

New gastropods from the Maastrichtian of the Mexcala Formation in Guerrero, southern Mexico, part II: Archaeogastropoda, Neritimorpha and Heterostropha*

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With 3 figures

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Abstract: Seventeen gastropod species including six new ones, belonging to the Archaeogastropoda, Neritimorpha and Heterostropha, are described from the lower Maastrichtian of the Mexcala Formation in Mexico. Most of the species appear to have their closest relatives on the North American Gulf Coast and the Atlantic and Tethyan shores of Europe, a few are cosmopolitans. The new species are: *Homalopoma chica*, *Pileolus cozatli*, *Mathilda mexicana*, *Mathilda gardnerae*, *Heliacus alencasterae* and *Ringicula coronai*.

Zusammenfassung: Siebzehn Arten der Archaeogastropoda, Neritimorpha und Heterostropha, darunter sechs neue, werden aus dem unteren Maastricht der Mexcala-Formation in Mexico beschrieben. Die meisten Arten scheinen ihre nächsten Verwandten an der nordamerikanischen Golfküste und der europäischen Atlantik- und Tethys-Küste zu haben, einige sind Kosmopoliten. Die neuen Arten sind: *Homalopoma chica*, *Pileolus cozatli*, *Mathilda mexicana*, *Mathilda gardnerae*, *Heliacus alencasterae* und *Ringicula coronai*.

* Part. I see KIEL & PERRILLIAT (2001). – N. Jb. Geol. Paläont. Abh., **222**: 407–426.

Introduction

This is the second part of a description of gastropods from the lower Maastrichtian of the Mexcala Formation in Mexico, collected by R. CÓZATL and S. KIEL in August 1998. In the first part, KIEL & PERRILLIAT 2001 described ten species of the Stromboidea. Here we report seventeen species belonging to the Archaeogastropoda, Neritimorpha and Heterostropha.

All fossils are deposited in the Paleontological Collection of the Instituto de Geología, Universidad Nacional Autónoma de México, labelled IGM 7811-7832.

Systematic Paleontology

Class	Gastropoda CUVIER, 1797
Subclass	Archaeogastropoda THIELE, 1925
Superfamily	Trochoidea RAFINESQUE, 1815
Family	Turbinidae RAFINESQUE, 1815
Subfamily	Colloniinae COSSMANN, 1916

Genus *Homalopoma* CARPENTER, 1864

Type species: *Turbo sanguineaum* LINNAEUS, 1758 living in the Mediterranean (WENZ 1938-44: 340, fig. 798).

Diagnosis: This genus contains small, low spired shells with convex volutions, a narrow or closed umbilicus and a roundish aperture (WENZ 1938-44).

Homalopoma chica n. sp.

Fig. 1.1, 2

Derivatio nominis: From the Spanish word *chica*, for small.

Holotype: IGM 7811, illustrated in figure 1.1, 2.

Material: One specimen.

Fig. 1. Archaeogastropoda and Neritimorpha from Mexico, scale bars = 1 mm except where indicated otherwise. **1-2:** *Homalopoma chica* n. sp.; holotype; IGM 7811; **3-4:** *Solariella mexcalensis* (PERRILLIAT, VEGA & CORONA, 2000); **3:** adult shell; IGM 7812; **4:** view on the protoconch; IGM 7813; scale bar = 0.5 mm; **5:** *Skenea* sp.; IGM 7814; **6-7:** *Dontostoma?* sp.; **6:** apical view; IGM 7817; **7:** aperture; IGM 7818; **8-10:** *Otostoma* sp.; **8:** aperture; IGM 7816; **9-10:** dorsal and apical view showing the strong ribbing; **11-13:** *Pileolus cozatli* n. sp.; **11, 13:** apical views on the paratype; IGM 7820; **12:** aperture of the holotype; IGM 7819.

