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Morphological changes of the cushion star, *Culcita novaeguineae* Müller et Troschel, during growth

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ABSTRACT: Development of the skeletal system was studied during growth in the cushion star to provide a basic knowledge how a cushion form of the adults is attained from the stellate juveniles. Unbalanced growth of the marginal length and the arm length may be responsible for the change from a stellate form with inwardly arched interbrachial edge to a pentagonal form with straight interbrachial edge. Loose abactinal skeletal architecture also seems to contribute to form the cushion style of the adults.

INTRODUCTION

Adults of asteroids are in general more or less stellate in form as they are called sea stars. However, some species have an atypical form against this sense. Among those, long armed and multiple arm-bearing species are fairly common in several taxonomic groups.

On the other hand, sea stars which have very short arms and disc-shaped form are relatively few among the atypical species. The cushion star, Culcita novaeguineae is a representative of disc-shaped sea stars.

However, nothing has been known how such a peculiar form becomes to be acquired by the adult, although juveniles and young individuals of this species have a stellate form.

Furthermore, very few papers are available for the morphological changes during growth (Hörstadius 1939, Kano et al. 1974), although many papers have been published on the early and larval development and metamorphosis in sea stars (Rev. Oguro 1989).

In the present study, it was attempted 1) to provide a basic knowledge on the growth of sea stars after the completion of metamorphosis, 2) to know morphological bases in C. novaeguineae by observing the changes during the growth.

MATERIALS AND METHODS

Many specimens of Culcita novaeguineae Muller et Troschel in various size (3.4 - 93.3 mm in R <distance from the center of the disk to a interbrachial margin>) were collected from Seabee Island, the Philippines, in 1988.

Specimens collected were dried and brought to the laboratory. They were arranged according to the size of the disk diameter. Skeletal structure of the abactinal and actinolateral walls were observed. Furthermore, number of the marginal plates, adambulacral plates and furrow spines were counted. The disk was often cut into two separate halves by a horizontal plane and abactinal skeletal structure was observed from the coelomic side after removing the connective tissue lining of the abactinal wall.

RESULTS AND CONCLUSION

Juvenile cushion star below 10 mm in R is typically star-shaped. Abactinal plates of these juveniles are pentagonal, hexagonal or polygonal and set very closely. They are contacting with other or slightly overlapped. Papulae are single and situated between the plates. Number

