

On the geographical and stratigraphical distribution of the nestling bivalve *Petricola ramirezi* Araya & Osorio, 2019 (Bivalvia: Veneridae)

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Abstract. *Petricola ramirezi* Araya & Osorio, 2019, a shallow-water nestling petricolid bivalve, was originally described from specimens collected washed ashore at El Tabo, central Chile (33°27'S, 071°38'W). This species is unique from all other bivalve species in the area in nestling inside empty shells of the barnacle *Balanus laevis*. In this study, we present new geographic records for this species based on specimens collected at several localities in northern and central Chile. These results extend the geographical distribution of *P. ramirezi* by approximately 1,089 km from its only previously known locality at El Tabo northwards to Caldera (27°04'S, 070°49'W) and southwards to Lirquén (36°42'S, 072°58'W). Additionally, we present the first fossil record for *P. ramirezi* based on specimens collected nestling inside empty shells of *B. laevis* from a Pleistocene site in the El Morro area, Caldera, northern Chile. These results confirm the presence of this species along an expanded geographical distribution on the present-day Chilean coasts and reveal that *P. ramirezi* has been present in the northern part of the country since at least the Pleistocene. The particular and specialized lifestyle of this species, nestling inside empty barnacle shells, suggests that this strategy—providing protection from predators and from sudden environmental changes—may have contributed to the survival of this species in the area since the Pleistocene.

Key words. Range extension, barnacles, ecological niche, Chile, southeastern Pacific Ocean

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INTRODUCTION

Venerid clams of the subfamily Petricolinae d'Orbigny, 1840 groups about 41 species of small bivalves (MolluscaBase Eds 2024), with most of them shallow-water species characterized by occupying cavities, crevices, or boreholes (sometimes made themselves) in hard substrates (Coan 1997). The most species-rich genus among the Petricolinae is *Petricola* Lamarck, 1801, with about 25 extant species; they usually present chemical and physical means to bore into rocks, molluscan shells, and other hard sediments, although some species have been found to have nestling habits, living exclusively inside communities of colonial polychaetes, scleractinian corals, or inside empty barnacle shells (Coan & Valentich-Scott 2012).

Four species of *Petricola* have been reported from Chilean waters. Three of them have the ability to tunnel inside rocks: *Petricola dactylus* G.B. Sowerby I, 1823, found in both the South Pacific and South Atlantic oceans (Valdivinos 1999; Aldea & Valdivinos 2005), *Petricola olsoni* F.R. Bernard, 1983, distributed from Tumbes Province, Peru to Antofagasta, northern Chile (Coan 1997), and *Petricola rugosa* G.B. Sowerby I, 1834 occurring from Lambayeque, Peru to Aysén, Chile (Coan 1997), and possibly to Cabo de Hornos (55°30'S) (Valentich-Scott *et al.* 2020). The fourth species, *Petricola ramirezi* Araya & Osorio, 2019, is a nestler, living inside the empty shells of the barnacle *Balanus laevis* Bruguière, 1789, and known only from its type locality at El Tabo (33°27'S, 071°38'W), Región de Valparaíso, central Chile (Araya & Osorio 2019). All these *Petricola* species are

rather uncommon and have been recorded exclusively in shallow waters, mostly from rocky shores.

We present the first records of *P. ramirezi* since its original description, based on several specimens collected at several new extant locations in Chile, from Caldera, Región de Atacama, to Lirquén, Región del Bio Bio. Additionally, we also report fossil specimens from a Pleistocene site in Caldera, Región de Atacama, northern Chile. These findings extend the geographical distribution range of *P. ramirezi* in the southeastern Pacific northwards by about 714 km and southwards by 381 km, and they also reveal that *P. ramirezi* has been present in the northern part of the country since at least the Pleistocene.

