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A new Pliocene mollusk fauna from Mejillones, northern Chile

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Abstract A new Pliocene (3.4 Ma) mollusk fauna from Mejillones Peninsula, northern Chile is described and compared with the Pliocene La Cueva fauna of little constrained age from central Chile and some species from the Huenteguapi Sandstone overlying the Ranquil Formation on Arauco Peninsula, south central Chile. Preliminary correlation is based on faunal similarities. A total of 45 taxa were identified, of which *Cyclocardia kieli* sp. nov. is new to science. New combinations are *Macron escalonia* (Vermeij and DeVries, 1997), *Austrofusius steinmanni* (Mörnicke, 1896) and *Leukoma antiqua* (King, 1832). For several species, the oldest occurrences and range extensions are reported. Co-occurrence of warm water taxa, previously assigned to MIS 11, and typical Pliocene taxa on Mejillones cannot be confirmed. Pliocene and Pleistocene mollusk faunas from Mejillones are listed for comparison.

Keywords Bivalvia · Chile · Gastropoda · Pliocene

Kurzfassung Eine neue pliozäne (3,4 Ma) Molluskenfauna von der Halbinsel Mejillones in Nordchile wird beschrieben und mit der ungenügend datierten pliozänen La Cueva-Formation aus Zentralchile und einigen Taxa aus dem Huenteguapi-Sandstein, welcher die Ranquil-Formation auf der Halbinsel Arauco im südlichen Zentralchile überlagert, verglichen. Die vorläufige Korrelation basiert auf faunalen Ähnlichkeiten. Insgesamt wurden 45 Taxa unterschieden, wovon *Cyclocardia kieli* sp. nov. eine neue Art ist. Neue Kombinationen sind *Macron escalonia*

(Vermeij and DeVries, 1997), *Austrofusius steinmanni* (Mörnicke, 1896) und *Leukoma antiqua* (King, 1832). Für verschiedene Arten werden die ältesten Nachweise und geographische Reichweiten erweitert. Ein gemeinsames Vorkommen von Warmwasserarten, welche dem MIS 11 zugerechnet wurden, und typisch pliozänen Arten auf Mejillones kann nicht bestätigt werden. Pliozäne und pleistozäne Molluskenfaunen von Mejillones werden zum Vergleich aufgelistet.

Schlüsselwörter Bivalvia · Chile · Gastropoda · Pliozän

Introduction

The Pliocene was a time of significant climate change, and several scenarios have been proposed within the last years. It is now widely believed that the Pliocene was warmer than today with permanent El Niño conditions due to a weak equatorial thermal gradient (e.g., Wara et al. 2005; Brierley and Fedorov 2010), and a weak or absent eastern Pacific cold tongue (Martínez-García et al. 2010). Brierley et al. (2009) showed data suggesting about 3–6 °C warmer midlatitudes during the Pliocene, and Haywood et al. (2009) presented model data assuming ~2 °C higher sea surface water temperatures (SSTs) for the southeastern Pacific than at present. However, both warmer and cooler SSTs were suggested by numerical modeling (Sepulchre et al. 2009; Garreaud et al. 2010), so direct observations are also important to validate different model setups. However, no direct proxy data are available for the southeastern Pacific region because there is no close-by deep sea drilling record reaching well into the Pliocene. Therefore, onshore deposits are currently the only way to assess the nature and impact of Pliocene climate change in this region.

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Pliocene faunas from Chile (Herm 1969) are scarce, not well dated and not as well known as assumed. For example, southern records seem to represent Pleistocene rather than Pliocene deposits (Nielsen and Valdovinos 2008). Philippi (1887) in his great work on Cenozoic faunas from Chile did not distinguish among Eocene, Miocene and Pliocene localities, but only listed species in a systematic order, and it took almost another century until Herm (1969) presented a first comprehensive account of northern and central Chilean Pliocene and Pleistocene deposits. Many of the classic localities have thus been put in a stratigraphic context, but the real ages of many localities remain unknown (Griffin and Nielsen 2008), and Herm's (1969) concept of ages needs to be updated (Le Roux et al. 2006). While the relative ages seem correct, the stratigraphic scheme have changed in the last 50 years. Only recently the Gelasian (~2.6–1.8 Ma) was included in the Pleistocene (Gibbart et al. 2010), leaving the Zanclean (~5.3–3.6 Ma) as Early Pliocene and the Piacenzian (~3.6–2.6 Ma) as Late Pliocene. Very likely many classic Chilean Pliocene localities will now turn out to be Pleistocene, including the younger part of the Tubul Formation (Nielsen and Valdovinos 2008). Some Pleistocene faunas of northern Chile were revised (Ortlieb et al. 1994, 1996; Guzmán et al. 2000), and Quaternary bivalves are supposed to have a good sampling coverage (Rivadeneira 2010). However, little work has been done on older Pliocene faunas. Here, three faunas spanning about 1,500 km of latitude (Fig. 1) are described.

Geology of fossil-bearing deposits

Morro Mejillones, Mejillones Peninsula, northern Chile

The Morro Mejillones fauna (MOM) comes from a densely packed coquina at the rim of the uppermost marine terrace on Morro Mejillones, Mejillones Peninsula, northern Chile (S 23°07.126', W 070°30.815'). Today, coquina and terrace are at an elevation of approximately 410 m. The deposits were briefly described by Nielsen (2009), but for some reason the GPS data given there, taken in the year 2002, are completely off-track. This coquina has a carbonate-rich sandy matrix and consists mainly of barnacle clusters and debris; it also contains well-preserved mollusks, indicating an environment of sandy beach and nearby rocky shore. Strontium isotope data (^{87}Sr - ^{86}Sr ratios) indicate a late Pliocene age of ~3.4 Ma for this coquina (Nielsen 2009; Victor et al. 2011). Biotite from a nearby ash layer on Morro Mejillones was dated as approximately 3 Ma (Marquardt et al. 2005) and supports this late Pliocene age. It also suggests tectonic uplift between 3.4 and 3 Ma (Victor et al. 2011).

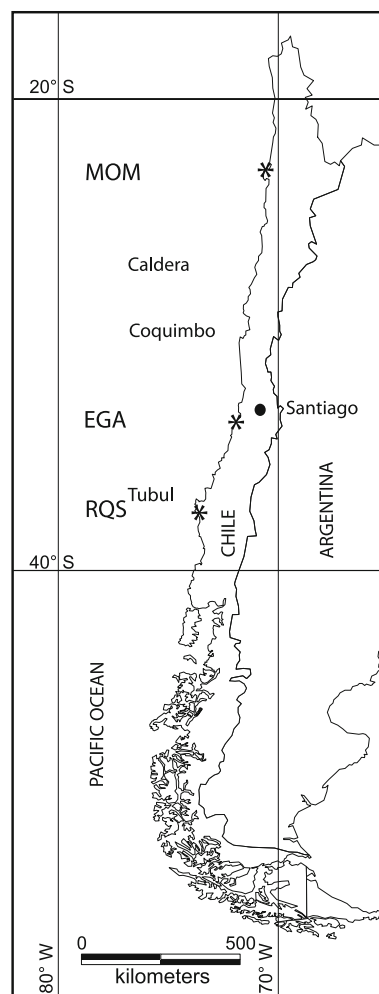


Fig. 1 Fossil localities

La Cueva Formation, central Chile

Most of the fauna from the La Cueva Formation comes from the Estero El Ganso (EGA), a locality already roughly described by Philippi (1887), who himself was not very lucky in finding fossils there but described several species sent to him by the owner of the hacienda. Mörnicke (1896) described some new species from this locality, but did not describe it. Both, locality and fauna were briefly described by Herm (1969), but sedimentology and stratigraphy of the La Cueva Formation were only recently described in some detail by Encinas et al. (2006). According to these latter authors, the La Cueva Formation consists mainly of sandstone with rare conglomerates and even less siltstones. It covers either the underlying Rapel Formation with a paraconformity or lies discordantly on the granitoid basement, and is covered discordantly by Pleistocene continental deposits (Encinas et al. 2008). The thickness of the La Cueva Formation is estimated to be about 100 m (Encinas et al. 2008). Encinas et al. (2008) confirmed the

Pliocene age given by previous authors based on macrofossils, mainly mollusks, but even absolute dating did not provide better constrained ages (Encinas et al. 2006).

Huenteguapi Sandstone, Arauco Peninsula, south-central Chile

A coarse grey sandstone of the Ranquil formation was called Huenteguapi Sandstone (RQS) and contains large reworked clasts from the underlying deposits (see Finger et al. 2007; Le Roux et al. 2008) with equally reworked mollusks like *Olivancillaria claneophila*, *Lamprodomina dimidiata* and *Sinum subglobosum*, but also the apparently younger species reported here. The Huenteguapi Sandstone consists of the main sandstone bed of about 5 to more than 30 m thickness, with an erosive basal contact and sandstone intrusions reaching into the underlying deposits at varying angles with a length of up to more than 30 m and up to 2 m width (Le Roux et al. 2008). This unit was interpreted as a tsunami backflow deposit eroding coastal dunes (Le Roux et al. (2008), which would explain reworked fossils and the scarcity of younger specimens. The underlying mudstones (RQT, MIB) and sandstones (RAN) of the Ranquil Formation yielded a late Miocene age based on the co-occurrence of *Neogloboquadrina continua* and *N. pachyderma*, while the overlying calcareous sandstone (RQK) has an early Pliocene age based on the occurrence of *Globorotalia puncticulata* (Finger et al. 2007). Without considering the strong reworking effect and the scarcity of youngest age markers (Finger et al. 2007), this makes an earliest Pliocene age for this deposit likely.

Systematic paleontology

Specimens are housed in the invertebrate collection of the Museo Nacional de Historia Natural in Santiago de Chile (SGO.PI) and in the Naturmuseum Seckenberg in Frankfurt am Main, Germany (SMF). Sizes are, if not otherwise stated, maximum length, height or diameter. Synonymy lists for extant species are not exhaustive and are only included to give a certain context.

Class Gastropoda Cuvier, 1795

Subclass Docoglossa Troschel, 1865

Family Nacellidae Thiele, 1891

Genus *Nacella* Schumacher, 1817

Type species: *Nacella mytiloides* Schumacher, 1817 (= *Patella mytilina* Helbling, 1779) by monotypy; Recent, southern South America.

Subgenus *Patinigera* Dall, 1905

Type species: *Patella magellanica* Gmelin, 1791 by original designation; Recent, southern South America.

***Nacella (Patinigera) intiforma* DeVries, 2008** (Fig. 2a–b)

*2008a *Nacella (Patinigera) intiforma* DeVries: 281, figs. 29–39, 46.

Material examined: SGO.PI.6453 (1 specimen, length 31 mm, height 10 mm), RQS.

Remarks: The only available specimen from Chile was included in the otherwise Peruvian *Nacella intiforma* by DeVries (2008a) because its aperture form, height and nearly obsolete sculpture are similar to those of a large specimen of that species from southern Peru. Although DeVries (2008a) gave a late early Pliocene to early late Pliocene age for this species, his listed material comes exclusively from the late early Pliocene. This fits well with a supposedly earliest Pliocene age of the Chilean specimen.

Subclass Vetigastropoda Salvini-Plawen, 1980

Family Trochidae Rafinesque, 1815

Genus *Chlorostoma* Swainson, 1840

Type species: *Trochus argyrostomus* Gmelin, 1791 by subsequent designation (Herrmannsen 1846); Recent, Japan.

Remarks: *Chlorostoma* is here recognized at the genus level in the restricted sense of Grant and Gale (1931), who limited this genus to species with ventricose whorls, an oblique aperture with teeth on the lower part of the inner lip, and a nacreous interior and a dark purplish exterior (DeVries 2007a). DeVries (2007a) argued that none of the Miocene Chilean chlorostomine species described by Nielsen et al. (2004) belongs to true *Chlorostoma* because they lack the conspicuous purple-black outer shell layer. Other arguments of DeVries (2007a) were that *C. austropacifica* is very small, *C. chilena* lacks the flattened base typical for chlorostomines, and *C. matanzensis* lacks critical portions of the columella. While all these latter arguments are true, coloration was not shown in those species because the first is coated with gold for SEM and the latter two were whitened for better contrast. The color of *C. chilena* cannot be deduced with certainty from the holotype because the specimen is rather abraded, but *C. matanzensis* is indeed black. The holotype of *C. austropacifica* may well be a juvenile specimen, which would account for its small size.

***Chlorostoma atrum* (Lesson, 1830)** (Fig. 2c–d)

*1830 *Trochus ater* Lesson: 344, pl. 16

1973 *Tegula (Chlorostoma) atra* (Lesson, 1831).–Marincovich: 24, fig. 42.

2007a *Chlorostoma atrum* (Lesson, 1830).–DeVries: 164, figs. 2–4, 7–9, 13 (synonymy).

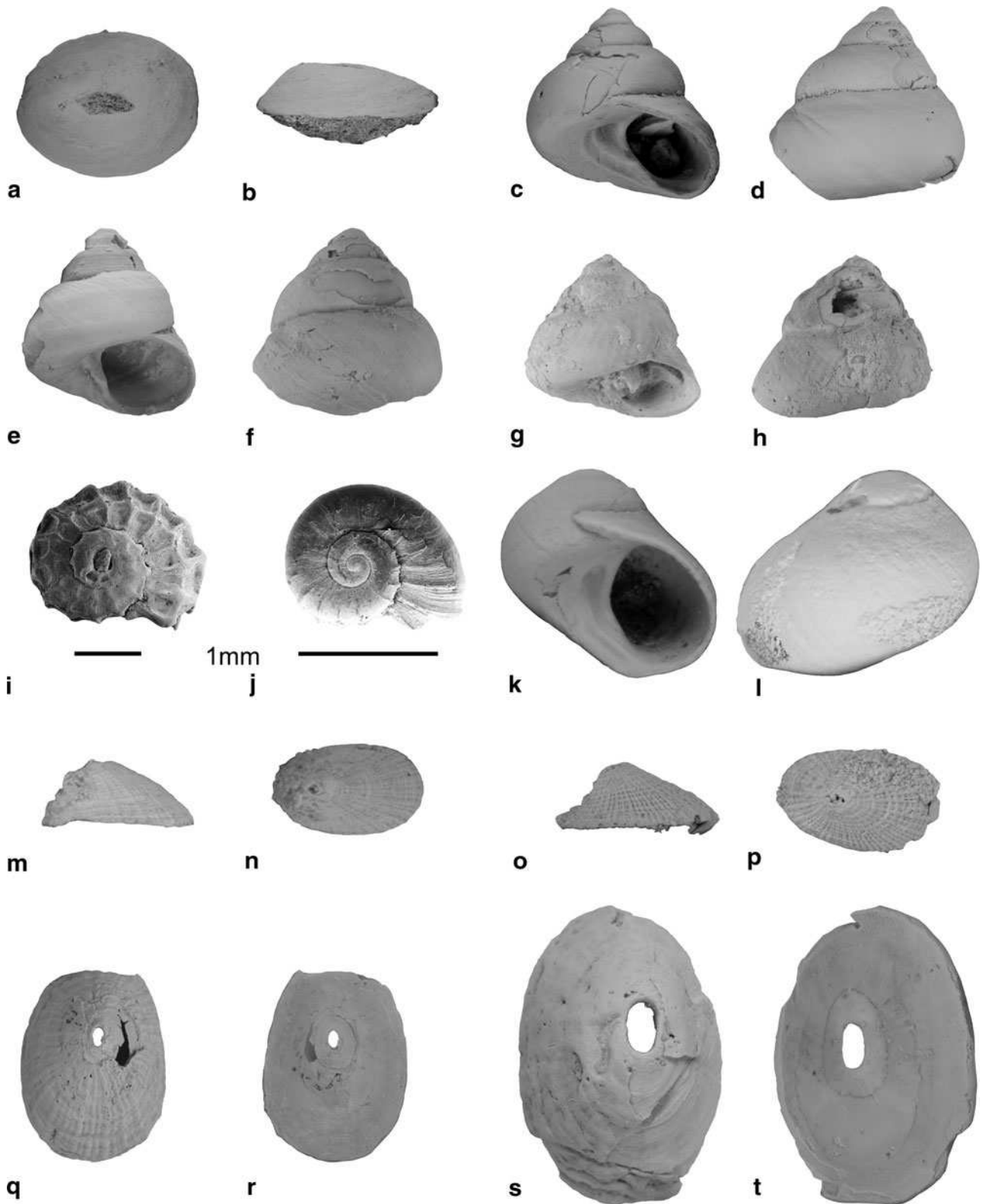


Fig. 2 a–b *Nacella intiforma* DeVries, 2008, SGO.PI.6453, length 31 mm, RQS. c–d *Chlorostoma atrum* (Lesson, 1830), SGO.PI.6454, height 33 mm, MOM. e–h *Chlorostoma quipua* DeVries, 2007, SGO.PI.6459, MOM. e–f height 32 mm. g–h height 28 mm. i–j *Liotia cancellata* (Gray, 1828), SGO.PI.6460, MOM. k–l

(Wood, 1828), SGO.PI.6505, EGA, height 18 mm. m–p *Diodora* sp., SGO.PI.6461, MOM. M–N length 13 mm. o–p length 14 mm (incomplete). q–t *Fissurella* spp., SGO.PI.6462, MOM. q–r length 32.7 mm. s–t length 51 mm

Material examined: SGO.PI.6454 (1 specimen, height 33 mm), MOM; SGO.PI.6455 (12 specimens, height 30 mm), MOM; SGO.PI.6456 (1 specimen, height 26 mm), EGA; SGO.PI.1319 (3 specimens, coll. Herm), EGA.

