PSAMMOBIONTIC CLIONAIDAE (DEMOSPONGIAE: HADROMERIDA) IN LAGOONS OF THE RYUKYU ISLANDS, SOUTHWESTERN JAPAN

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ABSTRACT

Cliona inconstans (Dendy, 1887) is reliably recorded from the Ryukyu Islands, southwestern Japan and redescribed. This sponge varies in shape from columnar to massive. At present we conclude that the sponge belongs to the genus *Cliona*. This species has variations in the number of spirasters, with some specimens totally lacking spirasters. *Ridleia peleia* de Laubenfels, 1954 lacks microscleres, but shares important characters with *C. inconstans*. Hence, it is found to be synonymous with *C. inconstans*. *C. inconstans* lives with most of its body buried in sandy sediments of lagoon, incorporating numerous calcareous particles in its tissue and eroding them. This is an effective strategy for living in an unconsolidated environment where hardly any other sessile animals live. The resulting erosion traces are observed and described for the first time for this species.

KEY WORDS

Cliona inconstans, Clionaidae, endopsammic habitat, coral reef, Ryukyu Islands.

INTRODUCTION

Pacific excavating sponges, especially those in Japan, are underrepresented in the literature, and species identification is quite difficult (*e.g.* ROSELL & URIZ, 1997; SCHÖNBERG, 2000). One of these difficulties is considered to be due to the possibility of the complete absence of microscleres in some specimens or populations, as noted in diagnosis of the family Clionaidae d'Orbigny, 1851 (RÜTZLER, 2002). In addition, overlooking microscleres causes misinterpretation even at the genus level or higher, e.g., misidentification of *Cervicornia cuspidifera* (Lamarck, 1815) as *Xestospongia tierneyi* (de Laubenfels, 1953) by overlooking rare spirasters (VICENTE *et al.,* 1991), and the transference of *Cliona quadrata* Hancock, 1867 to *Cliothosa* Topsent, 1905 through the discovery of amphiasters in the holotype (RÜTZLER & STONE, 1986). Here we report *Cliona inconstans* (Dendy, 1887) from the Ryukyu Islands, southwestern Japan, for the first time, and redescribe the species with a special focus on the microscleres. Another case of misidentification due to the absence of microscleres is also indicated, and the systematic status of *C. inconstans* is discussed. The sampling site is characterised by well-developed coral reefs, with lagoons situated in shallow waters. Lagoonal sediments are composed of calcareous materials such as coral sands, rubble and molluscan shells. It was revealed that *C. inconstans* incorporated lots of these calcareous particles in its tissue by vertically anchoring itself to the lagoon sediment. Uptake of sediments into sponge tissue has previously been observed for a number of other sponge species (*e.g.* CERRANO *et al.,* 1999; SIM & LEE, 1999). For bioeroding sponges, this phenomenon has been reported for *Cliona nigricans* in the Ligurian Sea (CALCINAI *et al.,* 1999). In addition to the systematic issue of *C. inconstans*, we report erosion traces made by *C. inconstans* on the incorporated calcareous particles for the first time, and discuss its psammobiontic habitat through comparison to other clionaid sponges.

MATERIAL AND METHODS

Thirtyfive specimens (from young small individuals to large ones) were collected by the first author by skin diving in lagoons of coral reefs around four islands, Hateruma-jima, Ishigaki-jima, Iriomote-jima & Kuro-shima, the Ryukyu Islands, southwestern Japan. The specimens collected were immediately preserved in 90% ethanol. Thick sections of sponge tissue were cut by hand to observe the skeletal architecture. Spicule preparations were made by dissolving small pieces of dried sponge tissue about 1cm^3 in boiling concentrated nitric acid, rinsing with distilled water, dehydrating by drying, and mounting in Canada balsam. The cleaned spicules were dried and coated with 400Å of gold-palladium for observation with a Jeol JSM 5200LV scanning electron microscope (SEM). Fragments of sponges were dissolved in a sodium hypochlorite solution to obtain undamaged incorporated calcareous materials for SEM observation. Fifty spicules of 10 randomly selected sponge specimens were measured under light microscopy and mean sizes were calculated with ranges in parentheses. A dried specimen previously identified as *Ridleia peleia* de Laubenfels, 1954, deposited in the National Science Museum, Tokyo (NSMT PO-0205), and glass slides of *Suberites inconstans* var. *mœandrina* (holotype; BMNH1887.8.4.1a), var. *globosa* (holotype; BMNH1887.8.4.2a) and var. *digitata* (syntype; BMNH1887.8.4.3a) deposited in the Natural History Museum, London, were examined for comparative studies.

