Zoological Studies **38**(4): 387-390 (1999)

Zoological Studies

A New Coral-inhabiting Barnacle from Taiwan (Cirripedia: Pyrgomatidae)

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(Accepted May 6, 1999)

Arnold Ross and William A. Newman (1999) A new coral-inhabiting barnacle from Taiwan (Cirripedia: Pyrgomatidae). *Zoological Studies* **38**(4): 387-390. *Cionophora* n. gen. is proposed for the coral-inhabiting barnacle *Cionophora soongi* n. sp. This obligatory symbiont lives on the hermatypic coral *Astreopora* sp. found in nearshore waters along the southern coast of Taiwan. The external surface of the wall develops tall pillars, a unique feature previously interpreted as simple ornamentation, but herein recognized as an integral part of the barnacle's symbiotic relationship with the coral. *Cionophora soongi* differs from all other known Pyrgomatini by possessing both a coalescent wall and fully calcified opercular plates, and in having a long, slender tergal spur with a closed external longitudinal furrow.

Key words: *Cionophora soongi* n. gen. and n. sp., Coral symbionts, Morphology.

There are more than 70 fossil and recent coral-inhabiting barnacles in the family Pyrgomatidae. The greatest diversity of these obligate symbionts occurs in the Indo-West Pacific region (Ross and Newman 1973, Newman and Ross 1976, Newman et al. 1976, Ogawa and Matsuzaki 1992, Asami and Yamaguchi 1997). Recent revisions of this group include those of Ross and Newman (1973 1995), Galkin (1986), and Anderson (1992).

The only survey of coral-inhabiting barnacles of Taiwan is that of Soong and Chang (1983). In their comprehensive base-line study they reported 15 species representing 6 of the 10 genera known at the time. Among the many species they reported was *Hiroa stubbingsi* Ross and Newman, 1973, previously known from but a few subfossil specimens (c^{14} date $\leq$ 500 BP) collected on Ullan I., Truk Is. (7°14'N, 151°38'E), and now also known to be living in Japan (Ogawa and Matsuzaki 1990).

Recently, we had the opportunity to restudy several specimens from Taiwan occurring with *H. stubbingsi*. These included 4 coalescent wall plates, and 6 disassociated, fully calcified, opercular plates that could be easily interpreted as advanced ontogenetic stages of *H. stubbingsi*. However, they are apparently smaller than *H. stubbingsi* and they differ significantly from all previously known species of Pyrgomatini. The new species is interpreted as representing a new genus, and thus it forms the basis for the present study.

METHODS

Specimens chosen for scanning electron microscopy were first soaked for several hours in a 5.25% solution of sodium hypochlorite (commercial bleach), rinsed several times in tap water and air dried. Any adhering particles were removed with a fine-tipped artist's brush. They were then mounted on aluminum stubs with double-sided tape, sputter coated with gold-palladium, and viewed and then photographed in a Cambridge S360 microscope operating at 10 kV.

The terminology now in use for describing the relationship of one opercular plate to the other has led to different interpretations. To resolve this, we recommend the following criteria and terminology to describe their relationship. 1, separate: plates movably articulated together and readily disarticulated

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manually, but commonly treated with bleach before attempting separation; 2, cemented: plates bound together by an organic cement that is partly or wholly destroyed by immersion in bleach before separation occurs; 3, calcified: secondary deposition of calcareous material on the internal surface, thereby obliterating the suture, not separable in bleach; and 4, fully calcified: no evidence of an external or internal suture between the plates, not separable.

SYSTEMATICS

Family Pyrgomatidae Gray, 1825
Subfamily Pyrgomatinae Gray, 1825
Tribe Pyrgomatini Gray, 1825

(nom. transl. Ross and Newman 1995 [ex Pyrgomatinae Gray, 1825])

Remarks: Ross and Newman (1995) divided the Pyrgomatinae into 3 tribes, Pyrgomatini (12 genera), Hoekiini (4 genera), and Pyrgopsellini (1 genus). This division was based on shell characters (wall and opercular plates), mode of feeding, and type of host.

Genus *Cionophora* n. gen.

Definition: Wall coalescent, ornamented externally with a series of tall, erect pillars; opercular plates fully calcified; scutum transversely elongated, disproportionately greater in size than tergum; limbus adductorum (adductor ledge) very large; spur of tergum long, narrow, furrow closed.

Type species: *Cionophora soongi* n. sp.

Etymology: Derived from the Greek, *kionos*-, pillar, and *-phora*, to bear, in allusion to the sequentially developing tall pillars on the exterior surface of the wall.

Remarks: The pillars found on the wall apparently form passages for the soft tissue of the coral as well as acting as a template for future coral overgrowths. These overgrowths frequently mimic the sclerosepta or calyx of the coral (Ross and Newman 1973: 139).

Cionophora soongi n. sp.

(Fig. 1A-F)

Holotype: wall, C-9974 (rostro-carinal dia. 2.6 mm).

Paratypes: wall, C-9975-a (1.9 mm), C-9975-b (2.8 mm), C-9975-C (3.2 mm); opercular plates, C-9975-d-i (4 broken or incomplete).

