The Veliger 50(3):219–224 (October 1, 2008)

THE VELIGER

Dendropoma mejillonensis sp. nov., a New Species of Vermetid (Caenogastropoda) from Northern Chile

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Abstract. *Dendropoma mejillonensis* sp. nov. is described based on morphology for the first time. This vermetid gastropod inhabits the rocky subtidal zone of Peninsula Mejillones in northern Chile. In July 2006, specimens were collected by SCUBA divers from the rocky "Anemones Wall" (23°28′17.30″S, 70°37′13.80″W) at 17 m depth. The morphology of *D. mejillonensis* is distinguished from that of other members of the family by its pointed lip on the external border of the protoconch and the two white bands on the head tentacles. This extends the geographical range of the genus *Dendropoma* into the Southeastern Pacific. The present species *D. mejillonensis* is the only known vermetid gastropod able to thrive under the cold upwelling conditions of the Humboldt Current ecosystem off northern Chile.

INTRODUCTION

Marine gastropods of the family Vermetidae are sessile organisms with an irregular, uncoiled shell providing a three-dimensional biogenic habitat for associated species. Their distribution is restricted to tropical and subtropical latitudes (Mexico, California and West Africa) as well as to locations in the warm Mediterranean Sea (Keen, 1961, 1971; Schiaparelli et al., 2003). Habitats are rocky intertidal and subtidal zones with warm and oxygenated waters (Keen, 1961; Calvo et al., 1998). Due to the irregular tube form, taxonomic identification has commonly been confused with *Vermicularia* (Turritellidae) (Bieler, 1996) and Serpulid polychaetes (Keen, 1961, 1971) resulting in a confused taxonomic status. The morphological characters deemed useful for taxonomic identification have changed over time (Bieler, 1995; Schiaparelli & Métivier, 2000). A genetic study further concluded that disjunct populations of *Dendropoma* species are close phylogenetic relatives (Rawlings et al., 2001), thus suggesting that taxonomic determination should be approached carefully.

The genus *Dendropoma* (Mörch, 1861) was reviewed by Keen (1961) on the basis of 10 species distributed among tropical and subtropical locations. Distinctive morphological characteristics for this genus are planorboid early whorls that become more loosely coiled in later stages; and the sculpture of lamellar growth-striations that may or may not be intersected by longitudinal lines, sinuous and rising toward a crest near the outer edge of the whorl in most species. The operculum is well developed and equal in diameter to the aperture. At present, the genus *Dendropoma* covers intertidal and sublittoral species and can be gregarious or solitary. So far, the most comprehensive information about *Dendropoma* spp. taxonomy is provided by Hadfield et al. (1972) for specimens found off Hawaii.

Information on the distribution of vermetids off continental Chile and its offshore islands is scarce and the taxonomic status is still uncertain (Rehder, 1980; Ramírez & Osorio, 2000; R. Bieler pers. comm.). In fact, extensive reviews of gastropod taxonomy and studies of invertebrate biogeographic patterns available from this coast do not mention the family in the region (Marincovich, 1973; Guzmán et al., 1998; Brattström & Johanssen, 1983; Valdovinos, 1999; Lancellotti & Vásquez, 2000). Anecdotally, vermetids have been observed associated with holdfasts of the kelp *Lessonia trabeculata* Villouta & Santelices, 1986 off central Chile (Vásquez & Vega, 2004). With the exception of the latter observation, there is no published evidence from the Chilean coast. Nonetheless, *Dendropoma platypus* Mörch, 1861; *Dendropoma* spp. and *Serpulorbis* Sassi, 1827 have been recorded from Easter Island (Rehder, 1980; Ramírez, 1987; Valdovinos, 1999) and *Serpulorbis* sp. was also observed at Robinson Crusoe Island (Juan Fernández archipelago) (Ramírez & Osorio, 2000), both insular Chilean locations.

