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Neogene Paleontology in the Northern Dominican Republic 20.

Holoplanktonic Mollusks

(Gastropoda: Heteropoda and Thecosomata)

by

Arie W. Janssen

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CONTENTS

	Page
Abstract	5
Resumen	5
Introduction	5
Acknowledgements	6
Abbreviations Used in the Text	6
Biostratigraphy and Correlations	6
Early Miocene	7
Late Miocene Assemblages	7
Pliocene Assemblages	8
Conclusions	9
Systematic Palaeontology	9
Order Heteropoda	11
Family Atlantidae	11
Order Thecosomata	13
Family Limacinidae	13
Family Cavoliniidae	15
Subfamily Creseinae	15
Subfamily Cuvierinae	19
Subfamily Clioinae	21
Subfamily Cavoliniinae	22
References Cited	28
Plates	33
Index of Holoplanktonic Mollusk Taxa	39

LIST OF ILLUSTRATIONS

Text-figure	Page
1. Chrono-, litho- and biostratigraphical interpretations (after Saunders <i>et al.</i> , 1986), and overall distribution of holoplanktonic mollusk species	8
2. Range chart of holoplanktonic mollusk species in the Río Gurabo section	10
3. Neotype of <i>Styliola subula</i> (Quoy and Gaimard, 1827).	19

LIST OF TABLES

Table	Page
1. Measurements (in mm) of <i>Cuvierina astesana</i> (Rang, 1827)?	20
2. Measurements of <i>Cavolinia gypsorum</i> (Bellardi, 1873)	23
3. Dimensions of complete specimens of <i>Cavolinia mexicana</i> (Collins, 1934)	25

NEOGENE PALEONTOLOGY IN THE NORTHERN DOMINICAN REPUBLIC 20. HOLOPLANKTONIC MOLLUSKS (GASTROPODA: HETEROPODA AND THECOSOMATA)

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ABSTRACT

Holoplanktonic gastropod faunas from the northern Dominican Republic Neogene, contained in the collections of the Natural History Museum at Basel (Switzerland) comprise two species of Heteropoda: *Atlanta cordiformis* Gabb, 1873 and *Protatlanta rotundata* (Gabb, 1873), and 17 euthecosomatous pteropods: *Limacina* (*Striolimacina*) *imitans* (Gabb, 1873), *L. (Striolimacina) inflata* (d'Orbigny, 1836), *Limacina* sp. indet., *Creseis acicula* (Rang, 1828), *Hyalocylis striata* (Rang, 1828), *Styliola subula* (Quoy and Gaimard, 1827), *Cuvierina astesana* (Rang, 1829)?, *Cuvierina* sp., *Clio cuspidata* (Bosc, 1802)?, *C. pyramidata* Linné, 1767 forma *lancoolata* (Lesueur, 1813), *Clio* sp., *Cavolinia gypсорum* (Bellardi, 1873), *C. aff. gypсорum*, *C. mexicana* (Collins, 1934), *C. cf. tridentata* (Niebuhr, 1775), *Diacria trispinosa* (de Blainville, 1821) and *Edithinella* sp. *Edithinella undulata* (Gabb, 1873), recorded in the literature from the same area but not represented in the present collection, is included on the basis of the type material. The number of holoplanktonic gastropod species from the Dominican Republic is thus 20.

The name *Striolimacina* is introduced to replace *Planorbella* Gabb, 1873a non Haldemann, 1843 (Mollusca).

From the Baitoa Formation (Río Yaque del Norte section), of assumed late Early Miocene age, a single pteropod (*Edithinella* sp.) was recorded. The Late Miocene Cercado Formation (Río Gurabo: *Globorotalia humerosa* Zone, Río Cana: no biozone indicated) and some samples lacking lithostratigraphical data, of ? Late Miocene age (Río Mao) yielded nine species, among which only *Cavolinia gypсорum* is indicative of a Late Miocene (Tortonian–Messinian) age. Other species are known only locally or have longer ranges.

Specimens from the late Early Pliocene Gurabo Formation (*Globorotalia margaritae* Zone; Río Gurabo) and the Mao Adentro Limestone (*G. margaritae* Zone; Río Cana), the Early to middle Pliocene Mao Formation (*G. margaritae/miocenica* Zone; Río Gurabo section), and a sample lacking lithostratigraphical data, of ? late Early Pliocene age (Río Yaque del Norte section) yielded 10 holoplanktonic mollusk species. So far as they could be identified to species these invariably belong to taxa ranging at least through the entire Pliocene, and still occur today.

RESUMEN

La asociación de Gasterópodos holoplanctónicos del Neógeno del Norte de la República Dominicana, que se encuentra en las colecciones del Museo de Historia Natural de Basilea (Suiza), está compuesta por dos especies de Heteropoda: *Atlanta cordiformis* Gabb, 1873 y *Protatlanta rotundata* (Gabb, 1873), y 17 pterópodos eutecosómatos: *Limacina imitans* (Gabb, 1873), *L. inflata* (d'Orbigny, 1836), *Limacina* sp. indet., *Creseis acicula* (Rang, 1828), *Hyalocylis striata* (Rang, 1828), *Styliola subula* (Quoy and Gaimard, 1827), *Cuvierina astesana* (Rang, 1829)?, *Cuvierina* sp., *Clio cuspidata* (Bosc, 1802)?, *C. pyramidata* Linné, 1767 forma *lancoolata* (Lesueur, 1813), *Clio* sp., *Cavolinia gypсорum* (Bellardi, 1873), *C. aff. gypсорum*, *C. mexicana* (Collins, 1934), *C. cf. tridentata* (Niebuhr, 1775), *Diacria trispinosa* (de Blainville, 1821) y *Edithinella* sp. Se incluye para su estudio la especie *Edithinella undulata* (Gabb, 1873), descrita de la misma región pero ausente en la colección de dicho museo, basándose en el material tipo. Así se conoce un total de 20 especies de Gasterópodos holoplanctónicos del Neógeno de la República Dominicana.

Se introduce el nuevo nombre *Striolimacina* para el genero *Planorbella* Gabb, 1873a non Haldemann, 1843 (Mollusca).

En la Formación Baito (el corte del Río Yaque del Norte), considerada de tener una edad Mioceno Final tardío, se ha encontrado un solo pterópodo: *Edithinella* sp. La Formación Cercado de edad Mioceno Final (Río Gurabo: *Globorotalia humerosa* Zona; Río Cana: no biozona indicada) y algunas muestras sin precisión litoestratigráfica consideradas de tener la misma edad (Río Mao) han librado nueve especies. Entre ellas *Cavolinia gypсорum* es la única especie característica del Mioceno Final (Tortonense–Messiniense). Las otras especies o bien son endémicas o tienen una distribución estratigráfica larga.

Especímenes de la Formación Gurabo (Río Gurabo) y de la Caliza de Mao Adentro (Río Cana) de edad Plioceno Antiguo tardío (*Globorotalia margaritae* Zona), de la Formación Mao de edad Plioceno Antiguo-Mediano (*G. margaritae/miocenica* Zona, Río Gurabo) y una muestra considerada de tener una edad Plioceno Antiguo tardío (Río Yaque del Norte) han producido 10 Moluscos holoplanctónicos que, en cuanto ha sido posible su determinación a nivel específico, pertenecen sin excepción a taxones con un rango temporal desde el Plioceno Antiguo hasta la actualidad.

INTRODUCTION

The material of holoplanktonic mollusks studied in this paper originally comprised almost 150 samples, collected from outcrops in the Cibao Valley, in the

Dominican Republic, between 1978 and 1980. Geographic and stratigraphic information on the various sections was supplied by Saunders *et al.* (1986), to which reference is made.

With a few exceptions, samples here referred to are

housed in the Naturhistorisches Museum at Basel. One taxon recorded in the literature from the Dominican Republic, but not represented in the material before me is included. The original material on which it was based, as well as type material for some species represented in the collection survives, and was received on loan from American institutions.

Quite a number of samples consist of pieces or small slabs of sediment with specimens preserved on bedding planes, usually in a rather poor state of preservation. Other samples, however, comprise excellently preserved isolated shells, which apparently were sorted from carefully collected sieving residues. In view of the fact that no special collecting techniques were applied, nor special attention paid to the occurrence of holoplanktonics, the composition of the material still is quite interesting and deserves to be studied in detail. The material does not include new taxa, but in various cases valuable additional information was obtained on rare or ill-known species.

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Dirk van der Marel (NNM) made the final version of Text-figure 1. Jeroen Goud (NNM) prepared the SEM micrographs of Plate 1, and Mrs. Mieke van Engelen (NNM) printed them and reduced and reproduced the drawings.

ABBREVIATIONS USED IN THE TEXT

The following abbreviations are used:

ANSP	The Academy of Natural Sciences, Philadelphia, U.S.A.;
GMHU	Geological Museum, Hebrew University, Jerusalem, Israel;
MHNP	Musée national d'Histoire naturelle, Paris, France;
NMB	Naturhistorisches Museum, Geology Department, Basel, Switzerland;
NNM	National Museum of Natural History (Invertebrate Department, Recent Mollusca), Leiden, The Netherlands;
RGM	National Museum of Natural History (Palaeontology Department, Cainozoic Mollusca), Leiden, The Netherlands (formerly: Rijksmuseum van Geologie en Mineralogie);
USNM	National Museum of Natural History, Smithsonian Institution, Department of Paleobiology, Washington DC, U.S.A.;
H	height of shell;
W	width of shell;
D	dorso-ventral diameter of shell.

BIOSTRATIGRAPHY AND CORRELATIONS

The holoplanktonic molluscan material from the Cibao Valley, as studied in the present paper, was found to comprise 19 species, of which 2 belong to the Heteropoda, and 17 to the Euthecosomata. Of these 11 (57.9%) could be identified at species level, two are identified with a query, and six remain in open nomenclature.

Material was available from 31 stations, distributed over four sections: Río Gurabo (16 stations), Río Cana (eight stations), Río Mao (five stations), and Río Yaque del Norte (two stations). The distribution of these samples and their species contents over the various chrono-, litho- and biostratigraphical units, as specified in Saunders *et al.* (1986) are shown in Text-figure 1.

The holoplanktonics from the Río Gurabo section offer the most interesting details and the most complete picture by far. Biostratigraphically these samples are assigned to three planktonic Foraminifera zones, viz. the Late Miocene *Globorotalia humerosa* Zone, the late Early Pliocene *Globorotalia margaritae* Zone, and the Early to middle Pliocene *Globorotalia margaritae/miocenica* Zone.

From the Río Cana section 8 samples yielded holoplanktonic mollusks. One of these is assigned a late Early Pliocene *Globorotalia margaritae* Zone age, whereas the remaining seven lack biozone details, their age being indicated as "? Late Miocene".

The same is true for the five Río Mao samples in which holoplanktonics were found. They are not zoned, and their age likewise is “? Late Miocene”.

Two samples are available from the Río Yaque del Norte section, both yielding but a single species. The upper one is not zoned; its age is assumed to be late Early Pliocene. The lower sample, from the late Early Miocene Baitoa Formation, finally, yielded a single specimen and lacks biostratigraphical data as well.

Early Miocene Assemblages

The sole specimen of *Edithinella* sp. known apparently belongs to an undescribed species and is therefore of little use for both biozonation and correlation. The related *Edithinella undulata*, also based on a single known specimen, has previously been recorded from the “Miocene” of the Dominican Republic, without any further information. This species is not represented in the material studied for this paper. *Edithinella caribbeana* (Collins, 1934) was based on a single “middle Miocene” specimen from the Panama Canal Zone, in addition to this occurrence the species is known only from three Miocene European localities (Janssen, 1995). It too is not represented in the present material.

Late Miocene Assemblages

In the Río Gurabo section the Late Miocene assemblage yielded seven species, one of which (*Limacina inflata*) has been recorded from the Middle Miocene of Australia and Turkey (Janssen, 1990), as well as from many younger assemblages, and is still extant. Its occurrence is therefore not surprising and its long range makes it of no use for correlations; the species, incidentally, has not been found in the Pliocene samples.

Of the other six species (one heteropod and five euthecosomatous pteropods) two are exclusively known from the Caribbean area (*Protatlanta rotundata* and *Limacina imitans*). *L. imitans* occurs in one sample only, *P. rotundata* is present in four samples (of seven).

P. rotundata, a heteropod originally described from “Santo Domingo”, has never been recorded from elsewhere, but it might be closely related or even conspecific with the Plio/Pleistocene *Protatlanta kakegawaensis*, from Japan. Furthermore, various related species are present in the RGM collections from localities of Miocene and Pliocene age in the Mediterranean area (unpublished).

Limacina imitans is an interesting species from a taxonomic point of view. It was likewise described from “Santo Domingo” and is also known from the Early Pliocene (Zone N19; Akers, 1972) Agueguex-

quite Formation of Santa Rosa, Vera Cruz, Mexico (as *Limacina elevata* Collins). The same or a very closely related species with the same type of microsculpture has also been recorded from the Early Pliocene (Zanclean) of the Mediterranean area (Italy and France). These occurrences will be evaluated in a paper in preparation.

Cavolinia mexicana, interestingly, was introduced from the same locality Santa Rosa in Mexico. This species has also been recorded from the Late Miocene–middle Pliocene of Japan (zones N18–20) (Shibata and Ujihara, 1990).

Of much interest also is the occurrence of *Cavolinia gypсорum*, found in two samples of the Río Gurabo section. This is the first extra-Mediterranean record of that species. It was described from the “Messinian” of northern Italy, but a nannoplankton analysis of the type lot showed its age to be Tortonian (Janssen, 1995, p. 102). Other records of this species from Europe are still considered to be Messinian. This is a good first-order correlation across the Atlantic, and, in fact, the only certain indication among holoplanktonic Mollusca that this is indeed a Late Miocene assemblage.

Two samples from the Gurabo section yielded specimens here referred to as *Cavolinia* aff. *gypсорum*, in both cases co-occurring with *C. gypсорum*. Very similar, if not identical, material has been recorded from the Late Miocene–Middle Pliocene of Japan (N18–20) (Shibata and Ujihara, 1990). A direct comparison with the Japanese specimens will be necessary to settle the identity of both.

In two samples of the Gurabo section specimens of a *Cuvierina* species were found, here indicated as *C. astesana*?. They differ morphologically slightly from the admittedly highly variable Pliocene individuals of *C. astesana*, from the type area in northern Italy. As they are apparently older than typical *C. astesana* they might represent a precursor species, which cannot clearly be related to any of the various Miocene *Cuvierina* species, however, from the Mediterranean area.

The samples from the Río Cana section indicated as “? Late Miocene” yielded six species, five of which are also known from the Gurabo Late Miocene, viz. *Protatlanta rotundata*, *Limacina imitans*, *Cavolinia gypсорum*, *C. aff. gypсорum*, and *C. mexicana*. Four samples from this interval, however, also contain *Diacria trispinosa*, a species that in the Río Gurabo section occurs exclusively in the Pliocene portion. *D. trispinosa*, however, is also known from Late Miocene sediments in Italy (Janssen, 1995) and thus its occurrence in the Cana section is more easily explained than its absence in the Late Miocene of the Gurabo section.

In the five samples from the Río Mao section four species were found. One of these is the heteropod *At-*

Sample	Chronostratigraphy	Lithostratigraphy	Biostratigraphy			Species
			no biozone	<i>Globorotalia humerosa</i> Zone	<i>Globorotalia margaritae</i> Zone	<i>Globorotalia margaritae/miocenica</i> Zone
	late Early Miocene Late Miocene ? Late Miocene Early Pliocene late Early Pliocene Early/Middle Pliocene	Baltosa Fm. Cercado Fm. Gorabo Fm. Mao Fm. Mao Adentro Lst. no formation				<i>Atlanta cordiformis</i> <i>Protatlanta rotundata</i> <i>Limacina imitans</i> <i>Limacina inflata</i> <i>Limacina</i> spec. <i>Creseis acicula</i> <i>Hyalocylis striata</i> <i>Styliola subula</i> <i>Cuvierina</i> ? <i>astesana</i> <i>Cuvierina</i> spec. <i>Clio</i> ? <i>cuspidata</i> <i>Clio pyramidata</i> f. <i>lancoelata</i> <i>Clio</i> spec. <i>Cavolinia gypсорum</i> <i>Cavolinia</i> aff. <i>gypсорum</i> <i>Cavolinia mexicana</i> <i>Cavolinia</i> cf. <i>tridentata</i> <i>Diacria trispinosa</i> <i>Edithinella</i> spec.
Rio Gurabo section						
15833						• •
15832						• • •
15829						• • • •
15823						• • • • •
15828						• • • • •
15827						• • • • •
15993						• • • • •
15851						• • • • •
15854						• • • • •
15906	•					• • • • •
15907	•					• • • • •
15904	•					• • • • •
15900	•					• • • • •
15903	•					• • • • •
15913	•					• • • • •
15914	•					• • • • •
Rio Cana section						
17023						• •
16835	•					• • • • •
16836	•					• • • • •
16837	•					• • • • •
16838	•					• • • • •
16844	•					• • • • •
16856	•					• • • • •
16875	•					• • • • •
Rio Mao section						
16915	•					• • • • •
16923	•					• • • • •
16927	•					• • • • •
16922	•					• • • • •
16932	•					• • • • •
Rio Yaque del Norte section						
17293						• •
17288	•					• • •

Text-figure 1.—Chrono-, litho-, and biostratigraphic interpretations of the Neogene of the northern Dominican Republic (after Saunders *et al.*, 1986), and overall distribution of holoplanktonic mollusk species.

lanta cordiformis, originally described from Santo Domingo and not recorded from elsewhere since. Two species, *Limacina imitans* and *Cavolinia gypсорum*, are also known from the Late Miocene interval of the Río Gurabo and Río Cana sections. The fourth species is again *Diacria trispinosa*, present in the Cana section, but absent along the Río Gurabo Miocene transect.

From the distribution of holoplanktonic mollusks it is clear that the Late Miocene samples from the Río Gurabo section, and the “? Late Miocene” ones from the Río Cana and Mao sections (as specified in Text-figure 1) are correlative.

The few possibilities of long-distance correlation to Europe, *i.e.*, especially the occurrence of *Cavolinia gypсорum*, could indicate a Tortonian/Messinian age of these intervals.

Pliocene Assemblages

Only from the Río Gurabo section is more or less substantial material from the Pliocene available: four samples of late Early Pliocene *Globorotalia margaritae* Zone age, and five samples from the Early to middle Pliocene *Globorotalia margaritae/miocenica* Zone yielded a total of 10 species, all euthecosomatous pteropods. These biozones have five pteropod species

in common (*Hyalocylis striata*, *Styliola subula*, *Clio pyramidata* forma *lanceolata*, *Cavolinia* cf. *tridentata* and *Diacria trispinosa*), all of them still occurring in the Recent faunas. A single specimen of another species, *Cuvierina* sp., is present only in the lower Pliocene biozone, and gives no further clues on correlations. Four species were found only in the upper biozone of the Gurabo Pliocene, viz. *Limacina* sp., *Creseis acicula*, *Clio cuspidata*?, and *Clio* sp. The first and the last-mentioned are represented by too young and insufficiently preserved shells to be of any help in biostratigraphy or correlations. The two remaining species again are fossil representatives of extant species.

The overall impression is that the assemblages from the Gurabo section are stratigraphically very young, and had these sediments not been dated with planktonic Foraminifera I would have estimated their age to be considerably younger, maybe even Quaternary. The only indication that the material is older is the fact that in some specimens of *Cavolinia* cf. *tridentata* a weak oblique transverse sculpture is seen, reminiscent of the Early Pliocene (Zanclean) species *Cavolinia grandis*, from northern Italy.

Assemblages of similar age from Europe usually contain several species that no longer form part of the Recent fauna, and the same is true for the Late Pliocene assemblage found in the Bowden Beds of Jamaica (Janssen, 1998).

Conclusions

1. The Río Gurabo interval indicated as Late Miocene (as specified in Text-fig. 2) contains a holoplanktonic molluscan association consisting of seven species.

2. On the basis of the holoplanktonic mollusks the intervals indicated as “? Late Miocene” in the Río Cana and Río Mao sections can be correlated with the Late Miocene Río Gurabo interval. In the three sections together the association consists of nine species: two Heteropoda and seven Euthecosomata (“Pteropoda”).

3. A biostratigraphical subdivision of the Late Miocene interval in the Río Gurabo, Cana and Mao sections does not appear possible on the basis of holoplanktonic Mollusca.

4. The presence of *Limacina imitans* and *Cavolinia mexicana* in the Dominican Late Miocene holoplanktonic molluscan association is reminiscent of an association described by Collins (1934, p. 155) from Santa Rosa, Veracruz, Mexico (U. S. Geological Survey Station 9995, Agueguexquite Formation). The age of that association was considered by Collins to be Middle Miocene, a view accepted by Perrilliat (1974).

