The Naturalis collections of pelagic Gastropoda (Mollusca)

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'Van onschatbare waarde …'
200 years of natural history collections in Naturalis

We present a history of the various collections of pelagic, or holoplanktic Mollusca, available in the Naturalis Biodiversity Center, Leiden The Netherlands. Both for the fossil and present-day collections numbers of available lots, stratigraphic and geographic origin and availability of type specimens are documented. We discuss four issues related to these collections: 1) preservation of pyritised fossils, 2) the backgrounds of the Maltese fossil collection material, 3) a list of all 505 taxa considered valid, 216 of which are currently living species (many of which also have a fossil record) and 4) diagnosis of Vaginellinae subfamily nov.

Key words: Gastropoda, pelagic, holoplanktic, Pteropoda, Heteropoda, Vaginellinae, Naturalis, collection, Recent, fossil, pyritised, preservation, Malta, checklist

INTRODUCTION

Pelagic (or holoplanktic, see Emiliani, 1991) Gastropoda form a heterogeneous group of marine molluscs belonging to several remote systematic units that strongly differ in anatomical structure, but have an entirely oceanic pelagic life cycle in common. After dying, the shells sink to the seafloor where they are incidentally preserved. The best known group among them are the pteropods (Order Pteropoda), belonging to the subclass Heterobranchia. The second important group is commonly referred to as heteropods, but these are officially classified as Pterotracheoidea, a superfamily of the Order Littorinimorpha, in the subclass Caenogastropoda (Bouchet et al., 2017). The Pterotracheoidea and Pteropoda both include shelled, partially shelled and unshelled species. A few species in the Order Nudibranchia also live a holoplanktic life but a shell is absent, apart from little known larval shells that are shed during metamorphosis. Epitoniidae belonging to subclass Caenogastropoda are also included herein, although they are not really holoplanktic but, living in the air-water interface as adults, they are considered neuston.

Shells of pelagic gastropods consist of aragonite, a metastable morph of calcium carbonate. The calcareous shells can be found as fossils, but because of the instability of aragonite and very thin nature of the shells they are frequently poorly preserved or completely dissolved. Internal moulds remain recognisable and identifiable in most cases though. Pterotracheoidea, and particularly the Bellerophinidae records extend as far back as the Triassic (Teichert & Nützel, 2015; Wall-Palmer et al., 2016; Pieroni & Nützel, 2020). Only few and usually doubtful records of pre-Cenozoic Pteropoda exist (reviewed in Janssen & Peijnenburg, 2017). After the Paleocene-Eocene boundary pteropods show a rapid evolution, developing numerous species (Janssen et al., 2016). Both groups of pelagic gastropods form an important component of the present-day oceanic zooplankton (Bednaršek et al., 2012; Wall-Palmer et al., 2016; Burridge et al., 2017; Buitenhuis et al., 2019).

Currently, holoplanktic molluscs, and especially the shelled pteropods, play an important role in the study of the effects of ocean acidification. In aragonite-undersaturated waters their shells dissolve which makes them potentially valuable indicator species. An extensive number of studies on the topic were performed during the last decennium (reviewed in Manno et al., 2017). This increased interest has simultaneously led to new studies concerning their systematics, biogeography and biostratigraphy, greatly amplifying the existing classical literature of the two last centuries. Modern techniques, such as scanning electron microscopy (SEM), CT-scanning, 3D-printing and especially DNA sequencing have opened up new research opportunities that have led, and will lead in the future, to a better understanding of these particular animal groups and their interrelationships. Two examples are the recent work of Peijnenburg et al. (2020) and Wall-Palmer et al. (2020) which explored the evolution of pteropods and shelled heteropods respectively, using a combination of genetic information and the ages of key fossils. Apart from shedding new light on the phylogenetic relationships in the respective groups, these studies also estimated divergence times. The results were surprisingly similar for the two groups of pelagic gastropods. Both the pteropods and the atlantid heteropods were found to be much older than previously thought, with both groups originating in the Early Cretaceous.

Currently only few universities and research institutes maintain animal systematics as a major topic. However, most of the current studies on pelagic molluscs require correct identifications at species level and therefore collections of material, both dry and preserved in buffered ethanol or formaldehyde solutions, are of utmost importance. It is for that reason that we present in this paper a survey and quantification of the important collections of these groups represented in the Naturalis Biodiversity Center, comprising both fossil and present-day material in a wide variety and counting up to approximately 25,000 lots, which makes it one of the larger, if not the largest, collection of its kind.

The sections below have been written by groups of authors that are abbreviated as AWJ = Arie W. Janssen; BVDB = Bram van der Bijl; DWP = Deborah Wall-Palmer; JG = Jeroen Goud; KTCAP = Katja T.C.A. Peijnenburg; RP = Ronald Pouwer; FPW = Frank P. Wesselingh.

THE NATURALIS MOLLUSC COLLECTIONS IN GENERAL (AWJ, RP & BVDB)

Naturalis Biodiversity Center in Leiden (The Netherlands) has a complex history. It started in 1990 with the merging of two museums, the 'Rijksmuseum van Natuurlijke Historie' (RMNH) and the 'Rijksmuseum van Geologie en Mineralogie' (RGM), forming the Nationaal Natuurhistorisch Museum (NNM). In 1998 a new museum building was opened and the museum adopted the name Nationaal Natuurhistorisch Museum Naturalis, using Naturalis as the common name. In 2010 another major step was made with the merging of Naturalis with the Zoölogisch Museum Amsterdam (ZMA) and the Nationaal Herbarium Nederland, forming the present-day Naturalis Biodiversity Center. The collections of recent molluscs of RMNH and ZMA were merged but the fossil molluscs of RGM were maintained as a separate collection. The two collections are differently organised: the RMNH/ZMA collection is basically stored in systematic order, whereas the RGM collection is arranged according to age and locality. Separation of fossil holoplanktic molluscs as a special, systematically arranged unit, was started in the 1980s by isolating species from the main collection of fossil molluscs.

Fig. 1. Naturalis mollusc collections in steel drawer cabinets.

	RGM lots	Pre-Eocene	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Pleistocene	Holocene	RMNH lots[1]
Family Atlantidae																				
***Atlanta ariejansseni* Wall-Palmer et al., 2016**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	7
Atlanta brunnea Gray, 1850	72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	107
Atlanta californiensis Seapy & Richter, 1993	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Atlanta diamesa Woodring, 1928	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Atlanta echinogyra Richter, 1972	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	4
Atlanta fragilis Richter, 1993	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Atlanta frontieri Richter, 1993	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Atlanta gaudichaudi Gray, 1850	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	20
Atlanta gibbosa Souleyet, 1852	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	5
Atlanta helicinoidea Gray, 1850	39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	76
Atlanta inclinata Gray, 1850	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	56
Atlanta inflata Gray, 1850	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	10
Atlanta lesueurii Gray, 1850	41	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	24
***Atlanta lingayanensis* Janssen, 2007**	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Atlanta meteori Richter, 1972	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
***Atlanta oligogyra* Tesch, 1906**	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	17
Atlanta peronii Lesueur, 1817	60	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	217
Atlanta plana Richter, 1972	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	3
***Atlanta richteri* Janssen, 2007**	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Atlanta rosea Gray, 1850	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
***Atlanta seapyi* Janssen, 2007**	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Atlanta selvagensis De Vera & Seapy, 2006	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	52
Atlanta tokiokai van der Spoel & Troost, 1972	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	26
Atlanta turriculata d'Orbigny, 1836[2]	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	24
***Atlanta vanderspoeli* Wall-Palmer, Hegmann & Peijnenburg, 2019[2]**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Atlanta sp.	229	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	50
Atlantidea rotundata (Gabb, 1873)	93	-	-	-	-	-	-	-	-	+	+	-	-	-	-	+	-	+	+	9
Mioatlanta soluta Di Geronimo, 1974	3	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Oxygyrus inflatus Benson, 1835	71	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	114
***Protatlanta kbiraensis* Janssen, 2012**	22	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
Protatlanta souleyeti (Smith, 1888)	81	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	97
Protatlanta sp.	12	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-
Atlantidae sp.	3	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Family Pterotracheidae																				
Firoloida desmarestia Lesueur, 1817	52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	18
Firoloida sp.	4	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-

Table 1. Listing of all holoplanktic mollusc taxa and numbers of lots in the RGM and RMNH/ZMA collections as registered in the two databases, with an indication of their approximate stratigraphic age. Included are 450 taxa (36 of them in open nomenclature), 372 of which are represented in the RGM collection, and 162 in the RMNH/ZMA collection.
In the collection are various taxa that were introduced after 1960 at infrasubspecific rank. Such taxa are basically unavailable under ICZN art. 45.6.3. In Table 1 their number of lots is added to the currently valid species name. Several of these, however, were subsequently validated before 1985 under ICZN art. 45.6.4.1. Availability of such taxon names has to be ascertained individually in each case.
Names printed in **bold** mean that their primary types are in the Naturalis collection. (table continued on pp. 218-228).

	RGM lots	Pre-Eocene	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Pleistocene	Holocene	RMNH lots[1]
Pterotrachea coronata Forsskål *in* Niebuhr, 1775	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	224
Pterotrachea hippocampus Philippi, 1836	8	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	18
Pterotrachea scutata Gegenbaur, 1855	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	3
Pterotrachea/Pterotracheidae sp. (div. ?)	51	-	+	?	?	-	-	-	-	-	-	-	-	-	-	-	-	+	+	1
Family Carinariidae																				
Cardiapoda placenta (Lesson, 1830)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	18
Carinaria cristata (Linné, 1767)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	12
Carinaria cithara Benson, 1835	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	24
Carinaria galea Benson, 1835	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	3
Carinaria lamarcki Péron & Lesueur, 1810	86	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	28
***Carinaria maempeli* Janssen, 2012**	4	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Carinaria rutschi Robba, 1972	1	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Carinaria sp.	45	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	+	+	2
Pterosoma planum Lesson, 1827	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	1
Striocarinaria hugardi (Pictet, 1855)	4	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
Carinariidae sp.	36	-	-	-	-	-	-	-	-	+	+	-	-	-	+	-	-	-	+	-
Family Epitoniidae																				
Janthina exigua Lamarck, 1816	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	59
Janthina globosa Swainson, 1822	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	116
Janthina janthina (Linnaeus, 1758)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	279
Janthina pallida Thompson, 1840	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	36
Janthina umbilicata d'Orbigny, 1841	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	22
Janthina/Epitoniidae sp.	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	14
Recluzia lutea (Bennett, 1840)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	14
Family Heliconoididae																				
Heliconoides atypicus (Laws, 1944)	6	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
Heliconoides auriformis (Curry, 1982)	4	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heliconoides bartonensis (Curry, 1965)	13	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Heliconoides curryi* (Janssen, 1990)**	6	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
***Heliconoides daguini* Janssen, 2010**	2	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heliconoides dilatata (von Koenen, 1892)	11	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Heliconoides ferax (Laws, 1944)	2	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
***Heliconoides hodgkinsoni* Garvie, 2020**	3	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heliconoides hospes (Rolle, 1862)	78	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-
Heliconoides inflatus (d'Orbigny, 1834)	421	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	349
***Heliconoides lillebaeltensis* Janssen, 2007**	21	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Heliconoides linneensis* Janssen, 2008**	8	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
***Heliconoides lunatus* (Janssen, 1990)**	3	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Heliconoides mercinensis (Watelet & Lefèvre, 1885)	174	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Heliconoides merlei* Janssen, 2010**	3	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Heliconoides mermuysi* Janssen, 2010**	4	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-

Table 1, continued.

	RGM lots	Pre-Eocene	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Pleistocene	Holocene	RMNH lots[1]
Heliconoides nemoris (Curry, 1965)	3	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Heliconoides nikkieae* Janssen, 2017**	31	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Heliconoides nitens (Lea, 1833)	44	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heliconoides paula (Curry, 1982)	3	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heliconoides planus (Tembrock, 1964)	1	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
***Heliconoides pyrenaicus* Janssen, 2010**	2	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Heliconoides sondaari* Janssen, 2007**	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Heliconoides stenzeli (Garvie, 1992)	9	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Heliconoides tatei* (Janssen, 1990)**	2	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Heliconoides taylori (Curry, 1965)	33	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heliconoides tertiarius (Tate, 1887)	90	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-
Heliconoides texanus (Garvie & Hodgkinson, 1992)	8	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Heliconoides vanderweideni* Janssen, 2004**	24	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
***Heliconoides vonhachti* Janssen, 2012**	14	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
***Heliconoides wardijaensis* Janssen, 2004**	3	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Family Limacinidae																				
Altaspiratella bearnensis (Curry, 1982)	41	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Altaspiratella choctavensis (Aldrich, 1887)	2	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Altaspiratella elongatoidea (Aldrich, 1887)	36	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Altaspiratella gracilens Hodgkinson, 1992	3	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Altaspiratella multispira (Curry, 1882)	13	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Altaspiratella tavianii* Janssen, 2013**	4	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Currylimacina asperita* Garvie, 2020**	1	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Currylimacina cossmanni (Curry, 1982)	19	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina acutimarginata (Korobkov, 1966)	9	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina adornata Hodgkinson, 1992	4	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina aegis Hodgkinson, 1992	37	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina andrussowi (Kittl, 1886)	27	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
***Limacina aryanaensis* Janssen, 2013**	3	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Limacina asiatica* Janssen, 2011**	9	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina atlanta (Mörch, 1874)	224	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-
Limacina bulimoides (d'Orbigny, 1834)	119	-	-	-	-	-	-	-	-	+	-	-	-	-	+	+	-	+	+	177
Limacina canadaensis Hodgkinson, 1992	6	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina conica (von Koenen, 1892)	5	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina convolutes Hodgkinson, 1992	2	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Limacina dzheroiensis* Janssen, 2011**	10	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Limacina erasmiana* Janssen, 2010**	22	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Limacina ernstkittli* Janssen, 2012**	34	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
Limacina gormani (Curry, 1982)	15	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina gramensis (Rasmussen, 1968)	95	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-
***Limacina guersi* Janssen, 2010**	23	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina helicina antarctica Woodward, 1854	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	39
Limacina helicina helicina (Phipps, 1774)	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	6

Table 1, continued.

	RGM lots	Pre-Eocene	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Pleistocene	Holocene	RMNH lots[1]
Limacina helicina rangii (d'Orbigny, 1834)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Limacina helicina pacifica Dall, 1871	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
***Limacina ingridae* Janssen, 1989**	173	-	-	-	-	-	-	-	-	-	?	+	-	-	-	-	-	-	-	-
***Limacina irisae* Janssen, 1989**	48	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Limacina karasawai Ando, 2011	11	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina lesueurii (d'Orbigny, 1836)	49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	130
Limacina lotschi (Tembrock, 1989)	26	-	?	+	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Limacina mariae* Janssen, 1989**	35	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
***Limacina novacaesarea* Janssen & Sessa, 2016**	6	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Limacina perforata* Janssen, 2013**	2	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina pygmaea (Lamarck, 1805)	42	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina retroversa retroversa (Fleming, 1823)	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	50
Limacina retroversa australis (Eydoux & Souleyet, 1840)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	3
Limacina robusta (Eames, 1952)	10	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina smithvillensis Hodgkinson, 1992	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Limacina tanzaniaensis* Janssen, 2017**	4	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina tarchanensis (Kittl, 1886)	1	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Heliconoides taylori (Curry, 1965)	33	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Limacina timi* Janssen, 2017**	20	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina trochiformis (d'Orbigny, 1834)	84	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	9
Limacina tutelina (Curry, 1965)	15	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina ujiharai Shibata, 1983	1	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Limacina umbilicata (Bornemann, 1855)	73	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina valvatina (Reuss, 1867)	626	-	-	-	-	-	-	+	+	+	+	+	-	-	-	-	-	-	-	-
***Limacina vegrandis* Janssen, 2010**	19	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina wechesensis Hodgkinson, 1992	6	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Limacina wilhelminae* Janssen, 1989**	57	-	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-
***Limacina yazdii* Janssen, 2013**	4	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limacina sp.	131	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	-	-	57
***Striolimacina andaensis* Janssen, 2007**	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Striolimacina imitans (Collins, 1934)	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Limacinidae sp.	62	-	+	+	-	+	+	+	+	+	+	-	-	-	+	+	-	-	+	-
Family Thieleidae																				
Thielea helicoides (Jeffreys, 1877)	4	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+	10
Family Creseidae																				
Boasia chierchiae (Boas, 1886) s.lat.	64	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	+	+	2
Bovicornu eocenense Meyer, 1886	19	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Bovicornu gracile Meyer, 1887	1	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bowdenatheca jamaicensis Collins, 1934	18	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	-	-	-
***Bowdenatheca miocenica* Janssen, 2004**	14	-	-	-	-	-	-	+	?	-	-	-	-	-	-	-	-	-	-	-
Bucanoides basiannulata Hodgkinson, 1992	1	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bucanoides divaricata Hodgkinson, 1992	2	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bucanoides tenuis Hodgkinson, 1992	7	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1, continued.

	RGM lots	Pre-Eocene	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Pleistocene	Holocene	RMNH lots[1]
Camptoceratops americanus Garvie, 1992	8	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Camptoceratops priscus (Godwin-Austen, 1882)	92	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Cheilospicata cedrus* Garvie, 2020**	2	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cheilospicata repanda Hodgkinson & Garvie, 1992	5	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Creseis acicula (Rang, 1828)	111	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	156
***Creseis antoni* Janssen, 2010**	3	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
***Creseis berthae* Janssen, 1989**	19	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Creseis conica Eschscholtz, 1829	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	32
Creseis corpulenta (Meyer, 1887)	3	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Creseis curta* Janssen, 2012**	22	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Creseis cylindrica Hodgkinson, 1992	10	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Creseis roesti* Janssen, 2010**	28	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
Creseis simplex (Meyer, 1886)	15	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Creseis spina (Reuss, 1867)	120	-	-	-	+	+	+	+	-	+	+	+	-	-	+	-	-	-	-	-
***Creseis tugurii* Janssen, 2010**	5	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Creseis virgula (Rang, 1828)	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	99
Creseis sp.	40	-	-	-	-	-	+	+	+	+	+	-	-	-	+	-	-	-	+	14
Euchilotheca elegans Harris, 1894	55	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Euchilotheca ganensis Curry, 1982	8	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Euchilotheca succincta (Defrance, 1828)	14	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Euchilotheca sp.	2	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Loxobidens aduncus Hodgkinson, 1992	1	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Styliola schembriorum* Janssen, 2012**	21	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
***Styliola subula* (Quoy & Gaimard, 1827)**	423	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	264
Styliola sp.	1	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Thecopsella fischeri Cossmann, 1888	2	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tibiella annulata Garvie, 1992	2	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tibiella marshi Meyer, 1884	4	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tibiella reflexa Hodgkinson, 1992	1	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tibiella texana Collins, 1934	1	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Tibiella watupuruensis* Janssen, 2013**	4	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Creseidae sp.	16	-	+	+	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-
Family Hyalocylidae																				
***Hyalocylis marginata* Janssen, 2007**	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Hyalocylis striata (Rang, 1828)	79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	60
Praehyalocylis cincta (von Koenen, 1892)	5	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Praehyalocylis maxima (Ludwig, 1864)	32	-	-	-	+	+	+	?	-	-	-	-	-	-	-	-	-	-	-	-
Praehyalocylis sp.	4	-	-	-	-	-	+	+	-	+	+	-	-	-	-	-	-	-	-	-
Family Praecuvierinidae																				
Praecuvierina lura (Hodgkinson, 1992)	1	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Texacuvierina guta (Hodgkinson, 1992)	1	-	-	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
***Texacuvierina hodgkinsoni* Janssen, 2013**	3	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1, continued.

