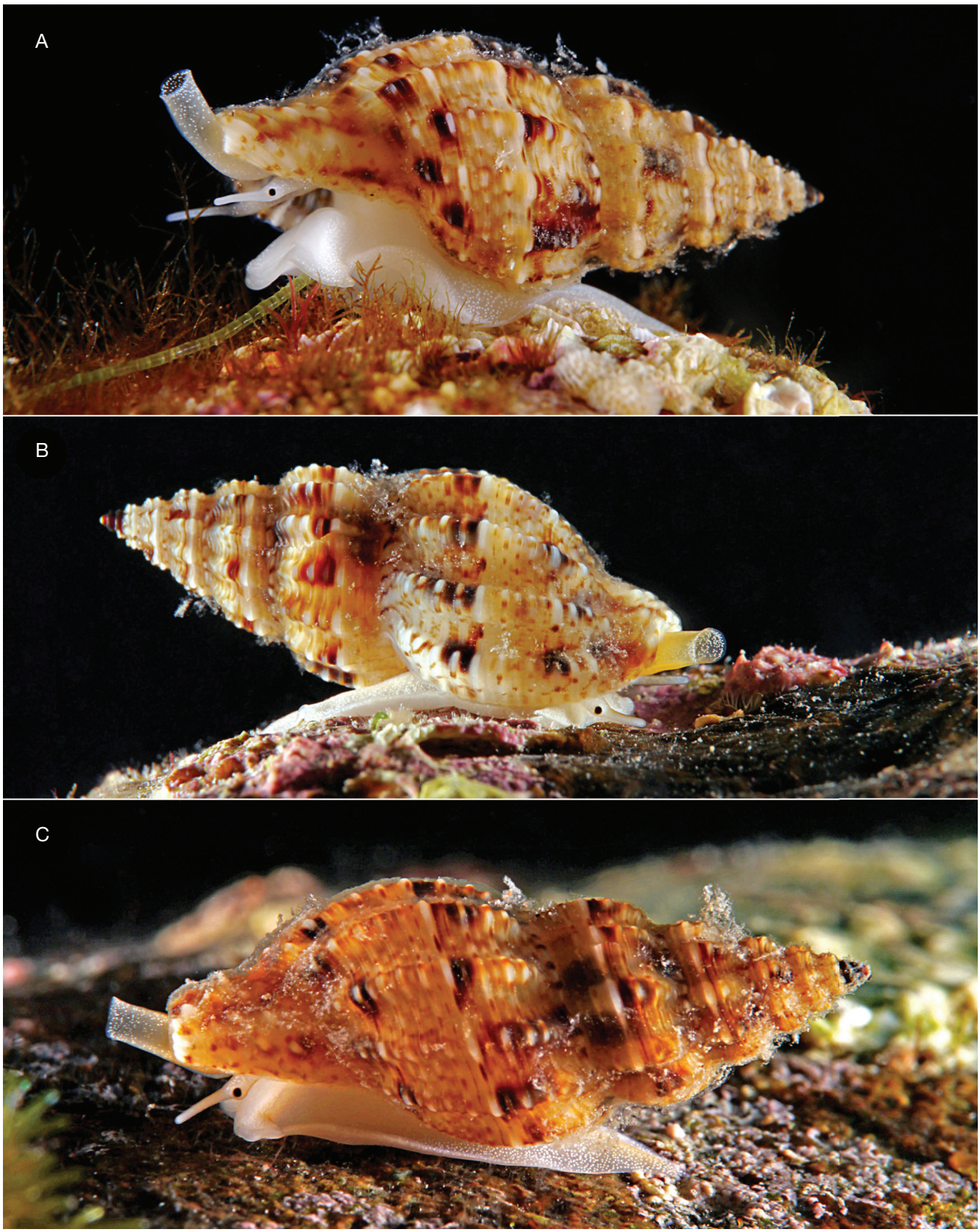

FIG. 7. — Underwater photographs of three living animals of *Leufroyia leufroyi* (Michaud, 1828). **A**-**C**, France, Cap d'Antibes, 13-17 m. Photo courtesy: Dominique Horst.

Porto Santo Stefano; coll. PAG • 7 sh; Gulf of Baratti; 5 m; coll. PAO • 7 sh; Gulf of Baratti; 5 m; coll. BAL • 1 sh; Livorno, Bagni Fiume; coll. PAG • 1 sh; Livorno, Bagni Fiume; coll. MAR • 1 sh; Livorno, Bagni Fiume; coll. PAG • 6 sh; Castiglioncello; coll. MAR • 1 sh; Vada; coll. PAG • 1 sh; Ladispoli, Torre Flavia; MCZR; coll. Pizzini • 2 sh; Ostia; coll. PIE • 1 sh; off Fiumicino; 30 m; coll. PAG • 7 sh; Santa Marinella; 27 m; coll. AGA • 1 sh; Zannone I.; coll. FUM • 1 sh; Ponza I., Secca dei mattoni; 26 m; coll. CRO • 23 sh; Procida I.; coll. CRO • 4 sh; Procida I., Punta Pioppeto; 6 m; coll. CRO • 3 sh; Napoli; var *albolineata* Monts ms.; MCZR-M • 1 sh; Sorrento, Marina di Puolo; coll. DUR • 3 sh; Capri I.; coll. CRO • 1 sh; Cetraro; coll. RON • 3 sh; Costa Viola; 38 m; coll. PAO • 4 sh; Scilla; coll. GER • 67 sh; Scilla; coll. VAZ • 1 sh; Scilla; 50 m; coll. PAG • 14 sh; Scilla; 50 m; coll. CRO • 1 sh; Scilla; 50 m; coll. TIS • 3 sh; Lazzàro; coll. VAZ • 15 sh; Isola di Capo Rizzuto; 45-60 m; coll. MEL • 4 sh; Maratea; coll. CAR • 5 sh; Campomarino; coll. DIN • 1 sh; Porto Cesareo; coll. MAC • 1 sh; Lama; coll. NOT • 1 sh; Novaglie; coll. MAC • 1 sh; Marina di Ugento; coll. MAC • 1 sh; Monopoli, Cala Corvino; coll. DUR • 2 sh; Giovinazzo; coll. MEL • 2 sh; San Nicola I.; coll. AGA • 1 sh; Ortona; 8 m; coll. PAG.
Morocco • 2 sh; Restinga; MRSNT no. 45337.
Malta • 1 sh; no precise locality; coll. MIF.
Croatia • 2 sh; Korcula I.; 5 m; coll. AGA • 1 sh; Dalmatia; coll. PUS • 2 sh; Zadar; SMNH 70482-70483 • 2 sh; Pag I., Košljun bay; 2-5 m; coll. PRK • 2 sh; Pag I., Ljubačka Vrata; 35 m; coll. UGA • 2 sh; Molat I.; amidst red coral colonies, 35-50 m; coll. PRK • 10 sh; Sukošan; 2-7 m; coll. PRK • 25 sh; Dugi Otok I., Veli Garmenjak; 32-40 m; coll. PRK • 37 sh; Murter I., Kosirina bay; 1-7 m; coll. PRK • 2 sh; Žirje I.; amidst red coral colonies, 70-100 m; coll. PRK • 2 sh; Primošten, Šparadići; 2-6 m; coll. PRK • 1 sh; Sevid; 18 m; coll. UGA • 33 sh; Sevid; 2-8 m; coll. PRK • 6 sh; Jabuka I.; 15-35 m; coll. UGA • 5 sh; Jabuka I.; 15-35 m; coll. STA • 2 sh; Čiovo I., Fumija; 10 m; coll. UGA • 2 sh; Šolta I.; 5-10 m; coll. STA • 23 sh; Split; 1-5 m; coll. PRK • 1 sh; Vis I., Komiža; 35 m; coll. UGA • 1 sh; Brač I., Milna; 10-18 m; coll. PRK • 13 sh; Brač I., Milna; 10-18 m; coll. STA • 2 sh; Brač I., Maslinova bay; 3-15 m; coll. PRK • 15 sh; Brač I., Maslinova bay; 3-15 m; coll. STA • 3 sh; Omiš, Balića Rat; 4-8 m; coll. PRK • 20 sh; Lastovo I.; amidst red coral colonies; 70-100 m; coll. PRK • 14 sh; Lastovo I.; amidst red coral colonies; 70-100 m; coll. STA • 1 sh; Palagruža I.; 28 m; coll. UGA • 2 sh; Pelješac, Žuljana; 1 m; coll. STA • 2 sh; Pelješac, Prapratno; 2-6 m; coll. PRK • 5 sh; Mljet I., Pod Škoji; 1-3 m; coll.PRK • 32 sh; Mljet I.; amidst red coral colonies, 70-100 m; coll. PRK • 1 sh; Zadar; 6 m; coll. PAG • 1 lv; Sevid; 43°28'46"N, 16°02'08"E; 2-4 m; BAU-2240.1.
Greece • 1 sh; Athens, Varkiza; coll. TRI • 1 sh; Astypalea I.; coll. TRI • 1 sh; Antiparos I.; coll. BIN • 1 sh; Achaia; 5 m; coll. PAG • 1 sh; Corfù I.; coll. BAR • 2 sh; Chalkidiki, Sani; coll. CRO • 1 sh; Crete Island, Mallia; coll. CRO.
Turkey • 1 sh; Bozcaada I.; coll. PUS • 1 sh; Adana, Yumurtalik, coll. CGS • 1 sh; Bodrum, Salih I.; 35 m; coll. CGS • 1 sh; Bodrum; 80 m; coll. CGS • 1 sh; Güllük Bay; 44 m; coll. OZT • 1 sh; Marmara Sea, Silivri; 25 m; coll. OZT.

Distribution. — Known with certainty from the Early Pliocene to Recent; records from the Middle Miocene (Langhian of the Loire Basin: Peyrot 1938, Glibert 1954; Langhian of the Paratethys: Hörnes 1854, Bałuk 2003, Friedberg 1912; Serravallian of Karaman Basin: Landau *et al*. 2003) and from the Late Miocene (Messinian of the Loire Basin: Brébion 1964) although morphologically broadly similar are probably not conspecific (B. Landau pers. comm.), and need to be reanalysed in the framework of a revision of the genus *Leufroyia* in the Miocene.
Early Pliocene: central Mediterranean, Italy (Sacco 1904). Early-late Pliocene: central Mediterranean, Italy (Cipolla 1914).
Early Pleistocene: central Mediterranean, Italy (Cerulli-Irelli 1910). [From Landau *et al*. 2003].
Recent: Northeastern Atlantic from the Atlantic coast of France (Belle Isle), south to Portugal, Açores, Madeira and Canary Islands. The entire Mediterranean and Marmara Sea (Ostroumoff 1896: 59). *Leufroyia leufroyi* is relatively common on rocky bottoms from a depth of 1 m to more than 100 m, where it lives under stones or amidst algae, but also in sciaphylous habitats, including amidst red coral colonies where it is also quite frequent. It often lives in sympatry/syntopy with other raphitomids, also with other *Leufroyia* spp.; in shallow water it is frequently found with *L. concinna* even under the same stone or amidst the same alga, while sampling in sciaphilous habitats all 4 *Leufroyia* species can be found together.

Original description. — "P. Testa turrito-conica; luteo-fusca, longitudinaliter costata, striis transversis decussantibus exarata; apice obtusa *[sic]*, anfractibus septenis; convexis, postremo duabus, fasciis spadiceis interruptis, superioribus una tantum, ornais; sutura excavata; apertura alba; labro incrassato; canali brevi, recto, extus eleganter plicato" (Michaud 1828:121).

Description

Shell

Robust and fusiform, of large size for the genus. Height: 10.83-22.93 mm (mean 15.26 mm, SD: 3.07); width: 5.07-9.59 mm (mean 6.76 mm, SD: 1.12); H/W: 2.0-2.62 (mean 2.27, SD: 0.13).

Protoconch

Multispiral with 2.6 to 3.0 (mean 2.84, SD: 0.14) convex whorls and small nucleus (d: 150 µm). Protoconch I of 0.9 whorls, diameter 242 µm, covered by dense cancellate sculpture; protoconch II with axial threads under suture and less dense and diagonally cancellate sculpture on rest of whorl. A keel at the end of last whorl of varying length. Protoconch-teleoconch boundary of flexuose, opisthocline growth lines. Colour always dark brown or blackish, with white or yellowish nucleus.

Teleoconch

Of 5.8-8.0 convex whorls (mean 6.87, SD: 0.58), with deep and distinct wavy sutures and prominent sculpture; suture area slightly thickened abapically and white coloured with brown dots or lines; whole external surface covered with relatively thick periostracum; dense and slightly pronounced growth lines present on ribs and interspaces, more pronounced on the subsutural ramp; surface glossy; microgranules absent on 1-2 adapical whorls, remaining ones covered with extremely fine and dense microgranulation.

Axial sculpture of 12-19 (mean 14.16, SD: 1.73) strong, equidistant, orthocline or slightly opisthocline ribs, broader than spiral cords, narrower than interspaces; ribs occasionally less elevated on body whorl of largest shells.

Spiral sculpture of 10-17 narrow cords (mean 13, SD: 1.75) above the aperture, of which 3-4 weak on subsutural ramp, remaining of almost equal strength and equally spaced, or with few additional thin cordlets between the strongest cords, rarely one thin cordlet between all pairs of strong cords; spiral interspaces 1.5-3 broader than cords; on first adapical whorl 2 or 3 strong spiral cords and one thin subsutural cordlet.

Siphonal fasciole with 6-11 (mean 8.21, SD: 1.11) strong and slightly nodulose cords, usually stronger than cords of body-whorl.

Cancellation rectangular, with very elongate and slightly elevated tubercles at the intersections.

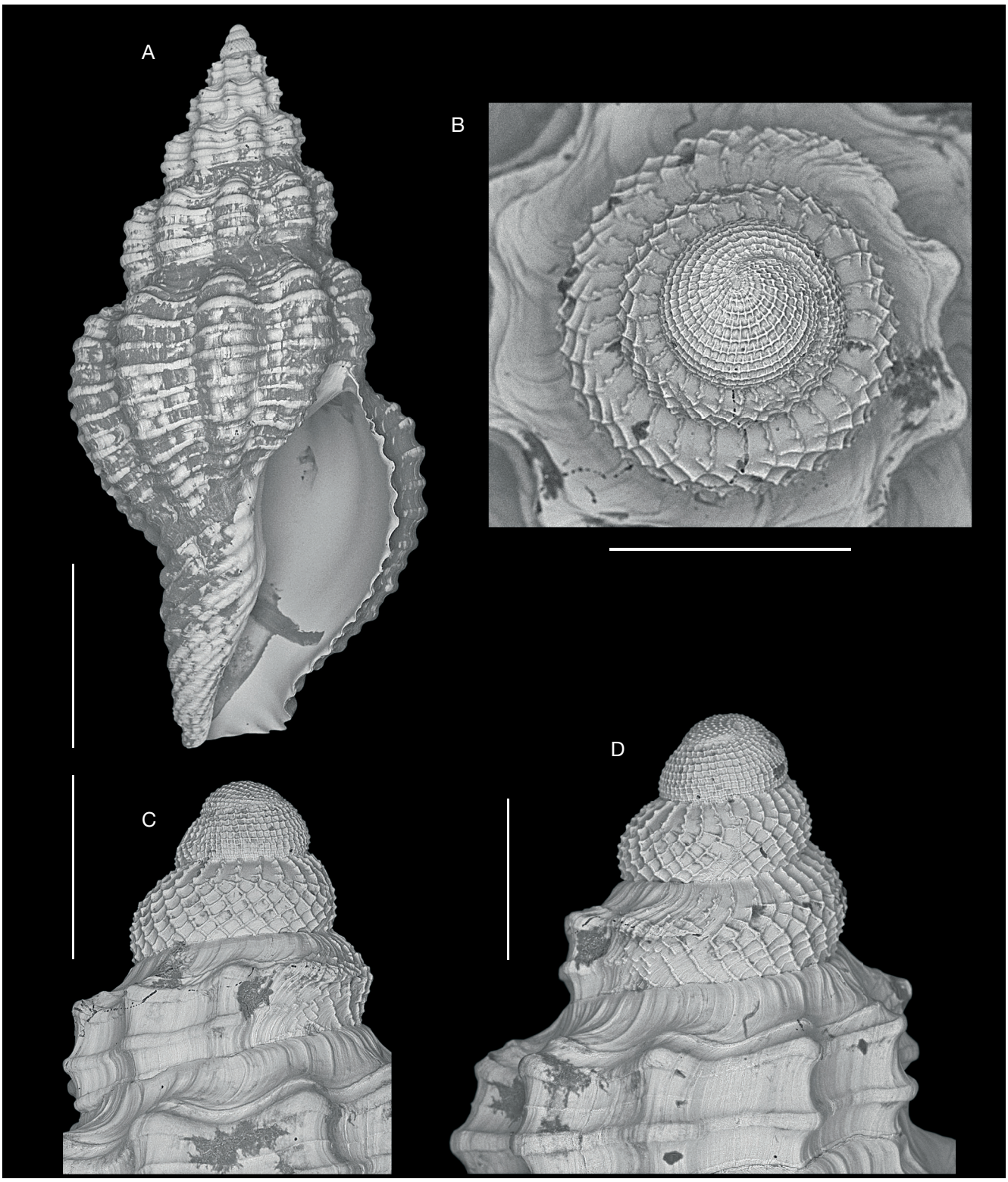

Fig. 8. — *Leufroyia leufroyi* (Michaud, 1828). Murter Island (Croatia), 3 m, h. 7.85 mm. **A**, Frontal view of shell; **B**-**D**, apical (B), frontal (D) and dorsal (C) view of protoconch. Scale bars: 2 mm (A), 300 µm (B-D).

