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The Miocene Architectonicidae (Gastropoda) of Chile

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with 5 figures

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Abstract: Three new species of Architectonicidae Heliacinae, *Heliacus* (*Torinista*) *chonos*, *Heliacus* (*Grandeliacus*) *antu* and *Solatisonax bieleri*, are described. These include the first reports of *Grandeliacus* and *Solatisonax* from Chile. *Solarium australe* PHILIPPI, 1887 is an earlier name for *Heliacus* (*Torinista*) *bahamondei* FRASSINETTI & COVACEVICH, 1981, but is a junior homonym of *S. australe* PHILIPPI, 1849. Type material and new specimens of the five previously described architectonicid species from Chile are described and figured for comparison. Together with other gastropod taxa from the same deposits, Architectonicidae provide evidence for tropical to subtropical water temperatures in central Chile during the early Miocene.

Keywords: Gastropoda, Architectonicidae, *Heliacus*, *Solatisonax*, Miocene, Chile, southeast Pacific

Kurzfassung: Drei neue Arten der Architectonicidae Heliacinae werden beschrieben: *Heliacus* (*Torinista*) *chonos*, *Heliacus* (*Grandeliacus*) *antu* und *Solatisonax bieleri*. Diese beinhalten die ersten Nachweise von *Grandeliacus* und *Solatisonax* aus Chile. *Solarium australe* PHILIPPI, 1887 ist ein älterer Name für *Heliacus* (*Torinista*) *bahamondei* FRASSINETTI & COVACEVICH, 1981, aber auch ein jüngeres Homonym von *S. australe* PHILIPPI, 1849. Typusmaterial und neue Exemplare der fünf bisher beschriebenen Architectonicidenarten von Chile werden zum Vergleich beschrieben und abgebildet. Zusammen mit anderen Gastropodenarten aus denselben Ablagerungen liefern die Architectonicidae Hinweise auf tropische bis subtropische Wassertemperaturen in Zentralchile während des unteren Miozäns.

Schlüsselwörter: Gastropoda, Architectonicidae, *Heliacus*, *Solatisonax*, Miozän, Chile, Südostpazifik

Introduction

Architectonicidae, commonly called sundials, are a family of subtropical to tropical marine gastropods (BIELER 1984) with long-lived free-swimming larval stages (BIELER & PETIT 2005) that allow rapid dispersal over long distances. All modern architectonicids feed on hexacorallian coelenterates and occur at all depths provided that suitable prey species are present (BIELER & PETIT 2005). The Recent Indo-Pacific species of Architectonicidae were reviewed by BIELER (1993) who previously revised the genus-level taxonomy of the family (BIELER 1985a, b) and his classification is followed here.

The first architectonicid described from the Chilean Miocene was *Solarium australe* PHILIPPI, 1887. Later, FRASSINETTI & COVACEVICH (1981a) transferred *Solarium australe* to *Heliacus* (*Torinista*) and described *Heliacus* (*Torinista*) *taverai* and *Heliacus* (*Torinista*) *bahamondei*. In the second part of their series, FRASSINETTI & COVACEVICH (1981b) reported *Architectonica karsteni* RUTSCH, 1934 from Chile, extending its range from the Caribbean into the south-east Pacific, and in the third part (FRASSINETTI & COVACEVICH 1982) the subgenus *Intitectonica* and the species *Architectonica* (*Intitectonica*) *inti* and *Discotectonica navidadensis* were described. DEVRIES (1985) later reported fossil *Architectonica karsteni* from Peru, thus closing the biogeographical gap, and showed that this species was and still is the coexisting deeper water sister taxon of *Architectonica nobilis*. Here we present a review of the known Chilean species and describe three further species as new and a fourth one in open nomenclature, thereby extending the geographical range of the family much further to the south than the Navidad Formation (Figure 1).

Description of fossil localities

Navidad Formation, central Chile

(Figure 2A)

A new stratigraphic concept for the Neogene deposits of the Navidad area has been proposed recently by ENCINAS et al. (2006). The age of the Navidad Formation was revised to late Miocene (Tortonian) to early Pliocene (Zanclean) by FINGER et al. (2007), while the early Miocene fauna (DEVRIES & FRASSINETTI 2003) has been shown by them to be reworked from older strata. The early Miocene age for the mollusks has been

confirmed by strontium isotope data (NIELSEN & GLODNY 2006). However, shallow and deeper water mollusk faunas can be distinguished in sandstones and mudstones respectively. North of the Río Rapel (locality abbreviation RAP) a block fall of dark grey to reddish-brown sandstone has been sampled (see NIELSEN et al. 2004). At Cerro Los Pololos (CLP), FRASSINETTI & COVACEVICH (1981a) measured a short section and listed the rich associated fauna of bivalves, gastropods, scaphopods, bryozoans and shark teeth. Several lithologies exist at Punta Perro (see FINGER et al. 2007), of which mainly siltstones of the intertidal platform (PPP) and sandstones (PPN) in the coastal bluffs further south have been distinguished, the latter yielding the specimen discussed here. The section at Punta Alta (PTA) was also measured by FRASSINETTI & COVACEVICH (1982) and the fossil-rich mudstone contains relatively large oysters, scaphopods and solitary corals. The locality about 1 km north of Matanzas (MAP) was described by FRASSINETTI & COVACEVICH (1993), who sampled today's intertidal platform. A very similar fauna was recovered about 2 m higher in the cliff (MAT) from greenish sandstone (NIELSEN et al. 2004).

Ranquil Formation, Peninsula Arauco, south-central Chile
(Figure 2B)

On the modern intertidal flat north of Ranquil at Punta Huenteguapi, brown sandstones with intercalated beds of coarse glauconite-rich greenish sandstone (RAN) occur. These sandstones contain an early Miocene shallow-water mollusk fauna (NIELSEN & GLODNY 2006) similar to that of the Navidad Formation (NIELSEN 2004, 2005b; NIELSEN et al. 2004), but microfossils indicate, as in the Navidad Formation, a late Miocene to early Pliocene age and bathyal depth for the surrounding sediments (FINGER et al. 2007).

Lemo Island, Chonos Archipelago, southern Chile
(Figure 2C)

Lemo Island is a small promontory which is located close to the southeastern coast of Ipún Island; east of it lies Stokes Island. The faunas of Ipún Island (FRASSINETTI 2004) and Stokes Island (FRASSINETTI 2001) are considered to be of the same age as that of the Navidad Formation (see NIELSEN & FRASSINETTI 2007). The studied samples come from the western part of the island. Locality numbers 041083.3 and 310884.2 come from todays marine intertidal platform and correspond to silty sandstone with abundant traces of bioturbation, whereas locality numbers 041083.4 and 310884.3 come from the coastal bluffs above the coastal abrasion platform.

Material and Methods

Macrofossils and sediment samples were collected in the field. In the species descriptions the terminology of Bieler (1993) is used for easier comparison even though the term rib for spiral cords is a bit misleading. Material is deposited in the Sección Paleontología, Museo Nacional de Historia Natural, Santiago, Chile (SGO.PI) and the Malacology Section, Senckenberg Museum Frankfurt, Germany (SMF).

Systematic paleontology

Family Architectonicidae GRAY, 1850

Subfamily Architectonicinae GRAY, 1850

Genus *Architectonica* RÖDING, 1798

Type species: *Trochus perspectivus* LINNAEUS, 1758 by subsequent designation of GRAY (1847); Recent, Indo-Pacific.

Architectonica karsteni RUTSCH, 1934

Figs. 3A-F

1934 *Architectonica nobilis karsteni* RUTSCH: 44, pl. 1 figs. 8-10.