Remarks: Herm (1969) listed this species for the Pliocene of La Cueva, and DeVries (2007a) reported this species from the late Pliocene onwards from southern Peru to southern Chile. In the late Pleistocene it extended into southern Argentina and later extended to northern Peru. The age of the Morro Mejillones fauna pushes the age of this species back to 3.4 Ma.

***Chlorostoma quipua* DeVries, 2007** (Fig. 2e–h)

*2007a *Chlorostoma quipua* DeVries: 167, figs. 24–40.

Material examined: SGO.PI.6459 (19 specimens, height 32 mm), MOM.

Remarks: DeVries (2007a) reported this species from the middle late Miocene to early late Pliocene of southern Peru. The occurrence on Mejillones Peninsula extends the geographic range of this easily recognizable species into northern Chile. Specimens of this species were reported by Nielsen (2009) to form nuclei for balanuliths, which is also the case in southern Peru (DeVries, written communication 2012). Early Pliocene Peruvian specimens occur together with *Concholepas kieneri*, *Xanthochorus ochuroma*, *Hermineospina saskiae* and *Prisogaster mcleani* (DeVries 2007a), none of which has been found on Morro Mejillones so far. This suggests that the southern Peruvian fauna is older than that of Morro Mejillones, i.e., older than 3.4 Ma, where species like *Concholepas camerata* and *Chorus doliaris* are present.

Family Liotiidae Gray, 1850

Genus *Liotia* Gray, 1842

Type species: *Delphinula cancellata* Gray, 1828 by monotypy; Recent, northern Chile.

***Liotia cancellata* (Gray, 1828)** (Fig. 2i–j)

*1828 *Delphinula cancellata* Gray: 3, pl. 6, fig. 8.

1843 *Delphinula cobijensis* Reeve: vol. 1, *Delphinula*, pl. 5, figs. 23a–b.

1973 *Liotia cancellata* (Gray, 1828).–Marincovich: 24, fig. 44 (synonymy).

Material examined: SGO.PI.6460 (9 specimens, diameter 2.5 mm), MOM.

Remarks: This is the oldest fossil record for this species, which previously was recorded since the early Pleistocene

by Ortlieb et al. (1996). Living specimens at Mejillones were found down to about 13 m water depth (Guzmán et al. 1998).

Family Turbinidae Rafinesque, 1815

Genus *Prisogaster* Mörch, 1850

Type species: “*Turbo (Prisogaster) niger* Gray” (= *Turbo niger* Wood, 1828 by monotypy; Recent, Ecuador to Chile).

***Prisogaster niger* (Wood, 1828)** (Fig. 2k–l)

*1828 *Turbo niger* Wood: 18, pl. 6, fig. 1.

1850 *Turbo (Prisogaster) niger* Gray.–Mörch: 21.

2006 *Prisogaster niger* (Wood, 1828).–DeVries: 141, figs. 4–10, 13, 14 (synonymy).

Material examined: SGO.PI.6505 (4 specimens, height 18 mm), EGA.

Remarks: DeVries (2006) reviewed the fossil record of *Prisogaster*, and described the Pliocene *P. valenciai* and the Miocene to Pliocene *P. mcleani* as new species in addition to Pleistocene to Recent occurrences of *P. niger*. The occurrence of *P. niger* in Pliocene deposits of the La Cueva Formation extends its fossil record back in time.

Family Fissurellidae Fleming, 1822

Genus *Diodora* Gray, 1821

Type species: *Patella apertura* Montagu, 1803 (= *P. graeca* Linnaeus, 1758) by monotypy; Recent, Europe.

***Diodora* sp.** (Fig. 2m–p)

Material examined: SGO.PI.6461 (6 specimens, length 14 mm), MOM.

Remarks: Several Miocene species of *Diodora* were described from the Navidad Formation and equivalents of central Chile (Nielsen et al. 2004). Of these, *Diodora* sp. resembles *D. fragilis* Nielsen, Frassinetti and Bandel, 2004, in having about 28 primary radial ribs, the same number of secondaries and sometimes presence of tertiary threads, but differs from that species in having a relatively higher shell and in some specimens a more strongly concave anterior slope. In relative shell height and concavity, *Diodora* sp. resembles *Diodora* sp. 2 of Nielsen et al. (2004), but is much smaller than the latter. From the currently available material, it cannot be stated if it represents one or more species, and no satisfactory diagnosis can be given. Pliocene and Pleistocene species reported from Chile are *D. inaequalis* (G.B. Sowerby I, 1835) from several

localities in northern Chile (Herm 1969) and *Diodora* sp. from the supposedly Pliocene Lo Abarca beds in central Chile (Covacevich and Frassinetti 1990). Recently, a late middle Miocene age based on diatoms has been proposed for the Lo Abarca beds (Encinas et al. 2010).

Genus *Fissurella* Bruguière, 1789

Type species: *Patella nimbosa* Linnaeus, 1758 by subsequent designation (Lamarck 1799); Recent, Caribbean Sea to Bahia, Brazil.

Fissurella (*Fissurella*) spp. (Fig. 2q–t)

Material examined: SGO.PI.6462 (6 specimens and several fragments, length > 46 mm), MOM.

Remarks: The southern Peruvian Pliocene and Pleistocene species of *Fissurella* were recently reviewed by DeVries (2008b). There is currently not enough material to safely assign the Morro Mejillones specimens to species. However, there are at least two taxa present. One has regular coarse ribs and possibly is either *F. aranea* DeVries, 2008, or *F. concolor* Philippi, 1887. The other is lower and has less defined ribs, and possibly represents *F. oriens* Sowerby, 1835.

Subclass Caenogastropoda Cox, 1960

Family Turritellidae Lovén, 1847

Genus *Incatella* DeVries, 2007

Type species: *Turritella cingulata* Sowerby, 1825 by original designation; Recent, Peru to Chile and southern Argentina.

Incatella cingulatiformis (Möricke, 1896) (Fig. 3a–d)

*1896 *Turritella cingulatiformis* Möricke: 556, pl. 11, fig. 4.

v1969 *Turritella cingulatiformis* Möricke.–Herm: 132, pl. 14, figs. 10–11.

2007b *Incatella cingulatiformis* (Möricke, 1896).–DeVries: 334, figs. 3.4–3.7, 3.20.

Type material: The Steinmann collection from which Möricke described this species was apparently destroyed during the wars, since the collections in Strasbourg, Freiburg and Bonn do not contain this or related material. The geological institute in Freiburg, where the material most likely was housed, was hit by bombs during World War II. Type localities are Coquimbo and Caldera.

Material examined: SGO.PI.6463 (68 specimens, height 36 mm), MOM.

Fig. 3 a–d *Incatella cingulatiformis* (Möricke, 1896), SGO.PI.6463, MOM, **a–b** height 37 mm, **c–d** height 29 mm. **e** *Caecum chilense* Stuardo, 1962, SGO.PI.6464, MOM. **f–i** *Polinices* cf. *panamaensis* (Récluz, 1844), SGO.PI.6465, MOM, **f–g** height 34 mm, **h–i** height 26.5 mm. **j–k** *Neverita* (*Glossaulax*) *obtectiformis* (Möricke, 1896), SGO.PI.6466, height 30 mm, EGA. **l–m** *Trochita* cf. *trochiformis* (Born, 1778), SGO.PI.6467, length 34.5 mm, MOM. **n–p** *Trochita colchaguensis* Philippi, 1887, holotype SGO.PI.686, height 17.4 mm, length 31 mm, EGA. **q–r** *Crucibulum quiriquinae* (Lesson, 1830), SGO.PI.6468, length 34 mm, MOM. **s–t** *Crepidatella dilatata* (Lamarck, 1822), SGO.PI.6469, length 36.5 mm, MOM. **u–x** *Priene scabrum* (King, 1832), SGO.PI.6470, MOM, **u, w** height 58 mm, **v, x** height 21.3 mm

Remarks: *Incatella cingulatiformis* has been reported from the late Miocene of southern Peru and the Pliocene to middle Pleistocene of southern Peru to central Chile (DeVries 2007b).

Family Caecidae Gray, 1850

Genus *Caecum* Fleming, 1813

Type species: *Dentalium trachea* Montagu, 1803 (= *D. imperforatum* G. Adams, 1798) by subsequent designation of Gray (1847); Recent, Europe.

Caecum chilense Stuardo, 1962 (Fig. 3e)

*1962 *Caecum chilense* Stuardo: 5–6, figs. 1–2.

1973 *Caecum chilense* Stuardo, 1962.–Marincovich: 30, figs. 62–63.

Material examined: SGO.PI.6464 (62 specimens, length 2 mm), MOM.

Remarks: This seems to be the first fossil record for this species.

Family Naticidae Guilding, 1834

Genus *Polinices* Montfort, 1810

Type species: *Polinices albus* Montfort, 1810 (= *Nerita mammilla* Linnaeus, 1758) by original designation; Recent, Caribbean.

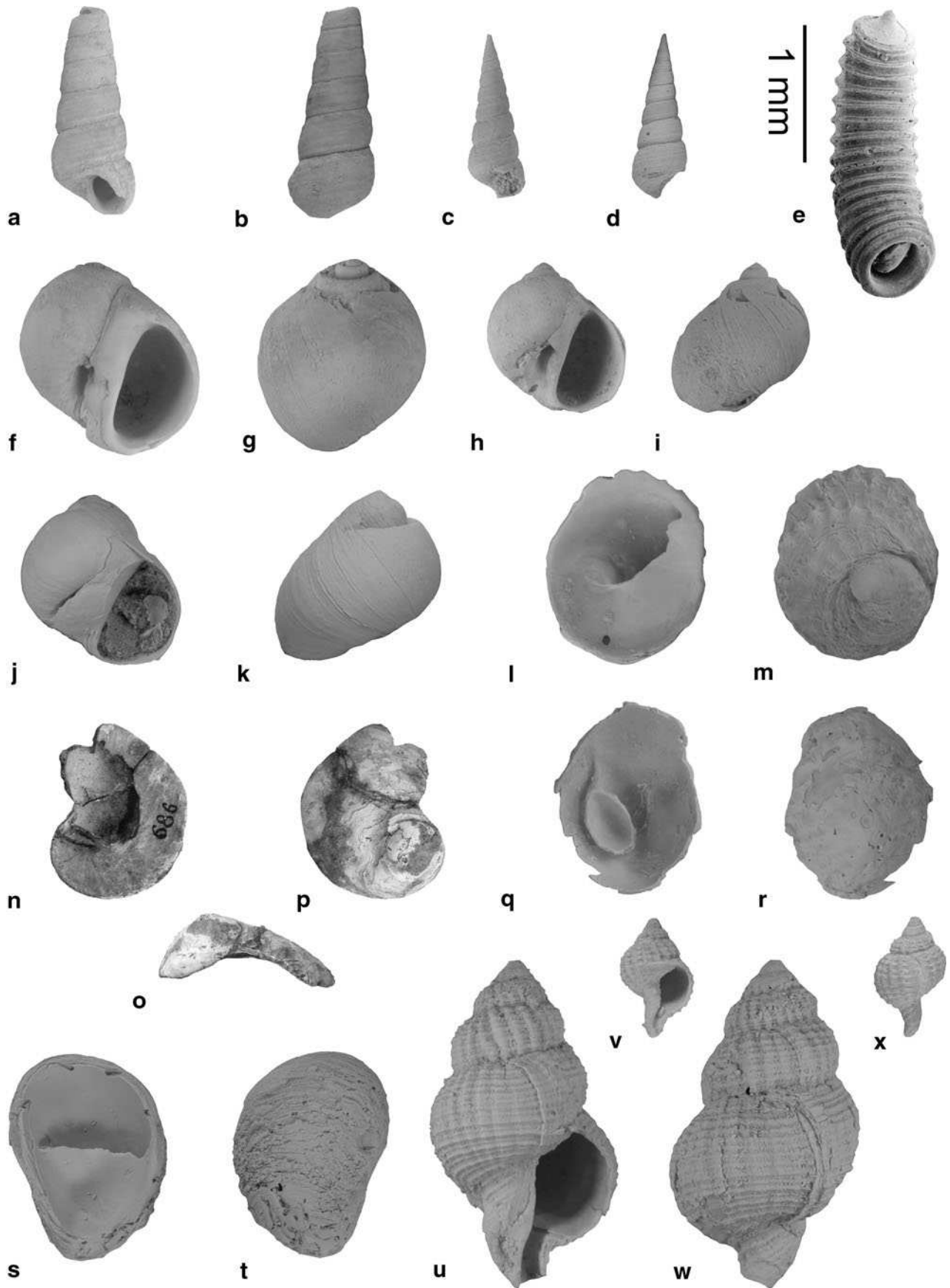
Polinices cf. *panamaensis* (Récluz, 1844) (Fig. 3f–i)

*1832 *Natica panamaensis* Récluz: 208.

1977 *Polinices* (*Polinices*) *panamaensis* (Récluz, 1844).–Marincovich: 252, pl. 22, figs. 5–7 (synonymy).

1992 *Polinices* (*Polinices*) *panamaensis* (Récluz).–Pitt and Pitt: 119, pl. 2, figs. 6–7.

Material examined: SGO.PI.6465 (22 specimens, height 34 mm), MOM.



Remarks: Northern Chilean *Polinices* are usually identified as *P. uber* (Valenciennes, 1832) (e.g. Guzmán et al. 1998), which is a more slender and high-spired species. Marinovich (1977: 248) gave a “Pliocene (?) or Pleistocene to Holocene” age for *P. uber*, Herm (1969) listed this species only for the Pleistocene, and Ortlieb et al. (1996) found it from MIS 11 onwards on Mejillones Peninsula. It was not confirmed if these records are indeed *P. uber* or refer to the more globose form here tentatively included in *P. panamaensis*. Both species range from Baja California to Peru and maybe into northern Chile (Marinovich 1977). The fossil record of *P. panamaensis* goes back to the late Miocene (Pitt and Pitt 1992). However, final placement of this species must await a more detailed treatment of extant and fossil naticids of the region.

Genus *Neverita* Risso, 1826

Type species: *Neverita josephina* Risso, 1826 by monotypy; Eocene to Recent, Europe.

Subgenus *Glossaulax* Pilsbry, 1929

Type species: *Natica reclusiana* Deshayes, 1839 by original designation; middle Eocene to Recent, Washington to Ecuador.

Neverita (Glossaulax) obtectiformis (Mörnicke, 1896) (Fig. 3j–k)

*1896 *Natica (Neverita) obtectiformis* Mörnicke: 557, pl. 11, figs. 22–23.

Type material: The types are presumably lost. Mörnicke (1896) gave the localities Caldera and La Cueva. See remarks on type material of *Incatella cingulatiformis*.

Material examined: SGO.PI.53 (6 specimens labeled as *Natica pachystoma*), La Cueva; SGO.PI.66 (4 specimens labeled as *Natica pachystoma*), La Cueva. SGO.PI.6466 (29 specimens, height 41 mm), EGA.

Remarks: This species is highly variable, like the extant type species *N. (G.) reclusiana* (see Pitt and Pitt 1992) and the Chilean early Miocene *N. (G.) pachystoma* (see Griffin and Nielsen 2008). The name *N. (G.) obtectiformis* is tentatively used here for Pliocene specimens from its type locality at La Cueva. The original characters given by Mörnicke (1896) to distinguish this species from the Miocene *N. (G.) obtecta* Philippi, 1887, and *N. (G.) pachystoma*, a shallower callus furrow and slightly higher spire, seem not to be reliable. Morphometric work on several species and larger numbers of specimens must be awaited before reliably delimiting species.

