論文内容の要旨

論文題目　Active food selection and feeding behavior of *Metacrinus rotundus* (Echinodermata, Crinoidea)

有柄ウミユリ類トリノアシが示す能動的エサ選択と採餌行動

氏名　北沢　公太

Crinoids (Echinodermata) have long been considered as a typical example of suspension feeders.　Crinoids are also regarded as a “non-selective” suspension feeder in general.　In order to test whether crinoids select their foods, and also whether they positively control surrounding water current actively, the following three experiments were conducted.

The existence or absence of food selection of *M. rotundus* is tested. Standardized gut contents were examined after supplying model food.　The model food contained zooplanktons, grass beads (medium- and small-sized), and phytoplanktons in descending order.　Among the grass beads, crinoids tend to contain larger particles. But comparing among all kinds of particles, crinoids took much greater amount of phytoplanktons than other particles.　In descending order, phytoplanktons, zooplanktons and medium beads are almost in the same volume, followed by small beads, respectively.　This result strongly demonstrated that crinoids select food materials at the particle level.　This is the first quantitative analysis of the crinoid food selection, and the first documentation about existence of active food selection of crinoid.

By the previous submersible observations, crinoids are thought to change their postures responding to the changes of current direction and velocity.　On the other hand, a preliminary experiment by the author indicated that crinoids also respond to approaching particles in a current.　Based on the food selection and this result, the crinoid behaviors were examined in aquarium condition.　Zooplanktons, phytoplanktons and quartz powder were applied to crinoids, firstly as not mixed (singly), then as mixed status.　Crinoids showed a common posture change after the supply of

all kind particles. If the suspended particles contained organic matters, crinoids swung the arms and swelled pinnules. On the other hand, when the particles were quartz powder only, crinoids did not show any movements, and their arms completely remained in a same posture. This result indicates that 1) crinoids can distinguish whether the suspended particles contained organic matters or not, depending on the chemical properties, and 2) the behaviors are regarded as adaptive or effective in the sense of feeding efficiency.

The possibility that crinoids could distinguish if the suspended particles contained organic matters, is examined by food extraction. The chemical properties of zooplanktons and phytoplanktons were extracted and packed into agarose gel. The gels were ground up and applied to crinoids. Crinoids showed peculiar behaviors as they showed when organic matters were supplied, but in the case of agarose gel only, they showed almost no movement. Thus it is concluded that crinoids can recognize the chemical properties of suspended particle. This is also the first discovery that the crinoids behave differently according to the different qualities of diets.

The means of crinoid behavior during their feeding were examined in the following two steps. At first, the water current around the crinoid individuals were visualized by carmine dye. Before feeding, currents were uniform; passing through the crown, but sometimes they were slightly disturbed by their arms. During feeding, currents were much more disturbed than those before feeding, and sometimes circular currents along curled arms occurred directly inside of crown. After feeding, the currents were passing away the crown. Such disturbed/passing seem to be produced by the current modification by the crinoid. Then the current changes were measured quantitatively. The current velocity and directions were recorded by a velocity meter around a crinoid individual among following three phases, before feeding, among feeding, and after feeding. The changes of current directions and the velocity are arrhythmic through all the phases. But during the feeding phase, the changes of current direction and velocity seemed to be maintained as minimum, indicating that the current conditions were kept in a certain range. Thus it is possible that crinoids maintain current conditions by their posture and by their behavior, during their feeding.

Living crinoids consist of about 600 species, by contrast fossil crinoids are more than 9,000 species. Crinoids were most diversified in the Paleozoic. General features of Paleozoic type crinoids are 1) dominance of ligamentaly arm articulations, 2) sessile lifestyle, and 3) absence of pinnules. On the other hand, Recent crinoids differ from Paleozoic type in the following characteristics; 1) arms are flexibly moving by well developed muscular articulations, 2) free living lifestyle (especially in comatulids and isocrinids), and 3) possession of pinnules. Arm flexibility and existence of pinnules have enabled Recent crinoids to change and adjust the density of filtration fan to the ambient current. Former study showed that crinoid linages which have variable fan density are long ranging. This study revealed that the arm flexibility serves not only for changing the fan density, but also for current stabilization by the moving. By the submersible observation, crinoids tend to stand on the environment where relatively strong currents prevail. Free living lifestyle allows crinoids to replace the micro habitat. Moreover, pinnules are used for the crawling locomotion. Free living lifestyle is an advantageous character also in the sense of escape from predators.

It is strongly suggested that 1) fossil crinoids (at least post-Paleozoic forms) could recognize, distinguish and select the suspended particles, 2) posture changes and arm behaviors among feeding are predominant characters in Recent crinoids. The other echinoderms are reported to use chemical sensory organs during their feeding. For example, an Atlantic starfish can recognize its favorable clam and distinguish the prey bivalves. Thus it is reasonable that echinoderms' chemical sensing is used in feeding not only in living but also in fossil echinoderms. Furthermore, particle sorting should be more important in the Paleozoic type crinoids than in case of Recent type crinoids to get a nutritious food, because the Paleozoic type crinoids could not feed efficiently as the Post-Paleozoic forms by adjusting their fan to catch desirable foods in optimum amount. In the Paleozoic, many crinoids formed highly dense communities so called "crinoid meadows" or "crinoid gardens" in shallow water. It is possible that food selection by crinoids and their low metabolic rate are a key factor for such highly dense communities.

Moreover, Paleozoic type crinoids and blastoids went extinct at the P/T boundary. They both had no "muscular arm" and they were both sessile benthos. According to this study, namely the absence of arm mobility or absence of optimal adjustment in feeding, are also considered as a possible cause of their decline. Through the experiment, the current velocity was kept as constant. The current velocities around crinoid individual were kept in a certain range (statistically not significance), and in this condition crinoids were moving. This moving and posture changing were made possible by the muscular articulations. Thus it is concluded that acquisition of muscular articulation has allowed the Recent type crinoids to adapt the wide-range of environmental changes, resulting in the long-term survivor of their linage.