The earliest fossil record of the poorly known family
Condylocardiidae from Argentina

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ABSTRACT. The scarcely known family Condylocardiidae (Bivalvia: Archiheterodonta) is poorly represented in the fossil record and their living representatives are also poorly known. This work presents a new representative of the family from the early Pliocene of marine terrace of Cerro Laciar (Santa Cruz Province). *Carditella pitufina* sp. nov. is described and characterized by a shell large for the genus, 15 radial ribs as wide as interspaces, high hinge plate and broad and large hinge teeth. The poor record of the family may be due to an identification bias, probably because the tiny size of specimens and its similarity with carditids. This new species resembles to the living *Carditella tegulata* from southern Argentina and Chile and they could be closely related. *Carditella pitufina* sp. nov. represents the most ancient record of *Carditella* in South America and the most ancient record of Condylocardiidae in Argentina.

Keywords: Archiheterodonta, Bivalvia, Carditella, Condylocardiidae, Patagonia, Pliocene.

RESUMEN. El registro fósil más antiguo de la poco conocida familia Condylocardiidae en Argentina. La muy poco conocida familia Condylocardiidae (Bivalvia: Archiheterodonta) está pobemente representada en el registro fósil y las especies vivientes del grupo han sido poco estudiadas. Este trabajo presenta un nuevo representante de la familia, procedente de la terraza marina de cerro Laciar (Provincia de Santa Cruz), de edad Plioceno temprano. *Carditella pitufina* sp. nov. es descrita y caracterizada por presentar valvas grandes para el género, 15 costillas radiales tan anchas como sus interespacios, charnela alta y ancha y dientes charnelares grandes. El pobre registro de la familia es referido a un sesgo de identificación, debido probablemente al pequeño tamaño de los especímenes y a su similaridad con los cardítidos. Esta nueva especie se asemeja a la especie viviente *Carditella tegulata* del extremo sur de Argentina y Chile y podrían estar estrechamente emparentadas. *Carditella pitufina* sp. nov. representa el registro más antiguo del género *Carditella* en América del Sur y el más antiguo de un Condylocardiidae para Argentina.

Palabras clave: Archiheterodonta, Bivalvia, Carditella, Condylocardiidae, Patagonia, Pliocene.
1. Introduction

The poorly known family Condylocardiidae Bernard, 1896 is characterized by its very small size and narrow hinge with anterior and posterior lateral teeth in each valve (according to Middlefart, 2002a). Major aspects of the biology of condylocardiids are unknown (Middelfart, 2002a). Their tiny size and relative low abundance may be the reason of the scarce knowledge and recognition of living specimens. The family was related to the Carditidae and placed together in the superfamily Carditoidea (Dall, 1903a; Thiele, 1935) and recently was considered a member of the clade Archiheterodonta (Giribet, 2008). Posterior analyses of molecular sequences placed Condylocardiidae as a clade nested within Carditidae (González and Giribet, 2014). This placement agrees with the proposal of Bernard (1897) who considered the condylocardiids derived by neoteny from carditids, and Coan (2003) who suggested a polyphyletic origin for the group.

The Condylocardiidae are frequently distinguished from other archiheterodonts by their tiny size, lateral teeth in both valves, presence of internal ligament, and the presence of large prodissocochns (Middelfart, 2002b). According other authors (Huber, 2010; Güller and Zelaya, 2013), some genera of condylocardiids present both, internal and external ligament (or exclusively external) and small prodissocochns. These discrepancies lead to discussions about the taxonomic composition of the family (Middelfart, 2002b; Coan, 2003; Huber, 2010; Coan and Valentich-Scott, 2012).

Living Condylocardiidae were reported from Australia (Middelfart, 2002a, b), tropical eastern Pacific (Coan, 2003), eastern Atlantic (Salas and Rolán, 1990) and southern Atlantic and Pacific (Güller and Zelaya, 2013). Fossil Condylocardiidae were reported from the Paleocene of Nigeria (Adegoke, 1977); Eocene of France (Sanders et al., 2015), United States (Palmer and Brann, 1965), and New Zealand (Maxwell, 1992); Oligocene of United States (Dockery, 1982); Miocene of Australia (Tate, 1886; Ludbrook, 1953), New Zealand (Gage, 1957), Belgium (Louwye et al., 2010), Germany (Moths et al., 2010), and Indonesia (Beets, 1983); Pliocene of New Zealand (Laws, 1940), Belgium (Marquet, 2002), Trinidad and Tobago (Jung, 1969), Indonesia (Oostingh, 1935) and United States (Ward and Blackwelder, 1987); and Quaternary of South Africa (Kensley and Pether, 1986) and Costa Rica (Olsson, 1942). A possible previous record comes from the Cretaceous of North America (Stephenson, 1941) represented by the dubious species *Uddenia texana* Stephenson, 1941.