Family Calyptraeidae Lamarck, 1809

Genus *Trochita* Schumacher, 1817

Type species: *Trochita spiralis* Schumacher, 1817 (= *Turbo trochiformis* Born, 1778) by subsequent designation (Rehder 1943); Recent, Ecuador to Chile.

Trochita cf. trochiformis (Born, 1778) (Fig. 3l–m)

*1778 *Turbo trochiformis* Born: 355.

1973 *Calyptraea (Trochita) trochiformis* (Born, 1778).–Marinovich: 31, fig. 65 (synonymy).

Material examined: SGO.PI.6467 (27 specimens, diameter 42 mm), MOM.

Remarks: The material is similar to the Miocene *T. costellata* Philippi, 1887, and may be a transitional form between that and the extant *T. trochiformis*. A detailed revision of Chilean calyptraeids is pending, and must be awaited before assigning this material safely to an existing or a new species.

Trochita colchaguensis Philippi, 1887 (Fig. 3n–p)

*v1887 *Trochita colchaguensis* Philippi: 93, pl. 11, fig. 5.

Type material: Holotype SGO.PI.686 (height 17.4 mm, length 31 mm) from La Cueva.

Remarks: The holotype is an eroded specimen without preserved outer shell layer and with broken septum. *Trochita colchaguensis* is probably a synonym of *T. trochiformis*, but it is kept separately until better material from the type locality is available.

Genus *Crucibulum* Schumacher, 1817

Type species: *Crucibulum rugosacostatum* Schumacher, 1817 (= *Patella auricula* Gmelin, 1791) by subsequent designation (Gray 1847); Recent, Caribbean.

Crucibulum quiriquinae (Lesson, 1830) (Fig. 3q–r)

*1830 *Calyptraea (Calypeopsis) quiriquinae* Lesson: 161. 1973 *Crucibulum (Crucibulum) quiriquinae* (Lesson, 1830).–Marinovich: 32, fig. 67 (synonymy).

Material examined: SGO.PI.6468 (1 specimen, length 34 mm), MOM.

Remarks: According to Véliz et al. (2001), two species of *Crucibulum* live currently in northern Chile, the morphologically variable *C. quiriquinae* (Lesson, 1830) with planktonic larval development and an unnamed species with a direct development with nurse eggs. Since the

protoconch is not preserved in the Morro Mejillones specimen, it is tentatively assigned to *C. quiriquinae*.

Genus *Crepipatella* Lesson, 1830

Type species: *Calyptraea (Crepipatella) adolphei* Lesson, 1830 (?= *Crepidula dilatata* Lamarck, 1822) by original designation; Recent, Chile and Argentina.

Crepipatella dilatata (Lamarck, 1822) (Fig. 3s–t)

*1822 *Crepidula dilatata* Lamarck vol. 6, pt. 2: 25.

?1830 *Calyptraea (Crepipatella) adolphei* Lesson: 389, pl. 15, fig. 2.

v1887 *Crepidula uncinata* Philippi: 94, pl. 11, fig. 6.

1971 *Crepipatella dilatata* (Lamarck, 1822).–Dell: 205 (synonymy).

1973 *Crepipatella dilatata* (Lamarck, 1822).–Marincovich: 32, fig. 66.

1977 *Crepidula dilatata* Lamarck.–Hoagland: 372 (synonymy).

Type material: Holotype of *C. uncinata* SGO.PI.825 (length 23 mm) from La Cueva.

Material examined: SGO.PI.6469 (3 specimens, length 38.5 mm), MOM.

Remarks: Herm (1969) also listed this species for La Cueva. There is currently some confusion as to the identity and names of Chilean *Crepipatella* species because they only differ in their mode of development (Gallardo 1979; Véliz et al. 2003) or are morphologically indistinguishable (Collin et al. 2007). Hoagland (1983) furthermore pointed out several possible synonyms of extant Chilean species.

Family Ranellidae Gray, 1854

Genus *Priene* H. and A. Adams, 1858

Type species: *Triton scaber* King, 1832 by subsequent designation (Cossmann 1903); Pliocene to Recent, Chile.

Priene scabrum (King, 1832) (Fig. 3u–x)

*1832 *Triton scaber* King: 348.

2010 *Priene scabrum* (King, 1832).–Beu: 109, pl. 24, figs. 5–6, pl. 25, figs. 2–3, 5–6, pl. 51, figs. 6, 8 (synonymy).

Material examined: SGO.PI.6470 (11 specimens, height 58 mm), MOM.

Remarks: Herm (1969) placed *Priene scabrum* in *Argobuccinum* [e.g. his sample 640 708-5 “*Argobuccinum scabrum* (King)” in Bayerische Staatssammlung München, Germany] and mentioned *Argobuccinum* sp. from the

Pliocene central Chilean La Cueva Formation. Most likely this refers to *Priene*, an interpretation supported by the presence of *Priene* in Herm’s collection (Beu 2010) from La Cueva. No record of true *Argobuccinum* from La Cueva is known.

Specimens of unrefined Pliocene and Pleistocene age from Coquimbo and Caldera were reported by Herm (1969, as *Argobuccinum*) and Smith (1970). Beu (2010) recently reviewed this species and synonymized it with the second usually recognized species, *Priene rude* (Broderip, 1833), because of specimens exhibiting sculpture changing from typical *scabrum* to typical *rude* or vice versa. The oldest records are those from the Pliocene of La Cueva (Herm 1969, as *Argobuccinum*) and Morro Mejillones, while that of Caldera needs to be dated. The Pleistocene distribution of *Priene scabrum* ranges from northern Peru to central Chile, and today it lives from central Peru to Puerto Montt (Beu 2010).

Family Pseudolividae de Gregorio, 1880

Genus *Macron* H. and A. Adams, 1853

Type species: *Pseudoliva kellettii* A. Adams, 1855 (= *Buccinum aethiops* Reeve, 1847); Recent, West Mexico.

Macron escalonia (Vermeij and DeVries, 1997) comb. nov. (Fig. 4a–d)

1997 *Testallium escalonia* Vermeij and DeVries: 26, figs. 2a–d.

Material examined: SMF 339610 (33 specimens, height 39 mm), SGO.PI.6471 (11 specimens), MOM; SGO.PI. 1302 (5 specimens, Herm’s collection), EGA.

Remarks: *Macron escalonia* was originally described by Vermeij and DeVries (1997) from the La Cueva Formation in central Chile, which is regarded as late early Pliocene in age (DeVries 2007a, b, c). My own unpublished strontium isotope data confirm that the La Cueva fauna is indeed somewhat older than that from Morro Mejillones. *Macron escalonia* resembles the Miocene Chilean *M. vermeiji* Nielsen and Frassinetti, 2003, as was noted by Nielsen and Frassinetti (2003) when describing the latter species. Indeed, it is much closer to *M. vermeiji* than to *Testallium cepa* (Sowerby, 1846), the type species of *Testallium* Vermeij and DeVries, 1997, and is therefore here transferred from *Testallium* to *Macron*.

Family Olividae Latreille, 1825

Genus *Oliva* Bruguière, 1789

Type species: *Voluta oliva* Linnaeus, 1758 by monotypy (Lamarck 1799); Recent, Indo-Pacific.

***Oliva peruviana* Lamarck, 1811** (Fig. 4e–j)

*1811 *Oliva peruviana* Lamarck, vol. 16: 317.

1842 *Oliva serena* d'Orbigny: 116, pl. 14, fig. 9 **syn. nov.**

v1887 *Oliva buchanani* Philippi: 73, pl. 8, fig. 12 **syn. nov.**

1973 *Oliva (Oliva) peruviana* Lamarck, 1811.–Marinovich: 37, fig. 82 (synonymy).

2008 *Oliva serena* d'Orbigny, 1842.–Griffin and Nielsen: 305, pl. 20, fig. 28 (from d'Orbigny).

Type material: Two syntypes of *Oliva buchanani* SGO.PI.538 and SGO.PI.529, both are molds from Guayacán. As stated by Griffin and Nielsen (2008), the holotype of *O. serena* is presumably lost.

Material examined: SGO.PI.525 (2 specimens) from La Cueva; SMF 339611 (32 specimens, height 48.7 mm), SGO.PI.6472 (3 specimens), MOM; SGO.PI.6473 (6 specimens, height 48 mm), EGA.

Remarks: *Oliva peruviana* is here reported from the early Late Pliocene. Although this constitutes the oldest well-dated record, it is likely that other records from the literature (e.g., Herm 1969) will prove to be older when more ages become available. *Oliva serena* d'Orbigny, 1842, was considered a likely synonym of *O. peruviana* (Griffin and Nielsen 2008). The holotype, however, is lost and was an internal mold, so Griffin and Nielsen (2008) considered it a *nomen dubium*. *Oliva serena* is here formally considered to be a subjective synonym of *O. peruviana*.

Family Mitridae Swainson, 1829

Genus *Mitra* Lamarck, 1798

Type species: *Voluta mitra* Linnaeus, 1758 by tautonymy (ICZN Opinion 885); Recent, Indo-Pacific.

***Mitra orientalis* Griffith and Pidgeon, 1834** (Fig. 4k–l)

*1834 *Mitra orientalis* Griffith and Pidgeon: pl. 40, fig. 5.

1976 *Mitra orientalis* Griffith and Pidgeon, 1834.–Cernohorsky: 361, pl. 256, fig. 1, pl. 315, figs. 1–6 (synonymy).

Material examined: SGO.PI.6474 (2 specimens), MOM.

Remarks: This species was listed in the subgenus *Atrimitra* by Guzmán et al. (1998), but Cernohorsky (1976) assigned it to *Mitra sensu stricto*, considering *Atrimitra* a synonym of *Mitra (Mitra)*. Cernohorsky (1976) recorded its southern end of distribution as Valparaíso but stated, without any reference, that this distribution extended at least 10° of latitude farther south during the Pliocene. This Pliocene record is based on Cernohorsky's (1976) opinion that *M. martini* Philippi, 1887, from Chiloé is a synonym,

Fig. 4 a–d *Macron escalonia* (Vermeij and DeVries, 1997), SGO.PI.6471, MOM, **a–b** height 37 mm, **c–d** height 25.7 mm. **e–j** *Oliva peruviana* (Lamarck, 1811). **e–f** SGO.PI.6472, height 44.5 mm, MOM. **g–h** SGO.PI.529, syntype of *Oliva buchanani* Philippi, 1887, Guayacán. **i–j** SGO.PI.538, syntype of *Oliva buchanani* Philippi, 1887, Guayacán. **k–l** *Mitra orientalis* Griffith and Pidgeon, 1834, SGO.PI.6474, height 37.7 mm, MOM. **M–N** *Austrofusus fontainei* (d'Orbigny, 1841), SGO.PI.6475, height 39 mm, MOM. **o–s** *Austrofusus steinmanni* (Mörnicke, 1896). **o** BSPG 1966 IV 145, neotype of *Fusus steinmanni* Mörnicke, 1896, Quebrada Blanca, Caldera, height 56.5 mm. **p–q** SGO.PI.6476, height 36.5 mm, MOM. **r–s** SGO.PI.6476, height 35.2 mm. **t–u** *Nassarius gayi* (Kiener, 1834), SGO.PI.6478, height 14.8 mm, EGA. **v–w** *Concholepas camerata* DeVries, 2000, SGO.PI.6479, height 68.5 mm, MOM

an opinion that is not shared here. Clarification of the status of *M. martini* must await availability of good topotypic material because the holotype consists only of a final whorl filled with sediment. Also the age of *M. martini* Philippi, 1887, is more likely early Miocene (see Finger et al. 2007; Nielsen and Glodny 2009) than Pliocene.

Family Buccinulidae Finlay, 1928

Genus *Austrofusus* Kobelt, 1879

Type species: *Fusus alternatus* Philippi, 1847 (= *Fusus fontainei* d'Orbigny, 1841) by subsequent designation of Cossmann (1901); Pliocene to Recent, western South America.

***Austrofusus fontainei* (d'Orbigny, 1841)** (Fig. 4m–n)

*1841 *Fusus fontainei* d'Orbigny: 447, pl. 63, fig. 2.

1847 *Fusus alternatus* Philippi: pl. 4, fig. 6.

1881 *Siphonalia (Austrofusus) alternata* Phil.–Tryon: 137.

1909 *Austrofusus fontainei* Orbigny.–Dall: 213.

1982 *Aeneator fontainei* (d'Orbigny, 1841).–McLean and Andrade: 13, figs. 31–39.

1998 *Aeneator fontainei* (d'Orbigny, 1841).–Guzmán, Saá and Ortlieb: 51, figure.

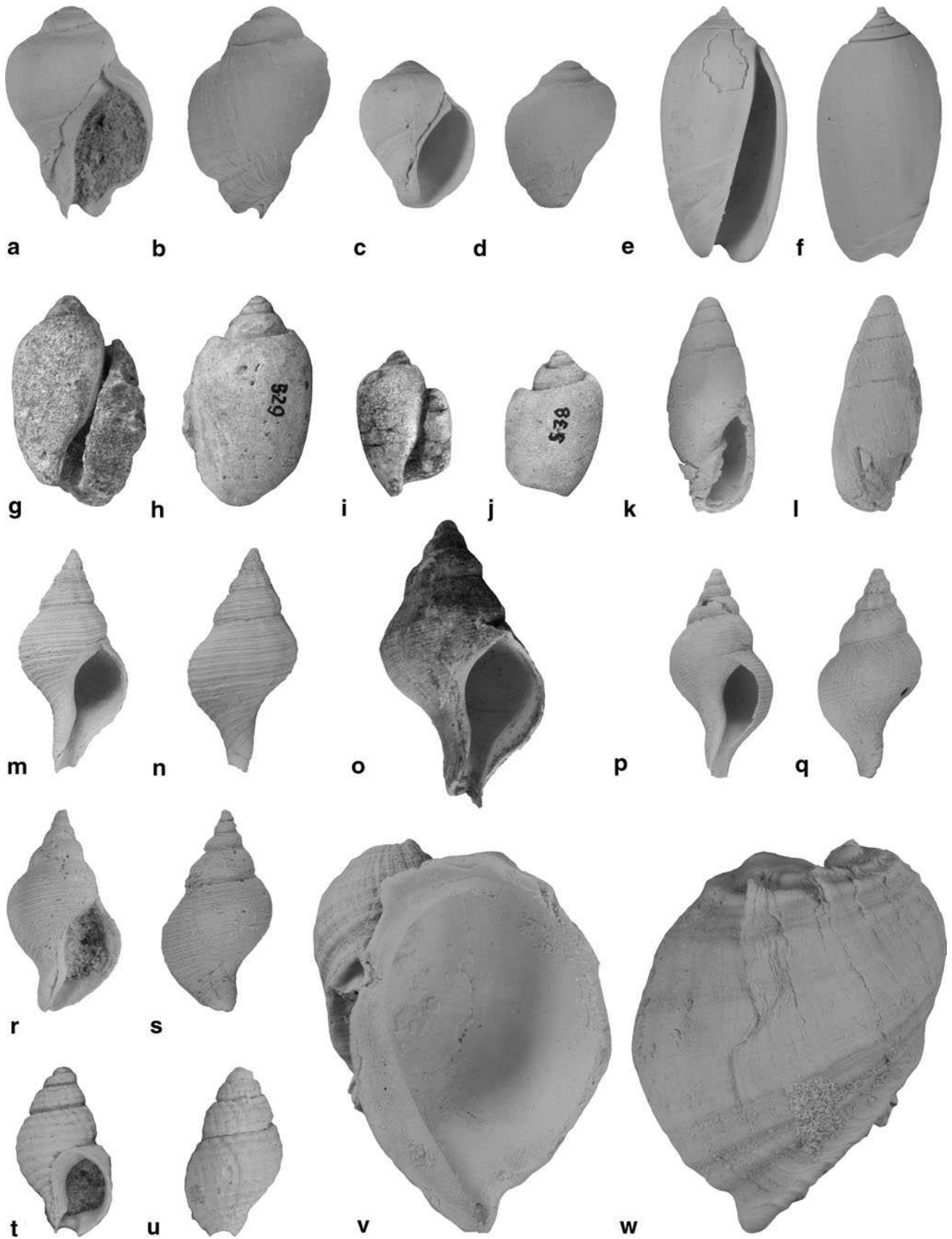
2000 *Aeneator fontainei*.–Guzmán, Marquardt, Ortlieb and Frassinetti: table 1.

2007 *Aeneator fontainei* (d'Orbigny, 1841).–Osorio and Ramajo: fig. 2A.

2010 *Austrofusus fontainei* (d'Orbigny, 1841).–Beu and Marshall: fig. 1A.