Akers (1972, p. 28), however, analysed samples from the Santa Rosa area for planktonic Foraminifera and calcareous nannoplankton and assigned a Zone N19 (Early Pliocene) age to them. This would mean that both *L. imitans* and *C. mexicana* range from the Late Miocene to the Early Pliocene. A closely related or conspecific *Limacina* species is indeed known from the Early Pliocene of the Mediterranean, whereas *C. mexicana* has been recorded from the Late Miocene to middle Pliocene (Zones N18–20) of Japan.

A Pliocene age for the Mexican locality is supported by the occurrence of the pteropod *Creseis acicula* (Rang, 1828) and not contradicted by the presence of *Cuvierina globosa* Collins, 1934. The former is known exclusively from the Early Pliocene to Recent and the latter has recently been synonymized (Janssen, 1995, p. 36) with *C. inflata* (Bellardi, 1873), a species from the Mediterranean area, ranging from (Tortonian?) Messinian to Zanclean.

5. The occurrence of *Cavolinia gypсорum* in the Late Miocene assemblage of the Dominican Republic indicates a correlation with deposits of Tortonian/Messinian age in the Mediterranean area.

6. The Pliocene holoplanktonic molluscan fauna from the Río Gurabo section comprises ten species. As far as these could be identified to species level they invariably belong to extant taxa. Only an apparently transitional form between *Cavolinia grandis* and *C. tridentata* indicates that the assemblage predates the Quaternary. The absence of forms restricted to the Pliocene is striking.

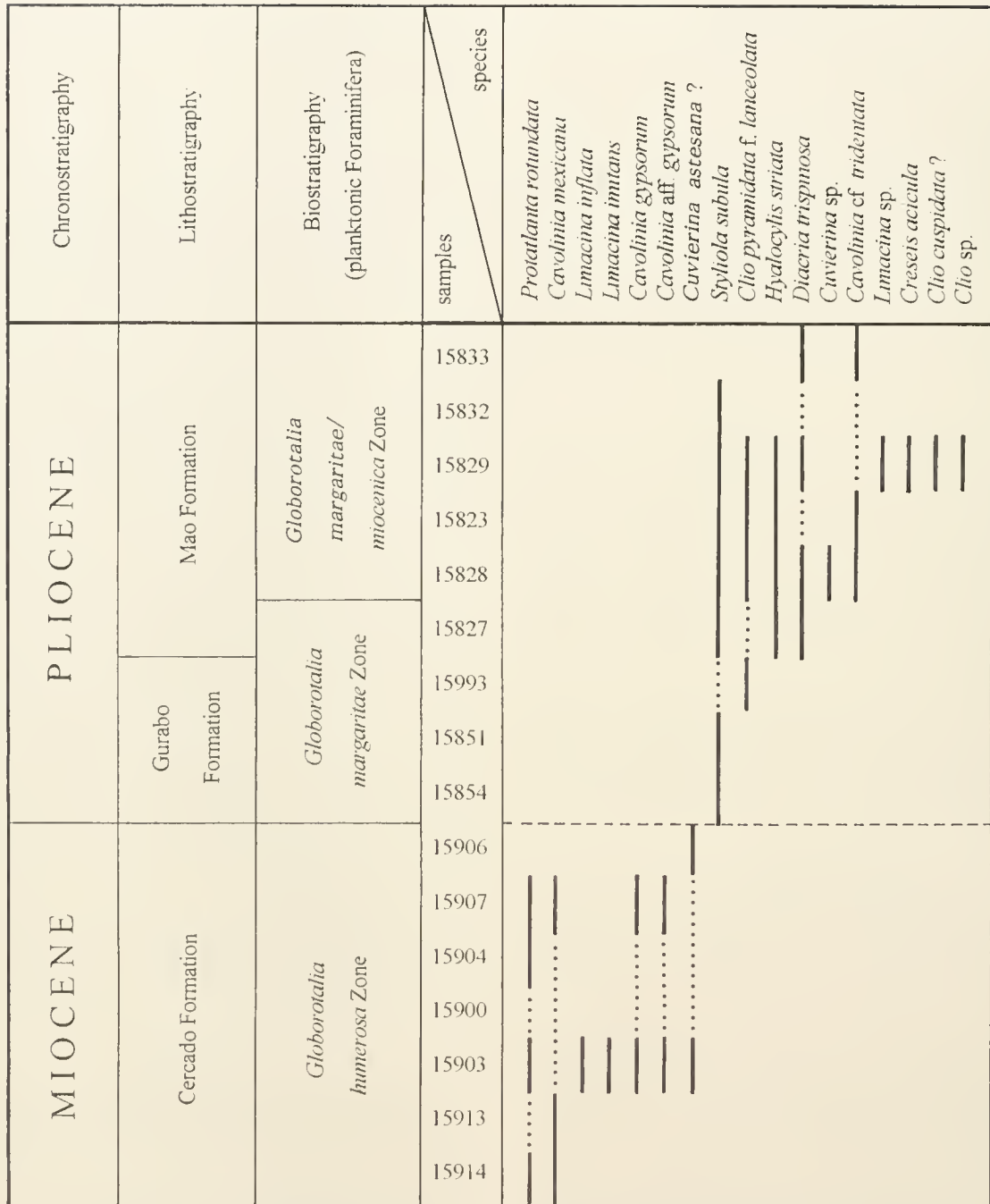
7. Both from the Río Cana and Río Yaque del Norte sections just one sample indicated as Pliocene yielded the species *Diacria trispinosa*, which ranges from the Late Miocene to Recent.

SYSTEMATIC PALEONTOLOGY

Introduction

Symbols used in the lists of synonyms in this paper are those of Richter (1948):

- * first valid introduction of the taxon;
- responsibility for the identification is accepted by the present author;
- (no symbol) responsibility for the identification is not accepted by the present author, but there is no reason for doubt;
- ? in the opinion of the present author there is reason to doubt the identification;
- v the original material of this reference was studied by the present author;
- (1881) (date in parentheses) the year of publication is uncertain (or the paper has not been published officially, e.g., thesis).



Text-figure 2.—Range chart of holoplanktonic mollusk species in the Rio Gurabo section.

Unlike systematics of Recent representatives of the group under study the taxonomy of fossil holoplanktonic Mollusca, as of course is true for all fossil organisms, is a three dimensional matter, with time as a third, complicating factor. The evolutionary pattern of this group is too incomplete yet to construct reliable lineages for the bulk of the genera. Contrary to the Heteropoda, known since the Jurassic (Bandel and Hemleben, 1987) Thecosomata ("Pteropoda") appear

only near the very end of the Palaeocene. They are supposed to develop from some heterobranch predecessor. Indeed, the protoconch morphology of, e.g., the Pyramidellidae, but also of Mathildidae and Architectonicidae, resembles the Limacinidae to a certain extent. The separation of Limacinidae and Cavoliniidae seems to have taken place already early in the Eocene. Some forms described from the Early Eocene (Ypresian) of western Europe, like *Plotophysops multispira*

Curry, 1981 and *Camptoceratops prisca* (Godwin-Austen, 1882) (see Curry, 1981) could well be considered transitional forms between these two families. The recently described family Sphaerocinidae has to be considered a further offshoot from the Cavoliniidae, more especially the Clioinae (Janssen and Maxwell, *in* Janssen, 1995).

Generic assignments in the fossil pteropods do not yet depend on evolutionary strategies, but merely on apparently natural groupings of shell morphologies around type species. It may be expected that in this respect changes will be necessary when especially the vertical distribution patterns will be more completely known. Developments in the study of this group during the last decades have clearly demonstrated our lack of knowledge. Thus, creating new species and, especially, new genera and higher systematic units has to be done with reluctance. In the present paper this attitude led to including some species with genus names only.

Order **HETEROPODA** Lamarck, 1819

Family **ATLANTIDAE** Wiegman and Ruthe, 1832

Genus **ATLANTA** Lesueur, 1817

Type species.—*Atlanta peroni* Lesueur, 1817 (Recent).

Atlanta cordiformis Gabb, 1873b

Plate 2, figures 1–2

- v* *Atlanta cordiformis* Gabb, n.s. Gabb, 1873b, p. 201.
- . *Atlanta cordiformis* Gabb, Guppy, 1882, p. 175 (reprinted in Harris, 1921).
- v. *Atlanta cordiformis* Gabb, Pilsbry, 1922, p. 315, text-fig. 14.

Description.—Shell dextral, lenticular, three times wider than high (lectotype), very thin-walled. First three whorls rather tightly coiled and slightly oblique, then more rapidly expanding laterally and developing an obvious peripheral carina, provided with a thin (but double-walled!) calcareous laminar keel, which apparently disappears a short distance before the apertural margin. The body whorl touches the preceding whorl and is not, as frequently seen in this genus, separated by the laminar keel of the foregoing whorl. In a frontal view the apex and the first two whorls are barely visible. The aperture is large, very slightly indented by the penultimate whorl and therefore slightly heart-shaped (hence Gabb's name "*cordiformis*"). The base of the shell is widely umbilicate, with the penultimate whorl not completely visible. Only the base of the protoconch's last whorl, just visible in the umbilicus, has

a thin but distinct spiral in the sole specimen in the NMB collection. Furthermore, the protoconch of the same shell is visible from aside, through the damaged part of the body whorl. It can clearly be seen that at least the last protoconch whorl has a spiral ornament of ca. five or six thin, but distinct spirals.

There is no surface ornament on the body whorl. The growth lines are not very distinct. On both the upper and lower side of the shell they describe a forward curve, and strongly curve backward at the carina. On the penultimate whorl the growth lines appear somewhat flexuous.

Lectotype.—Coll. ANSP no. 2896 (Pl. 2, fig. 1a–d). The original number of specimens was not mentioned by Gabb in his description of the species. Pilsbry (1922) was the first to provide illustrations. He referred to the figured shell as "type" and mentioned two additional specimens in the same sample. This fulfills the provisions of ICZN Art. 74-b for these specimens to be considered lectotype and paralectotypes, respectively. All three specimens survive.

Dimensions of lectotype.—H = 0.52 mm, W = 1.50 mm.

Type locality.—"Santo Domingo", Dominican Republic.

Material.—No formation name; age uncertain, ? Late Miocene, Río Mao 1979, Sta. 16923: one specimen (Pl. 2, fig. 2a–d), NMB H 17617.

Measurements.—H = 0.42 mm, W = 1.22 mm.

Distribution.—The species appears to be confined to the Dominican Republic, as based on the type material and the present specimen.

Remarks.—The only specimen (apart from the type material) available in the collection studied for this paper is poorly preserved. The apical shell part and a considerable part of the body whorl are damaged, and the peripheral keel is completely missing. Still, it resembles the lectotype of *A. cordiformis* to such an extent that it is undoubtedly conspecific.

Among the plethora of difficult-to-identify Recent species of the genus *Atlanta*, *A. inflata* Souleyet, 1852 is especially close to *A. cordiformis*. Such is the resemblance that I assume them to be synonymous. For the time being, however, I prefer to maintain Gabb's name as fossil material is too limited for a detailed discussion. The considerable age difference and the fact that I am not entirely convinced of the correct identification of the Recent material before me prevent me from premature conclusions.

Genus **PROTATLANTA** Tesch, 1908

Atlantidea Pilsbry, 1922 (objective).

Type species.—*Atlanta souleyeti* Smith, 1888 (by monotypy) (Recent).

Protatlanta rotundata (Gabb, 1873b)

Plate 2, figures 3–4

- v* *Atlanta rotundata*, Gabb, n.s. Gabb, 1873b, p. 201.
- . *Atlanta rotundata* Gabb. Guppy, 1882, p. 175 (reprinted in Harris, 1921, p. 244).
- v. *Atlanta rotundata* Gabb. Pilsbry, 1922, p. 314, text-fig. 15.
- ? *Protatlanta kakegawaensis* n. sp. Shibata, 1984, p. 75, pl. 23, figs. 1–3.
- non: *Atlanta rotundata* d'Orb. (*sic*). Reuss, 1867, p. 146 [= *Atlanta rotunda* d'Orbigny, 1836 = *Limacina helicina* (Phipps, 1774) forma *rangii* (d'Orbigny, 1836)].

Description.—Shell dextral, planispiral, slightly more than twice as wide as high. The axis of the protoconch is slightly oblique with respect to the teleoconch and is therefore partly covered by the body whorl. The sutures of the protoconch whorls are very shallow, as these whorls attach very high onto the preceding ones. The protoconch whorls are not visible in lateral view. There is no sharp boundary between the protoconch and the teleoconch, but the transition must be where the protoconch ornament, consisting of a small number of sharp and distant spiral lines (showing a zig-zag shape at a magnification of $\times 100$), disappears. After that point there is slightly more than one rapidly expanding teleoconch whorl. At the aperture, the width of the body whorl is ca. 4.5 times the width of the preceding whorl. The teleoconch whorls are separated by much deeper sutures than those of the protoconch. The aperture is distinctly wider than high, at the columellar side it is indented by the preceding whorl, which results in a cordiform shape. At the periphery the apertural margin is slightly angular.

The base of the shell has a similar shape as the apical side of the shell. The width of the umbilicus is ca. $\frac{2}{5}$ of the total shell diameter. The base of the last protoconch whorl is clearly visible in the umbilicus, and shows a spiral ornament similar to its upper part.

The ornament of the teleoconch consists of two relatively distinct spiral lines on the periphery together enclosing a kind of band on the periphery. Both the upper and lower part of the body whorl show a fine and slightly irregular spiral striation, visible only there where illumination reflects on the shell surface. The spirals are intersected by much less distinct growth lines that make a wide forward curve on both sides, being distinctly curved backward on the periphery.

Holotype.—Coll. ANSP no. 2891 (Pl. 2, fig. 3a–e).

Dimensions of holotype.—H = 1.20 mm, W = 2.56 mm.

Type locality.—Santo Domingo (Gabb, 1873b).

Material.—Cercado Formation, *Globorotalia humerosa* Zone, Late Miocene, Río Gurabo 1978, Sta. 15903: 1 specimen (Pl. 2, fig. 4a–c), NMB H 17618; Sta. 15904: one specimen, NMB H 17712; Sta. 15907: one slightly damaged specimen (rusty), NMB H 17713; Sta. 15914: one specimen, NMB H 17714.

Cercado Formation, probably Late Miocene, Río Cana 1979, Sta. 16837: two slightly damaged specimens, NMB H 17715.

Distribution.—Late Miocene of the Dominican Republic, ? Plio/Pleistocene of Japan (see Remarks below).

Very similar, but probably not conspecific material is available from Messinian and Early Pliocene deposits in Italy and southern France. Specimens of the same genus are also known from the Miocene phosphatic deposits in Italy and the Maltese archipelago (all RGM collections). This material will be described in papers now in preparation.

Remarks.—Through the kind cooperation of Drs. George M. Davis and Gary Rosenberg, at the Academy of Natural Sciences of Philadelphia, I was able to study Gabb's type specimen of *Atlanta rotundata* in 1990 (see Pl. 2, fig. 3a–e). It is a rather severely damaged specimen, but still demonstrates all the typical features, thus allowing to determine beyond doubt that the specimens studied for this paper belonged to the same species. Until now, the type was only illustrated once, by Pilsbry (1922, fig. 15).

Protatlanta kakegawaensis Shibata (1984) described from the "Nango sand and mud alternation Member of the Kakegawa Group" (Plio/Pleistocene transition, planktonic Foraminifera Zone 22) from Kakegawa (SW of Tokyo) closely resembles *P. rotundata*. There are only slight morphological differences, as could be ascertained from the data in Shibata's paper, as well as from two topotypical specimens donated by Professor Shibata in April 1992 (RGM collection). The Japanese species has a slightly flatter shell and stronger spiral striation. In the material available to me the protoconch is not visible, but a spiral ornament seems to be present on the larval shell. Such a sculpture was not mentioned in Shibata's description, but appears to be visible in his illustration (pl. 23, fig. 3). Furthermore, of course, there is the considerable age difference. Shibata (1984) compared his material with the Recent *P. souleyeti* only. I think that a more detailed comparison will show these taxa to be conspecific, in spite of the difference in age.

The only Recent species of *Protatlanta*, *P. souleyeti* (Smith, 1888) is invariably smaller (diameter to 2.2 mm, compare Plate 2, figure 5a–c) than *P. rotundata* and more flattened, especially towards the periphery. The protoconch is considerably higher and remains

visible in lateral view; its whorls are more convex and separated by much deeper sutures. The whorls of the teleoconch are less tightly coiled and therefore the aperture is hardly indented by the preceding whorl. Spiral sculpture is barely visible.

Living or fresh fully-grown specimens of *P. souleyeti* have a wide, cartilaginous keel on the periphery of their body whorl (van der Spoel, 1976, fig. 134a–b), which decays shortly after death and is therefore never present in specimens from bottom samples. This keel, however, leaves a distinct trace on the shell in the form of a peripheral belt. The presence of a similar belt in the fossil species indicates that these too had such a cartilaginous keel on the body whorl. It is one of the major morphological features that characterize the genus *Protatlanta*.

The differences between Recent and fossil representatives of *Protatlanta* and those of the protoconch morphology in particular, might justify separation at generic level. As only few species and specimens are available of these rare creatures I consider a subdivision to be premature now.

Order **THECOSOMATA** de Blainville, 1824

Suborder **EUTHECOSOMATA** Meisenheimer, 1905

Family **LIMACINIDAE** Gray, 1847

Genus **LIMACINA** Bosc, 1817

Spiratella de Blainville 1817 (type species: "*Clio* [sic] *helicina*").

Type species.—*Clio helicina* Phipps, 1774 (Recent).

Subgenus **STRIOLIMACINA** new name

Planorbella Gabb, 1873a non Haldemann, 1843 (Mollusca).

Type species.—*Limacina imitans* (Gabb, 1873).

Limacina (Striolimacina) imitans (Gabb, 1873a)

Plate 1, figure 1a–f; Plate 2, figures 6–9

- v* *Planorbella imitans* Gabb, 1873a, p. 270, pl. 11, fig. 2 (*mala*).
- v. *Planorbella imitans* Gabb, n.s. Gabb, 1873b, p. 201.
- . *Planorbella imitans* Gabb, Guppy, 1882, p. 175 (reprinted in Harris, 1921, p. 244).
- . *Planorbella imitans* Gabb, Cossmann, 1892, p. 8 (incorrectly designated as type species of *Valvatina* Bornemann).
- . *Planorbella imitans* Gabb, Dall, 1893, p. 430.
- . *Valvatella imitans* Gabb, Lörenthey, 1903a, p. 475.
- . *Valvatella imitans* Gabb, Lörenthey, 1903b, p. 523.
- v. *Limacina inflata* (Orbigny). Pilsbry, 1922, p. 308, text-fig. 1 (non d'Orbigny).

- v. *Limacina elevata* n. sp., Collins, 1934, p. 181, pl. 7, figs. 9–11.
- v. *Limacina inflata* (d'Orbigny). Collins, 1934, p. 179, pl. 7, figs. 6–8 (partim, non d'Orbigny, non pl. 7, figs. 3–5 and other specimens from Santa Rosa, Vera Cruz, Mexico = *Limacina inflata*?). *Limacina elevata* Collins. Gardner, 1951, p. 12. *Limacina elevata* Coll. Korobkov, 1966, p. 74, 76, 81, 84, 85. *Spiratella inflata elevata* (Collins). Woodring, 1970, p. 320, 324, 427, pl. 66, figs. 5, 7, 9.
- v. *Spiratella inflata elevata* (Collins). Perrilliat, 1974, p. 34. *Spiratella inflata elevata* (Collins). Bernasconi and Robba, 1982, p. 217. *Limacina elevata* Collins. Shibata, 1983, p. 68, 69.
- v. *Planorbella imitans* Gabb, 1873. Janssen, 1990, p. 16. *Limacina elevata* Collins, 1934. Zorn, 1991, p. 104. *Limacina elevata* Collins, 1934. Hodgkinson, Garvie and Bé, 1992, p. 21.

Description.—Shell discoidal, slightly more than 1.5 times wider than high, with ca. 2½–2¾ convex whorls. The nucleus is slightly raised, but subsequent whorls become planorboid and enclose foregoing whorls. Therefore the apical side of the adult shell becomes more or less concave, with a slightly protruding apex in the centre, which in fully-grown specimens may or may not be visible in frontal view. The whorls increase gradually and regularly in diameter. The upper shell wall attaches somewhat above the periphery of the preceding whorl, resulting in a slight overlap of the whorls in apical view. The lower shell wall is connected to the base of the shell, far below the periphery. Thus, the overlap of whorls in umbilical view is wider. The umbilicus is relatively narrow, occupying about one fifth of the shell diameter.

