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沖縄島産サンゴ被覆性海綿 *Terpios hoshinota* に関する研究

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Abstract

Studies on the coral-killing sponge *Terpios hoshinota* in Okinawa Island, Japan
沖縄島産サンゴ被覆性海綿 *Terpios hoshinota* に関する研究

The coral-killing sponge, *Terpios hoshinota* Rützler & Muzik, 1993, has a great potential to cover corals and becoming a threat to corals and coral reefs. *T. hoshinota* is a black, encrusting sponge that hosts numerous symbiotic cyanobacteria in its tissue. In addition to cyanobacteria, this sponge has numerous silicate spicules in the tissue, and particles on the tissue surface, which could have an important role in the growth and defense of the sponge. The sponge often overgrows live scleractinian corals, thereby causing widespread and accelerated coral loss. However, little is known about biology and ecology of this coral-killing sponge.

In Chapter 2, I report here the density measurement of cyanobacteria by grinding the coral branch covered by the sponge to remove sponge tissue remaining in coral skeleton, and estimated as 1.2×10^7 cells cm^{-2} . I also obtained the densities of spicules and particles as 4.7×10^5 cm^{-2} and 1.3×10^6 cm^{-2} , respectively. The spicule length of the Sesoko sample was shorter than those of previous studies. Size frequency distribution of the particles was measured for the first time, showing that the sponge selected silt-size particles with a mean size of 22.3 μm . I conclude that this study can be a basic information on measuring the important components of *T. hoshinota* and useful to compare the measurement of those morphological components in other coral reefs affected by this coral-killing sponge.

The aim of the study in Chapter 3 was to compare the composition of spicules and particles in *T. hoshinota* in relation to sediments to understand the relationship between hard components of the sponge and sediments surrounding the sponges in four different sites in Okinawa Island, Japan. Spicules and particles were isolated from sponge tissue by bleaching treatment. Obtained hard components were observed under a light microscope. Then, I quantified particles and sediments by decalcification with diluted HCl solution, and divided into acid-soluble (mostly as calcium carbonates) and acid-insoluble (mostly as silicates) substances. Length of spicules and sediment composition were compared. Sediment composition, spicule length and particles showed significant different among location. The composition of hard structures in different sites (limestone based or volcanic based reefs) in Okinawa Island may give us the better understanding of the factors that controlling the morphological traits of this coral-killing sponge.

Our understanding of how seasonal change affects on the progression rate of the sponge is poor. Therefore, to elucidate the progression dynamics over a year was studied in Chapter 4. I obtained monthly measurements of linear progression of *T. hoshinota* (mm month^{-1}) on the branching coral *Montipora digitata* in the subtropical waters of Sesoko Island, Okinawa, Japan from 2019 to 2020. The progression rate of *T. hoshinota* varied monthly

throughout the year. The progression rates were highest in summer (July, August, and October) with a mean value of 66 mm month⁻¹, except in September, when strong typhoons come close to Okinawa and the progression rate decreased temporarily. The progression rates were the lowest in February 2020, at 9 mm month⁻¹. The mean annual linear progression rate was estimated to be 28 mm month⁻¹. Therefore, the progression dynamics of *T. hoshinota* could be linked to their growth mechanisms in relation to the water temperatures in subtropical waters including the negative effect such as typhoons.

In Chapter 5, reproduction of *Terpios hoshinota* from Okinawa Island were determined. Sexual reproduction was quantified using histological sections from sponge samples collected in Okinawa Island. Histological and in situ examinations were carried out on 10 tagged individuals in shallow reef sites located in the north region of Okinawa Island, Japan. Sponge specimens were collected monthly from Nakijin, from June 2020 to June 2021. Rising sea temperature may potentially facilitate spermatogenesis and embryogenesis, however oocytes or oogenesis were observed through a year round.

In Chapter 6, monthly observations on maturity stages have been done for the sponge (May 2021 – May 2022). Sponge individuals (24 – 53 in number) in each site (Nakijin, Ogimi and Sate) were collected around full moon. Maturity were categorized as 3 stages based on the absence/presence of larvae and the position of larvae in/on the sponge tissue. Stage 1: no larva found, Stage 2: larvae are detectable, Stage 3: larvae are apparent. Sponges holding larvae ranged from 3 to 71% during sampling period except winter season (December to April). In three study sites, the number of individuals of stage 3 was higher in June (Ogiimi and Kunigami) and August (Nakijin). Conversely, higher number of mature individuals was determined in September in Nakijin in 2020. Environmental conditions such as seawater temperature and light intensity seem affect maturity stage, or double peaks of maturity stage as an intrinsic trait. Rate of mature individuals carrying larvae indicate the potential contribution to their prevalence in coral reefs. Monthly pattern of maturity stage of this sponge in relation to environmental factors could be important to evaluate their population dynamics in coral reefs.

In Chapter 7, we found tiny snails crawling on the sponge in Okinawa Island, Japan. We observed egg capsules inside the sponge tissue and veliger larvae released from the egg capsules. Molecular analyses of both the snails and veliger larvae (cytochrome oxidase I, COI) showed that they were identical and belonged to *Joculator* sp. (family Cerithiopsidae). There was no direct observation of predation on the sponge by this snail, this is the first report on a close association between a snail and the sponge *T. hoshinota*.

These results provide a better understanding how *Terpios hoshinota* survive in coral reef area in Okinawa Island, Japan in relation to environmental factors.

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