Northern Chile forms part of the Humboldt Current upwelling ecosystem, which is characterized by year-round high levels of primary production due to wind-driven cold upwelling water, which returns nutrients to the euphotic zone (Barber & Smith, 1981). There is a shallow oxygen minimum zone (OMZ) and only the upper 40 m are well oxygenated (Arntz et al., 2006).

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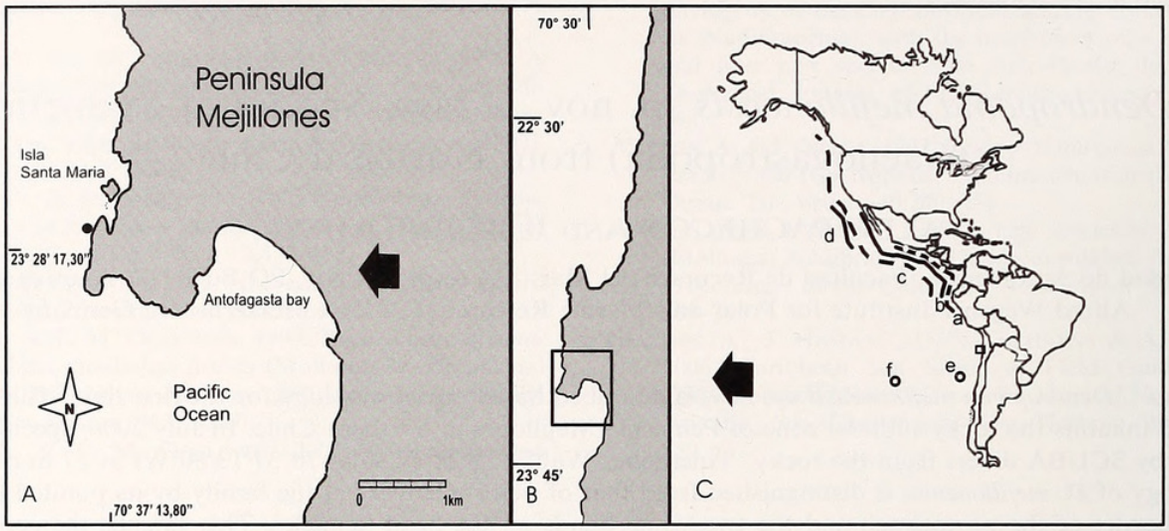

Figure 1. A. Sampling location "Anemones Wall" (23°28′17.30″S, 70°37′13.80″W) opposite the southeastern side of Isla Santa Maria. B. Peninsula Mejillones. C. Distributional range of related vermetid species (a) *Petalonchus innumerabilis* (b) *Serpulorbis squamigerus* (c) *Vermetus compta* (d) *Dendropoma rastrum* (e) *Serpulorbis* sp. (f) *Dendropoma platypus*.

This habitat is very different from that of warm-water subtropical and tropical vermetid species. In this study *Dendropoma mejillonensis* sp. nov. is described from Peninsula Mejillones, a location within this particular upwelling system. A detailed morphological characterization is provided.

MATERIAL AND METHODS

Individuals of *Dendropoma mejillonensis* sp. nov. colonizing a vertical rock wall in the subtidal zone (17 m depth) of Peninsula Mejillones (23°28′17.30″S, 70°37′13.80″W) were photographed and collected by SCUBA divers on July 11th, 2006 (Figure 1A, B). Several vermetid clusters were scratched from the rock with a knife and maintained in the laboratory for observations. Measurements were taken with a digital caliper or by using calibrated eyepieces on a dissecting microscope. Photographs were taken with a Canon Power Shot S50 camera connected to a binocular microscope Olympus SZ61. Animals were anesthetized by adding methanol drops in the small examination containers before sacrificing. Soft bodies were removed from the shell after cracking with a small clamp. Gross anatomy of the soft parts was studied under a dissection microscope. Air-dried shells, radula, protoconch and opercula were observed and photographed, using the scanning electron microscope JEOL, model JSM- 6360LV.