Subsutural ramp narrow and more or less inclined, covered with dense growth marks of the anal sinus crossed by 3-4 weak spiral cordlets.

Columella simple, straight medially and arcuate or angled posteriorly. Siphonal canal wide and moderately long, posterior canal deep and moderately wide.

Outer lip thickened and smooth internally, with edge crenated by spiral cords.

Height of aperture: 4.6-9.99 mm (mean 6.24 mm, SD: 1.40); A/H: 36.98-45.97% (mean 40.83%, SD: 2.46).

Coloration

Background colour variable but usually light, from whitish to pale brownish; darker blotches, light brown to dark brown-blackish, variable in number (rarely absent), size and colour, irregularly placed on upper half of whorls and below periphery, usually on axial ribs, occasionally also in interspaces; a broad light spiral band almost devoid of blotches at aproximately 1/3 to 1/2 of whorl height. Occasionally a thin brown or reddish-brown cordlet above the median ligth band. Cords in light coloured areas often with many brownish dots and short lines, more evident in living specimens. Cords on siphonal fasciole light, whitish or yellowish, often with some light brown or pale orange narrow bands in the interspaces between low tubercles. Aperture internally white, often with light or dark brown blotches visible by transparency.

Soft parts

Foot very long, broad and deeply bilobed anteriorly and with recurved anterolateral corners, narrowly tapering posteriorly. Siphon cylindrical with ventral slit, widely opening anteriorly, very extensile. Head small with a pair of long cylindrical tentacles, black eyes on bulges about halfway their length, distal part slightly longer and much narrower than basal. Operculum absent, toxoglossate radula present.

Colour translucent white or cream, with minute white speckles densely covering upper side of foot, scattered or absent on sole, head and along neck. Tentacles translucent white or cream, with white speckles only along broadest part. Siphon translucent yellowish-white, pale ochre or pale orange, with dense white speckles (Figs 6, 7).

Remarks

The collection Michaud was in part donated to the Musée de Lyon (now Musée des Confluences), in part passed to the city of Brive by Michaud's son Elysée, and in part bought by Locard (Locard, 1891b: 7). Only the Lyon material remains identifiable (Boyer & D'Audibert 2007: 13; pl. 1, fig. 2), the part in Brive having been lost, and the part in Locard's collection having lost the original labels. The possible syntypes of *Pleurotoma leufroyi* Michaud remaining in Lyon Museum (lot no. 45018065) consist of 2 shells, with handwritten labels by Michaud and Locard. This is the same material referred to by Locard (1891b: 11). Michaud gave as size 20 x 9 mm, making the identification of the Lyon material as syntypical still not conclusive.

Leufroyia leufroyi was mistakenly confused by many authors with *L. concinna*. The first source seems to be that of Forbes & Hanley (1853: 468) who nonetheless pointed out that their English specimens of *"leufroyi"* (evidently *L. concinna*) were different from the Mediterranean ones (clearly typical *L. leufroyi*) by being broader, with more obsolete colouration and by having some spirals cords of brownish colour. Also Jeffreys (1867: 366) recorded *"leufroyi"* from the British coast but his description seems to refer to a mix of characters of *L. leufroyi* and *L. concinna.* Other more recent misidentifications are e.g. in Fretter & Graham (1985: 539) and Wigham & Graham (2018: 137, fig. 161).

The maximum height of examined shells is 23 mm, but specimens larger than 18 mm are rare. The height and maximum diameter of the protoconch depend on the number of whorls; in the specimen of Fig. 8 with 2.7 protoconch whorls the protoconch is 525 µm high and 484 µm wide. The diameters of nucleus and first whorl are small, similar to *L. concinna*, and smaller than in *L. erronea* and *L. villaria*. The colour of the protoconch is always dark brown or blackish, even in specimens with very light teleoconch. The sexes are separated but we did not find any evidence of bimodality in morphometrics, thus guessing no size dimorphism. Diagnostic features of *L. leufroyi* with all other extant *Leufroyia* spp. are the very dark protoconch and the dark brown blotches on a light background of the teleoconch (although shells tend to fade out after some years from collection). Some problematic specimens with small and very pale or even absent blotches on the teleoconch can be easily diagnosed by the dark protoconch (if retained). Some dark coloured shells of *L. erronea* may be misleading, but they can be easily identified by the lighter and broader protoconch, the teleoconch spiral sculpture, less slender outline and shorter siphonal canal.

According to Høisaeter (2016: 28) *L. leufroyi* is not present along the European coasts North of Brittany (France) and all such records (like e.g. Lebour 1934: 553 from Plymouth, UK) should be in fact ascribed to *L. concinna*. As far as we know the northernmost confirmed record is Belle Isle (Bay of Biscay, Brittany, France) from the Locard coll. (MNHN-IM-2000-3104) under the name *Clathurella mirabilis*, whereas the southern limit should be at Canary Islands.

The records of *L. leufroyi* from southern Angola (Rolán *et al.* 1998: 108) are based on *L. villaria*, according to the different pattern of the living animal (cream colour with small white spots, siphon clear orange, with many light coloured spots) and the slightly different protoconch. It is quite common in the whole Mediterranean, including Israel from where it was recorded by Barash & Danin (1992) from various localities. Marquet (1998b) correctly separated the Pliocene North Sea Basin records as *Raphitoma pseudoleufroyi* (Marquet, 1998), a species with very similar teleoconch characters, but paucispiral protoconch (*vs* multispiral in *L. leufroyi*).

Leufroyia concinna (Scacchi, 1836)
(Figs 9-13)

Pleurotoma concinna Scacchi, 1836: 13, fig. 18.

Fusus boothi J. Smith, 1839: 98.

Defrancia leufroyi var. *carnosula* Jeffreys, 1867: 367.

Pleurotoma linearis var. *major-violacea* Monterosato, 1875: 270.

Homotoma michaudi Bellardi, 1877: 276.

Raphitoma (*Leufroyia*) *scacchii* De Casa & Hallgass, 1979: 6, pl. 1; non Bellardi, 1847.

Lineotoma concinna form *maderensis* Nordsieck & Talavera, 1979: 166, no. 34.

Clathurella (*Cirillia*) *linearis* var. *concinna* – Coen 1933: 72, no. 480.

Clathurella (*Cyrillia*) *linearis concinna* – Kobelt 1905: 368, pl. 96, figs 6, 7.

Clathurella concinna – Bucquoy *et al.*, 1883: 98, pl. 14, fig. 5 – Tryon 1890: 277, pl. 34, fig. 85 – Locard 1886: 116; 1892: 69 – Locard & Caziot 1899: 63.

Defrancia leufroyi – sensu Jeffreys, 1867: 366-368 non Michaud, 1828 – sensu Norman, 1879: 30, no. 237 non Michaud, 1828.

Leufroyia concinna – Monterosato 1884: 134 – Bellini 1929: 32 – Trono 2006: 65 – Mazziotti *et al*. 2008: 78.

Peratotoma (*Leufroyia*) *concinna* – Cerulli-Irelli 1910: 60 (252), pl. 5 (36), fig. 47 – Cipolla 1914: 61 (175), pl. 3 (14), figs 25, 26.

Peratotoma michaudi – Tropeano *et al*. 1984: 55.

Philbertia concinna – Van Straaten 1960: 112.

Philbertia leufroyi boothi – E.H. Smith 1967: 176-187.

Philbertia leufroyi – sensu Hubendick & Warén 1974: 28, fig. 222 non Michaud, 1828 – sensu Lebour 1934: 553 (veliger figured) non Michaud, 1828.

Pleurotoma (*Defrancia*) *concinna* – Monterosato 1877a: 43, pl. 5, fig. 1; 1877b: 336; 1877c: 425; 1878: 106; 1880: 230.

Pleurotoma (*Leufroyia*) *michaudi* – Sacco 1904: 53, pl. 13, figs 55, 56.

Pleurotoma concinna – Calcara 1839a: 5; 1839b: 17 – Philippi 1844: 166 – Petit de la Saussaye 1852: 133 – Weinkauff 1868: 133 [in the synonymy of *Murex linearis* Montagu, 1803]– Aradas & Benoit 1876: 251 [in the synonymy of *Murex linearis* Montagu, 1803] – Carus 1893: 251 [in the synonymy of *Murex linearis* Montagu, 1803] – Cretella *et al*. 2005: 115, 121.

Pleurotoma concinnum [sic] – Sandri & Danilo 1856: 137, no. 141 [in the synonymy of *Murex linearis,* Montagu, 1803].

Pleurotoma leufroyi – sensu Forbes & Hanley 1853: 468-470 non Michaud, 1828.

Raphitoma (*Cirillia*) *concinna* – Nordsieck 1968: 178, pl. 30, fig. 94.62.

Raphitoma (*Leufroyia*) *concinna* – Nordsieck 1977: 60, pl. 20, fig. 159 – Piani 1980: 156 – Luque & Templado 1981: 22 – Templado & Llanso 1981: 36 – Sabelli *et al*. 1990: 44, 216.

Raphitoma concinna – Parenzan 1970: 210, pl. 44, fig. 851 – Ghisotti 1972: 85 – Bogi, Coppini & Margelli 1980: 14, fig. 1 – Borja 1987: 217 – Poppe & Goto 1991: 174, pl. 1, fig. 20 – Koutsoubas *et al*. 1992: 73 – Cachia, Mifsud & Sammut 1993: 34 – Giribet & Peñas 1994: 52; 1997: 52 – Panetta & Imperatrice 1994: 39 – Tabanelli & Segurini 1994: 12 – Arduino *et al*. 1995: 94 (figured) – Consolado Macedo 1996: 121, fig. 152 – Borja & Muxika 2001: 76 – Cachia, Mifsud & Sammut 2001: 64, pl. 9, fig. 10 – Basso & Brusoni 2004: 40 – Öztürk, Buzzurro & Benli 2004: 59 – Repetto *et al*. 2005: 39, 216, fig. 888 – Peñas *et al*. 2006: 43; 2009: 25 – Oliver Baldoví 2007: 39 – Vardala-Theodorou & Nicolaidou 2007: 65 – Cecalupo *et al*. 2008: 32 – Cossignani & Ardovini 2011: 31, 324, 325 (figured) – Gofas, Moreno & Salas 2011: 339 (figured) – Manousis 2012: 178 (only central figure) – Oliver *et al*. 2012: 55; 2015: 109 – Trono & Macrì 2013: 35 – Ceulemans *et al*. 2018: 113 – Manousis *et al*. 2018: 11, fig. 6a-c.

Raphitoma leufroyi – Fretter & Graham 1985: 538-540, fig. 371 non Michaud, 1828 – Ardovini & Cossignani 2004: 225 non Michaud, 1828 [only the first shell of 2nd row in the figure] – Manousis 2012: 179 (lower figure) non Michaud, 1828 – Wigham & Graham 2018: 137, fig. 161 non Michaud, 1828.

Raphitoma michaudi – Chirli 1997: 84, pl. 24, figs 1-4.

TYPE MATERIAL. — *Pleurotoma concinna* Scacchi: presumably lost (Cretella *et al*. 2005). *Fusus boothi* J. Smith: presumably lost (Kathie Way pers. comm.). J. Smith's material was at the Anderson Museum (Glasgow) closed on 1887, thereafter moved at the Hunterian Museum (Glasgow) where this sample has not been found. *Defrancia leufroyi* var. *carnosula* Jeffreys: Types not found (Warén 1980: 33). *Pleurotoma linearis* var. *major-violacea* Monterosato: not found at the Museo Civico di Zoologia, Rome. *Homotoma michaudi* Bellardi: it should be at the Museo di Storia Naturale di Torino, currently not accessible. *Raphitoma* (*Leufroyia*) *scacchii* De Casa & Hallgass: private collection Alessandro Hallgass (Rome). *Lineotoma concinna* form *maderensis* Nordsieck & Talavera: SMF, Senckenberg Museum, Frankfurt/M (Germany) not seen.

TYPE LOCALITY. — *Pleurotoma concinna* Scacchi: "*In sinu Neapolitano et Tarentino parum frequens*" [scarcely frequent in the gulfs of Napoli and Taranto] (Scacchi 1836). *Fusus boothi* J. Smith: Oban and Skye (Scotland). *Defrancia leufroyi* var. *carnosula* Jeffreys: shetland. *Pleurotoma linearis* var. *major-violacea* Monterosato: Atlantic Ocean. *Homotoma michaudi* Bellardi: Pliocene of Zinola, Albenga and Vallone Torsero (Italy). *Raphitoma* (*Leufroyia*) *scacchii* De Casa & Hallgass: Sardinia and La Maddalena Island. *Lineotoma concinna* form *maderensis* Nordsieck & Talavera: Porto Santo (Madeira).