	RGM lots	Pre-Eocene	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Pleistocene	Holocene	RMNH lots[1]
Family Cuvierinidae																				
Cuvierina astesana (Rang, 1829)	36	-	-	-	-	-	-	-	-	-	-	-	-	?	+	+	-	-	-	-
Cuvierina atlantica Bé, MacClintock & Currie, 1972	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	140
***Cuvierina cancapae* Janssen, 2005**	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	25
Cuvierina columnella (Rang, 1827)	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	30
***Cuvierina curryi* Janssen, 2005**	19	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Cuvierina grandis d'Alessandro & Robba, 1981	19	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Cuvierina inflata (Bellardi, 1873)	14	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	-	-	-	-
Cuvierina intermedia (Bellardi, 1873)	13	-	-	-	-	-	-	-	-	-	+	+	+	-	+	-	-	-	-	-
***Cuvierina jagti* Janssen, 1995**	5	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Cuvierina ludbrooki (Caprotti, 1962)	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
***Cuvierina pacifica* Janssen 2005**	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Cuvierina paronai Checchia-Rispoli, 1921	122	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-
Cuvierina torpedo (Marshall, 1918)	1	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
***Cuvierina tsudai* Burridge et al., 2016**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	6
Cuvierina urceolaris (Mörch, 1850)	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	14
Cuvierina sp.	20	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	+	-	-
Ireneia calandrellii (Michelotti, 1847)	27	-	-	-	-	-	-	-	+	+	+	+	+	-	-	-	-	-	-	-
***Ireneia gracilis* Janssen, 2005**	22	-	-	-	-	-	-	-	+	+	+	+	+	-	-	-	-	-	-	-
***Ireneia marqueti* Janssen, 1995**	5	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
***Ireneia nieulandei* Janssen, 1995**	1	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Ireneia striatocarinata Piehl, 2007	4	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Ireneia tenuistriata (Semper, 1861)	47	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Ireneia testudinaria (Michelotti, 1847)	3	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
***Johnjagtia baharensis* Janssen, 2012**	7	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
Johnjagtia moulinsi (Benoist, 1873)	11	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
***Spoelia torquayensis* Janssen, 1990**	59	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Family Cliidae																				
Clio aichinoi Checchia-Rispoli, 1921	30	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Clio antarctica Dall, 1908	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	232
Clio bellardii Audenino, 1899	48	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Clio berglundorum Squires, 1989	7	-	-	-	-	-	-	+?	-	-	-	-	-	-	-	-	-	-	-	-
***Clio blinkae* Janssen, 1989**	53	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Clio braidensis (Bellardi, 1873)	24	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-
Clio caralitana Robba & Spano, 1978	38	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Clio carinata Audenino, 1899	15	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Clio chadumica Korobkov, 1966	2	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clio chaptalii Gray, 1850	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	3
Clio coebana Robba, 1972	3	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
Clio convexa (Boas, 1886) s.lat.	61	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	5
Clio cuspidata (Bosc, 1801)	85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	89
Clio deflexa von Koenen, 1882	1	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Clio distefanoi Checchia-Rispoli, 1921	94	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-

Table 1, continued.

	RGM lots	Pre-Eocene	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Pleistocene	Holocene	RMNH lots[1]
Clio fallauxi (Kittl, 1886)	2	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Clio garganica Sirna, 1968	2	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Clio ghawdexensis **Janssen, 2004**	25	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Clio giulioi **Janssen, 1995**	17	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Clio guidottii Simonelli, 1896	11	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Clio hataii (Noda, 1972)	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Clio itoigawai Shibata, 1983	1	-	-	-	-	-	-	-	-	?	?	-	-	-	-	-	-	-	-	-
Clio jacobae **Janssen, 1989**	2	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Clio lozoueti **Janssen, 2010**	3	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Clio lucai **Janssen, 2000**	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Clio merijni **Janssen, 2012**	4	-	-	-	-	-	-	+	?	-	-	-	-	-	-	-	-	-	-	-
Clio multicostata (Bellardi, 1873)	3	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Clio nielseni **Janssen, 1990**	7	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
Clio oblonga Rampal, 1996	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-
Clio pauli **Janssen, 1989**	2	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Clio pedemontana (Mayer, 1868)	87	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
Clio piatkowski **van der Spoel, Schalk & Bleeker, 1992**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	384
Clio polita Pelseneer, 1888	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	3
Clio pulcherrima (Mayer, 1868)	109	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Clio pyramidata angusta (Boas, 1886)	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Clio pyramidata pyramidata **Linné, 1767[3]**	267	-	-	-	-	-	-	-	-	-	?	-	+	+	+	+	+	+	+	455
Clio pyramidata tyrrhenica **Janssen, 2012**	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	?	-
Clio pyramidata Linné, 1767 s.lat.	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2312
Clio recurva (Children, 1823)	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	33
Clio ricciolii (Calandrelli, 1844)	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Clio "robbai Buonaiuto, 1979" (unpublished name)	2	-	-	-	?	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clio saccoi Checchia-Rispoli, 1921	43	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-
Clio scheelei (Munthe, 1888)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Clio sinuosa (Bellardi, 1873)	4	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Clio sturanii Robba, 1977	2	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Clio triplicata Audenino, 1899	27	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-
Clio vasconiensis **Janssen, 2010**	12	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Clio vilis **Janssen, 2012**	4	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Clio yatsuoensis Shibata, 1983	1	-	-	-	-	-	-	-	-	?	?	-	-	-	-	-	-	-	-	-
Clio sp.	92	-	-	-	-	-	-	+	-	+	+	+	+	+	-	-	+	-	-	11
Family Cavoliniidae																				
Subfamily Cavoliniinae																				
Cavolinia baniensis **Janssen, 2007**	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Cavolinia bituminata **Beets, 1953**	2	-	-	-	-	-	-	-	-	-	-	-	?	?	-	-	-	-	-	-
Cavolinia cookei Simonelli, 1895	71	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Cavolinia floridana Collins, 1934	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Cavolinia gatti **Janssen, 2012**	7	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Cavolinia gibbosa (d'Orbigny, 1834) s.lat.	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	83

Table 1, continued.

	RGM lots	Pre-Eocene	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Pleistocene	Holocene	RMNH lots[1]
Cavolinia gibbosa gibboides Rampal, 2002	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Cavolinia globulosa (Gray, 1850)	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	157
Cavolinia grandis (Bellardi, 1873)	16	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Cavolinia gypsorum (Bellardi, 1873)	22	-	-	-	-	-	-	-	-	-	+	?	+	+	-	-	-	-	-	-
Cavolinia inflexa imitans (Pfeffer, 1880)	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Cavolinia inflexa inflexa (Lesueur, 1813)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Cavolinia inflexa kakegawaensis Shibata 1984	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	?	-	-	-
Cavolinia inflexa labiata (d'Orbigny, 1834)	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Cavolinia inflexa (Lesueur, 1813) s.lat.	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	275
***Cavolinia landaui* Janssen, 2004**	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Cavolinia marginata hyugaensis Ujihara, 1996	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
***Cavolinia marginata limatula* Beets, 1943**	1	-	-	-	-	-	-	-	-	-	-	-	?	?	-	-	-	-	-	-
Cavolinia marginata (Bronn, 1862) s.lat.	13	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
***Cavolinia marginata pliomediterranea* Janssen, 2004**	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Cavolinia marginata vendryesiana (Guppy, 1873)	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Cavolinia mexicana (Collins, 1934)	5	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-
***Cavolinia microbesitas* Janssen, 2012**	7	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
***Cavolinia perparvula* Janssen, 2007**	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Cavolinia pycna Jung, 1971	38	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
***Cavolinia shibatai* Janssen, 2007**	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Cavolinia tridentata (Forsskål *in* Niebuhr, 1775) s.lat.	49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	160
Cavolinia uncinata (d'Orbigny, 1835) s.lat.	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	146
Cavolinia ventricosa (Guppy, 1882)	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Cavolinia yamabensis Shibata, 1983	1	-	-	-	-	-	-	-	?	?	-	-	-	-	-	-	-	-	-	-
Cavolinia zamboninii Checchia-Rispoli, 1921	17	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Cavolinia sp.	118	-	-	-	-	-	-	-	-	+	+	-	-	+	+	+	+	-	+	49
Diacavolinia angulosa (Gray, 1850)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	10
Diacavolinia aspina van der Spoel et al., 1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
***Diacavolinia atlantica* van der Spoel et al., 1993**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
***Diacavolinia bandaensis* van der Spoel et al., 1993**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
Diacavolinia bicornis van der Spoel et al., 1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
***Diacavolinia constricta* van der Spoel et al., 1993**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
***Diacavolinia deblainvillei* van der Spoel et al., 1993**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	2
Diacavolinia deshayesi van der Spoel et al., 1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Diacavolinia elegans van der Spoel et al., 1993	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Diacavolinia flexipes van der Spoel et al., 1993	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	14
***Diacavolinia grayi* van der Spoel et al., 1993**	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
Diacavolinia limbata (d'Orbigny, 1836)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
Diacavolinia longirostris (de Blainville, 1821) s. lat.	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	348
***Diacavolinia ovalis* van der Spoel et al., 1993**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
***Diacavolinia pacifica* van der Spoel et al., 1993**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
***Diacavolinia pristina* Janssen, 2007**	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Diacavolinia robusta van der Spoel et al., 1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Diacavolinia souleyeti van der Spoel et al., 1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1

Table 1, continued.

	RGM lots	Pre-Eocene	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Pleistocene	Holocene	RMNH lots[1]
Diacavolinia strangulata (Deshayes, 1823)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Diacavolinia striata van der Spoel et al., 1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
***Diacavolinia triangulata* van der Spoel et al., 1993**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
Diacavolinia v. vanutrechti van der Spoel et al., 1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Diacavolinia sp.	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	1
Gamopleura maxwelli Grebneff & Janssen, 2011	1	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
***Gamopleura melitensis* Janssen, 1995**	60	-	-	-	-	-	-	+	?	?	-	-	-	-	-	-	-	-	-	-
***Gamopleura pilula* Janssen, 2012**	3	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Gamopleura taurinensis (Michelotti, 1847)	4	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Subfamily Diacriinae																				
Diacria digitata (Guppy, 1882)	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Diacria italica Grecchi, 1982 s.lat.	21	-	-	-	-	-	-	-	-	-	-	-	-	-	?	+	-	-	-	-
Diacria major (Boas, 1886)	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	16
Diacria mbaensis Ladd, 1934	7	-	-	-	-	-	-	-	-	-	-	-	?	?	-	-	-	-	-	-
***Diacria microstriata* Janssen, 2007**	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
***Diacria paeninsula* Janssen, 2007**	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Diacria rampalae Dupont, 1979 emend.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	4
***Diacria rubecula* Bontes & van der Spoel, 1998**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
Diacria sangiorgii Scarsella, 1934	47	-	-	-	-	-	-	-	-	-	?	-	+	-	-	-	-	-	-	-
Diacria trispinosa (de Blainville, 1821)	166	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	552
Diacria trispinosa africana van der Spoel, 1974	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	+	1
Diacria sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	16
Diacrolinia aquensis (Grateloup, 1827)	7	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Diacrolinia aurita (Bellardi, 1873)	212	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-
***Diacrolinia elioi* Janssen, 1995**	54	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Diacrolinia interrupta (Bellardi, 1873)	32	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
***Diacrolinia larandaensis* Janssen, 1999**	3	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Diacrolinia orbignyi (Rang, 1827)	6	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
***Diacrolinia pumilionis* Janssen, 2012**	2	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Diacrolinia sp.	118	-	-	-	-	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-
Telodiacria costata (Pfeffer, 1879)	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	8
Telodiacria danae (van Leyen & van der Spoel, 1982)	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	99
Telodiacria erythra (van Leyen & van der Spoel, 1982)	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
***Telodiacria philippinensis* (Janssen, 2007)**	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Telodiacria quadridentata (de Blainville, 1821) s. lat.	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	42
Telodiacria schmidti (van Leyen & van der Spoel, 1982)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	15
Subfamily Vaginellinae Janssen subfam. nov.[5]																				
***Edithinella bonaviai* Janssen, 2004**	14	-	-	-	-	-	-	+	?	-	-	-	-	-	-	-	-	-	-	-
Edithinella caribbeana (Collins, 1934)	17	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-
***Edithinella curva* Janssen, 1998**	9	-	-	-	-	-	-	-	-	-	?	+	-	-	-	-	-	-	-	-
***Edithinella doliarius* Janssen, 2006**	17	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Edithinella katoi (Shibata, 1983)	2	-	-	-	-	-	-	-	-	?	-	-	-	-	-	-	-	-	-	-
***Edithinella varanica* (Sirna, 1968)**	32	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-

Table 1, continued.

	RGM lots	Pre-Eocene	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Pleistocene	Holocene	RMNH lots[1]
Edithinella sp.	1	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Vaginella acutissima Audenino, 1899	130	-	-	-	-	-	-	-	-	?	+	-	-	-	-	-	-	-	-	-
Vaginella austriaca Kittl, 1886	417	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-
***Vaginella basitruncata* Janssen, 2005**	2	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Vaginella bicarinata Tate, 1887	2	-	-	-	-	-	-	+	?	-	-	-	-	-	-	-	-	-	-	-
Vaginella chattica R. Janssen, 1979	69	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Vaginella chipolana Dall, 1893	1	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Vaginella depressa Daudin, 1800	145	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-
***Vaginella gaasensis* Janssen, 2010**	1	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaginella gibbosa Audenino, 1899	97	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Vaginella lapugyensis Kittl, 1886	168	-	-	-	-	-	-	-	-	?	+	+	-	-	-	-	-	-	-	-
***Vaginella sannicola* Janssen, 1990**	46	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
***Vaginella tricuspidata* Zorn & Janssen, 1993**	68	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Vaginella venezuelana Collins, 1934	2	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Vaginella victoriae Janssen, 1990	7	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
Vaginella sp.	105	-	-	-	-	-	-	-	+	+	+	+	+	-	-	-	-	-	-	-
Superfamily Cavolinioidea s.lat.																				
Cavoliniidae/Cavolinioidea sp.	45	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	+	162
Family Sphaerocinidae																				
***Hameconia edmundi* Janssen, 2008**	4	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
***Sphaerocina convolvula* Janssen, 2007**	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Sphaerocina formai (Audenino, 1899)	26	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
Sphaerocina sp.	5	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Family Cymbuliidae																				
Corolla calceola (Verrill, 1880)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
***Corolla cupula* Rampal, 1996**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
***Corolla intermedia* (Tesch, 1903)**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	6
Corolla ovata (Quoy & Gaimard, 1833)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	4
Corolla spectabilis Dall, 1871	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Corolla sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
Cymbulia parvidentata Pelseneer, 1888	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Cymbulia sp.	138	-	-	?	-	-	-	-	-	+	+	-	-	-	-	+	-	-	+	57
Cymbulia peronii de Blainville, 1818	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1183
***Cymbulia sibogae* Tesch, 1903**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	4
Gleba cordata Forsskål *in* Niebuhr, 1776	64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	5
Gleba sp.	5	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
Family Desmopteridae																				
Desmopterus papilio Chun, 1889	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	3
Family Peraclidae																				
***Peracle amberae* Janssen, 2012**	4	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Peracle bispinosa (Pelseneer, 1888)	15	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	+	+	20
***Peracle charlotteae* Janssen & Little, 2010**	3	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-

Table 1, continued.

	RGM lots	Pre-Eocene	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Pleistocene	Holocene	RMNH lots[1]
Peracle diversa (Monterosato, 1875)	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	23
Peracle elata (Seguenza, 1875)	18	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	+	17
***Peracle grebneffi* Janssen, 2012**	17	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Peracle lata (Krach, 1979)	1	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Peracle moluccensis (Tesch, 1903)	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	14
Peracle reticulata (d'Orbigny, 1834)	87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	53
***Peracle rissoides* Tesch, 1903**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Peracle valdiviae (Meisenheimer, 1905)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Peracle sp.	58	-	-	-	-	-	-	+	-	+	+	-	-	-	+	-	-	-	+	-
Family Pneumodermatidae																				
***Pneumoderma degraaffi* van der Spoel & Pafort-van Iersel, 1982**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Pneumoderma heronense Newman & van der Spoel, 1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Pneumoderma mediterraneum (van Beneden, 1838)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
Pneumoderma peroni (Cuvier, 1817)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Pneumoderma violaceum d'Orbigny, 1835	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	25
Pneumodermopsis ciliata (Gegenbaur, 1855)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	9
Pneumodermopsis michaelsarsi (Bonnevie, 1913)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	23
***Pneumodermopsis teschi* van der Spoel, 1973**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Spongiobranchaea australis d'Orbigny, 1836	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	237
Family Notobranchaeidae																				
***Notobranchaea bleekerae* van der Spoel & Pafort-van Iersel, 1985**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Notobranchaea inopinata Pelseneer 1887	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Notobranchaea macdonaldi Pelseneer, 1886	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	7
Notobranchaea tetrabranchiata Bonnevie, 1913	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	3
Family Cliopsidae																				
Cliopsis krohni Troschel, 1854	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	3
Pruvotella danae Pruvot-Fol, 1942	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Family Clionidae																				
Clione limacina antarctica Smith, 1902	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6
Clione limacina limacina (Phipps, 1774)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	565
***Clione? ignota* Janssen, 2012**	24	-	-	-	-	-	-	?	+	+	+	+	-	-	-	-	-	-	-	-
***Clione? imdinaensis* Janssen, 2012**	56	-	-	-	-	-	-	?	+	+	+	?	-	-	-	-	-	-	-	-
***Clione? phosphorita* Janssen, 2012**	11	-	-	-	-	-	-	?	+	+	+	-	-	-	-	-	-	-	-	-
***Clione? tripartita* Janssen, 2012**	6	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
***Clione? tumidula* Janssen, 2012**	13	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
Clione? sp.	143	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	+	+	-
***Fowlerina punctata* (Tesch, 1903)**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Paedoclione doliiformis Danforth, 1907	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Paraclione flavescens (Gegenbaur, 1855)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
***Paraclione pelseneeri* Tesch, 1903**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	4

Table 1, continued.

	RGM lots	Pre-Eocene	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Pleistocene	Holocene	RMNH lots[1]
Thliptodon antarcticus Meisenheimer, 1906	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Thliptodon diaphanus (Meisenheimer, 1902)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	4
Thliptodon gegenbauri Boas, 1886	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Thliptodon schmidti Pruvot-Fol, 1942	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Family Hydromylidae																				
Hydromyles globulosus (Rang, 1825)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	122
Family Glaucidae																				
Glaucus atlanticus Forster, 1777	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	1
Family Phylliroidae																				
Phylliroe bucephala Lamarck, 1816	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	4
Family Fionidae																				
Fiona pinnata (Eschscholtz, 1831)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	2
Incerti ordinis																				
Aff. *Cheilospicata* sensu Garvie, in Garvie et al., 2020	2	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aff. *Creseis* sensu Garvie, in Garvie et al., 2020	6	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aff. *Currylimacina* sensu Garvie, in Garvie et al., 2020	2	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aff. *Praehyalocylis* sensu Garvie, in Garvie et al., 2020	2	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Beaked larva sensu van der Spoel & Newman, 1990	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-
Veliger of benthic gastropod?	96	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	+	+	-

[1] No data signifies that either no samples are present in the RMNH collecion or no sample data are present in the RMNH registry at the time of writing.

[2] Samples listed as *Atlanta turriculata* in both RGM and RMNH collections require reidentification and may contain *A. vanderspoeli*.

[3] Reidentification of samples indicated in Table 11 as *Clio pyramidata lanceolata* is required; they are here grouped within *Clio pyramidata pyramidata*.

[4] For diagnosis see Appendix 4.

Table 1, continued.

The RMNH/ZMA collection consists of two separate parts, a dry collection and the alcohol collection. Both the dry RMNH/ZMA collection as the RGM collection are stored in steel drawer cabinets (Fig. 1).

To make the material in both collections more easily available and accessible for further research a list is given here of all available identified species, with the number of lots present and their approximate age (Table 1). However, especially the RMNH/ZMA alcohol collection is incompletely registered. Although all lots received a RMNH or ZMA collection number, the data as present on the accompanying labels are only for a small part entered into the central Naturalis collection database. This undesirable situation requires a long period of careful work to be completed. At the moment the fossil samples are registered in a separate database. Ultimately this will be incorporated into the central Naturalis database. Part of the RMNH/ZMA holoplanktic species is accessible through the 'Naturalis bioportal': https://bioportal.naturalis.nl.

There is a considerable overlap in the two collections. The RMNH/ZMA dry material includes numerous specimens collected from ocean bottom sediment samples, but many similar specimens are also in the RGM collection, dated as Holocene. Depending on the method used such samples may locally include material of Pleistocene age, as was several times the case in box cores from the Mediterranean.

