

Association of the little-cone limpet *Patelloida conulus* (Dunker, 1861) with creeping gastropods *Rhinoclavis kochi* (Philippi, 1848) and *Batillaria attramentaria* (Crosse, 1862) in Jeju Island on the south coast of Korea

Ronald G. Noseworthy and Kwang-Sik Choi

Department of Marine Life Science (BK21 PLUS), Jeju National University, Jeju 63243, Korea

ABSTRACT

The little-cone limpet *Patelloida conulus* (Dunker, 1861) is a member of the Lottiidae, occurring on sandy and muddy tidal flats in the intertidal zone, and is found living symbiotically on shells of mud snails, which often occurs in a high density in sandy and muddy intertidal areas. In this study, we first report association of the little-cone limpets with mud snails from an intertidal sandy beach at Sungsan on the northeast coast of Jeju Island. At the upper intertidal area, the common mud snail *Batillaria attramentaria* (G. B. Sowerby I, 1855) occurred at a high density, and *P. conulus* was found on the shell surface. Shell height of the little-cone limpet ranged from 2.6 to 6.6 mm (N = 7), and the host snail carried one *P. conulus* on its shell in most cases. The little-cone limpet and the mud snail association has been regarded as being restricted to the Batillariidae, while we observed for the first time the occurrence of *P. conulus* on the cerithiid snail *Rhinoclavis kochi* (Philippi, 1848).

Key words: *Patelloida conulus*, *Batillaria attramentaria*, *Rhinoclavis kochi*, Symbiotic Association, Jeju Island

INTRODUCTION

Patelloida conulus (Dunker, 1861), the little-cone limpet, is a small limpet in the family Patellidae occurring mainly on sandy or muddy tidal flats in Korea, Japan and Hong Kong (Morton 1980; Okutani 2000; Min *et al.* 2004; Nakano and Ozawa 2005). According to Higo *et al.* (1999), *P. conulus* can also be found in intertidal on rocks. In this type of environment, this species is usually found on the shells of the mud snails in the Genus *Batillaria* (Christiaens 1980), mainly from *B. multiformis* (Lischke 1869; Higo *et al.* 1999; Nakano and Ozawa

2005). Nakano and Ozawa (2005) reported that *P. conulus* may also occur on shells of *B. cumingii* (Crosse, 1862), a common synonym of *B. attramentaria* (G. B. Sowerby I, 1855). In Hong Kong, *P. conulus* also occurs on shells of *B. zonalis* (Bruguière, 1792) (Morton 1980).

The Lottiidae is a worldwide family of Gastropoda in the subclass Patellogastropoda. In South Korea, 19 species of this family have been reported, with 16 occurring in Jeju Island. The genus *Patelloida* consists of small limpets, usually mottled or striped with dull brown background color, and fine radial riblets, with a bluish interior and mottled brownish rim. According to Min *et al.* (2004), four species in *Patelloida* are distributed in Korean waters, on the west and south coast, and *P. conulus* was identified from a beach on the south coast of Jeju Island.

Jeju Island has a rich marine fauna, with more than 1000 species presently reported. Three species of *Batillaria* occur here, with *B. attramentaria* (G. B. Sowerby I, 1855) being by far the most abundant,

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Corresponding author: Kwang-Sik Choi

Tel: +82 (64) 754-3422, e-mail: skchoi@jejunu.ac.kr
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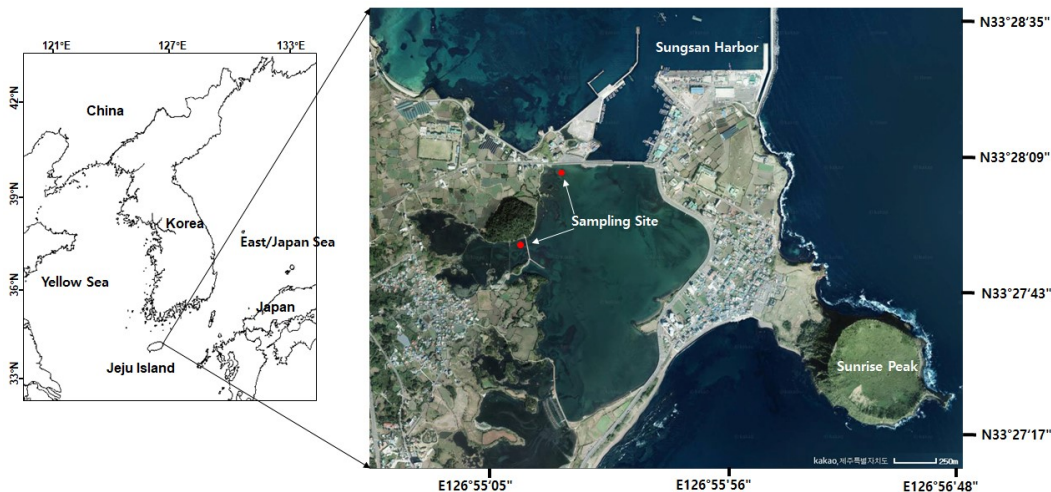


Fig. 1. Map of Ojo-ri lagoon showing the location of the surveys.

preferring mainly a shallow, open, somewhat silty environment. The northeastern coast of Jeju Island include a sand beach and a lagoon, where the mud snail *B. attramentaria* occurs at a high density. Previous surveys indicated that the mud snails on the upper intertidal zone in the lagoon have a symbiotic relationship with *P. conulus*. In this study, we report for the first time on the occurrence of *P. conulus* on *B. attramentaria* and cerithiid snail *Rhinocoelavis (Proclava) kochi* (Philippi, 1848).

