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著者	Kato Mutsuo, Hayasaka Kazuko, Matsuda Tatsuro
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ECOLOGICAL STUDIES ON THE MORPHOLOGICAL VARIATION OF A SESSILE BARNACLE, *CHTHAMALUS CHALLENGERI*[1,2]

By

Mutsuo Katô, Kazuko Hayasaka and Tatsurô Matsuda
加藤陸奥雄・早坂和子・松田達郎
Biological Institute, Tôhoku University, Sendai, Japan

(With two figures)

Concerning the variation of the external appearance of the sessile barnacle, there have been published numerous works by many authors (Trusheim 1932, Neu 1935, Hiro 1938, Utinomi 1943, Barnes and Powell 1950 etc.) and from them it is known that the ordinary barnacle has a conical form and that the cylindrical or trumpet-shaped shells are found in a densely aggregated population. However, there are but few studies from the viewpoint of population ecology with relation to the said morphological variation.

In the neighbourhood of the Asamushi Marine Biological Station, a sessile barnacle, *Chthamalus challengeri* is found commonly throughout the tidal zone. The present barnacle distributes rather thinly in the supra-tidal zone and its population is dense at the high tide level. The distributing zone extends downwards as far as the low tide level, where the density is very thin.

At the upper part of the said *Chthamalus* zone, there are many solitary old and large shells and their age distribution is generally homogeneous. But the solitary and conical ones become eliminated downwards and each individual comes into contact with each other to show a cylindrical shape, while in the lowermost part the solitary ones appear again and here almost all of the barnacles are small being young and conical in shape.

I. To investigate the morphological variation, fully grown specimens were collected from the middle part of the distributing zone.

Attention was given to collect the materials from different portions having various density of population and the dimensional characters were measured.

Here, five characters were selected, namely length and breadth of the opercular portion and of the shell base and the shell height.

From the measurements of the said characters, the following expression was obtained concerning the change of shell shape in relation to the population density.

1) Contributions from the Marine Biological Station of Asamushi, Aomori Ken, No. 255.
2) Details of this work will be reported in another occasion in the present Bulletin.

$$\log H + k \log B = K$$

Here, H is the shell height, B is the size of shell base (length × breadth) and k and K are constants.

The constant k may be considered as "index of morphological heterogeneity" of the constituents of the barnacle population, and if the value of k is small, the given population should consist of individuals having rather similar shell shape and if k has large value, it may be known that the constituent individuals are very variable in shape having conical or cylindrical shells.

On the other hand the constant k may be also considered as "index of denseness or sparseness" of the population, because the morphological variation of the shell or the heterogeneity of the shell shape in a given population is due to the density of that population.

It seems to be noteworthy that by "heterogeneity index" or "denseness-sparseness index" the constitutional characters of a given population may be defined.

II. As is already mentioned the population density and the age distribution are not similar throughout the whole area of the distributing zone.

Using the above index, the population dynamics of the barnacles ranging from the supra-tidal portion to the sub-tidal portion was studied.

In this study the population dynamics relating to the shell growth, population density and the distributing strata were studied. From upper to the lower parts of the distributing zone, Station A, B, C, D and E were set, here St. E is at the lower tide mark and St. A is in the supra-tidal zone.

(1) The second year stage of the barnacle. The population density was represented by the number of individuals in contact with the measured shell and is named as "contact-density".

The so-called contact-density is the highest in St. C and lowest in St. A, and judging from the frequency distribution of the contact-density it is found that the shell distributes rather uniformly and densely in Sts. C and E, but heterogeneously and thinly in St. A, where the heterogeneity index is 0.42, while it is low in St. C or E.

Judging from the fact that the size of shell base is generally larger in St. A than C or E and the relation in the case of the shell height is the reverse, it is recognized that the modification of shell shape and size introduced by the density occurs uniformly and strongly in Sts. C and E, but heterogeneously and weakly in St. A.

(2) The fourth year stage of the barnacle. The contact-density is not different statistically from the second year stage. In St. E the mortality of young animals is very high and thus no fourth year stage barnacle appears.

The heterogeneity index is larger than in the second year stage in both of Sts. A and C, and especially in St. A.

It is very interesting that, though the contact-density in Sts. A and C is similar to that in the second year stage, the heterogeneity index increases distinctly.

It may be said that this phenomenon is caused by the increasing of the inter-relation among individual shells with the advance of age, namely with the growth of shells, and therefore the modification of shell size and shape is strengthened in the densely colonized portion of the examined population, while is not so strong in other portions.

(3) The sixth year stage of the barnacle (Fig. 1). The contact-density is not still significantly different from the former second or fourth year old stages. But it is recognized remarkably that the heterogeneity index is very large in St. A, while it becomes small in St. C. The present fact may happened from the following phenomenon. Namely, in the colonized portion of St. A the individual growth is influenced markedly by the contact of other shell, but in the sparsely sessiled protion the individual barnacles grow typically being independent of other individuals. On the contrary, in St. C, as the initial population density is fairly high comparing with St. A, the division of densely distributed portion and sparsely populated protion becomes eliminated with the progress of individual growth, and the result may be that all of the individuals become to grow under similar inter-relationship and therefore the population consisting of equally grown individuals should be formed.