THE NATURALIS (RGM) COLLECTION OF FOSSIL HOLOPLANKTIC MOLLUSCA (AWJ, RP & FPW)

History

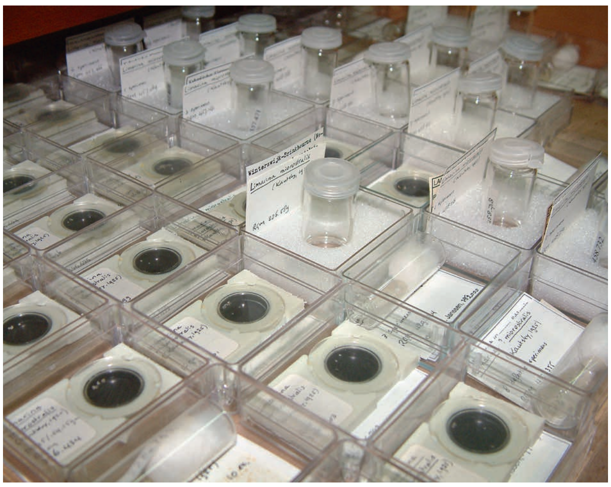
In the early 1980's Unesco launched the International Geological Correlation Programme (IGCP). In one of the subprojects, IGCP 124: 'The Northwest European Tertiary Basin', AWJ participated for the molluscan discipline, together with a number of international colleagues, on the subject of mollusc-based stratigraphic correlation possibilities in western European countries. After some time researchers concluded that the application of (mainly benthic) mollusc assemblages was quite useful for local correlations, but offered severe difficulties over longer distances, as such assemblages depend strongly on facies. Finally it was the late Dr Chris King (U.K.), who first applied the barely known holoplanktic molluscs for correlations (King, 1981) which appeared to offer better possibilities, especially over longer distances, more or less comparable to other pelagic organisms, such as planktic foraminifera and calcareous nannoplankton. Ultimately this led to a first pteropod-based biostratigraphical zonation for the Cenozoic of the North Sea Basin, published in the final IGCP 124 report (Janssen & King, 1988). This early work triggered a lasting interest in planktic mollusc biostratigraphy and systematics and it developed into AWJ's main research topic for many years, the more so after his retirement in 1997.

Isolating fossil pelagic gastropods from existing collections in the Leiden museum led to a first concentration of this fossil group in a separate collection that during the years was extended by targeted field work and support of colleague researchers and institutes. The research included extensive studies of type specimens and historical collections housed in institutions in London, Paris, Bordeaux, Copenhagen, Berlin, Warsaw, Basel, Vienna, Turin, Milan, Catania and Cagliari. The present worldwide collection of fossil holoplanktic molluscs comprises about 1200 lots, including a large number of primary and secondary type specimens and numerous illustrated specimens.

Preservation and storage

Specimens from unconsolidated rocks (sand or clay) have been isolated from the sediment by simple washing procedures. For sandy sediments usually a single treatment in water over a 0.2 or 0.3 mm sieve is sufficient to obtain a clean residue. For more clayey samples the procedure has to be repeated, soaking a residue in hot water after careful drying. Preservation in many types of clayey sediments is often in the form of internal pyritic moulds or specimens are filled with pyrite. For such samples application of hydrogenic peroxide (H_2O_2) to speed up disaggregation must be strongly discouraged, as it will damage or even completely destroy pyritic specimens.The tiny and fragile pelagic mollusc shells are easily damaged, so care has to be taken, also because frequently such specimens form only a minor part of residues that usually are dominated by benthic mollusc fragments that by their larger size and weight will rapidly damage heteropod and pteropod shells.

Incidentally, especially in fine-sandy sediments, smaller fossils including pteropods can be collected dry from the sediment contents of larger gastropods by careful tapping the shells. Samples obtained this way can be sieved without washing procedures. Specimens can be picked from dried and sieved residues using a 10 or 20 times magnification under a binocular microscope. Pelagic molluscs in shell preservation usually do not need further preservation and can be stored, after careful drying, in glass vials or slides. Pyritic specimens need special treatment for long term storage as pyrite will disintegrate under the influence of normal air humidity (Appendix 1). Pteropods (and similar fossils) in limestones or limestone concretions, mostly can-



Figs 2-3. Naturalis (RGM) fossil pelagic molluscs, stored in slides or in silicone oil glass vials (standing upright), in systematical order.

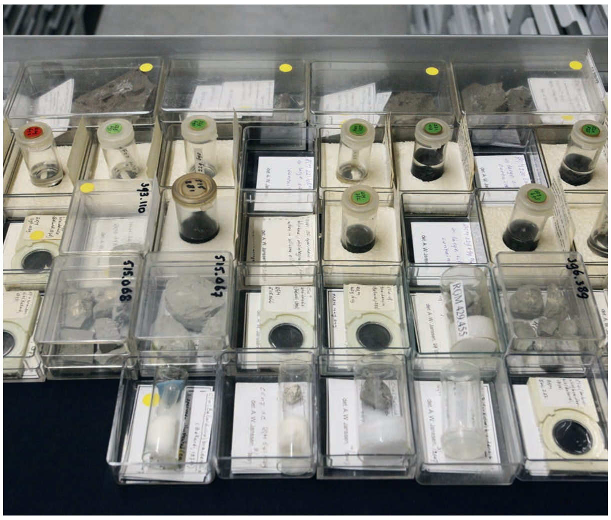


Fig. 4. Naturalis (RGM) fossil pelagic molluscs with smaller specimens in turn-top slides or glass vials and larger items in collection boxes, in systematical order; a red sticker indicates holotype, a green one paratype(s), specimens illustrated in publications are marked with a yellow sticker.

not be separated from the rock that has to be reduced in size for storage. If more specimens or species are represented on a single rock sample careful registration by cross-referencing has to be performed to be able to trace specimens.

In some Oligocene and Miocene limestones in the Mediterranean Basin (*e.g.* southern Italy, Malta, Sicily) specimens are preserved as internal phosphoritic moulds. These can be concentrated from the rock using formic or acetic acid, as described extensively in Janssen (2012). After careful washing in water to remove acid remnants such specimens do not need further preservation anticipating long term storage. Specimens in limonitic internal mould preservation (such as in some Maltese or Sicilian Miocene clays) sometimes need treatment with an artificial resin to obtain sufficient solidity. Because of their very thin shell walls, pteropod specimens in internal mould preservation remain identifiable in most cases, although external ornamentation will be lost.

In the Naturalis collection fossil pelagic molluscs (Tables 2-3) are stored, either in turntop slides, glass vials (mainly 45 × 15/16 or 45 × 25 mm), or as rock samples, as much as possible in systematic order (Figs 2-4). Documentation is done by a registration number in the vial or on the slide, and adding a label with locality and further basic data (age, formation, collector, donator, number, date of collecting) and additionally one (or more) identification labels, stored per lot in standard PVC collection boxes (55 × 45 mm, or a multiple thereof). All data are assembled in a Microsoft Access database with RGM registration numbers, and cross-referencing in cases where a single lot contains more than one species. Primary type specimens are indicated with a red sticker (also on the drawer), secondary types have a green sticker and specimens illustrated in publications have a yellow one.

Smaller specimens that were used for illustration by scanning electron microscopy (SEM) cannot easily be

	No of lots	Atlantic	Mediterranean	Caribbean	Red Sea	Indian Ocean	Indonesia	Pacific
Atlantidae	527	20	257	20	150	24	6	50
Pterotracheidae	89	-	73	-	11	1	-	4
Carinariidae	91	2	69	1	4	9	1	5
Epitoniidae	19	1	8	-	7	1	-	2
Heliconoididae	45	7	5	3	19	1	3	7
Limacinidae	345	23	240	22	31	3	6	20
Thieleidae	2	2	-	-	-	-	-	-
Creseidae[1]	282	17	123	24	71	1	12	34
Hyalocylidae	66	2	36	3	16	4	1	4
Cuvierinidae	37	6	10	-	-	5	1	15
Cliidae	254	25	172	8	19	5	6	19
Cavoliniidae	369	32	175	32	72	16	11	31
Peraclidae	164	14	112	11	15	3	1	8
Cymbuliidae	149	-	123	-	17	1	-	8
Clionidae	128	2	107	-	14	2	-	3
Incerti ordinis[2]	62	-	49	-	11	1	-	1

[1] Includes also the genus *Styliola*.
[2] Specimens provisionally included, but might be larvae of benthic species

Table 2. Quaternary (Pleistocene-Holocene) lots in the Naturalis (RGM) collection of fossil holoplanktic Mollusca and their origin per region.

	EOCENE					OLIGO-CENE		MIOCENE						PLIOCENE			
	pre-Eocene[1]	Ypresian	Lutetian	Bartonian	Priabonian	Rupelian	Chattian	Aquitanian	Burdigalian	Langhian	Serravallian	Tortonian	Messinian	Zanclean	Piacenzian	Gelasian	Totals
Belgium	-	30	3	-	-	118	-	-	-	26	-	-	6	3	4	-	190
Czech Republic	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	2
Denmark	4	6	29	-	-	4	38	11	50			9	-	-	-	-	151
England	-	75	9	20	-	-	-	-	-	2	-	-	-	-	-	-	95
Germany	-	9	-		-	29	126	39	275		582	146	19	1	-	-	1.226
France	-	109	22	3	-	14	114	21	167	5	8	-	-	123	-	-	586
Netherlands	-	263				90	7	-	-	69	12	14	-	19			469
Poland	-	-	-		-	1	-	-	-	43	-	-	-	-	-	-	44
Portugal	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	2
Portugal (Azores)	-	-	-	-	-	-	-	-	-	-	-	-	-	48	-	-	48
Spain	-	-	-	-	-	-	-	-	-	-	1	9	4	-	68	-	82
Ukraine	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	5
Cyprus	-	-	-	-	-	-	-	-	-	312	-	273	-	-	-	-	585
Egypt	-	4	6	1	-	-	-	-	1	6	-	-	-	-	-	-	17
Italy	-	-	-	-	-	2	1	40	40	1.452	80	80	7	187	44	18	1.951
Malta	-	-	-	-	-	-	115	-	471	1.092	126	103	15	-	-	-	1.922
Turkey	-	-	-	-	-	-	-	-	-	27	21	-	-	-	-	-	48
Iran	-	28		-	-	-	-	-	-	-	-	-	-	-	-	-	28
Kazakhstan	-	14	-	-	3	-	-	-	-	-	-	-	-	-	-	-	17
Uzbekistan	-	119		-	-	-	-	-	-	-	-	-	-	-	-	-	119
Nigeria	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	2
Tanzania	-	-	-	-	56	45	-	-	-	-	-	-	-	-	-	-	101
Australia	-	3				21		78						-	-	-	102
Fiji	-	-	-	-	-	-	-	-	-	-	-	-	-	61			61
Indonesia	-	-	-	-	-	-	-	14						5			19
Japan	-	-	-	-	-	-	-	18						3			21
New Zealand	-	-	-	-	-	-	1	11						1			13
Philippines	-	-	-	-	-	-	-	-	-	-	-	-	-	-	707	-	707
Canada	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Dominican Republic	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Jamaica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	51	-	51
Trinidad & Tobago	-	-	-	-	-	-	-	-	74		-	-	23	-	-	-	97
U.S.A.	13?	164	159	34	-	41		-	7	12	1	-	-	-	-	-	395
Chili	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
Venezuela	-	1				-	-	-	-	-	-	-	-				1

[1] Includes Maastrichtian and Paleocene lots.

Table 3. Available number of Pliocene and older lots of holoplanktic Mollusca, specified per country and approximate age. In cases where correlation of local stages with the European subdivision is not ascertained or unknown numbers of lots are given per larger interval.

removed from the SEM-stub without damage and consequently a number of SEM-stubs form part of the collection. In a large number of Mediterranean core and bottom samples numerous smaller specimens are stored together in so-called 'composite samples', in order to save space in the collection. Such specimens are registered under the same registration number, with added a, b, c etc. These composite samples frequently also contain larval bivalve shells (prodissoconchs) or larval specimens (protoconchs) of benthic gastropods from the same sample.

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Atlantidae									
Atlanta affinis[10]	6	-	-	-	-	-	-	6	-
Atlanta ariejansseni[2]	7	7[1]	-	-	-	-	-	-	-
Atlanta brunnea	102	9	85	3	-	2	1	-	2
Atlanta echinogyra	4	-	1	-	-	-	-	3	-
Atlanta fusca[3]	5	-	4	-	-	1	-	-	-
Atlanta gaudichaudi	20	1	1	-	-	6	-	12	-
Atlanta gibbosa	5	1	-	-	-	-	-	4	-
Atlanta helicinoidea	76	1	59	10	-	2	-	3	1
Atlanta inclinata	50	3	33	-	-	9	-	3	2
Atlanta inflata	10	2	1	-	-	2[4]	2	3	-
Atlanta keraudrenii	1[5]	-	1	-	-	-	-	-	-
Atlanta lesueurii	24	3	3	8	-	1	2	5	2
Atlanta oligogyra	17	1	-	-	-	-	-	14	2
Atlanta peronii	216	24	130	20	-	18	2	20	2
Atlanta plana	3	-	-	-	-	-	-	1	2
Atlanta selvagensis	52	1	49	-	-	-	2[6]	-	-
Atlanta tokiokai	26	-	13	-	-	5	-	8	-
Atlanta turriculata	24	1	1	-	-	-	-	20	1
Atlanta vanderspoeli	1	-	-	-	-	-	-	-	1
Atlanta sp.	50	45	3	-	-	2	-	-	-
Oxygyrus inflatus	58	-	56	-	-	-	-	2	-
Oxygyrus keraudrenii[7]	51	18	11	15	-	5	1	-	1
Oxygyrus rangii[8]	5	1	-	1	-	-	3	-	-
Protatlanta souleyeti[9]	97	4	81	7	-	5	-	-	-
Totals	**909**	**122**	**532**	**64**	**-**	**58**	**13**	**104**	**16**

[1] Not yet registered lots, data only available from the label.
[2] Data not in register, but available from original publication (Wall-Palmer et al., 2016; all specimens from the Southern Subtropical Convergence Zone of the Atlantic and Indo-Pacific oceans).
[3] Junior synonym of *Atlanta brunnea*.
[4] Needs reidentification, *A. inflata* is not known to occur in the Atlantic or Caribbean (Janssen & Seapy, 2009).
[5] Neotype (Janssen, 2012b), synonym of *Atlanta peronii*.
[6] Needs reidentification, *A. selvagensis* is not known to occur in the Indian Ocean.
[7] Incorrect identification of *Oxygyrus inflatus*.
[8] Synonym of *Oxygyrus inflatus*.
[9] Needs reidentification: may include *Protatlanta sculpta* Issel, 1911 (Wall-Palmer et al., 2016).
[10] Junior synonym of *Atlanta inclinata*.

Table 4. RMNH collection of Recent Atlantidae; number of lots specified per region. Taxon names in bold indicate that the primary type material is in the RMNH collection.

THE RECENT COLLECTION (BVDB & JG)

The study of pelagic Mollusca has always been a niche within the field of malacology. The number of Dutch scientists, who have been or still are active in this niche, is not very large, but as a result of their various publications their influence has been or still is quite substantial. The first Dutch researcher, who actively studied pelagic molluscs was Johan Jacob Tesch (1877-1954). Tesch was a biologist at the Dutch Institute for Fishery Investigations, where he worked on population structures of commercially important North Sea fish. He graduated 11-5-1906 cum laude at Utrecht University (promotor A.A.W. Hubrecht) with a thesis on Pterotracheid pelagic molluscs obtained during the famous Dutch Siboga Expedition in the Indo-Pacific. From August 1907 to March 1908 and from 1915 to 1918 he

Figs 5-6. The Naturalis (RMNH) present-day mollusc collection; left the dry collection (glass vials or boxes in systematical order, right the alcohol collection.

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Carinariidae									
Cardiapoda placenta	15	-	1	-	-	-	-	11	3
Cardiapoda sublaevis[2]	3	-	-	-	-	-	-	3	-
Cardiapoda trachydermon[3]	2	-	-	-	-	-	-	2	-
Carinaria cithara	4	-	-	-	-	-	4	-	-
Carinaria cristata	12	6	-	-	-	-	-	6	-
Carinaria cymbium[4]	1	-	-	1	-	-	-	-	-
Carinaria galea	3	-	-	-	-	-	1	-	2
Carinaria lamarcki	25	4	7	9	-	1		4	-
Carinaria macrorhynchus[5]	1	-	-	-	-	-	-	1	-
Carinaria mediterranea[4]	19	8	-	11	-	-	-	-	-
Carinaria sp.	2	1	1	-	-	-	-	-	-
Pterosoma planum	1	1	-	-	-	-	-	-	-
Totals	**88**	**20**	**9**	**21**	**-**	**1**	**5**	**27**	**5**

[1] Not yet registered lots, data only available from the label.
[2] Synonym of *Cardiapoda placenta*, according to van der Spoel (1976: 157).
[3] Synonym of *Carinaria lamarck*i, according to van der Spoel (1976: 152).
[4] Synonym of *Carinaria cithara*, according to van der Spoel (1976: 155).
[5] Synonym of *Carinaria lamarcki*, according to the WoRMS website (accessed February 2020).

Table 5. RMNH collection of Recent Carinariidae; number of lots specified per region. Taxon names in bold indicate that the primary type material is in the RMNH collection.

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Pterotracheidae									
Firoloida desmarestia	18	8	4	5	-	-	1	-	-
Pterotrachea challengeri[3]	6	-	-	-	-	-	-	6	-
Pterotrachea coronata	215	210	-	1	-	-	-	4	-
Pterotrachea mutabilis[2]	6	-	-	-	-	-	-	6	-
Pterotrachea hippocampus	10	1	-	3	-	-	-	6	-
Pterotrachea intermedia[3]	3	-	-	-	-	-	-	3	-
Pterotrachea microptera[4]	7	-	-	-	-	-	-	7	-
Pterotrachea minuta	2	-	-	-	1	-	-	1	-
Pterotrachea mutica[2]	1	-	-	1	-	-	-	-	-
Pterotrachea orthophthalmus[2]	1	-	-	-	-	-	-	1	-
Pterotrachea scutata	3	-	2	-	-	-	-	-	1
Pterotrachea xenoptera[1]	1	-	-	-	-	-	-	1	-
Totals	**273**	**219**	**6**	**10**	**1**	**-**	**1**	**35**	**1**

[1] Not yet registered lots, data only available from the label.
[2] Synonym of *Pterotrachea hippocampus*, according to van der Spoel (1976: 161-162).
[3] Synonym of *Pterotrachea coronata*, according to van der Spoel (1976: 160).
[4] Possibly a synonym of *Pterotrachea minuta*, according to van der Spoel (1976: 163).

Table 6. RMNH collection of Recent Pterotracheidae; number of lots specified per region. Taxon names in bold indicate that the primary type material is in the RMNH collection.

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Epitoniidae									
Janthina bicolor[2]	1	-	-	1	-	-	-	-	-
Janthina capreolata[3]	3	-	-	-	-	-	-	-	3
Janthina exigua	56	20	29	2	-	1	3	-	1
Janthina fragilis[2]	3	1	-	-	2	-	-	-	-
Janthina globosa	111	45	4	3	-	37	6	8	8
Janthina janthina	274	153	23	7	2	47	15	2	22
Janthina pallida	36	21	8	2	-	4	-	-	1
Janthina prolongata[4]	5	-	-	-	-	2	-	-	3
Janthina rotundata[5]	1	-	1	-	-	-	-	-	-
Janthina umbilicata	22	7	1	2	-	9	2	-	1
Recluzia jehennei[6]	3	1	-	-	-	-	1	1	-
Janthina sp.	10	5	2	-	3	-	3	-	-
Recluzia rollandiana[6]	11	4	-	-	-	4	1	-	2
Epitoniidae indet.	4	1	1	-	-	-	1	-	1
Totals	**540**	**258**	**69**	**17**	**7**	**104**	**32**	**11**	**42**

[1] Not yet registered lots, data only available from the label.
[2] Synonym of *Janthina janthina*, acording to Beu (2017: 186).
[3] Synonym of *Janthina exigua*, according to Beu (2017: 191).
[4] Synonym of *Janthina globosa*, according to Beu (2017: 181).
[5] Synonym of *Janthina janthina*, acording to WoRMS.
[6] Synonym of *Recluzia lutea* (Bennett, 1840), according to Beu (2017: 203)

Table 7. RMNH collection of Recent Epitoniidae; number of lots specified per region.

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Heliconoididae									
Heliconoides inflatus	349	58	214	39	-	30	-	8	-
Family Limacinidae									
Limacina balea[2]	7	7	-	-	-	-	-	-	-
Limacina bulimoides	177	24	127	5	-	14	-	7	-
Limacina helicina antarctica	39	28	11	-	-	-	-	-	-
Limacina helicina helicina	6	4	2	-	-	-	-	-	-
Limacina helicina pacifica	1	-	-	-	-	-	-	-	1
Limacina lesueurii	130	4	121	-	-	3	1	1	-
Limacina retroversa	43	15	19	8[3]	-	-	1[4]	-	-
Limacina retroversa australis	3	-	3	-	-	-	-	-	-
Limacina trochiformis	9	3	3	1	-	1	1	-	-
Limacina sp.	57	17	14	25	-	1	-	-	-
Family Thieleidae									
Thielea helicoides	10	5	5	-	-	-	-	-	-
Totals	**831**	**165**	**519**	**78**	**-**	**49**	**3**	**16**	**1**

[1] Not yet registered lots, data only available from the label.
[2] Usually considered a forma of *L. retroversa*.
[3] Most probably Quaternary fossils (from sediment samples).
[4] Needs reidentification; *L. retroversa* is not known to occur in the Indian Ocean.