There are only three fossil records of the Condylocardiidae in South America. The first is founded in the late Miocene of Uruguay (Camacho Formation) and refers to *Warrana antiqua* (Figueiras, 1990) (formerly described as *Americuna antiqua*). The second and third correspond to two mentions listed but not illustrated by Gordillo et al. (2005) from middle Holocene of Tierra del Fuego (Argentina) - *Carditella naviformis* (Reeve, 1843) and *Carditopsis flabellum* (Reeve, 1843)-. Nowadays four species of living condylocardiids are mentioned in the region, from southern Peru, Chile and Tierra del Fuego (Güller and Zelaya, 2013). The aim of this contribution is to report and to describe the most ancient fossil record of Condylocardiidae of Argentina, represented by a new species from early Pliocene marine terraces of Santa Cruz (Argentina).

2. Geological setting

Fossil locality of Terrace of Cerro Laciar (Fig. 1), studied by Feruglio (1933, 1950) and assigned to his System Terrace I, are located 50 km west to Puerto Deseado, Santa Cruz Province. These exposures are placed at 170-185 meters above sea level, overlaying the marine Monte León Formation (early Miocene) and consist of few meters of loose gravel with calcareous sandy matrix (Fig. 1). Condylocardiids are founded within the bivalves *Scalaricardita laciarina* (Feruglio, 1954), *Kolmeris tehuelchana* (Ihering, 1907), *Ostrea ferrarisi* d’Orbigny, 1842, *Chlamys* actinodes (Sowerby, 1846), and the gastropods *Trophon varians* (d’Orbigny, 1842) and *Pachycymbiola feruglioi* (Doello Jurado, 1931). The age of these marine fossiliferous beds has been discussed, and assigned to Miocene (Ameghino, 1906), Pliocene (Feruglio, 1950, 1954) or Pleistocene (Feruglio, 1933). Recently, Del Río et al. (2013) indicated for these deposits an early Pliocene age (5.10±0.21 Ma, Zanclean) based on $^{87}Sr/^{86}Sr$ analysis from valves of the pectinid “*Chlamys* actinodes.”

3. Material and methods

The fossil and recent specimens used for comparisons are housed at Museo Argentino de Ciencias Naturales “Bernardino Rivadavia”. Shells
were viewed with a Leika binocular magnifying glass. The preservation of fossil shells is moderate, they shows some degree of surface and edge alteration, and bioerosion product of the action of boring sponges -Entobia- (Gordillo et al., 2014). Besides, this attributes did not difficult the identification of morphological features. Hinge terminology follows Lamy (1917), other morphological terms (e.g., “ligamental pit”) follows Middelfart (2002a, b).


4. Systematic paleontology

Order Archiheterodonta
Family Condylocardiidae Bernard, 1896
Subfamily Carditellinae
Kuroda, Habe and Obaya, 1971

Remarks. Chavan (1969) and Middelfart (2002a, b) restricted the family for species with an external ligament only and divided the Condylocardiidae in two subfamilies: Condylocardiinae Bernard, 1896 and

FIG. 1. Geographical provenance (indicated by a grey star) of studied fossils and lithological section at Terrace of Cerro Laciar.
Cuniae Chavan, 1969. They placed small species with external and internal (Carditella Smith, 1881) or only external ligament (Carditellona Iredale, 1936 and Carditellopsis Iredale, 1936) within the family Carditidae, despite other characters. This approach was not followed by Coan (2003) who considered Carditella as a condylocardiid. Kuroda et al. (1971) suggested a third subfamily, Carditellinae, for these closely related species, following the original concept of Iredale and McMichael (1962) when they grouped the genera Carditellona and Carditellopsis. This approach with three subfamilies instead two was accepted by Huber (2010) and is followed here. Carditellinae taxa share with the Cuniae the presence of a small and poorly defined cup-shaped prodissoconch and triangular-shaped right middle and left posterior teeth.

Genus Carditella Smith, 1881

Type species. Carditella pallida Smith, 1881 by subsequent designation (Dall, 1903b) (Recent, southern Chile) (junior synonym of Carditella tegulata according to Güller and Zelaya, 2013).