Material examined: SGO.PI.6475 (4 specimens, height 71 mm), MOM.

Remarks: The genus name *Aeneator* Finlay, 1927, was introduced to the South American fauna by Rehder (1971) when describing *A. loisae* (see *A. steinmanni* below). However, he did not mention its much more common congener, *Fusus fontainei*, which, as recently shown by Beu and Marshall (2010), is the type species of



Austrofuscus. McLean and Andrade (1982) recorded living specimens of the latter from depths of 20–270 m. The here-reported specimens from Morro Mejillones extend the known fossil record for this species back to the middle Pliocene. Other extant Chilean species that likely need to be included in *Austrofuscus* are *Aeneator castillai* McLean and Andrade, 1982, *A. prograviter* Fraussen and Sellanes, 2008, and *A. portentosus* Fraussen and Sellanes, 2008 (see Fraussen and Sellanes 2008).

***Austrofuscus steinmanni* (Möricke, 1896) comb. nov.**

(Fig. 4o–s)

- *1896 *Fusus steinmanni* Möricke: 570, pl. 11, figs. 18–19.
 v1969 *Fusinus steinmanni* (Möricke).–Herm: 142, pl. 18, figs. 6a, b.
 1971 *Aeneator (Ellicae) loisae* Rehder: 593, figs. 7–8 **syn. nov.**
 1982 *Aeneator loisae* Rehder, 1971.–McLean and Andrade: 14, figs. 40–44.
 2007 *Aeneator loisae* Rehder, 1971.–Osorio and Ramajo: fig. 2B.

Type material: The types of *F. steinmanni* are presumably lost (see remarks to type material of *Incatella cingulatiformis*); type locality is Caldera. The specimen figured by Herm (1969), Bayerische Staatssammlung für Paläontologie und Geologie 1966 IV 145 from Quebrada Blanca near Caldera, is here designated as a neotype of *F. steinmanni*. Holotype of *Aeneator loisae* USNM 701667 (also figured by McLean and Andrade 1982), 200 m off Valparaíso, Chile.

Material examined: SGO.PI.6476 (10 specimens, height 42 mm), MOM.

Remarks: Living specimens were reported from 200 to 450 m depth (McLean and Andrade, 1982). However, other species occurring at similar depths in central Chile, like *Fusitriton magellanicus* (see Rehder, 1971; McLean and Andrade, 1982), live as shallow as low tide in the Magellan Strait (own observations). Fossil *Austrofuscus steinmanni* in apparently shallow water deposits may therefore reflect either a cooler climate or differing life habits through time.

The specimens from Morro Mejillones extend the known fossil record for this species back to the middle Pliocene.

Family Nassariidae Iredale, 1916

Genus *Nassarius* Duméril, 1806

Type species: *Buccinum arcularia* Linnaeus, 1758 by monotypy (Froriep, 1806); Recent, West Pacific.

***Nassarius gayi* (Kiener, 1834) (Fig. 4t–u)**

- *1834 *Buccinum gayi* Kiener: *Buccinum* 71, pl. 21, fig. 79.
 1896 *Buccinum* aff. *Gayi* Kien.–Möricke: 561.
 v1969 *Nassarius gayi* (Kiener).–Herm: 141, pl. 14, figs. 5–9.
 1973 *Nassarius gayi* (Kiener, 1835).–Marincovich: 37, figs. 80–81 (synonymy).

Material examined: SGO.PI.6477 (1 specimen, height 10.5 mm), MOM. SGO.PI.6478 (15 specimens, height 15 mm), EGA. SGO.PI.1321 (11 specimens, coll. Herm), EGA. SGO.PI.5597 (12 specimens, coll. Covacevich & Frassinetti), EGA.

Remarks: *Nassarius gayi* has been cited from several localities attributed to the Pliocene and Pleistocene (Herm 1969). However, Herm's (1969) age model, although correct in relative ages, does not conform to modern time tables and dating methods (see Le Roux et al. 2006). The material reported here from the early Late Pliocene of Morro Mejillones seems to be the earliest reliably dated occurrence.

Family Muricidae Rafinesque, 1815

Genus *Concholepas* Lamarck, 1801

Type species: *Concholepas peruviana* Lamarck, 1801 (= *Buccinum concholepas* Bruguière, 1789) by monotypy; Recent, southern Peru to southern Chile.

***Concholepas camerata* DeVries, 2000 (Fig. 4v–w)**

- *2000 *Concholepas camerata* DeVries: 43, figs. 2, 5, 6, 9–11, 14.

Material examined: SGO.PI.6479 (15 specimens and some fragments, height 81 mm), MOM.

Remarks: DeVries (2000) gave a late Pliocene age for *C. camerata* appearing at about 3 Ma. Based on this, the new record of *C. camerata* from 3.5-Ma-old deposits of Morro Mejillones would extend the record for this species by about 0.5 Ma back and 7° lat. to the South.

Genus *Acanthina* Fischer von Waldheim, 1807

Type species: *Buccinum monoceros* Chemnitz, 1788 (= *Buccinum monodon* Pallas, 1774) by subsequent designation (Gray 1847); Recent, Chile.

***Acanthina unicornis* (Bruguière, 1789) (Fig. 5a–b)**

- *1789 *Buccinum unicornis* Bruguière: 254.
 1816 *Monoceros crassilabrum* Lamarck: pl. 396, figs. 2a, b.
 1896 *Monoceros crassilabris* Brug.–Möricke: 563.

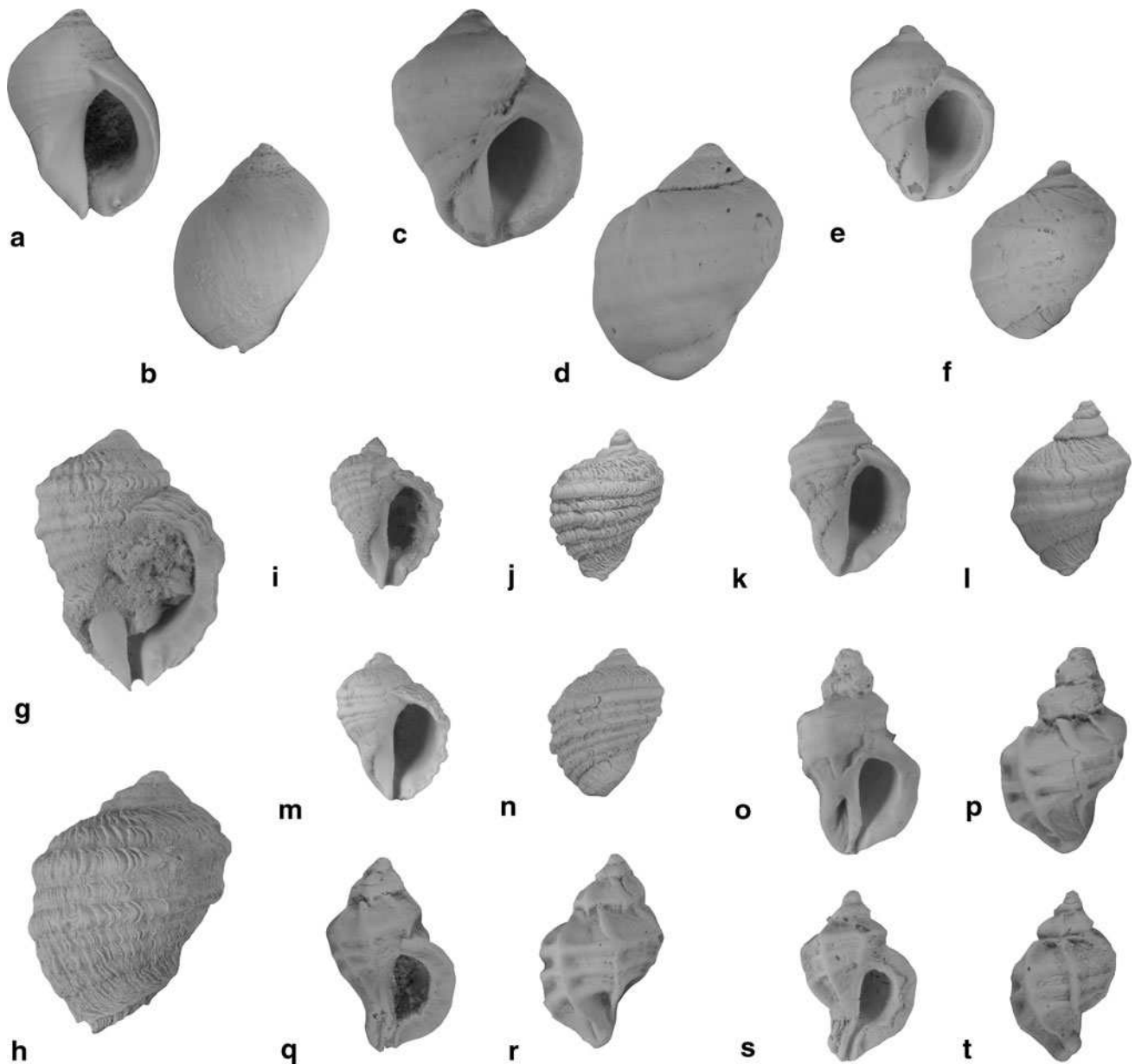


Fig. 5 a–b *Acanthina unicornis* (Bruguière, 1789), SGO.PI.6480, height 31 mm, EGA. c–n *Acanthina triangularis* DeVries, 2003, MOM. c–d SGO.PI.6481, height 35 mm. e–f SGO.PI.6481, height 26 mm. g–h SGO.PI.6482, height 38.7 mm. i–j SGO.PI.6482, height

22.5 mm. k–l SGO.PI.6482, height 26 mm. m–n SGO.PI.6482, height 21.9 mm. o–t *Crassilabrum crassilabrum* (Sowerby, 1834), MOM. o–p SGO.PI.6483, height 30.4 mm. q–r SGO.PI.6483, height 28.7 mm. s–t SGO.PI.6483, height 25.3 mm

1896 *Monoceros crassilabris* Brug. var. *costata* Sow.–Mörcke: 564.

2003 *Acanthina unicornis* (Bruguière, 1789).–DeVries: 334, figs. 8–22 (synonymy).

v2008 *Acanthina unicornis* (Bruguière, 1789).–Griffin and Nielsen: 291, pl. 17, figs. 13–14 (synonymy).

Material examined: SGO.PI.515 (1 specimen labeled *Monoceros crassilabris*) from La Cueva; SGO.PI.499 (2 specimens) from La Cueva; SGO.PI.497 (4 specimens) from La Cueva; SGO.PI.6480 (39 specimens, height 57.4 mm), EGA.

Remarks: *Acanthina unicornis* is well known from the recent fauna and has a fossil record back to the late Pliocene (DeVries 2003).

Acanthina triangularis DeVries, 2003 (Fig. 5c–n)

Material examined: SGO.PI.6481 (11 specimens, height 35 mm), SGO.PI.6482 (6 specimens, height 45.3 mm), MOM.

Remarks: Pliocene specimens from Morro Mejillones show a highly variable shell sculpture, including almost

smooth specimens (SGO.PI.6481) to imbricate specimens (SGO.PI.6482). Smooth specimens are here interpreted to be simply abraded or more exposed living shells. Morphologically, the material from Morro Mejillones is intermediate between *A. triangularis* DeVries, 2003 and *A. unicornis*, as was described by DeVries (2003, fig. 73) for a sequence in southern Peru. What is interesting, though, is that this Peruvian transition was dated between 3 and 2 Ma (DeVries 2003), while material from Mejillones dates at 3.4 Ma. However, there are also specimens with similar sculpture in the late Miocene *A. obesa* DeVries, 2003 (DeVries 2003, fig. 40). Although *A. triangularis* as figured by DeVries (2003) is rather smooth except the two prominent spiral cords, specimens from Morro Mejillones are here regarded as *A. triangularis* with imbricate sculpture rather than a new species.

Genus *Crassilabrum* Jousseume, 1880

Type species: *Purpura crassilabrum* G.B. Sowerby II, 1834 by original designation; Recent, southern Peru to Chile.

Crassilabrum crassilabrum (Sowerby, 1834) (Fig. 5o–t)

*1834 *Purpura crassilabrum* G.B. Sowerby II: fig. 14.
2005 *Crassilabrum crassilabrum* (Sowerby, 1834).–DeVries: 283, figs. 27–35 (synonymy).

Material examined: SGO.PI.829 (1 specimen, labeled by Philippi (1887, p. 56) as *Murex labiosus* Gray) from Guayacán; SMF 339612 (46 specimens, height 34.5 mm), MOM; SGO.PI.6483 (10 specimens, height 37.4 mm), MOM; SGO.PI.6484 (1 specimen, height 28 mm), RQS.

Remarks: DeVries (2005a) gave the fossil record of *Crassilabrum crassilabrum* as beginning in the early Pliocene of Peru, extending in the late Pliocene from northern to southern Peru, in the early Pleistocene from northern Peru to Chile and today from southern Peru to Chile. The Pliocene records from Mejillones and Arauco therefore considerably extend the geographic range southwards for this time.

Genus *Xanthochorus* Fischer, 1884

Type species: *Purpura xanthostoma* Broderip, 1833 (= *Purpura cassidiformis* Blainville, 1832) by original designation; Recent, Ecuador to Chile.

Xanthochorus cassidiformis (Blainville, 1832) (Fig. 6a–b)

*1832 *Purpura cassidiformis* Blainville: 230.
v1887 *Purpura subnodosa* Philippi: 55, pl. 4, fig. 6.
v1887 *Purpura porphyroidea* Philippi: 55, pl. 4, fig. 7.

Fig. 6 a–b *Xanthochorus cassidiformis* (Blainville, 1832), SGO.PI.6485, height 34 mm, MOM. **c–i** *Chorus doliaris* (Philippi, 1887). **c–d** SGO.PI.495, syntype of *Monoceros doliaris*, height 52.2 mm, La Cueva. **e** SGO.PI.5074, paralectotype of *Monoceros levis*, height 55.5 mm, Guayacán. **f–g** SGO.PI.500, syntype of *Monoceros doliaris*, height 52 mm, La Cueva. **h** SGO.PI.6486, height 51 mm, MOM. **i** SGO.PI.6487, height 42.3 mm, EGA. **j–s** *Chorus grandis* (Philippi, 1887). **j–k** SGO.PI.513, syntype of *Monoceros grandis*, height 57.9 mm, Coquimbo. **l** SGO.PI.510, syntype of *Monoceros grandis*, height 66.5 mm, La Cueva. **m** SGO.PI.507, syntype of *Monoceros tenuis*, height 42.1 mm, Coquimbo. **n–o** SGO.PI.511, syntype of *Monoceros tenuis*, height 25.8 mm, Guayacán. **p–q** SGO.PI.520, syntype of *Monoceros ventrosus*, height 47.4 mm, Coquimbo. **r–s** SGO.PI.508, lectotype of *Monoceros laevis*, height 43.7 mm, Guayacán

v1887 *Buccinum solidum* Philippi: 64, pl. 6, fig. 12 (*non* Schroeter 1805, *nec* Gravenhorst, 1807, *nec* Reeve, 1846).

1909 *Trophon cassidiformis* Blainville.–Dall: 218.

v1969 *Xanthochorus cassidiformis* (Blainville).–Herm: 136, pl. 16, figs. 6–8.

2005 *Xanthochorus cassidiformis* (Blainville, 1832).–DeVries: 61, figs. 3–12, 14, 16 (synonymy).

Type material: Holotype of *Purpura subnodosa* SGO.PI.717 from Guayacán. Holotype of *Purpura porphyroidea* SGO.PI.721 from Coquimbo. Two syntypes of *Buccinum solidum* SGO.PI.732 and SGO.PI.4568 from Guayacán.

Material examined: SGO.PI.518 (1 of 3 specimens labeled as *Monoceros blainvillei*) from Coquimbo; SGO.PI.6485 (2 specimens, height 34 mm), MOM.