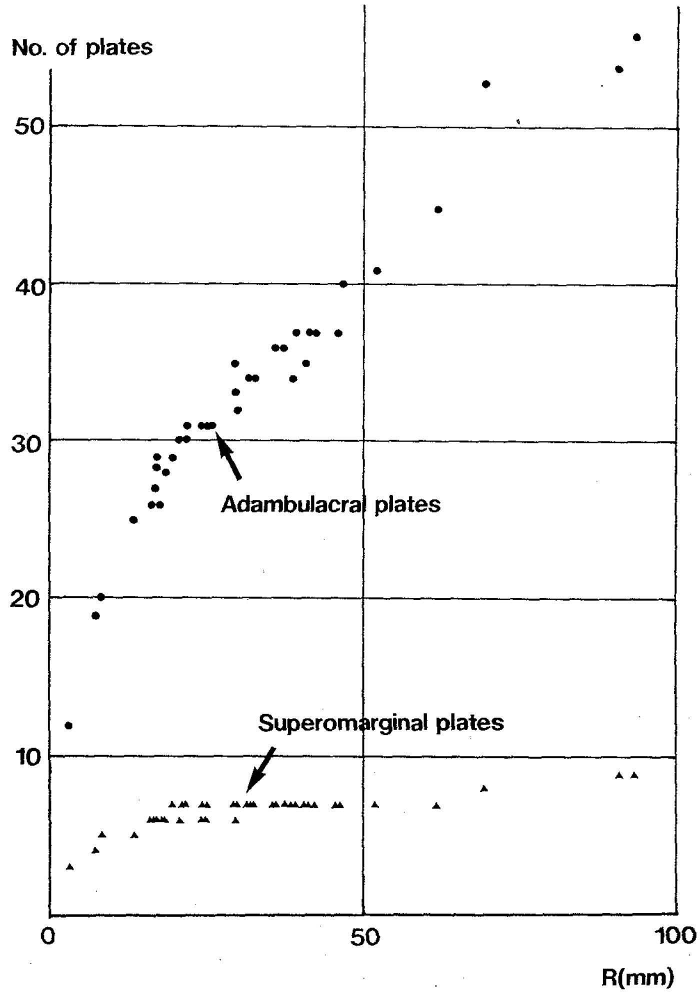

Fig. 1. Number of the superomarginal plates and adambulacral plates in Culcita novaeguineae, during growth. R shows distance from the center of the disk to a interbrachial margin.

of the inferomarginal plates is always the same to that of the superomarginal plates or 1 ahead. Therefore, number of the superomarginal plates is referred in the following description in this paper. Changes in the number of superomarginal plates and adambulacral plates are shown in Figure 1.

During the early growth, increase of the number of the superomarginal plates, which is taken as an indicator of marginal growth, is parallel to the increase of the number of the adambulacral plates, which are taken as an indicator of arm elongation. In an specimen having 3.4 mm in R, the superomarginal plates and adambulacral plates are 3 and 13, respectively (Fig. 1, Fig. 2A,B). A specimen with 9.5 mm in R has 4 superomarginal plates and 20 adambulacral plates. Thus, the number of the both plates doubled during the growth from 3.3 to 7.4 mm in R (Fig. 1, Fig. 2C,D).

However, increase of the number of the superomarginal plates is very slow as is shown by the fact that in an individual with 19 mm in R numbers of the superomarginal plates and adambulacral plates are 6 and

