# ECOLOGICAL STUDIES ON THE MORPHOLOGICAL VARIATION OF A SESSILE BARNACLE, CHTHAMALUS CHALLENGERI III. VARIATION OF THE SHELL SHAPE AND OF THE INNER ANATOMICAL FEATURE INTRODUCED BY THE POPULATION DENSITY

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# ECOLOGICAL STUDIES ON THE MORPHOLOGICAL VARIATION OF A SESSILE BARNACLE, *CHTHAMALUS CHALLENGERI* III. VARIATION OF THE SHELL SHAPE AND OF THE INNER ANATOMICAL FEATURE INTRODUCED BY THE POPULATION DENSITY[1,2]

By

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## INTRODUCTION

Concerning the variation of the external appearance of the sessile barnacle, there have been published numerous works by many authors (Neu 1935, Utinomi 1955, Barnes and Powell 1950 etc.) and the present writers have investigated on the external feature of a sessile barnacle, *Chthamalus challengeri* from the viewpoint of the population ecology (Katô et al. 1960).

But the morphological change of the inner anatomical feature had been scarcely studied in relation to the above mentioned variation of the external appearance.

In the present paper, the relation between the external appearance of the shell of *Chthamalus challengeri* and the anatomical feature of the body in the shell was investigated.

## MATERIAL AND METHOD

In the neighbourhood of the Marine Biological Station of Asamushi in Aomori Prefecture, various clusters consisting of fairly large number of *Chthamalus challengeri* having respectively different population density were obtained from the inter-tidal rock surface.

The individuals thus obtained were decalcified and thereafter the celloidin and paraffin methods were used for preparation of the microscopical observation which were also applied to the naked body.

For the statistical treatments the following measurable characters were chosen (Fig. 1).

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1) This paper is dedicated to Professor Tadao Jimbo for his 63rd birthday.

2) Contributions from the Marine Biological Station of Asamushi, Aomori Ken, No. 260.

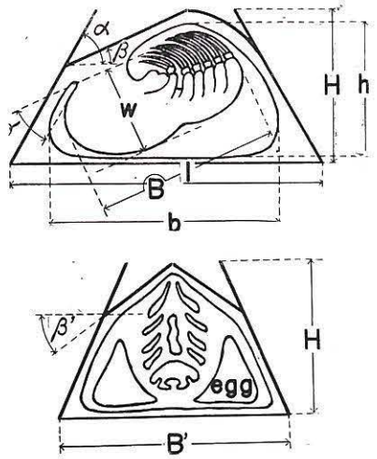


Fig. 1. Schemata showing the internal feature of *Chthamalus challengeri*.

Shell height (H), breadth and length of the shell base (B and B'), depth and length of the mantle cavity (h and b), length and thickness of the body (l and w), inclination degrees of rost. um ($\alpha$) and scutum ($\beta$) in the longitudinal section of the shell, inclination degree of scutum ($\beta'$) in the cross section at about the anal portion of the body, inclination degree of the body ($\gamma$) to the shell valve to which the body attaches.

## RESULTS AND DISCUSSIONS

I. *The Modification of the Morphological Feature of the Body and of the Arrangement of Various Inner Organs introduced by the Population Density.*

(1) The solitary barnacle (Figs. 2, 3 and 4).

The solitary barnacles which are conical in the external appearance were

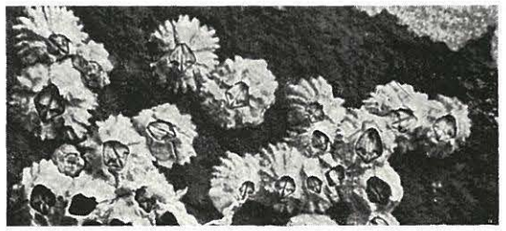

Fig. 2. Sparsely distributed conical barnacles.

