

# The shallow-water chitons (Mollusca, Polyplacophora) of Caldera, Region of Atacama, northern Chile

Juan Francisco Araya<sup>1,2</sup>, Marta Esther Araya<sup>3</sup>

1 Programa de Doctorado en Sistemática y Biodiversidad, Departamento de Zoología, Universidad de Concepción. Casilla 160-C, Concepción, Chile

2 Laboratorio de Invertebrados Acuáticos, Departamento de Ciencias Ecológicas, Facultad de Ciencias, Universidad de Chile, Las Palmeras 3425, Ñuñoa CP 780-0024, Santiago, Chile

3 Los Gladiolos 520, Caldera. Chile

<http://zoobank.org/6D9539C2-76A3-4803-95F6-8347908EA835>

Corresponding author: Juan Francisco Araya ([jfaraya@u.uchile.cl](mailto:jfaraya@u.uchile.cl))

## Abstract

Received 2 September 2014

Accepted 16 February 2015

Published 5 March 2015

Academic editor:

Matthias Glaubrech

## Key Words

Chile

*Calloplax*

*Callistochiton*

*Chaetopleura*

*Enoplochiton*

*Radsia*

*Tonicia*

Southeastern Pacific

intertidal

The Molluscan species of the northern littoral of Chile have been sparsely studied. This work reviews for the first time the diversity of polyplacophoran molluscs around the port of Caldera, in the Region of Atacama (26°45'49"S; 70°45'17"W to 27°20'23"S; 70°56'46"W), northern Chile. Eleven species were found in this study: *Acanthopleura echinata* (Barnes, 1824); *Callistochiton pulchellus* (Gray, 1828); *Calloplax vivipara* (Plate, 1899); *Chaetopleura peruviana* (Lamarck, 1819); *Chiton cumingsii* Frembly, 1827; *Chiton granosus* Frembly, 1827; *Chiton magnificus* Deshayes, 1827; *Enoplochiton niger* (Barnes, 1824); *Radsia barnesii* (Gray, 1828); *Tonicia atrata* (G. B. Sowerby II, 1840) and *Tonicia chilensis* (Frembly, 1827). All of the species occurring in the area have distributions in the southeastern Pacific Ocean, from Ecuador to central Chile, and three of them are species endemic to the Chilean coasts (*Calloplax vivipara*, *Radsia barnesii*, and *Tonicia atrata*). This diversity of species is comparable to that of better surveyed faunas of central and southern Chile or Patagonia. Of the eleven species recorded, the geographic distribution records for *Callistochiton pulchellus*, *Radsia barnesii* and *Tonicia atrata* are extended, and *Calloplax vivipara* is found alive again after 40 years, filling a gap in its known distribution. Illustrations of living specimens in their habitat, distribution records and a taxonomic key for all the studied taxa are also provided.

## Introduction

Research on marine molluscs of northern Chile began with the descriptions of some species by Sowerby (1832), d'Orbigny (1847), Hupé (1854) and Philippi (1860) in the late 19<sup>th</sup> century. Further works include the studies done by Dall (1909), mostly in deep water areas along the Chilean and Peruvian coasts; Gigoux (1934), which listed the species found in the Region of Atacama, Marinovich (1973), describing the intertidal molluscs of Iquique; Acuña (1977), Bretos (1980), Bretos et al. (1983) and McLean (1984) dealing with fissurellid limpets and, more recently, the works of Guzmán et al. (1998) which studied

the molluscan fauna of Antofagasta; Véliz and Vásquez (2000) reviewing the Trochidae species from northern Chile, and a few works, among others, describing new Calyptraeidae (Brown and Olivares 1996, Véliz et al. 2012), Limidae (Campusano et al. 2012) or Buccinidae species (Araya 2013).

Regarding the Chilean Polyplacophora — apart from the early works of Frembly (1827), Rochebrune and Mabile (1885), Rochebrune (1889), Pilsbry (1893), Plate (1901, 1902), Thiele (1906, 1911) or Melvill and Standen (1912) among others — it was the work of Leloup (1956) which produced the most detailed study dealing with this molluscan class in the country; encompassing

material from between Iquique (20°S) in northern Chile to Punta Arenas (53°S) in the extreme south of the country. Most of the subsequent works dealing with chitons have been focused on species from central and southern Chile (Castellanos 1948, 1951, Stuardo 1959, Osorio and Reid 2004, Schwabe and Sellanes 2004, 2010, Sirenko 2006), with a few works including shallow water species (Schwabe et al. 2006, Sirenko 2007). Further recent works including species from the Region of Atacama or northern Chile in particular only include the Kaas and Van Belle monograph series (Kaas and Van Belle 1985a, 1985b, 1987, 1990, 1994) which studied the worldwide chitons and, among them, Chilean species.

This molluscan class is often overlooked in Chile, as their species are mostly small and hard to collect and to preserve, however, three of the large species of Chilean

chitons (*Acanthopleura echinata* (Barnes, 1824), *Chiton* (*Chiton*) *magnificus* Deshayes, 1827 and *Chiton* (*Chiton*) *granosus* (Frembly, 1827)) are collected with gastronomic purposes (Osorio 2002), and some species are used in traditional medicine in northern Chile. Chitons play a role in controlling the green algal cover in mid-intertidal exposed rocky-shores of central Chile (Aguilera and Navarrete 2007) eating encrusting corallines (Camus et al. 2012), newly settled barnacles (Aguilera 2005) and other sessile and mobile invertebrates (Camus et al. 2008), and thus they have a direct impact on the intertidal ecosystem.

The coast of the Region of Atacama consists of rocky formations of volcanic origin with a few sandy beaches. The intertidal area of most of the coast, with the exception of a few scattered bays, is narrow (up to 20 m) and presents a diverse geography including cliffs, rocky plat-

**Table 1.** Sampling sites, arranged from north to south.

Locality	Habitat type/Macroalgae	Coordinates	Species present
Obispito	Rocky coast with tidal pools, crustose coralline algae.	26°45'49"S; 70°45'17"W	<i>Calloplax vivipara</i> , <i>Chiton cumingsii</i> .
Aguas Verdes	Rocky coast with tidal pools, large phaeophyta algae ( <i>Lessonia</i> sp.).	26°52'20"S; 70°49'25"W	<i>Chiton cumingsii</i> , <i>Chiton magnificus</i> , <i>Tonicia chilensis</i> .
Playa Granito Orbicular	Pebble beach, minor algae covering.	26°58'22"S; 70°47'43"W	<i>Chiton cumingsii</i> .
Playa Rodillo	Exposed rocky coast and pebble beach.	26°59'48"S; 70°47'27"W	<i>Enoplochiton niger</i> .
Sur de Playa Ramada	Rocky coast with tidal pools and rock intrusions in sandy beach. Great diversity of algae.	27°00'37"S; 70°48'04"W	<i>Callistochiton pulchellus</i> , <i>Calloplax vivipara</i> , <i>Chaetopleura peruviana</i> , <i>Chiton cumingsii</i> , <i>Chiton magnificus</i> , <i>Radsia barnesii</i> , <i>Tonicia chilensis</i> .
Islote Playa Ramada	Rocky coast, big boulders. Holdfasts of <i>Lessonia nigrescens</i> .	27°00'41"S; 70°48'23"W	<i>Chaetopleura peruviana</i> , <i>Chiton cumingsii</i> , <i>Enoplochiton niger</i> .
Playa El Pulpito	Pebble beach, rock formation. Several algae.	27°01'22"S; 70°48'30"W	<i>Chaetopleura peruviana</i> , <i>Callistochiton pulchellus</i> , <i>Chiton cumingsii</i> , <i>Enoplochiton niger</i> .
Playa El Pulpo	Rocky coast with protected sandy beach. Great diversity of algae.	27°01'37"S; 70°48'39"W	<i>Chaetopleura peruviana</i> , <i>Callistochiton pulchellus</i> , <i>Chiton cumingsii</i> , <i>Chiton granosus</i> , <i>Radsia barnesii</i> .
Norte Bahía de Caldera	Rocky coast, rock slabs and pockets of sand. Encrusting algae, <i>Ulva lactuca</i> , etc.	27°03'01"S; 70°48'30"W	<i>Acanthopleura echinata</i> , <i>Chaetopleura peruviana</i> , <i>Chiton granosus</i> , <i>Enoplochiton niger</i> .
Sur de Playa Negra	Sandy beach with rock formation. Minor algal covering.	27°03'38"S; 70°48'51"W	<i>Chaetopleura peruviana</i> , <i>Chiton cumingsii</i> .
Sur de Playa Brava	Rock formation among sandy beaches, <i>Ulva lactuca</i> and red algae.	27°03'50"S; 70°49'13"W	<i>Chaetopleura peruviana</i> , <i>Chiton cumingsii</i> .
Playa Mansa	Limestone slabs on sandy beach. Small algae covering, encrusting algae.	27°03'58"S; 70°49'36"W	<i>Acanthopleura echinata</i> , <i>Chaetopleura peruviana</i> , <i>Chiton cumingsii</i> , <i>Chiton granosus</i> , <i>Tonicia atrata</i> , <i>Tonicia chilensis</i> .
Sur Bahía de Caldera	Rock slabs, pebble beach. Encrusting algae.	27°03'33"S; 70°49'55"W	<i>Chaetopleura peruviana</i> , <i>Chiton cumingsii</i> , <i>Chiton granosus</i> , <i>Tonicia chilensis</i> .
Calderilla	Loose boulders on sandy beach, <i>Gracilaria</i> algae.	27°05'30"S; 70°50'56"W	<i>Chaetopleura peruviana</i> , <i>Chiton cumingsii</i> , <i>Tonicia chilensis</i> .
Peninsula Calderilla	Rocky coast with small pebble beach, <i>Ulva lactuca</i> and red algae.	27°05'15"S; 70°51'27"W	<i>Calloplax vivipara</i> , <i>Chaetopleura peruviana</i> , <i>Chiton cumingsii</i> , <i>Radsia barnesii</i> .
Norte Bahía Inglesa	Rocky beach, scattered sandy pockets.	27°05'14"S; 70°51'49"W	<i>Chaetopleura peruviana</i> , <i>Chiton cumingsii</i> .
Sur Playa Rocas Negras	Rocky formation on sandy beach. Encrusting corallines.	27°07'39"S; 70°54'53"W	<i>Chaetopleura peruviana</i> , <i>Chiton cumingsii</i> .
Playa Chorrillos	Rocky coast with scattered pebble beaches. Large algae holdfasts ( <i>Lessonia nigrescens</i> , <i>Lessonia trabeculata</i> )	27°12'44"S; 70°57'05"W	<i>Chaetopleura peruviana</i> , <i>Chiton cumingsii</i> , <i>Chiton magnificus</i> .
Bahía Cisne	Sandy beach with rock platforms. Filamentous algae.	27°14'57"S; 70°57'42"W	<i>Chiton cumingsii</i> .
Puerto Viejo	Sandy beach with limestone rocks intrusions. Minor algae communities.	27°20'23"S; 70°56'46"W	<i>Chiton cumingsii</i> .

forms, intertidal pools, and boulder fields. The exposed side of rocks and boulders are exposed to strong surf, with just a few sheltered areas, particularly in the area of the Bay of Caldera, Obispito and Calderilla (Table 1).