1959 *Architectonica* (*Architectonica*) *nobilis karsteni* – WOODRING: 167-168, pl. 30 figs. 1-3.

1965 *Architectonica* (*Architectonica*) *nobilis karsteni* – JUNG: 488, pl. 64 figs. 8-10.

1981 *Architectonica* (*Architectonica*) *nobilis karsteni* – FRASSINETTI & COVACEVICH: 149, figs. 2a-2c, 4a-4c.

1985 *Architectonica* (*Architectonica*) *karsteni* – DEVRIES: 282, figs. 2-12, 15-16, 18, 20.

1985 *Architectonica* (*Architectonica*) *nobilis karsteni* – FISCHER: 194, pl. 1 fig. 1.

1993 *Architectonica karsteni* – BIELER: 87, fig. 70.

Description (modified from BIELER 1993): Teleoconch medium-sized to large, diameter of specimens in collections usually 17-34 mm at 4 3/4 to 6 3/4 whorls. Shape fairly high-spired cone-shaped, with whorls inflated, umbilicus moderately wide (ca. 16.5% of shell diameter). Upper surface sculpture with subsutural rib

distinctly separated, upper midrib and lower midrib of about equal strength. Peripheral sculpture with strong peripheral ribs, with upper peripheral rib almost as prominent as lower peripheral rib, upper peripheral rib usually wider than lower peripheral rib, similar to midrib (often one ± fine additional spiral rib between the two). Upper point of whorl attachment on central to upper part of lower peripheral rib, therefore upper edge of lower peripheral rib ± visible in suture. Upper surface and periphery crossed by deeply incised oblique axial grooves, resulting in a general gemmate appearance on early whorls, becoming almost smooth on last whorl of larger specimens. Base with strong infraperipheral rib, basal field of larger specimens without distinct spiral ribs, but many specimens with 4-6 weakly developed spiral grooves. Younger specimens with 5-6 ± smooth, faintly separated spiral ribs, crossed by radial plications, stronger towards umbilicus, wide proxumbilical rib not separated or weakly separated from basal field, one wide, distinctly separated, irregular nodulose spiral rib (umbilical crenae) surrounding umbilicus. Columellar wall forming almost straight inner lip with plications, with deepest groove in umbilical crenae overhanging umbilicus. Umbilical surface smooth.

Dimensions: SGO.PI.5028 height 14.1 mm, diameter 24.8 mm, umbilicus diameter 5.4 mm. SGO.PI.6434 height 2.5 mm, diameter 5.7 mm.

Type material: Holotype Naturhistorisches Museum Basel H1836; Miocene, Cantaure Formation, Paraguaná Peninsula, Venezuela.

Other material examined: SGO.PI.5028 (ex 3122, PPN, 1 specimen), SGO.PI.6434 (RAP, 1 specimen).

Occurrence: Miocene: Costa Rica (FISCHER 1985), Panama (WOODRING 1959) to Navidad Formation, central Chile (FRASSINETTI & COVACEVICH 1981b). Recent: Baja California to Peru and Galapagos Islands (DEVRIES 1985; BIELER 1993).

Remarks: *Architectonica karsteni* has long been regarded as a typical Central American Miocene species (e.g., WOODRING 1959). However, a much more southward-extended occurrence was later reported by FRASSINETTI & COVACEVICH (1981b). The geographical gap was bridged by DEVRIES (1985), who found this species in Miocene deposits in Peru and gave a full description of it based on fossil and Recent material. DEVRIES (1985) was also the first to recognize it in museum collections of Recent material. The Recent and fossil occurrences have been revised and summarized by BIELER (1993). The fossil record of *A. karsteni* in southern Peru ranges

from late Early Miocene to late Late Miocene and it also occurs in latest Pliocene deposits of northern Peru (DEVRIES pers. commun. 2006).

Genus *Intitectonica* FRASSINETTI & COVACEVICH, 1982

Type species: *Architectonica* (*Intitectonica*) *inti* FRASSINETTI & COVACEVICH, 1982 by original designation; Navidad Formation, central Chile.

Intitectonica inti (FRASSINETTI & COVACEVICH, 1982)

Figs. 3G-N

1982 *Architectonica* (*Intitectonica*) *inti* FRASSINETTI & COVACEVICH: 102-104, figs. 1-9.

Description: Shell moderately large, depressed conical; umbilicus medium-sized with weak umbilical rib. Base convex; keel-forming lower peripheral rib rounded, aperture rhomboidal. Teleoconch of six and a half to seven whorls, separated by incised suture; dorsal side of whorls generally almost straight-sided, early whorls slightly convex, late whorls slightly concave; upper point of whorl attachment below median line of lower peripheral rib of proceeding whorl. Very characteristic weak spiral depression present towards external rim of basal surface, before the lower peripheral rib. Protoconch unknown, early spire-whorls eroded. Sculpture on upper surface consisting of rounded lower peripheral rib, subsutural rib and upper peripheral rib next strongest and of equal width, one finer rib between subsutural rib and suture, beginning at about 3 whorls; between subsutural rib and upper peripheral rib are four subequal ribs are present, of which the first is slightly weaker and begins as a secondary thread, the second and fourth are presumably equivalent to upper and lower midribs and the third begins as a secondary thread but becomes later as strong as the midribs; narrow flattened nodules produced by weakly incised growth increments present on whole upper surface, slightly more prominent on subsutural rib. On some specimens more spiral threads are present. Additionally, fine oblique growth lines are present. Numerous fine ribs on base, about 25 on holotype (SGO.PI.4997); eight or nine inner ribs wider, showing much more pronounced nodosity than outer ones. Those situated in the external spiral depression, next to the lower peripheral rib, are narrow, dense, fine spiral threads. Additionally, fine axial threads and striae are present, concave towards the aperture, oblique, somewhat irregular, and together with the spiral ornamentation form a

delicate reticulate pattern. Umbilical rib forming strong crenae, about 28 on penultimate whorl of SGO.PI.4996, swollen and not well defined in last whorl of paratype (SGO.PI.4998). The visible part of the lower peripheral rib shows small elongated nodes on early whorls, disappearing towards the end of the last whorl. Umbilicus diameter about 30.5 to 32.5 %. Surface of umbilical wall weakly convex and covered by fine concave growth lines, accentuated on the final part of the last whorl, and very low, weak spiral striae. The first ventral spiral rib clearly rises above the umbilical wall. The final part of the last whorl of the paratype (SGO.PI.4998) shows a general smoothing of the spiral ornamentation while the growth lines become more accentuated.

Dimensions: Holotype diameter 25.4 mm, height 9.7 mm, umbilicus diameter 8.2 mm (32.3%). Paratype diameter ~31.5 mm, height ~15 mm, umbilicus diameter 10 mm (31.5%). Specimen SGO.PI.4996 diameter about 20.5 mm at six whorls, height 10.1 mm, umbilicus diameter 6.3 mm (30.7% of shell diameter).

Type material: Holotype SGO.PI.4997 (ex 3120, Matanzas), paratype SGO.PI.4998 (ex 3121, Matanzas). The Holotype was loaned to the late Tom Garrard, but cannot be found at the Australian Museum (Ian Loch personal communication 2006).

Other material examined: SGO.PI.4996 (1 specimen, Matanzas).

Occurrence: MAP; Navidad Formation, central Chile.