Table 8. RMNH collection of Recent Limacinacea; number of lots specified per region. Taxon names in bold indicate that the primary type material is in the RMNH collection.

was employed at the RMNH. Apart from his fishery studies he published between 1904 and 1950 twelve papers on pelagic molluscs from several expeditions, among which the Dana expeditions, the material of which is housed in Copenhagen. Two of his publicatons (1908, 1909) are dedicated to material in the Rijksmuseum van Natuurlijke Historie (RMNH), Leiden. The Siboga material originally was in the Zoological Museum, Amsterdam, but currently in the Naturalis museum.

The second Dutch biologist, who actively studied pelagic Mollusca is Siebrecht van der Spoel. Apart from his PhD-thesis (van der Spoel, 1967) he wrote another substantial work on pelagic Mollusca (van der Spoel, 1976). Van der Spoel was professor at the University of Amsterdam, organised various expeditions on the Atlantic Ocean and published numerous papers on pelagic Mollusca, alone or with co-workers or students. Part of the type-material of the various new taxa described in these papers is nowadays incorporated in the Naturalis collection.

Next to his work on fossil pelagic Mollusca Arie W. Janssen also worked on present-day pelagic Mollusca. He performed extensive identification- and registration-work, mostly on substantial ocean bottom sediment samples collected during the various RMNH expeditions on the Atlantic and in the Caribbean (such as the CANCAP, Mauritania or Saba Bank expeditions). He published various papers on present-day pelagic Mollusca, alone or with co-workers. The type-material of the various newly described taxa is incorporated in the Naturalis collections. In the past years a new Naturalis research group under the leadership of Dr. K.T.C.A. (Katja) Peijnenburg on the topic of development and evolution of pelagic Mollusca emerged (see next chapter).

The way of storing the present-day collections is shown in Figures 5-6. A survey and quantification of the RMNH pelagic mollusc collection is presented in Tables 4-17.

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Creseidae									
Creseis sp.	14	12	-	-	-	2	-	-	-
Creseis acicula	123	69	2	15	1	31	4	1	-
Creseis clava[2]	33	1	16	-	-	14	-	1	1
Creseis conica	32	-	23	-	-	4	-	5	-
Creseis virgula	99	29	32	13	1	19	1	2	2
Creseis virgula constricta[3]	2	1	1	-	-	-	-	-	-
Styliola subula	264	55	117	73	-	18	1	-	-
Subtotals	567	167	191	102	2	88	6	9	3
Family Hyalocylidae									
Hyalocylis striata	60	17	18	18	1	2	1	2	1
Totals	**627**	**184**	**209**	**119**	**3**	**90**	**7**	**11**	**4**

[1] Not yet registered lots, data only available from the label.
[2] Synonym of *Creseis acicula*.
[3] Usually considered a forma of *Boasia chierchiae* (Boas, 1886) s.lat..

Table 9. RMNH collection of Recent Creseidae and Hyalocylidae; number of lots specified per region. Taxon names in bold indicate that the primary type material is in the RMNH collection.

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Cuvierinidae									
Cuvierina atlantica	140	38	84	-	-	18	-	-	-
Cuvierina cancapae	25	-	22	-	-	3	-	-	-
Cuvierina columnella	30	15	3[2]	1[2]	-	2[2]	1	5	3
Cuvierina pacifica	1	-	-	-	-	-	-	-	1
Cuvierina tsudai	6	6	-	-	-	-	-	-	-
Cuvierina urceolaris	14	6	-	-	-	-	1	7	-
Totals	**216**	**65**	**109**	**1**	**-**	**23**	**2**	**12**	**4**

[1] Not yet registered lots, data only available from the label.
[2] Needs reidentification, *C. columnella* does not occur in the Atlantic, the Mediterranean or the Caribbean.

Table 10. RMNH collection of Recent Cuvierinidae; number of lots specified per region. Taxon names in bold indicate that the primary type material is in the RMNH collection.

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Cliidae									
Clio antarctica	232	230	-	-	-	-	-	-	2
Clio chaptalii	3	2	-	-	-	-	-	-	1
Clio convexa	5	2	-	3[2]	-	-	-	-	-
Clio cuspidata	89	46	12	28	-	3	-	-	-
Clio piatkowskii	384	383	1[3]	-	-	-	-	-	-
Clio polita	3	3	-	-	-	-	-	-	-
Clio pyramidata[4] s.lat.	1602	1512	13	65	2	9	-	-	1
Clio pyramidata excisa	6	-	-	6	-	-	-	-	-
Clio pyramidata lanceolata	340	193	125	3	-	14	-	5	-
Clio pyramidata pyramidata	115	115	-	-	-	-	-	-	-
Clio recurva	33	27	6	-	-	-	-	-	-
Clio sulcata	704	694	9	-	-	-	1	-	-
Clio sp.	11	6	2	3	-	-	-	-	-
Totals	**3527**	**3213**	**168**	**108**	**2**	**26**	**1**	**5**	**4**

[1] Not yet registered lots, data only available from the label.
[2] Needs reidentification, *Clio convexa* is not known to occur in the Mediterranean.
[3] Holotype (from Weddell Sea, Antarctic Ocean).
[4] The *C. pyramidata*-group needs reidentification.

Table 11. RMNH collection of Recent Cliidae; number of lots specified per region. Taxon names in bold indicate that the primary type material is in the RMNH collection.

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Cavoliniidae									
Cavoliniidae non det.[2]	162	162	-	-	-	-	-	-	-
Cavolinia gibbosa s.lat.	83	28	31	10	-	7	2	5	-
Cavolinia globulosa	157	150	-	-	-	-	2	5	-
Cavolinia inflexa s.lat.	275	40	173	35	-	25	-	1	1
Cavolinia tridentata s.lat.	153	36	64	9	-	34	2	6	2
Cavolinia tridentata atlantica	1[4]	-	1	-	-	-	-	-	-
Cavolinia tridentata bermudensis	1[4]	-	1	-	-	-	-	-	-
Cavolinia tridentata dakarensis	1[4]	-	1	-	-	-	-	-	-
Cavolinia tridentata danae	1[4]	-	-	-	-	-	1	-	-
Cavolinia tridentata teschi	2	-	-	-	-	-	-	2	-
Cavolinia tridentata tridentata	1	-	-	-	-	1	-	-	-
Cavolinia uncinata	144	40	42	1	2	34	1	23	1
Cavolinia uncinata pulsatapusilla	1[4]	-	-	-	1	-	-	-	-
Cavolinia uncinata pulsatoides	1[4]	-	-	-	1	-	-	-	-
Cavolinia sp.	49	48	-	-	-	-	-	1	-

Table 12. RMNH collection of Recent Cavoliniidae; number of lots specified per region. Taxon names in bold indicate that the primary type material is in the RMNH collection (continued on p. 238).

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Diacavolinia angulosa	10	2	-	-	-	-	-	8	-
Diacavolinia aspina	1	-	-	-	-	-	1	-	-
Diacavolinia atlantica	2	-	2	-	-	-	-	-	-
Diacavolinia bandaensis	2	-	-	-	-	-	-	2	-
Diacavolinia bicornis	1	-	-	-	-	-	1	-	-
Diacavolinia constricta	1	-	1	-	-	-	-	-	-
Diacavolinia deblainvillei	2	-	2	-	-	-	-	-	-
Diacavolinia deshayesi	1	-	1[5]	-	-	-	-	-	-
Diacavolinia elegans	1	-	-	-	-	-	-	1[5]	
Diacavolinia flexipes	16	2	-	-	10	-	-	2	2
Diacavolinia grayi	2	-	-	-	-	-	-	2	-
Diacavolinia limbata	2	2	-	-	-	-	-	-	-
Diacavolinia longirostris africana	2	-	2	-	-	-	-	-	-
Diacavolinia longirostris angulata[3]	1	-	-	-	-	-	-	1	-
Diacavolinia longirostris flexipes[3]	1	-	-	-	1	-	-	-	-
Diacavolinia longirostris longirostris	4	-	-	-	-	4	-	-	-
Diacavolinia longirostris s. lat.[6]	361	100	112	-	3	131	-	14	1
Diacavolinia ovalis	1	-	1	-	-	-	-	-	-
Diacavolinia pacifica	2	-	-	-	-	-	-	2	-
Diacavolinia robusta	1	-	1	-	-	-	-	-	-
Diacavolinia souleyeti	1	-	-	-	-	-	1[5]	-	-
Diacavolinia strangulata	1	1	-	-	-	-	-	-	-
Diacavolinia striata	1	-	-	-	-	-	1[5]	-	-
Diacavolinia triangulata	2	-	-	-	-	-	-	-	2
Diacavolinia vanutrechti vanutrechti	1	-	-	-	-	-	-	-	1[5]
Diacavolinia sp.	1	1	-	-	-	-	-	-	-
Diacria atlantica	2	-	-	2	-	-	-	-	-
Diacria major	16	-	15	-	-	-	-	1	-
Diacria rampalae	4	3	-	-	-	-	-	-	1[5]
Diacria rubecula	2	-	2	-	-	-	-	-	-
Diacria trispinosa trispinosa	552	341	149	14	-	42	-	5	1
Diacria trispinosa africana	1	-	1[5]	-	-	-	-	-	-
Diacria sp.	16	15	-	-	-	1	-	-	-
Telodiacria costata	8	-	-	-	-	-	-	8	-
Telodiacria danae	99	1	96	-	-	-	-	2	-
Telodiacria quadridentata	36	14	3	1	5	12	1	-	-
Telodiacria quadridentata erythra crassa	1	-	-	-	1[5]	-	-	-	-
Telodiacria quadridentata erythra erythra	1	-	-	-	1[5]	-	-	-	-
Telodiacria quadridentata quadridentata	6	-	4	-	-	2	-	-	-
Telodiacria quadridentata quadridentata f. *schmidti*	15	13	-	-	-	-	-	-	2[5]
Totals	**2212**	**999**	**705**	**72**	**25**	**293**	**13**	**91**	**14**

[1] Not yet registered lots, data only available from the label.
[2] Includes Creseidae s.lat.
[3] Probably includes more taxa
[4] Paratype (taxon unavailable)
[5] Paratype(s).
[6] Needs reidentification, may include more taxa.

Table 12, continued.

Name	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Peraclidae									
Peracle apicifulva[2]	5	1	-	4	-	-	-	-	-
Peracle bispinosa	20	4	16	-	-	-	-	-	-
Peracle diversa	18	4	6	8	-	-	-	-	-
Peracle elata	14	2	12	-	-	-	-	-	-
Peracle moluccensis	14	2	-	-	-	-	-	12	-
Peracle reticulata	51	5	33	13	-	-	-	-	-
Peracle reticulata minor[3]	2	-	-	-	-	-	-	2	-
Peracle rissoides[4]	1	-	-	-	-	-	-	1	-
Peracle triacantha[5]	3	1	2	-	-	-	-	-	-
Peracle valdiviae	1	1	-	-	-	-	-	-	-
Subtotals	129	20	69	25	-	-	-	15	-
Family Cymbuliidae									
Corolla calceola	1	-	-	-	-	-	-	-	-
Corolla cupula	1	-	1	-	-	-	-	-	-
Corolla intermedia	6	-	-	-	-	-	-	6	-
Corolla ovata	4	2	-	-	-	-	-	2	-
Corolla spectabilis	1	-	-	-	-	-	-	-	1
Corolla sp.	2	2	-	-	-	-	-	-	-
Cymbulia parvidentata	1	1	-	-	-	-	-	-	-
Cymbulia peronii	1182	1176	-	7	-	-	-	-	-
Cymbulia peronii minor	1	-	1	-	-	-	-	-	-
Cymbulia sibogae	4	-	-	-	-	-	-	4	-
Cymbulia sp.	57	57	-	-	-	-	-	-	-
Gleba cordata	5	3	-	2	-	-	-	-	-
Subtotals	1265	1241	2	9	-	-	-	12	1
Family Desmopteridae									
Desmopterus papilio	3	3	-	-	-	-	-	-	-
Totals	**1397**	**1264**	**71**	**34**	**-**	**-**	**-**	**27**	**1**

[1] Not yet registered lots, data only available from the label.
[2] Synonym of *Peracle diversa*.
[3] Synonym of *Peracle reticulata*, according to Tesch (1913: 73).
[4] Synonym of *Peracle reticulata*, according to van der Spoel (1976: 30).
[5] Synonym of *Peracle elata*.

Table 13. RMNH collection of Recent Pseudothecosomata; number of lots specified per region. Taxon names in bold indicate that the primary type material is in the RMNH collection.

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Pneumodermatidae									
Pneumoderma atlanticum[2]	2	2	-	-	-	-	-	-	-
Pneumoderma degraaffi	1	-	-	-	-	-	-	-	1
Pneumoderma heronensis	1	-	-	-	-	-	-	-	1
Pneumoderma mediterraneum	2	1	-	1	-	-	-	-	-
Pneumoderma violaceum	19	17	1	1	-	-	-	-	-
Pneumoderma violaceum souleyeti[2]	1	1	-	-	-	-	-	-	-
Pneumoderma heterocotylum	1	-	-	-	-	-	-	1	-
Pneumoderma pygmaeum[2]	3	-	-	-	-	-	-	3	-
Pneumoderma teschi	1	1	-	-	-	-	-	-	-
Pneumodermopsis ciliata	9	8	-	1	-	-	-	-	-
Pneumodermopsis michaelsarsi	2	1	1	-	-	-	-	-	-
Spongiobranchaea australis	237	236	-	-	-	-	1	-	-
Subtotals	279	267	2	3	-	-	1	4	2
Family Notobranchaeidae									
Notobranchaea bleekerae	1	-	1	-	-	-	-	-	-
Notobranchaea inopinata	1	1	-	-	-	-	-	-	-
Notobranchaea macdonaldi	7	7	-	-	-	-	-	-	-
Notobranchaea tetrabranchiata	3	3	-	-	-	-	-	-	-
Subtotals	12	11	1	-	-	-	-	-	-
Family Cliopsidae									
Cliopsis krohni	2	1	-	1	-	-	-	-	-
Cliopsis microcephalus[3]	1	1	-	-	-	-	-	-	-
Pruvotella danae	1	1	-	-	-	-	-	-	-
Subtotals	4	3	-	1	-	-	-	-	-
Family Clionidae									
Clione gracilis[4]	3	1	2	-	-	-	-	-	-
Clione limacina antarctica	6	5	1	-	-	-	-	-	-
Clione limacina meridionalis	1	-	1	-	-	-	-	-	-
Clione limacina s.lat.	561	551	6	-	-	-	-	-	4
Fowlerina punctata	1	-	-	-	-	-	-	1	-
Paedoclione doliiformis	1	-	-	1[5]	-	-	-	-	-
Paraclione flavescens	2	2	-	-	-	-	-	-	-
Paraclione pelseneeri	4	-	-	-	-	-	-	4	-
Thliptodon antarcticus	1	1	-	-	-	-	-	-	-
Thliptodon diaphanus	4	3	-	-	-	-	-	1	-
Thliptodon gegenbauri	1	1	-	-	-	-	-	-	-
Thliptodon schmidti	1	1	-	-	-	-	-	-	-
Subtotals	586	565	10	1	-	-	-	6	4

Table 14. RMNH collection of Recent Gymnosomata; number of lots specified per region. Taxon names in bold indicate that the primary type material is in the RMNH collection (continued on p. 241).

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Hydromylidae									
Hydromyles globulosus	122	110	-	-	-	-	-	12	-
Family Laginiopsidae (not represented)	-	-	-	-	-	-	-	-	-
Totals for Gymnosomata	**1003**	**956**	**13**	**5**	**-**	**-**	**1**	**22**	**6**

[1] Not yet registered lots, data only available from the label.
[2] Synonym of *Pneomoderma violaceum*.
[3] Synonym of *Cliopsis krohni* 'morph' *modesta,* according to van der Spoel (1976: 94).
[4] Forma of *Clione limacina*, according to van der Spoel (1967: 114).
[5] Needs reidentification, *Paedoclione doliiformis* is not known to occur in the Mediterranean. The record is for a shell, but Clionidae larval shells are not yet identifiable. Currently a correct identification would be 'Clionidae sp.'.

Table 14, continued.

	Number of lots	No data[1]	Atlantic Ocean	Mediterranean	Red Sea	Caribbean	Indian Ocean	Indonesia	Pacific
Family Phylliroidae									
Phylliroe bucephala	4	-	1	3	-	-	-	-	-
Family Fionidae									
Fiona pinnata	2	-	-	2	-	-	-	-	-
Family Glaucidae									
Glaucus atlanticus	1	-	-	-	-	-	1	-	-
Totals	**7**	**-**	**1**	**5**	**-**	**-**	**1**	**-**	**-**

[1] Not yet registered lots, data only available from the label.

Table 15. RMNH collection of Recent pelagic Nudibranchia; number of lots specified per region.

	Number of lots	No data	Atlantic Ocean	Mediter-ranean	Red Sea	Carib-bean	Indian Ocean	Indone-sia	Pacific
Pterotracheoidea									
Atlantidae	909	122	532	64	-	58	13	104	16
Pterotracheidae	273	219	6	10	1	-	1	35	1
Carinariidae	88	20	9	21	-	1	5	27	5
Epitonioidea									
Epitoniidae	540	258	69	17	7	104	32	11	42
Limacinoidea									
Heliconoididae	349	58	214	39	-	30	-	8	-
Limacinidae	472	102	300	39	-	19	3	8	1
Thieleidae	10	5	5	-	-	-	-	-	-
Cavolinioidea									
Creseidae	567	167	191	101	2	88	6	9	3
Hyalocylidae	60	17	18	18	1	2	1	2	1
Cuvierinidae	216	65	109	1	-	23	2	12	4
Cliidae	3527	3213	168	108	2	26	1	5	4
Cavoliniidae	2212	999	705	72	25	293	13	91	14
Cymbulioidea									
Peraclidae	129	20	69	25	-	-		15	-
Cymbuliidae	1265	1241	2	9	-	-	-	12	1
Desmopteridae	3	3	-	-	-	-	-	-	-
Clionoidea									
Pneumodermatidae	279	267	2	3	-	-	1	4	2
Notobranchaeidae	12	11	1	-	-	-	-	-	-
Cliopsidae	4	3	-	1	-	-	-	-	-
Clionidae	586	565	10	1	-	-	-	6	4
Hydromyloidea									
Hydromylidae	122	110	-	-	-	-	-	12	-
Laginiopsidae	-	-	-	-	-	-	-	-	-
Nudibranchia									
Glaucidae	1	-	-	-	-	-	1	-	-
Phylliroidae	4	-	1	3	-	-	-	-	-
Fionidae	2	-	-	2	-	-	-	-	-
Totals	**11.630**	**7.518**	**2.411**	**534**	**38**	**644**	**79**	**360**	**98**

Table 16. Recapitulation of Recent pelagic Mollusca in the RMNH collection; numbers of lots specified per region.

	shells	whole/soft[1]	not specified
Atlantidae	806	102	-
Carinariidae	44	46	-
Pterotracheidae	16	257	-
Epitoniidae	515	24	-
Limacinidae	418	54	-
Thieleidae	5	5	-
Creseidae	436	22	62
Hyalocylidae	47	13	-
Cuvierinidae	145	70	1
Cliidae	322	3150	55
Cavoliniidae	1652	547	6
Peraclidae	128	-	1

	shells	whole/soft[1]	not specified
Cymbuliidae	16	1249	-
Desmopteridae	-	3	-
Pneumodermatidae	1	278	-
Notobranchaeidae	-	12	-
Cliopsidae	-	3	1
Clionidae	3	583	-
Hydromylidae	-	122	-
Laginiopsidae	-	-	-
Phylliroidae	-	4	-
Fionidae	-	7	-
Glaucidae	-	1	-
Totals	**4.910**	**6.591**	**126**

[1] Whole organism or soft parts.

Table 17. Recapitulation of Recent pelagic Mollusca in the RMNH collection (left column predominantly dry collection, middle column alcohol collection, right column not specified in the register).

THE NATURALIS PLANKTON DIVERSITY AND EVOLUTION RESEARCH GROUP (KTCAP & AWJ)

In recent years there has been renewed interest in pelagic molluscs worldwide and at Naturalis, which resulted in a new research group, established in 2020, named 'Plankton Diversity and Evolution' and led by Dr. Katja Peijnenburg. The work on pelagic gastropods in this group has focussed on establishing species boundaries, biogeography and evolution, employing a combination of phylogenetic, morphological and genomic approaches. For this purpose, new collections were obtained during large oceanographic research expeditions mainly focussing on the Atlantic Ocean. These samplings were realised using different types of plankton nets such as Bongo nets (Fig. 7) or the Rectangular Midwater Trawl (Fig. 8), usually at night. Sorted samples of pelagic gastropods are available for three basin-scale transects (~45° North to ~45° South from 2012, 2014 and 2017) sampled in collaboration with the Atlantic Meridional Transect programme (https://www.amt-uk.org). In addition, samples of pelagic gastropods from several locations in the Indian and Pacific Oceans are available. These samples are mainly preserved in 96% ethanol and stored at -20°C to be suitable for molecular as well as morphological analyses. Samples that are used in publications have appropriate registration codes and data are accessible in public databases such as Barcode Of Life Data System (BOLD: https://www.boldsystems.org) and GenBank. In addition, analysed specimens have museum registration numbers, DNA vouchers are stored at -80°C and type specimens of newly described species have been added to the collection.

