THE BREEDING AND SETTLEMENT OF CHTHAMALUS CHALLENGERI HOEK AT ASAMUSHI DURING 1967

著者	PENELOPE A. LUCKENS
journal or publication title	The bulletin of the Marine Biological Station of Asamushi, Tohoku University
volume	13
number	2
page range	75-82
year	1968-03-29
URL	http://hdl.handle.net/10097/00131318

BULLETIN OF THE MARINE BIOLOGICAL STATION OF ASAMUSHI
VOL. XIII, NO. 2, 1968

THE BREEDING AND SETTLEMENT OF *CHTHAMALUS CHALLENGERI* HOEK AT ASAMUSHI DURING 1967[1)]

By

PENELOPE A. LUCKENS

Biological Institute, Tôhoku University, Sendai, Japan

At Asamushi the dominant barnacle of the intertidal zone is *Chthamalus challengeri* Hoek which extends from above high tide mark down to the low tide mark. It occurs from the most sheltered to the most exposed areas of rocky shore (Hoshiai 1965) and also on small rocks and boulders. In general, with increasing exposure the level of the *Chthamalus* zone is raised, and its vertical extent increased. Besides being abundant on rocks it is also found on *Mytilus* shells (though its abundance there varies seasonally and with the age groups of *Mytilus* present) and on other bivalve and gastropod shells. The geographical and ecological distribution of *C. challengeri* has been discussed by Utinomi (1955).

Kato, Hayasaka and Matsuda (1960) published three papers on the morphological variation of *C. challengeri*, but although Hirai (1963) gives its breeding season as May and June, there appear to be no other published papers on its breeding at Asamushi.

BREEDING AT TWO LEVELS ON AN EXPOSED SHORE AT HADAKAJIMA

The area from which the samples were taken was at the northwest side of Hadakajima, and corresponded to that labelled E by Hoshiai (1965). Here the top of the *Mytilus* zone is just above, and the top of the *Chthamalus* zone approximately one metre above mean highest higher high water level. The upper sample was taken from a level roughly midway between the top of the *Mytilus* and *Chthamalus* zones, while the lower sample was from the upper 50 cm of the *Mytilus* zone. Samples of 100 or more barnacles more than six months old were taken weekly from March to October, and sporadically prior to March. High level samples contained specimens from the first year class to at least the sixth year class, but low level samples were mainly less than two years old. Because of largescale removal of mussels from the shore, barnacles older than two years are virtually absent from the *Mytilus* zone, except on occasional rock outcrops. All the low level samples were from *Mytilus* shells.

1) Contributions from the marine Biological Station of Asamushi, Aomori Ken, No. 351

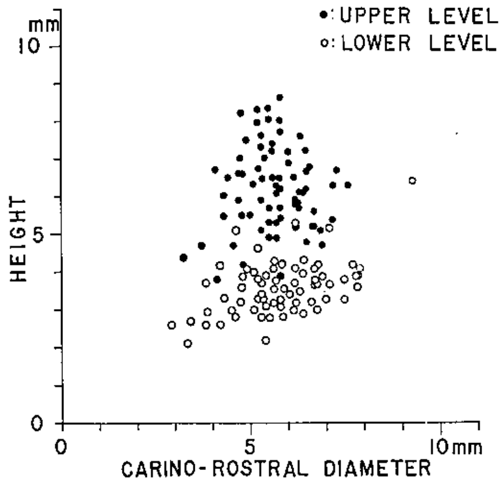

Fig. 1. The relation between height and basal carino-rostral diameter of *C. challengeri* at the two levels sampled.

Barnacles from these two levels were not of equivalent ages or sizes (fig. 1) and it was impracticable to take adequate samples of either equal size or age at both levels at weekly intervals throughout the breeding season. With the exception of those barnacles less than six months old, gonad condition appeared to be related to level rather than size. A comparison of large and small specimens from the upper level with the uniformly young specimens from the lower level showed that when the total samples differed markedly from one another, subsampling of the upper sample with respect to size, resulted in two similar samples both differing from the lower sample.