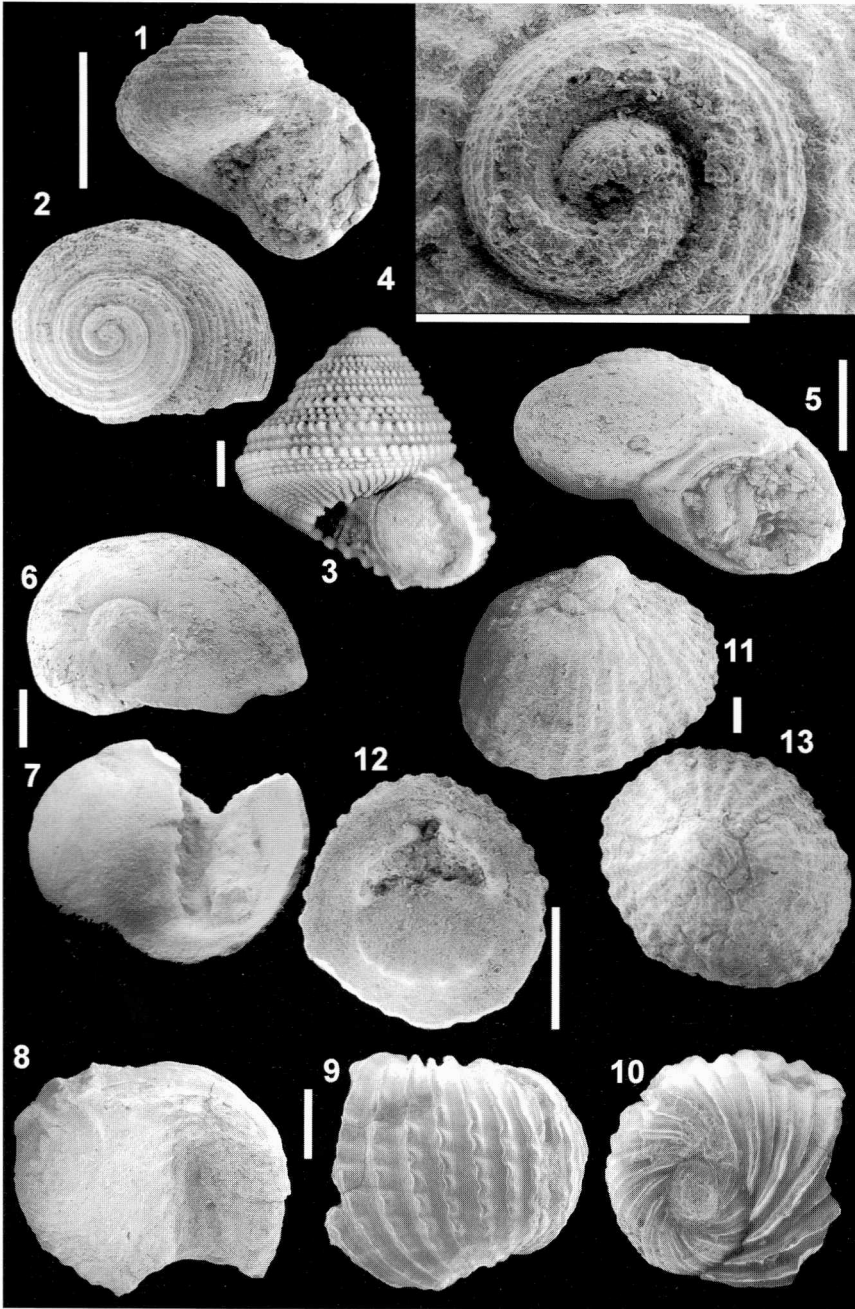


Fig. 1 (Legend see p. 320)

Diagnosis: A *Homalopoma* with rounded whorl-sides, an apical angle of about 110°, sculpture of equally sized and spaced spiral lirae, and a small umbilicus.

Description: The protoconch measures 0.15 mm across, the teleoconch is low turbiniform, consists of three convex volutions and the aperture is higher than the spire. On the first whorl of the teleoconch five spiral ribs are present, while the next whorl shows six. The body whorl has twelve such spirals, which appear beaded near the periphery. The base is smooth, shows a small umbilicus that is accompanied by a spiral rib, and the aperture is roundish. The holotype is 1.5 mm high, 1.8 mm wide, and has an apical angle of 110°.

Remarks: *Homalopoma minuta* (QUINTERO & REVILLA 1966) from the Campanian of Torallola, Spain is quite similar, it differs from the species described here only by its narrower apical angle and its slightly angulated whorls (QUINTERO & REVILLA 1966: pl. 7, fig. 7). *Homalopoma eurystoma* (WHITE 1885: 12, pl. 5, figs. 9-11) from the Campanian/Maastrichtian of Baja California, Mexico differs from *Homalopoma chica* n. sp. also by its narrower apical angle and by the presence of a denticle on the base of the columella.

Family Trochidae RAFINESQUE, 1815
Subfamily Solariellinae POWELL, 1951

Genus *Solariella* WOOD, 1842

Type species: *Solariella maculata* WOOD, 1842 from the Pliocene of Suffolk, England (WENZ 1938-44: 274, fig. 579).

Diagnosis: The small shells with more or less convex volutions have groove-like sutures, spiral cords, and transverse growth lines. The last whorl is large, the base convex or keeled, and the aperture is circular with an uninterrupted peristome (MARSHALL 1999).

Solariella mexcalensis (PERRILLIAT, VEGA & CORONA, 2000)
Fig. 1.3, 4

2000 *Calliomphalus (Planolateralus) mexcalensis*.—PERRILLIAT, VEGA & CORONA: 8, figs 5.7-5.11.

Material: More than 40 specimens (figured: IGM 7812-13).

Description: The embryonic part is smooth and measures about 0.23 mm across. The teleoconch ornament starts with six spiral cords and intimations of axial ribs. After one and half volutions the axial ribs are more dominant

than the spiral cords and the first, fourth and sixth spiral cords are strongest. On later whorls the ornament turns into a nodose pattern. The sutures are deep, the base is concave and shows dense, nodular spiral cords and an umbilicus with a beaded margin. The aperture is subcircular. The figured adult shell is 6 mm high and 6 mm wide.

Remarks: The Spanish *Solariella montsecana* (VIDAL, 1921) shows a very similar early ornamentation, but differs by having deeper sutures, less numerous spirals and a base sculptured only with few spirals (KIEL & BANDEL, 2001 b, pl. 4, figs. 8-10), while in *Solariella mexcalensis* the base is wholly covered with beaded spirals.

Similar adult shells are developed by *Calliomphalus* COSSMANN, 1888 and especially by its subgenus *C. (Planolateralus)* SOHL, 1960, but two species figured by DOCKERY (1993) show that their teleoconch ornament starts with axial ribs in contrast to the spiral cords of *Solariella mexcalensis*.

Family Skeneidae CLARK, 1851

Genus *Skenea* FLEMING, 1825

Type species: *Helix serpuloides* MONTAGU, living off England (WENZ 1938-44: 326, fig. 745).

Diagnosis: The small, low conical shells with convex volutions show deep sutures, a wide umbilicus and a round aperture (WENZ 1938-44).

Skenea sp.

Fig. 1.5

Material: One specimen (IGM 7814).

Description: The protoconch measures about 0.21 mm across and the adult shell is about 2.5 mm wide and 1.7 mm high. The spire is low, the volutions smooth and little convex and separated by low sutures. The fully grown shell consists of 3 whorls. The aperture is ovate and has a reflected inner lip.

Subclass Neritimorpha GOLIKOV & STAROBOGATOV, 1975

Order Cycloneritimorpha BANDEL & FRYDA, 1999

Family Neritidae RAFINESQUE, 1815

Genus *Otostoma* D'ARCHIAC, 1859

Type species: *Nerita rugosa* HOENIGHAUS 1830, by indication (DOUVILLÉ 1904). SQUIRES & SAUL (1993) have extensively discussed the nomenclatural history of *Otostoma*'s type species.