Diagnosis

Genus *Dendropoma* Mörch 1861

Solitary to colonial forms, corroding a trench in the substrate, in which the lower part of each volution is embedded; coiling planorboid in early whorls, becoming looser in later whorls, with tendency toward right-angle turns. The color of the adult is mostly white, intermittently stained with dark brown, especially within. The sculpture of lamellar growth-striations, that may or may not be intersected by longitudinal lines, is sinuous and rises toward a crest near the outer edge of the whorl in most species. Two nuclear whorls are dark brown in color, inflated, smooth to malleated or axially ribbed, and the aperture lip is pointed or claw-like in some species. The operculum is well developed, as large as the aperture, its inner surface having a distinct central attachment scar that is somewhat button-like, and its exterior composed of chitinous plates in a spiral arrangement, either compactly welded to form a smooth surface or variously agglutinated with foreign materials.

Dendropoma mejillonensis sp. nov.

Type locality: Live-taken syntypes collected from a large aggregation colonizing Anemones wall at 17 m depth, Peninsula Mejillones, northern Chile (23°28′17.30″S, 70°37′13.80″W) were deposited in the Field Museum of Natural History, Chicago, Illinois, U.S.A. (FMNH N°-312172 and N°-312173). Additional samples were deposited in the Museo Nacional de Historia Natural de Santiago de Chile (paratype MNHNCL N°-5159 and syntypes MNHNCL N°-5160, 5161, 5162)

Teleoconch *(Figure 2a, b)*: The tubes form continuous and compact colonies, which are grey to faintly green in the field, but white after cleaning. *In situ*, the tubes are slightly nested in the rocky substrate. The attached part of the tube appears eroded, and thus is thinner (Figure 2d). The aperture is circular and its mean