Remarks: When FRASSINETTI & COVACEVICH (1982) introduced *Intitectonica*, they noted that it seems most closely related to *Solatisonax* Iredale, 1931. According to FRASSINETTI & COVACEVICH (1982), *Intitectonica inti* differs from the Australian species of *Solatisonax* described by GARRARD (1977) in not having a finely nodulate dorsal rib in the centre of the first whorl, in having a rounded rather than a sharply edged periphery, and in not having a nodulate umbilical rib. However, a weak umbilical rib is present in the paratype of *Intitectonica inti*. The additional specimen SGO.PI.4996 was thought to represent a different species but not included in the original report of FRASSINETTI & COVACEVICH (1982). It shows the ornamentation much better than the type material, although the ventral side is covered by a thin layer of callus.

Genus *Discotectonica* MARWICK, 1931

Type species: *Architectonica balcombensis* FINLAY, 1927 by original designation (= *Solarium acutum* TENISON-WOODS, 1879, not *Architectonica acuta* CONRAD, 1854); middle Miocene, Victoria, Australia.

Discotectonica navidadensis (FRASSINETTI & COVACEVICH, 1982)

Figs. 4A-C

1982 *Architectonica* (*Discotectonica*) *navidadensis* FRASSINETTI & COVACEVICH: 104-106, figs. 10-17.

Description: Shell small, depressed conical; base convex, periphery with sharp keel, aperture subquadrate. Teleoconch of four and a half to five whorls, separated by an incised suture. Suture placed just below median line of lower peripheral rib. Umbilicus very wide, surrounded by up to 17 strong tubercles which are rounded at the top and well separated from each other. Dorsal ornamentation consists of a clearly nodded, strong lower peripheral rib forming peripheral keel, nodose upper peripheral rib and subsutural rib and up to three spiral threads between the latter, showing incipient nodosity; axial ornamentation formed by delicate growth lines. Upper peripheral rib more prominent and more strongly noded than subsutural rib. Ventral surface, including the base of the lower peripheral rib in a few specimens, with numerous very fine spiral and axial striations, which together form a submicroscopic reticulated ornamentation. On this surface a smooth narrow rib is present near the lower peripheral rib. Umbilicus diameter 3.0 mm in the holotype, corresponding approximately to 45% of the total shell diameter; it is surrounded by 17 very strong nodes from which elongated radial folds begin, but don't extend to the periphery. Interior umbilical wall bearing nodose umbilical rib which projects over the line determined by the umbilical nodes.

Dimensions: Holotype diameter 6.7 mm, height 3.1 mm, umbilical diameter 3.0 mm. Paratype SGOPI.3117 diameter 6.2 mm, height 2.9 mm, umbilical diameter 2.6 mm. Paratype SGOPI.3664 diameter 5.0 mm.

Type material: Holotype SGO.PI.3116, paratypes SGO.PI.3117, SGO.PI.3664, SGO.PI.4162, all from Punta Alta.

Type locality: PTA.

Occurrence: PTA; Navidad Formation, central Chile.

Remarks: *Discotectonica navidadensis* differs from the type species of this genus, *D. balcombensis*, by having a wider lower peripheral rib and dorsal ornamentation with of up to five primary spiral ribs compared to nine or more in the Australian species. The lower peripheral rib of *D. navidadensis* is wider than in other species assigned to *Discotectonica*, but the shell agrees in all other characters, and this single peripheral rib is a diagnostic character of *Discotectonica*, so we interpret it as an unusual species of *Discotectonica* with a wide periphery. It must also be noted that the available material consists of very small specimens which may represent juveniles.

Subfamily Heliacinae COTTON & GODFREY, 1933

Genus *Heliacus* D'ORBIGNY, 1842

Type species: *Solarium herberti* DESHAYES, 1830 by monotypy (= *Trochus cylindricus* GMELIN, 1791); Recent, Atlantic.

Subgenus *Torinista* IREDALE, 1936

Type species: *Torinista popula* IREDALE, 1936 by original designation (= *Solarium implexum* MIGHELS, 1845); Recent, Indo-Westpacific including northern New Zealand.

Heliacus (*Torinista*) *taverai* FRASSINETTI & COVACEVICH, 1981

Figs. 4D-L

1981 *Heliacus* (*Torinista*) *taverai* FRASSINETTI & COVACEVICH: 39, figs. 5-8.

Description: Shell medium-sized, conical, moderately high, with a convex base; umbilicus medium-sized; flattened contour with double keel produced by lower peripheral rib and infraperipheral rib; aperture rounded. Teleoconch with a minimum of five whorls, diameter 12.2 mm. Axial ornamentation present on both surfaces. Suture fine, incised; upper point of whorl attachment in the middle of lower peripheral keel. Protoconch unknown. Dorsal ornamentation, at a diameter of 3.3 mm – the beginning of the second spire-whorl – of four

dorsal granular spiral ribs; subsutural rib and upper peripheral rib being strongest, midribs narrower and of similar width. At a diameter of 6.0 mm – the beginning of the third spire-whorl – the insertion of two spiral threads is already notable, one between the lower midrib and the upper peripheral rib and the other between the upper peripheral rib and the lower peripheral rib; both threads increase in width and prominence down the shell. Above the last whorl, and at a diameter of 10.0 mm, the insertion begins of a last spiral thread between the midribs. This development of dorsal spiral ornament leads to six unequal dorsal ribs at the end of the last whorl. The subsutural rib is the widest, most prominent (comparable with the width of the lower peripheral rib) and remains separated from the suture by a narrow depression. Following, in descending width, are the upper peripheral rib, the lower midrib, the upper midrib, the former thread between upper peripheral rib and lower peripheral rib and the thread between lower midrib and upper peripheral rib. The ribs are crossed by prosocline radial striae that form granules on the ribs. The ventral surface bears an umbilical rib covered by 16-17 strong nodes. A broad furrow, weakly defined due to the worn surface of the holotype, separates it from the first ventral spiral rib, slightly wider than the umbilical rib and covered by numerous elongated nodes, about twice as many as on the umbilical rib. The rest of the ventral surface bears five narrow spiral ribs and two threads. The threads lie between the third and fourth ribs and between the fifth rib and the infraperipheral rib; this last one is the narrowest and appears latest. The ventral surface is covered by dense fine radial striation, which determines the weak granulosity of the five ventral ribs and spiral threads. A smooth projecting spiral ridge is present on the internal wall of the aperture, situated on the infreperipheral rib of the previous whorl. The lower peripheral rib is more prominent than the infraperipheral rib, the latter occupying a more internal position. The space between the two bears two well differentiated, finely granulated spiral threads. The umbilicus has a diameter of approximately 3.4 mm, or 27.9% of the shell diameter. The surface of the umbilical wall is covered with striae and threads, concave towards the aperture. In its upper third a change in gradient is produced, beginning at a carina, bending its surface towards the exterior until reaching the position of the interior suture.

Dimensions: Holotype, diameter 12.2 mm, height 7 mm, umbilicus diameter 3.4 mm. SGO.PI.4172 diameter 11.9 mm, height 5.3 mm. Diameter of SGO.PI.6435 is 7.6 mm

Type material: Holotype SGO.PI.4995 (ex 3118, MAP).

Other material examined: SGO.PI.4172 (MAP, 1 specimen), SGO.PI.6435 (MAT, 1 specimen).

Type locality: MAP.

Occurrence: MAP, MAT; Navidad Formation, central Chile.

