

DISTRIBUTION AND CHARACTERISTICS OF SEA URCHINS, GENUS ECHINOMETRA, FROM PALAU

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Introduction

In sea urchins, all of the genera of the family *Echinometridae* except *Echinometra* are confined to the Indo-Pacific. There are many forms of *Echinometra mathaei* de Blainville 1825 and there is controversy as to number of species these forms represented. Recent information concerning the embryology, ecology, morphology, karyotype and molecular biology of Indo-Pacific *Echinometra* indicate that separation into five distinct species is warranted (reviewed by Uehara, 1991, Uehara *et. al.*, unpublished). The five species are designated tentatively as *Echinometra* sp. "A" (Tumajiro-nagauni in Japanese), *E. sp.* "B" (Nagauni), *E. sp.* "C" (Ryukyu-nagauni), *E. sp.* "D" (Himekuro-nagauni) and *E. sp.* "E" (Kuro-nagauni).

These species provide a useful system for study of speciation for several reason. First, Indo-Pacific *Echinometra* is present as a complex of five closely related species. Second, these species provide an excellent example of a group organisms that are seldom studied with respect to speciation, namely high-dispersal marine organisms. Third, reproductive isolation at fertilization is particularly important in sea urchins of *Echinometra* that freely release their gametes into the environment, with minimal behavior prior to spawning.

Therefore, in order to understand speciation in *Echinometra* species, many investigations from all approaches are being carried out. The purpose of this study is to describe the distribution and characteristics of *Echinometra* species in Palau and to determine what intraspecific differences in the microhabitat and morphology between species from Palau and Okinawa.

Materials and Methods

Field surveys were mainly conducted at Sunabe seawall, Okinawa, south-western Japan. In Palau, thirteen sites of the seven islands were surveyed from intertidal zone to subtidal zone by snorkeling and by walking, from October 18, 1995 to December 2, 1995 (Fig. 1). At each site, *Echinometra* species were counted separately for each species. Those characters useful for quick discrimination (UEHARA, 1990) in field work are as follows.

Echinometra sp. "A": Color very variable, spine from entirely white to black but always with white tip, basal ring of spine white and clear.

E. sp. "B": Color variable, spine mostly brown and greenish brown, tip of spine not white, basal ring of spine unclear. The skin around their mouth like *E. sp.* "A" and "D" is red wine-colored.

E. sp. "C": Color very variable like *E. sp.* "B" and sometimes even creamish, spine tip not white, basal ring of spines white and clear. The skin around their mouth is pale and faded.

E. sp. "D": Color uniform black, test size generally smaller than other species.

Individuals separated for each species in the field were checked under microscope by

observing spicules from tubefoot and gonad. Other data recorded were the type of substrate, the presence of live coral and current patterns. The microhabitats and the distribution pattern of *Echinometra* species in thirteen sites of seven islands is described.

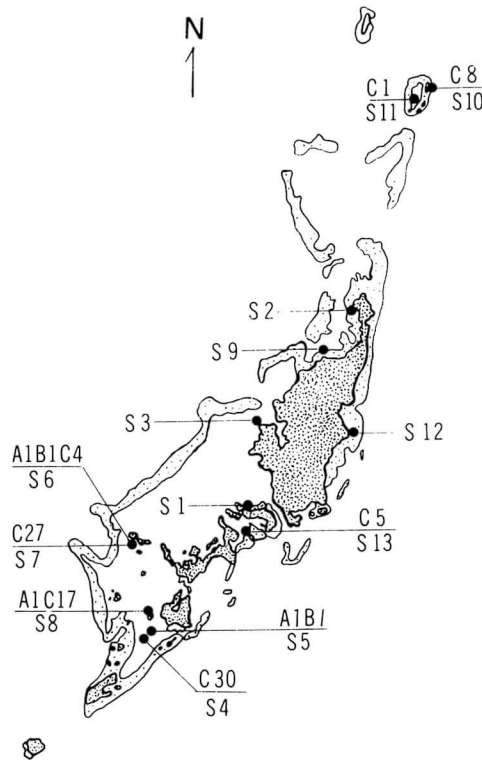


Fig. 1. Map of the study site in Palau and distribution of species of the sea urchin *Echinometra*. S1: Arakebesang, S2: Konrei, S3: Purengel, S4: Peleliu, S5: Peleliu, S6: Ulong, S7: Ulong, S8: Omokan, S9: Ngardmau, S10: Kayangel, S11: Kayangel, S12: Melekeok, S13: Koror. A, B, C and D show *E. sp.* "A", "B" and "C", respectively. Number means number of each *Echinometra* species collected at each site.