This work presents an overview, with distributions and illustrations, of all the species of Polyplacophora found in the Region of Atacama, northern Chile. The distribution range and a taxonomic key to all the studied species is also provided. The aim of this preliminary paper is thus to contribute on the knowledge of the molluscan fauna, in particular of northern Chile.

## Material and methods

The material considered in this study was mostly obtained by sampling in the rocky coastal areas around the port of Caldera (27°04'S; 70°50'W), between Calenta Obispito (26°45'49"S; 70°45'17"W) and Puerto Viejo (27°20'23"S; 70°56'46"W), and in specific localities along the coasts of the Region of Atacama, northern Chile, during the summers of 2011 to 2012 and in August–December 2012. A synopsis of all the stations is given in Table 1. The surveys used a similar approach to the work of García-Ríos et al. (2011). The terminology of shell morphology is based upon Schwabe (2010). Original descriptions of all species were carefully reviewed and voucher specimens, unless indicated, are deposited under accession number 3072014 in the collections of the Museo Paleontológico de Caldera, Caldera, Chile (MP-CCL). Abbreviations used are: LACM, Natural History Museum of Los Angeles County, Los Angeles, USA; SBMNH, Santa Barbara Museum of Natural History, Santa Barbara, USA; NHMUK, National History Museum, London, United Kingdom.

## Systematic taxonomy

**Class Polyplacophora Gray, 1821**

**Subclass Neoloricata Bergenhayn, 1955**

**Order Chitonida Thiele, 1909**

**Suborder Chitonina Thiele, 1909**

**Superfamily Chitonoidea Rafinesque, 1815**

**Family Callistoplacidae Pilsbry, 1893**

**Genus *Callistochiton* Carpenter MS, Dall, 1879**

**Type species.** *Callistochiton palmulatus* Carpenter MS, Dall, 1879, by monotypy.

***Callistochiton pulchellus* (Gray, 1828)**

Plate 1, Fig. 2; Table 2

*Chiton pulchellus* Gray, 1828: 6, pl. 3, fig. 9. *Chiton bi-costatus* d'Orbigny, 1847: 486, pl. 81, figs 7–9. *Callistochiton shuttleworthianus*: Bergenhayn 1937: 284, figs

3f–g (non *Callistochiton shuttleworthianus* Pilsbry, 1893). *Callistochiton carmenae* Smith & Ferreira, 1977: 87, figs 10–11. *Callistochiton pulchellus*: Ferreira 1979: 460, figs 25–26; Aguilera 2005a: 207, fig. 1. Detailed bibliography and synonymy in Kaas and Van Belle (1994: 161).

**Description.** Animal of small size, up to 11.5 mm in examined specimens, elongate oval, moderately elevated, color of tegmentum creamy white or bright white. Head valve semicircular, sculpture with 10–15 low rounded, equally spaced, nodulose, annulate, radial ribs, becoming obsolete towards the apex, the posterior ribs being strongest and more nodulose. Intermediate valves rectangular, lateral areas well defined, sculptured with two strong radial ribs. Central area with two series of equally spaced, diagonal lirae, forming rounded depressions in the interspaces. Tail valve semi-oval, slightly less wide than head valve, sculptured like head valve, with 8–11 weaker radial ribs. Girdle rather wide, yellowish white, dorsally covered with small, oval, imbricating scales (After Kaas and Van Belle 1994).

**Material examined.** Specimens found under sunken rocks in tidal pools in Playa El Pulpito (SBMNH 452240, 1 specimen), Sur de Playa Ramada and Playa El Pulpo (Table 1).

**Distribution.** This species has records from Islay (17°03'S; 72°06'W), Peru to Chanavayita cove, 54 km south of Iquique, Chile (20°42'S; 70°09'W), with records also in the Galápagos Islands (01°40'N; 92°01'W), Ecuador (Aguilera 2005a). The present record (at 27°S) is now the southernmost record for this species.

**Remarks.** This is a small (under 12 mm) chiton, easily overlooked but for its bright whitish color. It is a fairly rare species; they were not abundant and were found only in two of the studied locations (Table 1), under rocks sunken in tidal pools, associated to small communities of *Acar pusilla* Sowerby, 1832, *Liotia cancellata* Gray, 1842, *Rissoina inca* Sowerby, 1832, encrusting algae and sponges. It has been reported that this species feeds on sponges, bryozoa and diatoms (Aguilera 2005). This species can be mistaken for *Calloplax vivipara* (Plate, 1902), differing from this species in having a less elongate body shape, with a much finer and subtle sculpture (especially noticeable on the terminal valves), it differs from *C. vivipara* in having rounded depressions in the central-lateral areas of the valves, especially in the middle valves.

**Genus *Calloplax* Thiele, 1909**

**Type species.** *Chiton janeirensis* Gray, 1828, by monotypy.

***Calloplax vivipara* (Plate, 1899)**

Plate 1, Fig. 3; Table 2

*Callistochiton viviparus* Plate, 1899: 154, pl. 9, figs 267–281; Dall 1909: 246; Gigoux 1934: 281; Boudet 1945: 134; Leloup 1956: 46; Stuardo 1959: 144; Smith 1966: 436, 437, 441, 442. *Chiton janeirensis*, Var.?: Gray 1828: 5; Sowerby 1840: 6, sp. no. 78 (spelled *janierensis*). *Calloplax viviparus*: Ferreira 1978: 60, figs 2 & 5.

**Description.** Animal of small size, up to 12 mm in examined specimens, elongate oval, moderately elevated, color of tegmentum tan or creamy white. Head valve semicircular, sculpture with about nine equally spaced, nodulose, annulate and well defined radial ribs. Intermediate valves rectangular, lateral areas well defined, sculptured with two strong radial ribs. Central area with about eight longitudinal riblets per side, well-marked in the pleural areas but becoming obsolete at the jugum. The riblets tend to converge anteriorly and are not latticed. Posterior valve semi-oval, elevated at the central mucro, with nine well defined radial ribs. Girdle yellowish white, dorsally covered with small scales (After Ferreira 1978).

**Material examined.** Specimens found under rocks in a tidal pool at Obispito (MPCCL 3072014B, 1 specimen), Sur de Playa Ramada and under rock slabs sunken under boulders in Peninsula Calderilla (SBMNH 452241, 1 specimen).

**Distribution.** Plate (1899) described this species for Isla Pacharos (=Pájaros), near Coquimbo, Chile (29°58'S; 71°21'W). Ferreira (1978) additionally recorded this species from the intertidal of Pozo Toyo, South of Iquique, Tarapacá Province (20°25'S; 70°10.5'W) and mainland East of Isla Santa María, North of Antofagasta, Antofagasta Province (23°25'S; 70°36'W) from specimens housed at the LACM. A specimen labelled *Chiton janeirensis* (NHMUK 197742) identified by Ferreira (1978) as *C. viviparus* extended the southern distribution of this species at Valparaíso (33°02'S; 71°38'W). This is the first time this species is recorded, in the field, since its description and the present record fills a gap in the distribution in Chile of this rare species.

**Remarks.** This is a rare species, found in only two of the locations under study; in both places this species was found under rocks sunken in tidal pools, associated to encrusting sponges and to communities of the small mussel *Brachidontes granulata* (Hanley, 1843). According to Plate (1899) this species is ovoviviparous; that cited author found about 15 embryos, some with seven shell valves, in the ovary of a single specimen. In fact, this is the only chiton species ever reported to be ovoviviparous (Pearse 1979). This species is somewhat similar to *Callistochiton pulchellus* (Gray, 1828), differing in the coarse sculpture (especially in the anterior valve, with fewer and stronger ribs), the presence of longitudinal riblets in the central areas, and the more yellowish body color.

**Family Chaetopleuridae Plate, 1899****Subfamily Chaetopleurinae Plate, 1899****Genus *Chaetopleura* Shuttleworth, 1853**

**Type species.** *Chiton peruvianus* Lamarck, 1819, by subsequent designation.

***Chaetopleura (Chaetopleura) peruviana* (Lamarck, 1819)**

Plate 1, Fig. 4; Table 2

*Chiton peruvianus* Lamarck, 1819: 321; Barnes 1824: 70, pl. 3, fig. 2. *Chaetopleura peruviana*: Plate 1902: 182, pl. 2, figs 141–142, pl. 10, figs 294–301, pl. 11, figs 302–303; Dall 1909: 244; Marincovich 1973: 44, fig. 101; Aldea and Valdovinos 2005: 383, fig. 5C. *Chaetopleura (Chaetopleura) peruviana*: Kaas and Van Belle 1987: 62, fig. 27; Reid and Osorio 2000: 113, fig. 2A.