Fig. 8. Preparing the Rectangular Midwater Trawl (RMTFF) for sampling of zooplankton during Atlantic Meridional Transect 22 in 2012.

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Fig. 7. Sampling of zooplankton with a Bongo net during Atlantic Meridional Transect 27 in 2017.

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APPENDIX 1. STORAGE OF PYRITISED SPECIMENS (AWJ & RP)

Introduction

Long term preservation of pyritised fossils has always been a big problem in natural history collections, and there is extensive literature on the subject (see Howie, 1977a-b, 1978, 1979, 1992; Waller, 1987; Clark, 2003; Larkin, 2011; Cavallari et al., 2014, and references therein). Pyrite (FeS_2) is an unstable mineral that easily disintegrates when in contact with the atmosphere. Pyrite may replace fossils entirely, cover fossils, or fill cavities within. Many plant fossils have been found, in which tissues were completely replaced by pyrite, still preserving very fine details. Larger bones are sometimes filled or covered with pyrite. In the case of fossil molluscs usually the shell is filled with pyrite, but frequently the shell is dissolved, and only the internal pyrite mould remains. Especially the microcline type of pyrite is easily oxidised, but also other types of crystallisation are attacked.

Several treatments have been proposed. The minimal approach is to 'do nothing, it's no use'. Usual techniques involve covering the fossils with a natural or artificial resin, or another substance to prevent contact with air. Also pyritised specimens can be stored in various kinds of liquid (glycerine, paraffin oil, kerosine, even antifreeze, and silicone oil), treated with ammonium gas or closed-chamber treatment with ethanolamine thioglycollate (which required advanced laboratory facilities). For storage, specimens should be kept below a relative humidity of circa 45% (preferably 35% but certainly less than 60%) (Howie, 1992) and/or low oxygen levels (which needs micro- or macro-climate controlled storage). Another, but rather laborious method for the preservation of pyrite fossils is enclosing the specimens in blocks of artificial resin (Fig. 9). This method was applied in the Karl Gürs collection (see Gürs & Gürs, 1981). Air bubbles are difficult to avoid when embedding the specimens. The procedure, including polishing the blocks, is very timeconsuming.

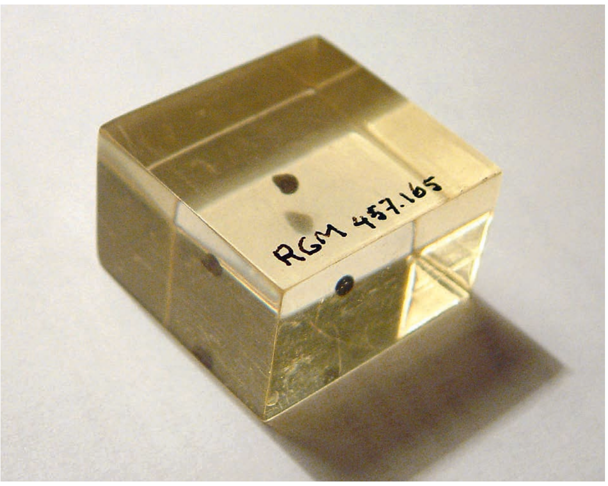


Fig. 9. RGM.457165, pyritic pteropod embedded in a block of artificial resin (donated by the late Karl Gürs).

Pyrite disintegration

Cadée (1961) formulated the deterioration of pyrite as follows:

$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2H_2SO_4 + 2FeSO_4$

(pyrite + oxygen + water → sulphuric acid + ferro sulphate)

In cases where the water soluble ferro sulphate is not removed (such as in collections) the ferro sulphate reacts with sulphuric acid and oxygen to form ferri sulphate:

$4FeSO_4 + 2H_2SO_4 + O_2 \rightarrow 2Fe_2(SO_4)_3 + 2H_2O$

(ferro sulphate + sulphuric acid + oxygen → ferri sulphate + water)

after which the ferri sulphate oxidises again:

$Fe_2(SO_4)_3 + H_2O \rightarrow 2FeSO_4 + H_2SO_4 + O$

(ferri sulphate + water → ferro sulphate + sulphuric acid + oxygen in statu nascendi)

Oxygen in statu nascendi of course strongly oxidises the pyrite:

$FeS_2 + 7O + H_2O \rightarrow FeSO_4 + H_2SO_4$

(pyrite + oxygen s.n. + water → ferro sulphate + sulphuric acid)

and the whole cycle starts all over again. If calcium carbonate is available (shells) it will be attacked by the sulphuric acid, and gypsum will precipitate:

$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$

(calcium carbonate + sulphuric acid → gypsum + carbon dioxide + water)

Similar reactions were proposed by Buurman (1970), who also noted the occurrence of the minerals goethite and jarosite in mollusc samples with oxidised pyrite.

Preservation methods used in the RGM collection

In the 1970s and early 1980s preventing pyrite disintegration in molluscs housed in the RGM collections was attempted by immersion of fossils in a solvent of acetone + any kind of 'plastic' glue (so-called 'placeton') or, applying a diluted mix of acetone and 'glyptal', a synthetic resin used for preserving fossil mammals bones. The general idea was to seal off the pyrite from air to prevent oxidation. Both methods seemed to be helpful initially, but in the long run it was clear that further disintegration of the pyrite could not be stopped in that way. Even carefully coated specimens seemed to be attacked from inside. Humidity is supposed to affect pyritic fossils most. Similar results were described by Neal Clark (2003), who wrote: 'We have had several carefully conserved specimens explode spectacularly due to pyrite "rot" building up under the protective skin of solvents.'

Fig. 10. Storage of pyritised pteropod samples in silicone oil, in upright glass vial, in polystyrene container, with labels separated, in standard RGM collection box.

Contact in 1986 with Mr John Cooper and Dr Peter Whybrow, of the (at that time) British Museum (Natural History), in London, led to the introduction of a strongly advised and entirely different way of preserving smaller pyritised fossils, viz. permanent immersion of specimens in silicone oil of a specifically prescribed type and extracting all air from the sample by using a vacuum pump. The type of silicone oil recommended was on sale from British Drug Houses (BDH) and indicated as DC 550 (viscosity 200/350 centistokes). Nowadays this type of silicone oil is widely available through many distributors. The inert silicone liquid is supposed to fill all fissures in the fossils and prevent air to come in contact. New oxygen or water from the air cannot reach the fossils in this way. To remove silicone oil from fossils for subsequent study many hydrocarbon solvents can be used, the least harmful and easiest available being white gas / solvent naphtha and white spirit / turpentine. This preservation method seemed so reliable and from the British Museum we experienced such favourable results that, after some tests, it was decided to transfer all Oligocene mollusc lots containing pyrite into silicone oil. For the purpose of smaller fossils special glass containers are used (with a plastic clip cap) that have to be stored upright, separate from labels, as the high surface tension of the silicone makes horizontal storage of the vials virtually impossible (Fig. 10). If stored horizontally, a thin layer of oil will creep onto the external surface of the vials as the plastic caps do not close them sufficiently. A small label with registration number is kept in the vials, together with the fossils. Lots in silicone oil are stored together with 'dry' lots, in drawer cabinets.

Ever since this system was initiated, over a thousand lots in silicone oil have been added to the holoplanktic mollusc collection. More than half of these lots (541) were obtained from the Landesamt für Natur und Umwelt Schleswig-Holstein, at Flintbek, Germany, through the mediation of the late Dr Karl Gürs, to which institute we 'guaranteed' the long-lasting preservation of the specimens in silicone oil. This procedure was finished in 1997, but afterwards additionally obtained specimens were added. Also a large collection, received on loan from the Instytut Nauk Geologicznych PAN, Zaklad Geologii Dynamicznej, at Kraków, Poland, was returned after publication (Janssen & Zorn, 1993), predominantly stored in silicone oil. The present state of this collection is not known.

Early 2003, when placing newly obtained material into the collection, it was discovered that some of the smaller labels bearing the registration numbers, inside the silicone vials, showed brown staining (Fig. 11).

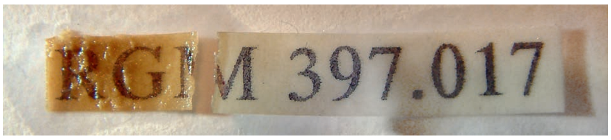


Fig. 11. Label attacked by pyrite disintegration, kept in vial with silicone oil.

Closer inspection, under a binocular microscope, revealed that in such samples, unexpectedly, pyrite specimens had severely disintegrated. It was found that quite a number of samples showed similar characteristics and an inventory of the damage seemed necessary. Apparently disintegration of pyrite, that practically always has started already before the specimens are picked, identified, registered and stored, had continued in spite of immersion in silicone oil. Frequently such silicone storage (especially in the case of borehole samples) takes place several to even many years after the moment of collecting the material, giving enough time to start the destructive process. The initial idea, that immersion in silicone oil would stop disintegration of pyrite evidently appeared to be wrong. An inventory of the state of the collection was executed in August 2003, by inspecting all silicone lots, estimating the amount of damage in four grades (see also Fig. 12):

1 bad – all specimens are to be considered lost;
2 mainly bad – one or few specimens may still be recognisable;
3 mainly good – most specimens still recognisable, but sample clearly attacked;
4 good – all specimens recognisable, but some disintegration may be visible.

Brown colouring of the label with the registration number occurred only in those samples in which disintegration was bad or mainly bad. In some larger lots even the polyethylene cap of the vials showed brown discoloration.

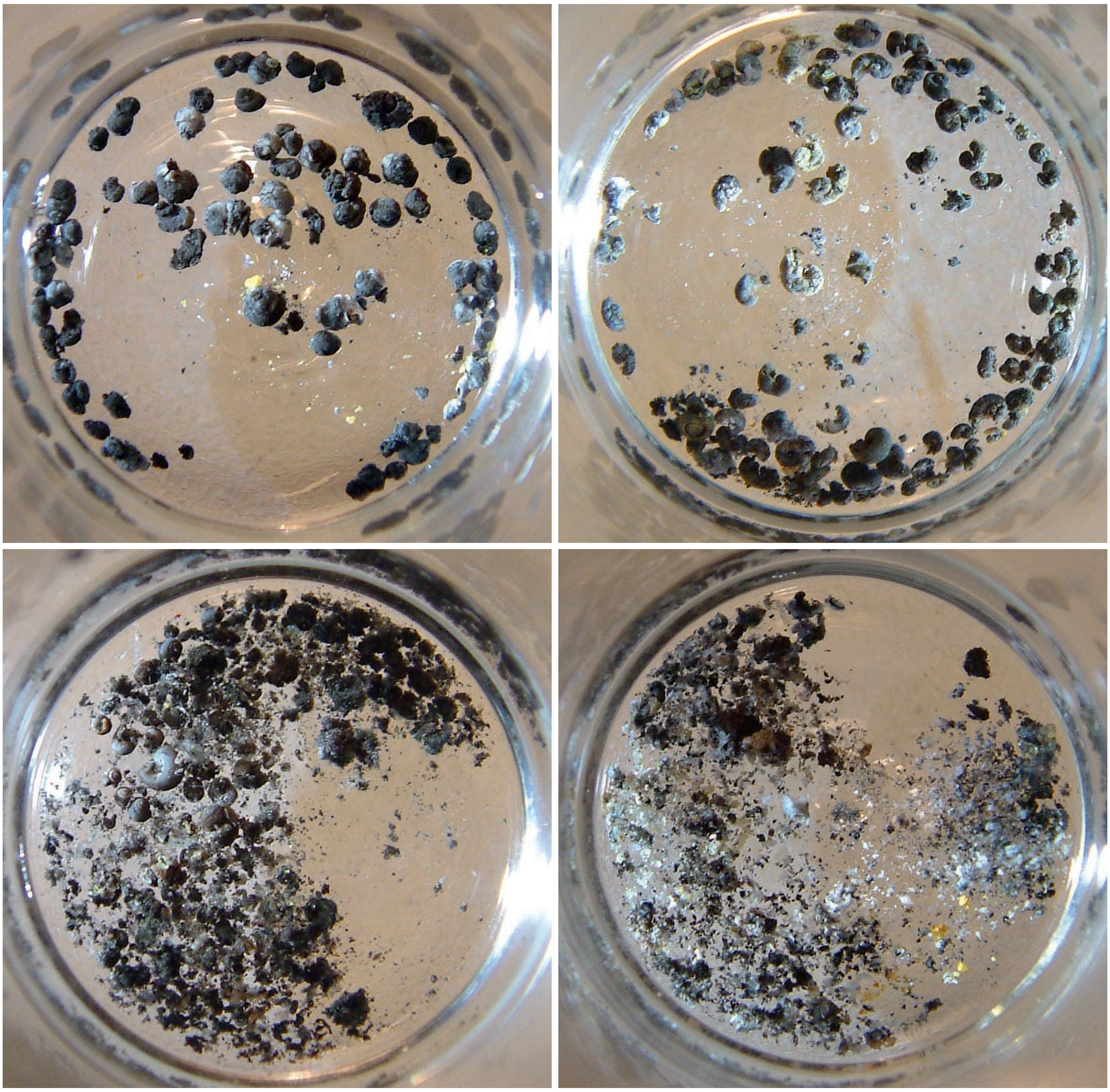


Fig. 12. Pyritised limacinid pteropods preserved in silicone oil, from upper left to lower right in good, mainly good, mainly bad and bad condition, respectively. *Limacina valvatina* (RGM.457059), indicated 'good', *Limacina miorostralis* (RGM.396519), indicated 'mainly good', *Limacina valvatina* (RGM.395976), indicated 'mainly bad', *Limacina atlanta* (RGM.397017), indicated 'bad'. Diameter of glass vial 18 mm.

Quantification of the damage

A total of 1.067 lots of holoplanktic molluscs in silicone oil were inspected, and the state of each sample was noted according to the four grades described above. The results were:

bad	186 lots	= 17.4%
mainly bad	114 lots	= 10.7%
mainly good	77 lots	= 7.2%
good	690 lots	= 64.7%

which means that more than a quarter of the samples were in bad condition. The 300 lots that have to be considered lost, or mainly lost, unfortunately include several holotypes, and quite a number of paratypes and/or illustrated specimens.

Holotypes of the species *Limacina ingridae, L. irisae, L. jessyae* and *Clio blinkae* are lost. Four other type specimens, however, are still in good condition: *Limacina mariae, L. wilhelminae, Creseis berthae* and *Clio jacobae*. All these species were introduced in Janssen (1989) and immersed in the silicone oil at the same time. For the first mentioned group of types a number of (paratype) lots are still in good condition. If the database with the results of the inventory is sorted by locality it becomes immediately clear, that the condition of the specimens usually is not identical for samples of the same origin. Even in series from the same borehole, from which samples may be supposed to be collected and immersed more or less simultaneously, the condition may vary considerably. Some examples are given in Table 18.

The boreholes Karlum and Reinfeld are the only ones in which all samples are still in good condition. Most probably those series were studied and curated shortly after the boreholes were made. Most samples collected after 1997 (ever since the collection was housed in Malta, see Appendix 2) have not been treated with a vacuum pump, as such equipment was not available there. However, the series of samples from Kruibeke was curated in Leiden (1988), where a vacuum pump was available, and more than half of the lots were in bad or mainly bad condition in 2003. According to F.P. Wesselingh, who was curator of the collection in 2003, especially thin-walled shells, such as *Thyasira* spp., kept in the silicone collection of fossil benthic molluscs housed in Leiden (mainly Oligocene of the North Sea Basin) suffered from disintegration. The damage, however, is less dramatic. Early 2020, when preparing the present paper, it was intended to execute another check of silicone lots, to find out if the damage has progressed since the first check in 2003. However, the COVID-19 crisis made work in the collection impossible. Consequently that task has to be postponed to a later date.

Future curation

According to the literature on pyrite preservation the best method to keep pyrite samples in good condition is housing them in environments with a low (c. 45%) relative humidity (RH) and low oxygen. The store rooms of Naturalis have a RH of 50%. For the majority of specimens, however, silicone immersion still seems to be a good method, provided that samples are curated as soon as possible after collecting. A certain amount of loss has to be accepted. A good suggestion might be to immerse specimens immediately when they are isolated from their original sediment samples, and not wait for identification and further curation. Possible application of silica gel, as in use for some products in the pharmaceutical industry, was suggested by the late Dr Karl Gürs as a solution for dry storage. An inquiry about these possibilities at 'Fisher Group Ltd. Airconditioning' at Glasgow (https://www.fishergroup.co.uk/) sent together with a description of the situation, resulted in the following answer (Mr Philip Handley, email dated August 18, 2003).

'From the paper you attached it seems that the major problem is not so much with moisture but with oxidation causing deterioration. Using a dessicant will have no effect on this at all and, in fact, having too dry an atmosphere could be detrimental as your samples may have "waters of crystallisation" as part of the mineral content. Dehydration could lead to the disintegration of the crystals. I would recommend the use of silicon oil to act as a barrier to air or moisture. If you must have a dessicant and oxygen free atmosphere then I would recommend the use of silica gel and an inert replacement atmosphere such as nitrogen.'

Clean pyrite does not have 'waters of crystallisation' (contrary to its weathering products goethite and jarosite), so after all application of silica gel might be helpful. In the latter case application of silica gel powder or grains, separated from the dry fossils by some cotton wool in a glass vial with tight screw cap might represent a long lasting solution. Creating a microclimate with not only low RH but also low oxygen levels will give the best results for dry storage. This can be achieved by storing the samples in a sealed bag or tightly closed box, using both a dessicant like silicagel and an oxygen scavenger (Larkin, 2011).

Condition	Good	Mainly good	Mainly bad	Bad
Bargfeld (borehole, 28 lots)	12	-	2	14
Bönningstedt (borehole, 74 lots)	60	8	3	3
Bovenau (borehole, 31 lots)	14	4	4	9
Glinde (borehole, 15 lots)	4	2	-	9
Gross Pampau (borehole, 57 lots)	35	7	11	4
IJsselmuiden (borehole, 54 lots)	39	3	-	12
Kaltenkirchen (borehole (97 lots)	41	10	21	25
Karlum (boreholes, 57 lots)	57	-	-	-
Kruibeke (claypit, 33 lots)	13	2	8	10
Lübtheen (borehole, 73 lots)	69	2	2	-
Opende (borehole, 46 lots)	16	1	8	21
Reinfeld (borehole, 47 lots)	47	-	-	-
Rösing (borehole, 30 lots)	20	5	3	2
Springhirsch (borehole, 22 lots)	9	6	4	3
Viöl (borehole, 23 lots)	22	1	-	-

Table 18. Quantification of preservation condition of pyritised pteropod lots from various borehole- or outcrop locations.

APPENDIX 2. HISTORY OF THE RGM MALTA COLLECTION (AWJ)

In 1981 D'Alessandro & Robba published their study of pteropods from Miocene deposits in Puglia, southern Italy, which covered two main areas of research, namely Gargano and Salento. Material from the Gargano localities, such as Sannicola Varano, was available in the Leiden RGM collection. Specimens from the Salento localities (Melpignano and Cursi), however, were not yet represented and in 1992 the first author (AWJ) decided to attempt some collecting there during a trip in southern Italy. Several localities in the area were sampled successfully and rich material was obtained. Puzzling in that material was the occurrence of the species *Cavolinia cookei* Simonelli, 1895 (Fig. 13), according to D'Alessandro & Robba (1981: 659) originally described from the Early Miocene (Aquitanian) Lower Globigerina Limestone of Malta. Surprisingly, however, the same species was also recorded from much younger (Langhian) rocks of northern Italy, as described by Robba (1971). The assemblages from Salento were dated as 'reworked from deposits of Late Langhian to Early Serravallian age', which made an Aquitanian age of the *C. cookei* type material unexplainable. Did these type specimens indeed originate from the Lower Globigerina Limestones in Malta? These deliberations led to a visit to the Maltese Archipelago during the same 1992 trip.