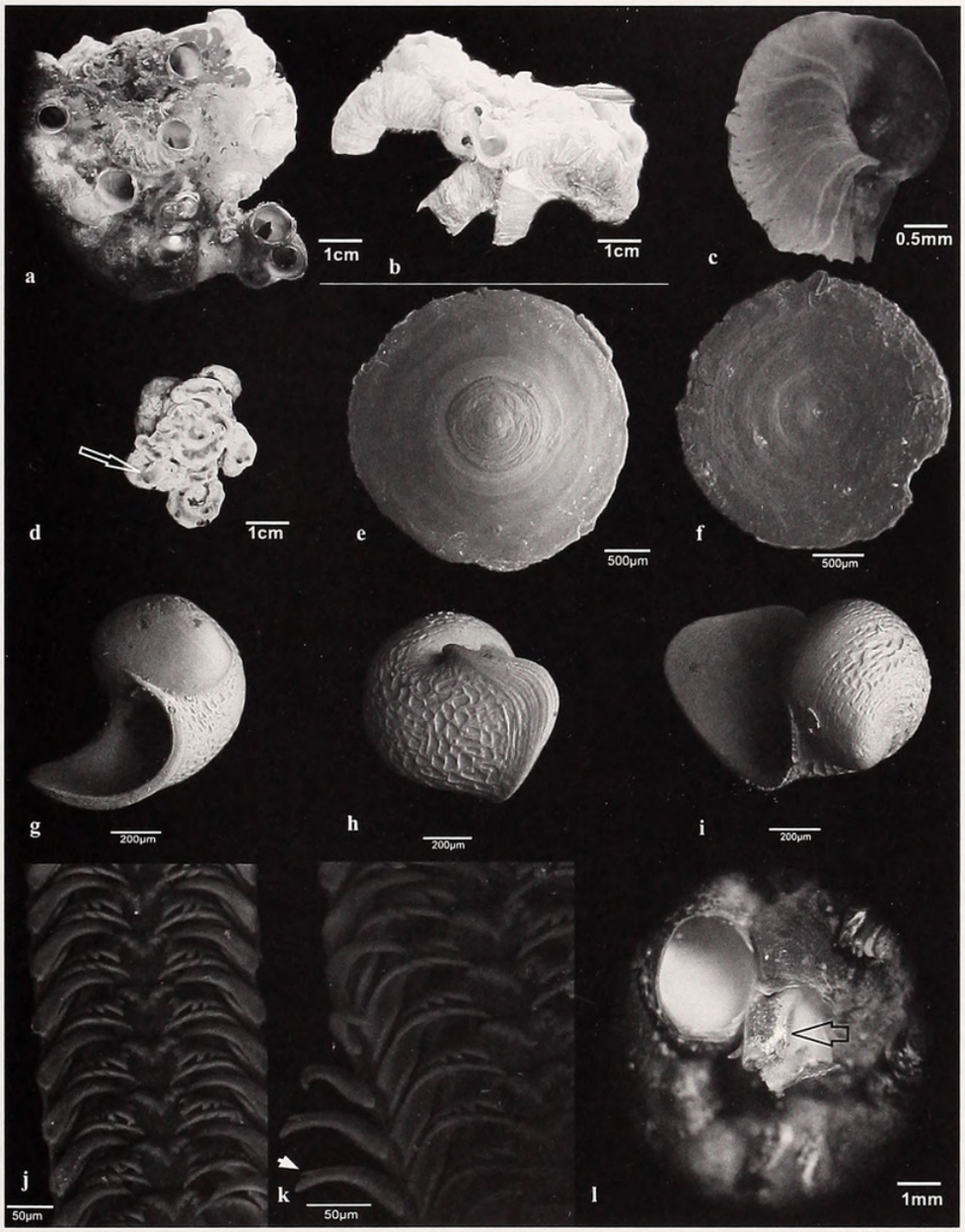

Figure 2. *Dendropoma mejillonensis* sp. nov. (a) Mass of living adult tubes. (b) Lateral view (c) Teleconch of juvenile showing concentric growth striations. (d) Smooth eroded part showed from the attached part of the tubes. (e) Operculum dorsal view. (f) Operculum ventral view. (g) Protoconch aperture. (h) Protoconch; detail of the sculpture and pointed lip-like external border. (i) Protoconch in ventral position, the earliest whorl is noted. (j) Radula displacement. (k) Detail of the cusp on the marginal teeth. (l) View of the animal head, the arrow points to the distinctive white mark.

diameter in adults is 4.29 mm (SD = 0.37; n = 16). The tube exhibits sinuous growth lines and the sculpture of lamellar growth-striations is not intersected by longitudinal lines (Figure 2c). The periostracum is white and the intermediate layer slightly cream. Observing from a cross-longitudinal section, three layers of the conch are present. The interior part is cream porcelain, darker towards the interior tube. Very soft longitudinal lines are only observed under magnification. There is no internal shell lamellar structure. The proximal part of the tube slightly tends to vertically rise from the rest of the mat. The coiling pattern is variable. Early whorls are like Planorbidae, coiling counterclockwise, followed by a very loose coiling or irregular pattern. The shell of the juvenile is white and translucent with clear axial ribs (Figure 2c).

Operculum ***(Figure 2e, f)*****:** The form is circular and concave, slightly flattened and reddish in the center, brown-orange to colorless towards the external border. The diameter is 2.7 mm (SD = 0.2; n = 10) in adult specimens and about 1/5 of the length of the relaxed

pedal disk diameter. The operculum is composed of concentric layers of chitinous material with visible concentric irregular lines, notably in juveniles. The small mamilla is inserted in the pedal surface. Almost 90% of the studied opercula were fouled with bryozoans.

Protoconch ***(Figure 2g, h, i)*****:** Globular, brown or colorless, white towards the earliest whorl. The shell shows 1 to 1.5 nuclear whorls, ornamented with longitudinal grooves. The grooves show no evident axial pattern, are variable in size and present a slightly rectangular or triangular shape with no marks at the corners. The external border presents a pointed lip shape and growths striations are present. At hatching, shell length (the distance from the external lip border to the opposite whorl margin) is 0.77 mm (SD = 0.07; n = 10).