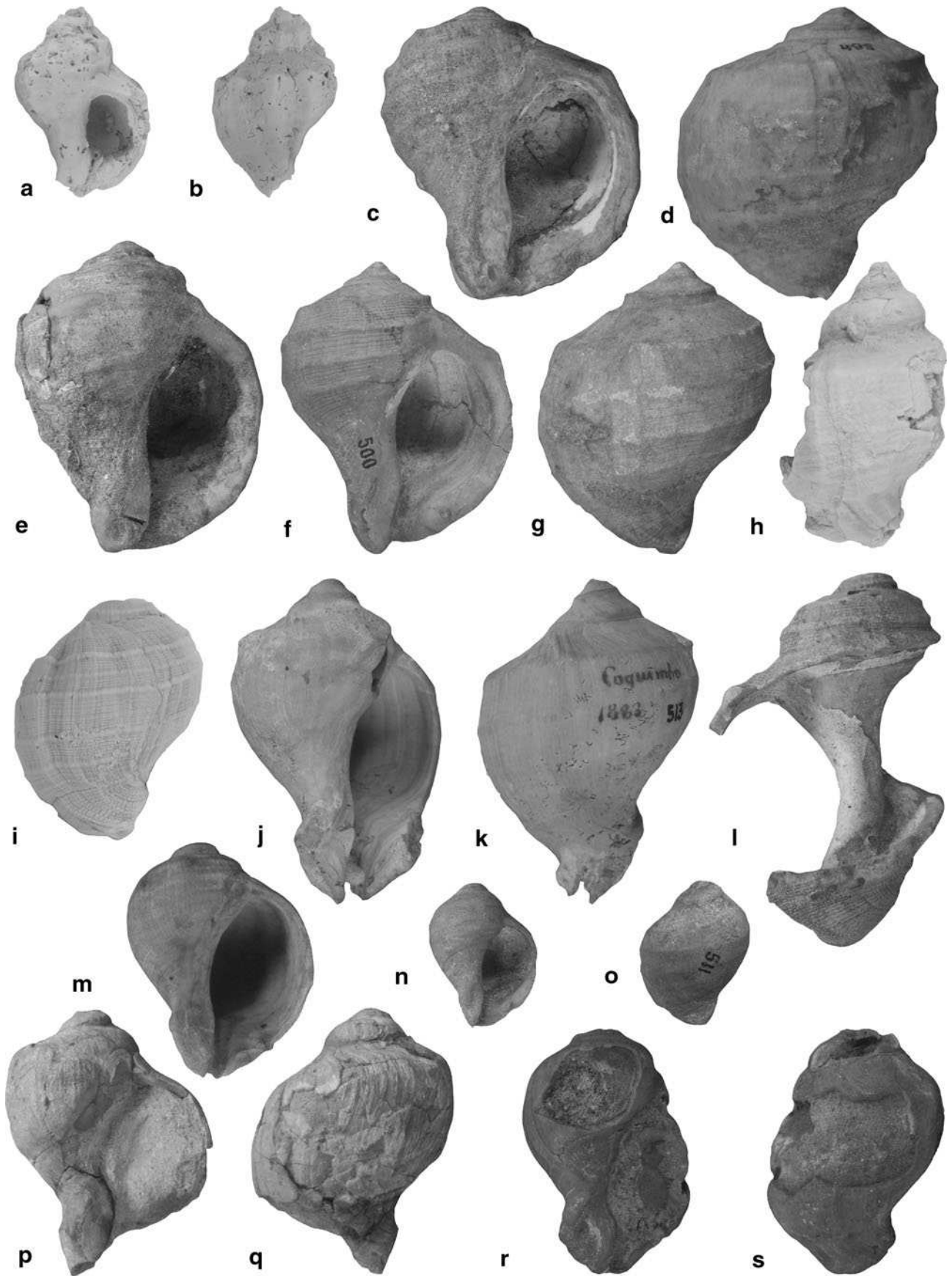
Remarks: According to DeVries (2005b) *Xanthochorus cassidiformis* occurs first in the late Pliocene (2–3 Ma) of southern Peru, but is present since the Pleistocene from Ecuador to Chile. The record from Morro Mejillones therefore seems to be the oldest record for this species.

Genus *Chorus* Gray, 1847

Type species: *Monoceros giganteus* Lesson, 1830 by original designation; Recent, Chile.

Chorus doliaris (Philippi, 1887) (Fig. 6c–i)

*v1887 *Monoceros doliaris* Philippi: 61, pl. 6, fig. 11.
1887 *Monoceros pyrulatus* Philippi: 61, pl. 5, fig. 7.
v1887 *Monoceros costatus?* Sowerby.–Philippi: 60, pl. 5, fig. 9 (*non* Sowerby).
v1887 *Purpura cingulata* (Buccinum) L.–Philippi: 58, pl. 6, fig. 8 (*non* Linnaeus).
v1969 *Chorus doliaris* (Philippi).–Herm: 134, pl. 15, fig. 6, pl. 16, fig. 3, pl. 17, fig. 1.



1997 *Chorus doliaris* (Philippi, 1887).—DeVries: 133, pl. 1 figs. 5–8, pl. 2, fig. 2.

v2000 *Chorus doliaris* (Philippi, 1887).—Frassinetti: 141, pl. 2, fig. 1.

Type material: DeVries (1997) mentioned SGO.PI.500 from La Cueva as being the holotype. This, however, is not the case since Philippi (1887) stated that he had two complete specimens from La Cueva, which were found by Domeyko. In Philippi's collection are three specimens labeled as *Monoceros doliaris*, two given to him by Domeyko from La Cueva (SGO.PI.495, SGO.PI.500) and one that Philippi's son Friedrich found in Coquimbo (SGO.PI.502). The former two are considered as being the syntypes of *Monoceros doliaris*. The latter is not considered a syntype because although it was given to Philippi in 1883, well before publication of the book, it is not mentioned in the text. Since both syntypes are conspecific, it is not considered necessary to select a lectotype.

As was noted by Herm (1969), no types of *Monoceros pyrulatus* are present in the Philippi collection at SGO.PI. Contrary to Herm's (1969) statement, there existed no holotype but two syntypes from Coquimbo.

Material examined: Two syntypes of *Monoceros doliaris* (SGO.PI.495, SGO.PI.500) from La Cueva; SGO.PI.502 (1 specimen labeled *Monoceros doliaris*) from Coquimbo; SGO.PI.841 (3 specimens labeled *Monoceros costatus*) from La Cueva; SGO.PI.498 (5 specimens and 4 fragments labeled *Monoceros costatus*) from Coquimbo; SGO.PI.517 (1 specimen labeled *Monoceros costatus*?) from Guayacán; SGO.PI.501 (2 specimens labeled *Monoceros costatus*) from Guayacán; SGO.PI.5074 (1 specimen, paralectotype of *Monoceros laevis*) from Guayacán; SGO.PI.692 (1 specimen labeled and figured as *Purpura cingulata*) from Coquimbo; SGO.PI.518 (1 of 3 specimens labeled as *Monoceros blainvillei*) from Coquimbo; SGO.PI.1303 (4 specimens) from Herm's collection, Estero del Ganso, La Cueva; SGO.PI.1305 (7 specimens) from Herm's collection, Estero del Ganso, La Cueva; SGO.PI.5592 (6 specimens) from Covacevich and Frassinetti's collection, Estero del Ganso, La Cueva; SGO.PI.6486 (1 specimen, height 51 mm), MOM; SGO.PI.6487 (19 specimens, height 43 mm), EGA.

Remarks: Two names were given to this species by Philippi (1887). Herm (1969) acted as first reviser to choose the name *Monoceros doliaris* for this species. Philippi's figure of *Monoceros costatus* (Philippi, 1887, pl. 5, fig. 9) could be based either on the specimen SGO.PI.517 or the largest of the three specimens in SGO.PI.841. It should be noted that the former comes from Guayacán and the latter from La Cueva; both localities

were not mentioned by Philippi for this species as Philippi mentioned only eight specimens from Coquimbo. However, Guayacán is close to Coquimbo, and it seems likely that the five specimens from Coquimbo and the three specimens from Guayacán are those mentioned by Philippi, while those from La Cueva are certainly not.

***Chorus grandis* (Philippi, 1887)** (Fig. 6j–s)

*v1887 *Monoceros grandis* Philippi: 60, pl. 5, fig. 4, pl. 6, fig. 5.

v1887 *Monoceros tenuis* Philippi: 60, pl. 5, fig. 10.

v1887 *Monoceros laevis* Philippi: 61, pl. 5, fig. 8.

v1887 *Monoceros ventrosus* Philippi: 61, pl. 6, fig. 4.

v1969 *Chorus grandis* (Philippi).—Herm: 134, pl. 15, figs. 2, 3, 5.

1997 *Chorus grandis* (Philippi, 1887).—DeVries: 136, pl. 2, figs. 3, 6, 7, pl. 3, fig. 8.

Type material: Philippi (1887) had material of *Monoceros grandis* from La Cueva and from Coquimbo and figured two specimens, one from each locality. SGO.PI.510 is the incomplete syntype from La Cueva (Philippi, 1887, pl. 5, fig. 4), while SGO.PI.513 is the figured syntype from Coquimbo (Philippi, 1887, pl. 6, fig. 5). It is likely that more syntypes were originally present, because Philippi (1887, p. 61) stated that “we possess specimens from La Cueva and also from Coquimbo.”

All syntypes of *Monoceros tenuis* are present. SGO.PI.507 is the adult specimen from Coquimbo and SGO.PI.511 includes the three juveniles from Guayacán, although Philippi (1887) noted the locality Coquimbo for all four. However, Guayacán was so close to Coquimbo that it is part of that town today.

There are five possible syntypes of *Monoceros laevis* present [SGO.PI.505, SGO.PI.5075 (ex 4569), SGO.PI.508 (Philippi's pl. 5, fig. 8), SGO.PI.503, SGO.PI.5074 (ex 4845)], all from Guayacán. Philippi stated that he had “a fairly high number of specimens,” so it can be supposed that some of them got lost. SGO.PI.5074 is a specimen of *Chorus doliaris*. It is not clear if it is really a syntype of *M. laevis*, because there is no original label attached to it, and it is rather heavily ornamented for Philippi's concept of *M. laevis*. To avoid future problems caused by this specimen, the specimen figured by Philippi as *M. laevis*, i.e., SGO.PI.508, is here selected as lectotype.

The syntype of *Monoceros ventrosus* from Coquimbo is present (SGO.PI.520), as are two from Guayacán (SGO.PI.516). It is likely that several more from Guayacán were originally present since Philippi (1887) stated that he had “several from Guayacán.”

Lectotype designations of DeVries (1997) by inference of holotype are invalid because the presence of several

specimens for all species is obvious from the text. It should be noted that DeVries (1997) himself listed several specimens of each species from the Philippi collection.

Material examined: All type material discussed was examined. SGO.PI.518 (1 of 3 specimens labeled as *Monoceros blainvillei*) from Coquimbo.

Remarks: There are four names available for this species, which have been published simultaneously by Philippi (1887). Again, Herm (1969) acted as first reviser to choose the name *Chorus grandis* for this species.

Genus *Stramonita* Schumacher, 1817

Type species: *Buccinum haemastoma* Linnaeus, 1767 by subsequent designation (Gray 1847); Recent, eastern and western tropical Atlantic.

Stramonita zinsmeisteri DeVries, 2007 (Fig. 7a–c)

*2007c *Stramonita zinsmeisteri* DeVries: 254, figs. 30–38.

Material examined: SGO.PI.6488 (1 specimen, height 51.5 mm), RQS; SGO.PI.1301 (1 specimen, Herm's collection), Estero El Ganso, La Cueva Formation.

Remarks: Type locality is La Cueva. Although DeVries obviously examined the specimen from the Herm collection in Santiago, he did not mention it when describing *Stramonita zinsmeisteri* (DeVries, 2007c). The specimen figured by DeVries (2007c, fig. 35) and said to come from SGO.PI. ("SGO.PI.6266") is at the same time attributed to Zinsmeister's collection 266. At the time of DeVries' publication, still no SGO.PI.6266 existed, and this specimen was likely moved with the Zinsmeister collection to PRI, Ithaca. Following Claremont et al. (2011), this species does not belong in *Stramonita* and was provisionally placed in *Thais* sensu lato. Until a better placement is available, I prefer to retain it in *Stramonita* to avoid taxonomic confusion.

Subclass Heterobranchia Burmeister, 1837

Family Bullidae Gray, 1827

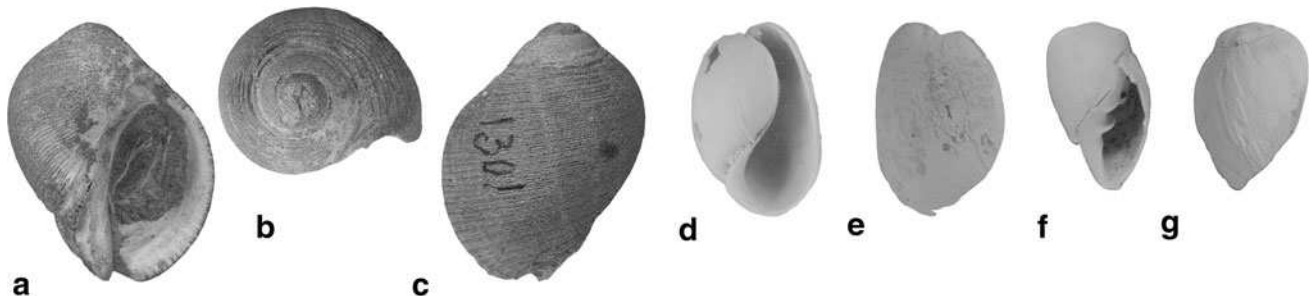


Fig. 7 a–c *Stramonita zinsmeisteri* DeVries, 2007, SGO.PI.1301, height 33 mm, EGA. d–e *Bulla punctulata* A. Adams, 1850, SGO.PI.6489, height 24.7 mm, MOM. f–g *Chilina* sp. SGO.PI.6490, height 21.4 mm, EGA

Genus *Bulla* Linnaeus, 1758

Type species: *Bulla ampulla* Linnaeus, 1758 by subsequent designation of Gray (1847); Recent, Indo-Pacific.

Bulla punctulata A. Adams, 1850 (Fig. 7d–e)

*1850 *Bulla punctulata* A. Adams: 577, pl. 123, fig. 77.
2008 *Bulla punctulata* A. Adams, 1850.–Malaquias and Reid: 497, figs. 2E, 4M–S, 5F, H, 6J–K, 17, 18G–H, 19G–H, 20G–H, 21H–J, 22G–H, 23H–I, 24H–I (synonymy).

Material examined: SMF 339613 (9 specimens, height 27 mm); SGO.PI.6489 (3 specimens, height 28 mm), MOM. ?SGO.PI.794 (3 molds labeled as *Bulla ambigua* d'Orb.) from Guayacán.

Remarks: Malaquias and Reid (2008) in their revision of Bullidae gave the geographic distribution as Mexico to northern Peru. However, there are records from as far south as Antofagasta, Chile (Guzmán et al. 1998). The fossil record of *Bulla ambigua* from Caldera (Möricke 1896) likely also relates to *Bulla punctulata* because Möricke (1896) noted that these were smaller than the molds from Coquimbo. *Bulla ambigua* d'Orbigny, 1842 (= *Bulla subambigua* d'Orbigny, 1852; see Griffin and Nielsen 2008) is a larger species also truly belonging in *Bulla*. However, so far there are only internal molds known.

Family Chiliniidae Dall, 1870

Genus *Chilina* Gray, 1828

Type species: *Auricula (Chilina) fluctuosa* Gray, 1828 by monotypy; Recent, Chile.

Chilina sp. (Fig. 7f–g)

Material examined: SGO.PI.6490 (1 specimen, height 21.5 mm), EGA.

Remarks: Species of *Chilina* live in fresh and brackish water, and this specimen was likely carried by a river into

the marine environment (see Cárdenas et al. 2008). Until the recent species of this complex genus are reviewed, there is little sense in attributing this worn specimen to a species. This is, however, not the oldest specimen of *Chilina*, as there are early Miocene ones from the Navidad Formation and equivalents (unpublished data).

Class Bivalvia Linnaeus, 1758

Subclass Pteriomorphia Beurlen, 1944

Family Arcidae Lamarck, 1809

Genus *Anadara* Gray, 1847

Type species: *Arca antiquata* Linnaeus, 1758 by original designation; Recent, Indian Ocean.

***Anadara chilensis* (Philippi, 1887)** (Fig. 8a–f)

*v1887 *Arca chilensis* Philippi: 187, pl. 36, fig. 6.

1896 *Arca chilensis* Phil.–Mörrike: 581.

v1969 *Anadara (Rasia) chilensis* (Philippi).–Herm: 99, pl. 1, figs. 3–4.

Type material: Syntypes SGO.PI.264, SGO.PI.268, SGO.PI.4799, SGO.PI.4800, SGO.PI.5031, SGO.PI.5032, all from La Cueva.

Material examined: SMF 339614 (6 specimens, length 73 mm), EGA.

Remarks: Herm (1969) reported this species from the Pliocene of Mejillones, Caldera, Tongoy and La Cueva, but he never found it in Pleistocene deposits.