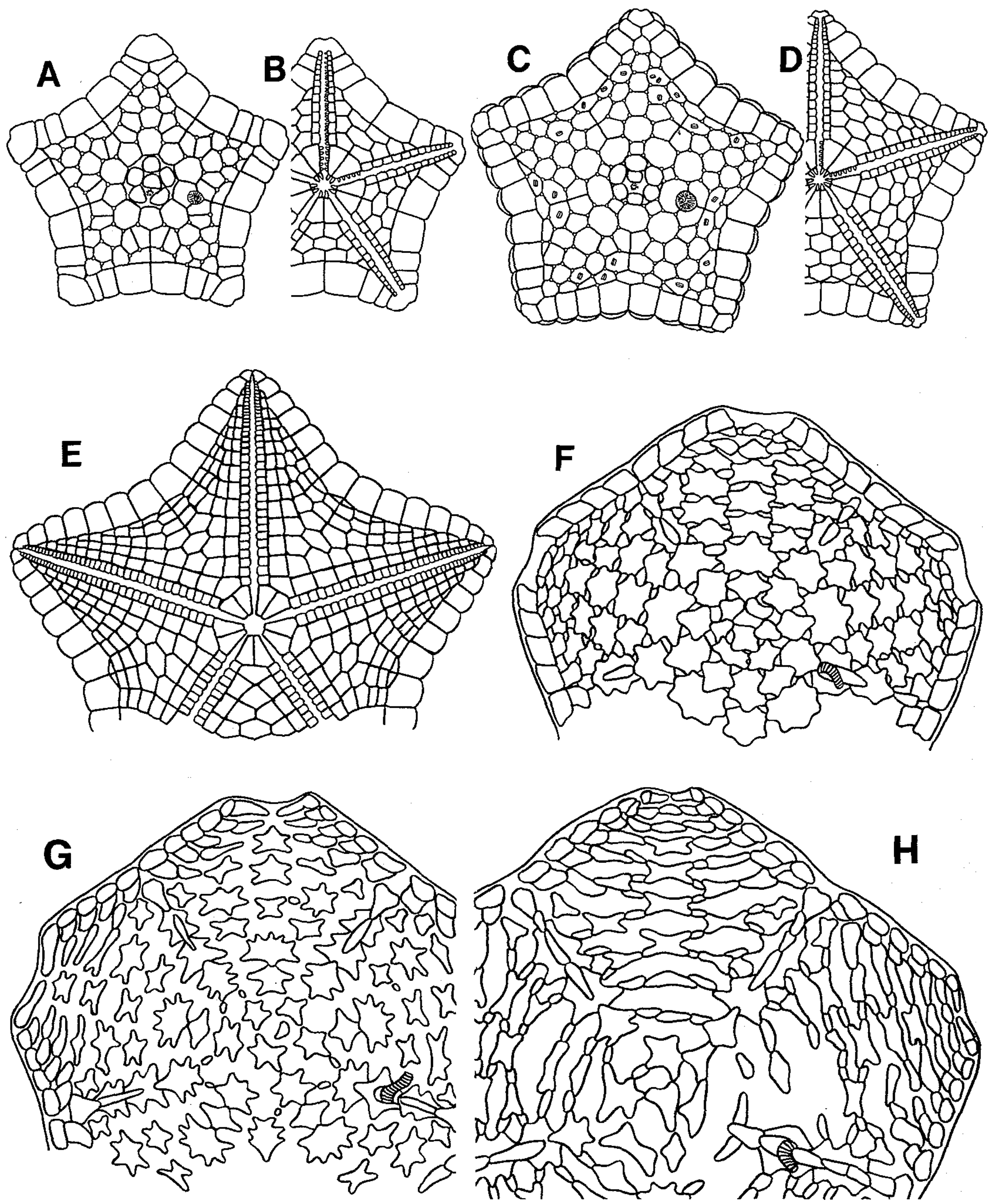

Fig. 2. Architecture of the skeletal plates of Culcita novaeguineae in different size. A,B: R=3.4 mm; A, abactinal; B, actinal. C,D: R=7.4 mm; C, abactinal; D, actinal. E: R=29.6 mm; actinal. F: R=46.5 mm; abactinal, viewed from the coelomic side. G: R=69.5 mm; abactinal, viewed from the coelomic side. H: R=93.3 mm; abactinal, viewed from the coelomic side.

30, respectively. Actually, the majority of specimens having 15-60 mm in R bear only 6 superomarginal plates. Thus no increase in the number of the superomarginal plates occurred during the growth in this term. Contrary to the situation in the superomarginal plates, numbers of the adambulacral plates increased linearly. A specimen with 46 mm in R bear 6 superomarginal plates and 40 adambulacral plates.

The abactinal plates tend to be stellate or polyarmed stellate in individuals reached 30 mm in R. Furthermore, the skeletal construction in the abactinal wall becomes loosen as some plates are placed with spaces (Fig. 2E). On the other hand, the plates are tightly arranged in the abactinal body wall.

Although increase of numbers of the plates is not necessarily parallel to the increase of size, difference in the increase of plate number may reflect in general differences in the growth. As shown above, increase of the marginal length is less than that of the arm length. Resultant change of the outline of the individual is a change from inwardly arched interbrachial edge to a straight one. Eventually, this causes a change of body contour from a stellate form to a pentagonal form.

In fact, when the sea stars reach 45 mm in R, the outline becomes subpentagonal with round tipped corners. In these individuals, abactinal plates, which are embedded in the thick connective tissue membrane, are mostly separated with each other (Fig. 2F,G). Independency of the abactinal skeletal plates makes to the abactinal wall to be flexible. In fact, C. novaeguineae larger than 50 mm in R have an inflated abactinal surface.

One individual having 93.5 mm in R bears 9 superomarginal plates and 55 adambulacral plates (Fig. 1). Abactinal skeleton comprises elliptic or elongated oblong plates. Although sometimes small plates are interconnecting the large plates (Fig. 2H), flexibility of the adambulacral wall seems to be retained as in the middle-sized (R=50-70 mm) individuals.

In the present study, change in the number of the superomarginal plates and adambulacral plates are followed during growth. Although it does not explain exclusively how C. novaeguineae takes a cushion-form, the present results show a morphological background of the peculiar form of this species. In addition, loose skeletal architecture due to independent abactinal plates in larger individuals lends to take a cushion form of this species.

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