Diagnosis: The globular neritid shell has a depressed spire and rapidly expanding whorls. The ornament consists of axial ribs above the periphery, below the periphery the axial ribs may be broken or crenulated. The periphery itself may be rounded, developed as an angulation, or as a strongly tuberculated keel. The semilunular aperture is provided with an expanded and thickened inner lip which bears strong subequal denticles on its columellar edge (WENZ 1938-44).

Otostoma sp.

Figs. 1. 8-10

2000 *Nerita* cf. *divaricata* D'ORBIGNY. – PERRILLIAT, VEGA & CORONA 9, figs 5.15, 5.16.

Material: Five specimens (figured: IGM 7815-16).

Description: A *Nerita*-like shell with strong ribs that are transverse on the upper side and crenulated at the flanks. The inner lip is heavily callused, straight and bears five denticles of about equal strength. The outer lip is convex. The largest specimen is about 4 mm wide and 3 mm high.

Remarks: The studied individuals represent juvenile shells. In order to compare them with species of *Otostoma* from other localities, fully grown shells would have to be found. However, a species with similarly crenulated ribs on the flank is *Otostoma angolensis* (RENNIE, 1930b: 39, pl. 5, fig. 12) from the "upper Senonian" of Angola.

Genus *Dontostoma* HERRMANNSEN, 1847

Type species: *Nerita polita* LINNAEUS, 1758 from the tropical Indo-Pacific (see WELLS & BRYCE 1988: 49, pl. 10, fig. 108).

Diagnosis: The neritiform shell has a flat spire and is smooth except for fine collabral growthlines. The aperture is D-shaped, the inner lip is straight to moderately convex and possesses several subequal denticles; the interior of the outer lip may have a ridge, may be crenulated, or may be armed with strong denticles.

Remarks: *Dontostoma* differs from *Nerita* by having no spiral ornament but only fine collabral growth lines. *Otostoma* is distinct from *Dontostoma* by its strong axial ribs.

Dontostoma? sp.

Figs. 1.6-7

Material: More than ten specimens (figured: IGM 7817-18).

Description: The shell is small, low spired and smooth and has a large last whorl with a semicircular aperture bearing four plications on the inner lip

callus. The largest specimen is 5 mm wide and has an aperture that is 4 mm high.

Family Pileolidae BANDEL, GRÜNDEL & MAXWELL, 2000

Genus *Pileolus* SOWERBY, 1823

Type species: *Pileolus plicatus* SOWERBY, 1823 from the Bathonian of England (WENZ 1938-44: 416, fig. 1011).

Diagnosis: The limpet shell has a subcentral apex, radial ribs, and a concave base. Its aperture is half-moon shaped (WENZ 1938-44).

Pileolus cozatli n. sp.

Figs. 1.11-13

Derivatio nominis: Named for ROBERTO CÓZATL, for the pleasant time during the field work.

Holotype: IGM 7819, illustrated in figure 1.12.

Paratype: IGM 7820, illustrated in figure 1.11, 13.

Material: Three specimens.

Diagnosis: This *Pileolus* has a triangular notch in the outer lip of the aperture, one denticle on both ends of the aperture and a semicircular callus-pad with a denticulate margin opposite the aperture.

Description: The protoconch is smooth, roundish, 0.75 mm long, 0.55 mm wide and 0.45 mm high. The adult shell is limpet-like, small, and is sculptured by 33 radial ribs and fine growth lines. In the roundish base, the aperture is sickle shaped with a convex inner lip. Its outer side is bordered by two beaded ridges and a small, triangular notch on the front. The inner side shows a denticulate margin. A semi-circular beaded ridge is situated opposite the aperture, bordering the flattened shelf of the inner lip callus. The largest specimen is 3 mm long, 2.5 mm wide, and 1.5 mm high.

Remarks: This new species is distinct from the type by its dented apertural margin. Similar apertures but also with non-dented outer margins are present in two species from the Cenomanian of Saxony, Germany, *Pileolus koninckianus* DE RYCKHOLT, 1874 and *Pileolus orbignyi* GEINITZ, 1871 (GEINITZ 1871-75). A new species of *Pileolus* was reported by SOHL (1987: Fig. 3) from the Maastrichtian of Puerto Rico, which lacks the small apertural notch of *Pileolus cozatli*.

Subclass Heterostropha FISCHER, 1885
 Order Allogastropoda HASZPRUNAR, 1985

Family Mathildidae DALL, 1889

Remarks: The Mathildidae are an often described but little known group of marine gastropods. WENZ (1938-44) listed no less than 15 genera and subgenera. GRÜNDEL (1976, 1997a) and SCHRÖDER (1995) added several new genera and relied strongly on the number of spirals on the first teleoconch-whorl to distinguish them. In a survey of Recent species from New Caledonia, BIELER (1995) demonstrated a broad variety of arrangements of the initial spirals among living species. He suggested that the validity of this character in mathildid classification needs to be tested by comparison with anatomical characters. However, he minutely described the initial spirals of his species. In all the more than 20 species described by him the number of spiral ribs on the first teleoconch-whorl range from four to six. Usually four of them remain visible on the spire; one of them develops into the peripheral keel within the course of the first teleoconch whorl. Of the mathildids from Temalac, two fit in this scheme of *Mathilda* while one shows only two initial spirals and a teleoconch with a broad apical angle in the adult, which is placed within *Carinathilda* GRÜNDEL, 1997.

Other gastropod groups that tend to develop similar adult shell include the Cerithiidae, Rissoidae and Nystiellidae (see BIELER 1995: 632-635). Thus it is usually necessary to have the heterostrophic protoconch preserved in order to recognise a member of this taxon.

Genus *Mathilda* SEMPER, 1865

Type species: *Turbo quadricarinata* BROCCHI, 1814 from the Pliocene of Italy. According to SABELLI & SPADA (1978) it still lives in the sublittoral rubble down to 30 m depth in the Mediterranean Sea of southern Italy.