Genus *Acar* Gray, 1857

Type species: *Byssoarca divaricata* G.B. Sowerby I, 1833 (= *Arca plicata* Dillwyn, 1817) by subsequent designation of Stoliczka (1871); Recent, Indo-Pacific.

***Acar pusilla* (Sowerby, 1833)** (Fig. 8g–h)

*1833 *Byssoarca pusilla* G.B. Sowerby I: 18–19.

1973 *Barbatia (Acar) pusilla* (Sowerby, 1833).–Marincovich: 8, fig. 2 (synonymy).

1998 *Barbatia (Acar) pusilla* (Sowerby, 1833).–Guzmán, Saá, and Ortlieb : 60.

Material examined: SGO.PI.6491 (4 specimens, length 9.3 mm), MOM.

Remarks: Type locality is Iquique. This is the oldest record for this species. Living specimens were found attached to undersides of intertidal rocks (Marincovich 1973). It is likely, that Herm' (1969) *Acar gradata* refers to *A. pusilla*, but this has not been verified.

Family Glycymerididae Dall, 1908

Genus *Glycymeris* da Costa, 1778

Type species: *Arca orbicularis* da Costa, 1778 (= *Arca glycymeris* Linnaeus, 1758 by tautonomy); Recent, Mediterranean.

***Glycymeris intermedius* (Broderip, 1832)** (Fig. 8i–j)

*1832 *Pectunculus intermedius* Broderip: 126.

1960 *Glycymeris ovatus* (Broderip, 1832).–Stuardo: 136, figs. 1–6.

1998 *Glycymeris ovatus* (Broderip, 1832).–Guzmán, Saá and Ortlieb: 60.

Material examined: SGO.PI.6492 (15 specimen, height 39 mm), MOM; SGO.PI.6493 (1 juvenile), MOM.

Remarks: According to Coan and Valentich Scott (2012: 196), *Glycymeris intermedius* differs from *G. ovata* “in being longer and more rounded posteriorly, and has fewer teeth (about 14 total teeth) and fewer crenulations (about 27).” Most authors (i.e., Stuardo 1960) considered these two species as synonyms, and accordingly *G. ovata* is usually cited for Chilean faunas. Living juveniles of *Glycymeris intermedius* occur in water depths of 8–13 m (Guzmán et al. 1998). Carcelles and Williamson (1951) gave its distribution as “Concepción, Chile to Isla Lobos, Perú. Quaternary of Caldera, Chile and Talara, Perú” [translated from Spanish].

Family Mytilidae Rafinesque, 1815

Genus *Crenella* T. Brown, 1827

Type species: *Crenella elliptica* T. Brown, 1827 (= *Mytilus decussatus* Montagu, 1808) by monotypy; Recent, North Atlantic.

***Crenella decussata* (Montagu, 1808)** (Fig. 8k–m)

Material examined: SGO.PI.6494 (39 articulated specimens, 37 isolated valves, height 4.5 mm), MOM; SGO.PI.6495 (1 specimen, height 2 mm), RQS.

Remarks: This is the first fossil record of *Crenella* from Chile. Extant specimens from Chile, listed as *Crenella* sp., are known from Bahía Inglesa to Fiordo Aisén (Valdivinos 1999; Instituto de Fomento Pesquero www.macrofauna.cl, accessed 24.06.2011). Without formal treatment, the species name *C. divaricata* d'Orbigny, 1842, is usually used for South American specimens of *Crenella*, both for Atlantic and Pacific occurrences (Orensanz et al. 2002). However, *C. divaricata* was originally described from Cuba and may be a strictly Caribbean species. Coan et al. (2000) and Coan and Valentich Scott (2012) synonymized *C. divaricata* with the

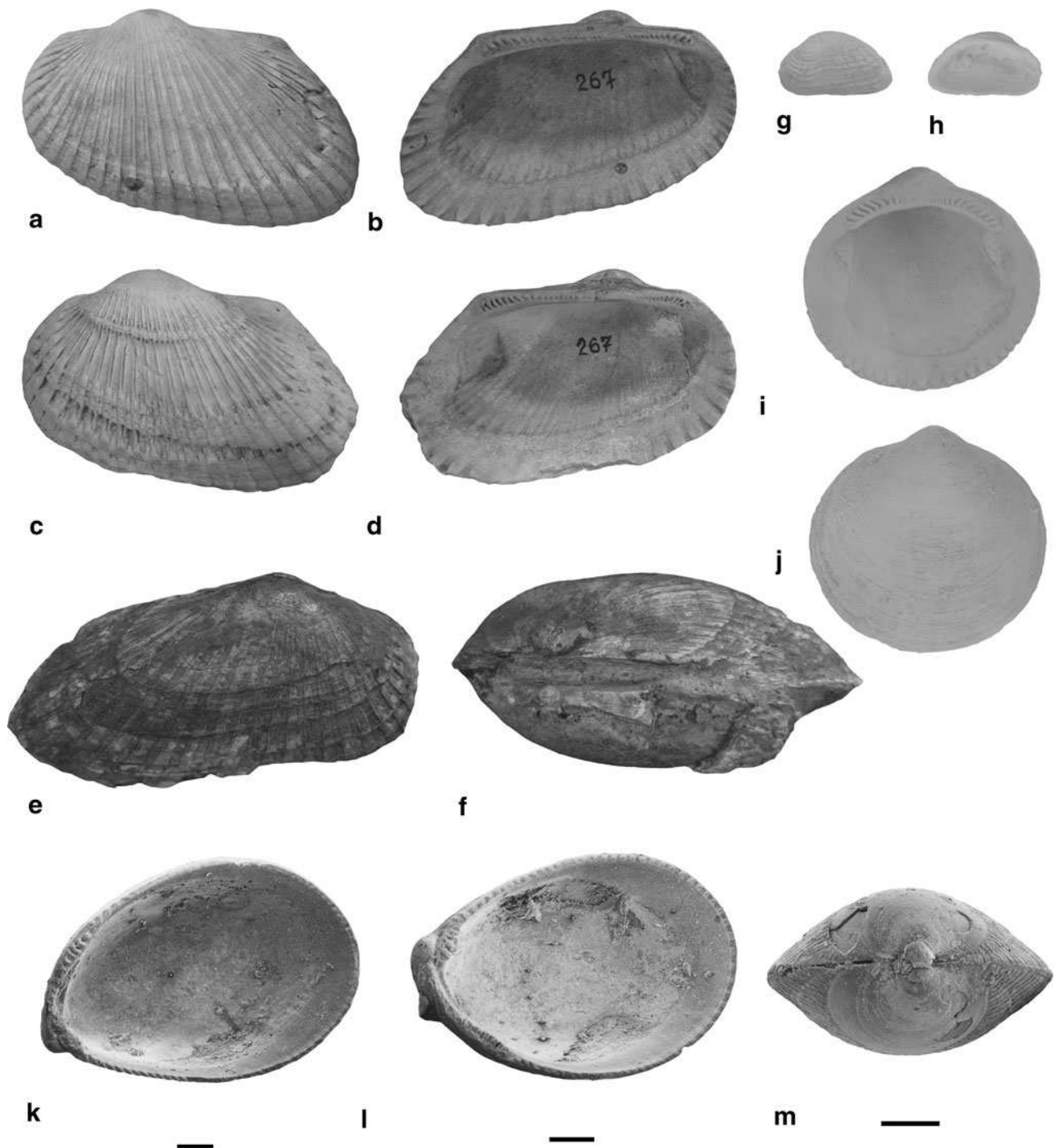


Fig. 8 a–f *Anadara chilensis* (Philippi, 1887). A–B SGO.PI.267-1, length 54.7 mm, Caldera. SGO.PI.267-2, length 54.6 mm, Caldera. e–f SGO.PI.264, syntype, length 66.7 mm, La Cueva. g–h *Acar pusilla* (Sowerby I, 1833), SGO.PI.6491, length 9.2 mm, MOM. i–

j *Glycymeris ovatus* (Broderip, 1832), SGO.PI.6492, length 38.5 mm, MOM. k–m *Crenella decussata* (Montagu, 1808), SGO.PI.6494, MOM. Scale bars are 300 μ m

type species *C. decussata*, and thus extended the range to Alaska. This species is recorded back to the Miocene of Panamá (Coan and Valentich Scott 2012). Very similar is also the extant New Zealand species *C. radians* (Suter, 1908) as figured by Fleming (1959). Detailed comparison of

these and other named *Crenella* species is needed before assigning the specimens from Morro Mejillones and the Huenteguapi Sandstone with certainty to a known species or describing a new one. Following Coan and Valentich Scott (2012), it is tentatively placed in *C. decussata*.

Subclass Heterodonta Neumayr, 1884

Family Veneridae Rafinesque, 1815

Genus *Retrotapes* del Río, 1997

Type species: *Retrotapes ninfasiensis* del Río, 1997 by original designation; middle Miocene, Valdés Peninsula, Argentina.

***Retrotapes fuenzalidae* (Philippi, 1887) comb. nov.**

(Fig. 9a–h)

*v1887 *Venus Fuenzalidae* Philippi: 125, pl. 19, fig. 3.

v1887 *Venus colchaguensis* Philippi: 122, pl. 17, fig. 4.

v1969 *Eurhomalea fuenzalidai* (Philippi).–Herm: 128, pl. 12, figs. 15–16.

1974 *Eurhomalea colchaguensis* (Philippi).–Frassinetti: 47.

Type material: Of the original seven syntypes of *Venus fuenzalidae*, six are still present: SGO.PI.83, SGO.PI.90, SGO.PI.5092, SGO.PI.5093, SGO.PI.5094 and SGO.PI.5095, all from La Cueva. The holotype of *V. colchaguensis* SGO.PI.120 is an internal mold from La Cueva.

Remarks: Herm (1969) unnecessarily corrected the name *Venus fuenzalidae* to *fuenzalidai* because it was named after Domingo Fuenzalida. Following ICZN Article 31.1, *fuenzalidae* is here interpreted to be the latinized form of Fuenzalida and thus is correctly spelled. Frassinetti (1974) incorrectly assumed that *V. colchaguensis* had priority because it appears earlier in Philippi's (1887) text. *Venus fuenzalidae* is here selected as the valid name for this species, because it has diagnostic syntypes, while the holotype of *V. colchaguensis* is an internal mold.

Genus *Leukoma* Römer, 1857

Type species: *Venus granulata* Gmelin, 1791 by subsequent designation (Kobelt 1881); Recent, western Atlantic.

***Leukoma antiqua* (King, 1832) comb. nov.** (Fig. 9i–j)

*1832 *Venus antiqua* King: 336.

1909 *Chione antiqua* King.–Dall: 267.

1950 *Protothaca antiqua* (King, 1831).–Carcelles: 80, pl. 5, fig. 86.

v1969 *Protothaca antiqua antiqua* (King).–Herm: 123, pl. 10, figs. 2–4, pl. 11, figs. 1–2.

1998 *Venus antiqua* King & Broderip, 1835.–Guzmán, Saá, and Ortlieb: 73.

Material examined: SGO.PI.6496 (5 specimens, length 47 mm), MOM.

Remarks: Coan and Valentich Scott (2012) synonymized *Protothaca* Dall, 1902 with *Leukoma*. Herm (1969)

erected *Protothaca antiqua tongoyensis* as a separate early Pleistocene subspecies, which shows clear morphological differences. *Protothaca antiqua antiqua* is recorded since the Pliocene (Herm 1969).

Genus *Amiantis* Carpenter, 1864

Type species: *Cytherea callosa* Conrad, 1837 by monotypy; Recent, California.

***Amiantis domeykoana* Philippi, 1887** (Fig. 10a–d)

*1887 *Venus Domeykoana* Philippi: 123, pl. 21, fig. 2.

v1887 *Venus crassa* Philippi: 123, pl. 21, fig. 1, 1b (*non* Gmelin, 1791).

v1887 *Venus Fernandezi* Philippi: 125, pl. 16, fig. 7.

v1969 *Amiantis domeykoana* (Philippi).–Herm: 124, pl. 12, figs. 1–3.

1974 *Amiantis domeykoana* (Philippi).–Frassinetti: 48, fig. 5.

Type material: It is not clear from the text how many syntypes of *V. crassa* were originally present. There are two preserved in Philippi's collection, SGO.PI.87 and SGO.PI.138, both right valves from La Cueva. The holotype of *V. fernandezi* is SGO.PI.77, San Vicente de Pucalán. Apparently the several syntypes of *V. domeykoana*, also coming from La Cueva, have been lost.

Material examined: SGO.PI.5595 (18 specimens, La Cueva), SGO.PI.1296 (7 specimens, La Cueva), SGO.PI.1298 (6 specimens, La Cueva).

Remarks: *Amiantis domeykoana* was also reported from Lo Abarca (Covacevich and Frassinetti 1990). A probably Miocene specimen was reported by Watters and Fleming (1972) from Chiloé. Herm (1969) apparently acted as first reviser in selecting the name *V. domeykoana* for this species. *Venus crassa* Philippi, 1887, is a junior homonym of *V. crassa* Gmelin, 1791, and therefore is not available for this species.

Family Ungulinidae Gray, 1854

Genus *Diplodonta* Bronn, 1831

Type species: *Venus lupinus* Brocchi, 1814 (= *Tellina rotundata* Montagu, 1803) by subsequent designation of Gray (1847); Miocene and Pliocene, Italy.

***Diplodonta inconspicua* Philippi, 1845** (Fig. 10e–h)

*1845 *Diplodonta inconspicua* Philippi: 53.

1969 *Diplodonta inconspicua* Philippi.–Herm: 115, pl. 3, figs. 5–7.

1998 *Diplodonta inconspicua* Philippi, 1842 [*sic*].–Guzmán, Saá, and Ortlieb: 66.

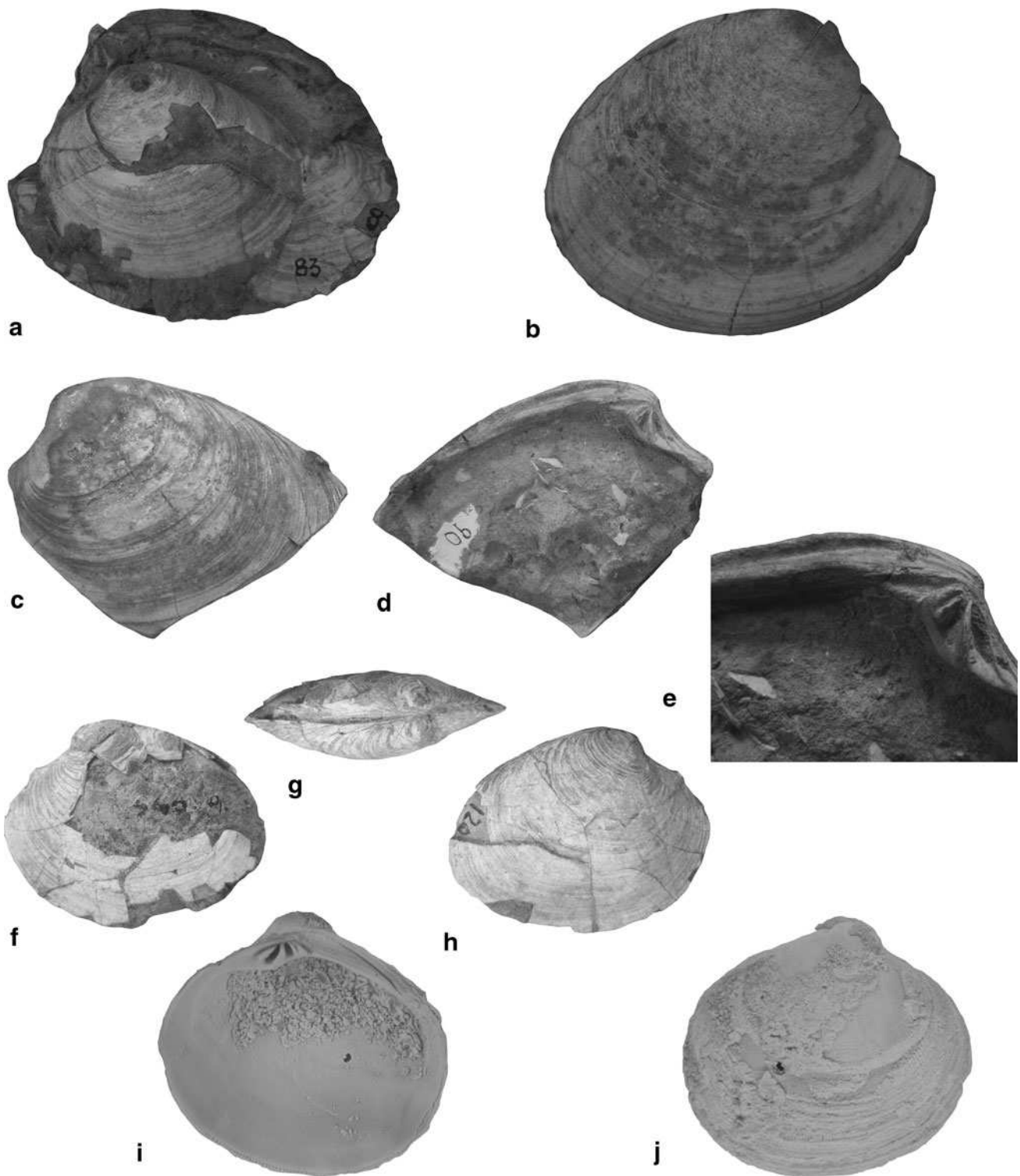


Fig. 9 a–h *Retrotapes fuenzalidae* (Philippi, 1887). a–b SGO.PI.83, syntype of *Venus fuenzalidae*, length 64 mm, La Cueva. c–e SGO.PI.90, syntype of *Venus fuenzalidae*, length 55.6 mm, La