Remarks: FRASSINETTI & COVACEVICH (1981a) separated *Torinista taverai* from the type species of the subgenus, *Torinista popula* (= *Heliacus implexus*), through the presence of only one spiral thread between lower peripheral rib and infraperipheral rib in the latter, while there are tow in *T. taverai*. *Torinista taverai* also has more dorsal and ventral spiral ribs than *T. implexus*. FRASSINETTI & COVACEVICH (1981a) stated that *Solarium australe* PHILIPPI, 1887 (not of PHILIPPI, 1849), which is below synonymised with *Torinista bahamondei* from Navidad, central Chile, differs by having four dorsal ribs. However, this is also true for *T. taverai*. A comparison between both species is given below under *T. bahamondei*.

Heliacus (*Torinista*) *bahamondei* FRASSINETTI & COVACEVICH, 1981

Figs. 4M-Q

1887 *Solarium australe* PHILIPPI: 81, pl. 9 fig. 12 (junior primary homonym of *S. australe* PHILIPPI, 1849).
1981 *Heliacus* (*Torinista*) *australe* – FRASSINETI & COVACEVICH: 38, fig. 2.
1981 *Heliacus* (*Torinista*) *bahamondei* – FRASSINETTI & COVACEVICH: 41, figs. 9-16.

Description: Shell small, conical, depressed, with a convex base; umbilicus narrow; with a double keel produced by lower peripheral rib and infraperipheral rib; aperture subquadragular. Teleoconch of four whorls with a diameter of 5.7 mm, which remain separated by a fine and incised suture and are covered by four nodose dorsal spiral ribs. Axial ornamentation present on dorsal and ventral surfaces. Protoconch eroded, slightly depressed at its beginning. Dorsal ornamentation consists basically of four nodose spiral ribs of different width. The subsutural rib is the widest and bears 35 rectangular nodes with blunt to flattened surfaces (holotype SGO.PI.4999); next widest is the upper peripheral rib, then the upper midrib and last the lower midrib, which is the least developed and begins as a weak thread at the beginning of the third whorl. On the base a prominent umbilical rib with 10-12 strong tubercles is present; it projects above the general level occupied by the other basal spiral ribs. It is enclosed by a deep spiral grove, slightly wider than the remaining basal grooves and separating it from the first ventral spiral rib. The latter has 20-21 strong radial corrugations which, weakened and with new divisions, continue unto the third ventral rib; later they divide into numerous radial threads and striae

with a fasciculate pattern, until reaching the infraperipheral rib. The holotype bears four ventral ribs at a diameter of 3.7 mm. The outer rib is very depressed and weak and fasciculated striation and threads predominate in this space. At a diameter of 5.7 mm two to three spiral threads are already intercalated: one between the third and fourth rib and another between the fourth rib and the infraperipheral rib; in this latter space a third finer spiral thread appears next to the infraperipheral rib. At a diameter of 7.7 mm (paratype SGOPI.5000) five spiral ribs of distinct width and two threads next to the infraperipheral rib are present. In decreasing order the most prominent is the first, continuing with the third, the second, the fifth, and the fourth (the second and fifth are almost equal). The nodosity covering them is better defined on the three inner ribs, while the two outer ones are traversed by fine axial striae and threads, which continue unto the periphery. The lower peripheral rib is wider and more prominent than infraperipheral rib and covered by wider and stronger nodes. The space between both is traversed by a well-defined central spiral thread and fine axial striae. The upper point of whorl attachment is below the lower peripheral rib. In the holotype and one of the paratypes (SGO.PI.5000) the diameter of the umbilicus is approximately 23% of the maximum shell diameter (22.8% and 23.3% respectively).

Dimensions: Holotype SGO.PI.4999, diameter 5.7 mm, height 2.8 mm, umbilicus diameter 1.3 mm. Paratype SGO.PI.5000, diameter 7.7 mm, height 4 mm, umbilicus diameter, 1.8 mm. Paratype SGO.PI.5001, diameter 8.9 mm, height 4.3 mm.

Type material: The holotype of *Solarium australe* could not be located in the Philippi collection, as was already noted by FRASSINETTI & COVACEVICH (1981a). Also the additional specimen, reported by PHILIPPI (1887) as probably belonging to another species, is not present. The holotype SGO.PI.4999 (ex 3123), and two paratypes SGO.PI.5000 (ex 3124) and SGO.PI.5001 (ex 3125) exist of *Heliacus* (*Torinista*) *bahamondei* (all from Cerro Los Pololos). The holotype of *Heliacus* (*Torinista*) *bahamondei* is here designated as the neotype of *Solarium australe* PHILIPPI, 1887.

Type locality: The type locality of *Solarium australe* was given broadly as “Navidad.” Because of the neotype designation, it is now restricted to the type locality of *Heliacus* (*Torinista*) *bahamondei* (FRASSINETTI & COVACEVICH 1981a): Cerro Los Pololos, Navidad Formation, central Chile.

Occurrence: Cerro Los Pololos; Navidad Formation, central Chile.

Remarks: The name *Solarium australe* is a junior primary homonym of a Recent species named by Philippi himself. The designation of the holotype of *Heliacus* (*Torinista*) *bahamondei* as neotype of *Solarium australe* PHILIPPI, 1887 (not *Solarium australe* PHILIPPI, 1849, = *Architectonica perspectiva*) places the two species in objective synonymy. *Heliacus* (*Torinista*) *bahamondei* FRASSINETTI & COVACEVICH, 1981, becomes the valid name for *Solarium australe* PHILIPPI, 1887 from Navidad.

FRASSINETTI & COVACEVICH (1981a) separated *Torinista bahamondei* from *T. taverai* through its smaller size, fewer dorsal and ventral spiral ribs, stronger ornamentation and two spiral keels at the periphery between which a single spiral thread is present. FRASSINETTI & COVACEVICH (1981a) noted that *Torinista bahamondei* was "very close" to *Solarium australe* but felt that not sufficiently was know about the latter for a more detailed comparison. We see no evidence which justifies separation of these two names and consequently synonymy them.

Heliacus (*Torinista*) *chonos* n. sp.

Figs. 4R-U

Diagnosis: Shell small, lens-shaped, with moderately wide umbilicus. Dorsal surface sculpture of four flattened ribs, double keel formed at periphery by two ribs with two to three fine additional threads between, ventral sculpture of seven ribs, increasing in width towards the umbilicus, 17 to 19 crenae on umbilical rib.

Description: Shell small, 5.8 mm in diameter at 2.5 adult whorls, teleoconch very low lens-shaped with slightly convex whorls and a moderately wide umbilicus (32.5% of shell diameter). Protoconch bulging slightly above teleoconch, surface smooth. Whorls flat, upper point of attachment at underside of lower peripheral rib. Sculpture on upper side with subsutural rib widest, becoming wider and more flattened on second whorl, subsutural rib followed by two narrow midribs, lower midrib slightly narrower than upper midrib, upper peripheral rib wider than upper midrib but narrower than subsutural rib. Narrow, flattened nodules produced by weakly incised growth increments present on whole upper side. Peripheral double keel formed by lower peripheral rib and infraperipheral rib, lower peripheral rib stronger than infraperipheral rib, two to three very fine additional threads present between lower peripheral rib and infraperipheral rib. Base with seven ribs, increasing in width towards the umbilicus, umbilical rib with 17-19 strong umbilical crenae on last whorl, umbilical side of columellar wall smooth except for axial growth increments.

Dimensions: Holotype SGO.PI.6436 diameter 3.7 mm. Paratype 6094.1 diameter 3.2 mm. Diameter of largest specimen 5.8 mm.

Type material: Holotype SGO.PI.6436, 20 paratypes SGO.PI.6094, all from Lemo Island, locality 310884.2

Other material examined: SGO.PI.6090 (six specimens), locality 041083.4, Lemo Island.

Type locality: SGO.PI locality 310884.2, Lemo Island.