Fig. 2. Allogastropoda from Mexico. **1-2:** *Mathilda mexicana* n. sp.; **1:** holotype with preserved protoconch; IGM 7821; scale bar = 0.5 mm; **2:** paratype; IGM 7822; scale bar = 2 mm; **3:** *Mathilda gardnerae* n. sp.; holotype; IGM 7823; scale bar = 1 mm; **4:** *Carinathilda diminuta* (PERRILLIAT, VEGA & CORONA, 2000); IGM 7824; scale bar = 2 mm; **5-6:** *Heliacus alencasterae* n. sp.; holotype; IGM 7825; scale bar = 0.5 mm; **7:** *Granosolarium* sp.; IGM 7826; scale bar = 1 mm; **8-9:** *Pseudomalaxis pateriformis* STEPHENSON, 1955; IGM 7827; scale bar = 0.5 mm; **10-11:** *Herewardia?* sp.; IGM 7828; scale bar = 0.5 mm.

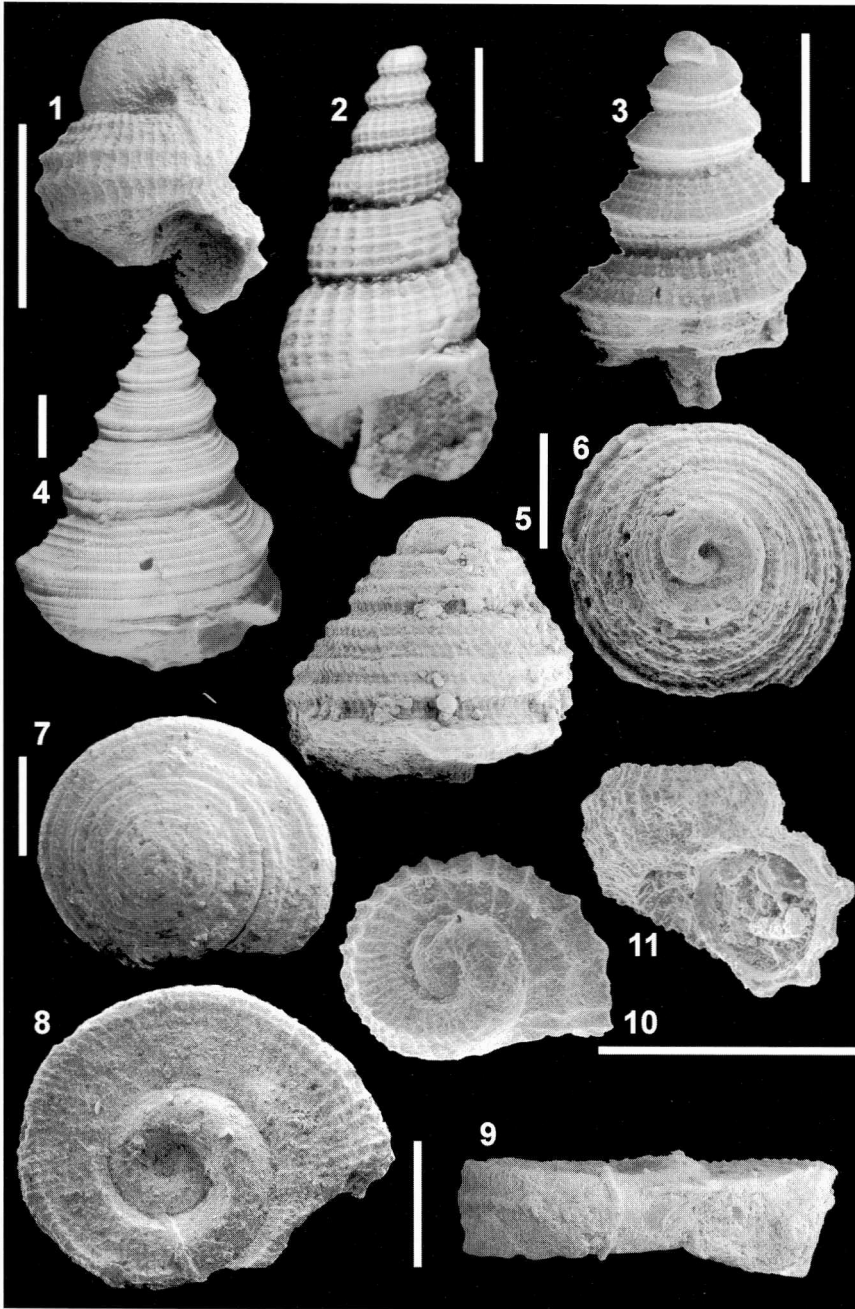


Fig. 2 (Legend see p. 326)

Diagnosis: *Mathilda* contains small, turiform shells with a sinistrally coiled protoconch. Sculpture consists of spiral cords which are often crossed by axial ribs. The number of spirals on the first whorl of the teleoconch ranges from four to six (BIELER 1995).

Mathilda mexicana n. sp.

Figs. 2.1-2

Derivatio nominis: Named after Mexico, the country of its occurrence.

Holotype: IGM 7821, illustrated in figure 2.1.

Paratype: IGM 7822, illustrated in figure 2.2.

Material: Three specimens.

Diagnosis: The protoconch stands in a right angle to the teleoconch and shows radial ribbing around the umbilicus. The initial spirals on the teleoconch show a $2 + 2 + 1$ -pattern, whorls of the adult shell are convex and spiral and axial sculpture is of equal strength.

Description: The protoconch measures 0.5 mm in diameter. Its base bears ribs that are best developed next to the 0.1 mm wide umbilicus. Of the teleoconch six whorls are preserved, but there may have been more. Ornamentation begins with five spiral cords in a $2 + 2 + 1$ -pattern, crossed by fine axial ribs. On the last three to four volutions spiral and axial elements are of equal strength and the whorls are well-rounded. Also the base is rounded, possesses a narrow umbilical slit and a sculpture of spiral cords. The inner lip is reflected and the peristome interrupted. The adult shell is 8 mm high and 3 mm wide.