Cueva. f–h SGO.PI.120, holotype of *Venus colchaguensis*, length 42.7 mm, La Cueva. i–j *Leukoma antiqua* (King, 1832), SGO.PI.6496, length 47.3 mm, MOM

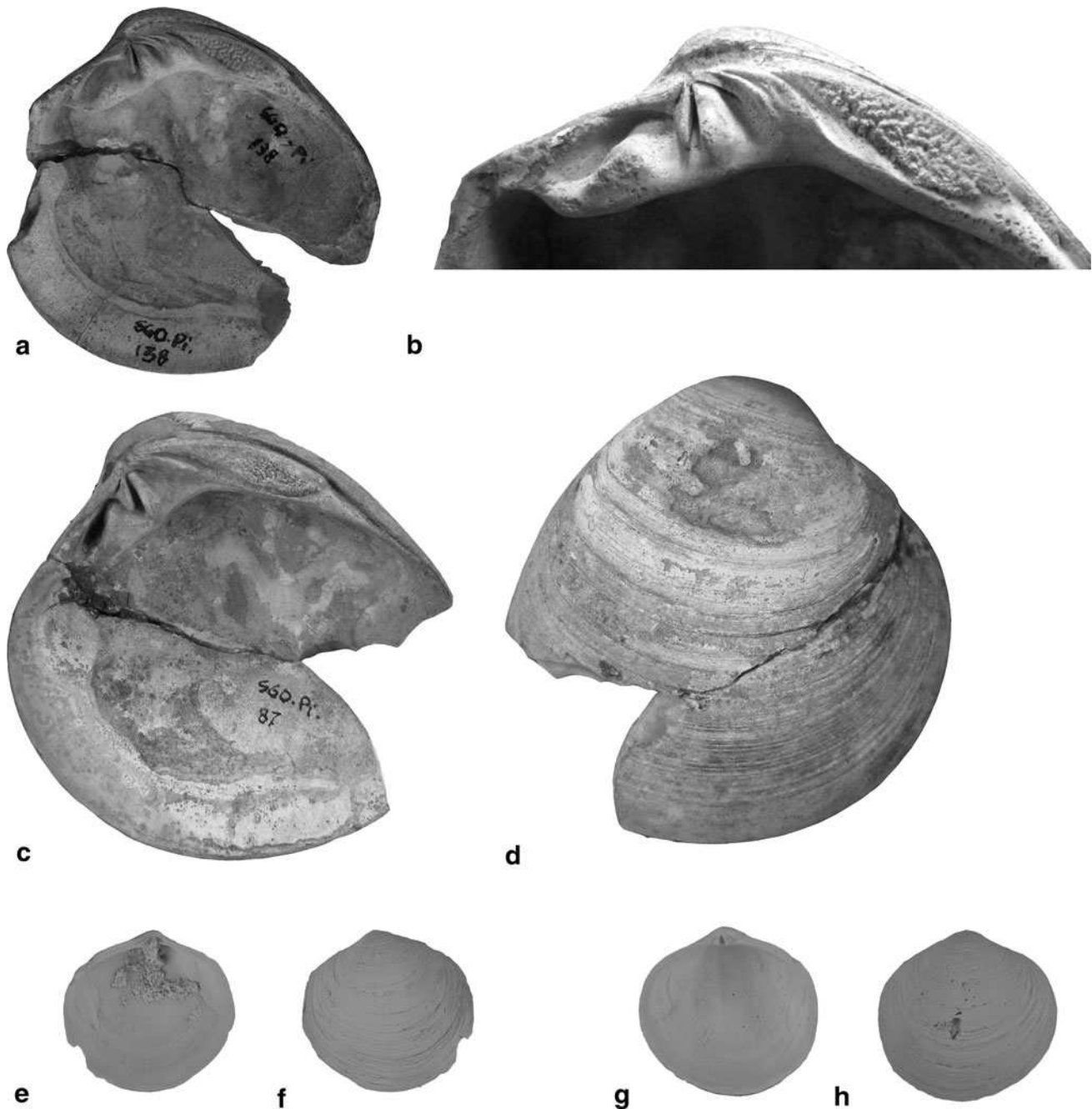


Fig. 10 a–d *Amiantis domeykoana* Philippi, 1887. a–b SGO.PI.138, length 57 mm, La Cueva. c–d SGO.PI.87, length 68 mm, La Cueva. e–h *Diplodonta inconspicua* Philippi, 1845. E–F SGO.PI.6497, length 26.3 mm, MOM. g–h SGO.PI.6497, length 27.4 mm, MOM

Material examined: SGO.PI.6497 (10 specimens, length 27 mm), MOM.

Remarks: The known current distribution of *Diplodonta inconspicua* is from Tocopilla to Puerto Montt. A very small

species, *Diplodonta minuta* Philippi, 1887, was reported from the Miocene deposits of Navidad (Philippi 1887).

Family Semelidae Stoliczka, 1870
Genus *Semele* Schumacher, 1817

Type species: *Semele reticulata* Schumacher, 1817 (= *Tellina proficua* Pulteney, 1799) by monotypy; Recent, western Atlantic.

***Semele solida* (Gray, 1828)** (Fig. 11a–d)

*1828 *Amphidesma solidum* Gray: 6 [cited figures were never published].

1973 *Semele solida* (Gray, 1828).—Marincovich: 14, fig 21.

1988 *Semele* (*S.*) *solida* (Gray, 1828).—Coan: 13, figs. 19–20 (synonymy).

Material examined: SGO.PI.6498 (13 specimens, length 70 mm), MOM.

Remarks: Regarding today's geographic range of other *Semele* species, listed by Herm (1969) for Pleistocene and Recent specimens of northern Chile, it seems unlikely that these really occur in Chile. However, Herm's material of *Semele* was not examined and may represent anomalously warm temperatures at the given locality and time. *Semele solida* lives from Callao, Peru, to Puerto Montt, Chile (Coan 1988).

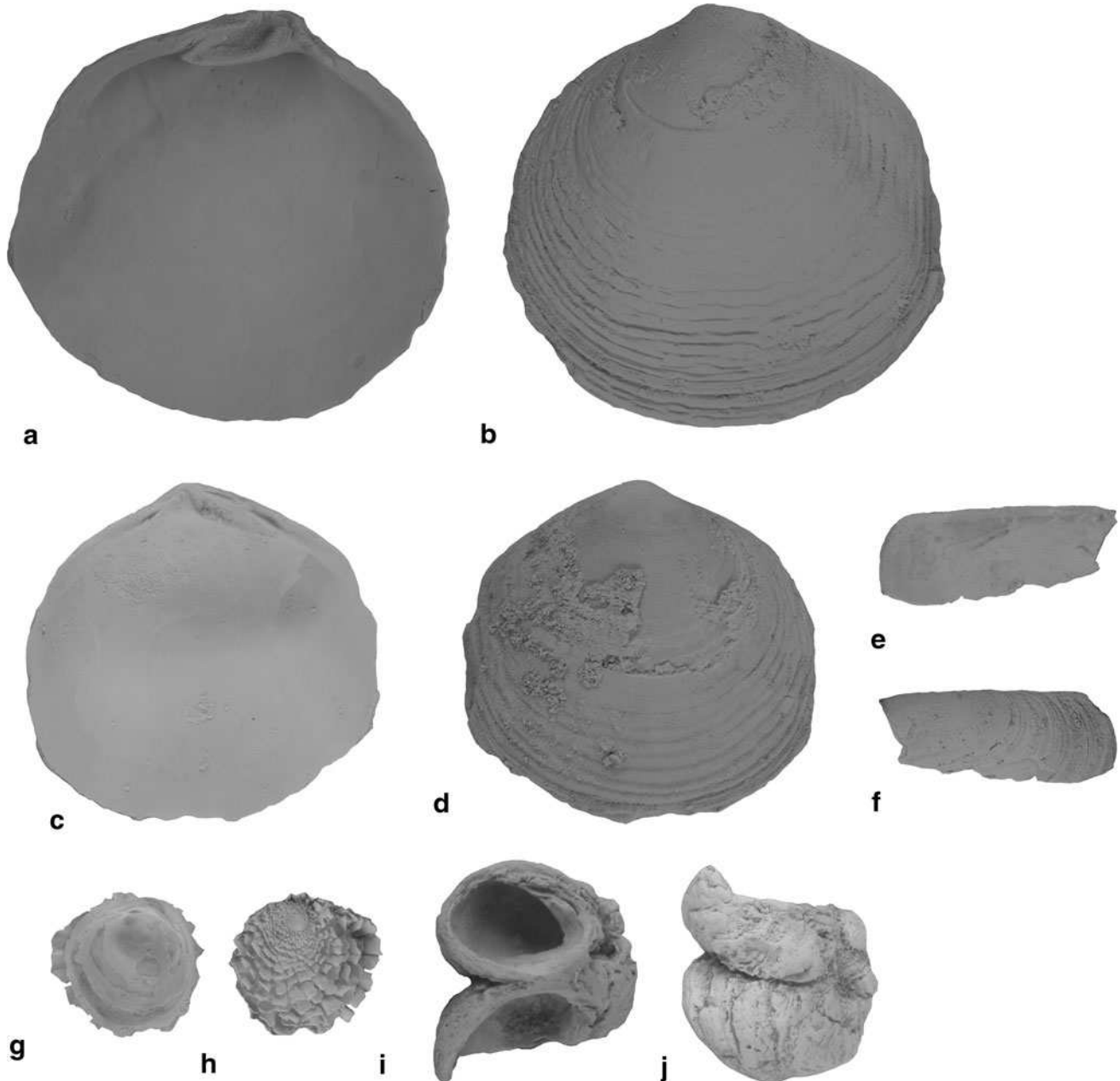


Fig. 11 a–d *Semele solida* (Gray, 1828). a–b SGO.PI.6498, length 65 mm, MOM. c–d SGO.PI.6498, length 52 mm, MOM. e–f *Tagelus dombeii* (Lamarck, 1818), SGO.PI.6499, length 35 mm, MOM.

g–j *Chama pellucida* Broderip, 1835 g–h SGO.PI.6500, length 22 mm, MOM. i–j SGO.PI.6500, length 30 mm, MOM

Family Solecurtidae d'Orbigny, 1846

Genus *Tagelus* Gray, 1847

Type species: “*Sol. guinensis*” (= *Solen adansonii* Bosc, 1801) by original designation; Recent, West Africa.

***Tagelus dombeyi* (Lamarck, 1818)** (Fig. 11e–f)

*1818 *Solen Dombeyi* Lamarck: 454.

1887 *Solen Dombeyi* Lam.–Philippi: 170, pl. 34, fig. 5.

1909 *Tegeus (Mesopleura) dombeyi* Lamarck.–Dall: 273, 160, pl. 27, fig. 3.

1969 *Tagelus dombeyi* (Lamarck).–Herm: 120.

1998 *Tagelus (Tagelus) dombeyi* (Lamarck, 1818).–Guzmán, Saá, and Ortlieb: 72.

2012 *Tagelus dombeyi* (Lamarck, 1818).–Coan and Valentich-Scott: 732, pl. 225.

Material examined: SGO.PI.6499 (5 fragments, length > 36 mm), MOM.

Remarks: Herm (1969) mentioned *Tagelus dombeyi* from the Pliocene of Coquimbo, Maitencillo, Horcón and La Cueva, making the record from Mejillones the northernmost and probably oldest for this species. Its modern distribution is from Panama to Isla Traiguén, Chile (Reid and Osorio 2000).

Family Chamidae Lamarck, 1809

Genus *Chama* Linnaeus, 1758

Type species: *Chama lazarus* Linnaeus, 1758 by subsequent designation (Children 1823; ICZN Opinion 484); Recent, Indo-Pacific.

***Chama pellucida* Broderip, 1835** (Fig. 11g–j)

*1835 *Chama pellucida* Broderip: 302–303, pl. 38, fig. 3.

1887 *Chama chilensis* Philippi: 180, pl. 37, fig. 9.

v1969 *Chama pellucida* Sowerby.–Herm: 115, pl. 5, fig. 6.

1973 *Chama pellucida* Broderip, 1835.–Marincovich: 11, fig. 10.

1998 *Chama pellucida* Broderip, 1835.–Guzmán, Saá and Ortlieb: 69.

2012 *Chama pellucida* Broderip, 1835.–Coan and Valentich-Scott: 437, pl. 144.

Material examined: SGO.PI.6500 (5 specimens, length 32 mm), MOM. Holotype of *Chama chilensis* is SGO.PI.632 (not seen).

Remarks: Philippi (1887) reported this species near Cahuil, supposedly in Pleistocene deposits. Herm (1969) listed material from several Pliocene and Pleistocene localities between Mejillones and Tongoy, all of which are

undated. Today this species lives from Ecuador to Mejillones (Marincovich 1973; Guzmán et al. 1998), suggesting that it can be used as a temperature indicator in Chile. Guzmán et al. (1998) reported this species down to 15 m depth on hard substrate.

Family Carditidae Férussac, 1822

Genus *Cyclocardia* Conrad, 1867

Type species: *Cardita borealis* Conrad, 1832 by subsequent designation of Stoliczka (1871); Recent, north-western Atlantic.

***Cyclocardia kielii* sp. nov.** (Fig. 12a–e)

Description: Shell minute, trigonal, solid. Sculpture of about 18 strong radial ribs with heavy cross bars; interspaces with fine commarginal threads. Umbones small. Hinge plate intermediate, teeth heavy. Lunule poorly defined. Length to 3 mm.

Type material: Holotype SGO.PI.6501, paratypes SGO.PI.6502, SGO.PI.6503, SGO.PI.6504 (300 specimens, maximum diameter 3 mm), SMF 339615 (100 specimens), all RQS.

Etymology: For Steffen Kiel (Göttingen), who worked on some of the Chilean bivalve material.

Remarks: Strong sculpture and a high number of radial ribs separate this species from its congeners. The sculpture is most similar to the extant *Cyclocardia bailyi* (Burch, 1944) from California (see Coan et al. 2000). However, the number of ribs is less in that species (about 15). According to Valdovinos (1999), there are six species of *Cyclocardia* living in Chile, one of them being Antarctic, and none of them exhibits a sculpture similar to *C. kielii* sp. nov.

Most mollusks from the Huenteguapi Sandstone are reworked (Le Roux et al. 2008). However, because of its abundance in the Huenteguapi Sandstone together with a complete absence from Miocene faunas (Kiel and Nielsen 2010), this species is presumably not reworked but contemporaneous with deposition. The fossil record of *Cyclocardia* is supposed to go back to the Eocene (Coan et al. 2000; Coan and Valentich Scott 2012).

Family Pharidae H. and A. Adams, 1856

Genus *Ensis* Schumacher, 1817

Type species: *Solen ensis* Linnaeus, 1758 by tautonymy; Recent, northern Europe.

***Ensis macha* (Molina, 1782)**

*1782 *Solen macha* Molina: 203.

1839 *Solen gladiolus* G.B. Sowerby I: 153, pl. 43, fig. 4.