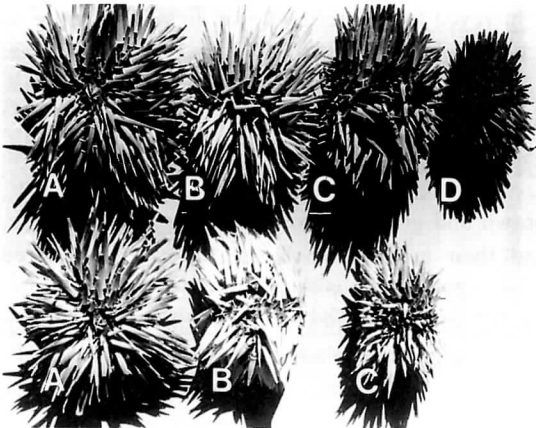


Fig. 2. Four Okinawan (upper row) and three Palauan (lower row) species of genus *Echinometra*. A; *E. sp.* "A", B; *E. sp.* "B", C; *E. sp.* "C", D; *E. sp.* "D".

Results

Okinawan *E. sp. "A"* is characterized by white-tipped spines and bihamate and needle spicules in tube feet and gonad, respectively. Individuals distinguished to *E. sp. "A"* by the appearance in the field were checked again under microscope in the laboratory. These characteristics of individuals from Palau were the same as those of Okinawan *E. sp. "A"*. In the same manner, the other two species, *E. sp. "B"* and "*C*", are distinguished in urchins from Palau (Fig. 2).

Okinawan individuals used in this study were collected at the Sunabe Sea wall. This site was selected to cover all of the possible environments that four species of *Echinometra* live in. Schematic distribution pattern of the four species of *Echinometra* on a generalized reef was shown in a profile (Fig. 3-A). The reef here is narrow and relatively flat. In the reef flat the coral is dead. Most of the reef is exposed for several hours at lowest tide and most of the urchins at low tide can be easily found in burrows by walking. The tide pools are less than 60cm in depth and the substratum of the tidepool is covered by sand and coral rubble. The sea urchins, *Echinometra sp. "A"* are mainly present in shallow tide pools. *E. sp. "B"* was rare, and *E. sp. "C"* and "*D*" were lacking in the tidepool. *E. sp. "C"* and "*D*" occur mostly in burrows at the reef crest exposed to wave action. Habitats of *E. sp. "D"* positioned slightly above that of *E. sp. "C"*. Furthermore, the burrows for *E. sp. "D"* are smaller than those of *E. sp. "C"* around the reef crest. It is consistent with the fact that *E. sp. "D"* urchins were smaller than those of *E. sp. "C"* (Fig.2). The burrows at the reef crest of Sunabe are shallow so the collection of the individuals is possible using only a screwdriver. *E. sp. "A"* was completely lacking and *E. sp. "B"* were rare at the reef crest. *E. sp. "B"* inhabited the rocky area close to the ocean and positioned slightly below those of *E. sp. "C"* and "*D*". Bottom substrate was free from sediments where it was exposed to relatively strong wave action.

Field surveys in this study were conducted at thirteen sites of seven islands in Palau (Fig.1). Four sites (S2, S3, S9 and S12) around Babeldaob island and one site (S1) near Arakebesang were large or small sea grass beds and were protected from strong wave action by the outermost barrier reef. No *Echinometra* species was found. Distribution of *E. sp. "A"* and "*B*" is limited to the south islands of Palau. S5 and S6 were covered with bleaching corals on sand and one *E. sp. "A"* urchin, one *E. sp. "B"* urchin and four *E. sp. "C"* urchins appeared in live coral and in crevices. S7 (Fig. 3-B), located near S6, was a small and shallow rocky shore exposed to

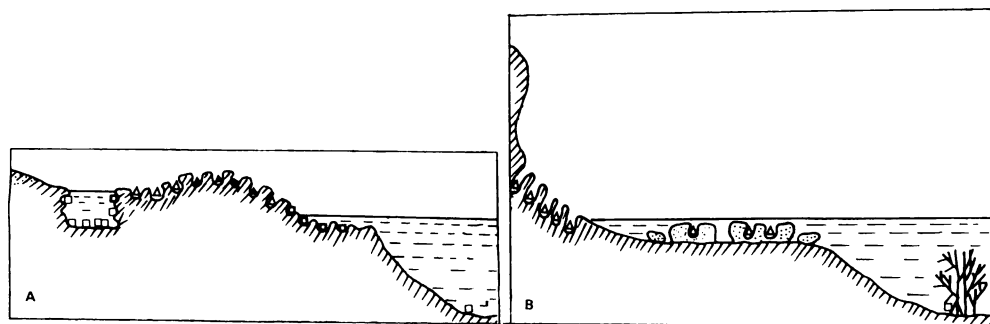


Fig. 3. Schematic distribution pattern of the species *Echinometra* at Sunabe in Okinawa (A) and S7 in Palau (B) shown in a profile. Symbols, □, ○, △ and ▲ represent *E. sp. "A"*, "*B*", "*C*" and "*D*", respectively.

wind-driven current and current due to tidal fluctuations. Only one *E. sp.* "A" urchin occurred under stone and *E. sp.* "B" urchin was lacking, while *E. sp.* "C" urchins were relatively abundant. They occupied deeper burrows than those for Okinawan *E. sp.* "C". S4 was a tiny protuberance land located near Peleliu, and S8 was a small and shallow coral reef flat and S10 was the east side of Kayangel and was a sandy bottom with cobbles and limestone rocks. These three sites were relatively exposed to wave action and *E. sp.* "C" urchins were abundant and live in holes. *E. sp.* "D" urchin was not found in any sites of present study.