MATERIAL EXAMINED. — Atlantic. **Norway** • 1 lv; 60°33'N, 4°52'12"E; ZMBN-H-3-69 • 1 lv; 60°18'N, 5°10'48"E; ZMBN-E-23-67 • 1 lv; 60°13'48"N, 5°12'E; ZMBN-020209-F.
Iceland • 1 sh; Reykjavík; coll. KEL.
Great Britain • 1 sh; Clyde (Scotland); USNM 305163 • 2 sh; Aberdeen Bank; 57°02'N, 01°12'W; 58 m, 27.VII.2011; coll. SWI • 1 sh; Cumbrae I.; Jeffreys coll. under "*leufroyi*"; USNM 190583 • 3 sh; North Sea, England; 53°1'N, 2°10'E; leg. S. Hanley; SMNH 70481 • 1 sh; Cornwall; leg. A. Gardiner in 1919; coll. FEN • 11 sh; Falmouth; 50°9'N, 5°4'W; leg. A. Gardiner in 1919; SMNH 70479 • 1 sh; Falmouth; 50°9'N, 5°4'W; SMNH 70480 • 1 sh; Herm I.; Jeffreys coll. under "*leufroyi*"; USNM 190585 • 2 sh; Guernsey I.; Jeffreys coll. under "*leufroyi*"; USNM 190584.
France • 1 sh; Roscoff; coll. DSC • 1 sh; Ouessant I; coll. DSC.
Spain • 1 sh; Gijòn; coll. GON • 1 sh; 10 km NNE Cap Finisterre; 42°55'N, 9°17'W; SMHN 73165A • 1 sh; La Coruña; coll. GUB • 1 sh; El Ferrol; SMHN 73164A.
Portugal • 1 sh; Sesimbra; SMNH 24101 • 1 sh; Faro; SMNH 25009 • 1 sh; Sagres; SMNH 73211.
Canary Islands • 1 sh; Lanzarote I., Puerto del Carmen; coll. DSC • 1 sh; Lanzarote I., Arrecife; coll. DSC.
Mediterranean.
Spain • 1 sh; Malaga; coll. PUS • 2 sh; Formentera I.; SMHN 70486A • 1 sh; Cadaqués; coll. PUS • 1 sh; Sitges; coll. PUS.
France • 1 sh; Bouche du Rhone; coll. PUS • 2 sh; S. Raphael, Le Dramont; coll. HOA • 1 sh; Antibes, Le Graillon; coll. HOA • 1 sh; Antibes, Le Graillon; BAU-1880.1 • 2 sh; Provence; "C[oste] di Provenza"; MCZR-M • 1 lv; Figuerolles, La Ciotat; 43°09'53"N, 5°35'45"E; 15 m; BAU-2263.1.
Corsica • 1 sh; Baie de Calvi; 7 m; SMNH 73171J • 1 sh; Ajaccio; coll. CRO • 1 lv; Corsica2019; Cap Corse; MNHN-IM-2019-4050.
Sardinia • 1 sh; Porto Conte; coll. OLI • 1 sh; Isola Rossa; coll. DSC • 2 sh; S. Teresa di Gallura; 6 m; coll. CRO • 1 sh; Cagliari; coll. PIS • 8 sh; Sant'Antioco; coll. PIS.
Sicily • 1 sh; Palermo Gulf; coll. GIR • 6 sh; Palermo; MCZR-M 17111 • 1 sh; Isola delle Femmine; coll. SER • 1 sh; Marettimo I.,

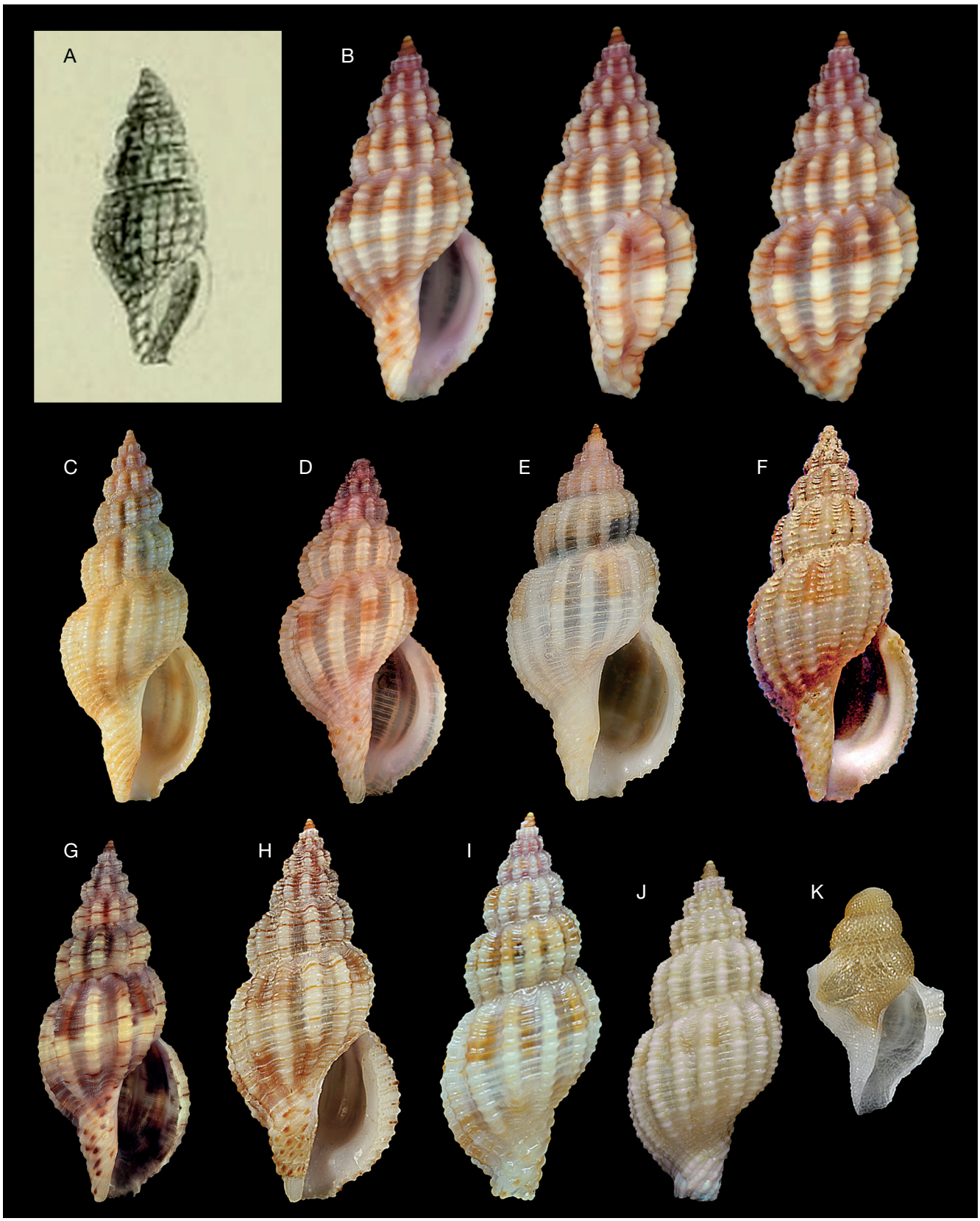

FIG. 9. — *Leufroyia concinna* (Scacchi, 1836) from Mediterranean Sea: **A**, original engraving; **B**, Korinthiakos Gulf (Greece) 60 m, h. 9.8 mm; **C**, Göçek (Turkey), h. 14.1 mm; **D**, Korinthiakos Gulf (Greece) 120 m, h. 10.7 mm; **E**, Capraia Island (Italy) 150 m, h. 15 mm; **F**, Mljet Island (Croatia) 60-100 m, h. 15.2 mm; **G**, Saronic Gulf (Greece) 30-70 m, h. 11.81 mm; **H**, Elba Island (Italy) 40 m, h. 14 mm; **I**, Le Dramont (Saint Raphael, France) 40 m, h. 14.7 mm; **J**, Le Dramont (Saint Raphael, France) 60 m, h. 10.8 mm; **K**, Elba Island (Italy), h. 1.1 mm. Photo courtesy: B, D, G, Costas Kontadakis; C, Bilal Oztürk; I, J, Dominique Horst.

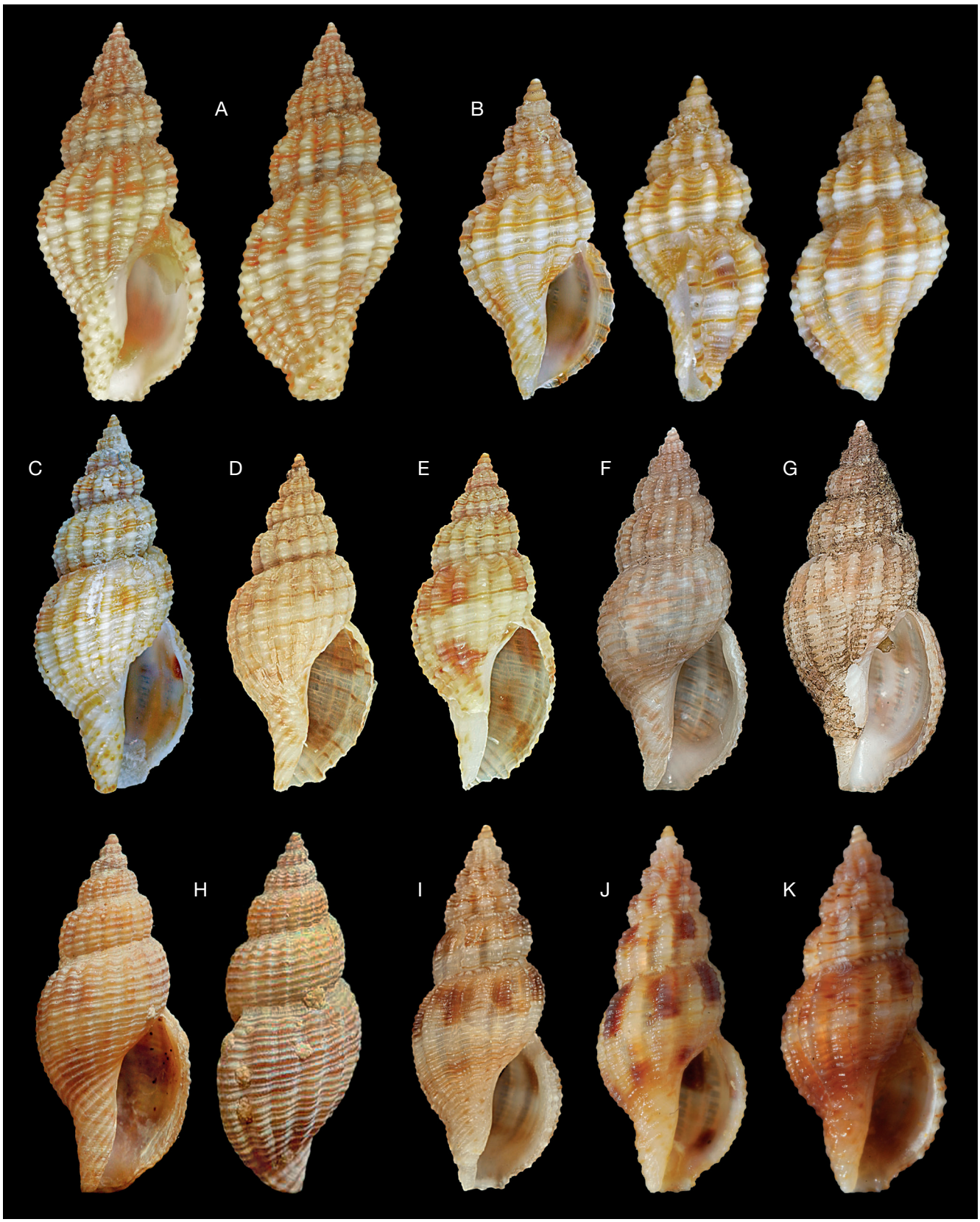

FIG. 10. — *Leufroyia concinna* (Scacchi, 1836) from NE Atlantic: **A**, Paimpol (Brittany, France), h. 13.6 mm; **B**, Ouessant Island (Finistère, France), h. 6.6 mm; **C**, Roscoff (Brittany, France) 85 m, h. 14.5 mm; **D**, Aberdeen Bank (57°02'N, 1°12'W) 58 m, h. 11.4 mm; **E**, Aberdeen Bank (57°01'N, 1°13'W) 54 m, h. 11.4 mm; **F**, Clyde (Scotland), USNM 305163 ex Henderson coll., h. 12.9 mm; **G**, Cumbrae Island (Scotland) (USNM 190583 ex Jeffreys coll.), h. 13.3 mm with periostracum; **H**, Cornwall (England), h. 9.8 mm; **I**, Puerto del Carmen (Lanzarote Island - Canaries), h. 9.5 mm; **J**, Playa de Sardina (Gran Canaria Island), h. 8.5 mm; **K**, Playa de Sardina (Gran Canaria Island), h. 8.8 mm. Photo courtesy: A-E, Christiane Delongueville; F-G, Jolanda Villacampa; H, David Fenwick; I, Ignazio Sparacio; J-K, Javier Martin.

FIG. 11. — Underwater photographs of two living animals of *Leufroyia concinna* (Scacchi, 1836). **A**, Italy; **B**, France, Cap d'Antibes, 21 m. Photo courtesy: A, Alessandro Falleni; B, Dominique Horst.

Punta S. Simone; 40 m; coll. PAO • 4 sh; Catania; MCZR-M 17342 • 1 sh; Ognina; coll. GER • 2 sh; Cannizzaro; coll. GER • 1 sh; Acitrezza; coll. CRO • 1 sh; Acicastello; 38 m; coll. PAG • 1 sh; Messina; 6 m; coll. PAG.

Tunisia • 1 sh; Kerkennah Islands; NMR 2633.

Italy • 5 sh; Bergeggi; 38 m; coll. REP • 1 sh; Capraia I.; coll. GOR • 1 sh; Elba I.; 40 m; coll. BAR • 1 sh; Elba I., Punta dell'Acqua Bona; coll. GOR • 9 sh; Golfi di Baratti; 7 m; coll. PAO • 3 sh; Formiche di Grosseto; coll. PAO • 2 sh; Porto Santo Stefano; coll. PAG • 6 sh; Secca delle Vedove; 80-100 m; coll. PAO • 1 sh; Castiglioncello; coll. MAR • 1 sh; Tor Paterno; coll. GER • 2 sh; Ostia; coll. PIE • 1 sh; Circeo; coll. NAP • 1 sh; Sorrento; coll. DUR • 1 sh; SMR; Giannutri I.; coll. • 1 sh; MCZR-M 16700; Napoli • 1 sh; Capri I.; sub nomine "*Philbertia* (*Leufroyia*) *leufroyi albida* BDD"; HUJ coll. Coen no. 8090; • 4 sh; Capri I.; coll. CRO • 5 sh; Maratea; coll. CAR • 1 sh; Calabria, Costa Viola; 36 m; coll. PAO • 3 sh; Scilla; coll. CRO • 1 sh; Scilla; 50 m; coll. VAZ • 15 sh; Lazzaro; coll. VAZ • 1 sh; Campomarino; coll. CRO • 1 sh; Marina