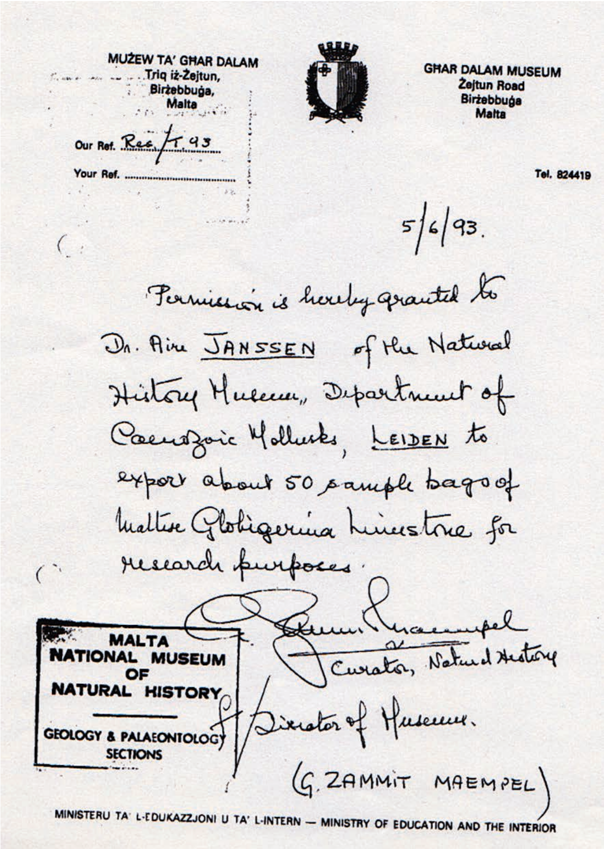
In Malta contact was made with the at that time curator of the Maltese National Museum of Natural History in Mdina and the Għar Dalam Cave and Museum in Birzebbuġia, Dr George Zammit Maempel (Fig. 14). Explaining the problem

Fig. 14. Dr George Zammit Maempel, during a visit to AWJ's working room at Xewkija, Gozo, August 2004.

of the origin of the pteropod *Cavolinia cookei* resulted in his immediate and enthusiastic cooperation and he demonstrated several outcrops on the main island of Malta. And indeed, the species was rather easily traced in several localities that were all located in the Upper Globigerina Limestone that is of a Langhian age. Together with Dr Zammit Maempel the information given in the publication of Simonelli (1895) was analysed. That author gave detailed stratigraphical data, inclusive of a composite section of Maltese rocks, supplied by the collector of the specimens, J.H. Cooke. Dr Zammit Maempel, being very well acquainted with Maltese stratigraphy, soon found out that the various layers composing Simonelli's section were upside down and that the lower layers of Simonelli that had yielded the *C. cookei* in reality represented the upper ones and so it was clear that the *C. cookei* type material was not of Aquitanian, but rather of Langhian age, agreeing with the occurrence in northern Italy (and also those in Gargano).

During the initial field work in Malta it was immediately clear how rich in pteropods various outcrops on the island are. Only the species *C. cookei* was documented from Malta, as well as some records of *Vaginella* sp. in older literature. In some of the outcrops pteropods occur by the thousands of specimens, in a wide range of species diversity. Collecting of this material was the second favourable result of this trip and it was followed by a second visit later in the same year and several ones in the following years, resulting in

Fig. 13. Specimens of *Cavolinia cookei* Simonelli, 1895 in phosphoritic internal mould preservation, from the Maltese Upper Globigerina Limestone Member (Langhian); specimen size approximately 6 mm.



MUŻEW TA' GHAR DALAM
Triq iż-Żejtun,
Birżebbuġa,
Malta

GHAR DALAM MUSEUM
Żejtun Road
Birżebbuġa
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5/6/93.

Permission is hereby granted to Dr. Arie JANSSEN of the Natural History Museum, Department of Caenozoic Molluscs, LEIDEN to export about 50 sample bags of Maltese Globigerina Limestone for research purposes.

MALTA NATIONAL MUSEUM OF NATURAL HISTORY
GEOLOGY & PALAEONTOLOGY SECTIONS

Curator, Natural History
Director of Museums.
(G. ZAMMIT MAEMPEL)

MINISTERU TA' L-EDUKAZZJONI U TA' L-INTERN — MINISTRY OF EDUCATION AND THE INTERIOR

Fig. 15. Example of export permit of Maltese palaeontological samples to The Netherlands, issued by Dr G. Zammit Maempel, June 1993.

an extensive pteropod collection. All collected material was exported to the Netherlands on the basis of export permits issued by Dr Zammit Maempel (see Fig. 15 for an example).

These frequent visits led to the decision of the author's emigration from the Netherlands to Malta after retirement from Naturalis in 1997. Residence was found in the village of Xewkija on the second Maltese island, Gozo, where also numerous interesting outcrops are accessible. The complete RGM collection of fossil holoplanktic molluscs, then existing of about 8.000 lots, was permitted on long-term loan to Malta and was subsequently housed in the author's premises in Xewkija (Fig. 16). Dr Zammit Maempel issued another permit stating that the collection was the property of the Leiden museum and that re-exportation from Malta was permitted when no longer needed.

A first paper on Maltese geology, including the description of a very common but yet unnamed pteropod species (*Gamopleura melitensis*[1] Janssen, 1995), was published in Facies (Rehfeld & Janssen, 1995). Several further new species were introduced in 2004, in the local periodical 'The Central Mediterranean Naturalist' (Janssen, 2004). Ultimately the study of the Maltese holoplanktic molluscs led to the publication of a voluminous monograph (> 400 pp) with the description of 85 species (20 of which new to science) and a biozonation based on the pteropods of the Maltese Late Oligocene and Miocene rocks, augmented with non-Maltese data to be valid for the entire Mediterranean Basin (Janssen, 2012). A collection of several hundred lots of Maltese 'microfossils', among which many pteropod species, was composed already in 2003 and donated to the National Natural History Museum in Mdina, Malta.

Problems concerning the formal status of the Maltese collection material started in 2007, when it was found that the Maltese government, already in 2002, had issued a 'Maltese Heritage Act' (https://wipolex.wipo.int/en/text/201428) covering the protection of Maltese cultural heritage objects, inclusive of palaeontological ones. Ultimately this situation led to long deliberations, but in 2017 it appeared to be possible to return the collection to the Netherlands on the basis of the originally issued permits. Currently the Maltese material is integrated in the main fossil pelagic mollusc collection where it will be accessible for any researcher.

[1] This cavoliniid species is very common in part of the Globigerina Limestone of Malta and it is as far as known the only fossil pteropod with a local vernacular name. The common presence of this 'qanneb' indicates bad quality of building stone (Zammit Maempel, 1982: 11).

Fig. 16. The RGM fossil pelagic mollusc collection in the house of AWJ, ca 2002. The cardboard boxes on top of the drawers contain the hundreds of RMNH lots of present-day specimens for identification and registration.

APPENDIX 3. SYSTEMATIC LIST OF VALID PELAGIC MOLLUSC SPECIES, FOSSIL AND RECENT (awj, ktcap, dwp)

Here we present a list of all species of pelagic (non-bottom-dwelling, cephalopods excluded) Mollusca we know and that we consider to be valid, with a rough indication of stratigraphic range (stages, E = Early, M = Middle, L = Late) and geographical distribution. The list is composed for the Pteropoda on the basis of the (simplified) table S4 of Peijnenburg et al. (2020) with minor additions and corrections and including the new family- and genus-names published since Rampal (2019). Pteropoda higher systematics are as proposed by Peijnenburg et al. (2020). The Pterotracheoidea and Nudibranchia parts of the list are based on our own observation, completed with data from the existing literature and several websites. The Epitoniidae are from Beu (2017). The list includes 505 taxa, 216 of which are currently living species, many of which also have a fossil record. Additionally, we include a list of Mesozoic taxa for which currently a pelagic way of life has been convincibly argued for (see Nützel et al., 2016).

Class Gastropoda		
Subclass Caenogastropoda		
Order Littorinimorpha		
Superfamily Pterotracheoidea		
Family Atlantidae		
Atlanta arenularia Gougerot & Braillon, 1965	Bartonian	France
Atlanta ariejansseni Wall-Palmer et al., 2016	present-day	circumglobal southern temperate
Atlanta brunnea Gray, 1850	Eemian - present-day	circumglobal tropic/subtropic
Atlanta californiensis Seapy & Richter, 1993	present-day	Pacific, California Current, northern temperate
Atlanta cordiformis Gabb, 1873	L Miocene ?	Dominican Republic
Atlanta diamesa Woodring, 1928	Piacenzian	Jamaica
Atlanta echinogyra Richter, 1972	Piacenzian? - present-day	Indopacific tropic/subtropic
Atlanta fragilis Richter, 1993	present-day	circumglobal tropic/subtropic
Atlanta frontieri Richter, 1993	present-day	Indopacific tropic/subtropic
Atlanta gaudichaudi Gray, 1850	Piacenzian - present-day	circumglobal tropic/subtropic
Atlanta gibbosa Souleyet, 1852	present-day	circumglobal tropic/subtropic
Atlanta helicinoidea Gray, 1850	Calabrian - present-day	circumglobal tropic/subtropic
Atlanta inclinata Gray, 1850	Gelasian - present-day	circumglobal tropic
Atlanta inflata Gray, 1850	Gelasian - present-day	Indopacific tropic/subtropic
Atlanta lesueurii Gray, 1850	Piacenzian - present-day	circumglobal tropic
Atlanta lingayanensis Janssen, 2007	Piacenzian	Philippines
Atlanta meteori Richter, 1972	present-day	circumglobal tropic/subtropic
Atlanta oligogyra Tesch, 1906	Piacenzian - present-day	circumglobal tropic/subtropic
Atlanta peronii Lesueur, 1817	Piacenzian - present-day	circumglobal tropic/subtropic
Atlanta plana Richter, 1972	Messinian - present-day	Indopacific tropic/subtropic
Atlanta richteri Janssen, 2007	Piacenzian	Philippines
Atlanta rosea Gray, 1850	present-day	circumglobal tropic/subtropic
Atlanta seapyi Janssen, 2007	Piacenzian	Philippines
Atlanta selvagensis De Vera & Seapy, 2006	present-day	Atlantic tropic/subtropic
Atlanta tokiokai van der Spoel & Troost, 1972	Piacenzian - present-day	circumglobal tropic/subtropic
Atlanta turriculata d'Orbigny, 1836	Gelasian - present-day	Indopacific tropic/subtropic
Atlanta vanderspoeli Wall-Palmer et al., 2019	present-day	Pacific southern tropic/subtropic
Atlantidea rotundata (Gabb, 1873)	Langhian - Piacenzian	Caribbean, Fiji
Mioatlanta soluta Di Geronimo, 1974	Langhian	Italy
Oxygyrus inflatus Benson, 1835	Eemian-present-day	circumglobal tropic/subtropic
Protatlanta kbiraensis Janssen, 2012	Langhian	Malta
Protatlanta sculpta Issel, 1911	Piacenzian - present-day	Atlantic tropic/subtropic; fossils from Indian Ocean, Philippines
Protalanta souleyeti (Smith, 1888)	Piacenzian - present-day	circumglobal tropic/subtropic

Family Pterotracheidae		
Firoloida desmarestia Lesueur, 1817	Eemian - present-day	circumglobal tropic/subtropic
Pterotrachea coronata Forsskål *in* Niebuhr, 1775	present-day	tropic/subtropic Atlantic, Pacific?
Pterotrachea hippocampus Philippi, 1836	present-day	no data
Pterotrachea keraudrenii Gray, 1850	present-day	no data
Pterotrachea scutata Gegenbaur, 1855	present-day	no data
Family Carinariidae		
Cardiapoda placenta (Lesson, 1830)	present-day	Indonesia (New Guinea)
Cardiapoda richardi Vayssière, 1904	present-day	Atlantic, Pacific
Carinaria cithara Benson, 1835	present-day	equatorial Indo-Pacific
Carinaria cristata (Linné, 1767)	present-day	Indo-Pacific
Carinaria galea Benson, 1835	present-day	Indo-Pacific
Carinaria japonica Okutani, 1955	present-day	NE Pacific
Carinaria lamarcki Péron & Lesueur, 1810	present-day	Atlantic-Pacific tropic/subtropic
Carinaria maempeli Janssen, 2012	Langhian	Mediterranean
Carinaria mirabilis Cossmann, 1902	Lutetian	France
Carinaria pseudorugosa Vayssière, 1904	present-day	N Atlantic
Carinaria rutschi Robba, 1972	Langhian	Mediterranean
Pterosoma planum Lesson, 1827	present-day	Indo-Pacific
Striocarinaria hugardi (Pictet, 1855)	Burdigalian	Mediterranean
Order ?		
Superfamily Epitonioidea		
Family Epitoniidae		
Janthina chavani (Ludbrook, 1978)	L Piacenzian - Calabrian	Atlantic, Pacific
Janthina exigua Lamarck, 1816	Holocene	circumglobal tropic/subtropic
Janthina globosa Swainson, 1822	Piacenzian - present-day	circumglobal tropic/subtropic
Janthina janthina (Linnaeus, 1758)	present-day	circumglobal tropic/subtropic
Janthina krejcii Beu, 2017	Zanclean	Azores
Janthina pallida Thomson, 1840	present-day	(almost) circumglobal, tropic/subtrop
Janthina typica (Bronn, 1861)	Messinian - L Piacenzian	Atlantic, Pacific
Janthina umbilicata d'Orbigny, 1841	present-day	circumglobal tropic/subtropic
Recluzia johnii (Holten, 1802)	present-day	tropical Indo-West Pacific, Red Sea
Recluzia lutea (Bennett, 1840)	present-day	circumglobal tropic/subtropic
Subclass Heterobranchia		
Infraclass Euthyneura		
Subterclass Tectipleura		
Order Pteropoda		
Suborder Thecosomata		
Subterorder Euthecosomata		
Superfamily Limacinoidea		
Family Heliconoididae		
Heliconoides atypicus (Laws, 1944)	Chattian - Aquitanian	New Zealand
Heliconoides auriformis (Curry, 1982)	ML Ypresian	SW France
Heliconoides bartonensis (Curry, 1965)	L Lutetian - Bartonian	W Europe, USA
Heliconoides curryi (Janssen, 1990)	Chattian	S Australia
Heliconoides daguini Janssen, 2010	ML Ypresian-Lutetian	SW France
Heliconoides dilatata (von Koenen, 1892)	Priabonian - E Rupelian	E Germany, Ukraine
Heliconoides ferax (Laws, 1944)	Burdigalian	New Zealand
Heliconoides hodgkinsoni Garvie, 2020	L Lutetian	U.S.A.
Heliconoides hospes (Rolle, 1862)	Rupelian - Chattian	North Sea Basin, Aquitaine Basin
Heliconoides inflatus (d'Orbigny, 1834)	Chattian - present-day	Circumglobal, tropic/subtropic
Heliconoides lillebaeltensis Janssen, 2007	L Lutetian	Denmark

Heliconoides linneensis Janssen, 2008	Chattian	Aquitaine Basin
Heliconoides lunatus (Janssen, 1990)	Chattian	Australia
Heliconoides mercinensis (Watelet & Lef., 1885)	Thanetian - Ypresian	W Europe, USA, Iran, Uzbekistan
Heliconoides merlei Janssen, 2010	ML Ypresian	SW France
Heliconoides mermuysi Janssen, 2010	Burdigalian	Aquitaine Basin
Heliconoides nemoris (Curry, 1965)	L Lutetian - Priabonian	North Sea Basin, Aquitaine Basin
Heliconoides nikkieae Janssen, 2017	Priabonian - Rupelian	Tanzania
Heliconoides nitens (Lea, 1833)	Lutetian - Bartonian	W Europe, U.S.A., Japan, Nigeria
Heliconoides paula (Curry, 1982)	ML Ypresian	Aquitaine Basin
Heliconoides planus (Tembrock, 1964)	Rupelian	Poland
Heliconoides pyrenaicus Janssen, 2010	ML Ypresian	Aquitaine Basin
Heliconoides sondaari Janssen, 2007	Piacenzian	Philippines, Fiji
Heliconoides stenzeli (Garvie, 1992)	Lutetian	USA
Heliconoides tatei (Janssen, 1990)	Langhian - Serravallian	Australia
Heliconoides taylori (Curry, 1965)	Ypresian	W Europe, USA?
Heliconoides tertiarius (Tate, 1887)	Langhian - Serravallian	Australia, Mediterranean
Heliconoides texanus (Garvie & Hodgkinson, 1992)	Lutetian	USA
Heliconoides vanderweideni Janssen, 2004	Chattian	Mediterranean
Heliconoides vonhachti Janssen, 2012	Zanclean	Mediterranean
Heliconoides wardijaensis Janssen, 2004	Chattian	Mediterranean
Family Limacinidae		
Altaspiratella bearnensis (Curry, 1982)	M-L Ypresian - Lutetian	Europe, USA, Tanzania, New Zealand?
Altaspiratella choctavensis (Aldrich, 1887)	L Ypresian	USA
Altaspiratella elongatoidea (Aldrich, 1887)	L Ypresian	USA
Altaspiratella gracilens Hodgkinson, 1992	L Ypresian - L Lutetian ?	USA, Iran
Altaspiratella labiata (Hodgkinson, 1992)	Bartonian	USA
Altaspiratella multispira (Curry, 1982)	M-L Ypresian	SW France, USA ?
Altaspiratella tavianii Janssen, 2013	L Ypresian - L Lutetian	Iran
Currylimacina cossmanni (Curry, 1982)	ML Ypresian - Lutetian	W Europe, USA
Currylimacina asperita Garvie, 2020	L Lutetian	USA
Limacina acutimarginata (Korobkov, 1966)	Rupelian	Russia, W Europe
Limacina adornata Hodgkinson, 1992	Bartonian	USA
Limacina aegis Hodgkinson, 1992	Ypresian	USA
Limacina andrussowi (Kittl, 1886)	Langhian	Mediterranean
Limacina antarctica Woodward, 1854	present-day	Antarctic
Limacina aryanaensis Janssen, 2013	L Ypresian - E Lutetian	Iran
Limacina asiatica Janssen, 2011	L Ypresian - E Lutetian	Uzbekistan
Limacina atlanta (Mörch, 1874)	Messinian - Piacenzian	W Europe, Mediterranean
Limacina bulimoides (d'Orbigny, 1834)	Burdigalian - present-day	circumglobal tropics/subtropics
Limacina canadaensis Hodgkinon, 1992	Bartonian - ? Rupelian	USA, Canada, Japan
Limacina conica (von Koenen, 1892)	Priabonian - Rupelian	North Sea Basin
Limacina convolutus Hodgkinson, 1992	Lutetian	Texas, U.S.A.
Limacina davidi Hodgkinson, 1992	E Ypresian	Canada
Limacina dzheroiensis Janssen, 2011	L Ypresian - E Lutetian	Uzbekistan
Limacina erasmiana Janssen, 2010	Ypresian	Kazakhstan, Uzbekistan, North Sea Basin
Limacina ernstkittli Janssen, 2012	Rupelian - Chattian	North Sea Basin, Malta
Limacina exceptispira (lKorobkov, 1966)	Rupelian	Paratethys
Limacina gormani (Curry, 1982)	M-L Ypresian	Aquitaine Basin, North Sea Basin
Limacina gramensis (Rasmussen, 1968)	Langhian ? - Tortonian	North Sea Basin, Poland, Australia
Limacina guersi Janssen, 2010	Ypresian	North Sea Basin
Limacina heatherae Hodgkinson 1992	Eocene ?	U.S.A.
Limacina helicina helicina (Phipps, 1774)	present-day	Arctic
Limacina helicina ochotensis Shkoldina, 1999	present-day	NW Pacific