Etymology: After the Chonos Archipelago, of which Lemo Island is part.

Occurrence: Lemo Island, southern Chile.

Remarks: The small size of the specimens from Lemo Island suggests that they represent juveniles. However, these small specimens are relatively abundant and no larger specimens have been found so they apparently represent a very small species. *Heliacus* (*Torinista*) *chonos* differs from other Chilean architectonicids chiefly by its small size. It can be distinguished from similarly sized specimens of *Heliacus* (*Torinista*) *taverai* by the unequal width of its midribs and the lower spire. *Heliacus* (*Torinista*) *bahamondei* has a narrower umbilicus and fewer umbilical crenae than the other two species.

Subgenus *Grandeliacus* IREDALE, 1957

Type species: *Grandeliacus mortensenae* IREDALE, 1957 by original designation (= *Trochus stramineus* GMELIN, 1791); Recent, Indo-Westpacific.

Heliacus (*Grandeliacus*) *antu* n. sp.

Figs. 5A-K

Diagnosis: Medium-sized, rounded cone-shaped shell with moderately wide umbilicus. Dorsal sculpture of four flat spiral ribs, rounded double peripheral keel formed by a strong lower peripheral rib and a weaker infraperipheral rib; basal sculpture of 6 flat ribs, differing markedly but not ordered in width.

Description: Shell medium sized, diameter 11.3 mm at 4.5 whorls, teleoconch rounded depressed cone-shaped with moderately wide umbilicus (19% of shell diameter). Protoconch abraded, so no sculpture is known. Whorls weakly bulging, upper point of attachment at underside of lower peripheral rib. Sculpture on dorsal surface with subsutural rib widest, one fine spiral thread between subsutural rib and suture, beginning at about 3.5 whorls, subsutural rib followed by two midribs, upper midrib slightly narrower than subsutural rib, lower midrib narrow, upper peripheral rib almost as wide as upper midrib but more prominent, one fine spiral thread between upper peripheral rib and lower peripheral rib, narrow flattened nodules produced by weakly incised growth increments present on whole upper side, most prominent on subsutural rib. Peripheral double keel formed by lower peripheral rib and infraperipheral rib, lower peripheral rib stronger than infraperipheral rib, one fine additional rib between lower peripheral rib and infraperipheral rib, one fine spiral thread between lower peripheral rib and additional rib, two fine spiral threads between additional rib and infraperipheral rib. Base with 6 different ribs, umbilical rib bearing 13-14 crenae on last whorl, second and fourth rib widest, second rib nodose, fourth rib flat and smooth apart from growth increments, third rib almost half as wide and almost smooth, sixth rib like additional rib at periphery, fifth rib double of sixth rib, with spiral groove giving it appeareance of double rib, one spiral thread between fourth and fifth rib, nearer to fourth one; interspaces between fifth and sixth rib and sixth and lower peripheral rib wide with fine spiral lirae; umbilical side of columellar wall smooth except for axial growth increments.

Dimensions: Holotype SGO.PI.6430 diameter 14.5 mm, height 9 mm. Paratype 1 SGO.PI.6431 diameter 11.3 mm, height 7.9 mm. Paratype 2 SGO.PI.6432 diameter 8.5 mm, height 5.3 mm. Paratype 3 SMF 329101 diameter 10.4 mm, height 6.4 mm.

Type material: Holotype SGO.PI.6430, 3 paratypes SGO.PI.6431, SGO.PI.6432, SMF 329101, all RAP.

Type locality: RAP.

Etymology: Antu, mapudungún (language of the Mapuche) for sun. Based on the sun-shaped shell.

Occurrence: RAP; Navidad Formation, central Chile.

Remarks: *Heliacus* (*Grandeliacus*) *antu* has a double-keeled periphery with a fine thread between the keels, agreeing with its placement within *Heliacus* (*Torinista*) or *H.* (*Grandeliacus*). Also, its six basal spiral ribs agree with both subgenera. However, it differs from the definition of both in having basal spiral ribs which do not increase in width towards the umbilicus but having irregularly wide, flat and almost smooth basal ribs. Generally, all subgenera of *Heliacus* have basal ribs increasing in width towards the umbilicus (BIELER 1993), but some species fuse ribs or secondary threads and may therefore deviate from this rule (BIELER pers. commun. 2004). Due to its sculpture, including a thread between upper and lower peripheral ribs, and its rounded whorls, a placement in *Grandeliacus* is favoured (see BIELER 1985b). Also the size agrees better with *Grandeliacus*; species of *Torinista* are rarely larger than 12 mm (Bieler 1985b).
The type species, *Heliacus* (*Grandeliacus*) *stramineus*, has been recorded from the late Pliocene and lower Pleistocene of Java (VAN REGTEREN ALTENA 1938; DHARMA 2005), otherwise the fossil record of this subgenus is rather poor.

Genus *Solatisonax* IREDALE, 1931

Type species: *Solatisonax injussa* IREDALE, 1931 by original designation; Recent, Australia.

Solatisonax bieleri n. sp.

Figs. 5L, M

Diagnosis: Medium-sized, lens-shaped shell with moderately wide umbilicus. Dorsal sculpture of five spiral ribs of which the three midribs increase in width towards periphery, periphery with strong keel-forming granular rib and a narrow rib below, basal sculpture of six beaded spiral ribs increasing in width towards umbilicus.

Description: Shell of medium size, diameter 11.3 mm at 4 whorls; teleoconch lens-shaped in cross-section with weakly convex whorls, peripheral keel formed by lower peripheral rib prominent, umbilicus moderately wide (22% of shell diameter). Protoconch unknown. Dorsal sculpture of subsutural rib, three midribs and upper peripheral rib. Subsutural rib narrow and moderately nodose, upper midrib like subsutural rib but less nodose, middle midrib slightly wider, one fine spiral lira between middle and lower midribs, lower midrib widest, one additional spiral thread between lower midrib and upper peripheral rib; upper peripheral rib like upper midrib but more prominent, one additional spiral thread between upper and lower peripheral rib; keel-forming lower

peripheral rib strong with regular granules; upper point of whorl-attachment at lower part of lower peripheral rib, thereby forming a narrow suture. Narrow, prominent infraperipheral rib, three to five additional spiral threads between lower peripheral rib and infraperipheral rib, middle one strongest. Base with six beaded spiral ribs, increasing in width towards umbilicus, the innermost (umbilical rib) surrounding the umbilicus with moderate crenae. Umbilical side of columellar wall covered by sediment, inner lip with groove in nodule of umbilical rib.

Dimensions: Holotype diameter 11.3 mm, height 5.6 mm.

Type material: Holotype SGO.PI.6433 (RAN).

Type locality: RAN.

Etymology: For Rüdiger Bieler (The Field Museum, Chicago, USA) who contributed greatly to our knowledge of Architectonicidae.

Occurrence: RAN; Ranquil Formation, central Chile.

Remarks: *Solatisonax bieleri* comprises the first record of this genus from the Cenozoic of Chile. Similar Recent species are *S. supraradiata* (MARTENS, 1904) from the Indopacific and *S.*? *orba* BIELER, 1993 from the Gulf of California. *Solatisonax bieleri* differs from *S. supraradiata* in its larger size, a wider umbilicus (22% of shell diameter in *S. bieleri*, 18% in *S. supraradiata*), and in the three midribs increasing in width towards the periphery while they are about equal in *S. supraradiata*. It differs from *S.*? *orba* in having a narrower umbilicus (29% in *S.*? *orba*), midribs increasing in width towards the periphery, having one additional spiral rib between the upper and lower peripheral ribs, and having a more prominent infraperipheral rib which is situated lower on the whorl base.