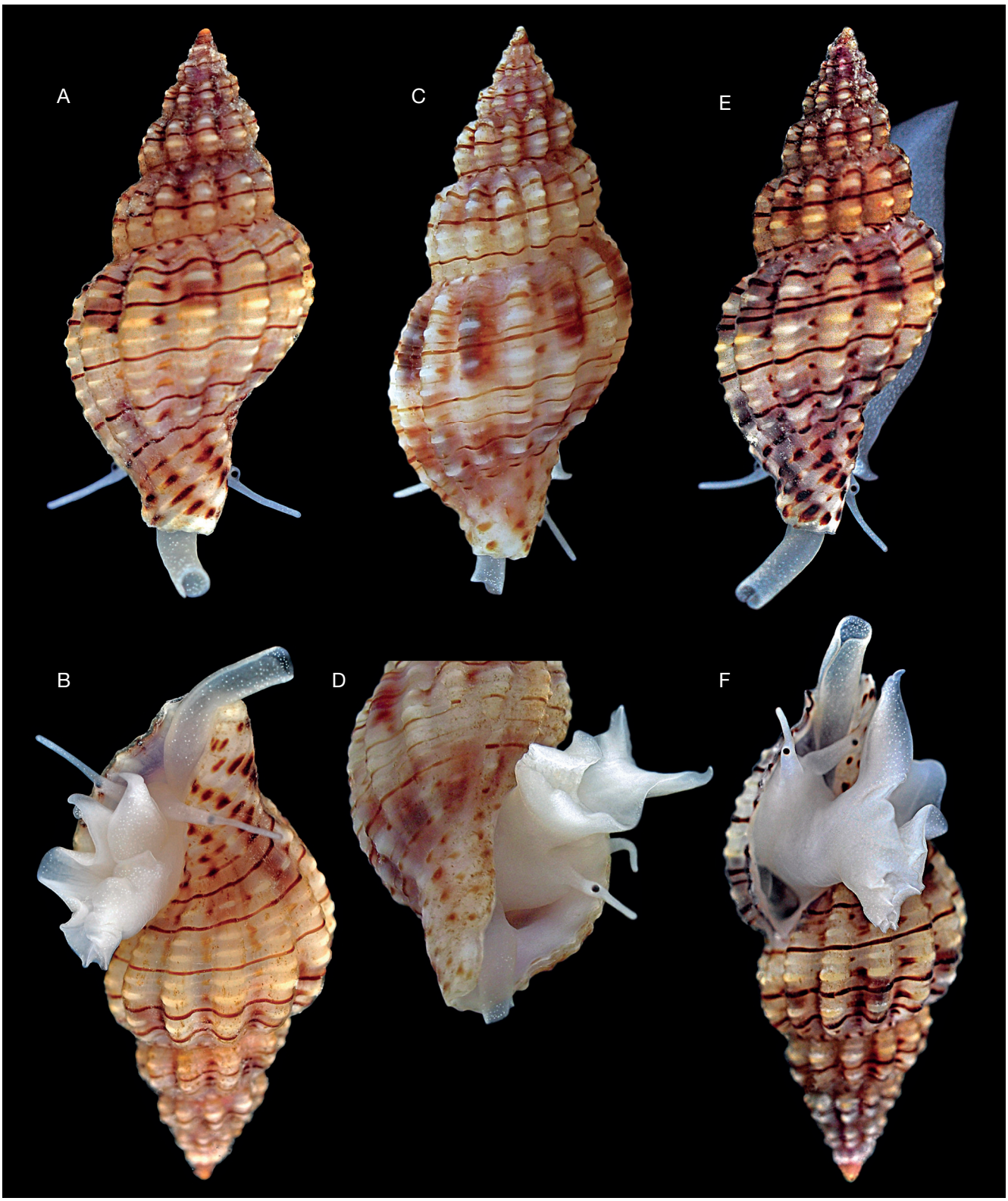

Fig. 12. — Photographs of three living animals of *Leufroyia concinna* (Scacchi, 1836): **A**-**B**, Čiovo Island (Croatia), 5 m, h. 9.5 mm; **C**-**D**, Pag Island (Croatia), 3 m; **E**-**F**, Čiovo Island (Croatia), 3 m, h. 11.5 mm. Photo courtesy: A-B, E-F, Pero Ugarković; C-D, Alen Petani.

di Ugento; coll. MAC • 2 sh; S. Isidoro; coll. TRO • 1 sh; Porto Badisco; coll. MAC • 2 sh; Otranto.

Croatia; coll. MAC • 1 sh; Dugi Otok I., Veli rat; as *concinna* var. *grata* ms; MCZR-M17342 • 5 sh; Pag I., Košljun bay; 2-5 m; coll. PRK • 1 sh; Molat I.; amidst red coral colonies; 35-50 m; coll. PRK • 3 sh; Rivanj I.; 18-30 m; coll. PRK • 1 sh; Ugljan I., Karantun; 1-3 m; coll. PRK • 8 sh; Sukošan; 2-7 m; coll. PRK • 3 sh; Dugi Otok I., Mežanj; 10 m; coll. UGA • 18 sh; Dugi Otok I., Veli Garmenjak;

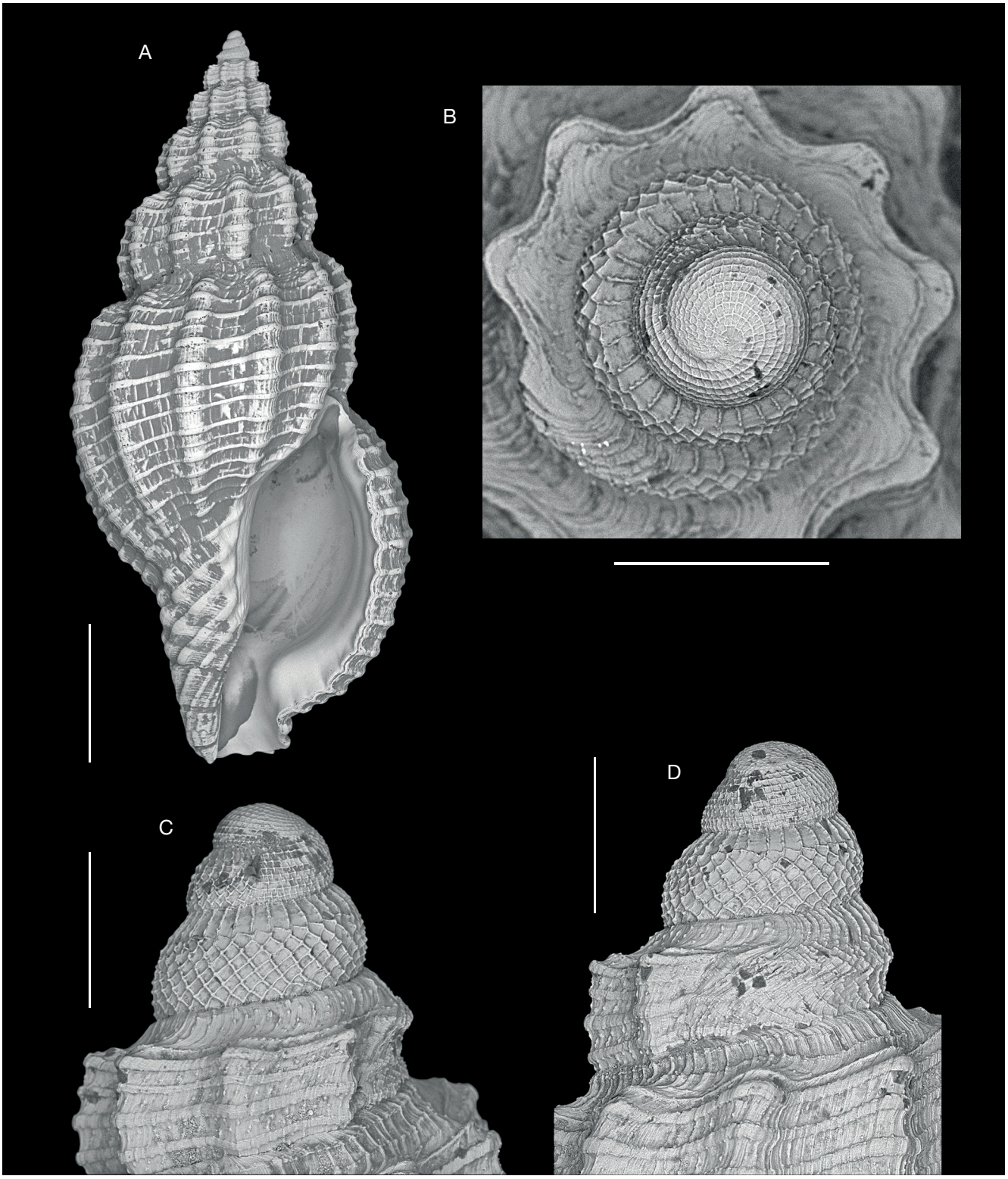

FIG. 13. — *Leufroyia concinna* (Scacchi, 1836). Dugi Otok Island (Croatia), 32-40 m, h. 10.53 mm. **A**, Frontal view of shell. **B-D**, apical (B), frontal (D) and dorsal (C) view of protoconch. Scale bars: 2 mm (A), 300 µm (B-D).

32-40 m; coll. PRK • 5 sh; Dugi Otok I., Nozdre bay; 1-10 m; coll. PRK • 29 sh; Murter I., Kosirina bay; 1-7 m; coll. PRK • 1 sh; Žirje I.; amidst red coral colonies; 70-100 m; coll. PRK • 6 sh; Primošten, Šparadići; 2-6 m; coll. PRK • 20 sh; Sevid; 2-6 m; coll. PRK • 2 sh; Voluja; 30-50 m; coll. PRK • 6 sh; Jabuka I.; 15-35 m; coll. STA • 13 sh; Jabuka I.; 15-35 m; coll. UGA • 4 sh; Čiovo I., Fumija; 10 m; coll. UGA • 7 sh; Šolta I.; 3-15 m; coll. STA • 2 sh; Šolta I.; 3-15 m; coll. UGA • 10 sh; Split; 1-6 m; coll. PRK • 1 sh; Split; 10 m; coll. UGA • 15 sh; Brač I., Milna; 7-10 m; coll. PRK • 19 sh; Brač I., Milna; 7-10 m; coll. STA • 1 sh; Brač I., Maslinova bay; 3-15 m;

coll. PRK • 74 sh; Brač I., Maslinova bay; 3-15 m; coll. STA • 14 sh; Omiš, Balića Rat; 4-8 m; coll. PRK • 1 sh; Brela; 5 m; coll. PRK • 18 sh; Lastovo I.; amidst red coral colonies, 70-100 m; coll. PRK • 6 sh; Lastovo I.; amidst red coral colonies, 70-100 m; coll. STA • 1 sh; Lastovo I.; 50 m; coll. BAR • 5 sh; Pelješac, Prapratno; 2-6 m; coll. PRK • 2 sh; Mljet I., Pod Škoji; 1-3 m; coll. PRK • 48 sh; Mljet I., amidst red coral colonies; 70-100 m; coll. PRK • 1 lv; Biograd; 43°55'51"N, 15°26'42"E; BAU-2254.1.
Greece • 3 sh; Kato Achaia; coll. CRO • 1 sh; Sane; coll. CRO • 1 sh; Crete Island, Elounda; coll. DSC • 2 sh; Korinthiakos Gulf; 60-120 m; coll. KON • 4 sh; Saronic Gulf; 30-70 m; coll. KON • 2 sh; Pylos; 6 m; coll. PAG.
Turkey • 1 sh; unprecised locality; coll. CGS • 1 sh; Göçek, Sarsala Bay; coll. CGS • 1 sh; Didim; 50-100 m; coll. CGS • 1 sh; Izmir Bay; 28 m; coll. OZT • 1 sh; Datça; coll. TRI • 1 sh; Mersin, Soguksu; coll. TRI.

DISTRIBUTION. — *Early-late Pliocene*: Northern Italy (Sacco 1904); Altavilla, Palermo, Italy (Cipolla 1914); Pliocene, Piedmont, Italy (Tropeano *et. al*. 1984); Rio Albonello, Emilia-Romagna (Tabanelli & Segurini 1994); Tuscany, Italy (Chirli 1997).
Recent: Northeastern Atlantic from Norway to Canary Islands. The entire Mediterranean. Common on rocky bottoms at 1-100 m depth. Collected alive under stones or amidst algae, and in sciaphilous habitats, including amidst red coral colonies where it is quite frequent. It often lives in sympatry/syntopy with other raphitomids, also with other *Leufroyia* spp.; in shallow water it is frequently found with *L. leufroyi* even under the same stone or amidst the same algae.

ORIGINAL DESCRIPTION. — "Pleurotoma concinna Nobis (18) Testa albo-sordida, lineis transversis rubro-fuscis inconcinne ornata; transversim striata; per longum costata; apertura dilute violacea. Alta lin. 7-8. P. C. similis at minor, gracilior, striis transversis rariobus et diversa colorum pictura. In sinu neapolitano et tarentino parum frequens. Consule" Fig. 18 (Scacchi 1836:13).

DESCRIPTION

Shell

Solid and fusiform, of medium size for the genus. Height: 9.0-15.17 mm (mean 11.8 mm, SD: 1.69); width: 3.3-7.91 mm (mean 5.32 mm, SD: 0.81); H/W: 1.84-2.77 (mean 2.24, SD: 0.18).

Protoconch

Multispiral with 2.4 to 2.9 (mean 2.66, SD: 0.14) convex whorls and small nucleus (d: 140 µm). Protoconch I of 1.0 whorl, diameter 265 µm, covered by dense cancellate sculpture; protoconch II with axial threads under the suture and less dense and diagonally cancellate sculpture on rest of whorl. A keel at the end of last whorl of varying length or absent. Protoconch-teleoconch boundary of flexuose, opisthocline growth lines. Colour usually brown with white nucleus, sometimes purplish-brown, rarely very light with pinkish hue, never dark brown or blackish. Transition from protoconch to teleoconch well visible by contrasting colours, brown *vs* pink or purple.

Teleoconch

Of 5.2-7.0 convex whorls (mean 6.16, SD: 0.48), with deep and distinct wavy sutures and prominent axial sculpture; suture area slightly thickened abapically and white coloured with brown dots or lines; whole external surface covered with relatively thick periostracum; dense and rough axial riblets (growth lines) present on ribs, interspaces, and on subsutural ramps; microgranules over the whole surface, scattered on 2-3 adapical whorls and dense on others.

Axial sculpture of 10-16 (mean 12.93, SD: 1.53)] strong, equidistant, orthocline or slightly opisthocline ribs slightly broader, equal or narrower than interspaces.

Spiral sculpture of 9-16 narrow and low cords (mean 11.53, SD: 1.74) above the aperture, of which 3-4 weak on subsutural ramp, remaining of almost equal strength and equally spaced, or with few additional thin cordlets between the strongest cords, occasionally one thin cordlet between all pairs of strong cords; interspaces 2-4 times broader than cords; on first adapical whorl 4 spiral cords almost equal in strength and one thin subsutural above them.

Siphonal fasciole with 6-9 (mean 7.86, SD: 0.75) strong and slightly nodulose cords, stronger than cords of body-whorl.

Cancellation rectangular to squared, with very elongate and slightly elevated tubercles at intersections.

Subsutural ramp narrow and inclined, covered with dense growth marks of the anal sinus, crossed by 3-4 weak spiral cordlets.

Columella simple, straight medially and arcuate or angled posteriorly. Siphonal canal wide and short, posterior canal deep and moderately wide.

Outer lip thickened and smooth internally, with edge crenated by spiral cords.

Height of aperture: 3.46-6.42 mm (mean 4.86 mm, SD: 0.74); A/H: 35.92-46.79% (mean 41.13%, SD: 2.50).

Coloration

Background colour light, from whitish to pale brownish, with pinkish, purple or purplish-brown areas present always on 1-3 adapical whorls, often inside aperture, on subsutural ramps and in interspaces between axial ribs, frequently darker above a median spiral brown cord. Some spiral cords completely or partially dark brown or reddish-brown, occasionally light brown, orange or yellowish, rarely only slightly darker than background; a broad light spiral band almost devoid of blotches at aproximately 1/3 to 1/2 of whorl height; a brown band often below periphery. Cords on siphonal fasciole light with some tubercles of intense brown or brownish-orange colour. Aperture white or pinkish.

Soft parts

Foot very long, broad and deeply bilobed anteriorly and with recurved anterolateral corners, narrowly tapering posteriorly. Siphon cylindrical with ventral slit, widely opening anteriorly, very extensile. Head small with a pair of long cylindrical tentacles, black eyes on bulges about halfway their length, distal part slightly longer and much narrower than basal. Operculum absent, toxoglossate radula present (G.O. Sars 1878: pl. VIII, fig. 2).

Colour translucent white with minute white speckles densely covering upper side of foot, scattered or absent on sole, head and along neck. Tentacles translucent white, with or without white speckles along entire lenght. Siphon translucent white or yellowish-white, with less dense white speckles.

