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Growth Mode and Function of Aboral Spine Canopy in the Sand Dollar *Scaphechinus mirabilis* (A. Agassiz, 1863)

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Sand dollar lives in or on sandy bottom in intertidal to sublittoral zone. The most distinctive morphological feature of the sand dollars is a very flatted shape adapted to maintaining the stable position against wave action, and the presence of enormous numbers of tiny spines. It was known that aboral spine of sand dollar mechanically blocked sediment particles from falling between the spines because they must maintain a flow of oxygenated water through their burrowed in sediments (Smith 1980, Mooi 1986). In this study we first attempted to understand the function of the aboral spine as the sand grain supporter based on quantitative examining for a correlation the grade of sediment inhabited and the structure (density, size, space of tip part) of both aboral miliary spines and club-shaped spines after due consideration about the variation inter each aboral plate, intraspecific variation and ontogenic change for aboral spine structure.

The sand dollar used in this study is *Scaphechinus mirabilis* (Agassiz, 1863) that is one of the most popular sand dollar around Japan. It is distributed in the northwest of the Pacific Ocean from southern Japan to the Aleutian Islands and they live in fine sandy bottoms from intertidal to sublittoral zone and burrows shallowly on the surface of the sediment (Shigei, 1986).

It is confirmed that there are some difference in areal densities of club-shaped spine amongst each aboral plate of an individual, and this difference has characteristic distribution pattern. The density increases concentrically from test margin to apical system. The density on interambulacrum 5 is slightly higher than other areas, and the density on petals is also higher in individuals with a test length under 5 cm. The mean aboral club-shaped spine density decreases until the length of the test reaches 5 cm, thereafter it levels off to a mean density of 16-18 spines/mm^2. It was observed that the aboral miliary spines had a regular geometrical arrangement pattern for the club-shaped spines on any plate in every test size. One club-shaped spine is always surrounded by six miliary spines, and one miliary spine is surrounded by three club-shaped spines, so that the number of aboral miliary spines would be approximately twice than the number of club-shaped spines. Therefore, it is thought that the change of the aboral miliary spine density through the ontogeny is same pattern of the club-shaped spines. In contrast to the mean spine density, the mean diameter of both the club-shaped spines and aboral miliary spines increase until the length of the test reaches 5 cm; thereafter, they become nearly constant. This turning point of growth for the spine diameter is the just same time with it of the spine density. In an individual the spine diameter has some areal difference amongst aboral plate, and the diameter in interambulacrum 5 where the spine is high density is always larger than another plate in all specimens The spines space (inscribed circle) of club-shaped spines and miliary spines has shown to be almost constant during ontogeny. It is sure that this uniformity for growth is caused by contrastive growth mode between spine density and diameter. The space of club-shaped spines ranges from 0.19 mm to 0.25 mm, and the space of miliary spines ranges from 0.08 mm to 0.1 mm. This fact shows that

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the most sediment grains of their habitat over their test pass through the first canopy composed of club-shaped spines and they can be supported by the second canopy composed of miliary spines (Fig. 1).

The spine space is relative constant through ontogeny and a little difference in areal spine spaces in aboral plate is corrected by contrast distribution pattern of spine density and diameter. This regularity is in harmony with the function of aboral spine canopy because the particle size which the canopy can support have not been changed through their ontogeny. In addition, the spines space can be fairly estimate an influence of the difference of spine size and shape. Furthermore, the indicator of the spine space has the advantage that it can show numerically the finest supportable particle size by the canopy. Therefore, we insist that the spine space is most suitable indicator as the role of sand grain supporter of aboral spines in sand dollars and previous studies for relation between the spine density and nature of the substratum needs to be reexamined by the spine space.

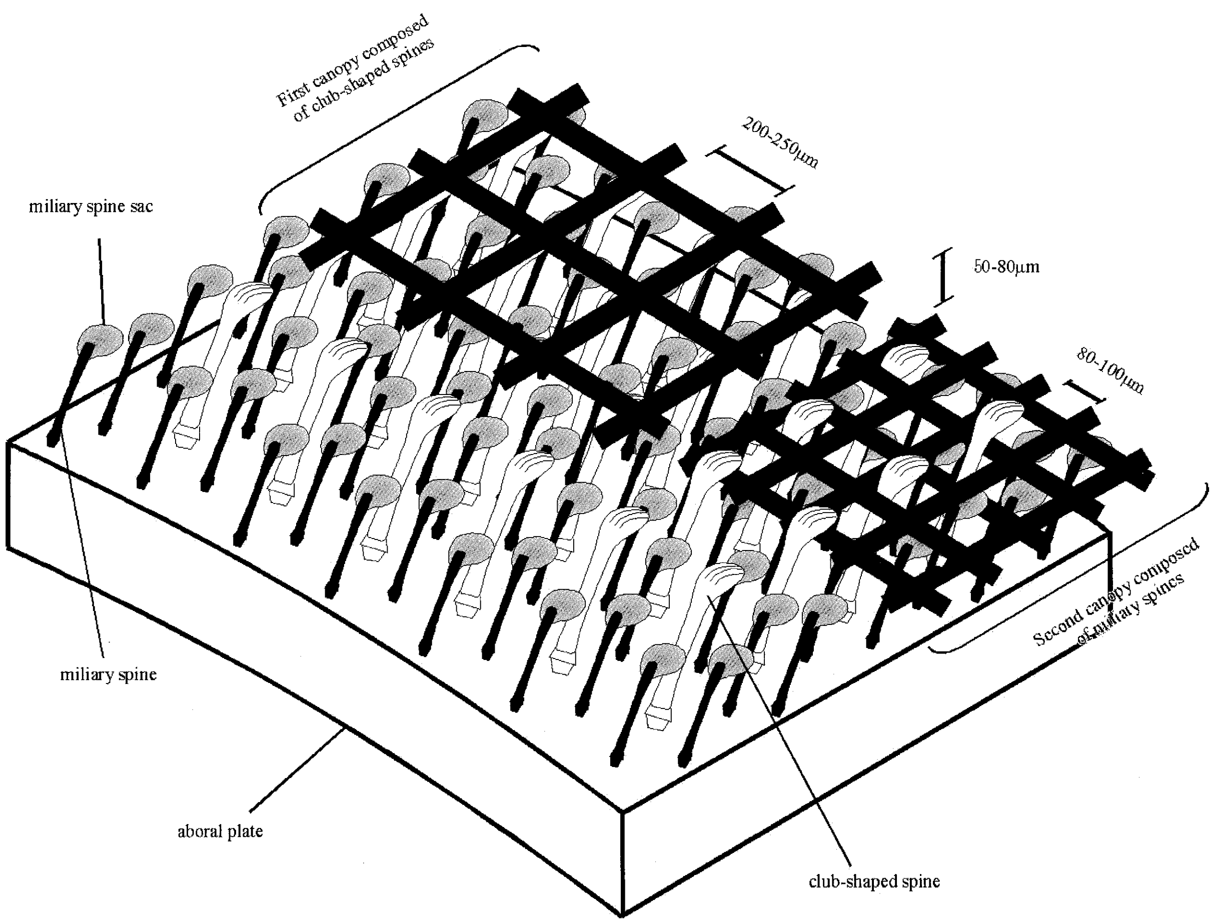

Figure 1 Schematic structure of double-ply spine canopy in *Scaphechinus mirabilis*. First canopy composed of club-shaped spines can support sand grains more than middle sand grain size. Second canopy composed of miliary spines can support mainly fine sand grains. Each canopy is different in height and have original inter-spine distance.

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