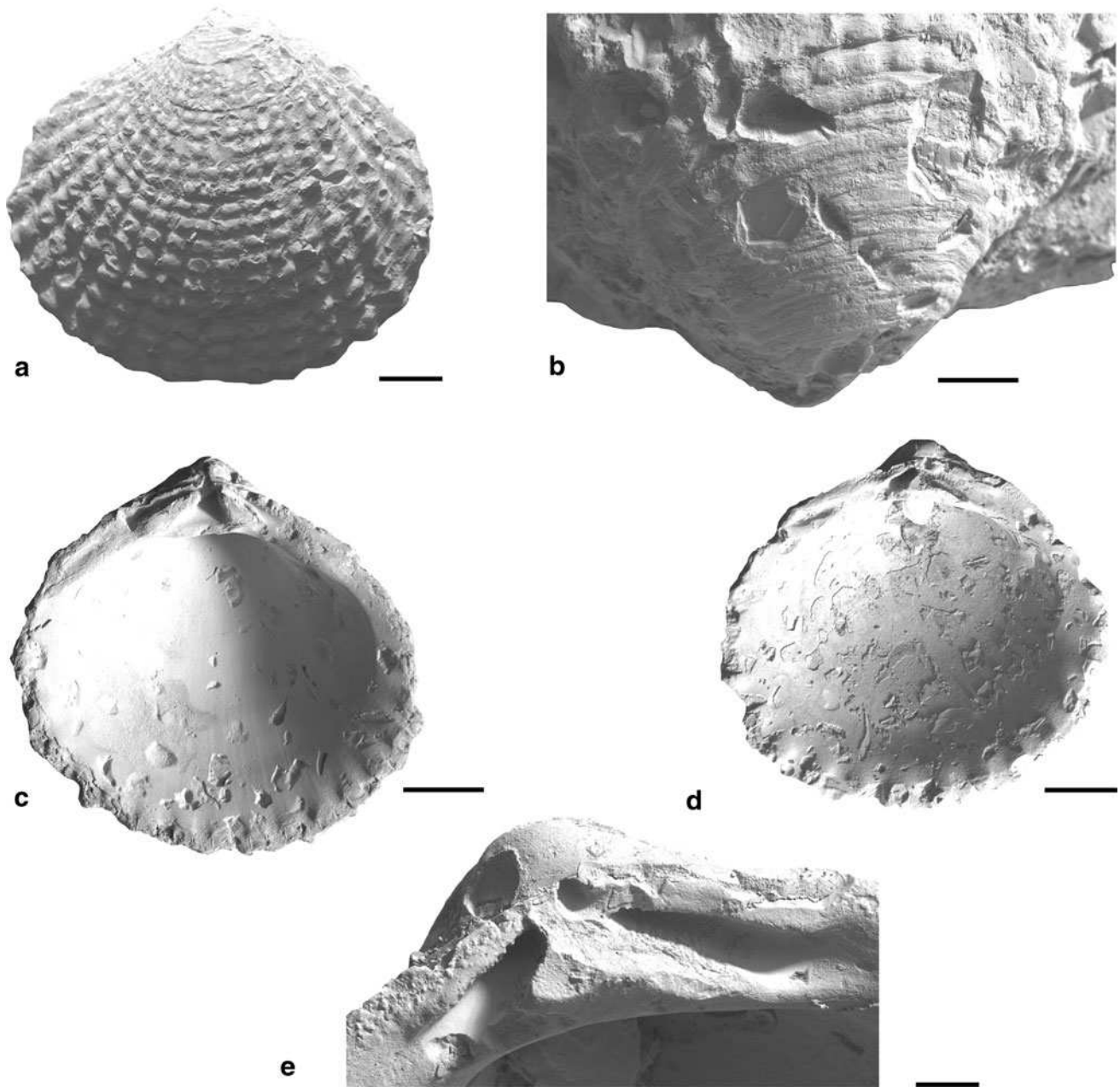


Fig. 12 a–e *Cyclocardia kielii* sp. nov. a–b SGO.PI.6502, paratype. c SGO.PI.6501, holotype. d–e SGO.PI.6503, paratype, all RQS. Scale b, e 100 µm. a, c, d 400 µm

v1887 *Solen gladiolus* Gray.–Philippi: 169, pl. 34, fig. 9.

1969 *Ensis macha* (Molina).–Herm: 119.

v2008 *Ensis macha* (Molina, 1782).–Nielsen and Valdovinos: 206, fig. 11 (synonymy).

Material examined: SGO.PI.359, La Cueva. This is the specimen identified by Philippi (1887) as *Solen gladiolus*.

Remarks: This extant species is well known because of its commercial importance. It is known since the Pliocene,

where it occurs at Coquimbo, Tongoy, Maitencillo, Horcon and La Cueva (Herm 1969).

Discussion

Comparison of Pliocene faunas

Several species in common link the Morro Mejillones fauna with that of the La Cueva Formation in central Chile,

but only few are shared with the Huenteguapi Sandstone on Arauco Peninsula (Table 1). However, the latter deposit contains few fossils in general, and a number of those are Miocene mollusks reworked from the underlying mudstone (Le Roux et al. 2008). It is expected that thorough sampling in the Huenteguapi Sandstone will produce more species and also accentuate similarities with other Pliocene units.

The occurrence of *Stramonita zinsmeisteri* in both the La Cueva Formation (DeVries 2007c) and the Huenteguapi Sandstone together with *Nacella intiforma* suggests a Pliocene age for the latter. It also extends the geographic range of *Stramonita zinsmeisteri* significantly to the south.

As listed in Table 1, several records presented here extend known stratigraphic or geographic ranges. Some species were described from southern Peru by Thomas DeVries (*Nacella intiforma*, *Chlorostoma quipua*, *Concholepas camerata*, *Acanthina triangularis*) and are here reported from Mejillones. This is their first record from Chile.

Herm (1969) cited *Chlorostoma luctuosum* from La Cueva, which according to DeVries (2007a) appears first in the late Pliocene. However, *Chlorostoma atrum* and *Prisogaster niger* were also considered as appearing in the late Pliocene (DeVries 2006, 2007a), and their first appearances are here pushed back to the early or middle Pliocene, so it would not be surprising if *C. luctuosum* would appear at Morro Mejillones or in other earlier Pliocene faunas in Chile.

Macron escalonia was only known from the La Cueva Formation and could suggest that the Morro Mejillones fauna may have a similar age. However, nothing is known about the age range of *M. escalonia*, and the presence of the possibly closely related early Miocene *M. vermeiji* (Nielsen and Frassinetti 2003) in central Chile suggests that the genus has been present in the area for some time before becoming restricted to more equatorial waters when waters cooled in the later Pliocene (Nielsen and Frassinetti 2003).

It is evident that, contrary to the modern pattern, the fauna from Mejillones is much more similar to that from southern Peru than to that from the La Cueva Formation. This may either reflect different biogeographic province boundaries than today or an age difference large enough to produce a relevant difference on the species level. Similarly, great faunal differences were reported by Nielsen and Frassinetti (2007) for Miocene Chilean volutes and resulted in the same possible explanations.

Comparison with the Navidad fauna

The Navidad Formation or equivalents underlie the Huenteguapi Sandstone and, indirectly, the La Cueva Formation. No Miocene mollusk fauna is known from the wider Mejillones area. It is notable that, except for *Incatella*, not a single genus that was abundant in the early

Miocene made it into the Pliocene. There are of course several genera still living in Chile that made their first known appearance in the early Miocene, such as *Acanthina*, *Adelomelon*, *Chlorostoma* and possibly *Fissurella*, but these are rare in the known early Miocene faunas (see Kiel and Nielsen 2010). Volutes were rather diverse in the Miocene (Nielsen and Frassinetti 2007), but except for the Pliocene or Pleistocene *Miomelon reconditus* from Guafo Island (Frassinetti 2000), the family is unknown from younger deposits. Subtropical to tropical families like Architectonicidae, Strombidae, Xenophoridae and Terebridae were present in the early Miocene Navidad, but are so far not known from younger units, as is the case in *Olivancillaria*. Genera like *Struthiochenopus* and *Testallium* apparently went extinct before the Pliocene.

Warm water fauna on Mejillones Peninsula

Ortlieb et al. (1996) reported a warm water mollusk fauna (Table 2) from several localities on Mejillones Peninsula, which, predating a marine terrace dated with U/Th and allo/isooleucine ratios as formed during MIS 9 (300–330 ka), was tentatively assigned to MIS 11 (400 ka). Neither U/Th dating nor aminostratigraphy yielded reliable results for these localities, thereby precluding direct ages for the warm water mollusks (Ortlieb et al. 1996). Following the work of DeVries and Wells (1990) based on a Holocene fauna from Peru, Ortlieb et al. (1996) suggested that this warm water fauna from Mejillones lived in sheltered lagoons, while along the exposed coast, a fauna lived that was like that living today in that region. In the context of warm water faunas, it is interesting to note that Ortlieb et al. (1996) mentioned *Mitra orientalis* from their MIS 9 and >MIS 11 deposits, but apparently did not collect it from the MIS 11. That species, however, is never abundant and may have been simply overlooked.

This same warm water fauna was assigned by Ragaini et al. (2008) to the Cuesta del Burro Member of the Pliocene La Portada Formation. According to Ragaini et al. (2008), the warm water fauna of Ortlieb et al. (1996) is mixed with a typical Pliocene fauna containing *Chlamys simpsoni* (Philippi, 1887), *Chlamys vidali* (Philippi, 1887), *Chorus blainvillei* (d'Orbigny, 1842), *Concholepas nodosa* Möricke, 1896, and *Herminespina mirabilis* (Möricke, 1896), none of which ranges younger than Pliocene, and *Fusinus remondi* (Philippi, 1887), which may reach the earliest Pleistocene (Herm 1969; DeVries and Frassinetti 2003).

My own fieldwork on Mejillones failed to confirm the results of Ragaini et al. (2008). The warm water fauna reported by Ortlieb et al. (1996) seems to be always younger than the typical Pliocene fauna, while none of the warm water taxa appears in late Pliocene beds at Cuenca

Table 1 Pliocene molluscan species from southern Peru, Morro Mejillones (MOM), La Cueva (Estero El Ganso, EGA) and the Huentequapi Sandstone (RQS)

Species	S Peru	MOM	EGA	RQS
<i>Nacella intiforma</i> ^b	●			●
<i>Chlorostoma atrum</i> ^a	●	● ^c	●	
<i>Chlorostoma quipua</i> ^b	●	● ^d		
<i>Liotia cancellata</i> ^a		● ^c		
<i>Prisogaster niger</i> ^a	●		● ^c	
<i>Diodora</i> sp.		●		
<i>Fissurella</i> (F.) spp.	●	●		●
<i>Incatella cingulatiformis</i> ^b	●	●	●	?
<i>Caecum chilense</i> ^a		● ^c		
<i>Polinices</i> cf. <i>panamaensis</i> ^a		●		
<i>Neverita obtectiformis</i> ^b			●	
<i>Trochita</i> cf. <i>trochiformis</i> ^a		●		
<i>Trochita colchaguensis</i> ^b			●	
<i>Crucibulum quiriquinae</i> ^a		●		
<i>Crepidatella dilatata</i> ^a		●	●	
<i>Priene scabrum</i> ^a	●	● ^c	●	
<i>Macron escalonia</i> ^b		● ^d	●	
<i>Oliva peruviana</i> ^a	●	●	●	
<i>Mitra orientalis</i> ^a		●		
<i>Austrofuscus fontainei</i> ^a		●		
<i>Austrofuscus steinmanni</i> ^a		●		
<i>Nassarius</i> cf. <i>gayi</i> ^a		●	●	
<i>Concholepas camerata</i> ^b	●	● ^{c,d}		
<i>Acanthina unicornis</i> ^a			●	
<i>Acanthina triangularis</i> ^b		● ^d		
<i>Crassilabrum crassilabrum</i> ^a	●	●		●
<i>Xanthochorus cassidiformis</i> ^a		●		
<i>Chorus doliaris</i> ^b	●	●	●	
<i>Chorus grandis</i> ^b	●		●	
<i>Stramonita zinsmeisteri</i> ^b			●	● ^d
<i>Bulla punctulata</i> ^a		●		
<i>Chilina</i> sp.			●	
<i>Anadara chilensis</i> ^b			●	
<i>Acar pusilla</i> ^a		● ^c		
<i>Glycymeris ovatus</i> ^a		●		
<i>Crenella decussata</i> ^a		●		●
<i>Retrotapes fuezalidae</i> ^b			●	
<i>Leukoma antiqua</i> ^a		●		
<i>Amiantis domeykoana</i> ^b			●	
<i>Diplodonta inconspicua</i> ^a		●		
<i>Semele solida</i> ^a		●		
<i>Tagelus dombeii</i> ^a		●	●	
<i>Chama pellucida</i> ^a		●		
<i>Cyclocardia kieli</i> sp. nov. ^b				●
<i>Ensis macha</i> ^a			●	

^a Recent species, ^b exclusively Pliocene species, ^c oldest record, ^d range extension

Tiburón, a locality also mentioned by Ragaini et al. (2008). Our efforts to date the warm water fauna of Ortlieb et al. (1996) resulted in strontium isotope stratigraphy ages of

about 1.01 and 1.23 Ma (Victor et al. 2011) obtained from shells coming from the Rinconada Block where most of the fauna of Ortlieb et al. (1996) was originally described, and

Table 2 Species of the thermally anomalous molluscan assemblage (RIN) in comparison with other mollusk assemblages from dated localities on Mejillones (ages from Victor et al. 2011)

Species	CMO1 (1.59 Ma)	RIN (1.1 Ma)	CMO2 (0.71 Ma)	CMO3 (0.59 Ma)
<i>Turbo (Callopoma) cf. fluctuosus</i> Wood, 1828		*		
<i>Chlorostoma atraluctuosa</i>	●	●	●	●
<i>Fissurella</i> sp.	●		●	●
<i>Diodora saturnalis</i> (Carpenter, 1864)		*		
<i>Cerithium stercusmuscarum</i> (Valenciennes, 1833)		*		
<i>Incatella cingulata</i>	●	●	●	●
<i>Polinices cf. panamaensis</i>		●		
<i>Trochita trochiformis</i>		*	●	●
<i>Crucibulum quiriquinae</i>	●	●	●	●
<i>Crepipatella dilatata</i>	●	●	●	
<i>Priene scabrum</i>	●	●	●	
<i>Austrofuscus fontainei</i>	●	●	●	
<i>Acanthina unicornis</i>	●	●	●	●
<i>Crassilabrum crassilabrum</i>		*	●	
<i>Xanthochorus cassidiformis</i>		●		●
<i>Oliva peruviana</i>		●	●	●
<i>Olivella</i> sp.		●		
<i>Cancellaria buccinoides</i> Sowerby, 1832	●			
<i>Prunum curtum</i> (Sowerby, 1832)		*		
<i>Bulla punctulata</i>		*		
<i>Stramonita chocolata</i> (Duclos, 1832)		*		●
cf. <i>Melampus</i> sp.		*		
<i>Arcopsis solida</i> (Sowerby, 1833)		*		
<i>Glycymeris ovatus</i>	●	●		
<i>Argopecten circularis</i> (Sowerby, 1835)		*		
<i>Argopecten purpuratus</i> (Lamarck, 1819)	●	*	●	●
<i>Anomia peruviana</i> (d'Orbigny, 1846)		*		
<i>Crassostrea transitoria</i> (Hupé, 1854)	●	●	●	
<i>Undulostrea megodon</i> (Hanley, 1846)		●		
<i>Leukoma</i> sp.		*	●	
<i>Transenella pannosa</i> (Sowerby, 1835)				●
<i>Donax peruvianus</i> (Deshayes, 1855)		*		
<i>Mactra velata</i> (Philippi, 1849)		*		
<i>Semele solida</i>				●
<i>Tagelus dombeii</i>		●		●
<i>Chama pellucida</i>	●		●	●
<i>Trachycardium (Mexicardia) procerum</i> (Sowerby, 1833)		●		
<i>Cyclocardia cf. spurca beebei</i> (Hertlein, 1958)		*		

Bold: Warm water species of Ortlieb et al. (1996); ● own record; * taken from Ortlieb et al. (1996)

from where the taxa listed and figured by Ortlieb et al. (1996) were confirmed. Therefore, although it apparently cannot be related to MIS 11 (400 ka), the fauna is much younger than that from Cuenca Tiburón, for which an age of 2.8 Ma was presented by Ishman et al. (2003). None of the terraces dated by Victor et al. (2011), neither those older nor younger than the Ortlieb et al. (1996) deposit with warm water mollusks, contain any of the unusual

warm water species (Table 2) or the typical Pliocene species listed above.

Understanding of stratigraphy and faunal evolution at Mejillones is still fragmentary, and it would not be surprising to find a certain extent of overlap in these faunas. It is, however, interesting to note that the 3.4 Ma fauna from Morro Mejillones contains mostly extant species, including many aragonitic ones, while the apparently younger fauna

from Cuenca Tiburón consists mostly of typical Pliocene species, but exclusively aragonitic species are not preserved at the latter locality.

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