Remarks: The similar *Mathilda pentelira* DOCKERY, 1993 from the Campanian of Mississippi differs in having a $3 + 1 + 1$ -pattern on the initial teleoconch whorl (DOCKERY, 1993). Among the Recent species described by BIELER (1995) *Mathilda houbricki* BIELER, 1995, *Mathilda maculosa* BIELER, 1995, *Mathilda decorata* HEDLEY, 1903 and *Mathilda* cf. *amanda* THIELE, 1925 possess similar initial ornamentation.

Mathilda gardnerae n. sp.

Fig. 2.3

Derivatio nominis: Named in honour of JULIA F. GARDNER who worked on Mexican fossils.

Holotype: IGM 7823, illustrated in fig. 2.3.

Material: Five specimens.

Diagnosis: The protoconch stands in an angle of 45° to the teleoconch, ornamentation of the teleoconch starts with spirals in a $3 + 2$ -pattern. On early whorls, the fourth spiral cord forms a strong keel, later whorls have rounded sides.

Description: The protoconch measures 0.35 mm in diameter, is partly imbedded in the first teleoconch whorl and forms an angle of about 45° with the teleoconch. The teleoconch consists of eight or more angulated volutions, its ornamentation starts with spirals in a 3 + 2 -pattern. The first of the strong spirals forms a keel. The spirals are tuberculate where they are crossed by fine axial ribs and the sutures are very deep. Later whorls are more rounded. The inner lip is reflected, the base is rounded and sculptured with spiral cords and bears a very narrow umbilical slit. The adult shell is 9.5 mm high and 4 mm wide.

Remarks: The early shell resembles *Mathilda ripleyana* WADE, 1926 from the Ripley Formation (DOCKERY 1993) and *Fimbriatella* sp. 1 from the Paleocene of Greenland (KOLLMANN & PEEL 1983), but the later whorls are similar to those of *Mathilda mexicana* described above.

Genus *Carinathilda* GRÜNDEL, 1997

Type species: *Carinathilda carinata* GRÜNDEL, 1997 from the Middle Jurassic of Poland (GRÜNDEL 1997b: 149, pl. 6, figs. 83-87).

Diagnosis: The sinistral protoconch forms an angle of up to 45° with the teleoconch, is smooth or with riblets and forms a sharp transition to teleoconch. On the high, trochispiral adult shell, sculpture starts with two spiral keels of which the second is the strongest. The shell is covered with a fine pattern of spirals and collabral axials (GRÜNDEL 1997b).

Carinathilda diminuta (PERRILLIAT, VEGA & CORONA, 2000)

Fig. 2.4

1980 *Pterocerella* cf. *poinsettiformis* STEPHENSON. – ALENCÁSTER: 40, fig. 7.

2000 *Nododelphinula diminuta*. – PERRILLIAT, VEGA & CORONA: 9, figs. 5.12-5.14.

Material: Eight specimens (figured: IGM 7824).

Description: The protoconch forms an angle of about 30° with the teleoconch into which it is partly imbedded, and measures about 0.4 mm across. The teleoconch has up to eight angular volutions with numerous fine nodular spiral cords crossed by even finer axial costae. A strong keel in the lower third marks the whorls greatest width. Its base is rounded and covered with fine spiral lirae, the umbilicus takes 1/3 of the basal diameter and shows fine spiral lirae inside. The aperture is roundish and the upper part of the inner lip is strongly reflected. The figured shell is 15 mm high and 10 mm wide.

Remarks: *Carinathilda diminuta* is distinguishable from the type species of *Carinathilda* by its two prominent spiral ridges on the later whorls. *Bathraspira fouadi* ABBASS, 1973 from the Albian of Folkstone, UK, may also belong here, but shows only one strong spiral ridge and has a lower apical angle (ABBASS 1973).

Family Architectonicidae GRAY, 1840

Remarks: Generally, distinction between the low-spired Architectonicidae and the high-spired Mathildidae is obvious. However, such genera as *Heliacus* (Architectonicidae) and *Tuba* (Mathildidae) are difficult to distinguish by shell characters alone (e.g. in the fossil record). BIELER (1984) suggested the architectonicid protoconch always to be coaxial and the mathildid to have an angle of at least 45° to the coiling axial of the teleoconch. BANDEL (1995, 1996) agreed on architectonicid protoconchs being coaxial, the mathildid, on the other hand, he found to be highly variable in its position.

Genus *Heliacus* D'ORBIGNY in SAGRA, 1842

Type species: *Solarium herberti* DESHAYES, 1830, Recent, Martinique, by monotypy (BIELER, 1985b: 95).

Diagnosis: These relatively high-spired, small architectonicids with dominant spiral sculpture are umbilicate and have a field of five spiral lirae on the base (DOCKERY 1993).

Heliacus alencasterae n. sp.

Figs. 2.5-6

2000 *Calliomphalus (Planolateralus) argenteus argenteus* WADE. – PERRILLIAT, VEGA & CORONA: 7, figs 5.1, 5.2.

Derivatio nominis: Named after GLORIA ALENCÁSTER, the first who described gastropods from this locality.

Holotype: IGM 7825, illustrated in figs. 2.5-6.

Material: Three specimens.

Diagnosis: This *Heliacus* has straight-sided whorls sculptured with four spiral cords - of which the third is the strongest - and fine, collabral growth lines. Its base is flat and shows axial and spiral lirae.

Description: The almost coaxial protoconch is smooth, is embedded in the early teleoconch, and measures 0.7 mm in diameter. Its suture to the teleoconch is reinforced. The trochiform teleoconch is made of up to five

straight-sided whorls with four nodular spiral cords, the third being the strongest. The base is flat and sculptured with spiral and axial lirae. The umbilicus occupies about 1/4 of the whorl's diameter and the aperture is roundish. The shells are up to 3 mm high and 2.5 mm wide.

Remarks: *Heliacus reticulatus* DOCKERY, 1993 from the Campanian Coffee Sand of Mississippi has more numerous spiral cords which are of equal strength and the whorls appear to be more rounded (DOCKERY 1993). A closely related European species may be "*Eutrochus*" *quadricinctus* MÜLLER (see HOLZAPFEL 1888: pl. 19, figs 4-6) from the Vaals greensands of Germany, which needs to be revised.