REMARKS

L. concinna has been largely misidentified as *L. leufroyi* by many authors, old and modern.

The maximum height of examined shells is 16 mm, but shells larger than 14 mm are rare. The height and maximum diameter of the protoconch depend on the number of whorls; in the specimen of Fig. 13, with 2.75 protoconch whorls, the protoconch is 580 µm high and 504 µm wide. The diameter of nucleus and first whorl are small and similar to *L. leufroyi*, smaller than in *L. erronea* and *L. villaria*. The colour of protoconch varies geographically, mostly brown in some areas (e.g. Adriatic Sea), purple or purplish-brown in others (e.g. Tyrrhenian Sea). The sexes are separated (male and female reproductive systems are described by E.H. Smith (1967) under the name *Philbertia leufroyi boothi*), but we did not find any evidence of bimodality in morphometrics, thus guessing no size dimorphism is present.

Diagnostic features of *L. concinna* from all other *Leufroyia* spp. are the constant presence of pinkish or purple areas on parts of the shell, the numerous brown spiral cords on all whorls recalling the colour pattern of *Cyrillia linearis* (Montagu, 1803), and the more intense brown colour of tubercles on the siphonal fasciole (although shells tend to fade out after some years from collection). A few shells may look more homogeneously coloured with very light spiral cords, but also in such cases the pinkish colour of at least the first teleoconch whorl is always diagnostic. We have observed that specimens stored in 96-100% ethanol does not change significantly intensity of colours after some years, whilst those stored in 70% ethanol or formalin do fade out rapidly and significantly. There is some geographic variation in colour and sculpture: almost uniformly dark brown shells are not known from the Mediterranean; some Atlantic specimens have stronger and broader spiral cords than Mediterranean ones, also the axial ribs can be very weak or absent on the body whorl (Høisæter 2016). Some specimens from Canary Islands are smaller (max. 10 mm), more slender and with a colour pattern recalling *L. leufroyi* (Fig. 10I-K). The northermost record (Høisæter 2016) is from southern Lofoten Islands at 67°10.7'N, 14°20.3'E. The southernmost record is from Canary Islands. We have no confirmed records from the Açores and Madeira.

Leufroyia erronea Monterosato, 1884
(Figs 14-16)

Defrancia leufroyi var. *coralligena* Monterosato, 1872: 51 (*nomen nudum*).

? Defrancia convexa Jeffreys, 1882: 33.

Leufroyia erronea Monterosato, 1884: 134.

Clathurella erronea – Locard & Caziot 1899: 63 (? *L. villaria*).

Comarmondia inflata – sensu Chirli 1997: 91, pl. 26, figs 5, 6 non De Cristofori & Jan, 1832.

Leufroyia erronea – Carus 1893: 428 [in synonymy with *Clathurella inflata* (De Cristofori & Jan, 1832)] – Cipolla 1914: 72 (176) [in synonymy with *Peratotoma* (*Leufroyia*) *inflata* sensu Cipolla 1914 non De Cristofori & Jan, 1832] – Pallary 1900: 257 – Van Aartsen 1988: 142.

Pleurotoma (*Leufroyia*) *leufroyi erronea* – Kobelt 1905: 366, no. 22.

Pleurotomella demosia – sensu Bogi 1986: 27-28 non Dautzenberg & Fischer, 1896 – sensu Crocetta & Spanu 2008: 67, 72, fig 3A, B non Dautzenberg & Fischer, 1896 – sensu Giribet & Peñas 1997: 52, Figs 66-68 non Dautzenberg & Fischer, 1896 – sensu Negri & Corselli 2016: 69, fig. 15Q-T non Dautzenberg & Fischer, 1896 – sensu Scaperrotta *et al.* 2012: 99 non Dautzenberg & Fischer, 1896.

Raphitoma (*Leufroyia*) *erronea* – Piani 1980: 156 – Sabelli *et al.* 1990: 44, 216.

Raphitoma (*Leufroyia*) *leufroyi erronea* – Nordsieck 1968: 179.

Raphitoma (*Leufroyia*) sp. De Casa & Hallgass, 1979: 11 pl. 1 (3-4).

Raphitoma erronea – Poppe & Goto 1991: 44, 174 – Peñas & Giribet 2003: 181 – Repetto *et al.* 2005: 39, 218, fig. 895 (uncertain, very badly figured) – Pusateri & Giannuzzi-Savelli 2008: 124, fig. 15 – Cossignani & Ardovini 2011: 31, 325 (figured) – Appolloni *et al.* 2018: 60-61, 112, fig 22M, N – Ceulemans *et al.* 2018: 113 – Manousis *et al.* 2018: 21, fig.11A-E.

TYPE MATERIAL. — *Leufroyia erronea* Monterosato: **Syntypes. Sardinia** • 1 sh; Sardinia, unprecised locality; Tiberi's handwriting label, *"Defrancia volutella* Valenciennes Sardegna", H: 15.8 mm, W: 7.5 mm, H/D = 2.1; MCZR-M-16704-L. **Mediterranean** • 1 sh; unprecised locality; Monterosato handwritten label "*Leufroya erronea*, Monts. in Nom. gen. e sp. p. 126 Adr. (Stossich) Palermo (Monts)", H: 10.2 mm, W: 4.9 mm. *Defrancia convexa* Jeffreys: type material lost (Warén 1980: 33); MCZR-M-17340-L.

TYPE LOCALITY. — *Leufroyia erronea* Monterosato: Originally described from Corsica (France), Sardinia, Palermo to San Vito lo Capo (Sicily) and Dalmatia (Croatia). *Defrancia convexa* Jeffreys: West of Italy.

MATERIAL EXAMINED. — Atlantic. **Great Britain** • 7 sh; Shetland Islands; USNM Jeffreys coll. • 1 sh; Moray Firth; under *leufroyi;* NMW 01065.
Spain • 1 sh; Galicia; coll. HOU.
Açores • 1 sh; São Miguel I., Ponta Delgada; 18 m, Josephine exp. 1869 • 1 sh; SMNH 70501; São Miguel; SMNHN 70499.
Madeira • 2 sh; unprecised locality; sub nomine *Defrancia leufroyi* with handwritten label by Watson; MCZR-M 16704.
Mediterranean. **Spain** • 1 sh; unprecised locality; coll. GUB • 1 sh; Malaga; coll. PUS.
Corsica • 1 sh; Capo Corso; coll. BAR.
Sardinia • 5 sh; Alghero; coll. SPM.
Sicily • 1 sh; Isola delle Femmine; coll. PUS.
Italy • 1 sh; Gorgona I.; coll. PAG • 1 sh; Capraia I.; coll. CAM • 1 sh; Livorno, Bagni Fiume; coll. PAG • 1 sh; off Fiumicino; 300 m; coll. PAG • 2 sh; Napoli; Tiberi label; MCZR-M-1730.
Croatia • 4 sh; Molat I.; 35-50 m; coll. PRK • 3 sh; Žirje I.; 70-100 m; coll. PRK • 78 sh; Lastovo I.; 70-100 m; coll. PRK • 43 sh; Lastovo I.; 70-100 m; coll. STA • 110 sh; Mljet I.; 70-100 m; coll. PRK • 6 sh; Mljet I.; 70-100 m; coll. TIS • 3 sh; Dugi Otok I., Veli Garmenjak; 32-40 m, rocky bottom; coll. PRK • 1 sh; Voluja; 40-60 m, rocky bottom; coll. PRK • 3 sh; Jabuka I.; 30 m, rocky bottom; coll. STA • 14 sh; off Dubrovnik; 300-380 m, soft bottom; coll. LET.
Greece • 1 sh; Saronic Gulf; coll. KON.

DISTRIBUTION. — North East Atlantic from Great Britain to Portugal, and the whole Mediterranean Sea. More frequently collected on rocky bottoms, from a depth of *ca.* 30 m to more than 100 m, than dredged from deep soft bottoms (100-400 m). In Croatia, *L. erronea* is the commonest raphitomid amidst the red coral colonies. Often found in sympatry/syntopy with other raphitomids, also with other *Leufroyia* spp.

ORIGINAL DESCRIPTION. — "= *P. volutella,* (non Valenc.) auct. = ? *P. fortis,* Forbes — Rep. 1843, p. 196 — Reeve t. 19, f. 165 (Mar Egéo). Coralligena, rarissima in Corsica e Sardegna (Tiberi); Palermo a S. Vito (Monts.); Dalmazia (Brusina)" (Monterosato 1884: 134).

Fig. 14. — *Leufroyia erronea* Monterosato, 1884: **A**, Sardinia (Italy), h. 15.8 mm, with original labels by Tiberi and Monterosato; **B**, *sine loco,* h. 10.5 mm; **C**, Gorgona Island (Italy), h. 12.5 mm; **D**, Spain, h. 24 mm; **E**, Capraia Island (Italy) 120 m, h. 27 mm; **F**, Latium (Italy), h. 15.5 mm; **G**, Capo Corso (Italy), h. 8.5 mm; **H**, Mljet Island (Croatia) 70-100 m, h. 10.6 mm; **I** , Mljet Island (Croatia) 70-100 m, h. 15.7 mm. Photo courtesy: D, Peter Stahlschmidt, E, Enzo Campani, H, Morena Tisselli.

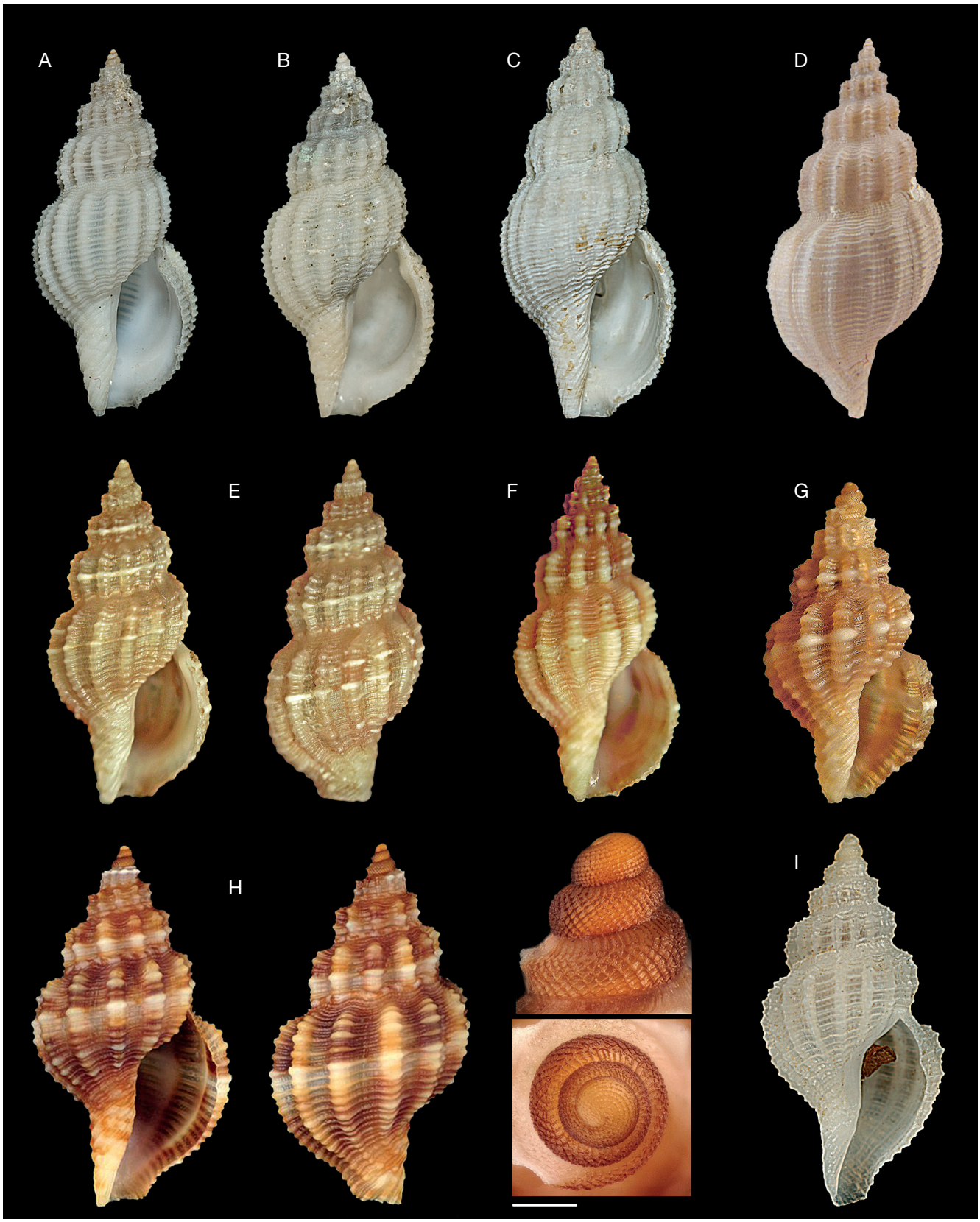

Fig. 15. — *Leufroyia erronea* Monterosato, 1884. **A**, Syntype, Shetland Islands (USNM 190581 ex Jeffreys coll.), h. 14.8 mm; **B**, Shetland Islands (USNM 190582 ex Jeffreys coll.), h. 14.5 mm; **C**, Shetland Islands (USNM 190578 ex Jeffreys coll.), h. 19.4 mm; **D**, Galicia (Spain), h. 16.2 mm; **E**, Mljet Island (Croatia), 70-100 m, amidst red coral colonies, h. 9.1 mm; **F**, Mljet Island (Croatia), 70-100 m, amidst red coral colonies, h. 8.3 mm; **G**, Mljet Island (Croatia), 70-100 m, amidst red coral colonies, h. 5.3 mm; **H**, Saronic Gulf (Greece), h. 6.15 mm - scale bar 200 µm. **I**, *Pleurotomella demosia* (Dautzenberg & Fischer, 1896), Açores (MNHN), 1300 m, 38°33'21"N, 30°28'54" W, h. 7.3 mm. Photo courtesy: A-C, Jolanda Villacampa (USNM); H, Costas Kontadakis.