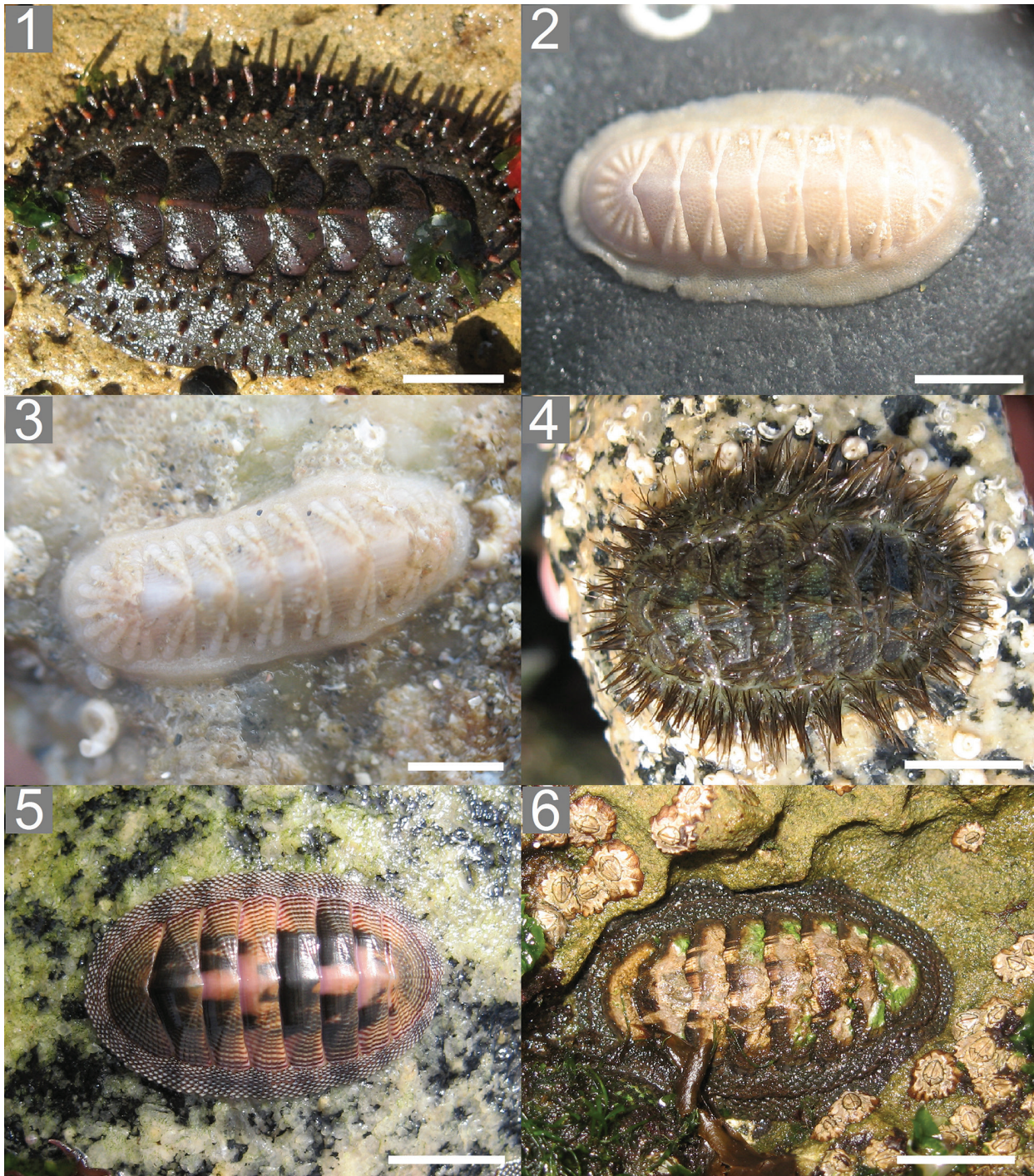
**Description.** Animal of medium to large size, up to 45 mm long in examined specimens. Oval to elongate oval, slightly depressed, color of tegmentum greenish-brown to dark brown. Head valve semicircular, front slope straight, posterior margin V-shaped. Intermediate valves broadly rectangular. Tail valve less than semicircular, almost as wide as head valve. Girdle profusely beset with very long (up to 10 mm) thick, coarse, corneous hairs, not only interspersed throughout girdle but in girdle bridges, protruding at sutures and extending over valves. Tegmentum pustulose sculptured with minute and neatly separated pustules, on the end valves the pustules are arranged in radiating rows. Body width/length, mean 0.66; height/length, mean 0.22 (After Ferreira 1983).

**Material examined.** Specimens found in almost all locations, with the exception of Bahía Cisne, Puerto Viejo and Playa Rodillo up to Obispito (Table 1). Calderilla (MPCCL 3072014C, 1 specimen).

**Distribution.** Kaas and Van Belle (1987) cited this species along the western coast of South America, between Cape San Lorenzo (1°4'0"S; 80°55'60"W), Ecuador to the Chonos Archipelago (45°0'0"S; 74°0'0"W), southern Chile. This species lives in the intertidal zone down to a depth of 40 m (Kaas and Van Belle 1987).

**Remarks.** This species is easily distinguished from all other chitons in the region by the presence of hairs covering the valves and sutures. A similar species, *Chaetopleura (Chaetopleura) benaventei* Plate, 1899 is slightly smaller in size and differs in the overall coloration and in the absence of the corneous bristles. *Chaetopleura hennahi* (Gray, 1828) found between El Callao, Peru and Arica, Chile (Kaas and Van Belle 1987) has a wine-red to reddish brown tegmentum and lacks the blackish corneous hairs which protrude at the sutures in *Chaetopleura peruviana*.





**Plate 1.** *Chiton* species photographed in situ; **1.** *Acanthopleura echinata*, Playa Mansa; **2.** *Callistochiton pulchellus*, Playa El Pulpo; **3.** *Calloplax vivipara*, Peninsula Calderilla; **4.** *Chaetopleura peruviana*, Sur Playa Ramada; **5.** *Chiton cumingsii*, Playa El Pulpo; **6.** *Chiton granosus*, Playa Mansa. Scale bars are: 2 cm for **1, 2, 3** and 1 cm for **4, 5, 6**.

**Family Chitonidae Rafinesque, 1815**  
**Subfamily Acanthopleurinae Dall, 1889**

**Genus *Acanthopleura* Guilding, 1829**

**Type species.** *Chiton spinosus* Bruguière, 1792, by subsequent designation.

***Acanthopleura echinata* (Barnes, 1824)**

Plate 1, Fig. 1; Table 2

*Chiton echinatus* Barnes, 1824: 71, pl. 3, figs 4a, b. *Chiton spiniferus* Frembly, 1827: 196, suppl. pl. 16, fig. 6; Sow-erby 1833, pl. 1, fig. 47. *Acanthopleura echinata*: Dall



**Table 2.** Distribution range of taxa considered in this work.

Species	Distribution	References
<i>Acanthopleura echinata</i> (Barnes, 1824)	Talara, Peru (04°34'S; 81°16'W) to Punta Tumbes, Bahía de Concepción, Chile (36°49'S; 73°03'W).	Ferreira 1986
<i>Callistochiton pulchellus</i> (Gray, 1828)	Islay (17°03'S; 72°06'W), Peru to Ramada Beach, Caldera (26°56'S; 70°47'W).	Aguilera 2005a and this study.
<i>Calloplax vivipara</i> (Plate, 1902)	Pozo Toyo, South of Iquique (20°25'S; 70°10.5'W) to Valparaíso (33°02'S; 71°38'W), Chile.	Plate 1902; Ferreira 1978 and this work
<i>Chaetopleura</i> ( <i>Chaetopleura</i> ) <i>peruviana</i> (Lamarck, 1819)	Cape San Lorenzo, Ecuador (01°04'S; 80°55'60"W) to the Chonos Archipelago, Chile (45°00'S; 74°00'W).	Kaas and Van Belle (1983)
<i>Chiton</i> ( <i>Chiton</i> ) <i>cummingsii</i> Frembly, 1827	Paita, Peru (05°05'34"S; 81°06'07"W) to Puerto Montt (41°28'S; 72°56'W), Chile.	Marincovich (1973).
<i>Chiton</i> ( <i>Chiton</i> ) <i>granosus</i> Frembly, 1827	Paita, Peru (05°05'34"S; 81°06'07"W) to Boca de Guafo (43°39'S; 74°00'W), Region of Aysén, Chile.	Marincovich (1973) and Osorio et al. (2005).
<i>Chiton</i> ( <i>Chiton</i> ) <i>magnificus</i> Deshayes, 1827	San Lorenzo Island, Peru (12°05'23"S; 77°13'26"W) south to Bahía Tictoc, Chiloé Province, Chile. (43°36'40"S; 72°57'15"W).	Bullock (1988)
<i>Enoplochiton niger</i> (Barnes, 1824)	Talara, Peru (04°34'S; 81°16'W) to Coquimbo Bay, Chile (29°58'S; 71°21'W).	Ferreira 1986
<i>Radsia barnesii</i> (Gray, 1828)	Ramada Beach, Caldera (26°56'S; 70°47'W) to the Chonos Archipelago (45°0'0"S; 74°0'0"W), Chile.	Bullock (1988) and this study
<i>Tonicia atrata</i> (Sowerby II, 1840)	Playa Mansa, Caldera (27°03'58"S; 70°49'36"W) to Tierra del Fuego (54°S), Chile.	Reid and Osorio (2000) and this study
<i>Tonicia chilensis</i> (Frembly, 1827)	Peru (12°S) to Chile (54°S).	Reid and Osorio (2000).

1909: 180, 248, pl. 23, fig. 6; Marincovich 1973: 44, fig. 100; Osorio 2002: 52.