Genus *Granosolarium* SACCO, 1892

Type species: *Solarium milligranum* LAMARCK, 1822, from the Tertiary of Italy, by original designation (BIELER 1985a: 245, pl. 5, fig. 20).

Diagnosis: The medium-sized, discoid shells with moderately broad umbilicus are sculptured with noded spiral elements. The umbilical margin is noded and not separated from remainder of base by a groove; the umbilical wall bears a spiral cord between margin and suture and noded carina is present at shell periphery (DOCKERY 1993).

Granosolarium sp.

Fig. 2.7

Material: Two specimens (figured: IGM 7826).

Description: The protoconch is coaxial and smooth, and measures 0.28 mm in diameter. The teleoconch consists of three volutions with incised sutures, shows two spiral ridges near the upper and two near the lower suture, transverse costae, and measures almost 3 mm in diameter. The whorl sides are rounded, the spire of low conical shape and the base shows spiral cords.

Remarks: The two other Maastrichtian species known from North America, *Granosolarium coffea* Sohl 1964 and *Granosolarium voragiformis* STEPHENSON, 1941 differ by their nodose spiral cords. A similar species from the Middle and Upper Eocene of north-eastern Mexico is *Granosolarium alveata* (CONRAD), see GARDNER (1945: 15 1, pl. 14, figs 17, 20, 21, 23) which has only two spiral cords near the lower suture and transverse growth lines.

Genus *Pseudomalaxis* FISCHER, 1885

Type species: *Bifrontia zanclea* PHILLIPI, 1844 from the Pliocene of Messina in Sicily, Italy (ABBOTT, 1974: 99).

Diagnosis: This genus unites discoidal shells with a very wide umbilicus, a flat or low spire and whorls angulated at peripheral and umbilical margins so that the whorls have a subrectangular cross section. The protoconch is smooth and forms an angle of 180° with the teleoconch (DOCKERY 1993).

Pseudomalaxis pateriformis STEPHENSON, 1955 Figs. 2.8-9

1955 *Pseudomalaxis pateriformis* n.sp. – STEPHENSON: 124, pl. 21, figs 19-21.

1960 *Pseudomalaxis pateriformis* STEPHENSON. – SOHL: 67, pl. 6, figs 35, 38.

Material: Two specimens (figured: IGM 7827).

Description: The protoconch is smooth, made of 1 1/2 volutions and has a diameter of 0.75 mm. It forms an angle of 180° with the teleoconch, terminates in a reinforced lip and on the last 1/4 volution appears a ridge. The teleoconch has angular whorls, deep sutures with jagged margins, and the upper whorl sides are ornamented with noded cords. The umbilicus is very wide with transverse lirae and nodose spiral keels. The aperture is round and an incomplete shell is 10 mm wide and 4 mm high.

Remarks: The protoconch is smaller than the average Recent one and the aperture is more trapezoidal as in the Recent forms figured by BIELER (1984).

Family Pyramidellidae GRAY, 1840

Genus *Herewardia* IREDALE, 1955

Type species: *Rissoina kesteveni* HEDLEY, 1907, living at the coasts of Queensland, Australia (PONDER 1985).

Diagnosis: The small, trochoid and umbilicate shells comprise only a few volutions, have no columellar folds and are sculptured with axial and spiral elements (PONDER 1985).

Herewardia? sp. Figs. 2.10-11

Material: One specimen (figured: IGM 7828)

Description: The protoconch measures 0.2 mm in diameter, is imbedded in the early teleoconch whorls and forms an angle of about 180° with the

teleoconch. It has some axial ribs near the centre of the base. There is only one teleoconch whorl which is sculptured with five strong spiral cords and axial ribs that form nodose intersections. The second spiral marks the whorls largest diameter, the last spiral forms the margin of the deep umbilicus which is axial ribbed. The aperture is round. The shell is 0.45 mm high and 0.5 mm wide.

Order Opisthobranchia MILNE-EDWARDS, 1848
Suborder Cephalaspidea FISCHER, 1883
Family Actaeonidae D'ORBIGNY, 1842

Genus *Actaeon* MONTFORT, 1810

Type species: *Voluta tornatilis* GMELIN, 1788, Recent, Mediterranean (WENZ & ZILCH 1959-60: 6, fig. 2).

Diagnosis: Adult shells are ovate, have a low to moderately elevated spire and the protoconch is heterostrophic and often partly buried in the teleoconch. There are about five convex teleoconch whorls, the last whorl is very capacious and sculptured with narrow spiral grooves and spiral rows of pits, typically with fine axial costae within. The aperture is large, its anterior end is rounded, and the apical end constricted. The columella is thick, subvertical with a single oblique plait at its apical end (SOHL 1964).

Remarks: Generic separation within the Actaeonidae is carried out mainly according to the number of columellar and parietal folds; the relative height of the spire is also considered but remains a minor character (WENZ & ZILCH 1959-1960; SOHL 1964).

Actaeon cicatricosus Sohl, 1964

Figs. 3.1-2

1964 *Actaeon cicatricosus* n. sp. – SOHL: 288, pl. 47, figs. 17, 18, 22.

Material: Six specimens (figured: IGM 7829).

Description: The protoconch measures 0.3-0.4 mm in diameter, forms an angle of about 45° with the teleoconch and the last protoconch whorl is thicker than the first teleoconch whorl. The eggshaped teleoconch consists of five moderately to well rounded volutions and is sculptured with fine spiral grooves with fine axial costae inside. The sutures are deep and the whorl shoulder bears a spiral groove. The columellar lip is reflected, the aperture is elongate, narrow and rounded on both ends. The largest specimen is 7 mm high and 3.5 mm wide.

Remarks: The specimen from the Ripley Formation of Mississippi is only about half as high as the Mexican ones.

Actaeon? sp.