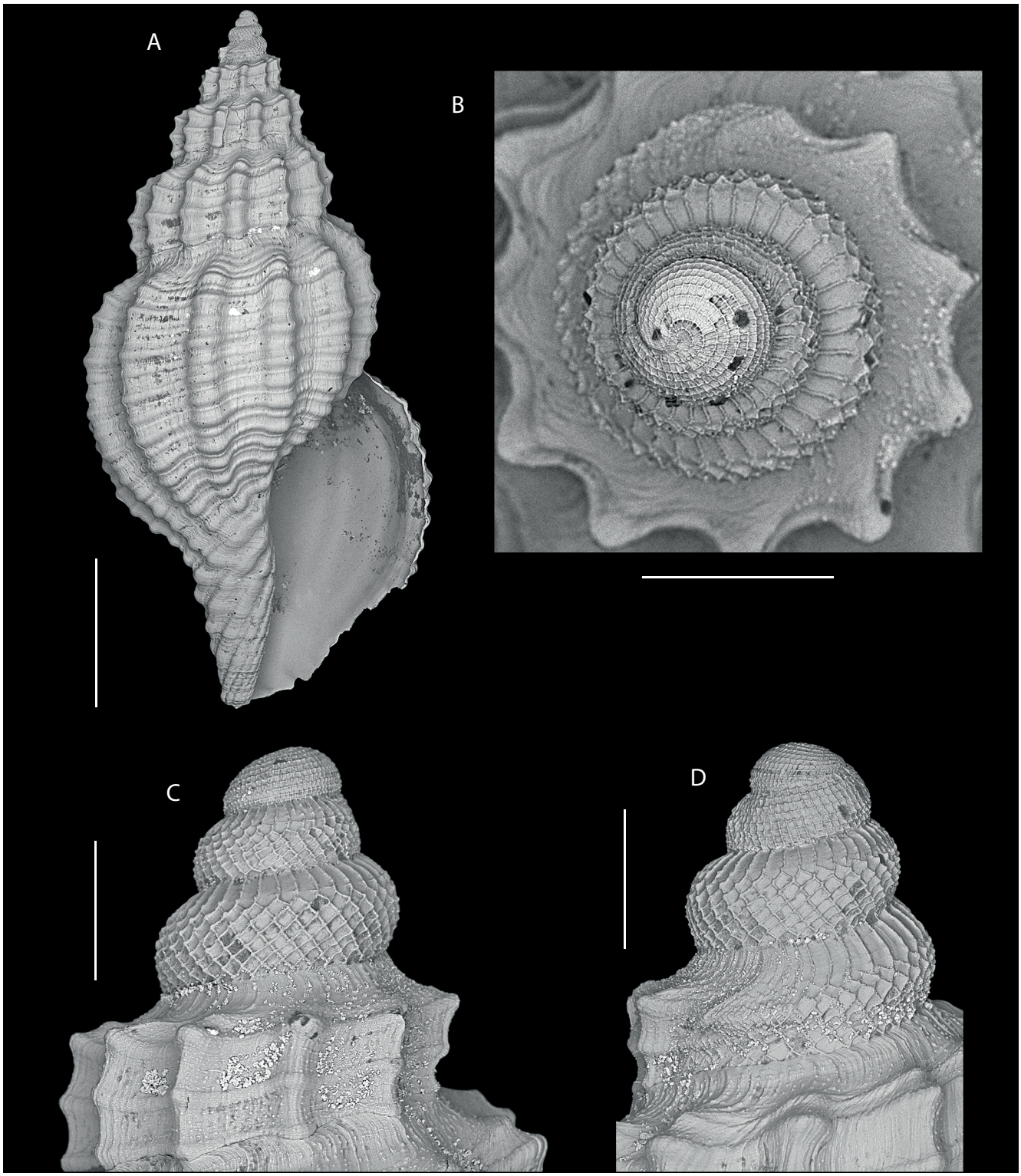

Fig. 16. — *Leufroyia erronea* Monterosato, 1884. Žirje Island (Croatia), 70-100 m, amidst red coral colonies, h. 9.32 mm. **A**, Frontal view of shell. **B**-**D**, apical (B), frontal (D) and dorsal (C) view of protoconch. Scale bars: 2 mm (A), 300 µm (B-D).

Description

Shell

Solid and suboval, of large size for the genus. Height: 9.04-20.8 mm (mean 13.52 mm, SD: 3.35); width: 4.4-8.8 mm (mean 6.28 mm, SD: 1.36); H/W: 1.95-2.36 (mean 2.15, SD: 0.11).

Protoconch

Multispiral with 2.55 to 3.1 (mean 2.82, SD: 0.15) convex whorls and large nucleus (d: 172 µm). Protoconch I of 1.15 whorls, diameter 315 µm, covered by dense cancellate sculpture; protoconch II with axial threads under the suture

and less dense and diagonally cancellate sculpture on rest of whorl. A keel at the end of last whorl of varying length or absent. Protoconch-teleoconch boundary of flexuose, opisthocline growth lines. Colour usually light, whitish to brown, occasionally darker brown, never very dark or blackish; with or without white nucleus.

Teleoconch
Of 4.7-7.15 convex whorls (mean 5.88, SD: 0.68), with deep and distinct wavy sutures and prominent axial sculpture; suture area often slightly thickened abapically; periostracum not observed; whole surface covered with fine and dense axial growth lines and extremely fine microgranules, less dense or scattered on 1-2 adapical whorls and very dense on others.

Axial sculpture of 11-22 (mean 14.89, SD: 2.41) strong, equidistant, orthocline or slightly opisthocline ribs, broader than spiral cords, narrower than interspaces; ribs occasionally very weak and low on body whorl, sometimes also on penultimate whorl, in largest shells.

Spiral sculpture of 12-26 narrow cords (mean 18.18, SD: 3.77) above the aperture, of which 3-4 weak on subsutural ramp, remaining never equally strong due to variable number of thinner cords (number of thinner cords lower than or equal to that of strong ones); interspaces narrower, equal or slightly broader than stronger cords; on first adapical whorl 3 spiral cords equal in strength and one thinner subsutural cordlet.

Siphonal fasciole with 8-16 (mean 11.15, SD: 1.87) strong and nodulose cords, stronger than cords on body-whorl, thinner cords often present between strong ones.

Cancellation rectangular, with elongate and slightly elevated tubercles at the intersections. When the ribs are weak and low, tubercles are also very weak; tubercles usually stronger on first 3-4 whorls.

Subsutural ramp narrow and inclined, covered with dense growth marks of the anal sinus, crossed by 3-4 weak spiral cordlets; ramp on first whorls less inclined; ramps less inclined in shells with strong ribs.

Columella simple, straight medially and angled posteriorly. Siphonal canal very short and wide, posterior canal deep and wide.

Outer lip thickened and smooth internally, with edge crenated by spiral cords.

Height of aperture: 3.8-8.4 mm (mean 5.65, SD: 1.35); A/H: 37.69-46.56% (mean 42.36%, SD: 2.02).

Coloration
Background colour variable but usually light, from whitish to light brown or reddish-brown, rarely dark brown, with areas or blotches of different colour, rarely uniformly coloured. One cord lighter than background, usually white-whitish, above suture, at approximately 1/3 to 1/2 of whorl height, the area above the cord often darker than the rest. Darker blotches and areas irregularly placed on axial ribs and interspaces on upper part of each whorl, sometimes below periphery. Cords on siphonal fasciole always same light colour as background, occasionally with some pale brownish lines in the interspaces. Aperture internally white or beige, often with some light brownish blotches visible by transparency.

Soft parts
Unknown.

Remarks
We suspect that *Defrancia convexa* Jeffreys, 1882 may be this species but the type material is lost (Warén 1980: 33). Description (based on a single specimen), size and colour fit relatively well a *L. erronea* with obsolete ribs. But it could be also a *L. villaria* for its "longer spire ... and the canal is not so short and abrupt" (Jeffreys 1882: 33). Therefore, we consider for the moment *Defrancia convexa* as *nomen dubium*.

Leufroyia erronea was proposed by Monterosato (1884: 134) to distinguish a specimen received around 1878 by Tiberi, as *Pleurotoma volutella* Kiener, 1839 ex Valenciennes ms. (Monterosato 1878: 106), considered to be a distinct species. Only in 1884, after the acquisition of Tiberi collection, Monterosato realized that misidentification and named *erronea* this species (see also Carus 1893: 428; Cipolla 1914: 72). The misidentification by Tiberi is quite strange as his specimen is very different from Kiener's *P. volutella* (see Fig. 21D).

The height and maximum diameter of the protoconch depend on the number of whorls; in the specimen of Fig. 16, with 3 protoconch whorls, the protoconch is 715 µm high and 596 µm wide. The diameter of nucleus and first whorl are quite large and similar to *L. villaria*, larger than in *L. leufroyi* and *L. concinna*.

The maximum height of examined shells is 27 mm, but shells larger than 18 mm are rare. The largest shell (27 mm) found so far was dredged from a depth of 120 m at Capraia Island, Italy (Fig. 14E).

Diagnostic features of *L. erronea* with all other *Leufroyia* spp. are the suboval profile, the wide aperture, the very short siphonal canal and the stronger and less spaced spiral cords. It differs from *L. concinna* also in the lack of brown coloured cords and pinkish/purple areas, and in its larger protoconch. From *L. leufroyi* it differs in the lack of dark brown or blackish blotches and in its larger protoconch, which is never very dark or blackish. *L. villaria* has a more slender shell, more stepped whorls and thinner spiral cords. After some years from collection the coloration tends to fade out, with shells becoming lighter and almost uniformly coloured.

The specimen MCZR-M-16704 from Sardinia, labeled by Tiberi as *Defrancia volutella*, has been figured by Pusateri & Giannuzzi-Savelli (2008: 123, fig. 15, as "holotype" and with wrong measures) and by Appolloni *et. al.* (2018: 112, fig. 22M, N, with wrong catalog number).

Specimens of *L. erronea* have been frequently identified erroneously as *Pleurotomella demosia* (Dautzenberg & Fischer, 1896) an Atlantic species, the actual presence of which in the Mediterranean is very doubtful (Fig. 15I). Small specimens of *L. erronea* have strong axial and spiral sculpture (Fig. 15G-H), making confusion easier with similarly sized specimens of *P. demosia*: the two species have protoconch with similar ranges of whorls number (2.5-3, see Bouchet & Warén 1980:

fig. 226) but *P. demosia* has a lower protoconch (H: 550 µm [Bouchet & Warén 1980] v. 650-720 µm in *L. erronea*). In fact, several Mediterranean records of *P. demosia* (e.g. Bogi 1986; Giribet & Peñas 1997; Crocetta & Spanu 2008; Scaperrotta *et al* 2012; Negri & Corselli 2016) are based on misidentification with *L. erronea*. Adriatic and Aegean specimens generally are smaller and more vividly colored than those in the central-western basin.

Leufroya villaria (Pusateri & Giannuzzi-Savelli, 2008) (Figs 17-20)

Raphitoma villaria Pusateri & Giannuzzi-Savelli, 2008: 119, figs 1-4, 6, 8, 10-12, 18.

Peratotoma (*Leufroyia*) *inflata* – sensu Cipolla 1914: 72 non De Cristofori & Jan, 1832.

Philbertia leufroyi – sensu Knudsen 1952: 173, pl. 2, fig. 11; 1956: 527, pl. 2, figs 16, 17 non Michaud, 1828.

Pleurotoma volutella – sensu Aradas & Benoit 1876: 251 non Kiener, 1839 – var. B sensu Brugnone 1862: 27 non Kiener, 1839.

Pleurotomella sp. – Peñas *et al*. 2006: 126, figs 274-276.

Raphitoma (*Leufroyia*) *erronea* – sensu Mifsud 2003: 44, fig. 15 non Monterosato, 1884.

Raphitoma cf. *erronea* – sensu Cachia *et al*. 2001: 66, pl. 10, fig. 3 non Monterosato, 1884.

Raphitoma leufroyi – sensu Ardovini & Cossignani 2004: 38, 225 [only the fourth of first row] non Michaud, 1832 – sensu Rolán *et al*. 1998: 108, figs 26-28 non Michaud, 1828.

Raphitoma villaria – Cossignani & Ardovini 2011: 328 (figured) – Manousis *et al*. 2018: 24, fig. 18A-E.

Type material. — **Holotype. Sicily** • 1 sh; Taormina; 15 m; H: 17.3 mm, W: 6.8 mm; MNHN-IM-2000-27244.
Paratypes. Malta • 1 sh; Ras il-Wahx; 80-100 m; paratype A, H: 11.5 mm, W: 4.6 mm; MNHN-IM-2000-23353 • 1 sh; Ras il-Wahx; 80-100 m; paratype B, H: 14.4 mm, W: 5.6 mm; coll. MIF.
Italy • 1 sh; Capraia I.; 150 m; paratype C, H: 16.9 mm, W: 6.5 mm; coll. GOR.
Sicily • 1 sh; Carini Bay; paratype D, H: 12 mm, W: 4.8 mm; coll. PUS.
Sardinia • 1 sh; unprecised locality; paratype F, H: 9.3 mm, W: 4.7 mm; sub nomine *Pleurotoma* (*Defrancia*) *volutella* with Tiberi's handwritten label); SMNH 70490.
Greece • 1 sh; Antiparos I.; paratype E, H: 8.6 mm, W: 3.9 mm; coll. BIN.

Type locality. — Taormina (Messina), bioclastic sediments.

Material examined. — Atlantic. **Angola** • 1 sh; Ilha de Luanda; 40-60 m; leg. S. Gofas, as *R. leufroyi;* MNHN-IM-2010-11650.
São Tomé & Príncipe • 1 sh; Príncipe I., S. Antonio beach; coll. Marche Marchad, as *R. leufroyi;* MNHN-IM-2010-11655.
Ivory Coast • 11 sh; Region d'Abidjan; as *R. leufroyi*.; MNHN Paris IM-2010-11653, MNHN-IM-2010-11651.
Gambia • 1 sh; SW Cap de Bald; 18 m, as *R. leufroyi;* MNHN-IM-2010-11656.
Senegal • 1 sh; Gorée Bay; coll. Knudsen, as *Philbertia leufroyi;* MNHN • 1 sh; Region de Dakar; 95 m, coll. Marche Marchad as *R. leufroyi;* MNHN-IM-2010-11654 • 1 sh; Sud Ile Madeleine; 48 m, as *R. leufroyi;* MNHN-IM-2010-11653.
Mediterranean. **Spain** • 1 sh; unprecised locality; coll. STH • 1 sh; Malaga; 80-150 m; coll. PUS.
Sicily • 1 sh; Marzamemi; coll. MAC • 1 sh; Cannizzaro; coll. BOG • 1 sh; Taormina; coll. PUS.
Italy • 2 sh; Capo Rizzuto; coll. ARD • 1 sh; Porto Cesareo; 70 m; coll. FIO.
Malta • 18 sh; Gnejna Bay; 80-100 m; coll. MIF • 5 sh; Qammich; 80 m; coll. MIF • 1 sh; Fomm ir-Riħ; 140 m; coll. PRK • 1 lv; Ras il-Wahx; 80-100 m; BAU 3590.1.
Lybia • 1 sh; Misurata; 60-80 m; coll. MIF.
Turkey • 1 sh; Bozcaada I.; coll. BAR.
Greece • 1 sh; unprecised locality; coll. PUS • 6 sh; Saronic Gulf; coll. KON.
Croatia • 2 sh; Kvarnerić; 60-90 m; coll. UGA • 2 sh; Dugi Otok Island, Veli Garmenjak; 35-57 m; coll. PRK • 2 sh; Voluja; 40-60 m; coll. PRK • 1 sh; Jabuka I.; 30 m; coll. STA • 1 sh; Hvar Channel; 80 m; coll. STA • 1 sh; Lastovo I.; 200 m; coll. UGA • 1 sh; Lastovo I.; coll. BAR • 2 sh; Lastovo I.; amidst red coral colonies, 70-100 m; coll. STA • 27 sh; Mljet I.; red coral colonies; 70-100 m; coll. PRK • 12 sh; Mljet I.; red coral colonies; 70-100 m; coll. LET • 2 sh; Mljet I.; red coral colonies; 70-100 m; coll. TIS • 2 sh; off Dubrovnik; 350-380 m; coll. LET.

Distribution. — East Atlantic (Senegal to Angola) and the Mediterranean Sea, from Spain to the Aegean Sea. More frequently collected by dredging on soft or mixed bottoms than on rocky bottoms, live specimens from *ca*. 20-30 m to 400 m. Most Croatian specimens were found amidst red coral colonies (70-100 m depth). It is frequently found in sympatry/syntopy with other raphitomids, also with other *Leufroyia* spp.

Original description. — "Protoconch multispiral, of 3.25 whorls [sic]. Protoconch I of 1.2, dome shaped whorls, with a sculpture of 8-9 spiral threads, covered by minute tubercles; tubercles tending to become oblong and anastomosing, giving rise to a somewhat clathrate pattern. Protoconch II of slightly more than 2 convex whorls, with a sculpture of only subsutural axial threads on the adapical third, tending to curve adaperturally. On the lower two thirds sculpture of diagonally crossing threads. Sinusigera outer lip at the protoconch-teleoconch boundary. Teleoconch of 6-7 whorls, with stepped spire. Subsutural ramp narrow, suborizontal, tending to obliterate after the sixth whorl. Adsutural marks of the anal sinus visible on the ramp. Axial sculpture of 15-18 ribs, narrower than the interspaces, reaching the base. Spiral sculpture of numerous continuous cordlets, 13-16 above the aperture, regularly spaced, on the body whor; 10-12 strong cords on the siphonal canal. Aperture suboval, tapering anteriorly. Outer lip, internally smooth. Anal sinus as deep as the interspace between two axial ribs. Inner lip smooth, arcuate posteriorly, straigth medially. Siphonal canal short, open. Background colour yellowish with a ligther narrow band on the lower third of the spire. The spiral cordlets within this band may be slightly stronger that the others. Animal with a short head and two short tentacles. Eyes placed on the external, thickened basal part of the tentacles, at about one third of their total height. Foot narrow and long with two anterior lateral triangular lobes and a pointed posterior end. Colour light yellow with a lighter coloured foot, darker tentacles and black eyes. Siphon much darker (nearly orange) in colour. Operculum absent." (Pusateri & Giannuzzi-Savelli 2008: 120).