The aperture is lunate, with a gradually convex abaxial margin and a columellar side indented by the penultimate whorl. The apertural margin is slightly reinforced by a weak internal thickening, sometimes visible externally as a less transparent opaque, margin-parallel seam.

The shell surface at first glance is smooth, apart from regular growth lines, but at a magnification of × 50 a very peculiar microsculpture appears, which has not previously been described in Limacinidae. This ornament is especially well visible on the periphery of the body whorl and consists of numerous extremely fine grooves, lengthwise incised on the periphery but diverging in backward direction above and below the

periphery. This body whorl ornament is indicated schematically in the line drawings given here; no pen is sufficiently fine to reflect this ornament correctly. Therefore photomicrographs are given of another specimen (Pl. 1), showing that this microsculpture effaces both below and above the periphery. In apical view it is not visible on the preceding whorls.

Neolectotype (here designated).—Coll. ANSP no. 2895 (Pl. 2, fig. 6a–d). The number of specimens in Gabb's sample was not stated in the original paper. Pilsbry (1922, fig. 1) refigured the specimen already illustrated by Gabb (1873a), referring to it as "the type". This is an acceptable lectotype designation. Pilsbry added to his description that "Besides the type of *Planorbella imitans*, no. 2895 A.N.S.P., there are two smaller examples and some fragments". Being syntypes, these specimens are thus paralectotypes. The lectotype was subsequently broken (Collins, 1934, p. 180) and nowadays the vial marked "type" contains nothing of use and the lectotype must be considered lost. A second vial in sample no. 2895, however, contains one complete specimen and several fragments of another shell, undoubtedly the additional specimens Pilsbry referred to. The diameter of the complete shell is roughly 1 mm, the same size as given for the lectotype by Pilsbry. The outline and proportions of this syntype match Pilsbry's illustration very well (Gabb's 1873b drawing is "poor" and misleading; Pilsbry, 1922: 308), and therefore we may safely assume this specimen to belong to the same species as the lost lectotype.

Considering the widely expressed, but incorrect opinion (see below), that *Planorbella imitans* Gabb, 1873a is a junior synonym of *Limacina inflata* (d'Orbigny, 1836) I hereby designate neolectotype the sole remaining complete specimen.

Dimensions of neolectotype.—H = 0.64 mm, W = 0.98 mm.

Type locality.—Santo Domingo (Gabb, 1873a).

Material.—Cercado Formation, *Glorobotalia humerosa* Zone, Late Miocene, Río Gurabo 1978, Sta. 15900: one specimen, NMB H 17716; Sta. 15907: one damaged specimen, NMB H 17717.

Cercado Formation, probably Late Miocene, Río Cana 1979, Sta. 16835: one damaged specimen, NMB H 17718.

No formation name; age uncertain, ? Late Miocene, Río Mao 1979, Sta. 16915: one specimen, NMB H 17719; Sta. 16922: one damaged specimen, NMB H 17720; Sta. 16927: one specimen (Pl. 2, fig. 8a–d), NMB H 17619.

Distribution.—Late Miocene of the Dominican Republic; Early Pliocene of Santa Rosa, Vera Cruz, Mexico. A closely related, if not conspecific form occurs

in the Early Pliocene of the Mediterranean area (coll. RGM).

Remarks.—I examined the holotype of *L. elevata* Collins, 1934, described from the "Middle Miocene" of Santa Rosa, Vera Cruz, Mexico, some years ago (see Pl. 2, fig. 9a–e). *L. elevata* appears to be a junior synonym of *L. imitans*, having same shape and proportions, and also demonstrating the peculiar microsculpture. Only the holotype was available, the remaining syntypes (forty specimens according to Collins) could not be traced in the Washington collection.

The specimen from the Río Mao (Cercado Formation), identified as *L. inflata* by Collins (1934) (here illustrated Pl. 2, fig. 7a–d), also definitely belongs to *L. imitans*. Another specimen mentioned and illustrated by Collins (1934, p. 180, pl. 7, figs. 3–5) as *L. inflata* has different proportions and lacks the microsculpture. However, assignment to *L. inflata* is tentative in view of a damaged apertural margin and apparent lack of the subperipheral thickening, frequently also seen in immature specimens.

On account of its unique surface microsculpture, *L. imitans* should be isolated from other limacinids in a separate subgenus. The name *Planorbella*, introduced by Gabb (1873a), however, is not available because of preoccupation by *Planorbella* Haldemann, 1843 (Mollusca). Therefore the replacement name *Striolimacina* is introduced here.

A very similar *Limacina* species was found to be a quite common element in some Pliocene faunas in the Mediterranean area (France and Italy). It has an almost identical shape and the same microsculpture, but it grows to a larger size and has a wider spiral of whorls. Whether such shells should be included in this taxon or considered to represent a separate species will be discussed in a forthcoming paper.

Subgenus **HELICONOIDES** d'Orbigny, 1836

Limacina (Heliconoides) inflata (d'Orbigny, 1836)

Plate 2, figures 10–11

- * *Atlanta inflata* d'Orb., d'Orbigny, 1836, p. 174, pl. 12, figs. 16–19.
- *Embolus rostralis* Souleyet (*Spirialis*). Seguenza, 1880, p. 277.
- v. *Spirialis tertiaria* spec. nov. Tate, 1887, p. 196 (partim, only pl. 20, fig. 12a–c; includes *Limacina tertiaria*).
- v? *Limacina inflata* (d'Orbigny). Collins, 1934, p. 179, pl. 7, figs. 3–5 (partim, non figs. 6–8 = *Limacina imitans*).
- v? *Spiratella inflata* (d'Orbigny). Perrilliat, 1974, p. 34.
- v. *Limacina inflata* (d'Orbigny, 1836). Janssen,

1990, p. 14, pl. 2, figs. 5–7, pl. 3, fig. 11, pl. 10, fig. 2.

Description.—The only available specimen is easily recognized on account of its planispiral shell form and the presence of a darker subperipheral zone around the body whorl. This zone is a slightly thickened part of the shell wall, which in fully-grown specimens forms a falciform thickening a short distance behind the apertural margin. This is not visible in the present specimen, but the thickening of the shell wall is distinctly visible on the (broken) apertural margin. In this shell the early whorls are not visible in frontal view, as is sometimes seen in this species.

Syntypes.—About 82 poorly preserved specimens are in The Natural History Museum, London (reg. 1854.12.4.38, catalogue 61) (see van der Spoel, 1976, p. 188).

Type locality.—Indicated as Atlantic and Pacific Oceans, 36° N – 6° (possibly meant is 6°W = Street of Gibraltar, 6°E is onshore Algeria; if d'Orbigny, however, used the Paris meridian possibly 6°E is meant, which would be just W of Sardinia in the Mediterranean) (Recent); see van der Spoel (1976, p. 188).

Material.—Cercado Formation, *Globorotalia humerosa* Zone, Late Miocene, Río Gurabo 1978, Sta. 15903: one specimen (Pl. 2, fig. 10a–b), NMB H 17620.

Measurements.—H = 0.7 mm, W = 1.05 mm.

Distribution.—Middle Miocene (Bairnsdalian to Balcombian) of Australia (Janssen, 1990), “Middle Miocene” (Serravallian) of Turkey (Janssen, in press), Late Miocene of the Dominican Republic (this paper) and Italy (Messinian; coll. RGM), ? Early Pliocene of Mexico (Collins, 1934; present paper), northern Italy (Janssen, 1990) and France (coll. RGM). Widely distributed in tropical and subtropical areas at the present day.

Remarks.—Apart from the first description only records of Tertiary occurrences are listed here. For younger material the reader is referred to van der Spoel (1967, 1976).

This species has frequently been mentioned from the fossil record, but whether or not these records really refer to it is difficult to determine from the literature as information on the apertural reinforcements is usually missing. Janssen (1990, p. 16) considered it possible that “*Planorbella imitans*” Gabb, 1873a is a junior synonym of *L. inflata*, but in the present paper it is demonstrated that Gabb's taxon is an independent species (see above). This restricts the number of synonyms for Tertiary specimens to the few citations given here. The specimens recorded by d'Alessandro *et al.* (1979) from the Miocene of Gargano (Italy) do not

belong to *L. inflata* either, but to *L. tertiaria* (Tate, 1887) (compare Janssen, 1995, p. 25).

From all the specimens recorded by Collins (1934) only the specimen from Santa Rosa, Mexico may be assigned to *L. inflata*. I studied the shell illustrated by Collins (1934, pl. 7, fig. 3–5) and new drawings are included in this paper (Pl. 2, fig. 11a–d). It closely resembles the Río Gurabo specimen, but lacks the subperipheral zone. The absence of microsculpture shows that it is not identical with *L. imitans*.

Limacina sp. indet.

Description.—The washing residue of a small quantity of sediment yielded a number of very immature limacinids, that are too small to be identified with any degree of certainty. These tiny shells comprise but a single whorl, and several of them are crushed.

Material.—Mao Formation, *Globorotalia margaritae/miocenica* Zone, Early to Middle Pliocene, Río Gurabo 1978, Sta. 15829: 13 juvenile specimens (from washing residue), NMB H 17721.

Remarks.—These specimens occur in an interval on the Río Gurabo section that yielded no other species of this genus. They may belong to the Miocene to Recent species *Limacina inflata*.

Family CAVOLINIIDAE Fischer, 1883

Subfamily CRESEINAE Rang, 1828

Genus CRESEIS Rang, 1828

Type species.—*Creseis acicula* Rang, 1828.

Creseis acicula (Rang, 1828)

Plate 3, figures 1–2

- * *Cleodora (Creseis) acicula* N. Rang, 1828, p. 318, pl. 17, fig. 6.
- Cleodora acicula* Rang, Philippi, 1844, p. 72, 233, 351.
- Cleodora (Creseis) acicula* Rang, Reuss, 1867, p. 145.
- Cleodora acicula*, Rang, Seguenza, 1876, p. 42.
- Creseis acicula (Cleodora)* Rang, Tiberi, 1878, p. 74.
- Hyalaea aciculata* d'Orbigny, Tiberi, 1878, p. 74.
- Vaginella acicula* Ponzi, Tiberi, 1878, p. 74.
- Creseis acicula* Rang, Seguenza, p. 276.
- Creseis acicula (Cleodora)* Rang, Tiberi, 1880, p. 36.
- Hyalaea aciculata* d'Orbigny, Tiberi, 1880, p. 36.
- Vaginella acicula* in Ponzi, Tiberi, 1882, p. 36.
- Creseis acicula* Rang, Dall, 1893, p. 432.
- Creseis acicula* Rang, Bellini, 1905, p. 43.

Clio (Creseis) acicula (Rang). Yamakawa and Ishikawa, 1912, p. 2, pl. 1, fig. 2 (non fig. 1a–b = *Limacina inflata*).

Clio acicula Yamakawa and Ishikawa, 1912, p. 24.

Creseis acicula Rang. Peyrot, 1932, p. 21.

Creseis acicula Rang. Collins, 1934, p. 207, pl. 9, figs. 6–7; pl. 13, figs. 7–8.

Creseis acicula Rang. Di Geronimo, 1970, p. 79, pl. 3, fig. 4; pl. 4, fig. 6.

Creseis acicula (Rang, 1828). Noda, 1972, p. 473–475, 481, pl. 57, figs. 1–5.

Creseis acicula (Rang). Jung, 1973, p. 753ff., pl. 2, fig. 9.

Creseis cf. *acicula* Rang. Di Geronimo, 1974b, p. 183.

Creseis acicula Rang. Perrilliat, 1974, p. 35.

Creseis acicula (Rang, 1828). Grecchi, 1975, p. 226, 230.

Creseis acicula acicula (Rang). LeRoy and Hodgkinson, 1975, p. 425, pl. 10, fig. 13.

Creseis acicula Rang, 1828. Buccheri, 1978, p. 128, pl. 2, fig. 5.

Creseis acicula Rang. Buccheri, Catalano and Heezen, 1980, p. 99.

Creseis acicula Rang. Shibata, 1980, p. 62, 64.

Creseis cf. *acicula* Rang. Shibata, 1980, p. 64, pl. 3, fig. 1.

Creseis acicula Rang. Buccheri and Torelli, 1981, p. 78, 79, 81, 83, figs. 2–3.

Creseis (cf.) *acicula* Rang. Shibata and Ishigaki, 1981, p. 57, figs. 5–6.

Creseis acicula Torelli and Buccheri, 1981, p. 177, 178.

Creseis acicula (Rang). Bernasconi and Robba, 1982, p. 217–220.

Creseis acicula Rang, 1828. Grecchi, 1982, p. 718, pl. 54, figs. 7, 8.

Creseis acicula Rang, 1828. Ruggieri, 1982, p. 260.

Creseis acicula acicula Rang, 1828. Shibata and Ujihara, 1983, p. 153, 159, pl. 44, fig. 1a–b.

Creseis acicula Rang. Shibata, 1983, p. 70.

Creseis acicula f. *acicula* Rang, 1828. Shibata, 1984, p. 78, pl. 23, figs. 9–10.

Creseis acicula Rang, 1828. Grecchi, 1984, p. 15, pl. 1, fig. 14.

Creseis acicula Rang. Buccheri, 1985, p. 119ff.

Description.—The few specimens before me were recovered from the washing residue of a small bit of sediment. Two of them are apical fragments preserving the protoconch. The tip of the shell is rounded and very slightly inflated. In adapical direction the shell

widens very gradually. The transverse section is circular. The fragments are included in this taxon with a query: as the larval shells are missing the very slightly conical tubes might as well belong to other organisms, although the thickness of the shell wall and their general appearance suggest that they belong to *C. acicula* as well.

Lectotype.—According to van der Spoel (1976, p. 189) the lecto- and paralectotypes are housed in the dry collection of MHNP.

Type locality.—"Mer des Indes" (Recent).

Material.—Mao Formation, *Globorotalia margaritae/miocenica* Zone, Early to Middle Pliocene, Río Gurabo 1978, Sta. 15829: two juvenile specimens (Pl. 3, figs. 1–2), NMB H 17621, ? seven fragments, NMB H 17722 (all specimens from washing residue).

Remarks.—Synonyms given here mainly refer to literature on fossil occurrences. For synonyms of Recent material the reader is referred to van der Spoel (1967, 1976).

It is extremely difficult to supply a reliable list of synonyms, especially for fossil occurrences of this species. Various authors merely listed the species, not indicating whether or not the protoconchs were preserved. Only when this shell part is preserved can the occurrence be considered certain. On the other hand, it appears likely that the minute and fragile shells have frequently escaped attention and that the species really is more common, at least in Pliocene deposits, than generally thought. To find this species it is necessary to take special precautions when washing the sediment: they disappear with the sediment through sieving meshes wider than 100 μ m, or are crushed by other components of the residue.

Genus **HYALOCYLIS** Fol, 1875

Type species.—*Hyalocylis striata* (Rang, 1828) (Recent).

Hyalocylis striata (Rang, 1828)

Plate 3, figures 3–6

* *Cleodora (Creseis) striata* N. Rang, 1828, p. 315, pl. 17, fig. 3.

Cleodora striata Rang. Philippi, 1844, p. 72, 233.

Cleodora striata Rang. Philippi, 1844, p. 351.

Creseis striata Rang. Seguenza, 1867, p. 12, fig. 13a–b.

Styliola striata Rang (*sic*). Gabb, 1873b, p. 200.

Clio striata Rang. Seguenza, 1875, p. 148.

Cleodora (Balantium) striata Rang sp. Seguenza, 1876, p. 43.

Creseis striata Rang. Tiberi, 1878, p. 74.

Creseis striata Rang. Tiberi, 1880, p. 37.

- ?v *Tentaculites cretaceus* n. sp., Blanckenhorn, 1889, p. 600, pl. 22, figs. 8–9.
Creseis striata Rang. Bellini, 1905, p. 43.
- ?v *Tentaculites cretaceus* Blanck. Blanckenhorn, tab.
- v *Hyalocylix haitensis* n. sp., Collins, 1934, p. 211, pl. 12, figs. 1–2.
- ?v *Tentaculites cretaceus* Blanck. Avnimelech, 1936, p. 210.
- ? *Hyalocylix euphratensis* Avnimelech n. sp., Avnimelech, 1945, p. 643, fig. 7.
- ?v *Clio cretaceum* (Blanckenhorn). Avnimelech, 1945, p. 644, fig. 9.
- ? *Praehyalocylix cretaceus* (Blanck.). Korobkov and Makarova, 1962, p. 84.
Praehyalocylix haitensis (Coll.). Korobkov and Makarova, 1962, p. 84.
Hyalocylix striata Rang. Korobkov and Makarova, 1962, p. 84.
- ? *Hyalocylix euphratensis* Amn. (*sic*). Korobkov, 1966, p. 88.
- ? *Clio cretaceum* Blanck. Korobkov, 1966, p. 88.
- ?v *Clio cretaceum* (Blanckenhorn). Avnimelech, 1966, p. 309.
Hyalocylix striata (Rang). Di Geronimo, 1970, p. 84, pl. 3, fig. 3; pl. 4, fig. 5.
Hyalocylix striata (Rang, 1828). Noda, 1972, p. 474, 478, pl. 57, figs. 7, 8.
Hyalocylix haitensis Collins, 1934. Noda, 1972, p. 478.
Hyalocylix striata (Rang). Jung, 1973, p. 753ff, pl. 3, figs. 6, 7.
- ? *Hyalocylix obtusa* n. sp., Di Geronimo, 1974a, p. 114, figs. 1–3.
Hyalocylix striata (Rang). Di Geronimo, 1974a, p. 113, 114, 116.
Hyalocylix striata (Rang). Vatova, 1974, p. 108.
Hyalocylix striata (Rang, 1828). Buccheri, 1978, p. 129, pl. 2, fig. 6a–b.
Hyalocylix striata (Rang). Shibata, 1979, p. 111ff.
Hyalocylix striata (Rang). Shibata, pl. 20, figs. 22–30.
Hyalocylix striata (Rang). Buccheri, Catalano and Heezen, 1979, p. 99–101, pl. 1, fig. 8.
Hyalocylix striata (Rang). Shibata, 1980, p. 62.
Hyalocylix striata (Rang). Buccheri and Torelli, 1981, p. 78, 83, figs. 2, 3.
Hyalocylix striata (Rang). Shibata and Ishigaki, 1981, p. 57ff, figs. 5–6.
Hyalocylix striata (Rang). Shibata and Ishigaki, 1981, p. 67.
Hyalocylix striata Torelli and Buccheri, 1981, p. 178.
- Hyalocylix striata* (Rang). Di Geronimo, Li Gioi and Sciacca, 1982, p. 585.
- ? *Praehyalocylix euphratensis* (Avnimelech). Bernasconi and Robba, 1982, p. 213.
- ? *Praehyalocylix cretacea* (Blanckenhorn). Bernasconi and Robba, 1982, p. 213.
Hyalocylix haitensis Collins. Bernasconi and Robba, 1982, p. 217.
Hyalocylix striata (Rang). Bernasconi and Robba, 1982, p. 218, 219.
Hyalocylix striata (Rang). Buccheri, 1983, p. 53, fig. 1.
Hyalocylix striata (Rang, 1824) (*sic*). Shibata and Ujihara, 1983, p. 153, 161, pl. 44, fig. 7.
Hyalocylix striata (Rang). Shibata, 1983, p. 77.
Hyalocylix striata (Rang, 1824). Shibata, 1984, p. 80, pl. 23, figs. 11–12.
Hyalocylix striata (Rang). Buccheri, 1984, p. 80ff, pl. 1, fig. 7.
Hyalocylix striata (Rang, 1828). Grecchi, 1984, p. 16, pl. 1, fig. 4.
Hyalocylix striata (Rang). Coppa and Crovato, 1985, p. 172, 204, pl. 8, fig. 4.
Hyalocylix striata (Rang, 1828). Hodgkinson, Garvie and Bé, 1992, p. 29.
Styliola striata Rang. Hodgkinson, Garvie and Bé, 1992, p. 30.
- ? *Praehyalocylix cretacea* (Blanckenhorn, 1899). Hodgkinson, Garvie and Bé, 1992, p. 7, p. 30.

Description.—See van der Spoel (1967, p. 65).

Syntypes of Hyalocylix striata.—Van der Spoel (1976, p. 189) referred to fragments of eight specimens with “damage too serious to select lectotype” in coll. MHNP.

Holotype of Hyalocylix haitensis.—USNM no. 371905, slightly distorted internal mould (see Pl. 3, fig. 4a–b). The specimen illustrated in Plate 3, figure 5a–d is a paratype.

Lectotype of Tentaculites cretaceus.—Blanckenhorn (1889, p. 600) referred to several internal and external moulds, two of which were illustrated (pl. 22, figs. 8 and 9). The original specimen of figure 9 was reillustrated by Avnimelech (1945), who incorrectly referred to it as the holotype. It is here designated lectotype (GMHU no. 2100). A new illustration is given here in Plate 3, figure 6.