Emended diagnosis. Shell small and flabellate. Lunule elongated. External sculpture of 11-15 radial ribs. Hinge composed by two left cardinal and three right cardinal teeth. Each valve also has two lateral teeth, one nearly marginal on the one side, the other on the opposite side being well within the outer edge, with a groove between it and the anterior margin. External and internal ligament small, internal placed beneath the apex of the valves in a small resilifer (Modified from Smith, 1881).

Remarks. In its original description, Smith (1881) recognized that external sculpture resembles carditids. The genus Carditella is characterized by their flabellate shell-outline with wide radial ribs covered by subrectangular nodes, hinge with two left and three right cardinal teeth and anterior and posterior lateral teeth in both valves. Also, Carditella has external and internal ligament, the latter marked by a ligamental pit beneath the apex in left valve. The presence of strongly developed lateral teeth and a small ligamental pit allow to place the new species in the condylocardiid genus Carditella. Hinge configuration and external sculpture do not differ from other species of Carditella.

Two fossil species of Carditella were recorded: C. baloguni Adegoke, 1977 (late Paleocene, Nigeria) and C. aldrichi (Casey, 1903) (middle Eocene-early Oligocene, United States of America). Carditella calipsmma Carrington and Kensley, 1969 (late Pliocene-early Pleistocene, South Africa) seems to be a representative of the genus Carditellona Iredale, 1936 instead a southern African Carditella species. Nowadays, the genus Carditella is represented by C. naviformis (Reeve, 1843) (southern South America), C. tegulata (Reeve, 1843) (southern Peru to Tierra del Fuego), C. semen (Reeve, 1843) (southern Peru to Chile), C. esulata Smith, 1885 (Tristan da Cunha), C. galapagana Coan, 2003 (western coast of Colombia and Galapagos Islands), C. marieta Coan, 2003 (western coast of Mexico), C. capensis Smith, 1885 (Recent, Angola and South Africa), C. dell Crozier, 1966 (northern New Zealand), C. ieijimensis Hayami and Kase, 1993 (southern Japan), C. laticosta Smith, 1904 (South Africa), C. mawsoni Dell, 1972 (Weddel Sea), and C. tridacnula Oliver and Chesney, 1997 (Oman).

Carditella pitufina sp. nov.

Fig. 2.1-13, 3.1

Etymology. The specific epithet refers to the Belgian comic characters created by Peyo, “Les Schtroumpfs” (called “The Smurfs” in English and “Los Pitufos” in Spanish speak countries). These creatures are characterized by their tiny sizes as the condylocardiids bivalves. This epithet is expressed in Spanish diminutive form to emphasize the reference.

Type material. Holotype MACN-Pi 6344 (a left valve). Paratype MACN-Pi 6344 (a left and three right valves).

Type locality and horizon. Terrace of Cerro Laciarc, Santa Cruz Province (lower Pliocene marine terraces).

Diagnosis. Shell large for the genus (length range 6.27-7.12 mm), external sculpture of 15 radial ribs as wide as interspaces, hinge plate high and hinge teeth broad and large.

Description. Shell large-sized for the genus (length range 6.27-7.12 mm) (Table 1), mainly subtriangular; convex anterior and posterior margins, rounded ventral margin, dorsal margin sharply sloping and very curved, angle between dorsal and posterior margins smooth, angle between dorsal and anterior margins weak marked. Umbo small, pointed or slightly rounded, anteriorly directed, placed at centre to anterior third of the valve length. Lunule large,
elongated and narrow, slightly concave, without sculpture and smoothly separated from remaining surface of shell. Escutcheon large and elongated, smooth, larger than lunule. Prodissococonch small, eroded in all specimens studied. Hinge plate high, three cardinal and two lateral teeth in right valve and two cardinal and two lateral teeth in left valve. Right valve hinge with rounded ventral edge; anterior cardinal tooth thin and straight, anteriorly inclined; middle cardinal tooth subtriangular, slightly inclined posteriorly, with broad base; posterior cardinal tooth thin, long and straight; anterior lateral tooth elongated, wide, separated from lunular margin; posterior lateral tooth elongated, high, not differentiated from anterior margin. Left valve hinge with a straight ventral edge; anterior cardinal tooth curved, anteriorly inclined, with broad base; posterior cardinal tooth long and curved, inclined posteriorly, with broad base and acute apex; anterior lateral tooth thin and high, close to anterior margin; posterior lateral tooth long and wider than anterior lateral. Small ligamental pit placed below beak in left hinge. External sculpture of 15 radial ribs as wide as interspaces, with subrectangular transverse section, covered by rectangular nodes; interspaces with subrectangular transverse section. Pallial line at a quarter of total valve height. Inner ventral margin crenulated; crenulations subrectangular and truncated, covering the entire margin.