Description

Shell

Moderately solid, slender, fusiform, of large size for the genus. Height: 10.62-19 mm (mean 14.56 mm, SD: 2.86); width: 4.33-7.94 mm (mean 5.77 mm, SD: 1.02); H/W: 2.29-2.89 (mean 2.51, SD: 0.14).

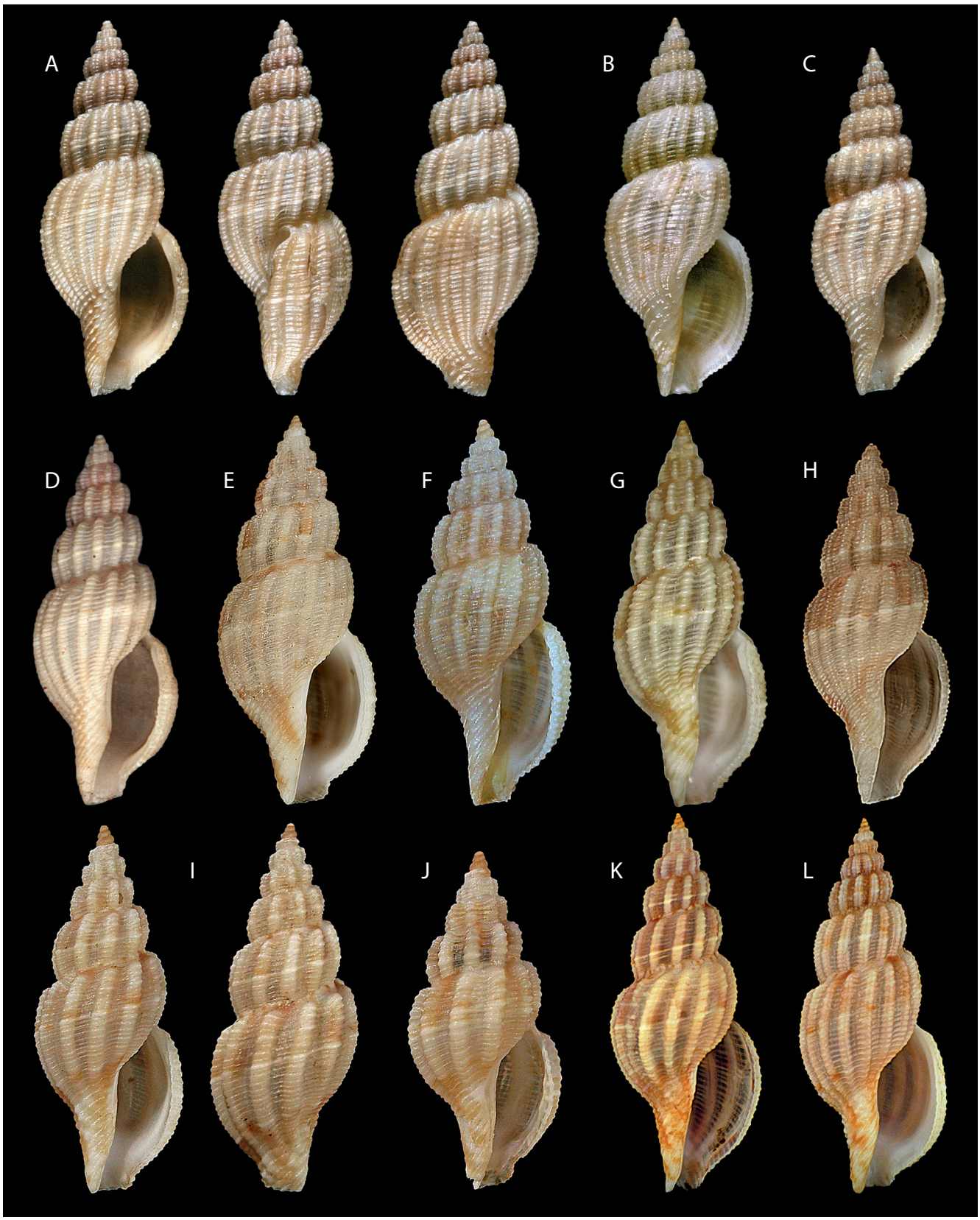

Fig. 17. — *Leufroyia villaria* (Pusateri & Giannuzzi-Savelli, 2008): **A**, holotype (MNHN-IM-2000-27244), Taormina (Italy) -15 m, h. 17.3 mm; **B**, paratype C (GOR), Capraia Island (Italy) 150 m, h. 16.9 mm; **C**, paratype A (MNHN-IM-2000-23353), Ras il-Wahx (Malta), 80-100 m, h. 11.5 mm; **D**, East Sicily (Italy), h. 12.4 mm; **E**, Porto Cesareo (Taranto - Italy), h. 14.2 mm; **F**, Fomm Ir-Riħ (Malta) 140 m, h. 10.76 mm; **G**, Ionian coasts of Calabria (Italy), h. 13.7 mm; **H**, Gorée (Senegal) (MNHN, Knudsen coll.), h. 11.4 mm; **I**, Mljet Island (Croatia), 70-100 m, amidst red coral colonies, h. 10.62 mm; **J**, Mljet Island (Croatia), 70-100 m, amidst red coral colonies, h. 8.58 mm; **K**, Saronikos Gulf (Greece), h. 17.1 mm; **L**, Saronikos Gulf (Greece), h. 16.6 mm. Photo courtesy: D, G, Roberto Ardovini; K, L, Costas Kontadakis.

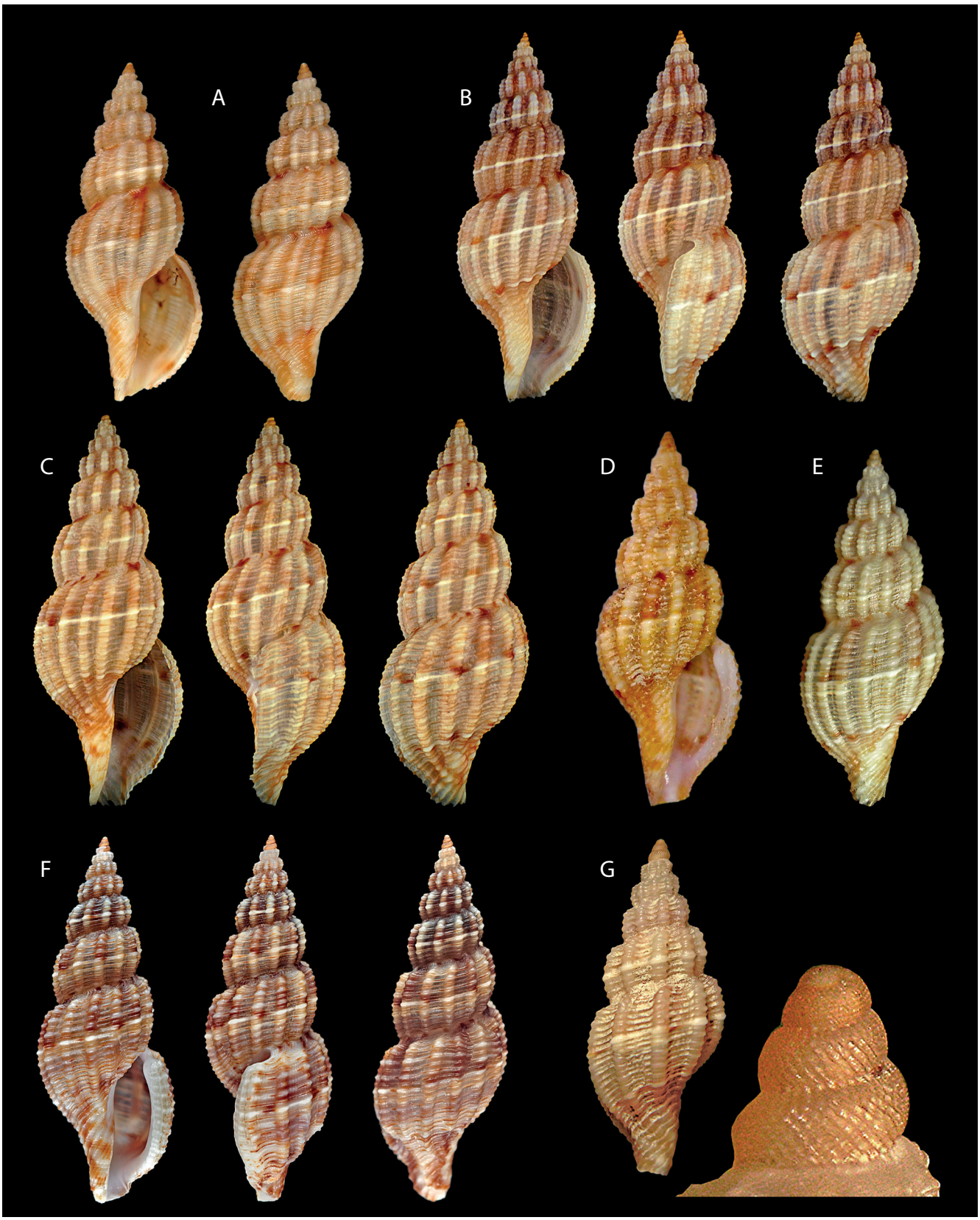

FIG. 18. — *Leufroyia villaria* (Pusateri & Giannuzzi-Savelli, 2008): **A**, Mljet Island (Croatia) -70-100 m, amidst red coral colonies, h. 12.22 mm; **B**, Saronic Gulf (Greece), h. 16.1 mm; **C**, Saronic Gulf (Greece), h. 18.3 mm; **D**, South Eastern Sicily (Italy), h. 13.1 mm; **E**, Mljet Island (Croatia) 70-100 m, amidst red coral colonies, h. 11.5 mm; **F**, Lastovo Island (Croatia) 200 m, h. 16.7 mm; **G**, Mljet Island (Croatia) 70-100 m, amidst red coral colonies, h. 8.1 mm. Photo courtesy: B, C, Costas Kontadakis; D, Roberto Ardovini; F, Pero Ugarković.

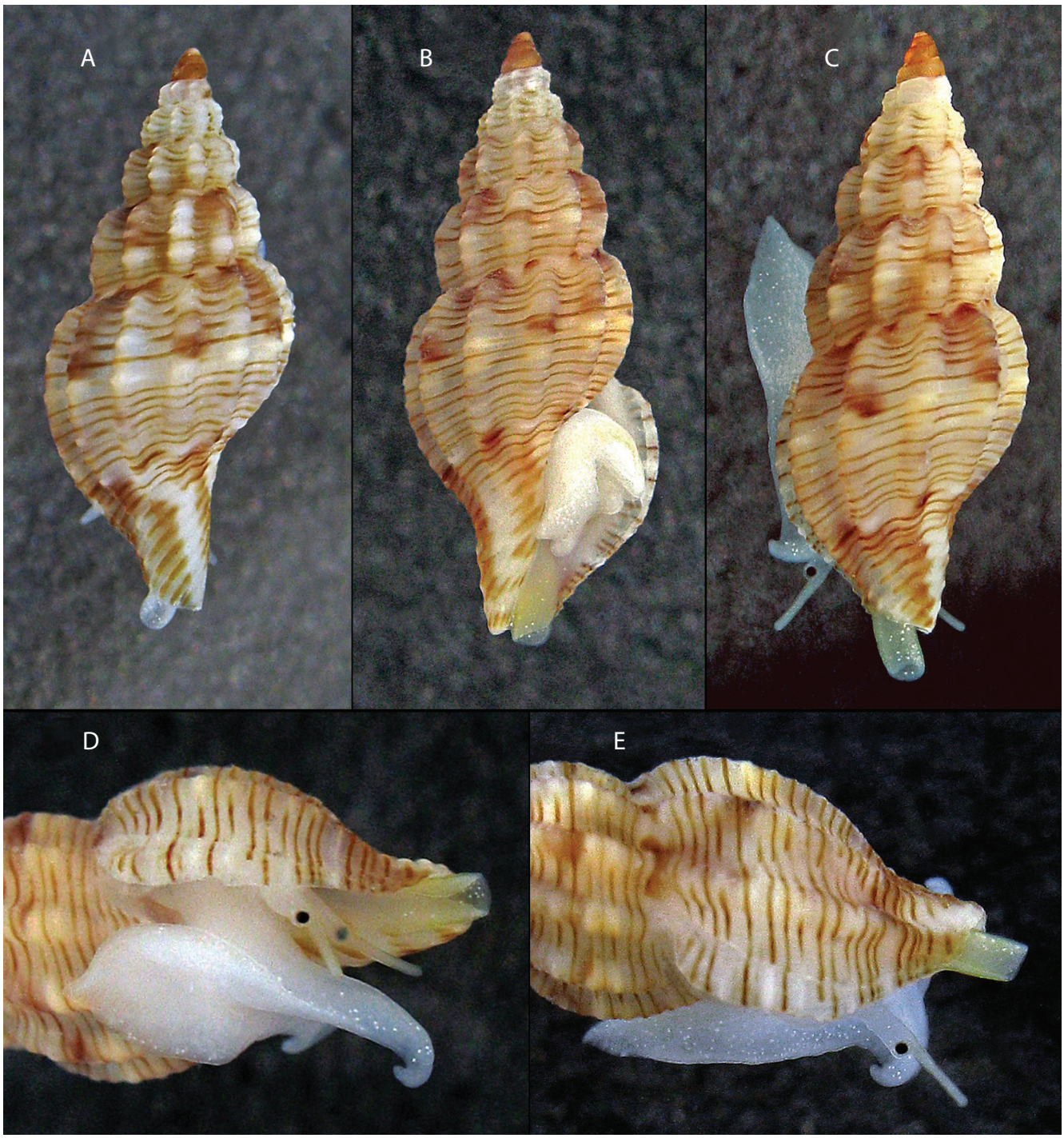

Fig. 19. — Photographs of two living animals of *Leufroyia villaria* (Pusateri & Giannuzzi-Savelli, 2008). Dugi Otok Island (Croatia), 35-57 m, h. 7 mm (**A**), h. 7.5 mm (**B**-**E**). Photo courtesy: Alen Petani.

Protoconch

Multispiral with 3 to 3.25 (mean 3.1, SD: 0.03) convex whorls and large nucleus (d: 170 µm). Protoconch I of 1.1 whorls, diameter 302 µm, covered by dense cancellate sculpture; protoconch II with axial threads under suture and less dense and diagonally cancellate sculpture on rest of whorl. A keel at the end of last whorl of varying length or absent. Protoconch-teleoconch boundary of flexuose, opisthocline growth lines. Colour always light, from whitish to light brown, never dark brown or blackish; with or without white nucleus.