Another syntype from Blanckenhorn’s material of *T. cretaceus* (GMHU no. 2099), possibly the one illustrated in Blanckenhorn’s fig. 8, was considered by Avnimelech (1945, p. 643, fig. 7) to represent a new spe-

cies, described as *Hyalocylix euphratensis* Avnimelech, 1945.¹

Type locality of Hyalocylix striata.—Indian Ocean (Recent).

Type locality of Hyalocylix haitensis.—Haïti, Port-au-Prince (near Pétienville), U. S. Geological Survey Sta. 9574; age "Miocene".

Type locality of Tentaculites cretaceus.—West of Nisib, Turkey (Miocene, ? Vindobonian).

Material.—Mao Formation, *Globorotalia margaritae* Zone, Early to Middle Pliocene, Río Gurabo 1978, Sta. 15827: two fragments, NMB H 17723; Sta. 15828: one damaged specimen, various fragments, NMB H 17724; Sta. 15829: one specimen (fragments of pyritic internal mould with remains of shell), many fragments (from washing residue), NMB H 17725, three damaged specimens on slab (Pl. 3, fig. 3), NMB H 17622.

Distribution.—Miocene (? Vindobonian) of Turkey (?), Pliocene of the Caribbean, Mediterranean and Japan; Quaternary and Recent widely distributed in the tropics and subtropics.

Remarks.—Synonyms given here predominantly refer to literature on fossil occurrences. For synonyms of Recent material the reader is referred to, e.g., van der Spoel (1967, 1976).

The type material of *Hyalocylix haitensis* Collins was considered to be of Miocene age. At the type locality, however, this species is accompanied by *Diacria digitata* (Guppy, 1882), a species described from the Bowden Beds in Jamaica. This indicates that the type material of *H. haitensis* more or less has the same age as these Bowden Beds, which is Late Pliocene (NN 16; Aubry, 1993). The Haitian specimens agree entirely with the unfortunately rather fragmentary material from the Dominican Republic, as specified above. In comparing the types and the Dominican material with numerous Recent samples I convinced myself of the conspecificity of all these samples. Generally speaking the Caribbean fossil specimens seem to have a rather coarse transverse ornament, but there are many specimens among the Recent ones with widely spaced annulations too, so that this characteristic cannot be used for a specific distinction. On the other hand the fossils are usually so fragmentary that the relatively rapidly expanding apical shell part as seen in the Recent specimens is only rarely preserved. In fact, only the holotype demonstrates this sufficiently

¹ It is interesting that lectotype sample no. 2100 of *Tentaculites cretaceus* contains also a syntype of *Balantium flabelliforme* Blanckenhorn, 1889, referred to by Avnimelech (1945, p. 644). This specimen, however, is an internal mould of the bivalve *Propeamussium* sp., which in having diverging internal ribs more or less resembles a representative of the genus *Clio*.

well to decide that on this feature specimens cannot be separated either. Thus, it is concluded that the Caribbean fossils fall within the range of variation of the Recent taxon.

Another, most certainly closely related taxon is *Tentaculites cretaceus* Blanckenhorn, 1889, based on several specimens from the Miocene of SE Turkey. One of the syntypes was later designated holotype of *Hyalocylix euphratensis* Avnimelech, 1945. Although I have only seen the lectotype of *T. cretaceus* it appears likely that *H. euphratensis* is the more apical shell part of *T. cretaceus* (especially so since both originate from the same locality), an interpretation also maintained by Blanckenhorn (1889). Avnimelech (1945) also considered this possibility, but remarked that "there are several reasons against this opinion", without specifying these reasons. Judging from Avnimelech's illustration the gradually widening apical shell part is much more elongate than in *H. striata*, in which species this shell part widens more rapidly than the more adult shell. Furthermore, the age of the Turkish material very probably is Miocene in age. In the lectotype sample of *T. cretaceus* occurs a specimen of a ? vaginellid species, identified as *Vaginella rotundata* Blanckenhorn, 1889. In my opinion this identification is in considerable doubt (Janssen, 1995), but the mere presence of a vaginellid excludes an age younger than Middle Miocene. For these reasons *T. cretaceus* is included in the present taxon with a query.

The elliptical transverse section and curved apical shell part show *T. cretaceus* to be a real representative of the genus *Hyalocylix* rather than of *Praehyalocylix* Korobkov, an assignment advocated by Korobkov and Makarova (1962, p. 84) and by Bernasconi and Robba (1982). In the latter genus the shell has a circular transverse section, the apical shell part is straight, and the larval shell is calcified, not shed.

I agree with van der Spoel (in press) that *Hyalocylix obtusa* Di Geronimo, 1974 probably is a junior synonym of the present species. For a final opinion, however, I have to see the types.

Genus *STYLIOLA* Gray, 1850

Type species.—*Styliola subula* (Quoy and Gaimard, 1827) (Recent).

Styliola subula (Quoy and Gaimard, 1827)

Plate 3, figures 7–9

* *Cleodora subula* Quoy and Gaimard, 1827, p. 233, pl. 8, figs. D1–D3.

· *Creseis spinifera* N., Rang, 1828, p. 313, pl. 17, fig. 1.

· *Styliola sulcifera* Gabb, n.s., Gabb, 1873b, p. 200.



Text-figure 3.—Neotype of *Styliola subula* (Quoy and Gaimard, 1827). Tydeman Selvagens-Canary Islands Expedition, 1980. CANAP-IV STA. 4.117; Canary Islands, S. of Palma, 28°26', 17°51'W, depth 503 m, gravel, sand, and shells; van Veen grab, 28-V-1980; a: frontal view, × 6; b: protoconch, × 25. NNM 57267

- Styliola sulcifera* Gabb, 1881, p. 337.
Styliola sulcifera Guppy, 1882, p. 175.
v. *Styliola Rangiana*, spec. nov., Tate, 1887, p. 194, pl. 20, fig. 2.
Styliola sulcifera Gabb. Dall, 1893, p. 430.
. *Clio (Styliola) Lamberti* Checchia-Rispoli, Checchia-Rispoli, 1921, p. 10, figs. 3, 3a.
v. *Styliola sulcifera* Gabb. Pilsbry, 1922, p. 309, text-fig. 3 (2 figs.).
. *Styliola sulcifera* Gabb. Collins, 1934, p. 202, pl. 9, figs. 9–12.
Styliola subula (Quoy and Gaimard, 1827). Shibata, 1984, p. 79, pl. 24, figs. 8–9.

Neotype.—The syntypes of *Cleodora subula* Quoy and Gaimard must be considered lost (van der Spoel, 1976, p. 189; Janssen, 1990, p. 33). As pointed out in this latter paper (p. 39) “an interpretation of the original description and illustration of this taxon is extremely hazardous and confusing”. Unlike *Creseis spinifera*, described by Rang (1828) one year after publication of Quoy and Gaimard’s paper, *Cleodora subula* cannot be recognized from the description and poor illustration. Rang (1828) had similar problems, assuming them to be separate species. To stabilize nomenclature around this situation once and for all it is necessary to designate a neotype in agreement with the modern concept of *Styliola subula*, from near the type locality (= Côte de Ténériffe). For that purpose I here select a specimen from the Canary Islands, S of Palma (28°26'N 17°51'W, see Text-figure 3). It is housed in the collections of the National Natural History Museum, Leiden, with registration number NNM 57267.

Holotype of *Styliola sulcifera*.—Coll. ANSP no. 2893 (Pl. 3, fig. 7a–b). This specimen was illustrated for the first time by Pilsbry (1922, text-fig. 3). The specimen has suffered damage since. Its present state is shown in my illustration, in which the outline of the

specimen as given by Pilsbry is indicated. From Collins’ drawing (1934, pl. 9, fig. 9) it may be concluded that at that time the specimen was still as it was in 1922.

Type locality of *Styliola sulcifera*.—Santo Domingo (Gabb, 1873: 200) (“Miocene”).

Description.—See van der Spoel (1967).

Material.—Mao Formation, *Globorotalia margaritae/miocenica* Zone, Early to Middle Pliocene, Río Gurabo 1978, Sta. 15823: three specimens, two damaged specimens, two fragments, NMB H 17726; Sta. 15827: two specimens, one fragment, NMB H 17727; Sta. 15828: two specimens, one specimen (with counterpiece), three fragments, NMB H 17728; Sta. 15829: three juvenile specimens, one fragment, three fragments (from washing residue), NMB H 17729; Sta. 15832: one specimen, one fragment, NMB H 17730.

Gurabo Formation, *Globorotalia margaritae* Zone, Early Pliocene, Río Gurabo 1978, Sta. 15851: one damaged specimen (Pl. 3, fig. 9a–b), NMB H 17624; Sta. 15854: one specimen (Pl. 3, fig. 8a–b), NMB H 17623.

Distribution.—Late Oligocene (Chattian) of the North Sea Basin; Miocene of the North Sea Basin, Poland, Australia, Mediterranean etc., Pliocene and younger: widespread.

Remarks.—For a more exhaustive list of synonyms see Janssen (1990, p. 32; 1995).

This long-ranging species nowadays has a large distributional area, covering the entire tropical and subtropical regions. An extensive discussion on the conspecificity of the various “species” is given in Janssen (1990, p. 36ff).

Subfamily **CUVIERININAE** van der Spoel, 1967

Genus **CUVIERINA** Boas, 1886

Type species.—*Cuvieria columnella* Rang, 1827 (Recent).

Cuvierina astesana (Rang, 1829)?

Plate 3, figure 10

? *Cuvierina Astesana* Rang, Rang, 1829, p. 498, pl. 19, fig. 2a–e.

Description.—Adult shell cylindrical tubiform, ca. three times higher than wide (H/W-ratio ranging between 2.76 and 3.14 in five complete specimens), very slightly inflated at about mid-height. In between this inflation and the aperture the shell demonstrates a very weak preapertural constriction. Juvenile shell shed during life and opening closed by a semispherical septum. The boundary between the septum and the adult shell is slightly oblique (lateral view), cutting the growth lines. From the septum to about mid height the shell

is regularly conical. Near the aperture the ventral side of the shell is somewhat flattened, as a result of which the aperture (adapical view) has a gradually rounded dorsal and a flattened ventral side. Also in front view the ventral apertural margin is straight, whereas the dorsal one is higher and gradually curved.

The shell's surface is glossy in well-preserved specimens and shows fine growth lines which are in fact only visible where the light is reflected. The growth lines are straight in dorsal and ventral view, but oblique in lateral view, agreeing with the oblique position of the aperture. A slight internal thickening of the shell is seen along the apertural margins as a zone of different colour. The surface does not show the radial sculpture that is found in many other species of this genus.

Type material.—A broken specimen is present in coll. MHNP (pers. comm. P. Lozouet, April 1996).

Type locality.—"l'Astésan" = Asti area, Piemonte province, northern Italy (Pliocene).

Material.—Cercado Formation, *Globorotalia humerosa* Zone, Late Miocene, Río Gurabo 1978, Sta. 15903: one specimen, NMB H 17731; Sta. 15906: two specimens, NMB H 17732; Sta. 15907: three specimens, NMB H 17733, one specimen (Pl. 3, fig. 10a-c), NMB H 17625.

Measurements.—Table 1.

Table 1.—Measurements (in mm) of *Cuvierina astesana* (Rang, 1827)? H = height, W = width, Wdv = dorso-ventral width, Wap = width at aperture, Wse = diameter of septum in front view.

	H	W	H/W	Wdv	Wap	Wse
Río Gurabo	5.57	1.93	2.89	1.97	1.72	1.11
Río Gurabo 15906	5.65	1.93	2.93	1.72	1.84	1.15
	5.57	1.84	3.03	1.72	1.72	1.15
Río Gurabo 15907	5.73	1.88	3.05	1.76	1.96	1.07*
	5.65	1.80	3.14	1.76	1.72	1.07
	6.15	2.07	2.28	1.72	1.89	—
	5.40	1.97	2.75	1.80	1.72	1.02
Mean value	5.67	1.92	2.86	1.78	1.80	1.10

* Pl. 3, fig. 10a-c.

Remarks.—For an extensive list of further synonyms of *Cuvierina astesana* the reader is referred to Janssen (1995).

The few available specimens strongly resemble the Pliocene species *Cuvierina astesana*, which in the Mediterranean area demonstrates a wide range of variation (Janssen, 1995, pl. 2). There are, however, some small differences that in the material at hand seem to be constant. The Dominican Republic shells have a very slight preapertural constriction. Such a constriction is only rarely found in the Mediterranean populations, which on average are also slightly more slender (H/W-ratio around 3.5). Furthermore the aperture

in the Dominican specimens is less triangular than in the typical *C. astesana*. The material agrees with *C. astesana* in the absence of a radial sculpture.

Cuvierina intermedia (Bellardi, 1873) (? Late Miocene of southern Portugal, Pliocene of the Mediterranean; Janssen, 1995) agrees with the Dominican specimens in proportions, but is slightly more inflated and has a distinct radial microsculpture.

Other species described from the European Neogene, such as *C. paronai* Checchia-Rispoli, 1921 (Middle Miocene), differ more strongly in size or H/W-ratio.

The material discussed here has a Late Miocene age (*Globorotalia humerosa* Zone), whereas the Mediterranean populations of *C. astesana* are dated as Pliocene (Zanclean/Piacenzian). Apparently we are dealing with an ancestral form, which in my opinion is insufficiently different to be described as an independent species.

In Janssen (1995) many data are presented on these European taxa. In that paper (p. 43) it was concluded that *C. tubulata* Collins, 1934, described from Santa Rosa, Mexico, possibly is a synonym of *C. astesana*. Indeed the holotype falls within the range of variation of that species, agreeing with the most slender specimens (H/W-ratio over 4.60). Comparing *C. tubulata* with the far more thick-set Dominican Republic specimens, on the other hand, makes this conclusion not very likely, but here too final decisions can only be drawn after a study of many specimens, which are not yet available.

Cuvierina sp.

Plate 3, figure 11

Description.—The only available specimen is in a poor condition. It is compressed and distorted, and only insignificant remains of the shell wall are still present. The basal part of the specimen could be freed from the surrounding matrix, showing the septum, which makes assignment to the genus *Cuvierina* certain. From what is left it can be determined that the shell was not inflated, with almost straight sidelines. Its H/W-ratio is ca. 3.25, which value is almost certainly too small because of its flattened condition. Neither can it be observed if the shell's surface had a radial sculpture, nor is it possible to observe the shape of the aperture.

Material.—Mao Formation, *Globorotalia margaritae* Zone, Early to Middle Pliocene, Río Gurabo 1978, Sta. 15828: one specimen (Pl. 3, fig. 11), NMB H 17626.

Measurements.—H = 10.8 mm, W = 3.3 mm.

Remarks.—Because of its large size this specimen

can in fact only be compared with the Recent *Cuvierina columbella* (Rang, 1827) and with the Miocene Italian species *C. grandis* (d'Alessandro and Robba, 1980). The former usually remains slightly smaller and always demonstrates a clear inflation below the middle of the shell. The height of *C. grandis* ranges from ca. 10.7 to 16.7. At a size comparable with the Río Gurabo specimen its width would be ca. 2.9 mm (d'Alessandro and Robba, 1980, p. 650, table). Furthermore the basal shell part of that species is considerably more conical. Thus, identification of the present specimen remains impossible.

Subfamily **CLIOINAE** van der Spoel, 1967

Genus **CLIO** Linné, 1767

Type species.—*Clio pyramidata* Linné, 1767.

Clio cuspidata (Bosc, 1802)?

Plate 3, figure 12

Description.—A single poorly preserved specimen is available. It is preserved on a small piece of sediment and shows its ventral side. It differs from *Clio pyramidata*, occurring in the same sample, especially in having transverse sculpture. The central riblet is relatively wide. There is no sign, however, of a lengthwise curvature of the shell. The apical part with the protoconch is missing, and the aperture is severely damaged. An attempt to free the dorsal side of the specimen from adhering sediment was not successful. Apparently this part of the shell is also missing.

Material.—Mao Formation, *Globorotalia margaritae/miocenica* Zone, Early to middle Pliocene, Río Gurabo 1978, Sta. 15829: one specimen (Pl. 3, fig. 12), NMB H 17627.

Remarks.—The specimen cannot be identified with certainty, as information on the sculpture of the dorsal side is not available. Thus it cannot be ruled out that it belongs to *Clio braidensis* (Bellardi, 1873), also of Pliocene age (see Janssen, 1995, pl. 5, figs. 3–5). That species differs from *C. cuspidata* by the presence of three radial riblets in the centre of the dorsal side, whereas only one is present in *C. cuspidata*. After comparison with some Recent samples of the latter species it seems that the elevated central rib on the ventral side is slightly wider than in *C. braidensis* and thus the shell is tentatively referred to the Recent species.

Clio pyramidata Linné, 1767 forma **lanceolata**
(Lesueur, 1813)

Plate 3, figures 3, 13–17

v *Cavolina* sp. Vaughan and Woodring, 1921, p. 154.

v *Cleodora* sp. cf. *bowdenensis* n. sp., Collins, 1934, p. 202, pl. 12, fig. 6.

v *Cleodora* sp. Collins, 1934, p. 202, pl. 12, fig. 7.
Clio pyramidata forma *lanceolata* (Lesueur, 1813). Shibata, 1984, p. 81, pl. 24, figs. 1–3.

Description.—See van der Spoel (1967, p. 68).

Type material.—Lesueur's material has not been found in the MHNP collections (van der Spoel, 1967, p. 190).

Material.—Mao Formation, *Globorotalia margaritae/miocenica* Zone, Early to Middle Pliocene, Río Gurabo 1978, Sta. 15823: two specimens, NMB H 17734; Sta. 15828: seven specimens, NMB H 17735; Sta. 15829: five specimens, one juvenile specimen (from washing residue), NMB H 17736, one specimen (Pl. 3, fig. 13), NMB H 17628.

Gurabo Formation, *Globorotalia margaritae* Zone, Early Pliocene, Río Gurabo 1978, Sta. 15993: one specimen (Pl. 3, fig. 14a–f), NMB H 17629.

Upper part of *Globorotalia margaritae* Zone, late Early Pliocene, Río Yaque del Norte, Santiago, 1980, Sta. 17293: 13 specimens, five damaged specimens NMB H 17737.

Mao Formation, *Globorotalia margaritae/miocenica* Zone, Early to Middle Pliocene, Río Gurabo 1978, Sta. 15829: one specimen, NMB H 17738.

Distribution.—Miocene (Serravallian) of northern Italy (Robba, 1977); widespread in Pliocene and Quaternary, plus Recent tropics and subtropics.

Remarks.—For references of fossil occurrences see Janssen (1995). For synonyms concerning Recent material the reader is referred to van der Spoel (1967, 1976).

Clio bowdenensis (Collins, 1934) was correctly synonymized with the present form by Robba (1977, p. 600). In 1990 I studied the type material, housed in the Smithsonian Institution (USNM 645194; Andrews-Lynn collection, ex Johns Hopkins University coll.), new drawings of the holotype are given here (Pl. 3, fig. 15a–c). In the RGM collections, material from the type locality (Bowden, Jamaica) is extremely scarce. Just a single protoconch in this material is referable to *C. pyramidata*, and its elongate form indicates that it indeed belongs to the forma *lanceolata*.

Also I agree with Robba (1977) that the specimens from El Mores, Dominican Republic (Yaque Group, "Miocene") and from Jacmel, Haiti (Pliocene) should be identified with *Clio pyramidata* forma *lanceolata*. New drawings of the specimens illustrated by Collins (1934, pl. 12, figs. 6–7) are given here on Plate 3, figures 17 and 16, respectively.

Clio sp.

Plate 3, figure 18a-c

Description.—A single specimen, consisting of a protoconch with the earliest part of the teleoconch, is available. The protoconch is about one and a half times higher than wide and has a well-developed apical spine. There is no sharp boundary with the teleoconch, the transition is indicated by a constriction only. The sidelines of the preserved part of the teleoconch enclose an angle of ca. 50°. There is a distinct dorso-ventral flattening.

Material.—Mao Formation, *Globorotalia margaritae/miocenica* Zone, Early to middle Pliocene, Río Gurabo 1978, Sta. 15829: one juvenile specimen (from washing residue) (Pl. 3, fig. 18a-c), NMB H 17630.

Measurements.—H = 0.64 mm, W = 0.36 mm.

Remarks.—Another larval shell available in the same sample clearly belongs to *C. pyramidata* forma *lanceolata*, from which the present specimen differs by its less slender form of the protoconch bulb, and the wider angle of the early teleoconch. In the typical form of *C. pyramidata* the protoconch is less slender than in forma *lanceolata*, but it is still considerably more elongate than in the specimen described here, and the same is true for the early teleoconch. Also, the specimen cannot belong to *Clio cuspidata*, of which a doubtful specimen was encountered in the same sample (see above). In this latter species the larval shell has a much more globular form, in addition there is a sharp boundary with the teleoconch. Thus it must be concluded that sample 15829 yielded three *Clio* species, only one of which could be identified with certainty.