Limacina helicina pacifica Dall, 1871	present-day	N Pacific
Limacina helicina rangii (d'Orbigny, 1835)	present-day	Antarctic
Limacina helikos Hodgkinson, 1992	Ypresian	N America
Limacina ingridae Janssen, 1989	Serravallian	North Sea Basin
Limacina irisae Janssen, 1989	Serravallian	North Sea Basin
Limacina karasawai Ando, 2011	Priabonian - L Rupelian	Japan, USA
Limacina konkensis (Zhizhchenko, 1937)	Miocene	Paratethys
Limacina lesueurii (d'Orbigny, 1836)	Saalian - present-day	circumglobal tropic/subtropic
Limacina lotschi (Tembrock, 1989)	Priabonian - E Rupelian	North Sea Basin
Limacina mariae Janssen, 1989	Priabonian - E Rupelian	North Sea Basin
Limacina minima (Zhizhchenko, 1937)	? Miocene	Paratethys
Limacina novacaesarea Janssen & Sessa, 2016	Ypresian	NE USA
Limacina nucleata (Zhizhchenko, 1934)	Langhian ?	Prearal, Russia
Limacina parvabrazensis Garvie & Janssen, 2020	L Lutetian	USA
Limacina perforata Janssen, 2013	L Ypresian - E Lutetian	Iran
Limacina planorbella (Korobkov, 1966)	Rupelian	Paratethys
Limacina pseudopygmaea Garvie & Janssen, 2019	L Lutetian	USA
Limacina pseudoumbilicata (Korobkov, 1966)	Rupelian	Paratethys
Limacina pygmaea (Lamarck, 1805)	ML Ypresian - Lutetian	W Europe
Limacina retroversa retroversa (Fleming, 1823)	Saalian - present-day	N Atlantic, Mediterranean
Limacina retroversa australis (Eydoux & Souleyet, 1840)	present-day	Australia
Limacina robusta (Eames, 1952)	Priabonian	India, Tanzania
Limacina smithvillensis Hodgkinson, 1992	Lutetian	USA
Limacina subtarchanenis (Zhizhchenko, 1936)	Miocene	Paratethys (Crimea)
Limacina tanzaniaensis Janssen, 2017	Priabonian	Tanzania
Limacina tarchanensis (Kittl, 1886)	Langhian	Ukraine, Paratethys
Limacina texanopsis Garvie, 2020	Lutetian	USA
Limacina timi Janssen, 2017	Priabonian - Rupelian	Tanzania
Limacina trochiformis (d'Orbigny, 1834)	Saalian - present-day	tropics/subtropics
Limacina tschokrakensis (Zhizhchenko, 1934)	Langhian ?	Prearal, Russia
Limacina tutelina (Curry, 1965)	Ypresian	North Sea Basin, USA
Limacina ujiharai Shibata, 1983	Miocene	Japan
Limacina umbilicata (Bornemann, 1855)	Rupelian	North Sea Basin, USA?
Limacina valvatina (Reuss, 1867)	Chattian - Langhian	Europe, ?Australia
Limacina variospirata (Korobkov, 1966)	Rupelian	Paratethys
Limacina vegrandis Janssen, 2010	ML Ypresian - Lutetian	W Europe
Limacina voluta Hodgkinson, 1992	ML ? Eocene	Canada
Limacina wechesensis Hodgkinson, 1992	Lutetian	USA
Limacina wilhelminae Janssen, 1989	Tortonian - Messinian	North Sea Basin, Spain
Limacina yasdii Janssen *in* Janssen et al., 2013	L Ypresian - E Lutetian	Iran
Striolimacina andaensis Janssen, 2007	Piacenzian	Philippines, Fiji
Striolimacina imitans (Collins, 1934)	Zanclean	USA, Mediterranean
Family Thieleidae		
Thielea helicoides (Jeffreys, 1877)	Tortonian - present-day	Mediterranean, Atlantic
Superfamily Cavolinioidea		
Family Creseidae		
Boasia chierchiae chierchiae (Boas, 1886)	present-day	tropic/subtropic, Indo-Pacific, patchy
Boasia chierchiae constricta (Chen & Bé, 1964)	Langhian - present-day	Australia, Philippines, tropic/subtropic circumglobal
Bovicornu eocenense Meyer, 1886	Rupelian	USA
Bovicornu gracile Meyer, 1887	L Bartonian - Priabonian	USA
Bowdenatheca jamaicensis Collins, 1934	Messinian - Piacenzian	Caribbean, Italy
Bowdenatheca miocenica Janssen, 2004	Chattian	Malta

Bucanoides basiannulata Hodgkinson, 1992	Lutetian	USA
Bucanoides divaricata Hodgkinson, 1992	Bartonian	USA
Bucanoides tenuis Hodgkinson, 1992	Bartonian	USA
Camptoceratops americanus Garvie, 1992	Lutetian	USA
Camptoceratops priscus (Godwin-Austen, 1882)	ML Ypresian	W. Europe, USA
Cheilospicata cedrus Garvie, 2020	Lutetian	USA
Cheilospicata repanda Hodgkinson & Garvie, 1992	Bartonian	USA
Creseis acicula (Rang, 1828)	Zanclean - present-day	tropic/subtropic, circumglobal
Creseis antoni Janssen, 2010	Rupelian	SW France, Canada?
Creseis berthae Janssen, 1989 (Annelida?)	Rupelian	North Sea Basin
Creseis conica Eschscholtz, 1829	Eemian - present-day	tropic/subtropic, circumglobal
Creseis corpulenta (Meyer, 1887)	Bartonian, Priabonian	USA, SW France
Creseis curta Janssen, 2012	Langhian	Malta
Creseis cylindrica Hodgkinson, 1992	Bartonian	USA
Creseis roesti Janssen, 2010	L Aquitanian	Aquitaine Basin
Creseis simplex (Meyer, 1886)	M Lutetian - Priabonian	W Europe, USA
Creseis spina (Reuss, 1867)	Bartonian - Zanclean	W-S Europe, USA
Creseis tugurii Janssen, 2010	Burdigalian	Aquitaine Basin
Creseis virgula (Rang, 1828)	present-day	tropic/subtropic, circumglobal?
Euchilotheca elegans Harris, 1894	Ypresian - Lutetian	W Europe, Uzbekistan
Euchilotheca ganensis Curry, 1982	ML Ypresian	SW Europe
Euchilotheca succincta (Defrance, 1828)	Lutetian - ? Bartonian	W Europe, USA
Loxibidens aduncus Hodgkinson, 1992	Lutetian	USA
Styliola schembriorum Janssen, 2012	Langhian	Mediterranean
Styliola subula (Quoy & Gaimard, 1827)	Chattian - present-day	tropic/subtropic circumglobal
Thecopsella fischeri Cossmann, 1888	Lutetian	W Europe
Tibiella annulata Garvie, 1992	Lutetian	USA
Tibiella marshi Meyer, 1884	Bartonian	USA
Tibiella reflexa Hodgkinson, 1992	Bartonian	USA
Tibiella texana Collins, 1934	Lutetian	USA
Tibiella watapuruensis Janssen, 2013	E Bartonian	Indonesia
Family Hyalocylidae		
Hyalocylis marginata Janssen, 2007	Piacenzian	Philippines, Fiji?
Hyalocylis striata (Rang, 1828)	? Miocene - present-day	tropics, subtropics circumglobal
Praehyalocylis maxima (Ludwig, 1864)	Priabonian - Rupelian	North Sea Basin, France (Paris, Mayence, Aquitane)
Family Praecuvierinidae		
Praecuvierina lura (Hodgkinson, 1992)	Lutetian	USA, SW France
Texacuvierina gutta (Hodgkinson, 1992)	Bartonian	USA
Texacuvierina hodgkinsoni Janssen, 2013	L Ypresian - L Lutetian	Uzbekistan
Family Cuvierinidae		
Cuvierina astesana (Rang, 1829)	Zanclean	Mediterranean, Mexico?, Dominican Republic?
Cuvierina atlantica Bé et al, 1972	present-day	Atlantic, Caribbean
Cuvierina cancapae Janssen, 2005	present-day	C Atlantic, Caribbean
Cuvierina columnella (Rang, 1827)	present-day	Indo-Pacific Ocean
Cuvierina curryi Janssen, 2005	Langhian	Mediterranean
Cuvierina grandis D'Alessandro & Robba, 1981	Serravallian	Mediterranean
Cuvierina inflata (Bellardi, 1873)	Tortonian	Mediterranean
Cuvierina intermedia (Bellardi, 1873)	Serravallian	Portugal, Mediterranean, Fiji, ?Japan
Cuvierina jagti Janssen, 1995	Tortonian	Mediterranean
Cuvierina ludbrooki (Caprotti, 1962)	Piacenzian	Mediterranean
Cuvierina pacifica Janssen, 2005	present-day	Pacific Ocean
Cuvierina paronai Checchia-Rispoli, 1921	Langhian	Mediterranean, C Paratethys
Cuvierina torpedo (Marshall, 1918)	Aquitanian	New Zealand

Cuvierina tsudai Burridge et al., 2016	present-day	Pacific Ocean
Cuvierina urceolaris (Mörch, 1850)	Piacenzian - present-day	tropic/subtropic Indo-Pacific
Ireneia calandrellii (Michelotti, 1847)	L Burdigalian	Mediterranean, New Zealand, Chili
Ireneia gracilis Janssen, 2005	Burdigalian - Langhian	Mediterranean
Ireneia marqueti Janssen, 1995	Tortonian - Messinian ?	North Sea Basin
Ireneia nieulandei Janssen, 1995	Burdigalian	Aquitaine Basin, New Zealand, Patagonia?
Ireneia tenuistriata (Semper, 1861)	Chattian	North Sea Basin
Ireneia testudinaria (Michelotti, 1847)	L Burdigalian	Mediterranean
Johnjagtia baharensis Janssen, 2012	Chattian - Aquitanian	Malta
Johnjagtia moulinsi (Benoist, 1873)	Burdigalian	Aquitaine Basin
Spoelia torquayensis Janssen, 1990	Chattian - Aquitanian	Australia, Mediterranean, Aquitaine Basin
Family Cliidae		
Clio aichinoi Checchia-Rispoli, 1921	Langhian	Italy
Clio andreae (Boas, 1886)	present-day	Atlantic, Pacific
Clio antarctica Dall, 1908	present-day	Antarctic
Clio bellardii Audenino, 1899	Langhian	Mediterranean, North Sea Basin?
Clio berglundorum Squires, 1989	Oligocene (Rupelian ?)	USA
Clio bittneri (Kittl, 1886)	Langhian	Paratethys
Clio blinkae Janssen, 1989	Rupelian	North Sea Basin
Clio braidensis (Bellardi, 1873)	Zanclean	Mediterranean
Clio calix (Bellardi, 1873)	Aquitanian ?	Italy
Clio caralitana Robba & Spano, 1978	Langhian	Sardinia
Clio carinata Audenino, 1899	Burdigalian	Mediterranean
Clio chadumica Korobkov, 1966	Rupelian	Russia, USA
Clio chaptalii Gray, 1850	present-day	tropics, subtropics circumglobal
Clio coebana Robba, 1972	Chattian - Aquitanian	Mediterranean
Clio collina Janssen & Zorn, 2001	Burdigalian - Langhian	Italy
Clio convexa convexa (Boas, 1886)	Piacenzian - present-day	Indo-Pacific
Clio convexa cyphosa Rampal, 2002	present-day	Red Sea
Clio cuspidata (Bosc, 1801)	Piacenzian - present-day	tropics, subtropics circumglobal
Clio deflexa von Koenen, 1882	Aquitanian	North Sea Basin
Clio distefanoi Checchia-Rispoli, 1921	Langhian	Mediterranean
Clio fallauxi (Kittl, 1886)	Langhian	C Paratethys
Clio gailae Goedert & Janssen, 2020	Chattian	USA
Clio garganica Sirna, 1968	Langhian	Mediterranean
Clio ghawdexensis Janssen, 2004	Chattian	Malta
Clio giulioi Janssen, 1995	Tortonian	Mediterranean
Clio goedertorum Squires, 1989	E Miocene	USA
Clio guidottii Simonelli, 1896	Zanclean	Mediterranean
Clio hataii (Noda, 1972)	Zanclean	Japan, Philippines?
Clio itoigawai Shibata, 1983	E ? Miocene	Japan
Clio jacobae Janssen, 1989	Rupelian	North Sea Basin
Clio lavayssei Rutsch, 1934	Langhian ?	Trinidad
Clio lozoueti Janssen, 2010	Chattian	Aquitaine Basin
Clio lucai Janssen, 2000	Calabrian	Italy
Clio merijni Janssen, 2012	Chattian	Malta
Clio multicostata (Bellardi, 1873)	Serravallian	Mediterranean
Clio nielseni Janssen, 1990	Chattian	North Sea Basin, SW France
Clio nuda Korobkov, 1966	L Eocene	Paratethys
Clio oblonga Rampal, 1996	L Pleistocene	Mediterranean
Clio ortheziana (Benoist, 1889)	Serravallian	Aquitaine Basin
Clio pauli Janssen, 1989	Langhian	North Sea Basin
Clio pedemontana (Mayer, 1868)	Aquitanian ?- Langhian	Mediterranean

Clio piatkowskii van der Spoel et al., 1992	present-day	Antarctic
Clio polita Pelseneer, 1888	present-day	Atlantic
Clio pulcherrima (Mayer, 1868)	Langhian	Mediterranean, Caribbean?
Clio pyramidata angusta (Boas, 1886)	present-day	N Atlantic
Clio pyramidata pyramidata Linné, 1767	Tortonian - present-day	tropical/subtropical circumglobal
Clio pyramidata tyrrhenica Janssen, 2012	L Pleistocene	Mediterranean
Clio recurva (Children, 1823)	present-day	tropical/subtropical circumglobal
Clio ricciolii (Calandrelli, 1844)	Piacenzian	Italy
Clio saccoi Checchia-Rispoli, 1921	Langhian	Mediterranean
Clio scheelei (Munthe, 1888)	present-day	South Africa (Cape Horn)
Clio sinuosa (Bellardi, 1873)	Serravallian	Italy
Clio sturanii Robba, 1977	Serravallian	Italy
Clio sulcosa (Bellardi, 1873)	Burdigalian - Langhian	Italy
Clio superba Fuchs, 1902	Oligocene ?	?Czech Republlic, ?USA
Clio triplicata Audenino, 1899	Aquitanian - Langhian	Mediterranean, New Zealand
Clio vasconiensis Janssen, 2010	Chattian	Aquitaine Basin
Clio vilis Janssen, 2012	Chattian	Malta
Clio yatsuoensis Shibata, 1983	Miocene	Japan
Family Cavoliniidae		
Subfamily Cavoliniinae		
Cavolinia baniensis Janssen, 2007	Piacenzian	Philippines
Cavolinia bituminata Beets, 1953	Tortonian - Messinian	Indonesia
Cavolinia cookei Simonelli, 1895	Langhian	Mediterranean
Cavolinia floridana Collins, 1934	M-L Pliocene	USA, Mediterranean, ? Japan
Cavolinia gatti Janssen, 2012	Serravallian - Tortonian	Mediterranean
Cavolinia gibbosa flava (d'Orbigny, 1834)	present-day	Atlantic, Mediterranean, ?Pacific
Cavolinia gibbosa gibboides Rampal, 2002	present-day	E Mediterranean
Cavolinia gibbosa gibbosa (d'Orbigny, 1834)	present-day	Pacific, ?Atlantic
Cavolinia gibbosa plana (Meisenheimer, 1905)	present-day	Pacific
Cavolinia globulosa (Gray, 1850)	present-day	tropics/subtropics circumglobal
Cavolinia grandis (Bellardi, 1873)	Zanclean	Mediterranean, New Zealand
Cavolinia gypsorum (Bellardi, 1873)	Tortonian - Messinian	Mediterranean, Fiji
Cavolinia inflexa imitans (Pfeffer, 1880)	present-day	tropical/subtropical, circumglobal
Cavolinia inflexa inflexa (Lesueur, 1813)	present-day	tropical/subtropical, mainly Atlantic
Cavolinia inflexa kakegawaensis Shibata, 1984	Piacenzian ?	Japan
Cavolinia inflexa labiata (d'Orbigny, 1834)	present-day	Indo-Pacific
Cavolinia inflexa robusta Rampal, 2002	present-day	Mediterranean
Cavolinia landaui Janssen, 2004	Piacenzian	Spain, Philippines
Cavolinia longicostata Rampal, 2002	present-day	NW Mediterranean
Cavolinia marginata hyugaensis Ujihara, 1996	Zanclean	Japan, Philippines
Cavolinia marginata limatula Beets, 1943	Tortonian/Messinian	Indonesia
Cavolinia marginata marginata (Bronn, 1862)	Zanclean	Azores
Cavolinia marginata pliomediterranea Janssen, 2004	Piacenzian	Spain
Cavolinia marginata vendryesiana (Guppy, 1873)	Piacenzian	Jamaica
Cavolinia mexicana (Collins, 1934)	Tortonian ? - Zanclean	Caribbean, Japan, Fiji, Indonesia
Cavolinia microbesitas Janssen, 2012	Langhian - L Burdigalian	Italy, Malta
Cavolinia pachysoma Rampal, 2002	present-day	NW Mediterranean
Cavolinia perparvula Janssen, 2007	Piacenzian	Philippines
Cavolinia pycna Jung, 1971	Langhian	Caribbean, Mediterranean
Cavolinia shibatai Janssen, 2007	Piacenzian	Spain, Philippines
Cavolinia tridentata (Niebuhr, 1775)	Piacenzian - present-day	tropical/subtropical circumglobal
Cavolinia uncinata (d'Orbigny, 1835)	present-day	tropical/subtropical circumglobal
Cavolinia ventricosa (Guppy, 1882)	Piacenzian	Caribbean, Philippines

Cavolinia yamabensis Shibata, 1983	Aquitanian - Burdigalian	Japan
Cavolinia zamboninii Checchia-Rispoli, 1921	Langhian	Mediterranean
Diacavolinia angulata (Souleyet, 1852)	present-day	tropics, Indian Ocean
Diacavolinia angulosa (Gray, 1850)	present-day	Indian Ocean
Diacavolinia aspina van der Spoel et al., 1993	present-day	tropical Atlantic
Diacavolinia atlantica van der Spoel et al., 1993	present-day	Indonesia
Diacavolinia bandaensis van der Spoel et al., 1993	present-day	Indonesia
Diacavolinia bicornis van der Spoel et al., 1993	present-day	tropical W Atlantic
Diacavolinia constricta van der Spoel et al., 1993	present-day	tropical Atlantic
Diacavolinia deblainvillei van der Spoel et al., 1993	present-day	tropical W Atlantic
Diacavolinia deshayesi van der Spoel et al., 1993	present-day	tropical/subtropical W Atlantic
Diacavolinia elegans van der Spoel et al., 1993	present-day	N Atlantic, C Pacific
Diacavolinia flexipes van der Spoel et al., 1993	present-day	tropical Atlantic
Diacavolinia grayi van der Spoel et al., 1993	present-day	tropical Atlantic
Diacavolinia limbata (d'Orbigny, 1836)	present-day	tropical Atlantic
Diacavolinia longirostris (de Blainville, 1821)	present-day	tropics, Atlantic, Indonesia
Diacavolinia mcgowani van der Spoel et al., 1993	present-day	Caribbean
Diacavolinia ovalis van der Spoel et al., 1993	present-day	N Atlantic
Diacavolinia pacifica van der Spoel et al., 1993	present-day	Indo-Pacific
Diacavolinia pristina Janssen, 2007	Piacenzian	Philippines
Diacavolinia robusta van der Spoel et al., 1993	present-day	central W Atlantic
Diacavolinia souleyeti van der Spoel et al., 1993	present-day	Indian Ocean
Diacavolinia strangulata (Deshayes, 1823)	present-day	central W Atlantic
Diacavolinia striata van der Spoel et al., 1993	present-day	Indian Ocean
Diacavolinia triangulata van der Spoel et al., 1993	present-day	Indian Ocean
Diacavolinia vanutrechti van der Spoel et al., 1993	present-day	Pacific
Gamopleura maxwelli Grebneff & Janssen, 2011	Chattian	New Zealand
Gamopleura melitensis Janssen, 1995	Chattian - ?Burdigalian	Malta
Gamopleura pilula Janssen, 2012	Burdigalian	Malta
Gamopleura taurinensis (Michelotti, 1847)	Burdigalian?	Mediterranean, Aquitaine Basin
Subfamily Diacriinae		
Diacria digitata (Guppy, 1882)	Piacenzian	Jamaica
Diacria italica fissicostata Janssen, 2007	Piacenzian	Philippines, Italy
Diacria italica italica Grecchi, 1982	Piacenzian	Mediterranean
Diacria major (Boas, 1886)	present-day	Atlantic, Pacific
Diacria mbaensis Ladd, 1934	Tortonian - Messinian	Fiji, Indonesia
Diacria microstriata Janssen, 2007	Piacenzian	Philippines, Fiji
Diacria paeninsula Janssen, 2007	Piacenzian	Philippines
Diacria piccola Bleeker & van der Spoel, 1988	present-day	Phillippines
Diacria rampalae Dupont, 1979	present-day	Caribbean
Diacria sangiorgii Scarsella, 1934	Tortonian	Mediterranean
Diacria trispinosa (de Blainville, 1821)	Messinian - present-day	Circumglobal tropic/subtropic
Diacrolinia aquensis (Grateloup, 1827)	Burdigalian	France
Diacrolinia aurita (Bellardi, 1873)	Langhian	N. Sea Basin, C. Paratethys, Mediterranean
Diacrolinia cluzaudi Janssen, 2010	L Aquitanian	Aquitaine Basin
Diacrolinia elioi Janssen, 1995	Tortonian	Mediterranean
Diacrolinia interrupta (Bellardi, 1873)	Burdigalian	Mediterranean
Diacrolinia larandaensis Janssen, 1999	Serravallian	Turkey, N. Italy
Diacrolinia orbignyi (Rang, 1827)	Burdigalian	Aquitaine Basin
Diacrolinia pumilionis Janssen, 2012	Langhian	Malta
Diacrolinia revoluta (Bellardi, 1873)	Burdigalian	Mediterranean
Telodiacria costata (Pfeffer, 1879)	present-day	Pacific
Telodiacria danae (van Leyen & van der Spoel, 1982)	present-day	circum tropical/subtropical