**Description.** Animal of very large size, up to 158 mm in examined specimens. Tegmentum smooth to shiny (but often eroded), dark reddish-brown, with occasional small blue spots. Lateral areas hardly raised, smooth except for two radial rows, one of 5–9 round granules indenting sutural edge. Anterior valve with some 10 radial rows of round granules; space between rows smooth. Central areas with raised, well-defined, smooth jugal band bordered by shallow, longitudinal grooves with short, wavy, longitudinally oriented riblets on pleural areas. Girdle upper surface with erect, strong, spike-like spines, round in cross section, up to 8 mm long in large specimens (longer if not broken), often encrusted. Girdle bridges empty (After Ferreira 1986). According to Osorio (2002) this is a dioecious species, which can reach a maximum length of 200 mm.

**Material examined.** Specimens found in two locations; Norte Bahía de Caldera (MPCCL 3072014A, 1 specimen) and in Playa Mansa, in subtidal areas in exposed rocks and in rocks associated with the giant kelp *Lessonia nigrescens* Bory de Saint-Vincent, 1826.

**Distribution.** According to Ferreira (1986) this species is found from Talara, Peru (04°34'S; 81°16'W) to Punta Tumbes, Bahía de Concepción, Chile (36°49'S; 73°03'W), and is limited to the intertidal zone and shallow subtidal, 0–4 m depth, on rocks often exposed to heavy surf.

**Remarks.** This is one of the largest polyplacophoran in Chile, differing from the also large *Enoplochiton niger* in having conspicuous spines in the girdle, not sparse scales

as in *E. niger*. This species prefers the subtidal zone and wave-exposed shores, and it is often covered with algae and epibionts (*Scurria* species, *Mytilus* species, etc) which allow this species to blend in with its surroundings. The spines are often covered with encrusting algae in older specimens. This is a commercially important species (Osorio 2002).

### Genus *Enoplochiton* Gray, 1827

**Type species.** *Chiton niger* Barnes, 1824, by monotypy.

### *Enoplochiton niger* (Barnes, 1824)

Plate 2, Fig. 1; Table 2

*Chiton niger* Barnes, 1824: 71, pl. 3, fig. 3. *Enoplochiton niger*: Pilsbry 1893: 14: 252, pl. 52, figs 22–29; Marincovich 1973: 43, fig 99. *Acanthopleura nigra*: Ferreira 1986: 266, figs 106–111 and 113–N.

**Description.** Animal very large in size, up to 190 mm in examined specimens. Tegmentum dark chocolate-brown, shiny, but easily eroded. Anterior valve with 4–6 concentric, zig-zagged furrows. Lateral areas elevated, well defined by strong round rib at diagonal line, with zig-zagged furrows as on anterior valve. Central areas well defined, smooth jugum bordered by narrow, depressed area with irregular, short, oblique furrows; para-jugal area smooth; pleural area with longitudinal, parallel furrows, not usually reaching anterior border of valve. Girdle thick, muscular; dorsal surface dark brown, conspicuously dotted with light brown scales, scales irregular in size (larger in middle

1/3 of girdle), up to 1.5–2 mm long in specimens 50 mm long (larger in larger specimens), vaguely striate, usually eroded at upper edge, clearly separated from each other by area as wide as scale; on outer 1/5 of girdle, scales much smaller, shorter, dark brown, erect, spine-like; girdle surface completely covered otherwise with minute, dark brown, lanceolate spicules, up to 100 µm long, 25 µm thick. Girdle bridges, empty in middle third, but crowded with small, dark brown spiculoid elements (akin to those on girdle proper) in outer thirds (After Ferreira 1986).

**Material examined.** Specimens found exposed on large boulders in the surf-zone, in Playa Rodillo, Playa El Pulpito (MPCCL 3072014E, 1 specimen) and in Norte Bahía de Caldera.

**Distribution.** This species is confined to the western temperate coast of South America, from Talara, Peru (04°34'S; 81°16'W) to Coquimbo Bay, Chile (29°57'S; 71°20'W). Its bathymetric range is limited to the intertidal zone (Ferreira 1986).

**Remarks.** With sizes up to 200 mm (Sanhueza et al. 2008), this is one of the largest polyplacophoran species in the country. It lives almost exclusively in exposed rocks or in the surf zone. Although this species is mostly herbivore, it has been described also as a generalist polyphagous consumer, and a potential omnivorous, (Sanhueza et al. 2008). A brown-colored variety of the limpet species, *Scurria variabilis* (Sowerby, 1839), lives on the valves of this species, having been found in all the specimens examined in this study. An unidentified barnacle was also observed on the valves of a few specimens. In some places (Rodillo beach, Obispito bay; Table 1) juvenile specimens can be found among crevices of large boulders. It was observed that this species is predated by the common gull, *Larus dominicanus* (Lichtenstein, 1823), an omnivore species that also predaes on the intertidal large keyhole limpets of the genus *Fissurella* (Bahamondes & Castilla, 1986).

## Family Chitonidae Rafinesque, 1815

### Subfamily Chitoninae Rafinesque, 1815

#### Genus *Chiton* Linnaeus, 1758

**Type species.** *Chiton tuberculatus* Linnaeus, 1758, by subsequent designation.

#### *Chiton (Chiton) cumingsii* Frembly, 1827

Plate 1, Fig. 5; Table 2

*Chiton cumingsii* Frembly, 1827: 198, suppl. pl. 16, fig. 3;

Dall 1909: 247. *Chiton cumingsii*: Reeve, 1847, pl. 1, figs 2a, b; Plate 1902: 46, pl. 3, figs 179–184, pl. 4. *Chiton cumingi*: Pilsbry 1893: 164, pl. 30, figs 29–31. *Chiton (Amaurochiton) cumingsii*: Bullock 1988: 166, figs 59–63, 69, 74 and 77.

**Description.** Animal of large size, reaching almost 60 mm in length in examined specimens. Anterior valve straight; post-mucronal slope of posterior valve slightly concave. Shell color yellowish white with concentric brown bands crossing lateral triangle longitudinally, then proceeding antero-medially over ribs of central area. Girdle light olive green or pinkish-brown. Interior of shell white with some dull green in posterior depression (After Bullock 1988).

**Material examined.** Specimens found in all the rocky shore stations (except Playa Rodillo and Norte Bahía de Caldera). Collected under rocks and rock slabs, Sur de Playa Brava (MZUC 39613, 1 specimen).

**Distribution.** Marincovich (1973) cites this species from Paita (05°05'S; 81°06'W), Peru to Puerto Montt (41°28'S; 72°56'W), Chile.

**Remarks.** This colorful species is the most common and abundant chiton distributed in the zone; found in almost all the locations. It is commonly found in accumulations of several individuals on the underside of rocks at low tide, crawling quickly to the dark if exposed to sunlight. Among the examined specimens, some of them had a pink/orange coloration when juveniles with some adult specimens retaining a uniform pink coloration. This species has been cited as an introduced species in Las Palmas Port, Canary Islands (28°06'N, 15°25'W), being one of the few alien polyplacophoran found in European waters (Arias and Anadón 2013).

#### *Chiton (Chiton) granosus* Frembly, 1827

Plate 1, Fig. 6; Table 2

*Chiton granosus* Frembly, 1827: 200, suppl. pl. 17, fig. 1; Plate 1902: 56, pl. 4, fig. 190; Pilsbry 1893: 167, pl. 30, figs 27, 28; Dall 1909: 247. *Chiton (Chiton) granosus*: Marincovich 1973: 43, fig. 98. *Chiton (Chondroplax) granosus*: Bullock 1988: 185, figs 96, 97, 103, 140, 141, 143, and 144; Osorio 2002: 56.

**Description.** Animal of large size, up to 45 mm in examined specimens. Intermediate valves often eroded and rather flat. Anterior valve convex, post-mucronal slope straight. Mucro moderately blunt; centrally located on posterior valve. Jugal tract smooth, central areas with somewhat beaded longitudinal ribs. Lateral triangle barely raised; low, broad, nodular rib extends along diagonal line. Often a few other radiating rows of nodules appear

on lateral triangle. Terminal areas with 10–12 radiating rows of widely spaced nodules. Color of tegmentum nearly totally dark brown to greenish brown, with occasional streaks of cream white on jugal and central areas. Girdle black. Interior of valves white with dull blue muscle scars and reddish brown on posterior slope of callus (After Bullock 1988). According to Osorio (2002) this species is gonochoric, like almost all other chiton species that have been studied. It can reach a maximum length of 80 mm.

**Material examined.** Specimens found in Playa El Pulpo, Norte de Bahía de Caldera, Playa Mansa and Sur de Bahía de Caldera, in crevices in large rocks, often in surf zone in large colonies. Playa el Pulpo (MPCCL 3072014D, 1 specimen).

**Distribution.** Marinovich (1973) gives the northernmost distribution for this species at Paita (05°05'34"S; 81°06'07"W), Peru. Osorio et al. (2005) records the southernmost record of this species at Boca del Guafo (43°39'S; 74°00'W), Region of Aysén, southern Chile.

**Remarks.** This species is somewhat uncommon in shallower waters; it is found mostly in crevices and in rocky outcrops, mostly in clustered distributions. Juvenile specimens are somewhat similar to the juvenile specimens of *Chiton cumingsii* differing in the paler coloration (of various shades of green), the granulation on the valves and in the overall wider body. It has been reported that this species feeds on barnacle cyprids (Moreno and Jaramillo 1983, Aguilera 2005) and is preyed on by the common gull *Larus dominicanus* (Lichtenstein, 1823). It was observed also that some specimens had barnacles on the valves. This species is a physiological omnivore, having the digestive flexibility and enzymatic capacity to digest and assimilate animal preys (Camus et al. 2009) and it is also a commercially important species (Osorio 2002).