Subfamily **CAVOLINIINAE** van der Spoel, 1967

Genus **CAVOLINIA** Abildgaard, 1791 (emend. Philippi, 1853)

Type species.—*Cavolinia tridentata* (Niebuhr, 1775) (Recent).

Cavolinia gypсорum (Bellardi, 1873)

Plate 4, figures 1-3

- ? *Cavolinia* n. sp. Collins, 1934, p. 186, pl. 8, figs. 1-3.
 ?v *Cavolinia* sp. indet. Collins, 1934, p. 187, pl. 8, figs. 8-9.
 v. *Cavolinia gypсорum* (Bellardi, 1873). Janssen, 1995, pl. 8, figs. 9-12.
Cavolinia gypсорum (Bellardi, 1873). Zorn, 1997, pl. 1, figs. 1-2, pl. 2, figs. 1-4, pl. 3, figs. 1, 3.

Description.—The shell is typically cavoliniid, with a moderately convex dorsal side and a much more

swollen ventral part. Dorsal and ventral parts are only fused on the posterior margin, on both sides of the distinctly protruding apical spine. Therefore a slit is present all around the shell, but on both sides of the aperture an interlocking mechanism connecting the dorsal and the ventral side is present. The posterior margins usually are straight and in line, but occasionally they can be a little concave or convex, or enclose an angle slightly less than 180°. The lateral corners can be a bit spiny, pointing downward.

The shape of the dorsal shell part is roughly elliptical, with a straight base. The greatest width is situated at a point just below mid-height. The part protruding beyond the much lower ventral shell part is separated from the more apical part by a faint constriction, situated just above the position of the internal closing mechanism. The sculpture comprises five radial ribs, the three middle ones separated by somewhat narrower and flattened interspaces, and the lateral ones lying somewhat closer. A slightly swollen rim is present, separating a distinct semicircular to triangular apertural lip overhanging the aperture which is not visible in an adapical view.

The ventral side is very convex with a slightly flattened to somewhat concave adapical part. It can be as wide as high, but in most specimens it is wider than high (see Table 2). Especially important is the presence of two radial furrows, running obliquely into the direction of the transition between the lateral and the apertural margins. These furrows are not always very clear, but could be demonstrated in each specimen, albeit in low-angle light only.

The apertural lip of the ventral side is distinctly recurved and occasionally slightly thickened, as in most cavoliniids. The growth lines are very regular and especially well visible on the usually abapical portion of the ventral shell part. In various specimens, however, these lines are already visible much lower on the shell. In their center these growth lines show a distinct bend in apical direction.

The apical spine is only partly preserved in a few specimens. It is dorso-ventrally flattened and slightly curved in dorsal direction. The protoconch is missing in all specimens. On the preserved part of the apical spine distinct lateral wrinkles are seen.

In a damaged specimen (Río Cana Sta. 16837) the inner wall of the dorsal shell part demonstrates well the morphology of the interlocking mechanism connecting the dorsal and ventral parts (Pl. 4, fig. 2). Close to the left lateral margin the inner dorsal shell wall bears a lunate thickening covering a relatively deep excavation on its outer side. Opposite the concave margin of this thickening a denticle projects from the margin, likewise overcapping the same excavation. It

is easy to imagine how a bulb-shaped thickening at the inner shell wall of the ventral side could fit into this excavation, thus keeping the two parts connected with a sort of press-button. The construction of this lock in the ventral shell part could not be studied without damaging complete specimens, but it is clearly visible in Collins' (1934, pl. 8, fig. 1) drawing of his "*Cavolinia* n. sp.". From the excavation in the dorsal lock structure a distinct line runs parallel to the margin in downward direction, showing a strong resemblance to the mantle line of many bivalve species. Apparently this is the line along which the mantle tissue was connected to the shell. The surface of the inner dorsal shell part furthermore shows a distinct wavy lustre, not unlike the effect of nacre, which is brought about by the inner shell layer consisting of helical aragonite crystals.

Lectotype.—A lectotype for this species was designated by Janssen (1995, p. 100, pl. 8, fig. 9a–b). It is housed in the collections of the Dipartimento di Scienze della Terra, in Torino, Italy, reg. no. BS 007.01.002/1.

Type locality.—Guarene d'Alba (Italy, Piemonte province) (Miocene, Tortonian).

Material.—Cercado Formation, *Globorotalia humerosa* Zone, Late Miocene, Río Gurabo 1978, Sta. 15903: three specimens, one damaged specimen, NMB H 17739; one specimen (Pl. 4, fig. 1a–c), NMB H 17631; Sta. 15907: one specimen, NMB H 17740.

Cercado Formation, probably Late Miocene, Río Cana 1979, Sta. 16837: one damaged specimen (Pl. 4, fig. 2, interlocking system of dorsal shell part), NMB H 17632.

No formation name; ? Late Miocene, ? NN11, Río Mao 1979, Sta. 16932: one specimen, NMB H 17741.

Measurements.—The six more complete specimens available in the present material were measured (Table 2), giving shell height, shell width, dorso-ventral diameter, and height of the ventral shell part. It should be realized that the height of the shell includes the apical spine and the apertural lip, which are nearly always more or less damaged. The height of the ventral side was measured from the posterior shell margin, thus excluding the apical spine.

Table 2.—Measurements of *Cavolinia gypсорum* (Bellardi, 1873).

Sample no.	Height	Width	Dorso-ventral diameter	Height of ventral side
15903	6.43	4.40	3.75	4.08
	6.36	4.08	3.59	4.08
	6.45	4.89	3.91	3.91
	5.70	4.24	3.67	3.75
15907	6.11	4.40	3.34	3.91
16932	—	5.05	3.91	4.07

Remarks.—For a complete list of synonyms of *Cavolinia gypсорum* the reader is referred to Janssen (1995).

Undoubted records of *Cavolinia gypсорum* in the literature are rare and up to now exclusively from Italy. Zorn (1997) described the first records from outside Italy, *i.e.*, from the Heraklion Basin in Crete (eastern Mediterranean).

Although this species is usually cited from Messinian deposits a nannoplankton analysis proved the type material to be of Tortonian age (Janssen, 1995). The species has also been collected from Tortonian sediments near Sant'Agata Fossili, close to the Tortonian stratotype section on the Rio Mazzapiedi in northern Italy (Janssen, 1995, p. 104). Two more samples from Italy referred to by the same author are dated as Messinian. The sediments yielding the material from Crete, described in Zorn (1997) were dated as Early Messinian by means of planktonic Foraminifera. The records given here from the Dominican Republic are the first ones from outside the Mediterranean area and demonstrate the presence of this species on both sides of the Atlantic.

The Dominican material is in a much better state of preservation than the Italian samples, from which it differs morphologically only in minor details. Thus, the above description and the illustrations given here supply much additional information on this species.

Collins (1934, pl. 8, figs. 1–3) illustrated a damaged specimen from U. S. Geological Survey Station 8519, on the Río Mao (Gurabo Formation), as "*Cavolinia* n. sp.". Both description and illustration suggest that this specimen could be identical with the material here identified as *C. gypсорum*, although the radial furrows of the ventral part of the shell are neither mentioned nor visible in the illustration. I include this specimen in this species with a query. It was noted missing in the USNM collection as of November 1948 (F. J. Collier, in litt., May 1990).

The fragmentary specimen illustrated by Collins (1934, pl. 8, figs. 8–9) as *Cavolinia* sp. indet., originating from U. S. Geological Survey Station 8525 on the Río Mao (Cercado Formation), was studied several years ago. This specimen, an isolated ventral shell part, is here illustrated in Plate 4, figure 3a–c, showing that, although not visible in Collins' illustration, the two radial furrows are indeed present. So, there is no doubt that this fragmentary specimen belongs to either *C. gypсорum* or *Cavolinia* aff. *gypсорum*.

Cavolinia* aff. *gypсорum (Bellardi, 1873) an sp.
nov.

Plate 4, figure 4

?v *Cavolinia* sp. indet. Collins, 1934, p. 187, pl. 8, figs. 8–9.

Distribution.—See below.

Description.—The dorsal side (Pl. 4, fig. 4a) of two damaged specimens (sample Río Gurabo 15907) differs in some respects from the more typical *C. gypsorum* specimens as described above. In these shells the two outer ribs of the dorsal side are reduced and do not reach the apertural margin. The three central ribs are less distinctly separated and close to the margin the lateral ones of these are in each case subdivided into a wide inner and a narrow outer riblet. The fact that these two shells are also markedly larger than the other specimens contributes to the idea that they represent a separate, yet undescribed species. Considering the restricted number of specimens, however, they might as well represent extremes in the range of variation, and so a description is thought premature. They are here provisionally indicated *Cavolinia* aff. *gypsorum* an sp. nov., which identification could change when more and better material becomes available.

In sample Río Gurabo 15903 a single ventral shell part matches the dimensions of this form, but in the absence of the dorsal side it cannot be identified positively. In both localities the more typical *C. gypsorum* co-occurs with this form, indicating that they are either separate species or just formae.

Material.—Cercado Formation, *Globorotalia humerosa* Zone, Late Miocene, Río Gurabo 1978, Sta. 15903: ? one fragment of ventral side, NMB H 17742; Sta. 15907: one damaged specimen, NMB H 17743; one damaged specimen (Pl. 4, fig. 4a–c), NMB H 17633.

Remarks.—The ventral shell part illustrated by Collins (1934, p. 187, pl. 8, figs. 8–9) as *Cavolinia* sp. indet. could belong to either *C. gypsorum* or to the present form, because of the presence of oblique furrows.

Quite interestingly very similar specimens were described from Japan (Ujihara *et al.*, 1990; Shibata and Ujihara, 1990). At least the specimens illustrated by the last mentioned authors agree completely with the few specimens from the Dominican Republic in details of the dorsal side ornament, and also in being larger than the more typical *C. gypsorum* specimens. The Japanese specimens, however, are dated from the Pliocene (planktonic Foraminifera zones N18–20).

Cavolinia mexicana (Collins, 1934)

Plate 4, figures 5–7

*v *Cavolina mexicana* n. sp., Collins, 1934, p. 182, pl. 7, figs. 12–15.

v. *Cavolina (Cavolina) mexicana* Collins. Perrilliat, 1974, p. 36.

Cavolinia mexicana Collins, Bernasconi and Robba, 1982, p. 217.

Cavolinia globulosa (Gray, 1850). Shibata, Ishigaki and Ujihara, 1986, p. 50, pl. 8, fig. 9 (non Gray).

Cavolinia mexicana (Collins, 1934). Ujihara, Shibata and Saito, 1990, p. 321, pl. 2, figs. 11–12.

Description.—Shell typically cavoliniform, roughly one and a half times as high as wide when complete (*i.e.*, inclusive of the apertural dorsal lip). The dorso-ventral diameter equals more or less the shell width. The maximum shell width is situated slightly below mid-height.

The dorsal side of the shell is relatively convex. Its ornament consists of three more or less equally wide and rather indistinct radial ribs developing in the anterior half of the shell. These ribs are usually separated by narrow interspaces, but occasionally these can be up to half as wide as the ribs themselves. At both sides of the set of three ribs there is a flat to very slightly convex area, that with some imagination could be interpreted as weak lateral ribs. At their sides they are bordered by a somewhat convex marginal rim, which is present all around the dorsal side, from the left to the right posterior margin, thickened at those places where the outer margins of the set of three radial ribs touch the margin. At this place the interlocking mechanism must be present at the inner shell wall. The outline of the dorsal shell part is slightly constricted here. The anterior part of the dorsal shell wall is strongly curved in ventral direction, overhanging the aperture and part of the ventral shell part, procured with a recurved apertural lip occupying less than half the shell width. The dorsal surface shows faint concentric growth lines.

The ventral shell part is about as wide as high, or just slightly higher, and considerably more convex than the dorsal side. The place of strongest curvature is situated in the anterior shell part, where it is curved to an almost horizontal position (lateral view). From this point towards the apertural margin the shell wall is almost flat to slightly concave. The ventral apertural margin is strongly recurved as a strengthening device. Quite regular transverse striae are seen, especially on the most convex part. In their center they are usually faintly bent in apical direction. The lower parts of the ventral side are smooth or show some faint growth lines.

Dorsal and ventral shell parts are fused on the posterior margins, which are in line on both sides of the apical spine, or very slightly excavated. From these posterior corners towards the aperture lateral slits are

present, the lower parts of which are visible in a straight dorsal view.

The apical spine itself is flattened dorso-ventrally, with an elliptical transverse section, and strongly curved in dorsal direction. The protoconch is missing in all specimens, but it is still visible that the curvature of the spine has been more than 90° in complete specimens. On both sides of the spine wrinkles are present close to the posterior margins.

Holotype.—USNM no. 645206 (Wade leg., ex Johns Hopkins University collection), specimen with damaged dorsal apertural margin, Plate 4, figure 5a–d.

Dimensions of holotype.—H = 3.1 mm; W = 2.6 mm; D = 2.1 mm.

Type locality.—US(GS) Station 9995, Santa Rosa, Vera Cruz, Mexico (Agueguexquite Formation, Early Pliocene).

Material.—Cercado Formation, *Globorotalia lumerosa* Zone, Late Miocene, Río Gurabo 1978, Sta. 15907: one specimen, one damaged specimen, NMB H 17744; Sta. 15913: one fragment, NMB H 17745; one specimen (specimen with oblique furrows on ventral side, Pl. 4, fig. 8a–b), NMB H 17636; Sta. 15914: one damaged specimen, NMB H 17746.

Cercado Formation, probably Late Miocene, Río Cana 1979, Sta. 16837: 20 specimens, eight fragments, NMB H 17747, one specimen (Pl. 4, fig. 6a–c), NMB H 17634, one specimen (Pl. 4, fig. 7a–d), NMB H 17635; Sta. 16838: three specimens, NMB H 17748; Sta. 16856: two specimens, NMB H 17749; Sta. 16857: one specimen, NMB H 17750.

Measurements.—Some of the best preserved specimens were measured (Table 3), excluding shells with damaged apertural dorsal lip. In all of these the apical spine is incomplete, which by its strong curvature does hardly influence measurements of the shell height. The height of the ventral side was measured from the posterior margin, thus excluding the apical spine, inclusive of the ventral apertural lip.

Table 3.—Dimensions of complete specimens of *Cavolinia mexicana* (Collins, 1934).

Sample no.	Height	Width	Dorso-ventral diameter	Height of ventral side
15903	6.44	4.40	3.75	4.08
	6.36	4.65	3.59	4.08
	6.45	4.89	3.91	3.91
	5.71	4.24	3.67	3.75
16932	4.58	5.05	3.91	4.08
15907	6.11	4.40	3.34	3.91

Distribution.—Late Miocene of the Caribbean, Late Miocene–middle Pliocene of Japan, Early Pliocene of Mexico.

Remarks.—The holotype of this species is a small

shell with a height of ca. 3 mm (apertural margin missing). Practically all specimens studied here are larger, up to a height of 6.1 mm. Such variability in size is often seen in cavoliniids.

Similar observations were published for Japanese occurrences by Ujihara *et al.* (1990, p. 321), but their statement that the holotype of *C. mexicana* represents a juvenile specimen is incorrect; it is an admittedly small, but fully grown specimen with a well-developed apertural rim. On the basis of some specimens in the RGM collections from Miyazaki (Kiushu, Japan) (Late Miocene–middle Pliocene, Miyazaki Group, zone N18–20), obtained from Professor H. Shibata (Nagoya, Japan), the occurrence of this species in the Japanese Neogene could be confirmed.

Cavolinia mexicana bears some resemblance to the (occasionally co-occurring) species *Cavolinia gypsorum*. Usually, however, the difference is clear; *C. gypsorum* reaches larger dimensions, has a considerably less convex dorsal shell part (especially so towards the apertural lip), the sculpture of the dorsal side is more distinctly subdivided into five radial ribs, separated by generally wider interspaces, a marginal rim is much less distinctly developed in *C. gypsorum*, the ventral side has two oblique furrows, and finally the apical spine is less strongly curved in dorsal direction.

There is one specimen, however, offering intermediate characteristics (sample Río Gurabo 15913). In this shell (Pl. 4, fig. 8a–b), which has the shape, convexity and marginal rim of typical *C. mexicana*, the radial ribs are rather widely separated, and, of special note, the ventral shell part has two distinct, not quite symmetrical radial furrows. In the basal part of the shell, just beyond the apical spine, this shell shows some deformations, both on the ventral and on the dorsal side, that clearly indicate an early shell injury repair. Still, it is difficult to imagine how such an injury could have given rise to the radial furrows.

***Cavolinia cf. tridentata* (Niebuhr, 1775)**

Plate 5, figures 1–3

? *Cavolina tridentata* Forskål n. subsp. Vaughan and Woodring, 1921, p. 137.

Description.—The few specimens present in the Basel collection are in a rather poor state of preservation, shell material having largely disappeared, leaving sediment moulds with only traces of the original aragonitic shell. A single specimen (Pl. 5, fig. 1) still shows a more or less complete shape of the dorsal side. The specimen is slightly higher than wide (apical parts missing). The center of the shell is occupied by a triangular swelling with an apical angle of ca. 45°. This swelling has a rather distinct and narrow central radial

rib and two much less obvious lateral ribs. In its ab-apical part the central rib is convex and bent in ventral direction. An apertural lip is distinctly separated and partly preserved. Of the posterior margins only the left one is still present. It is relatively short and connected to the left lateral margin under an obtuse angle. Both lateral margins are convex and therefore the greatest width of the shell is situated at some distance above the posterior margins, at about one third of the shell height. The semicircular lateral fields are slightly concave, and show neither ornament nor growth lines. A very weak oblique transverse sculpture is indicated on the triangular swelling, in between the central rib and the lateral ones.

On a fragment with more or less the same preservation an apertural rim is distinct (Pl. 5, fig. 3), comparable with the one frequently seen in Recent specimens of this species.

The ventral side is quite convex, wider than high and has a distinctly backfolded apertural margin. Regularly distributed transverse striae are seen in the upper half of the ventral side, increasing in strength towards the lip. In their center they are slightly bent in apical direction.

Syntypes.—Niebuhr's description of "*Anomia tridentata*" was based on material in the Forskål collection, which is housed in the Zoological Museum of the Copenhagen University. Unfortunately all planktonic mollusks are missing from this collection (van der Spoel, 1976, p. 194).

Material.—Mao Formation, *Globorotalia margaritae/miocenica* Zone, Early to middle Pliocene, Río Gurabo 1978, Sta. 15823: one specimen (deformed internal mould), one specimen (ventral side); two specimens showing dorsal side, one fragment (ventral side), NMB H 17751; one specimen (ventral side, Pl. 5, fig. 2), NMB H 17638; one specimen showing dorsal side (Pl. 5, fig. 1), NMB H 17637; Sta. 15828: one fragment (dorsal side) (Pl. 5, fig. 3), NMB H 17639, one damaged specimen showing dorsal side, NMB H 17752; Sta. 15829: ? one fragment, NMB H 17753; Sta. 15833: one fragment, NMB H 17754.

Remarks.—The more or less completely preserved dorsal side described above (NMB H 17637, Pl. 5, fig. 1) differs in some respects from typical *Cavolinia tridentata*. The radial rib in the center of the elevation is narrower than in many Recent specimens compared and also the shell differs in the position of its greatest shell width, which in Recent specimens almost coincides with the position of the lateral spines. Another difference is the presence of the weak obliquely transverse folds, reminding strongly of the Early Pliocene Italian species *C. grandis* (Bellardi, 1873) (compare Janssen, 1995, pl. 8, fig. 8). This might indicate that the Río Gurabo specimens represent an evolutionary stage in between *C.*

grandis and *C. tridentata*, which is not contradicted by the supposed age of the Dominican specimens (Early to middle Pliocene). In other specimens these transverse folds are much weaker to completely absent.

Three specimens in the RGM collections, obtained from Professor H. Shibata (Nagoya, Japan), identified as *Cavolinia angusticostata* (Blanckenhorn, 1901), from Miyazaki (Kishu, Japan) (Late Miocene–middle Pliocene, Miyazaki Group, zone N18–20) distinctly demonstrate the transverse riblets of *C. grandis* (Bellardi, 1873) and have to be included in this latter taxon (see also Ujihara *et al.*, 1990, p. 318, pl. 2, figs. 4–6).

Additional to the list of synonyms of *C. grandis* given in Janssen (1995) is a fine specimen of this species illustrated by Cavallo and Repetto (1992, fig. 493, as *C. tridentata*).