Teleoconch

Of 5.5-7.5 (mean 6.57, SD: 0.59) convex and more or less stepped whorls, with deep and distinct sutures and prominent

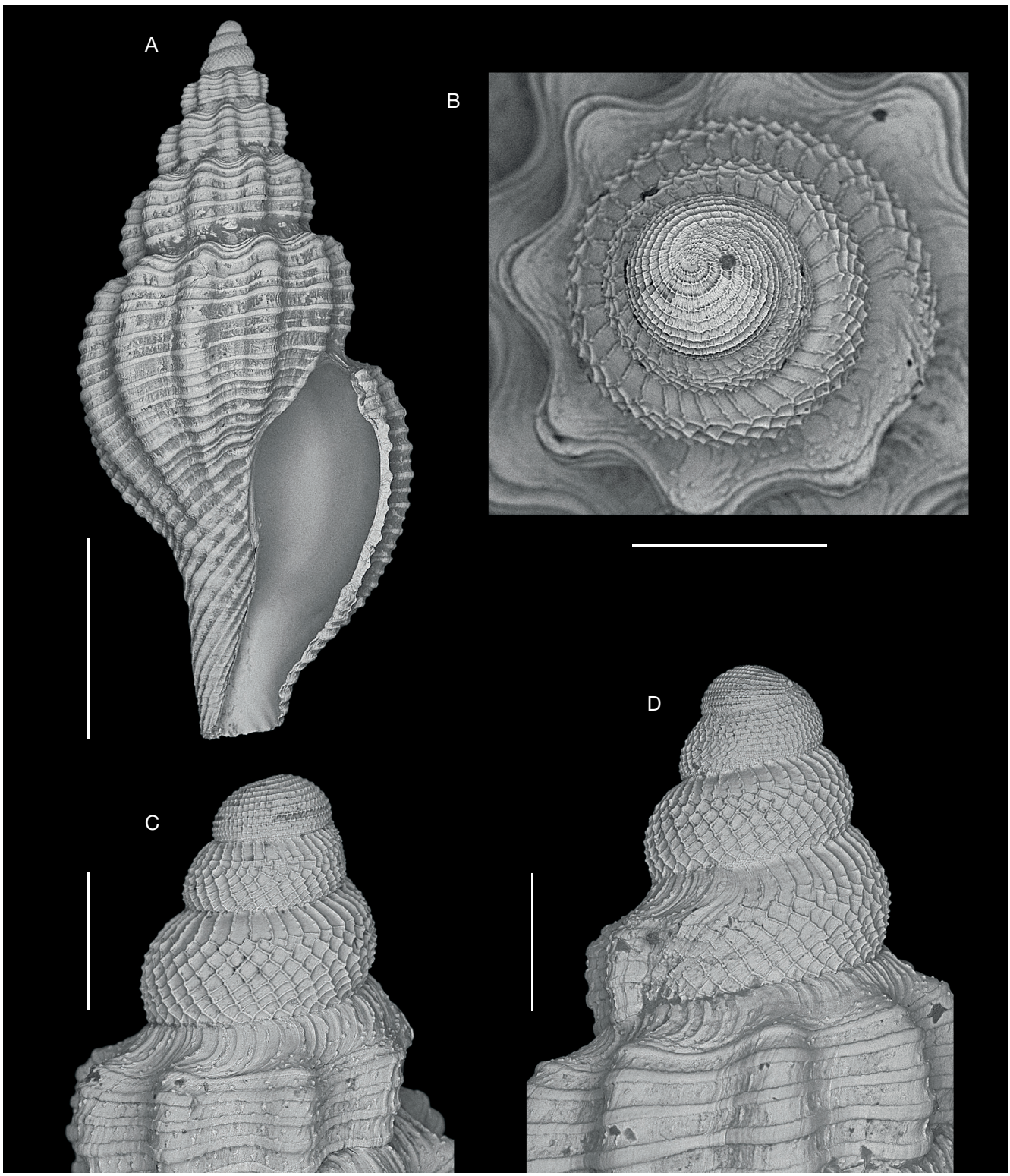

Fig. 20. — *Leufroyia villaria* (Pusateri & Giannuzzi-Savelli, 2008). Dugi Otok Island (Croatia), 35-57 m, h. 7.18 mm. **A**, Frontal view of shell; **B**-**D**, apical (B), frontal (D) and dorsal (C) view of protoconch. Scale bars: 2 mm (A), 300 µm (B-D).

axial sculpture; periostracum very thin, hardly visible and not persistent; whole surface covered with fine and dense axial growth lines and extremely fine microgranules, scattered on 1-2 adapical whorls and very dense on others.

Axial sculpture of 12-17 (mean 14.5, SD: 1.54) strong, equidistant, orthocline or opisthocline ribs (often on the same shell), broader than spiral cords and usually narrower than interspaces.

FIG. 21. — **A**, *Pleurotoma inflata* De Cristofori & Jan, 1832, Lectotype, (MCSNM i4296) Tabiano (Parma) Piacentian (Pliocene), h. 15.3 mm (after Pinna & Spezia, 1978, pl. 40); **B**, *P. inflata*, Ficarazzi (Palermo) (Lower Pleistocene), h. 18.9 mm (NMW, 12930), erroneously identified by Monterosato as *Leufroyia volutella*; **C**, *P. inflata,* Monte Pellegrino (Palermo) (Plio-Pleistocene) (MCZR-M-16706), h. 23.9 mm; **D**, *Pleurotoma volutella* Kiener, 1839, original drawings by Kiener, h. 25.4 mm; **E**, *P. volutella*, Ficarazzi (Palermo) (Lower Pleistocene), h. 21.5 mm; **F**, *Pleurotoma* cf. *volutella* Monte Pellegrino (Palermo) (Pliocene), h. 25.8 mm.

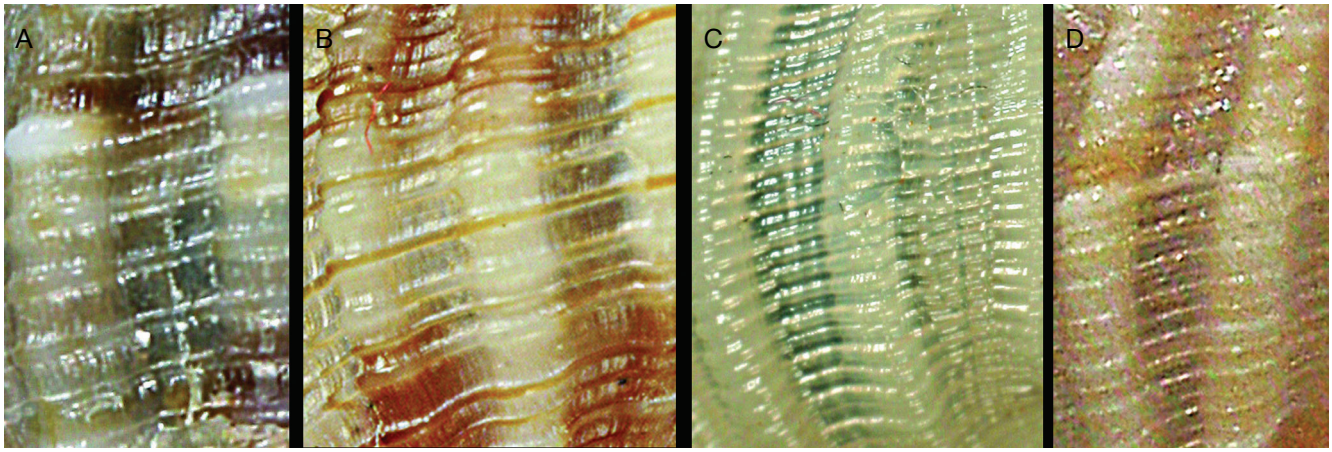

Fig. 22. — Details of spiral cordlets. **A**, *L. leufroyi* (Michaud, 1828), Ile Rousse (Corse), h. 9.8 mm (coll. BAR); **B**, *L. concinna* (Scacchi, 1836), Elba Island, 40 m, h. 14 mm (coll. BAR); **C**, *L. erronea* Monterosato, 1884, Bagni Fiume (Livorno), h. 16 mm (coll. PAG); **D**, *L. villaria* (Pusateri & Giannuzzi-Savelli, 2008), Porto Cesareo (Taranto), 70 m, h. 14.2 mm (coll. PAG).

Spiral sculpture of 13-24 (mean 16.55, SD: 2.33) very narrow and low cords above the aperture, of which 3-4 very weak on narrow subsutural ramp, the most adapical cordlet well spaced from suture and often slightly stronger than other cordlets. Remaining cords equally strong and regularly spaced, often with a variable number of thinner cordlets between pairs of stronger ones; interspaces 3-5 times broader than cords; on first adapical whorl 5 thin spiral cords, the most adapical thinner than others.

Siphonal fasciole with 9-12 (mean 10.35, SD: 1.0) moderately strong, well spaced and slightly nodulose cords.

Cancellation rectangular, with elongate and only slightly elevated tubercles at the intersections.

Subsutural ramp narrow, subhorizontal on first whorls, concave and slightly inclined on lower ones, covered with dense growth marks of the anal sinus, crossed by 3-4 thin spiral cordlets.

Columella simple, straight medially and arcuate or angled posteriorly. Siphonal canal moderately long and wide, posterior canal deep and wide.

Outer lip thickened and smooth internally, with edge crenated by spiral cords.

Height of aperture: 4.3-7.03 mm (mean 5.92 mm, SD: 0.96); A/H: 35.93-43.46% (mean 39.61%, SD: 2.21).

Coloration

Background colour variable but always light, from whitish to light brown, with areas, blotches and lines of different colour, occasionally uniformly coloured; first two teleoconch whorls often whitish. One cord (occasionally two) lighter than background, usually white-whitish, above suture, at approximately 1/3 to 1/2 of whorl height, the area above the cord usually slightly darker than the rest. Darker blotches and areas irregularly placed on axial ribs and interspaces on upper part of each whorl, often also below periphery and on siphonal fasciole and on subsutural ramps. Spiral cords occasionally of same colour as background, more often entirely or dashed brown or reddish-brown. Aperture internally white or beige, sometimes with light brownish blotches and lines visible by transparency.

Soft parts

Foot very long, broad and deeply bilobed anteriorly and with recurved anterolateral corners, narrowly tapering posteriorly. Siphon cylindrical with ventral slit, widely opening anteriorly, very extensile. Head small with a pair of long cylindrical tentacles, black eyes on bulges about halfway their length, distal part slightly longer and narrower than basal. Operculum absent.

Body translucent white with some parts yellowish or orange. Scattered white speckles on siphon, tentacles and upper side of foot. Posterior part of foot yellowish; tentacles translucent yellowish or pale orange; siphon pale yellowish in small specimens, orange in large ones (Fig. 19).

Remarks

The foregut anatomy of a specimen from Malta, Qummick, 80 m depth (vi.1988, C. Mifsud leg; 15.5 x 6.1 mm, protoconch tip missing, 1.5 protoconch whorls remaining, diagonally cancellate) was examined and described by Don Tippett (in litt., 2001). The specimen lacked a proboscis, poison apparatus, radula and salivary glands. The rhynchodaeum was very retracted and folded, with the posterior end bearing a tiny circular opening into the oesophagus.

This species is everywhere less common than the other 3 species of the genus. The first specimen of this species was submitted to our attention by Alberto Villari who identified it as *Raphitoma volutella* Kiener, 1839. With the same name, additional specimens were present in some other private collections. Kiener (1839: 67) described *P. volutella* as recent from Sicily, yet it is known that sometimes he reported the fossil species as living (Palazzi, unpublished ms.). In fact, *Pleurotoma volutella* is relatively well known from the Plio-Pleistocene (Seguenza 1880; Cerulli-Irelli 1910; Harmer 1915). Aradas & Benoit (1876: 251) reported the finding of a fresh specimen of *Pleurotoma volutella* from Acitrezza. Unfortunately, a search in the Aradas collection at the Museo di Storia Naturale di Milano (merged into that of Priolo), was unsuccessful. This specimen must be considered lost as subsequently confirmed by Leonardi (MSNM,

pers. com.). The type material of *P. volutella* has also not been found, despite a meticulous search in the Delessert collection studied by Kiener himself (Y. Finet, MHNG, pers. com.). The comparison with fossil specimens from Monte Pellegrino (Plio-Pleistocene) and Ficarazzi (Low Pliestocene) from the Monterosato collection and that of Melvill-Tomlin (NMW, 12930, given by Monterosato) showed that *L. villaria* and *P. volutella* are different species. This last specimen (Fig. 21B) is labelled by Monterosato "*Leufroyia volutella* Kiener, fossile di Ficarazzi, non vivente". The second handwritten label reads: "Kiener a cru vivant un specimen ramassé par la mer". However, the specimens identified by Monterosato as *"volutella"* are quite different from each other and do not seem to be conspecific. The specimen (Fig. 21E) from Ficarazzi is the most similar to Kiener's drawings of *P. volutella*. According to Cipolla (1914: 73), *Pleurotoma volutella* falls within the chronological variation of *Pleurotoma inflata* De Cristofori & Jan, 1832 whereas for Cerulli-Irelli (1910: 63 (255)) the two entities are separated. We are inclined to share the opinion of Cerulli-Irelli and believe that *P. inflata* and *P. volutella* are two different species (both known only as Plio-Pleistocene fossils, Fig. 21), and that both of them are different from *L. villaria*.
L. villaria is distinguished from *L. inflata* by having:

1 – different outline (with less arched spire);
2 – axial ribs weaker (less high and wide), opistocline vs orthocline or slightly prosocline;
3 – much thinner and less dense spiral cords, and alternating cords and cordlets;
4 – interspaces between cords quite large vs very narrow;
5 – different opening shape (more oval vs more oblong);
6 – very short siphonal canal vs long one;

L. villaria is distinguished from *L. volutella* by having:

1 – more rounded outline;
2 – greater number of axial ribs which are flatter;
3 – more prominent, more numerous and less spaced spiral cords;
4 – different opening shape (more oval vs piriformis elongated);
5 – less wide and shorter siphonal canal.

The height and maximum diameter of protoconch depend on the number of whorls, in the photographed specimen (Fig. 20) with PW = 3.04 these two features are: H = 735 µm and max. D = 593 µm. Diameter of nucleus and first whorl are quite large and similar to *L. erronea*, while in *L. concinna* and *L. leufroyi* these features are significantly smaller.

Maximum height of examined shells is 19 mm, those larger than 20 mm are very rare. Mifsud (2003, as *Raphitoma erronea*) reported the maximum size of 25 mm.

The original description was based on light and uniformly coloured specimens, but at least in the Adriatic and Aegean Sea they are usually brightly coloured, with brown or reddish-brown spiral cords and brown areas and blotches. Peñas *et al.* (2006: 126, figs 274-276 as *Pleurotomella* sp.) mentioned the presence of some brown cords also on the shells examined by them from Alboran Sea.

After a few years from collection the shells always look significantly different from the fresh ones, since the darker colours fade out and the shells become much lighter in colour, so even the shells with brown spiral cords often look almost uniformly coloured.

Diagnostic features of *L. villaria* from all other living *Leufroyia* spp. are: somewhat thinner and generally more slender shell, very thin spiral cords and narrow axial ribs, narrower subsutural ramps and more stepped whorls, medially the largest protoconch, differently coloured tentacles and foot of the animal.

Its identification is usually relatively easy, especially of large specimens, due to their slender shell and very thin spiral cords. Smaller specimens have less slender shell and can be confused with some untypical small shells of other species.

It differs from *L. concinna*, which also have brown spiral cords, by absence of pinkish/purple areas on the teleoconch, by thinner spiral cords and much larger protoconch, also by much bigger maximum size of shell.

L. leufroyi sometimes has similar colour pattern of shell (Fig. 5H) to some colour forms of *L. villaria*, but even in such cases they can easily be differentiated by several features: small and dark *vs* large and light protoconch, wide and less spaced *vs* very thin and well spaced spiral cords; none or only one brown cord on each whorl *vs* often almost all.

L. erronea has much lower H/W ratio; wider aperture; shorter siphonal canal; much stronger thickening of outher lip; stronger, denser and never brown coloured spiral cords.

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