### *Chiton (Chiton) magnificus* Deshayes, 1827

Table 2

*Chiton (Chiton) magnificus* Deshayes, 1827: 454. *Chiton magnificus*: Pilsbry 1893: 160, pl. 30, figs 23, 24; *Chiton (Amaurochiton) magnificus magnificus*: Bullock 1988: 163, figs 52–54, 57, 58, 64, 65, 68, 72, 73 and 76. *Chiton magnificus*: Schwabe et al. 2006: 9, figs 7, 8 and 15. A more detailed bibliography and synonymy can be found in Bullock (1988: 163).

**Description.** Animal of large size, reaching 115 mm in examined specimens. Body dark bluish-grey, broad-oval, slightly carinated, rather flat. Valves flattened to moderately carinated. Anterior valve slightly convex, semicircular, with wide V-shaped to straight posterior margin unnotched in middle, with numerous radially arranged, shallow ribs; intermediate valves rectangular with slight-

ly concave posterior margin at both sides of faintly protruding apex, lateral areas slightly elevated, sculptured with up to 5 radial ribs between a wider diagonal ridge and a very wide posterior rib; tail valve semicircular with an anterior mucro; post-mucronal area with same sculpture as head valve and lateral areas (After Schwabe et al. 2006). According to Osorio (2002), this species can reach a maximum length of 174 mm.

**Material examined.** Specimens found in Aguas Verdes, Sur de Playa Ramada and in Playa Chorrillos, in subtidal areas attached to large boulders.

**Distribution.** Bullock (1988) gives a distribution for this species from Isla San Lorenzo, Peru south to Bahía Tictoc (43°36'40"S; 72°57'15"W), Chiloé Province, southern Chile. This species can be found in rock pools and boulder fields with strong water exchange, from the intertidal down to a maximum of 30.5 m depth at the Comau Fjord (42°23'S; 72°27'W), Region of Aysén (Schwabe et al. 2006). Smith and Ferreira (1977) considered the records of this species from Galapagos Islands as erroneous.

**Remarks.** A shiny, large and conspicuous chiton, this species has been overlooked in recent molluscan literature, being cited by Valdovinos (1999) as *Chiton latus* and by Osorio (2002) as *Chiton magnificus boweni*. It seems to be an uncommon species, restricted to specific localities along the coast of Chile. Juvenile specimens may be misidentified as *Chiton cumingsii*, differing from this species in having a wider and flatter body, with smoother sculpture and with bright blue spots on the valves, which are cream white to greenish yellow in color. Apparently, in northern Chile this species is found only in subtidal areas. This is a commercially important species (Osorio 2002).

### Genus *Radsia* Gray, 1847

**Type species.** *Chiton barnesii* Gray, 1893 by monotypy.

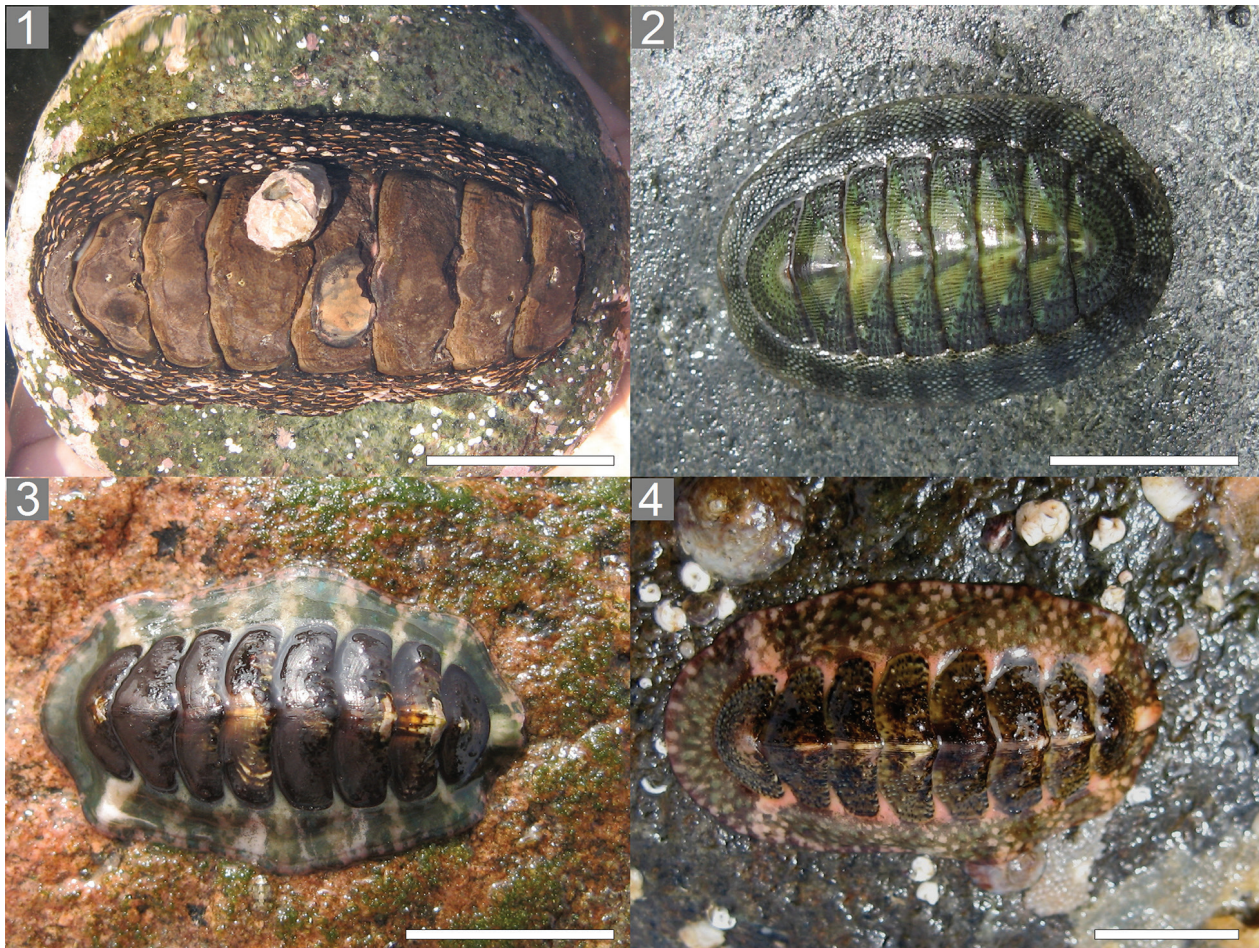
### *Radsia barnesii* (Gray, 1828)

Plate 1, Fig. 2; Table 2

*Chiton barnesii* Gray, 1828: 5; Reeve 1847: pl. 1, sp. 1. *Chiton (Radsia) barnesii*: Pilsbry 1893: 190, pl. 29, figs 10–12; Dall 1909: 247. *Chiton barnesii*: Plate 1899: 59, pl. 4, fig. 191; Leloup 1956: 46. *Radsia barnesii*: Bullock 1988: 282, figs 2,4,6,7, 11–13, 15, 31, 32. A more complete synonymy in Bullock (1988: 282)

**Description.** Animal of medium size, reaching a length of 28 mm in the examined specimens. Anterior valve straight; post-mucronal slope of posterior valve straight to slightly concave. Valves quite flat. Jugal region smooth;





**Plate 2.** *Chiton* species photographed in situ; 1. *Enoplochiton niger*, Isla Playa Ramada, 123 mm; 2. *Radsia barnesii*, Sur Playa Ramada, 22 mm; 3. *Tonicia atrata*, Sur de Playa Brava, 30 mm; 4. *Tonicia chilensis*, Playa Mansa, 32 mm. Scale bars are: 1 cm for 2 and 4, 2 cm for 3 and 4 cm for 1.

central area with numerous uneven longitudinal ribs. Lateral triangle barely raised, with 5–7 irregular nodules. Shell color cream white with reddish brown splotches on central areas, irregular longitudinal dark reddish brown bands on lateral triangles, and occasional dark reddish brown on jugum. Girdle light greenish brown with faint trace of alternating lighter bands in some specimens. Interior of valves white (After Bullock 1988).

**Material examined.** Specimens found in three locations; Peninsula Calderilla, Sur de Playa Ramada and in Playa El Pulpo Beach (Table 1). Collected under rocks and rock slabs, Peninsula Calderilla (MZUC 39614, 1 specimen).

**Distribution.** Bullock (1988) cites this species from Coquimbo (29°58'S; 71°21'W), to the Chonos Archipelago (45°0'0"S; 74°0'0"W), Chile. The present record (at 27°S) is now the northernmost record for this species.

**Remarks.** This species was uncommon in the zone under study; only a few specimens were found in the undersides of rocks at low tide. This species is clearly identified from the other species found in this work by having a wide, flat shell, with narrower valves and a pattern of clear and

darker alternating bands in the girdle. It can be misidentified as *Chiton granosus*; differing from this species in the smaller size, the much smaller girdle scales, a much weak valve sculpture and in the alternating bands of the perinotum, absent in *Chiton granosus*.

#### Family Chitonidae

##### Subfamily Tonicinae Pilsbry, 1893

#### Genus *Tonicia* Gray, 1827

**Type species.** *Chiton chilensis* Fremby, 1827, non De Blainville 1825 (= *Chiton chilensis* Fremby, 1827), by subsequent designation (Gray 1847: 168).

#### *Tonicia atrata* (G.B. Sowerby II, 1840)

Plate 2, Fig. 3; Table 2

*Chiton atratus* G.B. Sowerby II, 1840: 294. *Tonicia atrata* Aldea & Valdovinos, 2005: 368, Table 1, fig.

5I; Schwabe et al. 2006: 12, figs 9, 18; Gordillo and Schwabe 2009: 267, fig. 2D. A more detailed synonymy can be found in Kaas and Van Belle (1998: 25).