MATERIALS AND METHODS

Empty shells of *Petricola ramirezi* were collected at a few locations in northern and central Chile (Fig. 1) inside washed-ashore specimens of the shallow-water cirriped *Balanus laevis* (Fig. 2A–C). Additionally, fossil specimens were collected in a Pleistocene site near Caldera, Región de Atacama, northern Chile, inside the same barnacle species still attached to rocks (Fig. 2f). We identified *P. ramirezi* using the species' original description by Araya and Osorio (2019). Voucher specimens have been deposited in the collections of the Museo Nacional de Historia Natural (Santiago, Chile; MNHN). The distribution map was prepared using SimpleMappr (Shorthouse 2010). In Materials examined, “specimens” means paired valves and “valves” means unpaired, disarticulated valves.

RESULTS

Petricola ramirezi Araya & Osorio, 2019

Figures 1, 2

Material examined. Modern specimens: 2 valves, Playa Rodillo (26°59'S, 070°47'W), Caldera (MNHNCL MOL 101653); 2 specimens, Norte Playa Ramada (27°00'S, 070°47'W), Caldera (MNHNCL MOL 101654); 2 specimens, Sur Playa Ramada (27°00'S, 070°48'W), Caldera (MNHNCL MOL 101655); 1 specimen, Playa Negra (27°03'S, 070°48'W), Caldera (MNHNCL MOL 101657); 4 specimens, Playa Mansa (27°03'S, 070°49'W), Caldera (MNHNCL MOL 101659); 1 specimen, Playa Las Machas, (27°06'S, 070°51'W), Bahía Inglesa, Caldera; 1 valve (MNHNCL MOL 101658), Norte de Chañaral de Aceituno (29°03'53.5"S, 071°28'47.9"W), Freirina (MNHNCL MOL 101651); 1 valve, Playa Lirquén (36°41'S, 072°58'W),

Penco, central-southern Chile (MNHNCL MOL 101650); 1 specimen and 1 valve, Playa Lirquén (36°41'S, 072°58'W), Penco, central-southern Chile (MNHNCL MOL 101652).

Fossil specimens: 1 specimen (removed) (MNHNCL MOL 101656), 2 specimens (remaining inside *Balanus*



Figure 1. Known geographical distribution of *Petricola ramirezi* and its position in South America (inset, red rectangle). Red circles: new records in this study, from north to south: Caldera (27°04'S, 070°50'W), Chañaral de Aceituno (29°03'S, 071°28'W), and Lirquén (36°41'S, 072°58'W). Black star: fossil record at Caldera. Black square: type locality at El Tabo (33°27'S, 071°38'W), central Chile.