Discussion

The family Architectonicidae is a group of exclusively subtropical to tropical marine gastropods (BIELER 1984) and its presence in early Miocene deposits of Chile is yet another indicator of tropical to subtropical water temperatures in central Chile during this time. Further warm water taxa occurring together with the

architectonicids here described include *Xenophora* (Xenophoridae; NIELSEN & DEVRIES 2002), *Strombus* (Strombidae; NIELSEN 2005a), *Zonaria* (Cypraeidae; GROVES & NIELSEN 2003), *Distorsio* (Personidae; PHILIPPI 1887), *Ficus* (Ficidae; COVACEVICH & FRASSINETTI 1980), but also *Astele* (Calliostomatidae; NIELSEN et al. 2004), *Triumphis* (Pseudolividae; NIELSEN & FRASSINETTI 2003) and *Olivancillaria* (Olividae; NIELSEN 2004). These new records of architectonicids from Ranquil and Lemo Island extend the geographical distribution of this family in South America about 10° farther to the south. Occurrences of *Grandeliacus* and *Solatisonax* are here reported for the first time for southern South America and therefore provide significant extensions of the known paleobiogeography of these two taxa. The records of *Grandeliacus* and *Solatisonax* seem to be the oldest for the respective taxa. The oldest *Grandeliacus* previously known seems to come from the late Pliocene (DHARMA 2005) and we are not aware of any fossil *Solatisonax*.

Only *Architectonica karsteni* had previously been reported from Peru (DEVRIES 1985) and no architectonicids are known from Argentina; those reported by DEL RÍO (1985) and DEL RÍO & MORRA (1985) belong in Trochidae (DEL RÍO 1998). GARRARD (1977), in his monograph on Recent and fossil Australian Architectonicidae, lists no fossil species of *Architectonica* while *Discotectonica* is represented by two middle Miocene species, *D. balcombensis* and *D. squamogranosa* CHAPPLE, 1941, and a single specimen of *Discotectonica* sp. from the late Miocene. *Heliacus* (*Torinista*) *darraghi* GARRARD, 1977 from the late Eocene is the only fossil species of this subgenus listed for Australia (GARRARD 1977) while no fossil *Heliacus* (*Grandeliacus*), treated as synonym of *Heliacus* (*Heliacus*), has been listed. No fossil species of *Solatisonax* is known from Australia but two living species have been reported (GARRARD 1977). From New Zealand an early Miocene species of *Architectonica*, three Miocene species of *Discotectonica* and a Pleistocene *Heliacus* have been recorded together with seven species belonging to other architectonicid genera (BEU & MAXWELL 1990).

The absence of architectonicids, especially *Architectonica karsteni*, in the southeast Pacific after the latest Miocene is most plausibly due to decreasing water temperatures during the late Miocene or around the Miocene-Pliocene boundary which forced this species to retreat towards the north, where it is still living from northern Peru to Baja California (DEVRIES 1985).

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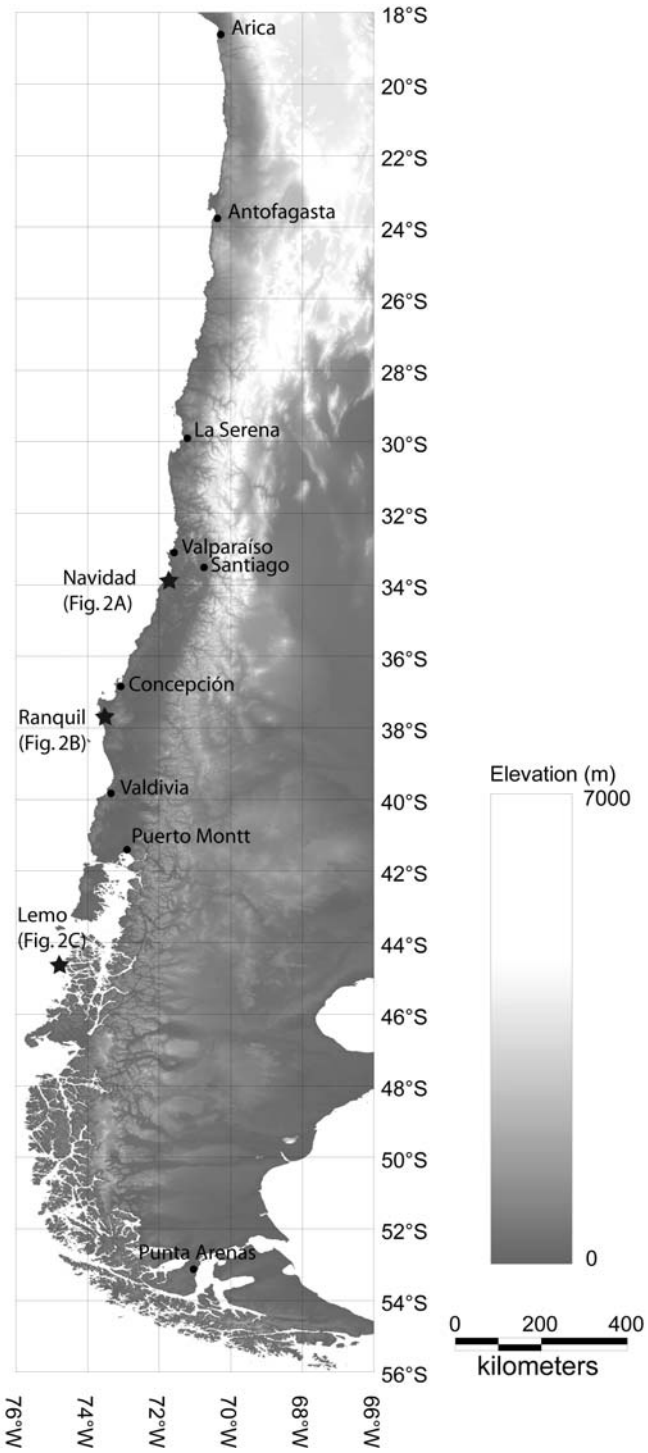

Figure 1. Map of southern South America showing fossil localities of Chilean Neogene Architectonicidae. See Figure 2 for details.