**Description.** Animal of medium to large size, reaching 51 mm in examined specimens. Shell elongate-oval, moderately elevated, subcarinated dorsum. Color reddish brown to blackish purple. Head valve semicircular, with straight posterior valve margin unnotched in middle; intermediate valves broadly rectangular, with distinct protruding apex and concave posterior valve margins. Lateral area hardly elevated, but clearly indicated by faint depression in front of diagonal ridge. Jugal area weakly developed, but showing partly a more or less distinct keel, especially in the more posterior intermediate valves. Tail valve with centrally situated, forward-directed, and slightly elevated mucro, straight antemucronal area and rather steep, straight postmucronal slope. Jugal area of tail valve extending towards anterior. Tegmentum without sculpture, except for growth marks and faint radial striations on terminal valves and lateral areas. Perinotum wide and fleshy (After Schwabe et al. 2006).

**Material examined.** Specimens collected in a single location; Playa Mansa, in submerged rocky platform (Table 1), MPCCL 011928A, 1 specimen.

**Distribution.** According to Reid and Osorio (2000), this species distributes in Chile between 40°S and 54°S, at Tierra del Fuego and around the Falkland Islands. The species ranges in depth from the low eulittoral to a depth of 36 m (Schwabe et al. 2006). The record presented here (at 27°S) is now the northernmost record for this species.

**Remarks.** Two specimens of this species were found in a single location; among a community of *Tonicia chilensis*, from which it distinguishes in attaining larger sizes and in having a darker body and almost smooth valves with minute granulation at the sides. It is interesting to note also that the valves of the examined specimens were widely separated, almost as in *Tonicia disjuncta* (Frembly, 1827). The presence of this species extends considerably the northernmost record of this species in about 1040 km (from 40°S to 27°S).

### *Tonicia chilensis* (Frembly, 1827)

Plate 2, Fig. 4; Table 2

*Chiton chilensis* Frembly, 1827: 203, pl. 17, fig. 6; Reeve 1847: pl. 4, f. 19. *Tonicia elegans* Subspecies *chilensis*: Pilsbry 1893: 196, pl. 41, figs 22–24, pl. 42, figs 31–35. *Tonicia chilensis*: Gordillo and Schwabe 2009: 269, fig. 2E, F. A more complete synonymy can be found at Kaas and Van Belle (1998: 45).

**Description.** Animal of medium to large size, reaching 43 mm in examined specimens. Shell elongate-oval, not

much elevated, the dorsal ridge rounded, side-slopes straightened. Color umber-brown at the sides, becoming chestnut in the middle, delicately and peculiarly speckled and blotched and streaked with buff or buff-white. Lateral areas hardly raised, but separated from the central areas by an obtuse diagonal ridge bearing a series of low tubercles, sometimes subobsolete; sculptured with subradiating rows of small granules, and showing a band of irregularly placed black eyes on the forward part. Central area of second valve having in the middle, a keel or a group of lirae; central areas of the other valves having a narrow smooth dorsal band with several longitudinal furrows on each side of it; and at the sides there are longitudinal diverging delicate rows of granules. End valves radially sub-granulate, and crowded with eye-spots subradially arranged (After Pilsbry 1893).

**Material examined.** Specimens found on rocks at low tide in Aguas Verdes, Sur de Playa Ramada, Playa Mansa (MPCCL 3072014F, 1 specimen), Sur Bahía de Caldera and in Calderilla.

**Distribution.** According to Reid and Osorio (2000) this species distributes in Chile and Peru between latitudes 12° and 54°S. It has a bathymetric range from 0–28 m (Schwabe et al. 2006).

**Remarks.** This species has large and colorful mantles and plates of variable shades, which are similar to the encrusting calcareous algae commonly found in the rocky coasts. Due to the high diversity of forms, several synonyms have been described (see Kaas and Van Belle 1998), and this species needs a complete revision according to Schwabe et al. (2006). This species was found only in the lower intertidal to the subtidal areas, especially in protected locations.

## Discussion

Schwabe and Sellanes (2010) reported 41 species of chitons from Chilean waters. Our results from the Region of Atacama, with eleven species found, accounts for 27 % of those reported species. All of the species occurring in the area have distributions in the southeastern Pacific Ocean, from Peru to southern Chile, with *Calloplax vivipara*, *Radsia barnesii* and *Tonicia atrata* as the only species endemic to the Chilean coast. The polyplacophoran diversity of the Region of Atacama is thus comparable to that described for southern areas of Chile, including central Chile (Aldea and Valdovinos 2005), the Comau fjord (Schwabe et al. 2006) and the Estero Elefantes and Laguna San Rafael areas (Osorio and Reid 2004), from where a similar diversity of this molluscan class has been recorded (with eleven, nine and nine species, respectively). With the exception of *Callistochiton pulchellus*, all of the species found in the Region of Atacama also occur in central and southern Chile.



All of the studied species can be classified in two main groups according to their habitat; species with a higher relative frequency on exposed areas include the very large species *Acanthopleura echinata* and *Enoplochiton niger*. The other group includes species associated with protected intertidal areas: *Callistochiton pulchellus*, *Calloplax vivipara*, *Chiton cumingsii*, *Chiton granosus* (mostly found in rock fissures and crevices) and *Radsia barnesii*. *Chiton magnificus* was found in the Region of Atacama only in subtidal areas, always near large boulders in hold-fast communities of the giant kelp *Lessonia nigrescens*. *Chiton magnificus*, however, is much more common in central and southern Chile, being found mostly in intertidal areas (Osorio 2002). The small-bodied species, *Callistochiton pulchellus* and *Calloplax vivipara*, were always restricted to submerged rocks in the bottom of tidal pools. This last habitat may explain the feeding behaviour of these small species, living over encrusting sponges and calcareous algae. Regarding feeding preferences; most of the large species of chitons from the Region of Atacama should have generalist diets, however it is possible that the smaller species have more specific diets, for example feeding in sponges, algal species, diatoms or barnacles.

The new distribution records of *Callistochiton pulchellus*, *Radsia barnesii* and *Tonicia atrata* and the new record of *Calloplax vivipara* may reflect the lack of sampling in the Atacama region or in northern Chile in general, where the scientific studies on invertebrates are still lacking. In particular, *Callistochiton pulchellus* and *Calloplax vivipara* may be more widespread in the country; however their particular habitat (and small adult size) may prevent their sampling by traditional methods. Some of these species may have also been overlooked or misidentified as juvenile specimens of other chiton species

(for example *Radsia barnesii* as *Chiton granosus*). The considerable new range extension of *Tonicia atrata* found in this study may reflect the current complicated, unresolved status of the genus *Tonicia* in Chile; the revision of some particular species or species-groups is thus imperative, considering the great diversity in the valve and mantle morphology, which has derived in a large synonymy for some species, for instance for *Tonicia chilensis* (Schwabe et al. 2006).

The absence of other species, for example those cited by Valdovinos (1999) in the last complete revision of the Chilean mollusks (which have been traditionally considered as having distribution records in northern Chile), including *Acanthochitona hirudiniformis* (Sowerby, 1832), *Acanthopleura granulata* (Gmelin, 1791), *Chaetopleura benaventei* Plate, 1902, *Chaetopleura hennahi* (Gray, 1828), *Ischnochiton imitator* (Smith, 1881), *Ischnochiton (Ischnochiton) punctulatissimus* (Sowerby in Broderip & Sowerby, 1832) or *Ischnochiton pusio* (Sowerby, 1832) may be explained because the sampling activities in the Region of Atacama were restricted to, at most, sublittoral areas (2 m depth). Deep water areas must definitely harbor more unrecorded or undescribed species, as is the case with other invertebrate groups like sponges (Reiswig and Araya 2014) or stony corals (Araya et al. in prep.). It is, then, very probable that the number of chitons known from the Region of Atacama, or northern Chile in general, will increase with larger collecting efforts, including additional sampling methods such as dredges and samples from greater depths, even subtidal waters (incorporating also the bycatch of the commercial deep water fisheries). Like other zones of Chile, the deep water areas off Caldera (or off northern Chile in general) have not been investigated in detail and could yield interesting results.

## Identification key

This key is primarily macroscopic (intended for identification of adult specimens) including external characters as shell features and general girdle features.

- |    |  |   |
|----|--|---|
| 1  | Whitish or cream colored chiton, of small size (up to 14 mm).....  | 2   |
| 1a | Animal of green, brown, pink or black coloration.....  | 3   |
| 2  | Animal bright whitish in color, with 10–16 radial ribs on head valve, with rounded depressions on the lateral areas of the valves .....  | <i>Callistochiton pulchellus</i> (Gray, 1828) |
| 2a | Animal whitish-cream in color, with about nine radial ribs on head valve, with longitudinal riblets in the lateral areas....   | <i>Calloplax vivipara</i> (Plate, 1902)       |
| 3  | Girdle naked or covered with small scales or by blunt spines .....   | 4   |
| 3a | Girdle covered by hairs, which can be also found between the valves, fleshy girdle .....   | <i>Chaetopleura peruviana</i> (Lamarck, 1819) |
| 4  | Girdle covered by visible round scales, in neat rows.....  | 5   |
| 4a | Girdle fleshy, naked or with sparse spines .....   | 8   |
| 5  | Valves visible granulate, often eroded and rather flat, with two white fringes on the central areas of the valves, terminal areas with 10–12 radiating rows of widely spaced nodules, girdle black ..... | <i>Chiton granosus</i> Frembly, 1827          |
| 5a | Valves striated in the middle, central valves narrow .....   | 6   |
| 6  | Valves carinate, of green, light brown or pink-yellowish color, girdle with alternating bands of color.....  | <i>Chiton cumingsii</i> Frembly, 1827         |
| 6a | Valves rather flat, olive green to black .....   | 7   |



- 7 Girdle with alternating pale and dark bands, central valves with uneven longitudinal ribs, color olive green, size small (up to 35 mm) and rather flat..... *Radsia barnesii* (Lesson, 1828)
- 7a Girdle black, valves flattened with central areas with fine longitudinal lirae, color dark green to nearly black, with tiny blue points, size up to 174 mm..... *Chiton magnificus* Deshayes, 1827
- 8 Girdle naked, ample, decorated with green and pink spots, plaques with variegated colouration..... 10
- 8a Girdle muscular, covered by blunt spines or lanceolate spicules..... 9
- 9 Girdle covered by blunt spines, anterior valve with some ten radial rows of rounded granules, valves usually encrusted with algae..... *Acanthopleura echinata* (Barnes, 1824)
- 9a Girdle covered with irregularly-sized scales, anterior valve with 4-6 concentric, zig-zagged furrows, valves often eroded..... *Enoplochiton niger* (Barnes, 1824)
- 10 Valves sculptured with minute granulation, central areas with a narrow smooth dorsal band or a group of lirae, with an obtuse diagonal ridge bearing a series of low tubercles..... *Tonicia chilensis* (Frembly, 1827)
- 10a Valves almost smooth; only sculptured by growth marks and faint radial striations on terminal valves and lateral areas..... *Tonicia atrata* (G. B. Sowerby II, 1840)

## Acknowledgements

We are thankful to Raúl Zuñiga and to Edison Villalobos (Caldera, Chile), for their help in field collections. We also give our thanks to Douglas Eernisse (Department of Biological Science, California State University Fullerton, Fullerton, California, U. S. A.) and to an anonymous reviewer for their helpful corrections, suggestions and comments, which greatly improved our manuscript. We are also indebted to the academic editor, Matthias Glaubrecht (Museum für Naturkunde, Leibniz Institute for Evolution and Biodiversity Science, Berlin, Germany) for his essential collaboration with this work.