Figs. 3.5-6

Material: Two specimens (figured: IGM 7830).

Description: The large, smooth protoconch measures 0.45 mm across, is deeply imbedded in the teleoconch and has an inclined axis. The one teleoconch whorl shows numerous nodose spiral cords connected vertically by fine axial lamellae.

Remarks: Only half a teleoconch whorl is preserved, its ornament resembles that of *Actaeon cicatricosus* but the protoconch has a different mode of coiling, is larger and more deeply imbedded in the teleoconch. A very similar ornament is known from the mid-Jurassic *Actaeon* cf. *ooliticus* HUDLESTON (SCHRÖDER 1995: pl. 11, figs 7-10).

Family Ringiculidae FISCHER, 1883

Genus *Ringicula* DESHAYES, 1838

Type species: *Auricula ringens* LAMARCK, 1804, from the Eocene of Grignon, France (WENZ & ZILCH 1959-60: 21, fig. 54).

Diagnosis: These small, globular or egg-shaped shells with a short spire usually have a sculpture of incised spirals. The aperture is often narrowed by columellar and parietal folds, the outer margin is thickened and attached to the spire, and often dented within.

Ringicula coronai n. sp.

Fig. 3.3

2000 *Ringicula* (*Ringiculina*) cf. *clarki* GARDNER. – PERRILLIAT, VEGA & CORONA: 19, fig. 7. 10.

Derivatio nominis: Named after RODOLFO CORONA, Mexico City, who worked on the molluscs of the Temalac fauna.

Holotype: IGM 7831, illustrated in fig. 3.3.

Material: About 20 specimens.

Diagnosis: This *Ringicula* has a high spire, deep sutures, and a sculpture of fine, incised spirals. The columella has two plates, a horizontal one in its centre and an oblique one bordering the anterior end of the aperture.

Description: The protoconch forms an angle of 180° with the teleoconch and has a diameter of about 0.15 mm. The teleoconch is egg-shaped with six

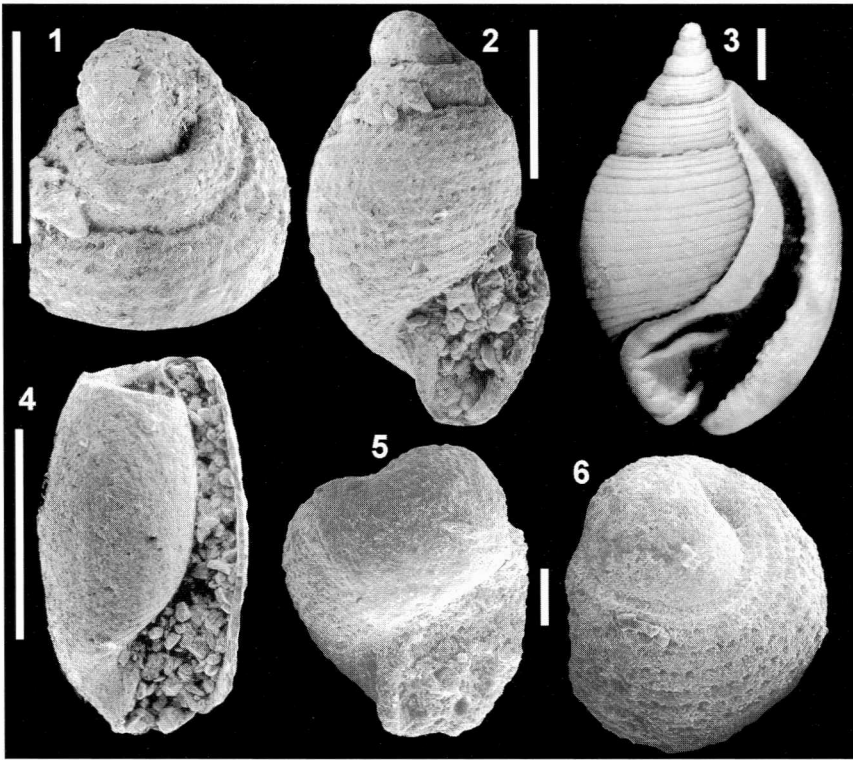


Fig. 3. Opisthobranchia from Mexico. **1-2:** *Actaeon cicatricosus* SOHL, 1964; IGM 7829; **1:** view on the protoconch; scale bar = 0.5 mm; **2:** apertural view; scale bar = 0.5 mm **3:** *Ringicula coronai* n. sp.; holotype; IGM 7831; scale bar = 1 mm; **4:** *Cylichna recta* GABB, 1860; IGM 7832; scale bar = 1 mm; **5-6:** *Actaeon* sp.; IGM 7830; scale bar = 0.1 mm.

volutions, the first two are smooth and straight sided, while later whorls are convex and sculptured by fine spiral grooves. These grooves are only weak on the central body whorl and interspaces are much closer next to the upper suture than elsewhere. The outer lip is thickened with callus and reaches up to the two preceding volutions, has axial grooves on its outer side and fine

denticles on its inner side. The parietal lip is thickened with callus, the columellar lip is reflected and bears two plates: a horizontal one in its centre and an oblique one bordering the anterior end of the aperture. The holotype is 8 mm high and 5 mm wide.

Remarks: *Ringicula clarki* GARDNER, 1916 shows no denticles on the outer lip and the outer lip does not reach as high on the spire as *Ringicula coronai* n. sp. (GARDNER 1916). *Ringicula pulchella* SHUMARD, 1861 and *Ringicula yochelsoni* SOHL, 1964 have a denticle on the parietal lip and a zigzagged ornament (SOHL 1964).

Informal group Bullomorpha

Remarks: Due to the strong convergence among Recent bullomorph gastropod shells (see MIKKELSEN 1993 for a review), we place our species only tentatively in the genus *Cylichna* LOVÉN, 1846. However, it is not assigned to a certain bullomorph family because this would pretend a more precise classification than it is possible using shell-characters alone.