Materials: Near shore coral reefs, South Bay (Nanwan) southern Taiwan, approximately 21°56'N, 120°45'E; K. Soong coll., 30 Mar. 1983; on *Astreopora* sp. All of the type specimens, consisting of 4 wall plates and 6 disassociated opercular plates, are cataloged in the collections of the Scripps Institution of Oceanography (SIO), Benthic Invertebrates.

Diagnosis: Because there is only a single known species, the diagnosis is the same as for the genus.

Description: Wall white externally, mottled with purple internally, elongate-oval, slightly concave in young to nearly flat in older individuals, small (rostro-carinal diameter 1.9-3.2 mm), slightly wider at rostral end; growth ridges beaded on young individuals, poorly discernible on large specimens. Surface elaborations consisting of sequentially enlarging tall pillars radiating from orifice (Fig. 1A), pillars in 23-24 radial rows; pillars distinct, separate at rostral end but commonly confluent at carinal end; young individuals lack pillars around the aperture and may lack pillars at various positions around periphery (Fig. 1B). Orifice elongate-oval, rostro-carinal dimension ranging from 1/3 to slightly less than 1/2 that of wall. Internal surface of wall smooth, slightly granular; sheath forming inner lamina (Fig. 1C), growth ridges descending lower at carinal than at rostral end of wall; lineations in sheath where spur membrane attaches to wall barely discernible. Marginal radial septa tall, slender, denticulate, corresponding with radial pillars on outer wall; shallow, marginal interspaces with narrow pits or deeper pockets between sheath and outer lamina (Fig. 1F).

Opercular valves white; scutal portion about 3 times greater than tergal; suture between scutum and tergum lacking internally and externally, fully calcified (Fig. 1D); growth ridges slightly granular, hirsute, not produced along occludent margin; tergal portion of plate with long, narrow, depending spur (Fig. 1E); apical and medial portion of external longitudinal furrow "pinched" closed; distal end of spur furrow open; adductor ledge thin, translucent when immersed in water, large, depending from original (true) plate, confluent with rostral portion of tergum, hollowed out at juncture between plates; rostral tooth narrow, short; 1 or 2 ridges for insertion of lateral depressor muscle on apical surface of adductor ledge above highest point of hollow; adductor muscle depression medial, clearly delimited, large, moderately deep. Basis unknown, but in consideration of the interlocking wall teeth it is undoubtably calcareous.

Etymology: Named in honor of Dr. Keryea Soong, National Sun Yat-sen University, Taiwan, in appreciation of his studies on the cirripeds of Taiwan, and for querying the identity as well as providing us with the specimens described herein.

DISCUSSION

The Pyrgomatini contains 12 genera of which seven have a fully coalescent wall. Among these, only *Nobia* Sowerby, 1839, *Paranobia* Galkin, 1986, and *Darwiniella* Anderson, 1992 purportedly have fully calcified opercular plates. In *Nobia* the opercular plates are essentially equal in size, with the tergum quadrate to subquadrate in outline. Those of *Darwiniella* are similarly equal in size, but the tergum is triangular in outline, and it has a prolonged extension of the scutal (articular) margin that effectively replaces the spur, and therefore is referred to as a false spur herein.

In the 3 species of *Paranobia*, the opercular plates retain a suture on the external as well as the internal surface, and therefore, while apparently "cemented" together to varying degrees, they are not known to be partly or fully calcified together (cf. Anderson 1992: 305). Our examination of a syntype of the type species, *P. kuri* (Hoek, 1913), has shown that its opercular plates are readily separable after immersion in bleach, and therefore the validity of this character in distinguishing the genus is questionable.

In *C. soongi* there is a gross disparity in the size of the scutum relative to the tergum, and it is transversely elongated (Fig. 1D, E). It also has a significantly large adductor ledge that likely serves as a broad surface for attachment of the prosomal muscles (Anderson 1992: 290). The tergal portion of the plate, unlike that found in any of the foregoing genera, lacks crests for the depressor muscles, and has a distinct, long, slender, true spur with a closed furrow, except for the distal-most portion.

The opercular morphology of *C. soongi* more closely approximates that of *H. stubbingsi* and *Pyrgoma cancellata* Leach, 1818 than any of the species of *Nobia* or *Darwiniella*. However, among other features, the 4-plated wall and separate opercular plates of *H. stubbingsi* distinguish this species, whereas the cemented but separable opercular plates of *P. cancellata* and *P. kuri* distinguish these species. Nonetheless, all of these are allied by a transversely elongated scutum with a large, depending adductor ledge, and a tergum furnished with a true spur. In addition, both *Hiroa* and *Cionophora* occur on the coral *Astreopora* (see Ross and Newman 1995: 169), whereas *Pyrgoma* settles on a wider range of azooxanthellate as well as zooxanthellate corals, the surfaces of many of which are not greatly unlike that of *Astreopora*.