Genus **DIACRIA** Gray, 1847

Type species.—*Diacria trispinosa* (de Blainville, 1821) (Recent).

Diacria trispinosa (de Blainville, 1821)

Plate 5, figures 4–8

- v *Diacria bisulcata*. Gabb, n.s., Gabb, 1873a, p. 200.
- . *Diacria bisulcata* Gabb. Guppy, 1882, p. 175 (reprinted in Harris, 1921, p. 244).
- . *Cavolinia (Diacria) bisulcata* Gabb. Dall, 1893, p. 430.
- v. *Diacria bisulcata* Gabb. Pilsbry, 1922, p. 309, text-fig. 4 (3 figs.).
- ? *Cavolina* sp. cf. *C. bisulcata* (Gabb). Woodring, Brown and Burbank, 1924, p. 164 (name only).
- . *Diacria bisulcata* Gabb. Woodring, 1928, p. 116, pl. 1, figs. 14–15 (partim, material includes *Styliola subula*, see Collins, 1934: 199).
- . *Diacria bisulcata* Gabb. Collins, 1934, p. 197, pl. 9, figs. 13–17, figs. 18–20 (copied from Pilsbry, 1922); pl. 10, figs. 1–3 (only pl. 9, figs. 18–20 belong to *bisulcata* Gabb).
- ? *Diacria bisulcata* Gabb, 1873. Noda, 1972, p. 478, pl. 57, fig. 18.
- . *Diacria* cf. *D. bisulcata* Gabb. Perrilliat, 1974, p. 35.
- . *Diacria bisulcata* Gabb. Pavia and Robba, 1979, p. 564.
- . *Diacria trispinosa* forma *trispinosa* (Blainville, 1821). Shibata, 1984, p. 84, pl. 25, figs. 1–3.
- v. *Diacria trispinosa* (de Blainville, 1821). Janssen, 1995, p. 107, pl. 9, figs. 3–5.

Description.—See van der Spoel, 1967, p. 84, figs. 76–78.

Type material of Diacria trispinosa.—Van der Spoel (1976, p. 193) was unable to trace the syntypes in coll.

MHNP, where they could be expected to have been deposited.

Holotype of Diacria bisulcata.—Coll. ANSP no. 2894 (Pl. 4, fig. 6a–d). Apparently part of the dorsal apertural margin of the type specimen was broken subsequent to publication of Pilsbry's (1922, text-fig. 4) illustration.

Type locality of Diacria bisulcata.—Santo Domingo (Gabb, 1873a).

Material.—Specimens of the typical form: Mao Formation, *Globorotalia margaritae/miocenica* Zone, Early to middle Pliocene, Río Gurabo 1978, Sta. 15823: one specimen (Pl. 5, fig. 5), NMB H 17641; Sta. 15827: six specimens, NMB H 17755; Sta. 15828: 22 specimens, two specimens (pyritic internal moulds, in silicone oil), one specimen (with counterpiece), NMB H 17756; Sta. 15829: two specimens, NMB H 17757; Sta. 15833: one fragment, NMB H 17758.

Cercado Formation, probably Late Miocene, Río Cana 1979, Sta. 16836: one specimen, NMB H 17759; Sta. 16837: two specimens, six fragments, NMB H 17760; Sta. 16844: one specimen (Pl. 5, fig. 4a–c), NMB H 17640.

Mao Adentro Limestone, *Globorotalia margaritae* Zone, late Early Pliocene NN16–NN18, Río Cana 1979, Sta. 17023: one specimen (internal mould), NMB H 17761.

Upper part of *Globorotalia margaritae* Zone, late Early Pliocene, Río Yaque del Norte, Santiago, 1980, Sta. 17293: 1 specimen, NMB H 17762.

Specimens referable to *Diacria trispinosa* (de Blainville, 1821) forma *bisulcata* Gabb, 1873:

No formation name; age unclear, ? Late Miocene, Río Mao 1979, Sta. 16915: 1 specimen (Pl. 5, fig. 7a–b), NMB H 17642.

Mao Formation, *Globorotalia margaritae/miocenica* Zone, Early to middle Pliocene, Río Gurabo 1978, Sta. 15823: 1 specimen (Pl. 5, fig. 8), NMB H 17643.

Distribution.—Late Miocene (Tortonian–Messinian), Mediterranean; Pliocene: widespread; Recent: tropics and subtropics of the Atlantic Ocean, in the E. Atlantic up to 70° N; subtropics of the Pacific and Indian Oceans (van der Spoel, 1967, fig. 354).

Remarks.—A list of synonyms mainly referring to fossil occurrences is given in Janssen (1995). For references concerning Recent material the reader is referred to van der Spoel (1967, 1976).

The taxon *Diacria bisulcata* Gabb was based on a single small specimen (H = 5.5 mm) from the “Miocene” of “Santo Domingo”. It is characterized by a wide central elevation on the dorsal side of the shell, not subdivided by longitudinal ridges. Woodring (1928) wrote: “The type of *D. bisulcata* probably is a young shell, as it has a length of only 4.3 millimeters”.

The holotype, however, although small, is a fully-grown shell, as is clear from the presence of wrinkles on both sides of the preserved part of the apical shell part, indicating that shell metamorphosis had been completed. Also the reinforced apertural margins indicate the specimen to have reached the adult state. Among the material before me occurs a specimen of identical size, which demonstrates the longitudinal furrows of the dorsal side very clearly (Río Gurabo 15827). Although smaller it cannot be distinguished from Recent *D. trispinosa*.

At least two specimens (Río Gurabo 15823, and Río Mao 16915), however, do indeed show the typical features of *D. bisulcata*. The Río Gurabo specimen is illustrated here in Plate 5, figure 8 and the other one in Plate 5, figure 7a–b. Both specimens, when seen in low-angle light, have a very slight longitudinal ornament in the center of the dorsal side.

In the Italian Miocene (Tortonian) and younger deposits, *Diacria trispinosa* is also found to occasionally show a reduction of the dorsal longitudinal ornament (Janssen, 1995, pl. 9, figs. 3a, 4). Also in view of the observed co-occurrence of the two forms in the Río Gurabo section, I do not believe that the differences suffice to subdivide the material into two species. Therefore *D. bisulcata* could, if at all, be maintained as a name of infrasubspecific rank.

Genus EDITHINELLA Janssen, 1995

Type species.—*E. undulata* (Gabb, 1873) (Miocene, Santo Domingo).

Edithinella undulata (Gabb, 1873a)

- v* *Balantium undulatum*. Gabb, n.s., Gabb, 1873a, p. 200.
- . *Balantium undulatum* Gabb. Guppy, 1882, p. 175 (reprinted in Harris, 1921, p. 244).
- . *Cleodora (Balantium) undulatum* Gabb. Dall, 1893, p. 430.
- v. *Vaganella (sic) undulata* (Gabb). Pilsbry, 1922, p. 309, text-fig. 2 (2 figs.).
- v. *Vaginella undulata* (Gabb). Collins, 1934, p. 219, Pl. 14, figs. 14–15.
- . *Vaginella undulata* (Gabb). Woodring, 1970, p. 320, 324, 427.
- ? *Vaginella aff. undulata* (Gabb). Jung, 1971, p. 215, pl. 19, figs. 8–11.
- . *Vaginella undulata* (Gabb). Robba, 1977, p. 592.
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 . *Vaginella undulata* (Gabb). Bernasconi and Robba, 1982, p. 217.
 v. *Edithinella undulata* (Gabb, 1873). Janssen, 1995, Pl. 10, fig. 5a-d.

Description.—Shell medium-sized, vaginelliform, elongate triangular, with a slight dorso-ventral curvature, with the ventral side convex, bilaterally symmetrical. Apex pointed. Protoconch missing, opening not closed by a septum in the available specimen. Transverse section in the apical shell part circular, but soon becoming elliptical in anterior direction. At mid-height the dorso-ventral diameter is about $\frac{2}{5}$ th of the transverse diameter. The aperture is elliptical, two times wider than high, slightly constricted, especially so on its ventral side. The side-lines of the shell are faintly convex in frontal view, with the strongest curvature in the more apical part of the shell. At a short distance from the apex two lateral grooves develop, separating the dorsal from the ventral side. These grooves are visible in a dorsal, but invisible in a ventral view. No wrinkles are present on the lateral margins near the apex.

The ventral side of the shell is smooth, even growth lines being invisible. The dorsal side bears a transverse undulation, consisting of four folds, that increase in strength towards the aperture.

Holotype.—Coll. ANSP no. 2892, recently illustrated in Janssen (1995, Pl. 10, fig. 5a-d).

Type locality.—Santo Domingo (Gabb, 1873a).

Material.—The holotype is the only specimen known.

Remarks.—Janssen (1995) selected this species as type of the new genus *Edithinella*, separating it from *Vaginella* on differences in the development of the lateral carinae and the presence of transverse sculpture. Other species included in this genus are *E. caribbeana* (Collins, 1934), from the Middle Miocene Gatun Formation of the Panama Canal Zone, and *E. varanica* (Sirna, 1968), from the Miocene of Italy.

Although originally described from "Santo Domingo" the type species *E. undulata* unfortunately is not represented in the material at hand.

Edithinella sp.

Plate 5, figure 9a-c

Description.—The only available specimen is rather

strongly damaged: the apex with the protoconch, as well as a large part of the dorsal side inclusive of the aperture are missing. It differs in several respects from *Edithinella undulata*, and most probably represents another, yet undescribed species. The main differences are the absence of the transverse undulations and the more distinctly developed lateral grooves. In *E. undulata* these are visible only in the basal shell part, whereas in the present specimen they can be seen all along the shell's length. More or less identical are size, proportions and degree of curvature, but the dorso-ventral diameter is slightly larger than in *E. undulata*. The specimen has a fairly well-preserved shell surface and growth lines are visible, unlike in the holotype of *E. undulata*. On the convex side of the shell they are more strongly curved in apertural direction than on the concave side. On the lateral grooves they follow a v-shaped course.

Material.—Baitoa Formation; ? late Early Miocene, Río Yaque del Norte 1980, Lopez section, Sta. 17288; one damaged specimen (Pl. 5, fig. 9a-c), NMB H 17644.

Measurements.—H = 6.64 mm, W = 2.30 mm.

Remarks.—The age of the present specimen is assumed to be late Early to early Middle Miocene (Baitoa Formation, Saunders *et al.*, 1986, tab. 1). The age of the holotype of *Edithinella undulata* (also from the Dominican Republic, but exact locality unknown) is merely indicated as "Miocene".

The curvature of the growth lines seems to indicate that the apertural margin of the convex side in fully grown state would have been higher than that of the concave side. In a specimen of *E. caribbeana* (Collins, 1934) from the Aquitaine Basin (France), which preserves its apertural margins the margin of the concave side is the higher one (Janssen, 1995, pl. 10, fig. 9a-c), which is why the concave side is considered to be dorsal, as it is in curved *Clio* and *Vaginella* species.

In the absence of transverse undulations the present specimen is included in *Edithinella* with a query. General shell form and the lateral grooves are very similar to what is found in species belonging to that genus. Possibly such undulations are not typical of all species of the genus.

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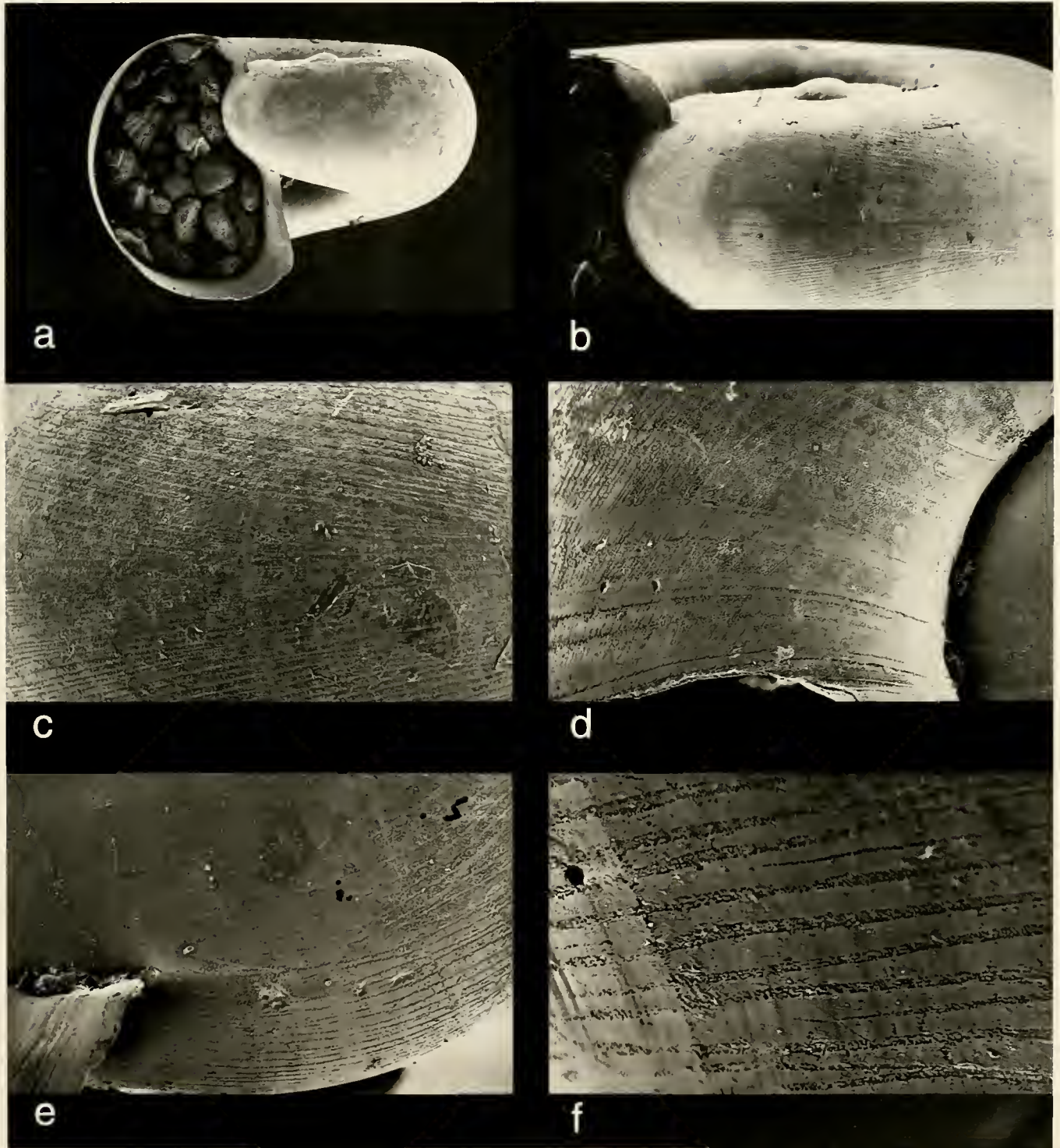
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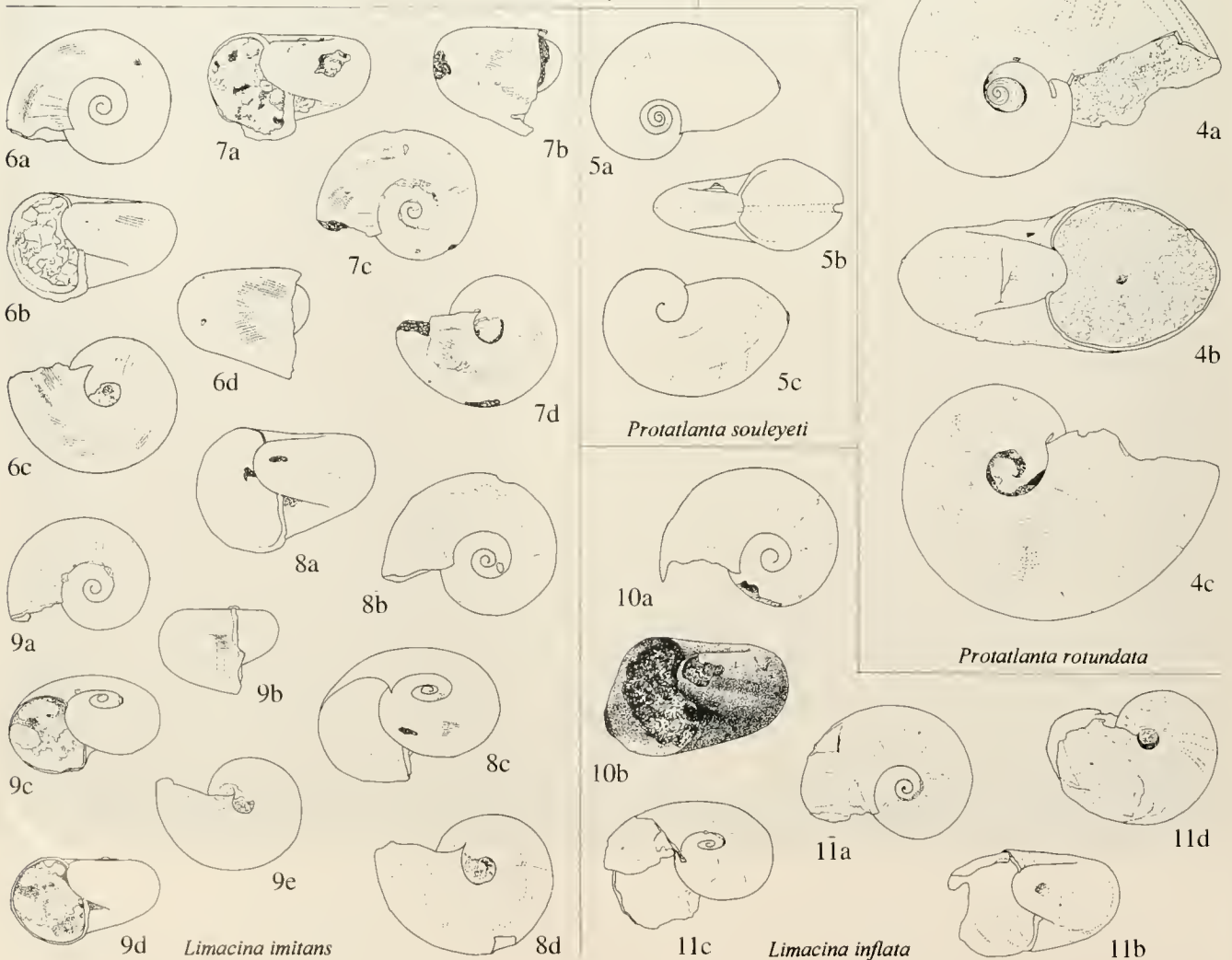
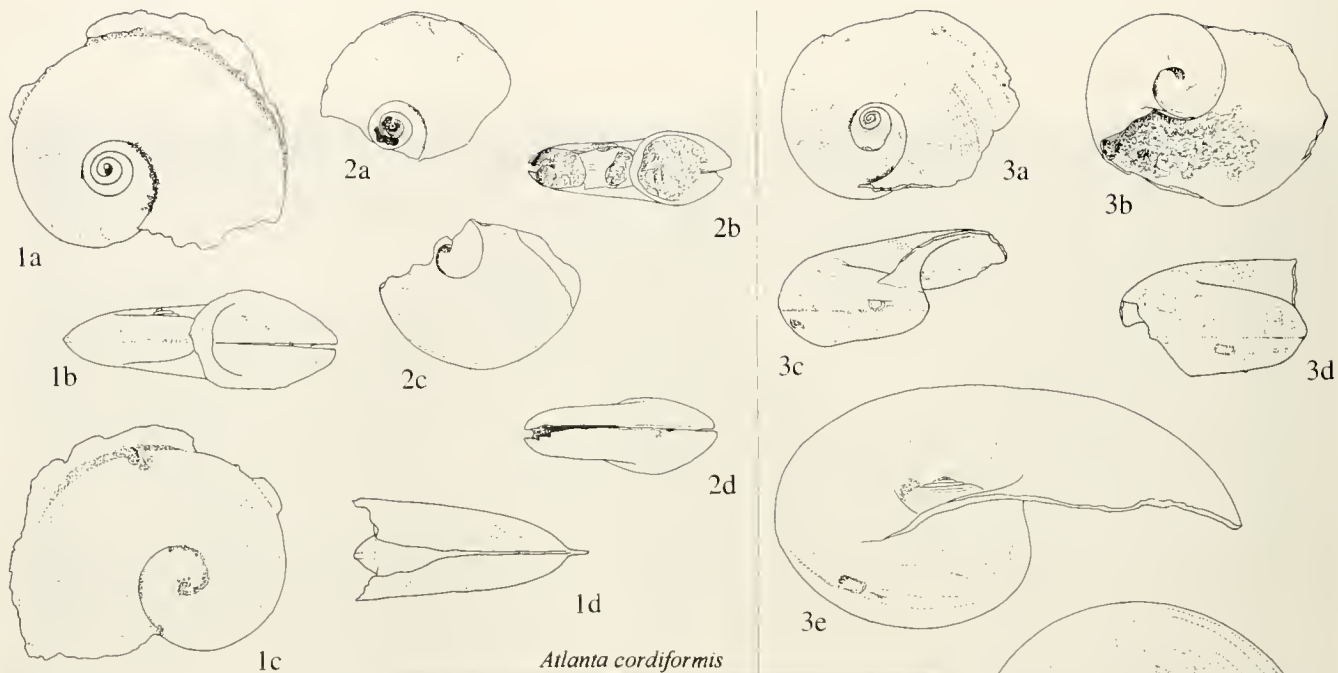
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PLATES