FIG. 2. 1-13. Carditella pitufina n. sp., MACN-Pi 6344; 1. Left hinge (Holotype); 2. Right hinge (Paratype); 3. Right valve, lateral view (Paratype); 4. Left valve, lateral view (Holotype); 5. Left valve, dorsal view (Holotype); 6. Right valve, internal view (Paratype); 7. Left valve, internal view (Holotype); 8. Right valve, internal view (Paratype); 9. Right valve, lateral view (Paratype); 10. Left valve, internal view (Paratype); 11. Left valve, lateral view (Paratype); 12. Right valve, lateral view (Paratype); 13. Right valve, internal view (Paratype); 14-16. Kolmeris tehuelchana (Ihering, 1907), MACN-Pi 2214; 14. Right valve, dorsal view; 15. Right valve, lateral view; 16. Right valve, internal view. Scale bar represents 5 mm for 1-2, and 2 mm for 3-16.
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Remarks. Shell of the new species shows some variability from more to less triangular outlines. Placement of umbos is more or less centrally. Development of shell margins and radial ribs varying in studied specimens but they are due to taphonomic processes (e.g., surface alteration).

This new species strongly resembles to Carditella tegulata (Reeve, 1843) (Recent, Valparaíso [33º S] to Beagle Channel [55º S]) (Güller and Zelaya, 2013: Fig. 5) but is distinguished by its quite larger shell with narrower radial ribs, higher hinge plates, larger and broader cardinal teeth, and right hinge with less curved middle tooth. Also, the dorsal margin in the fossil species is more curved and the prodissoconch is smaller than those of C. tegulata. On the other hand, the new species can be distinguished from Carditella pitufina sp. nov. because the expanded outlines in the living species, with the presence of a more prominent prodissoconch separated from teleoconch by a bulging rim, fine comarginal lines between radial ribs, and with smaller and narrower hinge teeth.

5. Discussion

There are very few previous records of the family Condylocardiidae in South America (Figueiras, 1990; Gordillo et al., 2005), which may be due to an identification bias. Shells of this group are very small sized (see Table 1 for Carditella pitufina sp. nov. sizes), and hinge features are visible only by magnification. Small bivalves are difficult to assign taxonomically (Valentine et al., 2006). Externally, condylocardiids resemble to small specimens of Carditidae taxa, and Smith (1881) already mentioned the external similarity between Carditella and carditids. At the marine terraces of Cerro Laciar, two small carditid species are recorded: Kolmeris tehuelchana (length range of 6.3-15.9 mm) (Fig. 2.14-16, Fig. 3.2, 3.4) and Scalaricardita laciarina (length range of 8.4-26 mm) (Fig. 3.3), but differences on adult size among them are noticeable (Fig. 3). Carditid species share external sculpture of radial ribs with Carditella pitufina sp. nov., but they present 25-27 (S. laciarina) or 13-15 ribs stacked at sides (K. tehuelchana) (Pérez and Del Río, 2017), while the condylocardiid has 15 not stacked radial ribs. In S. laciarina, radial ribs are covered by subrectangular nodes as in C. pitufina sp. nov., but in K. tehuelchana, radial ribs are smooth (Pérez and Del Río, 2017). Also, carditids have not lateral teeth or ligamental pit. These features distinguish the new species from the known carditids of the Cerro Laciar marine terraces. Some juvenile specimens of K. tehuelchana with similar size of adult C. pitufina sp. nov. present these strong differences in hinge teeth and external sculpture (Fig. 2.15). Specimens of C. pitufina sp. nov. here described were founded among very small Carditidae specimens originally collected by E. Feruglio.