“*Cylichna*” *recta* GABB, 1860

Fig. 3.4

1860 *Cylichna recta* n.sp. – GABB: 302, pl. 48, fig. 16.

1916 *Cylichna recta* GABB. – GARDNER: 411, pl. 18, figs 10-11.

2000 *Cylichna secalina* SHUMARD. – PERRILLIAT, VEGA & CORONA: 19, fig. 7.9.

Material: 14 specimens (figured: IGM 7832).

Description: The cylindrical, convolute shell has an apical umbilicus which measures about one third of the whorls diameter. The top is flattened and the margin marked by a weak ridge. The aperture is long and narrow, ends anteriorly in a sinus, posteriorly it widens as the whorl is constricted near the base and the outer lip is only very little convex. The columella is a little reflected and has a rounded base. The sculpture of weak spiral grooves is best developed in the lower half of the whorl. The largest specimen is about 1.8 mm high.

Remarks: *Cylichna secalina* SHUMARD, 1861 and *Cylichna recta* are most probably synonymous as the only difference reported and visible is the distribution of the fine spiral grooves. The weaker development of this ornament on the Mexican species than on those figured by GARDNER (1916) probably is a matter of corrosion rather than a distinctive character. *Cylichna intermissia intermissia* SOHL, 1964 might be another synonym.

Taxonomical and paleogeographical notes

Archaeogastropoda

Solariella and *Calliomphalus* often develop very similar adult shells, but are distinguishable by the sculpture of the first whorl (KIEL & BANDEL 2001 b). While *Solariella* starts with spiral sculpture which turns into a pattern of crenulated spirals after the first whorl - as documented here for *Solariella mexcalensis*, *Calliomphalus* starts with axial ribs (KIEL & BANDEL 2001 b). The large number of individuals of *Solariella montsecana* in Torallola, Spain and of *Solariella mexcalensis* in southern Mexico combined with the absence of *Calliomphalus* from these localities, may indicate that the Late Cretaceous *Solariella montsecana* / *mexcalensis*-group lived south of 30° N, whereas *Calliomphalus*, abundant in the Ripley Formation in Mississippi (SOHL 1960, DOCKERY 1993), lived north of this latitude.

Assigning fossil species to *Skenea* is not without doubt. The modern Skeneidae are not well known and probably represent a polyphyletic group (WARÉN 1992, HICKMAN & MCLEAN 1990). HICKMAN & MCLEAN (1990) summarised problems concerning skeneid classification and considered also their own treatment to be 'highly provisional'. They traced the fossil record of this group back only to the lower Miocene. BANDEL (1993) illustrated similar shells from the Triassic which would be placed within the Skeneidae if they had lived today.

Neritimorpha

Three species belonging to the Neritoidea are presented here. They are all relatively small compared to the average size of their genera. Two belong to the typical Mesozoic Tethyan genera *Otostoma* and *Pileolus*, the third may belong to *Dontostoma*, a genus which still lives in the modern oceans.

Heterostropha

The Mathildidae are known since the Triassic (BANDEL 1995), and modern Architectonicidae appeared in the Campanian (DOCKERY 1993). The mathildids and architectonicids described here are quite similar to their contemporary relatives around the Atlantic Ocean (see below), and thus do not provide new insights into the evolutionary history of this group. Shells comparable to those of modern Opisthobranchia are known from the Triassic onwards (BANDEL 1994). During the Jurassic, the Ringiculidae, Actaeonidae and a few convolute "Bullomorpha" appeared (SCHRÖDER 1995; GRÜNDEL 1997c), but the latter group started its major radiation only with the

beginning of the Late Cretaceous (SOHL 1964). The opisthobranch species described herein fit well into the known lineages.

All genera of the Heterostropha from Temalac reported here except *Carinathilda* and *Herewardia* are also known from the Campanian to Maastrichtian Coffee Sand and Ripley Formations in Mississippi (see SOHL 1960, 1964; DOCKERY 1993), although mostly represented by different species. All genera of the Heterostropha from Temalac except *Mathilda*, *Heliacus* and *Herewardia* also occur in the Navarro Group of Texas (STEPHENSON 1941). Relationships to other regions of the North American continent are strikingly few: Neither the Californian ringiculid *Biplica* (POPENOE 1957), nor the Actaeonidae and bullomorphs from the Western Interior Seaway presented by SOHL (1967) and ERICKSON (1974) show closer relationships to those in tropical Mexico.

Along the west coast of South America only few related taxa occur. No similar shell was reported from the Maastrichtian of the Amotape and Paita regions in northern Peru (OLSSON 1934, 1944). The Maastrichtian of Quiriquina in central Chile, but this locality shares only the cosmopolitan genus *Cylichna* with Temalac (BANDEL & STINNESBECK, 2000). WHITE (1887) has figured shells resembling *Pseudomalaxis* and *Heliacus* from north-eastern Brazil, which are probably closely related to their Mexican counterparts. On the other hand, the Brazilian members of the Actaeonidae show no close affinities to the Mexican species.

Compared to the Campanian of northern Spain, Temalac shares the genera *Mathilda*, *Herewardia*, *Ringicula* and *Cylichna* (KIEL & BANDEL 2001a). In the Campanian/Maastrichtian of north-western Europe, all genera of the Heterostropha from Temalac except *Carinathilda*, *Herewardia*, and *Granosolarium* occur (HOLZAPFEL 1888, KAUNHOWEN 1897).

Only some relationships exist to the somewhat older faunas from Africa. In the Mungo River Coniacian in Cameroon occur the rather cosmopolitan *Ringicula* and *Cylichna* (RIEDEL 1932), and in the Santonian/Campanian of the Umzamba Formation in South Africa, a shell resembling the Mexican *Carinathilda diminuta* is known, besides the cosmopolitan *Cylichna* (WOODS 1906; RENNIE 1930a; own. obs.). In the Indian Trichinopoly Formation (Coniacian/Santonian) a species similar to the Mexican *Carinathilda diminuta* occurs (STOLIZCKA 1868, BANDEL 2000).

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