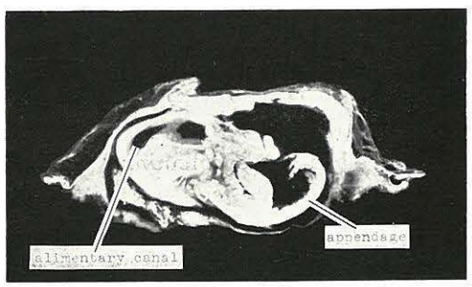


Fig. 3. The longitudinal section of a solitary barnacle.



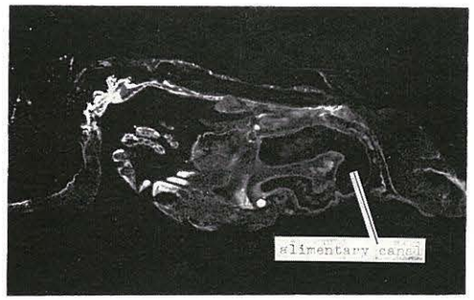


Fig. 4. The longitudinal section of a conical barnacle (paraffin section).

obtained from the sparsely distributed population (Fig. 2).

As is obviously shown in the longitudinal section of the shell (Fig. 3), the body occupies the greater part of the mantle cavity and lies nearly horizontally in it. The scutum of the opercular valves is also nearly horizontal. In Fig. 4 it is shown that the turning of the alimentary canal is rather simple.

(2) Barnacle which is loosely in contact with only one or two other individuals.

In Fig. 5 two barnacles adjacent is shown, one is a longitudinal section at about the median line of the body and the other is crossed at the anterior part of the body.

The shell height becomes a little high and the inclination of rostrum is strengthened and thus the scutum and also the body axis become somewhat inclined.

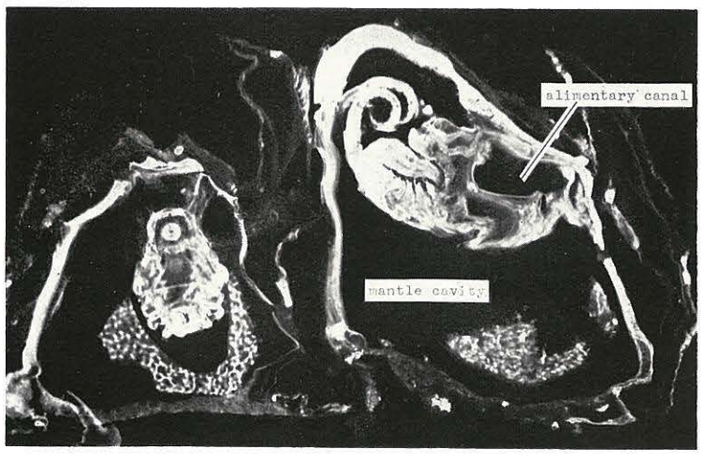


Fig. 5. Two barnacles, one is sectioned longitudinally and the other cross sectioned.

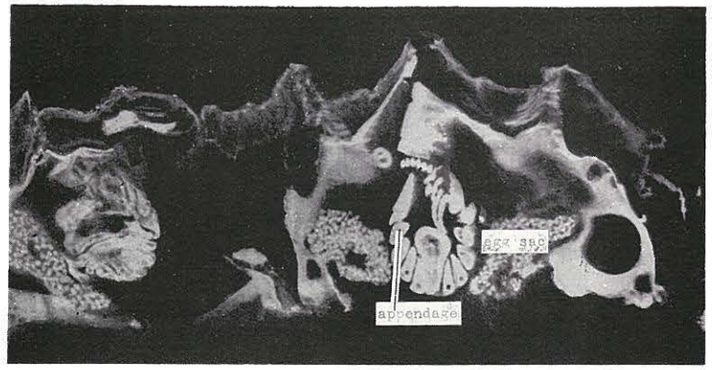


Fig. 6. The cross-sections of barnacles obtained from the rather thinly distributed population as compared with those in Fig. 5.