MATERIALS AND METHODS

In May 2018 and 2020, we surveyed the upper intertidal zone of Ojo-ri lagoon on the northeast coast of Jeju Island (Fig. 1). The mud snails with the little-cone limpets were identified *in situ*, and the snails were collected by hand from the substrate.

The live mud snails which exhibited the little-cone limpet on their shell surface were brought to the laboratory to measure the size. At the laboratory, the shell height (SH) of each host snail and the symbiotic limpet was determined using an electronic caliper to mm.

RESULTS AND DISCUSSIONS

At low tide, large areas of the lagoon were exposed. Among the many mollusk species inhabiting the northwestern side of the lagoon was an abundance of

B. attramentaria. Individuals possessed one to five specimens of *P. conulus* attached to their shells, usually near the aperture, but some also on the spire (Figs 2, 3). Table 1 summarizes size sizes of the host snail and the symbiotic limpets.

The little-cone limpet *P. conulus* is highly variable in shell morphology and color pattern (Nakano and Ozawa, 2005). There appears to be two forms of this species, one with a high, somewhat rounded apex and a relatively narrower aperture, and the other which is more triangular in form with a somewhat more



Fig. 2. *Batillaria attramentaria* with attached specimens of *Patelloida*.

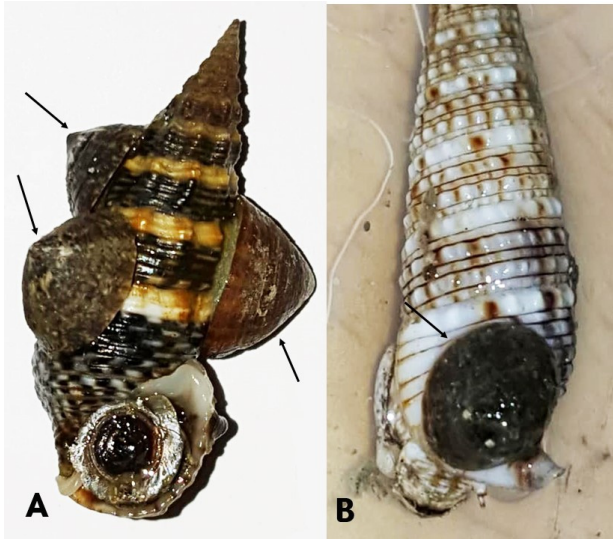


Fig. 3. *P. conulus* on living specimen of *Batillaria attramentaria* and *Rhinoclavis kochi* from Ojo-ri lagoon on the northeast coast of Jeju Island.

pointed apex and a relatively wider aperture; those forms appear to intergrade. The high, narrow form is figured in Min *et al.* (2004) and the lower, more triangular form is figured in Zhang *et al.* (2016). Both are found in Nakano and Ozawa (2005). Almost all specimens obtained at Ojo-ri were of the latter form (Fig 4). In general, *P. conulus* has a higher, more conical shape than other *Patelloida* species, which suits it well for living in low-energy environments.

Several specimens of this lottiid were also found on dead shells of several species. Dead shells of *Rhinoclavis (Proclava) kochi* (Philippi, 1848) were quite common on the substrate, and a few possessed



Fig. 4. Top view of *P. conulus* attached on *Batillaria attramentaria* collected in May 2020.

specimens of *P. conulus* (Fig. 3).

Patelloida conulus ranges from Northern Japan, eastern coast of the East Sea, and southern and southwestern Korea to China and Taiwan. *B. attramentaria* ranges from Sakhalin, eastern Russia and East Sea to Korea and China, on sand on tidal flats or rocky shores; sometimes sympatric with *B. multififormis* (Lischke, 1869) *Rhinoclavis kochi* ranges from Japan to the Indo-Pacific, and occurs on muddy to sandy substrates from shallow water to approximately 60 m. At the Ojo-ri lagoon, living specimens of *R. kochi* were also found exposed on wet, muddy sand after the tide had receded. The association of *P. conulus* with *R. kochi* suggests a type of symbiotic association.

Few studies have been conducted on how the symbiotic species is attracted to the host species. Nakano and Ozawa (2005) state that species attaching

Table 1. Size measurements of the host mud snails and the symbiotic limpet. SH=shell height in mm

Host Species	Host Size (SH mm)	Number of <i>P. conulus</i> on the host shell	SH of <i>P. conulus</i> (mm)
<i>Patelloida conulus</i>	20.3	1	6.6
	28.4	1	2.8
	19.1	1	5.6
	21.2	1	4.3
	20.0	1	4.2
	15.6	1	2.6
	23.5	3	4.0
	<i>Rhinoclavis kochi</i>	25.0	1

to other mollusks may possibly recognize their hosts by chemical means, as is the case with *Crassostrea* spp. and barnacles. In laboratory studies Morton (1980) has demonstrated a positive attraction of *P. conulus* to specimens of *Batillaria*. Both species appear to benefit from their selective association: *P. conulus* keeps its host free from encrusting barnacles and oysters. Indeed, at Ojo-ri, specimens of *B. attramentaria* were found with one to three adult specimens of *P. conulus* attached (Table 1). *Batillaria* spp. provide the limpet with a hard surface on soft substrates. Males and females may be brought together, thus enhancing breeding potential (Morton, 1980). Since this species is sometimes found on empty shells or small rocks, it appears that it may move from one host shell to another (Nakano and Ozawa, 2005).

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