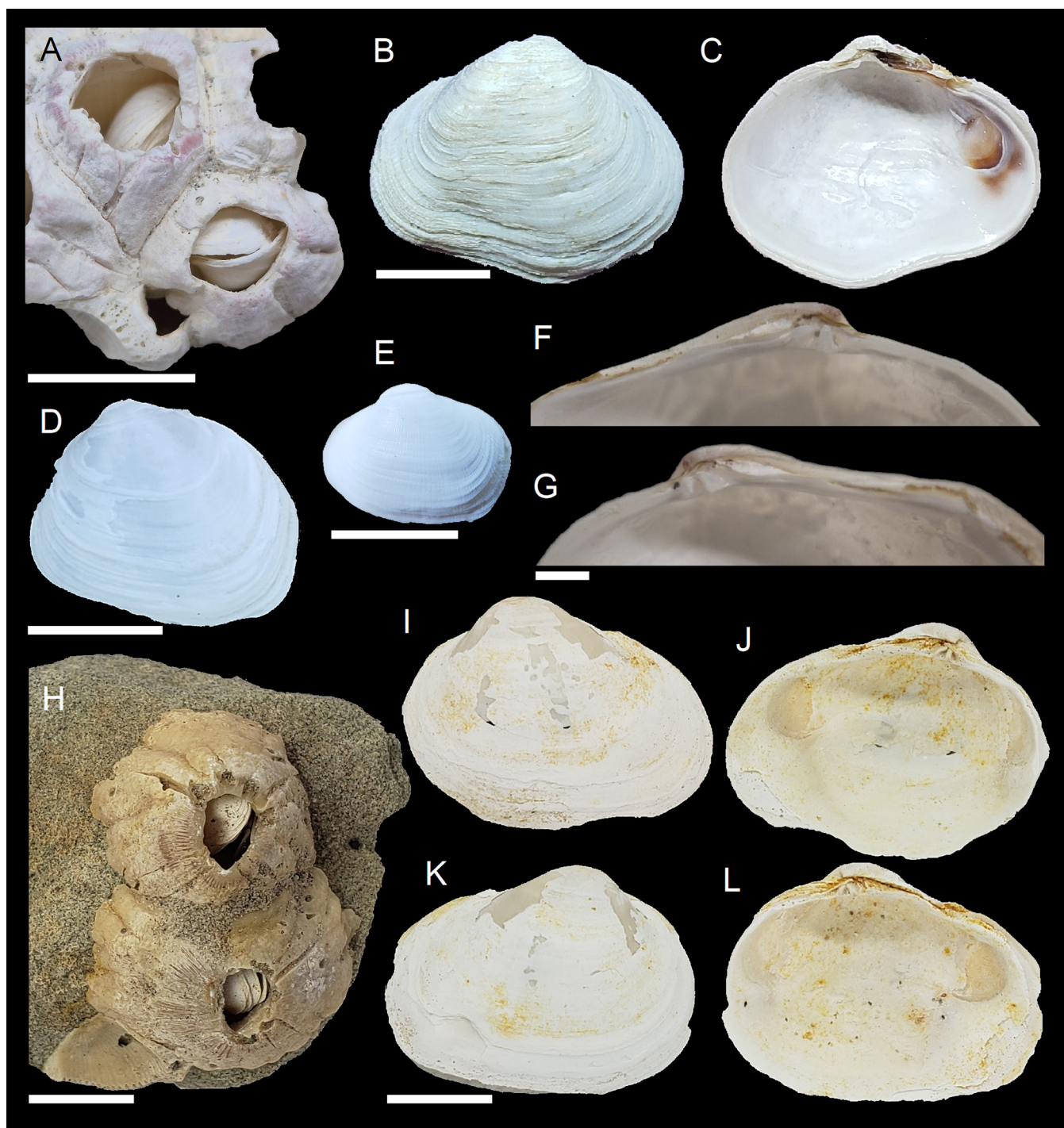


Figure 2. *Petricola ramirezi* Araya & Osorio, 2019. **A–G**, modern specimens in situ inside empty shells of *Balanus laevis* empty shells: (**A**) from Caldera; (**B**, **C**) from Playa Rodillo; (**D**) from Chañaral de Aceituno; (**E**) Lirquén (**F**, **G**) details of hinge of specimen from Lirquén. **H–K**, specimens from the Pleistocene of Caldera: (**H**) in situ inside *Balanus* sp.; (**I**) dorsal view of left valve; (**J**) internal view of left valve; (**K**) dorsal view of right valve; (**L**) internal view of right valve. Scale bars: A, H = 10 mm; B–E, I–L = 5 mm; F, G = 1 mm.

laevis on rock), Estratos Caldera, Sector el Morro (27°09'S, 070°55'W), Caldera (MNHCL MOL 101655).

Diagnosis. Shell small, to 16.3 mm long, stout, oval-ovate, tumid in juvenile specimens, sculptured with 100–120 fine

radial ribs on entire teleoconch. Escutcheon and lunule absent. Umbo in anterior 1/3 of valve. Beaks prosogyrate and slightly enrolled. Nymph wide, solid. Fibrous layer of ligament occupying about 1/4 of valve length. Pallial sinus deep,

broadly rounded. Shell white or pale yellowish, with a porcelain white interior and, in some cases, a brownish hue near the adductor scars.

Comparisons with other species. *Petricola ramirezi* can be distinguished from two similar Chilean species, *P. dactylus* and *P. rugosa*, by its smaller maximum size, with a less elongate and more rounded shell than *P. dactylus*, or less inflated shell than *P. rugosa*. In general, the exterior of the shell of *P. ramirezi* is also more densely sculptured with finer, weaker ribs, than either *P. dactylus* or *P. rugosa*, which have much coarser, stronger ribs. From *P. olssoni*, *P. ramirezi* differs in having more radial ribs, a more impressed pallial sinus, and a bright withish interior of the shell (internally mottled with orange-brown in *P. olssoni*).