## References

- Acuña SE (1977) Estudio preliminar de edad y crecimiento de *Fissurella latimarginata* en Tocopilla, Chile. *Revista Biología Marina (Valparaíso)* 16(2): 117–124.
- Aguilera MA (2005) Barnacles in the diet of the molluscan grazer *Chiton granosus* (Frembly, 1827) present on the intertidal rocky shore of Iquique, northern de Chile. *Investigaciones Marinas* 33(1): 109–113.
- Aguilera MA (2005a) Consideraciones taxonómicas de *Callistochiton pulchellus* (Gray, 1828) (Mollusca, Placophora) en Iquique, norte de Chile. *Investigaciones Marinas* 33(2): 207–210.
- Aguilera MA, Navarrete SA (2007) Effects of *Chiton granosus* (Frembly, 1827) and other molluscan grazers on algal succession in wave exposed mid-intertidal rocky shores of central Chile. *Journal of Experimental Marine Biology and Ecology* 349(1): 84–98. doi: 10.1016/j.jembe.2007.05.002
- Aldea C, Valdovinos C (2005) Moluscos del intermareal rocoso del centro-sur de Chile (36–38 S): taxonomía y clave de identificación. *Gayana* 69(2): 364–396.
- Araya JF (2013) A new species of *Aeneator* Finlay, 1926 (Mollusca, Gastropoda, Buccinidae) from northern Chile, with comments on the genus and a key to the Chilean species. *ZooKeys* 257: 89–101. doi: 10.3897/zookeys.257.4446
- Arias A, Anadón N (2013) *Tonicia atrata* and *Chiton cumingsii* (Polyplacophora: Chitonidae): First records in European waters. *Zootaxa* 3626(4): 593–596. doi: 10.11646/zootaxa.3626.4.14
- Bahamondes I, Castilla JC (1986) Predation of marine invertebrates by the kelp gull *Larus dominicanus* in an undisturbed intertidal rocky shore of central Chile. *Revista Chilena de Historia Natural* 59(1): 65–72.
- Barnes DH (1824) Description of five species of *Chiton*. *American Journal of Science* 7(1): 69–72.
- Bergenhayn JRM (1937) Antarktische und Subantarktische Polyplacophoren. *Scientific Results of the Norwegian Antarctic Expedition* 17: 1–12.
- Boudet Rommel I (1945) Los Quitones Chilenos. *Revista Chilena de Historia Natural* 48(144): 122–140.
- Bretos M (1980) Age determination in the keyhole limpet *Fissurella crassa* Lamarck (Archaeogastropoda: Fissurellidae), based on shell growth rings. *Biological Bulletin* 159: 606–612. doi: 10.2307/1540826
- Bretos M, Tesorieri I, Alvarez L (1983) The biology of *Fissurella maxima* Sowerby (Mollusca: Archaeogastropoda) in Northern Chile. 2. Notes on its reproduction. *Biological Bulletin* 165: 558–568. doi: 10.2307/1541465
- Brown DI, Olivares CA (1996) A new species of *Crepidula* (Mollusca: Mesogastropoda: Calyptraeidae) from Chile: additional characters for the identification of eastern Pacific planar *Crepidula* group. *Journal of Natural History* 30(10): 1443–1458. doi: 10.1080/00222939600770821
- Bullock RC (1988) The genus *Chiton* in the new world (Polyplacophora: Chitonidae). *The Veliger* 31(3–4): 141–191.
- Campusano CA, Ruz PM, Oliva ME (2012) *Limatula chilensis* sp. nov. Un nuevo Limidae (Mollusca: Bivalvia) en el norte de Chile. *Revista de Biología Marina y Oceanografía* 47(2): 311–316.
- Camus PA, Daroch K, Opazo LF (2008) Potential for omnivory and apparent intraguild predation in rocky intertidal herbivore assemblages from northern Chile. *Marine Ecology Progress Series* 361: 35–45. doi: 10.3354/meps07421
- Camus PA, Cid YY, Cisterna L, Cáceres CW (2009) Consumption and digestion of animal food by rocky intertidal herbivores: An evaluation of digestive flexibility and omnivory in three grazer species. *Latin American Journal of Aquatic Research* 37: 191–197. doi: 10.3856/vol37-issue2-fulltext-6
- Camus PA, Navarrete AH, Sanhueza AG, Opazo LF (2012) Trophic ecology of the chiton *Acanthopleura echinata* on Chilean rocky shores. *Revista Chilena de Historia Natural* 85: 123–135. doi: 10.4067/S0716-078X2012000100010