EXPLANATION OF PLATE 1

Figure	Page
1. <i>Limacina imitans</i> (Gabb, 1873)	13
<p>1a-f. NMB H 17616, Sta. 15900 Río Gurabo; Cercado Formation (Late Miocene, <i>Globorotalia humerosa</i> Zone); 1a. frontal view, microsculpture barely visible (bar length = 100 μm); 1b. frontal view of body whorl, showing peripheral spiral and backwards diverging microsculpture below and above periphery (bar length = 100 μm); 1c. peripheral view of body whorl showing dense diverging microsculpture (bar length = 100 μm); 1d. apical side of body whorl near apertural margin, showing diverging sculpture fading out towards the suture (bar length = 100 μm); 1e. oblique view of body whorl near aperture, showing irregular fading of microsculpture (bar length = 10 μm); 1f. close up of early body whorl, showing growth lines intersected by microsculpture and new sculptural elements inserting in apertural direction (bar length = 10 μm).</p>	



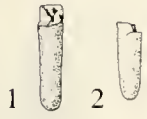


EXPLANATION OF PLATE 2

Figure	Page
1–2. <i>Atlanta cordiformis</i> Gabb, 1873	11
1a–d. Lectotype (Pilsbry, 1922), ANSP 2896; Santo Domingo (Miocene); 1a. apical view; 1b. frontal view; 1c. umbilical view; 1d. left lateral view; × 25.	
2a–d. NMB H 17617, Sta. 16923; Río Mao, at mouth of Arroyo Bajón; level E no formation name (age unclear, ? Late Miocene); 2a. apical view; 2b. frontal view; 2c. umbilical view; 2d. rear view; × 25.	
3–4. <i>Protatlanta rotundata</i> (Gabb, 1873)	11
3a–e. Holotype, ANSP 2891; Santo Domingo (Miocene); 3a. apical view; 3b. umbilical view; 3c. frontal view; 3d. right lateral view; × 25; 3e. oblique frontal view (with protoconch in upright position); × 50.	
4a–c. NMB H 17618, Sta. 15903; Río Gurabo, at mouth of Arroyo Bajón; level E; Cercado Formation (Late Miocene, <i>Globorotalia humerosa</i> Zone); 4a. apical view; 4b. frontal view; 4c. umbilical view; × 12.5.	
5. <i>Protatlanta souleyeti</i> (Smith, 1888)	12
5a–c. NNM collection, Canary Islands, Sta. 2.114, Tydemann Expedition 1977 (Recent); 5a. apical view; 5b. frontal view; 5c. umbilical view; × 12.5.	
6–9. <i>Limacina imitans</i> (Gabb, 1873)	13
6a–d. Neolectotype (hic design.), ANSP 2895; Santo Domingo (Miocene); 6a. apical view; 6b. frontal view; 6c. umbilical view; 6d. right lateral view; × 25.	
7a–d. <i>Limacina inflata</i> Collins, 1934 (non d'Orbigny, 1836); USNM 483145; Río Mao, Sta. 8525 (Vaughan and Cooke); Cercado Formation (Miocene); 7a. frontal view; 7b. right lateral view; 7c. apical view; 7d. umbilical view; × 25.	
8a–d. NMB H 17619, Sta. 16927; Río Mao 1979, at mouth of Arroyo Bajón, level E; no formation name (Late Miocene); 8a. frontal view; 8b. apical view; 8c. oblique frontal view; 8d. umbilical view; × 25.	
9a–e. Holotype of <i>Limacina elevata</i> Collins, 1934; USNM 645189; Santa Rosa, Vera Cruz, Mexico (Miocene); 9a. apical view; 9b. right lateral view; 9c. oblique frontal view; 9d. frontal view; 9e. umbilical view; × 25.	
10. <i>Limacina inflata</i> (d'Orbigny, 1836)	14
10a–b. NMB H 17620, Sta. 15903; Río Gurabo 1978; Cercado Formation (Late Miocene, <i>Globorotalia humerosa</i> Zone); 10a. apical view; 10b. frontal view showing opaque subperipheral belt, the thickening is visible at the apertural margin; × 25.	
11. <i>Limacina inflata</i> (d'Orbigny, 1836)?	14
11a–d. USNM 645188; Santa Rosa, Vera Cruz, Mexico (Miocene); same specimen illustrated in Collins, 1934, pl. 7, figs. 3–5 (as <i>Limacina inflata</i>); 11a. apical view; 11b. frontal view; 11c. oblique frontal view; 11d. umbilical view; × 25.	

EXPLANATION OF PLATE 3

Figure	Page
1–2. <i>Creseis acicula</i> (Rang, 1828)	15
1–2. NMB H 17621, Sta. 15829; Río Gurabo; Mao Formation (Early to middle Pliocene, <i>Globorotalia margaritae/miocenica</i> Zone); × 50.	
3–5. <i>Hyalocylix striata</i> (Rang, 1828)	16
3. NMB H 17622, Sta. 15829; Río Gurabo; Mao Formation (Early to middle Pliocene, <i>Globorotalia margaritae/miocenica</i> Zone); × 6 (a damaged specimen of <i>Clio pyramidata</i> f. <i>lanceolata</i> is visible in the lower left).	
4a–b. Holotype of <i>Hyalocylix haitensis</i> (Collins, 1934); USNM 371905; Port-au-Prince, near Pétiönville, Haïti, US Geol. Surv. Sta. 9574 (Miocene); 4a. ventral view; 4b. left lateral view; × 7.5.	
5a–d. Illustrated paratype of <i>Hyalocylix haitensis</i> (Collins, 1934); USNM 371905; same locality as 4a–b; 5a. upper transverse section; 5b. ventral view; 5c. lower transverse section; 5d. right lateral view; × 7.5.	
6. <i>Hyalocylix striata</i> (Rang, 1828)?	16
6. Lectotype (Janssen, 1995) and illustrated specimen of <i>Tentaculites cretaceus</i> Blanckenhorn, 1889; GMHU 2100; Nisib, Turkey; yellowish-white limestone (Miocene, ? Vindobonian); also illustrated in Blanckenhorn, 1899, pl. 22, fig. 9 (as <i>Tentaculites cretaceus</i>) and in Avnimelech, 1945, fig. 9 (as <i>Clio cretaceum</i> (Blanckenhorn); × 6 (same slab also contains “ <i>Vaginella rotundata</i> ” Blanckenhorn (no syntype) (= <i>Vaginella</i> sp.?), “ <i>Balantium flabelliforme</i> ” Blanckenhorn (syntype) (= <i>Propeamussium</i> sp.), and “ <i>Cavolinia</i> ” sp. (= indet., foraminifer?).	
7–9. <i>Styliola subula</i> (Quoy and Gaimard, 1827)	18
7a–b. Holotype of <i>Styliola sulcifera</i> Gabb, 1873; ANSP 2893; Santo Domingo (“Miocene”), also illustrated in Pilsbry, 1922, text-fig. 3 (2 figs., as <i>Styliola sulcifera</i>) and Collins, 1934, pl. 9, figs. 9, 9a–10 (as <i>Styliola sulcifera</i>); 7a. upper transverse section; 7b. ventral view (dotted line is outline of specimen in Pilsbry, 1922); × 12.5.	
8a–b. NMB H 17623, Sta. 15854; Río Gurabo; Gurabo Formation (Early Pliocene, <i>Globorotalia margaritae</i> Zone); 8a. ventral view, × 12.5; 8b. apical shell part (tip damaged), × 50.	
9a–b. NMB H 17524, Sta. 15851; Río Gurabo; Gurabo Formation (Early Pliocene, <i>Globorotalia margaritae</i> Zone); 9a. adapical view; 9b. ventral view; × 12.5.	
10. <i>Cuvierina astesana</i> (Rang, 1827)?	19
10a–c. NMB H 17625, Sta. 15907; Río Gurabo; Cercado Formation (Late Miocene, <i>Globorotalia humerosa</i> Zone); 10a. adapical view; 10b. ventral view; 10c. right lateral view; × 6.	
11. <i>Cuvierina</i> sp.	20
NMB H 17626, Sta. 15828; Río Gurabo; Mao Formation (Early to middle Pliocene, <i>Globorotalia margaritae</i> Zone); ventral view (?), × 12 (surrounding matrix omitted).	
12. <i>Clio cuspidata</i> (Bosc, 1802)?	21
12. NMB H 17627, Sta. 15829 Río Gurabo; Mao Formation (Early to middle Pliocene, <i>Globorotalia margaritae/miocenica</i> Zone); ventral view, × 6.	
13–17. <i>Clio pyramidata</i> (Linné, 1767) f. <i>lanceolata</i> (Lesueur, 1813)	21
13. NMB H 17628, Sta. 15829; Río Gurabo; Mao Formation (Early to middle Pliocene, <i>Globorotalia margaritae/miocenica</i> Zone); dorsal view, × 6.	
14a–f. NMB H 17629, Sta. 15993 Río Gurabo; Gurabo Formation (Early Pliocene, <i>Globorotalia margaritae</i> Zone); 14a. dorsal view; 14b. left lateral view; 14c. ventral view, 14d. adapical view, × 12.5; 14e. protoconch, frontal view; 14f. idem, left lateral view (tip missing), × 25.	
15a–c. Holotype of <i>Cleodora bowdenensis</i> Collins, 1934, USNM 645194; Bowden, Bowden Beds, lower zone (Late Pliocene, but indicated “Miocene”); 15a. dorsal view; 15b. transverse section at aperture; 15c. ventral view; × 5.	
16. Specimen illustrated by Collins (1934, pl. 12, fig. 7: “may also belong to <i>C. bowdenensis</i> ”), USNM 371908; Jaemel, Haïti; US(GS) Sta. 9604 (Pliocene); dorsal view, × 10.	
17. Specimen referred to by Vaughan and Woodring (1922, p. 166) as <i>Cavolina</i> sp., and by Collins (1934, p. 202) as <i>Cleodora</i> sp. cf. <i>bowdenensis</i> ; USNM 371907; El Mores, Monte Cristi, Dominican Republic; USGS Sta. 8783; Yaque Group (Miocene?); dorsal view, × 5.	
18. <i>Clio</i> sp.	21
Protoconch. NMB H 17630, Sta. 15829 Río Gurabo; Mao Formation (Early to middle Pliocene, <i>Globorotalia margaritae/miocenica</i> Zone); 18a. transverse section at aperture; 18b. frontal view; 18c. lateral view; × 25.	



Criseis acicula



3



4a



4b



5a

5b



5c



5d



6

Hyalocylis striata



10a

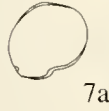


10b



10c

Cuvierina ? astesana



7a



7b

Styliola subula



8a



8b



9a



9b



12

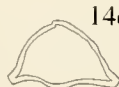
Clio ? cuspidata



13



14a



14d



14b



14c



14e



14f



18a



18b



18c

Clio sp.



11

Cuvierina sp.



15a



15b

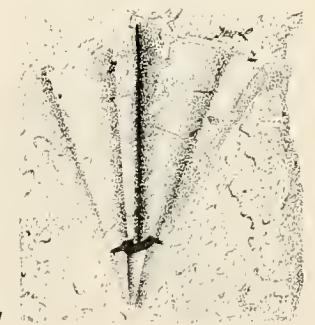


15c



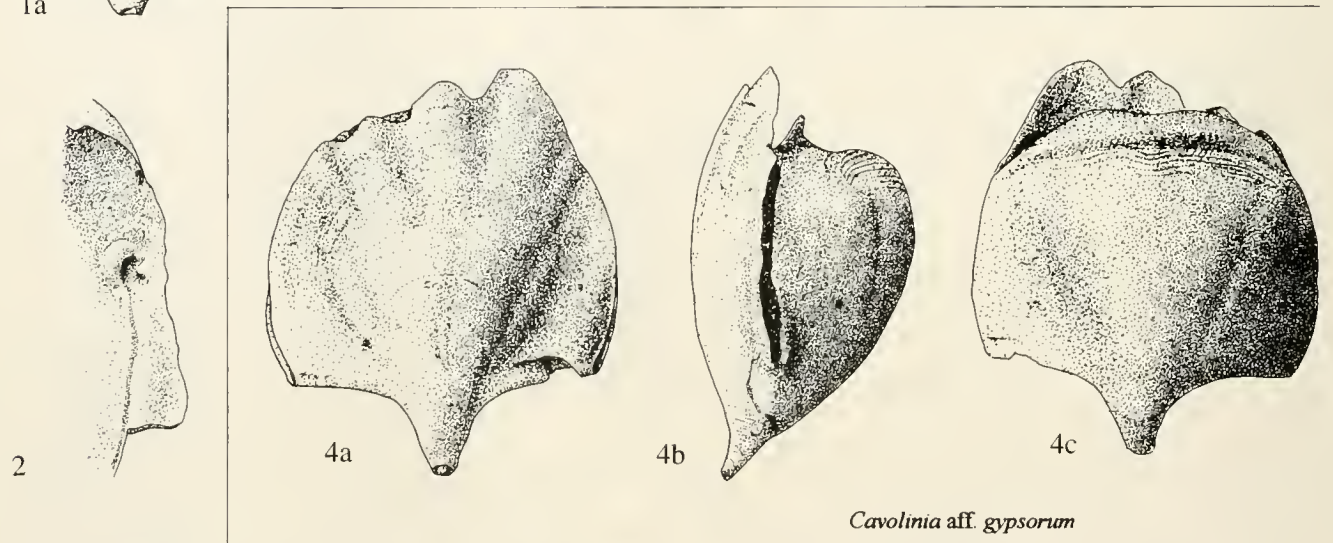
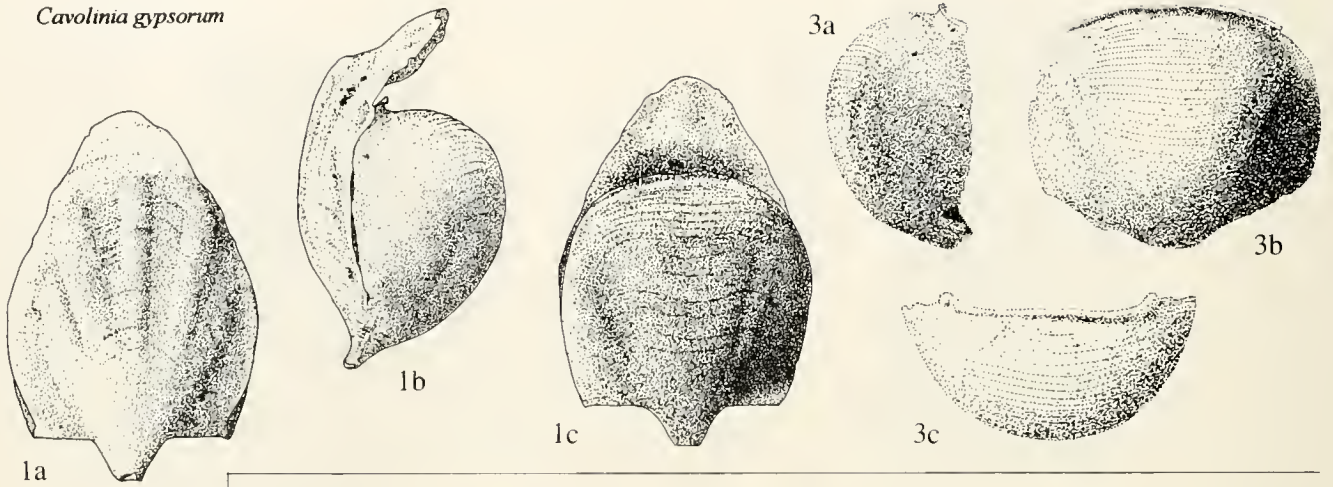
16

Clio pyramidata f. *lanceolata*

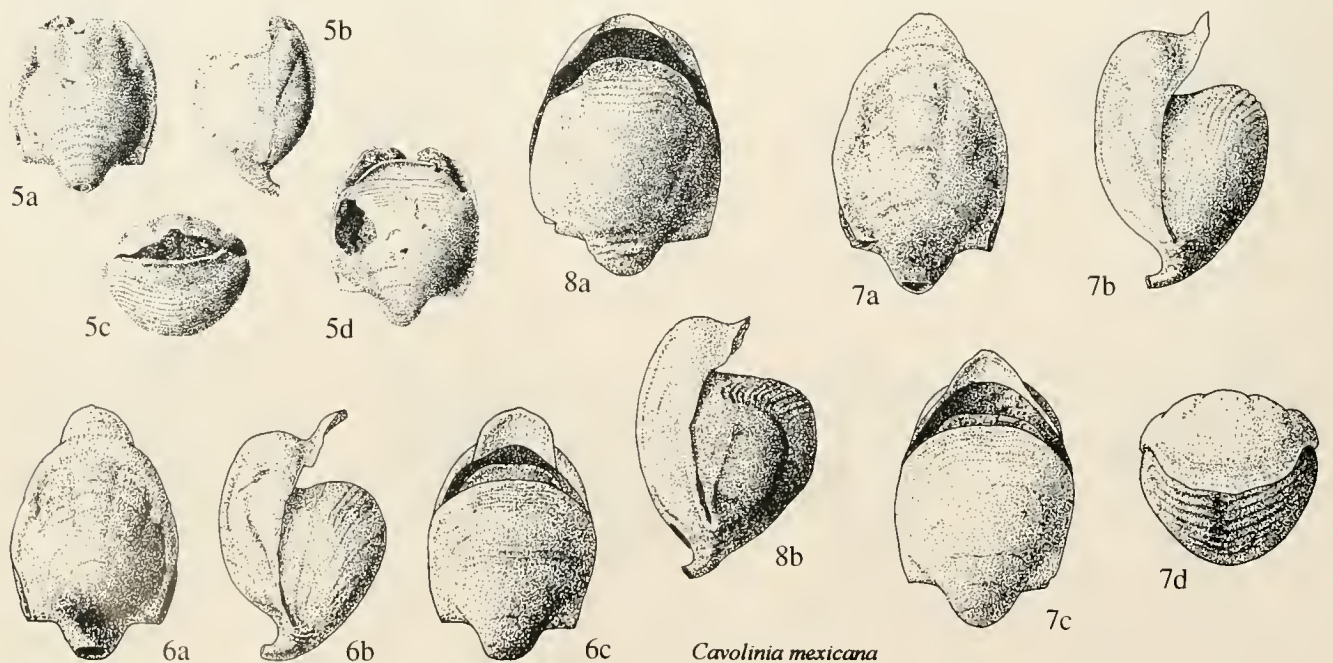


17

Cavolinia gypsorum



Cavolinia aff. gypsorum



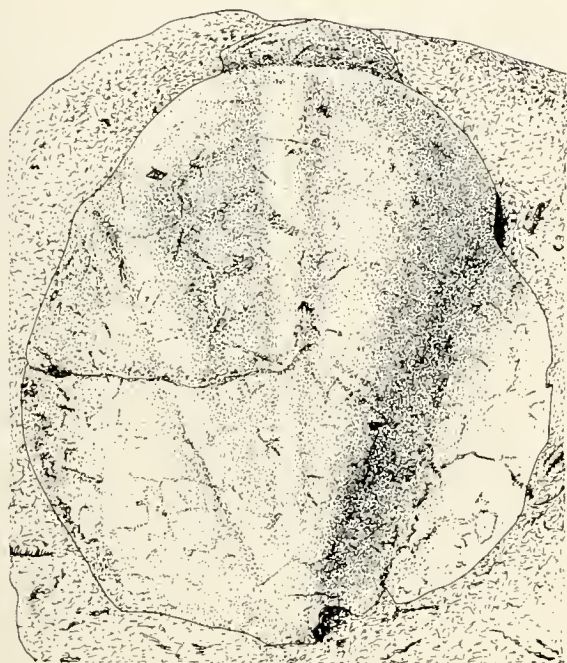
Cavolinia mexicana

EXPLANATION OF PLATE 4

Figure	Page
1-3. <i>Cavolinia gypсорum</i> (Bellardi, 1873)	22
1a-c. NMB H 17631, Sta. 15903 Río Gurabo; Cercado Formation (Late Miocene, <i>Globorotalia humerosa</i> Zone); 1a. dorsal view; 1b. right lateral view; 1c. ventral view; × 6.	
2. Interlocking mechanism of dorsal shell part, left side; NMB H 17632, Sta. 16837 Río Cana; Cercado Formation (probably Late Miocene); × 12.5.	
3a-c. Isolated ventral shell part, illustrated by Collins (1934, pl. 8, figs. 8-9, as <i>Cavolinia</i> sp. indet.); USNM 371904; Río Mao, Sta. 8525; Cercado Formation ("Middle Miocene"); 3a. left lateral view; 3b. ventral view; 3c. adapical view; × 6.	
4. <i>Cavolinia</i> aff. <i>gypсорum</i> (Bellardi, 1873) an sp. nov.?	23
4a-c. NMB H 17633, Sta. 15907 Río Gurabo; Cercado Formation (Late Miocene, <i>Globorotalia humerosa</i> Zone); 4a. dorsal view; 4b. right lateral view; 4c. ventral view; × 6.	
5-8. <i>Cavolinia mexicana</i> (Collins, 1934)	24
5a-d. Holotype, USNM 645206; Santa Rosa, Vera Cruz, Mexico; US(GS) Sta 9995 ("Middle Miocene"); 5a. dorsal view; 5b. left lateral view; 5c. adapical view; 5d. ventral view; × 6.	
6a-c, 7a-d. NMB H 17634 (fig. 6) and NMB H 17635 (fig. 7), Sta. 16837 Río Cana; Cercado Formation (probably Late Miocene); 6a-7a. dorsal views; 6b-7b. right lateral views; 6c-7c. ventral views; 7d. adapical view; × 6.	
8a-b. Aberrant specimen with oblique furrows on ventral side; NMB H 17636, Sta. 15913 Río Gurabo; Cercado Formation (Late Miocene, <i>Globorotalia humerosa</i> Zone); 8a. ventral view; 8b. right lateral view; × 6.	