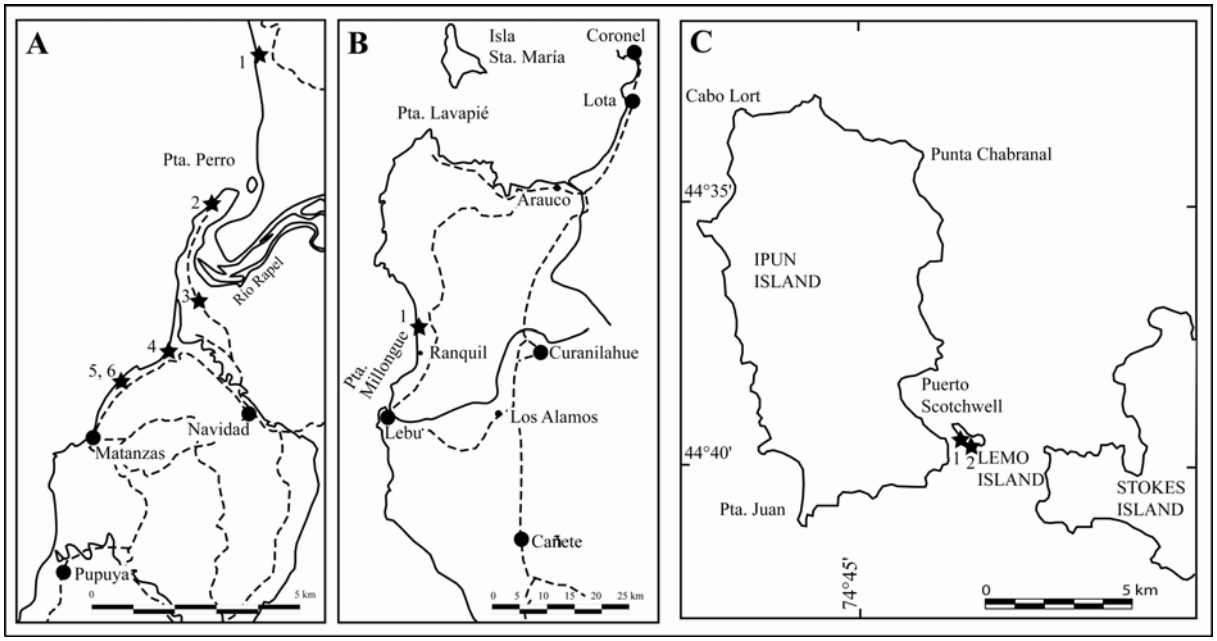

Figure 2. Architectonicid-bearing fossiliferous localities of **A.** Navidad Formation, **B**. Ranquil Formation, and **C**. Lemo Island; see Figure 1 for location of the detail maps. Navidad localities: 1 = RAP; 2 = PPN; 3 = CLP; 4 = PTA; 5 = MAT; 6 = MAP. Ranquil locality: 1 = RAN. Lemo localities: 1 = 310884.2; 2 = 041083.4.

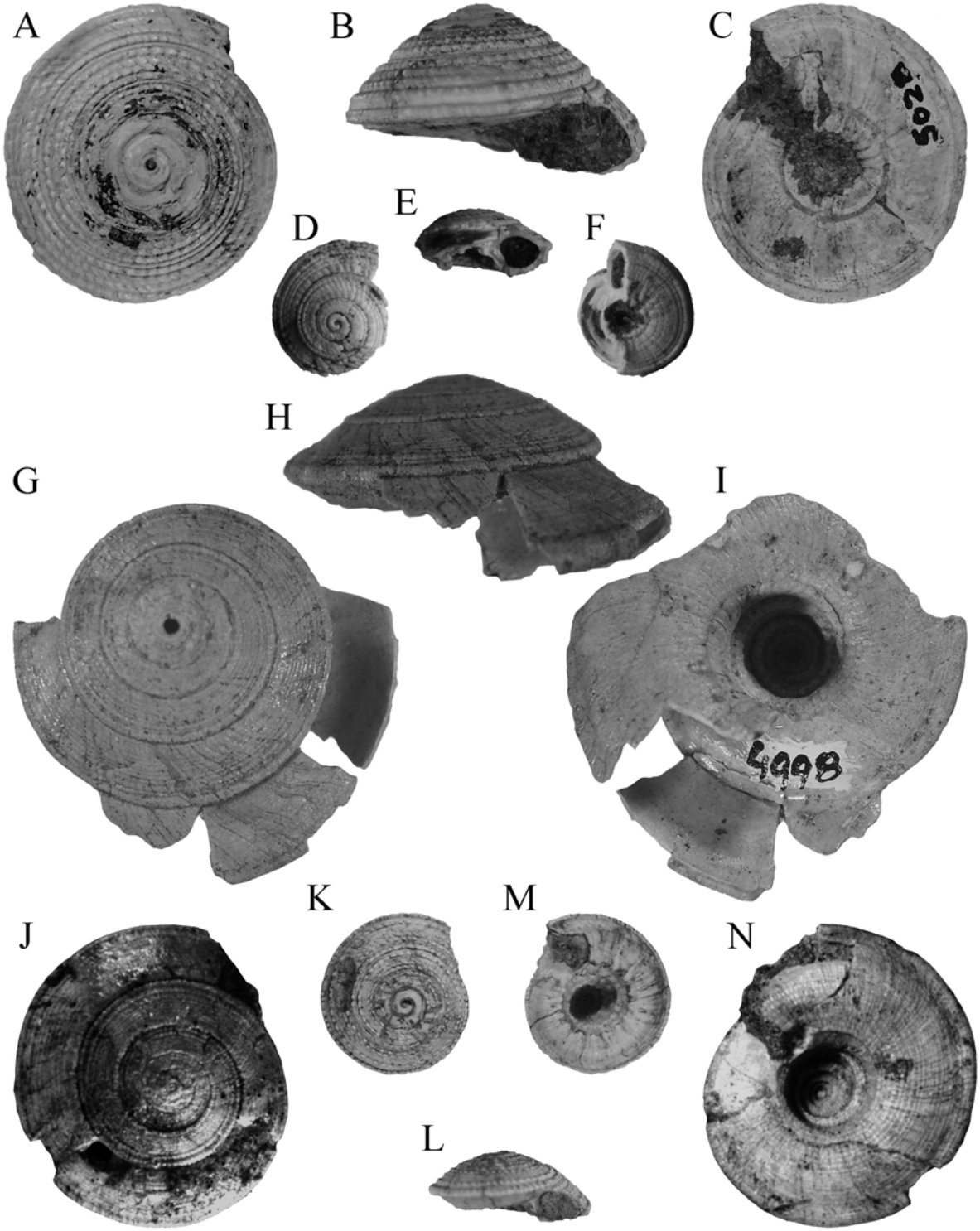

Figure 3. A-F. *Architectonica karsteni* RUTSCH, 1934. **A-C.** SGO.PI.5028, height 14.1 mm, diameter 24.8 mm. **D-F.** SGO.PI.6434, height 2.5 mm, diameter 5.7 mm. **G-N.** *Intitectonica inti* (FRASSINETTI & COVACEVICH,

1982). **G-I.** Paratype SGO.PI.4998 height ~15 mm, diameter ~31.5 mm. **J, N.** Holotype SGO.PI.4997 height 9.7 mm, diameter 25.4 mm. **K-M.** SGO.PI.4996 height 10.1 mm, diameter about 20.5 mm.