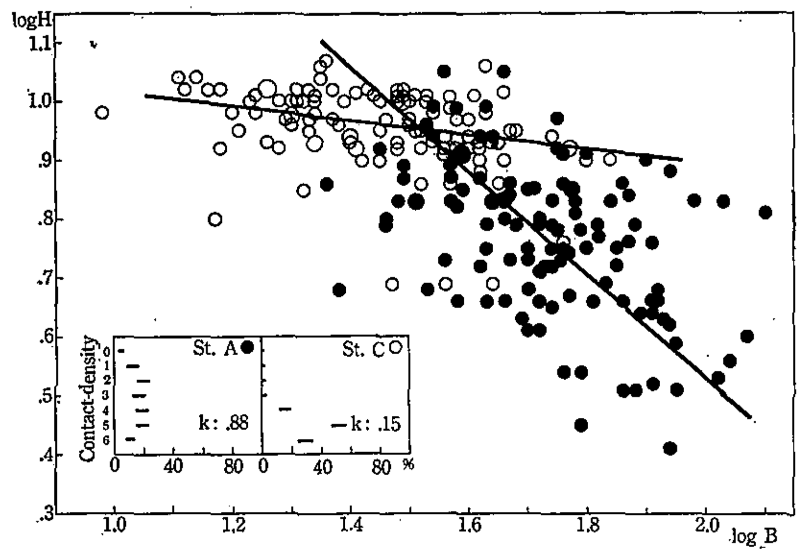


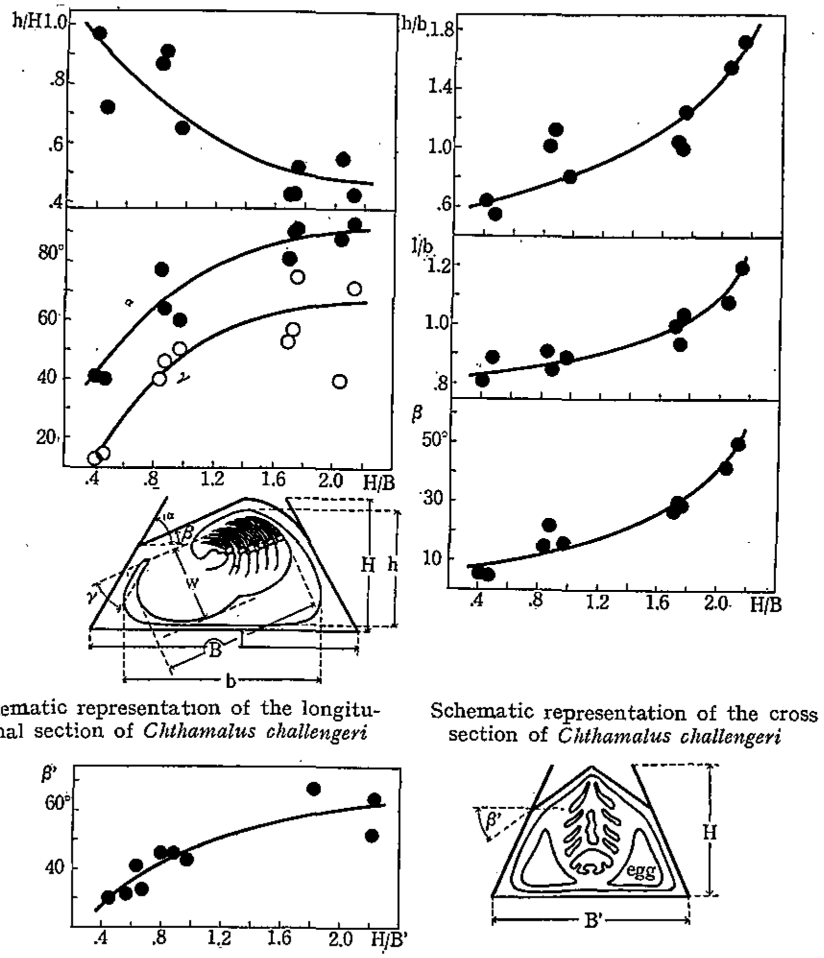
Fig. 1.

From the above, the following conclusion may be given concerning the morphological variation.

The fact that the characteristic appearance of *Chthamalus* shell size and shape found in each stratum of the distributed zone should be introduced by the character of the initially sessiled population density, the degree of mortality during the course of the shell growth and the dynamics of interrelation among the individuals in contact with each other.

III. It may be of interest that there is a relation between the said modification of shell appearance and the arrangement of the various inner organs.

Concerning this problem statistical treatment was also done and the dimensional characters were measured with the results shown in Fig. 2.



Schematic representation of the longitudinal section of *Chthamalus challengeri*

Schematic representation of the cross section of *Chthamalus challengeri*

Fig. 2.

Namely the degree of inclination of lateralia (α) and scutum (β and β') of the shell plates and of body axis (γ) increase with the increase of the population density, that is, the increase of the value of H/B, but here the increasing mode of β differs from the others.

Changes in the shape of the mantle cavity (h/b) and the rate of body length to the width of mantle cavity (l/b) are parallel with the elongation of the shell (H/B) and these changing modes are similar to β.

The rate of the height of mantle cavity to the shell height markedly decreases with the elongation of the shell (H/B).

From the above the following conclusion was reached:

The shell shape attains a cylindrical form with the increasing of the population density, in other words the shell plates (lateralia) and opercular plates (scuta) increase the inclination degree and therefore the mantle cavity becomes narrow in width and to take a cylindrical form accompanied with the elongation of the shell height. Thus the body axis situated horizontally in the base of the mantle cavity changes to become inclined being pressed by the wall of the narrowed mantle cavity.

Corresponding to the elongation of the mantle cavity, the body becomes situated 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.