Fig. 6 shows the cross section at about the pharyngeal portion of an individual which was obtained from the rather thinly distributed population as compared with the above individuals, and it is noted that the egg sacs are situated at the lateral sides of the body.

(3) Barnacles which are closely in contact with each other (Figs. 7, 8 and 9). The shell is remarkably high and cylindrical in form and the lateral valves are nearly perpendicular

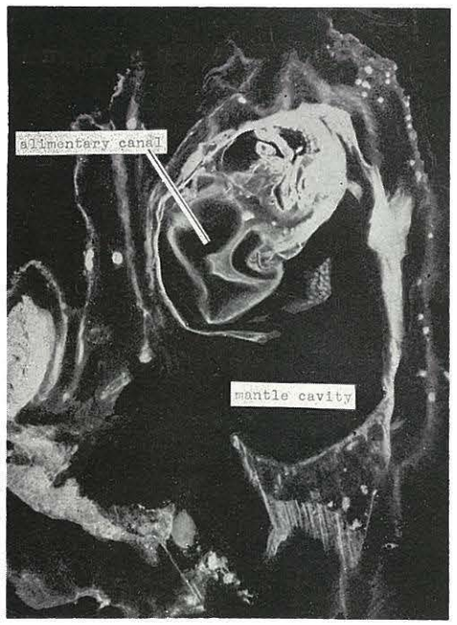


Fig. 7. The longitudinal section of barnacle obtained from the densely distributed population.

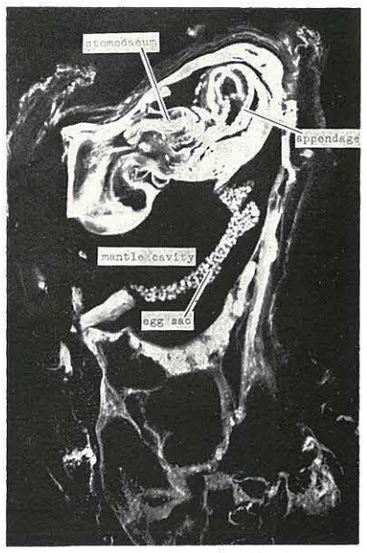


Fig. 8. The longitudinal section of densely populated barnacle.



(Fig. 7), occasionally the lower part of the cylindrical shell is rather narrow as compared with the width of the upper opercular portion (Fig. 8). Together with this phenonemon the inclination degree of the scutum becomes increased. The mantle cavity becomes also narrow and cylindrical in parallel with the elongation of the shell, but as the shell is superior to the mantle cavity in elongation, the latter occupies only the upper portion of the cylindrical shell cavity (Fig. 9). Owing to the stress of the elongated mantle cavity, the body axis tends to increase its inclination degree.

It must be noticed that the body occupies only the upper portion of the elongated mantle cavity and the alimentary canal tends to undulate and moreover is bent strongly at the attaching portion of the body to the shell, and with the elongation of the mantle cavity the egg sacs move downwards to the lower part of the cavity.

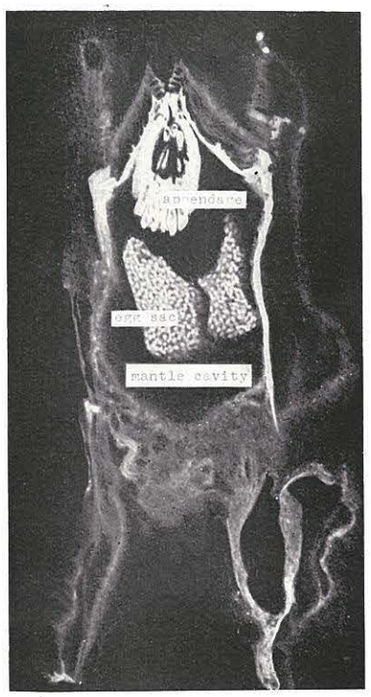


Fig. 9. The cross-section of barnacle obtained from the densely distributed population.