Test size of the urchins of *E. sp.* "C" from different sites in Palau and Okinawa was measured and compared. *Echinometra* species is not circular but elliptical in shape. The test size is shown using the test length along the elliptical axis, test width as the minor axis and the test height. The mean average test length was 36 mm (n.27), 32 mm (n.17), 28 mm (n.8) and 41 mm (n.9), calculated for urchins from S7, S8, S10 and Sunabe, respectively. About the test width, 27 mm (n.27), 24 mm (n.17), 21 mm (n.8) and 30 mm (n.9) are for urchins from S7, S8, S10 and Sunabe, respectively. On the test width, 21 mm (n.27), 18 mm (n.17), 16 mm (n.8) and 24 mm (n.9) are calculated for urchins from the sites listed above. A difference in test size of urchins from different habitats in Palau and Okinawa correlates positively the size of burrow or hole.

Discussion

Four species of genus *Echinometra*, *E. sp.* "A", "B", "C" and "D" are abundant on Okinawa island. There are two species in Hawaii, *E. sp.* "B" and *E. sp.* "E". *E. sp.* "E" is not yet found in the sea shores of other countries in the world. (KELSO, 1971, UEHARA, unpublished). Two species, *E. sp.* "A" and "B" are found in Guam (UEHARA, unpublished). Four species occur in Indonesia like in Okinawa (ARAKAKI & UEHARA, 1995). Only two species, *E. sp.* "B" and "D" are present in Mauritius, the type locality of Indo-Pacific *Echinometra* (ARAKAKI & UEHARA, unpublished). In this study, three species, *E. sp.* "A", "B" and "C" were found. Both *E. sp.* "A" and "B" are found around and inside live and dead coral, but were rare. The same ecological distributions of *E. sp.* "A" and "B" were observed at the sea shore of Sunabe (Uehara's observation) and Sesoko island (NISHIHARA et al., 1991) in Okinawa. As to *E. sp.* "A" and "B" in Okinawa (NISHIHARA et al., 1991) and Guam (Neill, 1988; Uehara's observation), they showed apparently different ecological distribution. Namely, urchin of *E. sp.* "A" inhabits only subtidal habitats and urchin of *E. sp.* "B" inhabits both above and below ELWS (NISHIHARA et al., 1991). McCLANAHAN and MUTHIGA (1989) showed in Kenya that local fishing pressure decreased density of the predators, and this in turn resulted in the increases in density and extension of lower distribution range of *E. mathaei*. *E. sp.* "A" and "B" are rare at the sites in Palau, while many kinds of fishes are abundant there. Therefore, Palau is a good place for study of the relationship between density of the urchins and fish predation.

At all sites of 4, 7, 8 and 11 in Palau, rocky shore sand and coral reef are relatively exposed to wave action, where only urchins of *E. sp.* "C" live in borrows or holes. In Sunabe and other places in Okinawa, *E. sp.* "C" and "D" had generally similar distribution patterns, but *E. sp.* "D" preferred more wave-beaten places than *E. sp.* "C" (NISHIHARA et al., 1991 and present study). *E. sp.* "C" urchins had a range broader than *E. sp.* "D" in Okinawa.

There is a positive correlation between sizes of urchin and burrows. It is consistent with the present study that *E. sp.* "C" urchins living in deep and small burrows at S10 were smaller than those of same species occurring in relatively shallow ones at S7. It was also suggested that the

deeper burrows are more suitable for sea urchins in the high energy environment than the shallower ones. A slight difference of distribution pattern of *E. sp. "C"* at the sites between Palau and Okinawa seems attributable to the difference in topography, location on the reef margin and intensity of wave action. These findings suggest that similar phenomena occur rather widely in the habitats separating these species of *Echinometrae*. So far, it is from small Okinawa island that four species were reported occurring sympatrically on a reef, yet showing habitat preference slightly different from each other. It is suggested from this study together with other data that habitats for *Echinometra* species in Okinawa are more diversified than other regions in Indo-Pacific. Further studies on ecological distribution and habitat preference are needed to answer the question how five species of *Echinometra* have evolved their preference to habitat, and how only *E. sp. "B"* have been widely distributed in the Indo-Pacific.

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