RESULTS

<u>Habitat and external morphology</u>

Cliona inconstans is very common sponge in the study area, inhabiting lagoon sediments (intertidal to ca. 5m depth). Usually most of the body is buried in the calcareous sandy ground, sometimes penetrating coral rock underneath the uppermost sediment cover (Fig. 1). Individual sponges vary in shape and form single columns (Fig. 1a), multiple branching cylinders connected by underground basal mass (Fig. 1b) or massive shapes (Fig. 1c). The largest specimen collected is columnar, 20 cm in length and 18 cm in width, bearing 12 short cylinders on the epibenthic part.

The epibenthic part is dark brown in life and turns pale orange in ethanol. Single or multiple oscular openings are located on top of the exposed portion of the sponge. Associated barnacles, *Membranobalanus* cf. *longirostrum*, are usually found within the epibenthic part. The buried part is pale brown to cream in life and turns pale cream in ethanol.

Fig. 1. Intact live specimens of *Cliona inconstans* collected from sandy sediment bottoms. **a,** specimen of single columnar shape. **b,** specimen of multiple columnar shape. **c,** specimen of massive shape. Scale bars, 5 cm.

Spicule arrangement

The surface of the epibenthic part of the sponges appears to be smooth when examined without magnification, but is minutely hispid when observed by light microscopy; ectosomal brushes of tylostyles are arranged perpendicular to the surface, and subectosomal tylostyles form tangential strands (Fig. 2a). The surface of the buried part of the sponge is smooth; tylostyles are arranged tangentially in the peripheral region. Spirasters, if present, line the peripheral region of the ectosome of the epibenthic part of the sponge (Fig. 2b). Only few spirasters were found in the mesohyle. The number of spirasters varies among the specimens examined. Some specimens lack spirasters altogether.

Megascleres

Megascleres are represented by two size classes of tylostyles (Fig. 2c) with few intermediate sizes. The heads of larger tylostyles are relatively small and sometimes reduced. Tips are sharply pointed. Shafts are usually bent at the midregion. The maximum diameter of the shaft is found in the last third or quarter closest to the tip. Average dimensions (min-max) of shaft length/shaft width/head width are 477.6/14.6/13.6 µm (343-742/8.5-27.5/8.5-22.5). Smaller tylostyles are usually straight, with elongated heads and sharply pointed tips; their average dimensions of shaft length/shaft width/head width are 245.8/8.3/8.7 µm (148-325/4.5-12.5/4.0-13.5).

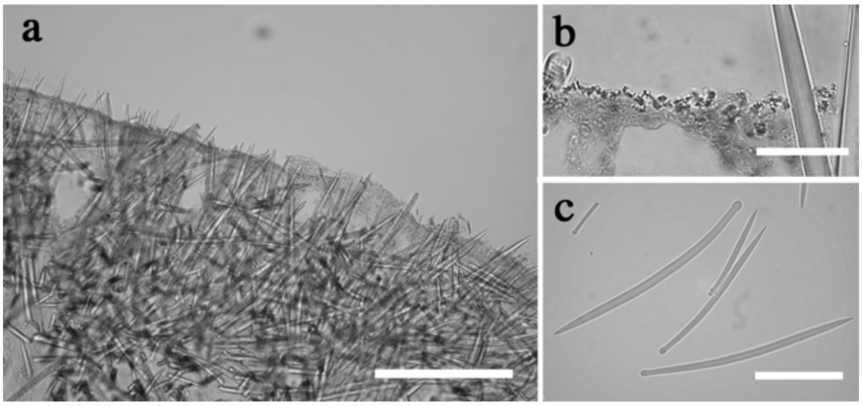

Fig. 2. Spicule arrangement and megascleres in *Cliona inconstans* (light microscopy). **a,** perpendicular section of the ectosome of the epibenthic part of the specimen. **b,** magnified image of the surface of the section, showing minute spirasters lining the peripheral region. **c,** tylostyles. Scale bars, a; 500 μm, b; 50 μm, c; 200 μm, respsctively.

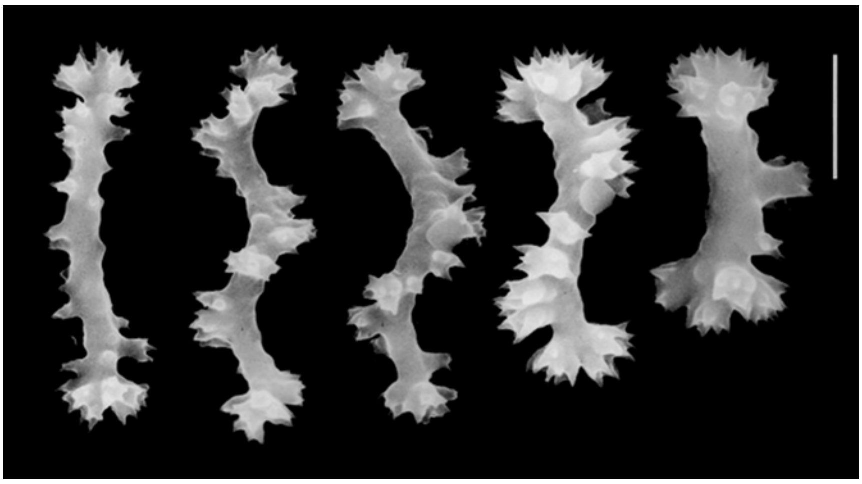

Fig. 3. SEM images of spirasters of *Cliona inconstans*. Scale bar, 5 μm.