- Castellanos ZJA de (1948) Sobre seis especies de Poliplacóforos Argentinos. *Notas Zoología*, Museo de La Plata 13: 191–202.
- Castellanos ZJA de (1951) Poliplacóforos del Museo Argentino de Ciencias Naturales. Comunicaciones del Instituto Nacional de Investigación de Las Ciencias Naturales anexo al Museo Argentino de Ciencias Naturales “Bernardino Rivadavia”. *Ciencias Zoología* 1(15): 1–31.
- Castellanos ZJA de (1956) Catálogo de los poliplacóforos Argentinos y de aguas vecinas al Estrecho de Magallanes. *Revista del Museo Universidad Nacional de La Plata (Facultad de Ciencias Naturales, Zoología)* 6(49): 465–486.
- d’Orbigny A (1835–1847) *Voyage dans l’Amérique Méridionale (Le Brésil, La République Orientale de l’Uruguay, La République Argentine, La Patagonie, La République du Chili, La République de Bolivie, La République du Pérou)*, exécuté pendant les années 1826, 1827, 1828, 1829, 1830, 1831, 1832 et 1833. P. Bertrand, Paris, V. Levraut, Strasbourg.
- Dall WH (1909) Report on a collection of shells from Peru, with a summary of the littoral marine Mollusca of the Peruvian Zoological Province. *Proceedings of the US Natural History Museum* 37(1704): 147–294.
- Ferreira AJ (1978) The genus *Calloplax* Thiele, 1909 (Mollusca: Polyplacophora) in the Americas. *Bulletin of the Southern California Academy of Sciences* 77(2): 56–64.
- Ferreira AJ (1979) The genus *Callistochiton* Dall, 1879 (Mollusca: Polyplacophora) in the Eastern Pacific, with the Description of a New Species. *Veliger* 21(4): 444–466.
- Ferreira JA (1983) The genus *Chaetopleura* Shuttleworth, 1853 in the warm temperate and tropical Eastern Pacific, Southern California to Peru, with the description of two new species. *Veliger* 25: 203–224.
- Ferreira AJ (1986) A revision of the genus *Acanthopleura* Guilding, 1829 (Mollusca: Polyplacophora). *The Veliger* 28(3): 221–279.
- Frembly J (1827) A description of several new species of chitons, found on the coast of Chile, in 1825; with a few remarks on the method of taking and preserving them. *The Zoological Journal* 3(10): 193–205.
- García-Ríos CI, Álvarez-Ruiz M (2011) Diversidad y microestructura de quitones (Mollusca: Polyplacophora) del Caribe de Costa Rica. *Revista de Biología Tropical* 59(1): 129–136.
- Gigoux EE (1934) Los moluscos marinos de Atacama. *Revista Chilena de Historia Natural* 38: 274–286.
- Gordillo S, Schwabe E (2009) First Quaternary fossil record of Polyplacophorans from southern South America. *Geobios* 42(3): 265–271. doi: 10.1016/j.geobios.2008.10.005
- Gray JE (1828) *Spicilegium Zoologicum*; or original figures and short systematic descriptions of new and unfigured animals (Part 1). Würtz and Co, London, 8 pp.
- Guzmán N, Saá S, Ortlieb L (1998) Catálogo descriptivo de los moluscos litorales (Gastropoda y Pelecypoda) de la zona de Antofagasta, 23 S (Chile). *Estudios Oceanológicos* 17: 17–86.
- Hupé LH (1854) Fauna Chilena, Moluscos (Orden VI) – Pectinibranchios. In: Gay C (Ed.) *Historia física y política de Chile*. Museo de Historia Natural de Santiago 8: 133–276.
- Kaas P, Van Belle RA (1985a) Monograph of living chitons. (Mollusca: Polyplacophora) 1, Order Neoloricata, Lepidopleurina. E. J. Brill / W. Backhuys, Leiden, 240 pp.
- Kaas P, Van Belle RA (1985b) Monograph of living chitons (Mollusca: Polyplacophora) 2 – Suborder Ischnochitonina, Ischnochitonidae: Schizoplacinae, Callochitoninae & Lepidochitoninae. EJ Brill and W Backhuys, Leiden, 198 pp.
- Kaas P, Van Belle RA (1987) Monograph of Living Chitons (Mollusca: Polyplacophora) (Volume 3) – Suborder Ischnochitonina. Ischnochitonidae: Chaetopleurinae, & Ischnochitoninae (pars). Additions to Vols 1 & 2. EJ Brill and W Backhuys, Leiden.
- Kaas P, Van Belle RA (1990) Monograph of living chitons (Mollusca: Polyplacophora) – 4, Suborder Ischnochitonina: Ischnochitonidae: Ischnochitoninae (continued). Additions to vols 1, 2 and 3. EJ Brill, Leiden, 298 pp.
- Kaas P, Van Belle RA (1994) Monograph of living chitons (Vol 5.) Suborder Ischnochitonina: Ischnochitonidae: Ischnochitoninae (concluded), Callistoplacinae; Mopaliidae. Additions to Volumes 1–4. EJ Brill, Leiden.
- Kaas P, Van Belle RA (1998) Catalogue of living chitons (Mollusca, Polyplacophora). Second, revised edition. Backhuys Publishers, Leiden, 204 pp.
- Lamarck JB (1819) *Histoire Naturelle des Animaux sans Vertèbres* 6. Librairie Verdière, Paris.
- Leloup E (1956) Reports of the Lund University Chile Expedition 1948–49 (27) – Polyplacophora. *Lunds Universitets Arsskriften (NS)* 52(15): 1–94.
- McLean JH (1984) Systematics of *Fissurella* in the Peruvian and Magellanic faunal provinces (Gastropoda: Prosobranchia). *Contributions in Science, Natural History Museum of Los Angeles County* 354: 1–70.
- Marincovich L (1973) Intertidal mollusks of Iquique, Chile. *Natural History Museum. Los Angeles County Science Bulletin* 16: 42–49.
- Melville JC, Standen R (1912) The marine Mollusca of the Scottish National Antarctic Expedition. *Transactions of the Royal Society of Edinburgh* 48: 333–366. doi: 10.1017/S0080456800002908
- Moreno CA, Jaramillo E (1983) The role of grazers in the zonation of intertidal macroalgae of the Chilean coast. *Oikos* 41: 73–76. doi: 10.2307/3544348
- Osorio C (2002) Moluscos marinos en Chile: especies de importancia económica: Guía para su identificación. Universidad de Chile, 211 pp.
- Osorio C, Reid DG (2004) Moluscos marinos intermareales y submareales entre la Boca del Guafo y el Estero Elefantes, sur de Chile. *Investigaciones marinas* 32(2): 71–89.
- Osorio C, Reid DG, Ramajo L (2005) Moluscos en los canales del Sur de Chile entre boca del Guafo y estero Elefantes (CIMAR 7 Fioridos). *Ciencia y Tecnología del Mar* 28(1): 91–98.
- Pearse JS (1979) Polyplacophora. In: Giese, Pearse (Eds) *Reproduction of marine Invertebrates* (volume 5). Academic Press, New York, 27–85.
- Philippi RA (1860) *Reise durch die Wüste Atacama, auf Befehl der Chilenischen Regierung im Sommer 1853–54 unternommen*. Anton, Halle.
- Pilsbry HA (1892–1894) Monograph of the Polyplacophora. In: Tryon GW (Ed.) *Manual of Conchology* 14(1892): 1–350; 15(1893): 1–133.
- Plate LH (1899) Die Anatomie und Phylogenie der Chitonen. *Fauna Chilensis* 2(1). *Zoologische Jahrbücher, Abteilung für Systematik, Ökologie und Geographie der Tiere* 2 (Suppl. 5): 15–216.
- Plate LH (1901) Die Anatomie und Phylogenie der Chitonen. *Fauna Chilensis* 2(2). *Zoologisches Jahrbuch (Syst.)* 3 (Suppl. 5): 281–600.
- Plate LH (1902) Die Anatomie und Phylogenie der Chitonen – Fauna Chilensis (volume 2). *Zool. Jahrbücher* 5(suppl.): 15–216.
- Reeve LA (1847–1848) *Conchologia Iconica*, or illustrations of the shells of molluscan animals. 4, -Monograph of the genus *Chiton*, Monograph of the genus *Chitonellus*. pls 1–27 (1847), pl. 28 (1848).
- Reid DG, Osorio C (2000) The shallow-water marine Mollusca of the Estero Elefantes and Laguna San Rafael, southern Chile. *Bulletin of the Natural History Museum, London (Zoology)* 66(2): 109–146.

- Reiswig H, Araya JF (2014) A review of the Hexactinellida (Porifera) of Chile, with the first record of *Caulophacus* Schulze, 1885 (Lyssacinosida: Rossellidae) from the Southeastern Pacific Ocean. *Zootaxa* 3889(3): 414–428. doi: 10.11646/zootaxa.3889.3.4
- Rochebrune AT, Mabille J (1885) Diagnoses de mollusques nouveaux, recueillis par les membres de la misión de Cap Horn et M. Lebrun, Préparateur au Muséum, chargé d'une misión a Santa-Cruz de Patagonie. *Bulletin of the Société Philomathique de Paris* 9(7): 100–111.
- Rochebrune AT (1889) Polyplacophores in Rochebrune AT & Melville, 1889. *Mission Scientifique du Cap Horn 1882-1882, (Zool)* 6: 131–143.
- Sanhueza AG, Navarrete AH, Opazo LF, Camus PA (2008) Caracterización trófica del placóforo intermareal *Enoplochiton niger* en el norte de Chile: variación ambiental y patrones dietarios a nivel local y region. *Revista chilena de historia natural* 81(4): 533–546. doi: 10.4067/S0716-078X2008000400007
- Schwabe E, Sellanes J (2004) A new species of *Lepidozona* Pilsbry, 1892 (Mollusca: Polyplacophora: Ischnochitonidae) found on whale bones off the coast of Chile. *Iberus* 22(1): 147–153.
- Schwabe E, Försterra G, Häussermann V, Melzer RR, Schrödl M (2006) Chitons (Mollusca: Polyplacophora) from the southern Chilean Comau Fjord, with reinstatement of *Tonicia calbucensis* Plate, 1897. *Zootaxa* 1341: 1–27.
- Schwabe E, Sellanes J (2010) Revision of Chilean bathyal chitons (Mollusca: Polyplacophora) associated with cold-seeps, including description of a new species of *Leptochiton* (Leptochitonidae). *Organisms Diversity & Evolution* 10(1): 31–55. doi: 10.1007/s13127-009-0002-6
- Schwabe E (2010) Illustrated summary of chiton terminology. *Spixiana* 33: 171–194.
- Sirenko B (2006) Report on the present state of our knowledge with regard to the chitons (Mollusca: Polyplacophora) of the Magellan Strait and Falkland Islands. *Venus* 65(1-2): 81–89.
- Sirenko BI (2007) New Chilean chiton-epizoophagus *Gallardoia valdiviensis* gen. et sp. nov. (Mollusca, Polyplacophora). *Ruthenica* 17(1-2): 13–21.
- Smith AG (1966) The larval development of chitons (Amphineura). *Proceedings of the California Academy of Sciences. G. Dallas Hanna Anniversary volume* 32(15): 433–446.
- Smith AG, Ferreira AJ (1977) Chiton fauna of the Galápagos Islands. *Veliger* 20(2): 82–97.
- Sowerby GB II (1840) In: Broderip WJ, Sowerby I GB (Eds) Characters of new species of Mollusca and Conchifera, collected by Mr. Cumming. *Proceedings of the Malacological Society of London for 1832, 1833.* 25–33, 50–61, 104–108, 124–126 [1832]; 173–179, 194–202 [1833].
- Sowerby GB II (1840) Description of some new Chitons. *The Magazine of Natural History (new series)* 4 (suppl.): 287–294.
- Sowerby GB II (1840) The conchological illustrations. A catalogue of the Recent species of chitons. *Conchological illustrations.* Sowerby, London, 10 pp.
- Stuardo J (1959) Ensayo de una clave para familias y generos chilenos de Polyplacophora, con generalidades del grupo e inclusión de algunas especies comunes. *Investigaciones Zoológicas Chilenas* 5: 139–148.
- Thiele J (1906) Ueber die Chitonen der deutschen Tiefsee-Expedition. *Wissenschaftliche Ergebnisse der deutschen Tiefsee Expedition* 9: 325–336.
- Thiele J (1908) Die Antarktischen und Subantarktischen Chitonen. *Deutsche Südpolar-Expedition 1901–1903, 10. Zoologie.* Georg Reimer, Berlin, 23 pp.
- Thiele J (1911) *Amphineura. Deuxieme Expédition Antarctique Française (1908-1910).* Sciences naturelles: Documents scientifiques. Paris, 5–6.
- Valdovinos C (1999) Chilean mollusks biodiversity: taxonomic and distributional data base. *Gayana Zoología* 63: 111–164.
- Véliz D, Vásquez JA (2000) La Familia Trochidae (Mollusca: Gastropoda) en el norte de Chile: consideraciones ecológicas y taxonómicas. *Revista chilena de historia natural* 73(4): 757–769. doi: 10.4067/S0716-078X2000000400018
- Veliz D, Winkler FM, Guisado C, Collin R (2012) A new species of *Crepipatella* (Gastropoda: Calyptraeidae) from northern Chile. *Molluscan Research* 32(3):145–153.



# ZOBODAT - [www.zobodat.at](http://www.zobodat.at)

Zoologisch-Botanische Datenbank/Zoological-Botanical Database

Digitale Literatur/Digital Literature

Zeitschrift/Journal: [Zoosystematics and Evolution](#)

Jahr/Year: 2015

Band/Volume: [91](#)

Autor(en)/Author(s):

Artikel/Article: [The shallow-water chitons \(Mollusca, Polyplacophora\) of Caldera, Region of Atacama, northern Chile 45-58](#)