One interesting aspect of *C. soongi* is the presence of tall cylindrical pillars on the external surface of the wall (Fig. 1A, B). Although the coral may subsequently contribute to them, they are produced by the barnacle. No other pyrgomatine has been reported to develop such widely spaced and tall pillars. However, the low, nodose ridges, such as those found in *H. stubbingsi* by Soong and Chang (1983) are at least comparable if not homologous structures that in both species provide passages for the soft tissue of the coral as well as form the template for eventual coral overgrowths. We have not surveyed all of the species with similar but more subtle tubercles, but we infer, where present, they result from a common growth process.

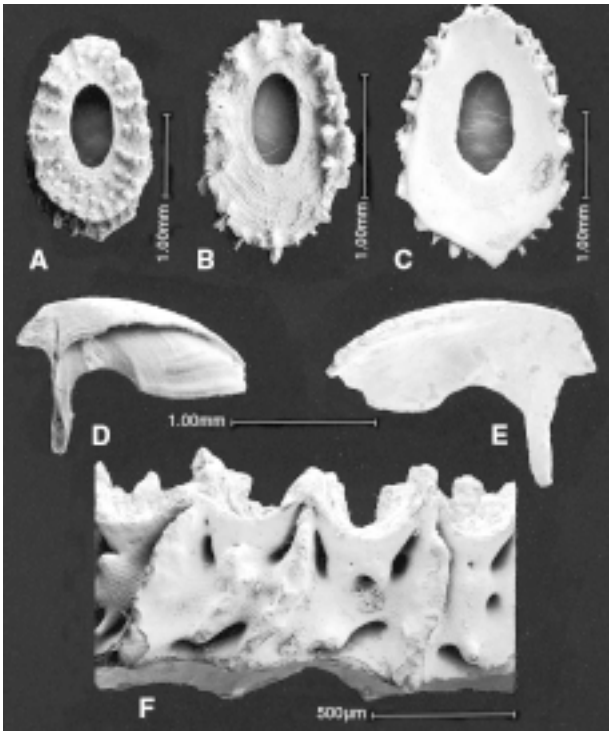

Fig. 1. Scanning electron micrographs of the wall and opercular plates of *Cionophora soongi* n. gen., n. sp., from *Astreopora* sp., Taiwan. A, external view of wall, holotype, SIO C-9974. B, external view of juvenile; note the absence of pillars at various positions around the circumference, paratype, SIO C-9975-a. C, internal view of wall showing sheath; raised areas on either side of rostral end, toward bottom, reflect lower margins of the adductor ledge of the opercular plates and the median depression between them for the adductor ledge, paratype, SIO C-9975-b. D, external view of opercular plate, paratype, SIO C-9975-d. E, internal view of opercular plate, paratype, SIO C-9975-e. F, lateral view of margin of wall showing the outer lamina partially covering the apical portions of the marginal denticles, below which are the shallow pits and deeper pockets between the marginal septa. Of the 3 marginal septa visible, the outer lamina above the 1st, at the left, is just beginning to elevate, that of the 2nd is completing the pillar, and that of the 3rd is close to reaching its definitive height, paratype, SIO C-9975-c.

The pillars develop at the margin of the wall. The apical denticle occurring on the radial edge of the septum periodically elongates in concert with elevation of the outer lamina, thereby forming a pillar. The first formed, which occur closest to the orifice, are short, but subsequent ones increase in size from the first to the last formed at the periphery. They begin as a low hemispherical, or hood-like projection of the outer lamina that quickly becomes taller with the rapid growth of the marginal apical denticles found on the radial septa (Fig. 1F). Upon reaching its final height, the outer lamina grows over and around the crest of the denticle, in effect enshrouding it to become circular in cross section. The process is repeated again after a certain period, thereby leaving spaces between each succeeding pillar. Thus, the completed pillars are extensions of the outer lamina covering the apical denticle of the marginal septa that articulate with the basis.

In many 4-plated Pyrgomatini, the carina occupies a relatively small portion of the circumference of the wall, and it is the same or slightly higher than the adjoining plates. In coalescent form there is no appreciable change in the area the carina occupies. The transition to an essentially flat-lying wall similarly fails to change the proportions, but it does, in effect, greatly foreshorten the carina. As a result the sequential development of pillars on the surface of the carina is compressed, and thus the space between them is reduced or eliminated, resulting in their more or less contiguous development (Fig. 1A).

Acknowledgments: We thank Keryea Soong, National Sun Yat-sen University, Taiwan, for bringing these specimens to our attention. We also thank Charles Graham, SIO Analytical Facility, for taking the scanning electron micrographs of this new species.

A Contribution of the Scripps Institution of Oceanography, new series.

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臺灣發現與珊瑚共生之新屬新種藤壺（蔓腳目：塔藤壺科）

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在臺灣南部沿岸的珊瑚礁上發現了一種與星孔珊瑚共生的藤壺。牠是新屬新種，命名為宋氏高柱藤壺。牠外壁表面有高的隆起，以往認為此類構造是簡單的裝飾，但實際上是此共生藤壺自己產生的。此種與其它所有同一分類族的藤壺的差別，在於牠具有癒合的體壁以及完全鈣化的蓋板，其內面有狹長型的突起，而外有長條、已覆蓋的溝狀構造。

關鍵詞：高柱藤壺新屬新種，珊瑚共生，型態。

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