Radula ***(Figure 2j, k)*****:** Taenioglossan type, similar to the description of other vermetids (i.e., *Vermetus triquetrus* Bivona-Bernardi, 1832 and *Thylaeodus rugulosus* Monterosato, 1878; Bieler, 1995), transparent, consisting on average of 39.8 (SD = 6.06) rows of teeth (counts and measurements based on adult animals of 4 mm shell aperture, n = 10, no differences between sexes were noted). Total length of radular ribbon is 2.35 mm (SD = 0.34) and 0.196 mm width (SD = 0.011, mid ribbon). A trapezoidal rachidian tooth with a strong main cusp and 4–5 flanking cups on either side (diminishing toward margin), basal denticles strongly developed. Lateral tooth cusp arrangement of triangular cutting shape, as in the central tooth, with two flanking cusps on either side. The inner marginal tooth is slender with a strong main cusp and the inner marginal with one flanking cusp on inside and two on outside. The outer marginal teeth present a single flanking cusp smooth on outside. Radular formula: 2+1+R+1+2.

Animal: Removed from the shell the body is short and narrowest towards the terminal part, which is slightly coiled. The average length of relaxed large adult specimens is 18.66 mm (SD = 1.68; n = 10). The head is mainly light grey or reddish with black, white and yellow specks. The posterior part is reddish or dark brown in color. Two white bands on the head tentacles are distinctive appearing as a white eyebrow (Figure 2l). The head tentacles are brown or light grey in color with black and yellow dots, no distinctive marks at the tips are visible. The pedal tentacles are light grey with yellow specks. In both sexes the light orange/melon mantle is entire and is characterized by a light brown border. The foot is a similar color to the mantle; however it has a white band around the operculum insertion. The gill filaments are about 1/3 of the size of the mantle and slightly triangular in shape. The columellar muscle appears as a white triangular narrow strip, enabling the animal to retreat deeply into its shell. Female's broods comprise three to four egg capsules, which are ovoid and the membrane is translucent. Each capsule contains between three to ten juveniles. Early capsules contain nurse yolk (Figure 3). Feeding is carried out by mucous threads.

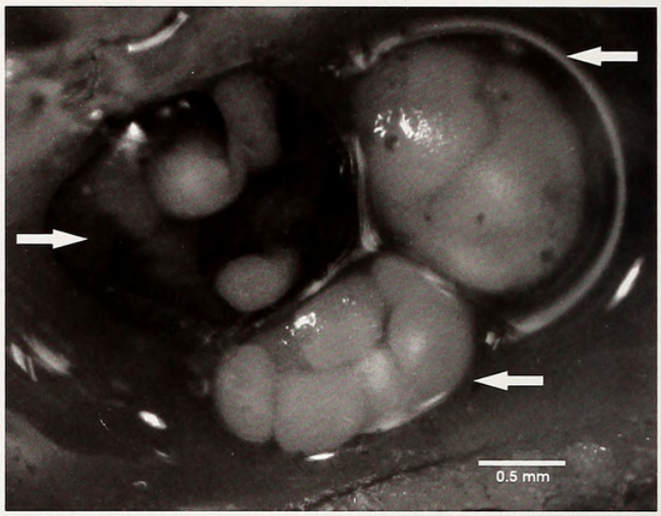

Figure 3. Capsules of *Dendropoma mejillonensis* sp. nov. containing juveniles (arrow left side) and nurse yolk (arrows right side).

Habitat: The specimens were attached to a vertical rock wall, which extends from the shallow subtidal down to 50 m depth. In the field, colonies showed a light grey to white color and were commonly fouled by calcareous algae causing a red/purple coloration. The surrounding benthic community is dominated by the kelp *Lessonia trabeculata* from 13 m depth down to 25 m. Below 25 m, kelp abundance is substantially reduced and relatively small epibenthic taxa such as calcareous algae (*Lythothamniom* sp. and *Lithophyllum* sp.), red algae (*Rhodymenia corallina* Bory de Saint Vincent & Greville), bryozoans (*Membranipora isabelleana* D'Orbigny, 1847 and *Lagenicella variabilis* Moyano, 1991), and Porifera cover the substrate. *Dendropoma mejillonensis* sp. nov. colonies were observed between 15 and 25 m.