Telodiacria erythra (van Leyen & van der Spoel, 1982)	present-day	Red Sea
Telodiacria philippinensis (Janssen, 2007)	Piacenzian	Philippines, Fiji
Telodiacria quadridentata (de Blainville, 1821)	present-day	C Atlantic
Telodiacria schmidti (van Leyen & v.d. Spoel, 1982)	present-day	C + S Pacific
Subfamily Vaginellinae n. subfam.		
Edithinella bonaviai Janssen, 2004	Langhian	Malta
Edithinella caribbeana (Collins, 1934)	L Serravallian	Panama, Mediterranean, Aquitaine Basin
Edithinella curva Janssen, 1998	Langhian	Malta
Edithinella doliarius Janssen, 2006	Langhian	Malta
Edithinella katoi (Shibata, 1983)	Miocene	Japan
Edithinella varanica (Sirna, 1968)	Langhian	Mediterranean, Aquitaine Basin
Vaginella acutissima Audenino, 1899	L Langhian	Mediterranean
Vaginella austriaca Kittl, 1886	L Burdigalian - Langhian	Paratethys, North Sea Basin, Aquitaine Basin
Vaginella basitruncata Janssen, 2005	Chattian	North Sea Basin
Vaginella bicarinata Tate, 1887	Langhian	Australia
Vaginella chattica R. Janssen, 1979	Chattian	North Sea Basin, Aquitaine Basin, Mediterranean
Vaginella chipolana Dall, 1893	Burdigalian ?	Caribbean
Vaginella depressa Daudin, 1800	Aquitanian	Europe, Caribbean, Japan, Australia, New Zealand
Vaginella floridana Collins, 1934	Aquitanian/Burdigalian	USA
Vaginella gaasensis Janssen, 2010	Rupelian	France
Vaginella gibbosa Audenino, 1899	Langhian	Mediterranean
Vaginella lapugyensis Kittl, 1886	Langhian	W Europe, C. Paratethys, Meditteranean, Australia?
Vaginella sannicola Janssen, 1990	Langhian	Mediterranean
Vaginella tricuspidata Zorn & Janssen, 1993	Chattian	Aquitaine Basin, C. Paratethys, Mediterranean
Vaginella venezuelana Collins, 1934	Chattian - Aquitanian	Malta, Venezuela
Vaginella victoriae Janssen, 1990	Burdigalian	Australia, Aquitaine Basin, Mediterranean
Family Sphaerocinidae		
Hameconia edmundi Janssen, 2008	Chattian	Aquitaine Basin
Sphaerocina convolvula Janssen, 2007	Piacenzian	Philippines, Fiji
Sphaerocina formai (Audenino, 1899)	Langhian	Mediterranean
Suborder Pseudothecosomata		
Family Cymbuliidae		
Corolla calceola (Verrill, 1880)	present-day	Atlantic, W Pacific?
Corolla cupula Rampal, 1996	present-day	S Atlantic
Corolla intermedia (Tesch, 1903)	present-day	subtropical Atlantic, E Indian Ocean
Corolla ovata (Quoy & Gaimard, 1833)	present-day	tropical Atlantic, Pacific
Corolla spectabilis Dall, 1871	present-day	tropics, W Pacific, E Atlantic?
Cymbulia parvidentata Pelseneer, 1888	present-day	circumglobal
Cymbulia peronii de Blainville, 1818	present-day	Atlantic
Cymbulia sibogae Tesch, 1903	present-day	tropical Atlantic/Indo-Pacific
Cymbulia tricavernosa Zhang 1964	present-day	China
Gleba chrysosticta (Troschel, 1854)	present-day	S Atlantic, E Indian Ocean
Gleba cordata Forsskål *in* Niebuhr, 1776	Eemian - present-day	global, tropic/subtropic
Family Desmopteridae		
Desmopterus gardineri Tesch, 1910	present-day	Indian Ocean
Desmopterus pacificus Essenberg, 1919	present-day	NE Pacific
Desmopterus papilio Chun, 1889	present-day	tropics, subtropics circumglobal
Family Peraclidae		
Peracle amberae Janssen 2012	Chattian	Malta
Peracle bispinosa (Pelseneer, 1888)	Piacenzian - present-day	Atlantic
Peracle charlotteae Janssen & Little, 2010	Langhian	Cyprus
Peracle depressa Meisenheimer, 1906	present-day	Atlantic
Peracle diversa (Monterosato, 1875)	present-day	Atlantic, Mediterranean

Peracle elata (Seguenza, 1875)	present-day	Atlantic
Peracle grebneffi Janssen, 2012	Langhian	Mediterranean
Peracle lata (Krach, 1981)	Langhian	Poland
Peracle michaelsarsi (Bonnevie, 1913)	present-day	N Atlantic
Peracle moluccensis (Tesch, 1903)	present-day	tropical Indo-Pacific
Peracle philiporum (Gilmer, 1990)	present-day	Bahamas
Peracle reticulata (d'Orbigny, 1834)	Zanclean - present-day	tropics, subtropics circumglobal
Peracle rissoides Tesch, 1903	present-day	Indonesia
Peracle valdiviae (Meisenheimer, 1905)	present-day	Indian Ocean
Suborder Gymnosomata		
Superfamily Clionoidea		
Family Cliopsidae		
Cliopsis krohni Troschel, 1854	present-day	tropics, subtropical circumglobal
Pruvotella danae Pruvot-Fol, 1942	present-day	N Atlantic, S Indo-Pacific
Pruvotella pellucida (Quoy & Gaimard, 1832)	present-day	Indian Ocean, Indonesia
Family Clionidae		
Cephalobranchia bonnevii Massy, 1917	present-day	N Atlantic
Cephalobranchia macrochaeta Bonnevie, 1913	present-day	N Atlantic, trop. Indo-Pacific
Clione elegantissima Dall, 1871	present-day	NW Pacific
Clione limacina antarctica Smith, 1902	present-day	Antarctic
Clione limacina limacina (Phipps, 1774)	present-day	northern oceans
Clione okhotensis Yamazaki & Kumahara, 2017	present-day	Okhotsk Sea, Japan
Clione? *ignota* Janssen, 2012	Chattian - Langhian	Mediterranean
Clione? *imdinaensis* Janssen, 2012	Chattian - Langhian	Mediterranean
Clione? *phosphorita* Janssen, 2012	Chattian - Langhian	Mediterranean
Clione? *tripartita* Janssen, 2012	Langhian	Mediterranean
Clione? *tumidula* Janssen, 2012	Chattian - Langhian	Mediterranean
Fowlerina punctata (Tesch, 1903)	present-day	central N Atlantic, Indonesia
Fowlerina zetesios Pelseneer, 1906	present-day	NE Atlantic
Massya longecirrata (Massy, 1917)	present-day	NE Atlantic
Paedoclione doliiformis Danforth, 1907	present-day	NW Atlantic
Paraclione flavescens (Gegenbaur, 1855)	present-day	C Mediterranean
Paraclione longicaudata (Souleyet, 1852)	present-day	Tropical/subtropical Atlantic, Indo-West Pacific
Paraclione pelseneeri Tesch, 1903	present-day	Indonesia
Thalassopterus zancleus Kwietniewski, 1910	present-day	Mediterranean, W Indian Ocean
Thliptodon akatukai Tokioka, 1950	present-day	Japan
Thliptodon antarcticus Meisenheimer, 1906	present-day	Antarctic
Thliptodon diaphanus (Meisenheimer, 1902)	present-day	Tropical/subtropical Atlantic + Pacific
Thliptodon gegenbauri Boas, 1886	present-day	S Atlantic, SE Pacific
Thliptodon schmidti Pruvot-Fol, 1942	present-day	Indonesia
Family Notobranchaeidae		
Notobranchaea bleekerae van der Spoel & Pafort, 1985	present-day	N Atlantic, N Indian Ocean
Notobranchaea grandis Pruvot-Fol, 1942	present-day	Indian Ocean, central E Pacific
Notobranchaea hjorti Bonnevie, 1913	present-day	N Atlantic
Notobranchaea inopinata Pelseneer, 1887	present-day	W Pacific
Notobranchaea longicollis (Bonnevie, 1913)	present-day	N Atlantic
Notobranchaea macdonaldi Pelseneer, 1886	present-day	tropics, subtropics circumglobal
Notobranchaea tetrabranchiata (Bonnevie, 1913)	present-day	Atlantic, SW Pacific
Notobranchaea valdiviae Meisenheimer, 1905	present-day	Indian Ocean
Family Pneumodermatidae		
Abranchaea chinensis Zhang, 1964	present-day	China Sea
Platybrachium antarcticum Minichev, 1976	present-day	Antarctic Ocean
Pneumoderma degraaffi van der Spoel & Pafort, 1982	present-day	N Atlantic

Pneumoderma heronense Newman & v.d. Spoel, 1989	present-day	Australia, Heron Reef
Pneumoderma mediterraneum (Van Beneden, 1838)	present-day	Central Atlantic, central Indo-Pacific
Pneumoderma meisenheimeri Pruvot-Fol, 1926	present-day	Indonesia
Pneumoderma pacificum (Dall, 1871)	present-day	tropics/subtropics, Indo-Pacific
Pneumoderma peroni (Cuvier, 1817)	present-day	N Atlantic, tropical W Pacific
Pneumoderma violaceum d'Orbigny, 1835	present-day	tropics/subtropics, Atlantic, Pacific?
Pneumodermopsis brachialis Minichev, 1976	present-day	Antarctic Ocean
Pneumodermopsis canephora Pruvot-Fol, 1924	present-day	tropical/subtropical E Atlantic
Pneumodermopsis ciliata (Gegenbaur, 1855)	present-day	N Atlantic, Indo-Pacific
Pneumodermopsis macrochira Meisenheimer, 1905	present-day	circumglobal
Pneumodermopsis macrocotyla Zhang, 1964	present-day	NW Pacific
Pneumodermopsis michaelsarsi Bonnevie, 1913	present-day	N Atlantic
Pneumodermopsis minuta (Pelseneer, 1887)	present-day	N Pacific
Pneumodermopsis paucidens (Boas, 1886)	present-day	N Atlantic, scattered southern oceans
Pneumodermopsis polycotyla (Boas, 1886)	present-day	NE Atlantic
Pneumodermopsis pupula Pruvot-Fol, 1926	present-day	NE Atlantic
Pneumodermopsis simplex (Boas, 1886)	present-day	Mediterranean
Pneumodermopsis spoeli Newman & Greenwood, 1988	present-day	no data
Pneumodermopsis teschi van der Spoel, 1973	present-day	NE Atlantic
Schizobrachium polycotylum Meisenheimer, 1903	present-day	all oceans
Spongiobranchaea australis d'Orbigny 1836	present-day	Antarctic oceans
Spongiobranchaea intermedia Pruvot-Fol, 1926	present-day	scattered all oceans
Superfamily Hydromyloidea		
Family Hydromylidae		
Hydromyles globulosus (Rang, 1825)	present-day	?Atlantic, ?Indo-Pacific
Family Laginiopsidae		
Laginiopsis triloba Pruvot-Fol, 1922	present-day	Indo-Pacific
Subterclass Ringipleura		
Order Nudibranchia		
Suborder Cladobranchia		
Superfamily Aeolidioidea		
Family Glaucidae		
Glaucilla bennettae (Churchill et al., 2014)	present-day	S Pacific subtropical gyre system
Glaucilla mcfarlanei (Churchill et al., 2014)	present-day	N Pacific subtropical gyre system
Glaucilla marginata Reinhardt & Bergh, 1864	present-day	Indo-Pacific tropic/subtropic
Glaucilla thompsoni (Churchill et al., 2014)	present-day	N Pacific subtropical gyre system
Glaucus atlanticus Forster, 1777	present-day	Atlantic, Pacific tropic/subtropic
Superfamily (unassigned)		
Family Phylliroidae		
Cephalopyge trematoides Chun, 1889	present-day	circumglobal tropic/subtropic
Phylliroe bucephala Lamarck, 1816	present-day	circumglobal
Phylliroe lichtensteinii Eschscholtz, 1825	present-day	circumglobal tropic/subtropic
Superfamily Fionoidea		
Family Fionidae		
Fiona pinnata (Eschscholtz, 1831)	present-day	circumglobal
Mesozoic gastropods considered to be pelagic species		
Family Bellerophinidae		
Bellerophina minuta (Sowerby, 1814)	Albian	UK
Freboldia fluitans Nützel & Schneider, 2016	Jurassic	Canada
Freboldia carinii Pieroni & Nützel, 2020	Triassic	Italy

Family Carinariidae		
Brunonia annulata (Yokoyama, 1890)	Cretaceous	Japan, Tethys ?
Family Pterotracheidae		
Pterotrachea liassica Bandel & Hemleben, 1987	Jurassic	Germany
Family Coelodiscidae		
Coelodiscus minutus (von Zieten, 1830)	Jurassic	Germany
Coelodiscus fluegeli Bandel & Hemleben, 1987	Jurassic	Germany
Tatediscus aratus (Tate, 1870)	Jurassic	UK, Germany, Argentina
Family ?		
Costasphaera franconica Gründel & Nützel, 2015	Jurassic	Germany
Globorilusopsis arcuatus Maubeuge, 1998	Jurassic	Luxemburg
Globorilusopsis simoni Maubeuge, 1994	Jurassic	Luxemburg
Globorilusopsis simoniiformis Maubeuge, 1998	Jurassic	Luxemburg
Globorilusopsis turbinatus Maubeuge, 1998	Jurassic	Luxemburg
Globorilusopsis erectusiformis Maubeuge, 1998	Jurassic	Luxemburg
Globorilusopsis compactus Maubeuge, 1998	Jurassic	Luxemburg
Globorilusopsis obesus Maubeuge, 1998	Jurassic	Luxemburg
Globorilusopsis baculatus Maubeuge, 1998	Jurassic	Luxemburg
Globorilusopsis gracilis Maubeuge, 1994	Jurassic	Luxemburg
Globorilusopsis elegans Maubeuge, 1997	Jurassic	Luxemburg
Globorilusopsis resurgens Maubeuge, 1998	Jurassic	Luxemburg
Globorilusopsis inguis Maubeuge, 1998	Jurassic	Luxemburg
Globorilusopsis regressum Maubeuge, 1998	Jurassic	Luxemburg
Simoniceras commotum Maubeuge, 1998	Jurassic	Luxemburg
Simoniceras concinnaticium Maubeuge, 1998	Jurassic	Luxemburg
Simoniceras cornu Maubeuge, 1998	Jurassic	Luxemburg
Simoniceras cornuaammoni Maubeuge, 1998	Jurassic	Luxemburg
Simoniceras curvatum Maubeuge, 1998	Jurassic	Luxemburg
Simoniceras delsatei Maubeuge, 1998	Jurassic	Luxemburg
Simoniceras erectum Maubeuge, 1998	Jurassic	Luxemburg
Simoniceras incurvatum Maubeuge, 1998	Jurassic	Luxemburg
Simoniceras mirum Maubeuge, 1998	Jurassic	Luxemburg
Simoniceras orbiculatum Maubeuge, 1998	Jurassic	Luxemburg
Simoniceras spiratissimum Maubeuge, 1998	Jurassic	Luxemburg
Simoniceras stompi Maubeuge, 1998	Jurassic	Luxemburg

APPENDIX 4.
Diagnosis for Vaginellinae Janssen subfam. nov. (AWJ) (Fig. 17)

Contrary to Cavoliniinae and Diacriinae the shell is not globose but more or less elongately triangular, dorsal and ventral shell parts equally convex, separated by lateral carinae at least in the apical part of the shell, no lateral slits; protoconch straight or obliquely positioned with a single subapical swelling, persisting (although usually broken) in most, but shed in two species (*V. basitruncata, V. floridana*) and then with a basal septum; dorsal apertural margin somewhat higher than ventral one, simple, slightly flaring, with weak radial folds or with cusps. Shell with post-larval metamorphosis during which the flexibler early teleoconch with a wide apical angle and small dorso-ventral diameter changes into the adult shell shape with a smaller apical angle and a wider dorso-ventral diameter, a process similar as seen in other Cavoliniidae.

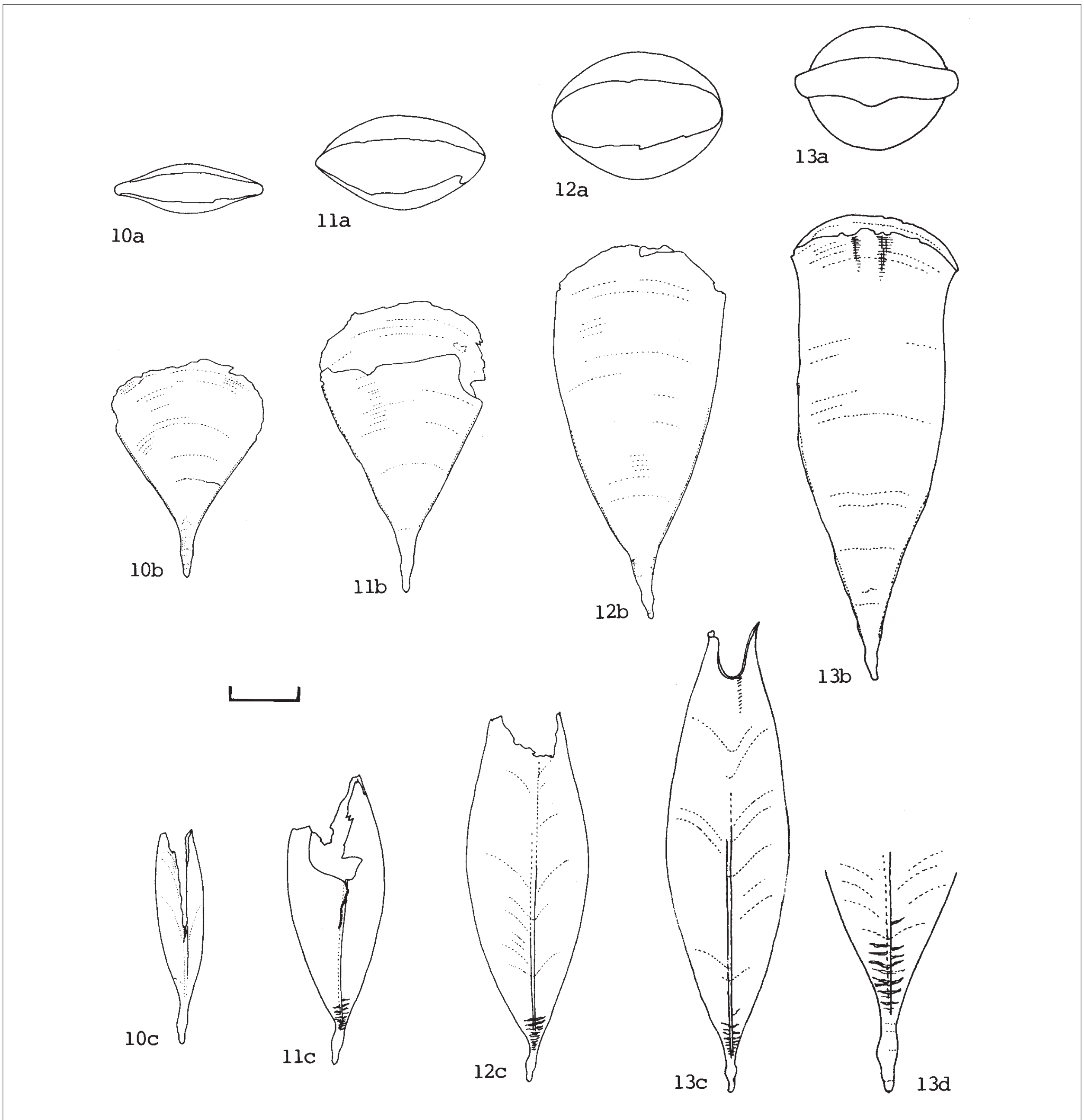

Fig. 17. Ontogenetic development of *Vaginella depressa* Daudin, 1800. Specimens from the Miocene (Burdigalian, Falun de Léognan) of Pas-de-Barreau, Martillac (Gironde, France); from Janssen, 1985: 202-203, figs 10-13. 10-12: successive stadia of juvenile shell, RGM.227565-7. 13: adult specimen, RGM.227568; a – apertural, b – ventral, c – left lateral views; 13d – protoconch, left lateral view. Bar = 1 mm, 13d magnified from 13c.