EXPLANATION OF PLATE 5

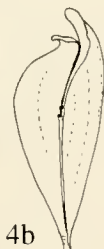
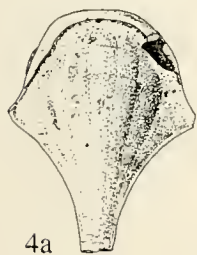
Figure	Page
1-3. <i>Cavolinia</i> cf. <i>tridentata</i> (Niebuhr, 1775)	25
1. NMB H 17637, Sta. 15823 Río Gurabo; Mao Formation (Early to middle Pliocene, <i>Globorotalia margaritae/miocenica</i> Zone); × 6.	
2. Isolated ventral shell part; NMB H 17638, locality data as in fig. 1; × 6.	
3. Fragment of dorsal side; NMB H 17639, Sta. 15828 Río Gurabo; Mao Formation (Early to Middle Pliocene, <i>Globorotalia margaritae</i> Zone); dorsal view, × 6.	
4-8. <i>Diacria trispinosa</i> (de Blainville, 1821)	26
4a-c. NMB H 17640, Sta. 16844 Río Cana; Cercado Formation (probably Late Miocene); 4a. dorsal view; 4b. left lateral view; 4c. ventral view; × 6.	
5. NMB H 17641, Sta. 15823 Río Gurabo; Mao Formation (Early to middle Pliocene, <i>Globorotalia margaritae/miocenica</i> Zone); dorsal view, × 6 (surrounding matrix omitted).	
6a-d. Holotype of <i>Diacria trispinosa</i> f. <i>bisulcata</i> Gabb, 1873; ANSP 2894; S. Domingo, Dominican Republic ("Miocene"); also illustrated in Pilsbry (1922, text-fig. 4, 3 figs.) and Collins (1934, pl. 9, figs. 18-20 (copied from Pilsbry)); 6a. dorsal view; 6b. adapical view; 6c. right lateral view; 6d. ventral view; × 6.	
7a-b. Specimen of f. <i>bisulcata</i> Gabb, 1873; NMB H 17642, Sta. 16915 Río Mao; at mouth of Arroyo Bajón, level E (? Late Miocene); 7a. dorsal view; 7b. ventral view; × 6.	
8. Specimen of f. <i>bisulcata</i> Gabb; NMB H 17643, Sta. 15823 Río Gurabo; Mao Formation (Early to middle Pliocene, <i>Globorotalia margaritae/miocenica</i> Zone); dorsal view, × 6 (surrounding matrix not drawn).	
9. <i>Edithinella</i> sp.	27
9a-c. NMB H 17644, Sta. 17288 Río Yaque del Norte; Lopez section; Baitoa Formation (? late Early Miocene); 9a. adapical view; 9b. left lateral view; 9c. dorsal view; × 6.	



Cavolinia cf. tridentata

1

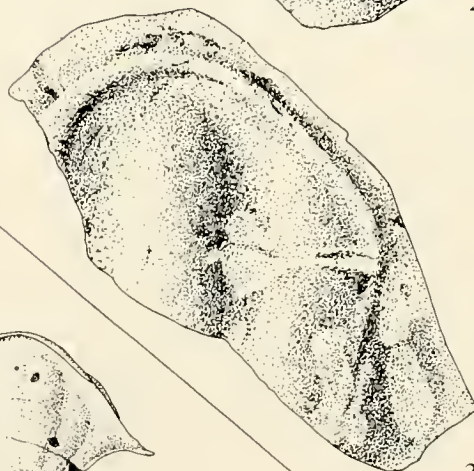
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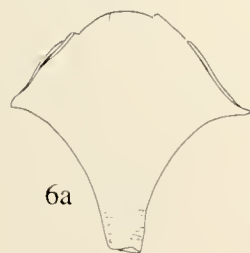
4a

4b

4c



3



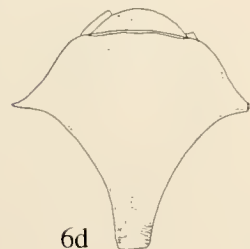
6a



6b



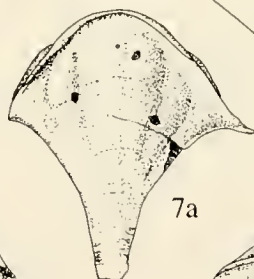
6c



6d



5



7a



7b



8

Diacria trispinosa



9a



9b



9c

Edithnella sp.

INDEX OF HOLOPLANKTONIC MOLLUSK TAXA

<i>acicula acicula, Creseis</i>	16	<i>Clio (Creseis) acicula</i>	15
<i>acicula forma acicula, Creseis</i>	16	<i>Clio (Styliola) Lamberti</i>	18
<i>acicula, Cleodora</i>	15	<i>Clio acicula</i>	15
<i>acicula, Cleodora (Creseis)</i>	15	<i>Clio bowdenensis</i>	21
<i>acicula, Clio</i>	15	<i>Clio braidensis</i>	21
<i>acicula, Clio (Creseis)</i>	15	<i>Clio cretaceum</i>	17
<i>acicula, Creseis</i>	9, 15, 16; Pl 3, figs. 1–2	<i>Clio cuspidata</i>	21, 22
<i>acicula, Creseis acicula</i>	16	<i>Clio cuspidata?</i>	9, 21; Pl. 3, fig. 12
<i>acicula, Creseis acicula forma</i>	16	<i>clio helicina</i>	13
<i>acicula, Vaginella</i>	15	<i>Clio pyramidata</i>	21, 22
<i>aciculata, Hyalaea</i>	15	<i>Clio pyramidata forma lanceolata</i>	9, 21, 22; Pl. 3, figs. 13–17
<i>angusticostata, Cavolinia</i>	26	<i>Clio sp.</i>	9, 21; Pl. 3, fig. 18
<i>Anomia tridentata</i>	26	<i>Clio striata</i>	16
<i>astesana?, Cuvierina</i>	3, 7, 19, 20	<i>columnella, Cuvierina</i>	19
<i>astesana, Cuvierina</i>	7, 20; Pl 3, fig. 10	<i>columnella, Cuvierina</i>	20
<i>Atlanta</i>	11	<i>cordiformis, Atlanta</i>	7, 11; Pl. 2, figs. 1–2
<i>Atlanta cordiformis</i>	7, 11; Pl. 2, figs. 1–2	<i>Creseis</i>	15, 16
<i>Atlanta inflata</i>	11, 14	<i>Creseis acicula</i>	9, 15, 16; Pl. 3, figs. 1–2
<i>Atlanta peroni</i>	11	<i>Creseis acicula acicula</i>	16
<i>Atlanta rotunda</i>	11	<i>Creseis acicula forma acicula</i>	16
<i>Atlanta rotundata</i>	11, 12	<i>Creseis spinifera</i>	18, 19
<i>Atlanta souleyeti</i>	11	<i>Creseis striata</i>	16
<i>Atlantidea</i>	11	<i>cretacea, Praehyalocylis</i>	17
<i>Balantium</i>	16, 27	<i>cretaceum, Clio</i>	17
<i>Balantium flabelliforme</i>	18	<i>cretaceus, Praehyalocylis</i>	17
<i>Balantium undulatum</i>	27	<i>cretaceus, Tentaculites</i>	16–18
<i>bisulcata, Cavolinia (Diacria)</i>	26	<i>cuspidata?, Clio</i>	9, 21; Pl. 3, fig. 12
<i>bisulcata, Diacria</i>	26, 27	<i>cuspidata, Clio</i>	21, 22
<i>bisulcata, Diacria trispinosa forma</i>	27; Pl. 5, fig. 8	<i>Cuvierina columnella</i>	19
<i>bowdenensis, Cleodora</i>	21	<i>Cuvierina</i>	7, 19, 20
<i>bowdenensis, Cleodora sp. cf.</i>	21	<i>Cuvierina astesana</i>	3, 7, 19; Pl. 3, fig. 10
<i>bowdenensis, Clio</i>	21	<i>Cuvierina columnella</i>	21
<i>braidensis, Clio</i>	21	<i>Cuvierina globosa</i>	9
<i>Camptoccratops prisca</i>	11	<i>Cuvierina grandis</i>	20
<i>caribbeana, Edithinella</i>	7, 28	<i>Cuvierina inflata</i>	9
<i>Cavolina sp.</i>	21, 26	<i>Cuvierina intermedia</i>	20
<i>Cavolina tridentata</i>	25	<i>Cuvierina paronai</i>	20
<i>Cavolinia</i>	22	<i>Cuvierina sp.</i>	9, 20; Pl. 3, fig. 11
<i>Cavolinia (Diacria) bisulcata</i>	26	<i>Cuvierina tubulata</i>	20
<i>Cavolinia aff. gypsorum</i>	7, 23; Pl. 4, fig. 4	<i>Diacria</i>	26
<i>Cavolinia angusticostata</i>	26	<i>Diacria bisulcata</i>	26, 27
<i>Cavolinia cf. tridentata</i>	9, 25; Pl. 5, figs. 1–3	<i>Diacria digitata</i>	18
<i>Cavolinia globulosa</i>	24	<i>Diacria trispinosa</i>	7–9, 26, 27; Pl. 5, figs. 4–7
<i>Cavolinia grandis</i>	9; 26	<i>Diacria trispinosa forma bisulcata</i>	27; Pl. 5, fig. 8
<i>Cavolinia gypsorum</i>	3, 7–9, 22–25; Pl. 3; figs. 1–3	<i>Diacria trispinosa forma trispinosa</i>	26
<i>Cavolinia mexicana</i>	3, 7, 9, 24, 25; Pl. 4; figs. 5–8	<i>digitata, Diacria</i>	18
<i>Cavolinia n. sp.</i>	22, 23	<i>Edithinella</i>	27, 28
<i>Cavolinia sp.</i>	22, 23	<i>Edithinella caribbeana</i>	7, 28
<i>Cavolinia tridentata</i>	9, 22, 26	<i>Edithinella sp.</i>	7, 28; Pl. 5, fig. 9
<i>Cleodora</i>	15	<i>Edithinella undulata</i>	7, 27, 28
<i>Cleodora (Balantium) striata</i>	16	<i>Edithinella varanica</i>	28
<i>Cleodora (Balantium) undulatum</i>	27	<i>elevata, Limacina</i>	7, 13, 14
<i>Cleodora (Creseis) acicula</i>	15	<i>elevata, Spiratella inflata</i>	13
<i>Cleodora (Creseis) striata</i>	16	<i>Embolus rostralis</i>	14
<i>Cleodora acicula</i>	15	<i>euphratensis, Hyalocylis</i>	16–18
<i>Cleodora bowdenensis</i>	21	<i>flabelliforme, Balantium</i>	18
<i>Cleodora sp.</i>	21	<i>globosa, Cuvierina</i>	9
<i>Cleodora sp. cf. bowdenensis</i>	21	<i>globulosa, Cavolinia</i>	24
<i>Cleodora striata</i>	16	<i>grandis, Cavolinia</i>	9, 26
<i>Cleodora subula</i>	18, 19	<i>grandis, Cuvierina</i>	20
<i>Clio</i>	17, 21, 22, 28	<i>gypsorum, Cavolinia</i>	3, 7–9, 22–25; Pl. 4, figs. 1–3

<i>gypsorium</i> , <i>Cavolinia</i> aff.	7, 23, 24; Pl. 4, fig. 4
<i>haitensis</i> , <i>Hyalocylix</i>	18
<i>haitensis</i> , <i>Hyalocylix</i>	16, 17
<i>haitensis</i> , <i>Praehyalocylix</i>	17
<i>helicina</i> forma <i>rangii</i> , <i>Limacina</i>	11
<i>helicina</i> , <i>Clio</i>	13
<i>Hyalaea aciculata</i>	15
<i>Hyalocylix</i>	16, 18
<i>Hyalocylix euphratensis</i>	16–18
<i>Hyalocylix haitensis</i>	18
<i>Hyalocylix obtusa</i>	17, 18
<i>Hyalocylix striata</i>	9, 16–18; Pl. 3, figs. 3–5
<i>Hyalocylix striata?</i>	Pl. 3, fig. 6
<i>Hyalocylix haitensis</i>	16–17
<i>Hyalocylix striata</i>	17
<i>imitans</i> , <i>Limacina</i>	7–9, 13–15; Pl. 1, Pl. 2, figs. 6–9
<i>imitans</i> , <i>Planorbella</i>	13–15
<i>imitans</i> , <i>Valvatella</i>	13
<i>inflata elevata</i> , <i>Spiratella</i>	13
<i>inflata</i> , <i>Atlanta</i>	11, 14
<i>inflata</i> , <i>Cuvierina</i>	9
<i>inflata</i> , <i>Limacina</i>	7, 13–15; Pl. 2, fig. 10
<i>inflata?</i> , <i>Limacina</i>	Pl. 2, fig. 11
<i>intermedia</i> , <i>Cuvierina</i>	20
<i>kakegawaensis</i> , <i>Protatlanta</i>	7, 11, 12
<i>Lamberti</i> , <i>Clio</i> (<i>Styliola</i>)	18
<i>lanceolata</i> , <i>Clio pyramidata</i> forma	9, 21, 22
<i>Limacina</i>	14
<i>Limacina elevata</i>	7, 13, 14
<i>Limacina helicina</i> forma <i>rangii</i>	11
<i>Limacina imitans</i>	7–9, 13–15; Pl. 1, Pl. 2, figs. 6–9
<i>Limacina inflata</i>	7, 13–15; Pl. 2, fig. 10
<i>Limacina inflata?</i>	Pl. 2, fig. 11
<i>Limacina</i> sp.	9
<i>Limacina</i> sp. indet.	15
<i>Limacina tertiaria</i>	14–15
<i>mexicana</i> , <i>Cavolinia</i>	3, 7, 9, 24, 25; Pl. 4, figs. 5–8
<i>multispira</i> , <i>Plotophysops</i>	10
<i>obtusa</i> , <i>Hyalocylix</i>	17, 18
<i>paronai</i> , <i>Cuvierina</i>	20
<i>peroni</i> , <i>Atlanta</i>	11
<i>Planorbella</i>	14
<i>Planorbella imitans</i>	13–15
<i>Plotophysops multispira</i>	10
<i>Praehyalocylix</i>	18
<i>Praehyalocylix cretacea</i>	17
<i>Praehyalocylix cretaceus</i>	17
<i>Praehyalocylix haitensis</i>	17
<i>prisca</i> , <i>Camptoceratops</i>	10
<i>Protatlanta</i>	11–13
<i>Protatlanta kakegawaensis</i>	7, 11, 12
<i>Protatlanta rotundata</i>	7, 11, 12; Pl. 2, figs. 3–4
<i>Protatlanta souleyeti</i>	12; Pl. 2, fig. 5
<i>pyramidata</i> forma <i>lanceolata</i> , <i>Clio</i>	9, 21, 22
<i>pyramidata lanceolata</i> , <i>Clio</i>	21
<i>pyramidata</i> , <i>Clio</i>	21, 22
<i>Rangiana</i> , <i>Styliola</i>	18
<i>rangii</i> , <i>Limacina helicina</i> forma	11
<i>rostralis</i> , <i>Embolus</i>	14
<i>rotunda</i> , <i>Atlanta</i>	11
<i>rotundata</i> , <i>Atlanta</i>	11, 12
<i>rotundata</i> , <i>Protatlanta</i>	7, 11, 12; Pl. 2, figs. 3–4
<i>rotundata</i> , <i>Vaginella</i>	18
<i>souleyeti</i> , <i>Atlanta</i>	11
<i>souleyeti</i> , <i>Protatlanta</i>	12; Pl. 2, fig. 5
sp., <i>Clio</i>	Pl. 3, fig. 18
sp., <i>Cuvierina</i>	Pl. 3, fig. 11
sp., <i>Edithinella</i>	Pl. 5, fig. 9
<i>spinifera</i> , <i>Creseis</i>	18, 19
<i>Spiratella</i>	13
<i>Spiratella inflata elevata</i>	13
<i>Spirialis tertiaria</i>	14
<i>striata</i> , <i>Cleodora</i>	16
<i>striata</i> , <i>Cleodora</i> (<i>Balantium</i>)	16
<i>striata</i> , <i>Cleodora</i> (<i>Creseis</i>)	16
<i>striata</i> , <i>Clio</i>	16
<i>striata</i> , <i>Creseis</i>	16
<i>striata</i> , <i>Hyalocylix</i>	9, 16–18; Pl. 3, figs. 3–5
<i>striata?</i> , <i>Hyalocylix</i>	Pl. 3, fig. 6
<i>striata</i> , <i>Hyalocylix striata</i>	17
<i>striata</i> , <i>Hyalocylix</i>	17
<i>striata</i> , <i>Styliola</i>	16, 17
<i>Styliola</i>	18
<i>Styliola Rangiana</i>	19
<i>Styliola striata</i>	16, 17
<i>Styliola subula</i>	3, 9, 18, 19; Pl. 3, figs. 7–9
<i>Styliola sulcifera</i>	18, 19
<i>subula</i> , <i>Cleodora</i>	18, 19
<i>subula</i> , <i>Styliola</i>	3, 9, 18, 19; Pl. 3, figs. 7–9
<i>sulcifera</i> , <i>Styliola</i>	18, 19
<i>Tentaculites cretaceus</i>	16–18
<i>tertiaria</i> , <i>Limacina</i>	14, 15
<i>tertiaria</i> , <i>Spirialis</i>	14
<i>tridentata</i> , <i>Anomia</i>	26
<i>tridentata</i> , <i>Cavolinia</i>	9, 22, 25, 26
<i>tridentata</i> , <i>Cavolinia</i> cf.	9, 25; Pl. 5, figs. 1–3
<i>trispinosa</i> forma <i>bisulcata</i> , <i>Diacria</i>	27; Pl. 5, fig. 8
<i>trispinosa</i> forma <i>trispinosa</i> , <i>Diacria</i>	26
<i>trispinosa</i> , <i>Diacria</i>	7–9, 26, 27; Pl. 5, figs. 4–7
<i>trispinosa</i> , <i>Diacria trispinosa</i> forma	26
<i>tubulata</i> , <i>Cuvierina</i>	20
<i>undulata</i> , <i>Edithinella</i>	7, 27, 28
<i>undulata</i> , <i>Vaginella</i>	27
<i>undulata</i> , <i>Vaginella</i>	27
<i>undulata</i> , <i>Vaginella</i> aff.	27
<i>undulatum</i> , <i>Balantium</i>	27
<i>undulatum</i> , <i>Cleodora</i> (<i>Balantium</i>)	27
<i>Vaginella undulata</i>	27
<i>Vaginella</i>	28
<i>Vaginella acicula</i>	15
<i>Vaginella</i> aff. <i>undulata</i>	27, 28
<i>Vaginella rotundata</i>	18
<i>Vaginella</i> sp.	28
<i>Vaginella undulata</i>	27
<i>Valvatella imitans</i>	13
<i>varanica</i> , <i>Edithinella</i>	28