Pleuromeris Conrad, 1867 is another small carditid genus recorded in the late Oligocene-middle Miocene of Argentina (San Julián, Monte León and Carmen Silva formations). This genus is represented by two species, P. sulcolunularis (Ihering, 1907) and P. fueguina (Steinmann and Wilckens, 1908). Pleuromeris is characterized by small (less than

### Table 1. Measurements of studied specimens of Carditella pitufina sp. nov.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Length (mm)</th>
<th>Height (mm)</th>
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<tbody>
<tr>
<td>MACN-Pi 6344-1</td>
<td>7.04</td>
<td>6.8</td>
</tr>
<tr>
<td>MACN-Pi 6344-2</td>
<td>6.27</td>
<td>6.03</td>
</tr>
<tr>
<td>MACN-Pi 6344-3</td>
<td>6.91</td>
<td>6.79</td>
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<tr>
<td>MACN-Pi 6344-4</td>
<td>6.63</td>
<td>6.44</td>
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<tr>
<td>MACN-Pi 6344-5</td>
<td>6.8</td>
<td>7.01</td>
</tr>
<tr>
<td>MACN-Pi 6344-6</td>
<td>6.85</td>
<td>6.06</td>
</tr>
<tr>
<td>MACN-Pi 6344-7</td>
<td>7.12</td>
<td>6.17</td>
</tr>
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</table>
30 mm in length) and subtriangular outlined shells. This taxon has a broad and triangular right middle tooth and a reduced left anterior tooth that are not present in Carditella. Also, the condylocardiid genus has lateral teeth in both hinges. Some small species of Pleuromeris from New Zealand (e.g., P. benthicola, P. ultima) externally resemble to Carditella but they have wider radial ribs and a broader right middle tooth. Argentinian species of Pleuromeris have larger shells (near to 20-25 mm), broad right middle tooth and a higher number of radial ribs.

Carditella was present in the Paleocene of Africa and in the Oligocene-Eocene of North America, but this is its first Pliocene record. The present distribution of Carditella ranges from southern South America towards Pacific coast to Colombia and Mexico, and by Atlantic coast towards southern Africa. The genus is also present in New Zealand, Japan and Oman.

The species of Condylocardiidae from the southern South America are distributed from Tierra del Fuego towards Chile and Peru, and they are represented by four species: Carditella tegulata (Reeve, 1843), C. naviformis (Reeve, 1843), C. semen (Reeve, 1843) and Carditopsis flabellum (Reeve, 1843) (Güller and Zelaya, 2013). The new record of C. pitufina sp. nov. indicates a more northern distribution of the group in western Atlantic for Pliocene times, and the most ancient record of the genus in South America. Carditella pitufina sp. nov. is very similar to the Recent C. tegulata, which is recorded from middle Holocene (Gordillo et al., 2005), and could be a Pliocene relative for this species.

Pliocene marine terraces of Argentina were recently recognized because their debated age (Del Rio et al., 2013), the faunal composition of Terrace of Cerro Laciár was not revised after Feruglio (1933,
The earliest fossil record of the poorly known family Condylocardiidae from Argentina (1950, 1954), notwithstanding some mentions (Del Río and Martínez, 2006; Aguirre et al., 2008; Pérez and Del Río, 2017; Trovant et al., 2017). In contrast of Miocene molluscs of Patagonia (Martínez and Del Río, 2002; Del Río et al., 2010), Pliocene molluscs seems to be more related to actual malacological faunal composition. According to the faunal list provided by Feruglio (1950) (and the previously mentioned posterior revisions), Terrace of Cerro Laciar includes a certain amount of extant taxa [e.g., Mactra isabelleana d’Orbigny, 1846, Mytilus edulis Linnaeus, 1758, Perumytilus purpuratus (Lamarck, 1819), Tegula patagonica (d’Orbigny, 1835), Trochita pileolus (d’Orbigny, 1842), Falsilunatia patagonica (Philippi, 1845), “Trophon” varians (d’Orbigny, 1842), Boreoscala magellanica (Philippi, 1845)] and other taxa closely related to extant species [e.g., Amiantis laziarina (Ihering, 1903), “Chione” laciaria Feruglio, 1954, Urosalpinx sp., Pachycymbiola feruglioi (Doello Jurado, 1931)]. The new record of Carditella are placed in the second group, and enriches the connections between Pliocene and modern faunas. New revisions of this mollusc fauna are needed for enlighten the origins of modern faunal composition of southern South America.

6. Conclusions

A new species of the genus Carditella Smith, 1881, C. pitufina sp. nov., is described from the early Pliocene marine terraces of Cerro Laciar, Santa Cruz Province, Argentina. This finding represents the most ancient fossil record of Condylocardiidae of Argentina and the most ancient record of the genus Carditella for the south end of South America.

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