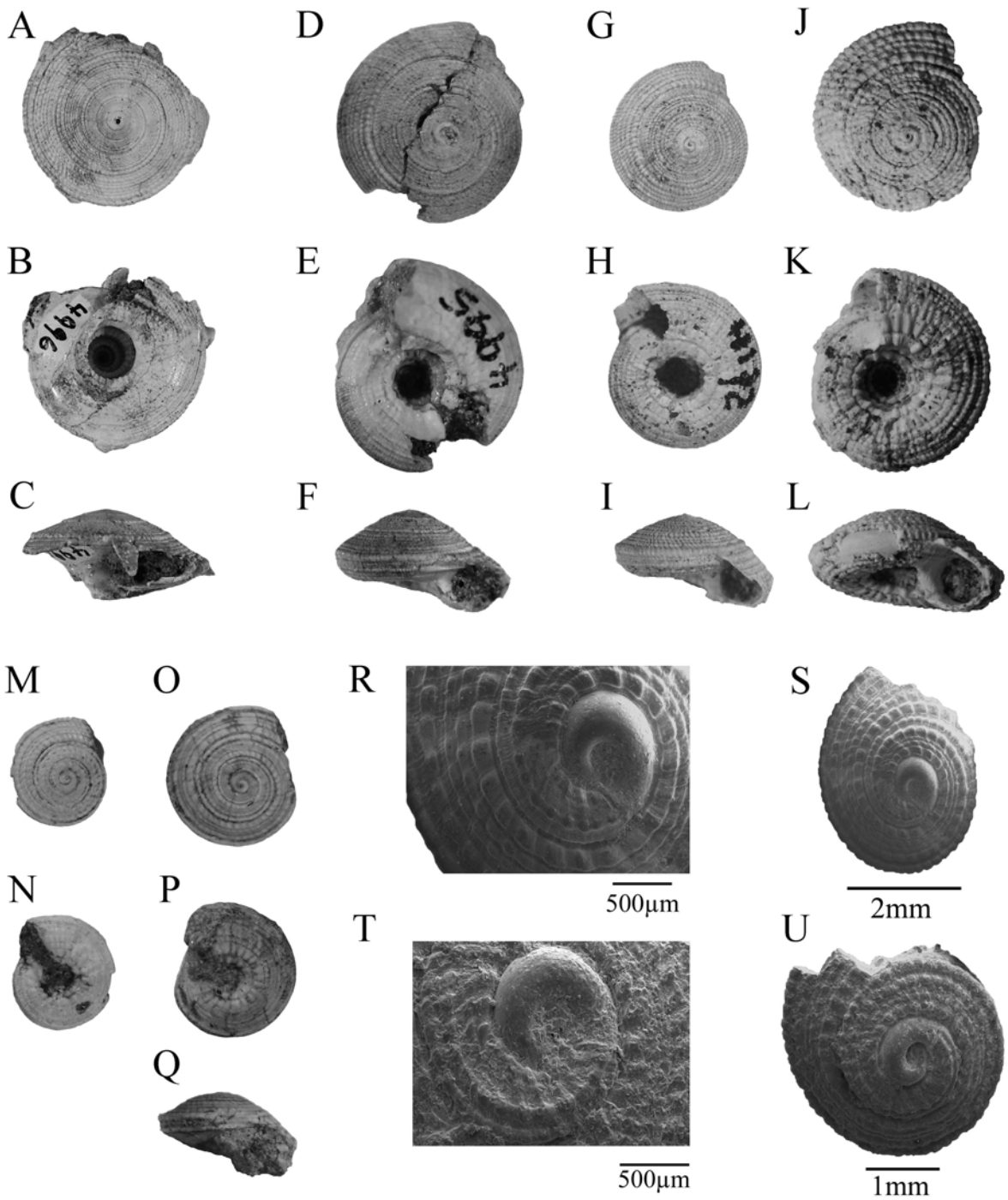

Figure 4. A-C. *Discotectonica navidadensis* (FRASSINETTI & COVACEVICH, 1982), holotype SGO.PI.4993 height 3.1 mm, diameter 6.7 mm. **D-L.** *Heliacus* (*Torinista*) *taverai* FRASSINETTI & COVACEVICH, 1981. **D-F.** Holotype

height 7 mm, diameter 12.2 mm. **G-I.** SGO.PI.4172 height 5.3 mm, diameter 11.9 mm. **J-L.** SGO.PI.6435 diameter 7.6 mm. **M-Q.** *Heliacus* (*Torinista*) *bahamondei* FRASSINETTI & COVACEVICH, 1981. **M, N.** Holotype SGO.PI.4999 height 2.8 mm, diameter 5.7 mm. **O-Q.** Paratype SGO.PI.5000 height 4 mm, diameter 7.7 mm. **R-U.** *Heliacus* (*Torinista*) *chonos* n. sp. **R, S.** Holotype SGO.PI.6436 diameter 3.7 mm. **T.** Paratype 6094.2. **U.** Paratype 6094.1 diameter 3.2 mm.

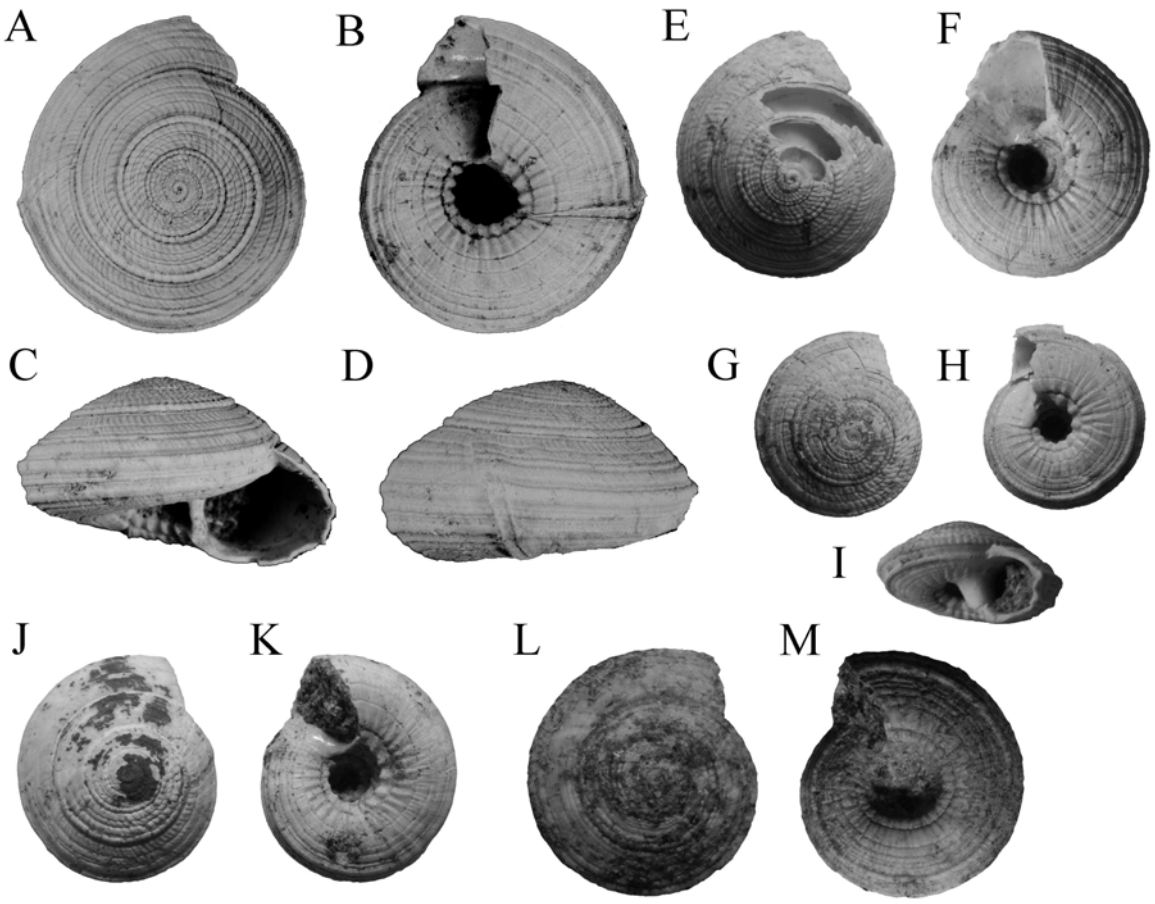

Figure 5. A-K. *Heliacus* (*Grandeliacus*) *antu* n. sp. **A-D.** Holotype SGO.PI.6430 height 9 mm, diameter 14.5 mm. **E, F.** Paratype 1 SGO.PI.6431 height 7.9 mm, diameter 11.3 mm. **G-I.** Paratype 2 SGO.PI.6432 height 5.3 mm, diameter 8.5 mm. **J, K.** Paratype 3 SMF 329101 height 6.4 mm, diameter 10.4 mm. **L, M.** *Solatisonax bieleri* n. sp, holotype SGO.PI.6433 height 5.6 mm, diameter 11.3 mm.