Etymology: The species is named *Dendropoma mejillonensis* in reference to the discovery location Peninsula Mejillones.

DISCUSSION

Taxonomic remarks

The morphological classification of the species to the *Dendropoma* genus was carried out following Keen (1961). *Dendropoma mejillonensis* sp. nov. shows similarities to *Dendropoma gregaria* Hadfield & Kay,

1972 (Hadfield et al., 1972) from Hawaii, sharing the circular pattern in the operculum and dense white pigmentation around the eyes. The most noteworthy difference is in the protoconch sculpture, while *D. gregaria* has light axial ribs crossed by finer spiral striations, *D. mejillonensis* shows soft grooves without evident design shape and pattern.

Distributional Remarks

As already mentioned, the presence of vermetid gastropods is limited along the Pacific coast of South America. Alamo & Valdivieso (1997) reported *Petaloconchus innumerabilis* Pilsbry & Olsson 1935 from Mazatlán (Mexico) to Bocapan and Huacho (Peru), *Serpulorbis squamigerus* Carpenter, 1857 from San Diego (California) to Paita (Peru) and *Vermetus compta* Carpenter, 1857 from British Columbia (Canada) to Paita. Keen (1971) recorded *Dendropoma lituella* Mörch, 1861 and *Dendropoma rastrum* Mörch, 1861 from the northern part of the Eastern Pacific; both were found from southern California to the southern Gulf of California at La Paz, Baja California (see also Figure 1c).

The presence of *Dendropoma mejillonensis* in the rocky subtidal zone of Peninsula Mejillones clearly extends the geographic range of the family into the Southeastern Pacific, almost 2000 km southwards. According to the literature the closest distribution limit of vermetids is Huacho (11°6′56.21″S, 77°37′9.46″W) (Alamo & Valdivieso, 1997). Easter Island and Juan Fernández may be source locations if *Dendropoma* sp. is *D. mejillonensis*, in this case the range would be extended from insular to continental Chile. However, it is not possible to define the biogeography of this species, as we did not sample south or north of the type locality.

Our record provides evidence that *D. mejillonensis* is able to thrive under cold upwelling conditions. The observed recruitment at Anemones Wall (A. Pacheco unpublished data) indicates that this species has the capacity to adapt to cold upwelling conditions. The species' distribution may be limited by the presence of a short larval stage. As in the case of many other vermetids (Keen, 1961; Hadfield et al., 1972; Calvo et al., 1998), larvae of *D. mejillonensis* leave the female mantle cavity well developed and crawl around for less than one hour before cementing themselves to the substrate. The recent discovery from Peninsula Mejillones suggests that several unexplored areas with unreported species may still exist along the northern Chilean coastline, particularly in zones difficult to reach (Camus, 2001). Furthermore, distributions of rafting species (a dispersal mechanism suggested for vermetids (Bieler, 1995)) may extend quickly with an increasing amount of anthropogenic floating material, facilitating the supply of sessile species to new regions (Thiel & Haye, 2006). A genetic study is necessary to reveal linkages between *D. mejillonensis* and other vermetids.

Acknowledgments. We are grateful to Christian Guerra and Ivan Marin for their support during diving. Martha Calvo provided useful literature. José Riascos, Olaf Heilmayer, Ricardo Guíñez are thanked for their suggestions on an earlier version of the manuscript. Carrie Auld and Ruth Alheit kindly edited the English. Pabla Vega helped with the SEM photographs. Rüdiger Bieler provided taxonomic advice. We appreciated the comments made by two anonymous reviewers. This study was conducted in the framework of the EU-funded INCO project, "Climate Variability and El Niño-Southern Oscillation: Implications for Natural Coastal Resources and Management" (CENSOR) and Programa Bicentenario de Ciencia y Tecnología RUE-02. This is CENSOR publication N° 341.

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