II. *The Statistical Treatment of the Modification of the Anatomical Features of the Barnacle introduced by the Population Density.*

Concerning the relation between the modification of the shell and the arrangement of various inner organs, further investigation was done from the statistical view-point (Fig. 10).

As it was ascertained in the previous paper (Katô et al. 1960) that the antagonistic relation is recognized between the shell height and the size of the shell base, the value of H/B or H/B′ was used as an index of the shell shape or of the population density.

(1). Changes in the shape of the mantle cavity (h/b) and the rate of body length to the width of the mantle cavity (l/b) are parallel with the elongation of the shell (H/B), namely with the increasing of the population density, and these changing modes are similar to the inclination mode of the scutum ($\beta$).

From the above it is known that the mantle cavity elongates with the shell elongation and the inclination degree of the scutum also increases.

As the body increases relatively in its length as compared with the width of

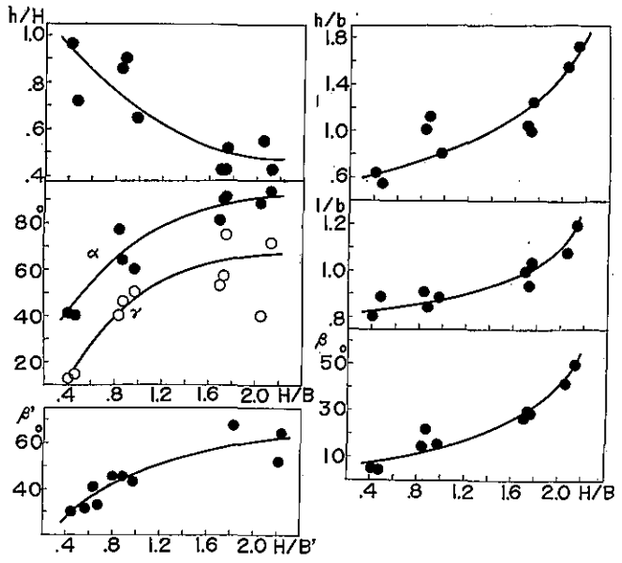


Fig. 10. The relations among the various dimensional characters of barnacles with special reference to the population density.

the mantle cavity, the body axis tends to incline.

It is noticeable that the increasing rate of these three values becomes larger with the increasing of the value of H/B, namely with the increasing of the population density.

(2). The rate of the depth of the mantle cavity to the shell height (h/H) decreases with the increasing of the shell elongation attaining to a limiting value. It is known from the above that the elongation of the mantle cavity is inferior to that of the shell.

Changes in the degree of the inclination of rostrum ($\alpha$), scutum ($\beta'$) and body axis ($\gamma$) are respectively similar in their modes. The value of $\gamma$ changing in parallel with the elongation of the shell seems to relate closely to the already mentioned inclination of the body axis and to the strong bending of the alimentary canal.

## CONCLUSION

From the above mentioned observations and the statistical treatments, the modification of the arrangement of inner organs of *Chthamalus challengeri* introduced by the population density is summarized as follows:

1. The conical shell attains a cylindrical form with the increasing of the population density.

2. Owing to the crowding of individuals the shell plates (lateralia) and



opercular plates (scuta) increase the inclination degree and therefore the mantle cavity becomes narrow in width and cylindrical in form accompanied with the elongation of the shell.

3. Thus the body situated horizontally in the mantle cavity changes to become inclined being pressed by the wall of the narrowed mantle cavity. Moreover the alimentary canal becomes undulated and bends strongly at the portion where the body attaches to the shell.

4. Corresponding to the elongation of the mantle cavity, the body situates in the upper portion of the said cavity and the egg sacs which are at the lateral sides of body in a conical shell move downwards to the base of the mantle cavity.

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