<u>Microscleres</u>

Microscleres are minute spirasters that usually have two or three bends and are ornamented with clusters of small spines mostly on the convex side of the shaft (Fig. 3). Clusters of spines are concentrated at both ends. Average dimensions of shaft length/shaft width are 14.0/1.8 μm (8.1-20.7/1.4-2.4).

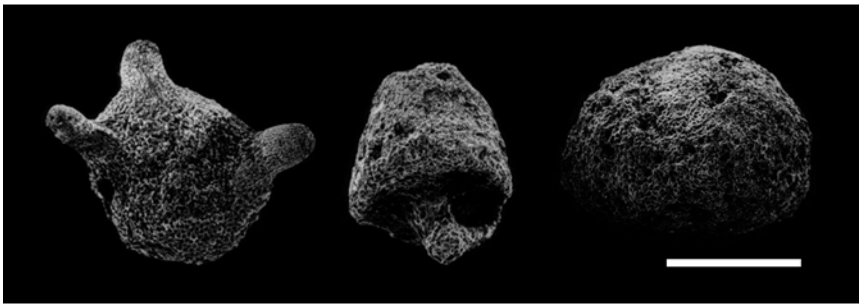

Fig. 4. SEM images of calcareous materials incorporated in the sponge body of *Cliona inconstans*. Left, shell of Foraminifera. Middle, shell of gastropod. Right, coral sand. Scale bar, 1 mm.

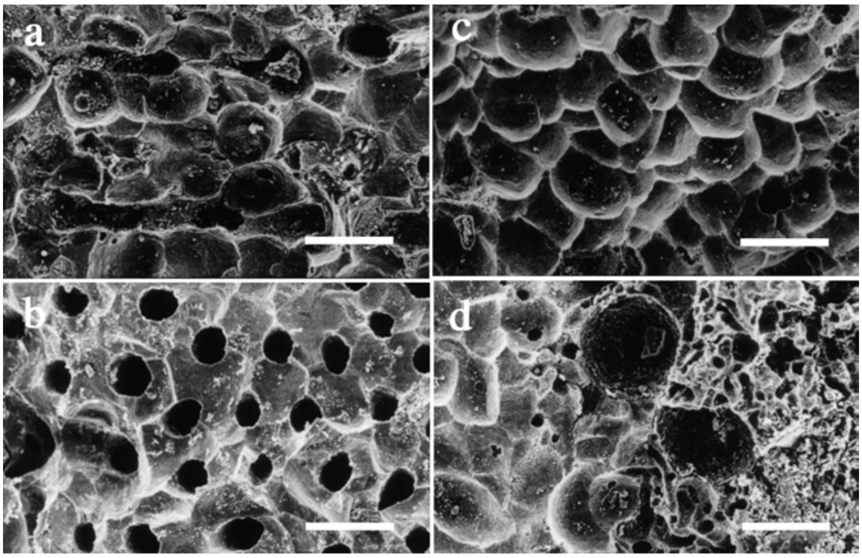

Fig. 5. SEM images of surfaces of the incorporated calcareous materials in *Cliona inconstans*, showing numerous polygonal subcircular pits. **a,** spine of echinoderms. **b,** shell of a Foraminifera; numerous small pores are in the original shell structure of the Foraminifera. **c,** shell of gastropod. **d,** coral sand; the left half is etched. Scale bars, 50 μm.

<u>Incorporated material and erosion traces</u>

Various calcareous materials such as coral rubble, coral sand, molluscan and foraminiferan shells are incorporated in the buried part (Fig. 4). Coral rubble and sand are predominant among these materials. The calcareous materials are evenly distributed in the sponge body, which reflects the sediment environment where the sponge lives. The sponges erode incorporated particles. Many conspicuous polygonal subcircular pits of 39-63 μm in diameters were observed on the surfaces of these materials (Fig. 5). Pit morphology is a typical indicator for sponge bioerosion.