Geographic and stratigraphical distribution. *Petricola ramirezi* is endemic to the coast of Chile and previously known only from El Tabo, central Chile (Araya & Osorio 2019). We add new localities from Playa Rodillo (26°59'S, 070°47'W), Commune of Caldera, Región de Atacama, south to Lirquén (36°41'S, 072°58'W), Commune of Talcahuano, Región del Bio Bio. Our new data also includes the first fossil records of the species, from the Pleistocene of Caldera. We collected the fossil specimens (Fig. 2F–I)) reported here from the same place and stratigraphy where the fossil littorinid *Echinolittorina nielsenii* Araya & Reid, 2016 was originally described (Araya & Reid 2016), indicating no more than a Pleistocene age for the specimens of *P. ramirezi*.

DISCUSSION

All our specimens are all empty shells recovered from the inside of empty shells of the barnacle *Balanus laevis*, including also fossil specimens from a Pleistocene deposit in Caldera. All our specimens of *Petricola ramirezi* have a similar number (100 to c. 120) of fine radial ribs, but they do differ somewhat in outline due to their nestling habit (Araya & Osorio 2019). In general, most specimens have ovate or round shells; the valves of smaller specimens are more elongate and tumid, while in larger specimens, they always have some distortion, some with an enlarged right valve which partly covers the margin of the left valve. This enlargement of the right valve likewise occurs in *Petricola japonica* Dunker, 1882 from Japan (Morton 1978) and is also evident in some *P. rugosa*. Our largest specimen, which is larger than the size mentioned in the original description of *P. ramirezi* (Araya & Osorio 2019), is unique among all

known specimens (including the type specimens) in having a coloured anterior adductor-muscle scar and part of the surrounding area (Fig. 2d).

We extend the known geographical distribution of *P. ramirezi* from a previous single locality to a very wide geographic span of about 1,089 km along the coasts of northern-central Chile. Our new records also expand the stratigraphical presence of this species from the present to the Pleistocene, providing a geological record somewhat similar to that of the congeneric *P. rugosa*, which has been cited in the Pliocene of Caldera and which has a similar extant geographical distribution (Herm 1969; Araya & Osorio 2019). The distinctive nestling life habit of this species, which provide a stable, protected habitat, may have contributed to the persistence of this species since the Pleistocene. Examination of boreholes in rocks, shells, barnacle shells, and tubeworm communities in localities in northern Chile reveals that *P. ramirezi* is found exclusively inside empty shell chambers of *Balanus laevis*, which is different from all the other species in the genus in the area (Valentich-Scott *et al.* 2020). The ecological niche of *P. ramirezi* is unique among species of Veneridae, as the only other documented nestling species in this family is the Northeast Pacific *Petricola carditoides* (Conrad, 1837) which, in contrast, begins life as a nestler, then changes to a borer (Yonge 1958). In Chile, no specimens of any other *Petricola* species, or of any other bivalve species, have been documented from the inside the empty shell chambers of any other barnacle species, including *Austromegabalanus psittacus* (Molina, 1788), a large-bodied species, or smaller ones, like *Elminius kingii* Gray, 1831, *Jehlius cirratus* (Darwin, 1854), and *Notochthamalus scabrosus* (Darwin, 1854). Indeed, considering the body size of *P. ramirezi*, there also may be an optimal chamber volume within *Balanus laevis* shells that support successful nestling of this species, which may potentially hinder the use of the shells of these larger and smaller barnacle species.

Given our new data, it appears that *P. ramirezi* is likely rare in shallow water, although it was rather abundant (several specimens living in the same barnacle colonies) in the few locations where we found it. However, we have been unable to find living specimens, even after careful searches of barnacle communities.

The currently extensive geographical distribution of *P. ramirezi* exemplifies the greatly unexplored faunal biodiversity of even comparatively well-known groups like molluscs. There is a need for more studies of the invertebrate fauna of northern Chile. Moreover, *P. ramirezi* should be looked

along the neighbouring coast of Peru to determine if this species also occurs there.

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