DISCUSSION AND CONCLUSIONS

This species was originally described as *Suberites inconstans* by Dendy (1887), with three varieties *mœandrina*, *globosa* and *digitata*, from Madras, India. BURTON (1934) recorded this species from the Great Barrier Reef and transferred it to the genus *Spirastrella* Schmidt, 1868, probably because he found spirasters. This generic assignment was initially followed in later publications (BURTON, 1937; LÉVI, 1965; THOMAS, 1972, 1979, 1985; VACELET *et al.,* 1976). Then VACELET (1981) transferred this species to the genus *Cliona* Gray, 1826 for the first time, because he discovered its excavating ability. ROSELL & URIZ (1997) certified this transference based on cladistic analysis of the morphological characters. However, LÉVI (1998) considered the systematic position of this species to be with the genus *Spheciospongia* Marshall, 1892. In a recent paper dealing with this group, CALCINAI *et al.* (2000) reported this species as *Cliona* from the Indian Ocean. According to the latest diagnosis of each genus of the family Clionaidae (RÜTZLER, 2002), however, morphological characters of this species do not match those of *Spheciospongia. Cliona inconstans* lacks complex, incurrent pore sieves (cribiporal chones), which are an important diagnostic character of the genus *Spheciospongia* (RÜTZLER, 2002). Another psammobiontic genus *Cervicornia* Rützler & Hooper, 2000 is comparable to this species in morphological characters and habitat. However, the epibenthic part of *Cervicornia* is a special inhalant fistule, and the exhalent stolons end underground (RÜTZLER, 1997, 2002; RÜTZLER & HOOPER, 2000). In contrast to this character, *C. inconstans* has oscular openings on top of the epibenthic part. This means that the water flow inside the sponge body is reversed in these two species. For the above reasons, we tentatively remained this species to the genus *Cliona* although external morphology and psammobiontic habitat of this species are distinct from other species of the genus.

Microscleres as diagnostic character

DENDY (1887) did not mention the presence of microscleres in his original descriptions of three varieties of *Suberites inconstans*, but BURTON (1934) wrote "spinispirae are abundantly present in the type of *S. inconstans* var. *globosa*, although Dendy failed to remark them." Later authors such as BURTON (1937), LÉVI (1965, 1998), THOMAS (1972, 1979, 1985) and VACELET *et al.* (1976) also noted the presence of spirasters. At present it is not certain whether "the type" in BURTON's (1934) description means the type specimen or morphotype, but our re-examination of spicules of the holotype of *Suberites inconstans* var. *mœandrina*, the holotype of var. *globosa* and the syntype of var. *digitata* revealed that there are no microscleres, at least in the specimens dealt with by the original author. HOSHINO (1981) reported *Ridleia peleia* de Laubenfels, 1954, from the Ryukyu Islands. This species originally reported from the Palau islands is characterised by its epibenthic cylinders, endopsammic habit and tylostyles (DE LAUBENFELS, 1954). The genus *Ridleia* Dendy, 1888 now belongs to the family Polymastiidae Gray, 1867, but it has suggested that *R. peleia* does not belong to Polymastiidae (BOURY-ESNAULT, 2002). Although *R. peleia* lacks microscleres, other characters are very similar to those of *S. inconstans* var. *digitata* such as external form, habitat, spicule composition, and size and shape of tylostyle. As mentioned by RÜTZLER (2002), the complete absence of microscleres in some specimens or populations of clionaid sponges is very probable. Hence the occasional absence of spirasters in *C. inconstans* suggests that the specimen of *R. peleia* reported by HOSHINO (1981) from the Ryukyu Islands is an intraspecific variation of *C. inconstans*. Here we conclude that *R. peleia* is a synonym of *C. inconstans*.

Calcareous sandy bottom as habitat

Most clionaid species excavate solid calcareous substrate and live in the resulting cavities as endoliths. *C. inconstans*, however, lives within unconsolidated sandy sediments with most of its body buried. There are many characteristic erosion traces pitted on the surfaces of calcareous materials incorporated by *C. inconstans*, which suggests that this species has the ability not only to excavate hard calcareous materials but also to etch incorporated calcareous grains, as has been stated for *Cliona nigricans* (CALCINAI *et al.,* 1999). Incorporation of sediments is probably passive in the process of anchoring and depends on the environment, not on the selection of proper-sized sediments observed in other sponges, such as *Dysidea etheria* (TERAGAWA, 1986a,b). Incorporated sediments of *C. inconstans* are very variable in size and do not compose a special auxiliary skeleton. The reason for the etching was not totally clarified, but the positions where aquiferous canals pass through are clearly perforated, as observed in *C. nigricans* (CALCINAI *et al.,* 1999). Incorporation of calcareous grains by anchoring and erosion is a very effective strategy for living in an unconsolidated environment like lagoonal sandy ground where other sessile animals hardly live. Another clionaid species inhabiting lagoonal sandy ground is *Cervicornia cuspidifera*. The endopsammic habit of *C. inconstans* is similar to that of *C. cuspidifera*. Both *C. inconstans* and *C. cuspidifera* are found to be well-adapted to these unconsolidated environments, and are ecologically distinct from the other clionaid species.

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