In barnacles eggs develop in the ovary, are shed into the mantle cavity where fertilisation and development occur, and are released into the sea as nauplii. The barnacles were examined under a binocular microscope and classified into the following stages. —

1. Ovary clear or granular, eggs absent.
2. Eggs in ovary.
3. Immature embryos in mantle cavity.
4. Eyed embryos.
5. Mature embryos capable of hatching if immersed in seawater.

Barnacles with mature embryos in the mantle cavity often also contained eggs of the next brood in the ovary at the same time, but were classified as stage five.

Figure 2 shows the results of samples from the two levels from November 1966 to November 1967, together with a few early samples from the highest level of the barnacle zone and from the lower half of the mussel zone. Mature larvae first appeared at the beginning of April and the end of March at the upper and lower levels respectively, and were last noted in October at both levels. The

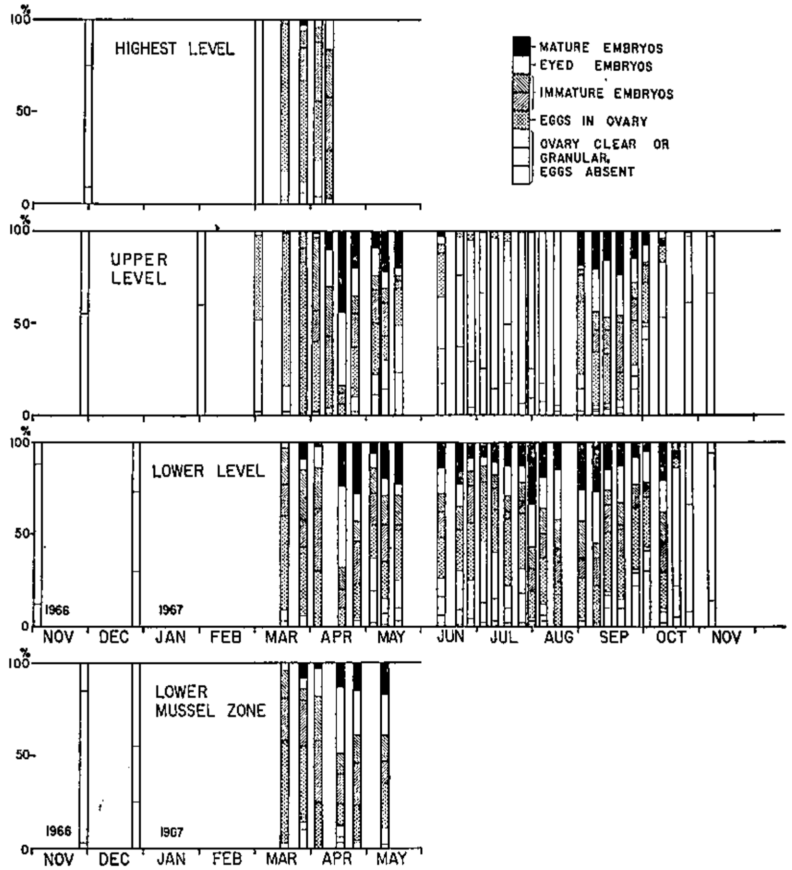

Fig. 2. Samples of *C. challengeri* from the two sampled levels at Hadakjima during 1967, together with early samples from the highest and lowest levels, showing the percentage at each breeding stage.

breeding season of the upper level was distinctly divided into two phases, one from April to early June, and the other from late August to early October. Between these two periods larvae were scarce and mature larvae absent from the samples. The lower level samples from late March to October all contained mature larvae.

Originally it was intended to take samples at four levels throughout the breeding season. Since *C. challengeri* is assumed to be a cross-fertilising species, samples must be of contiguous individuals. At the highest levels, the population becomes split into small groups often occupying crevices or drainage channels. These differ in aspect and the length of time that the barnacles are able to feed. Early samples showed that subsamples taken at the same level and within a metre of one another tended to be fairly consistent within a subsample from one isolated patch, but the subsamples differed greatly from one another. Since the number of barnacles in this upper fringe is comparatively small, and since, because of subsample variation, large samples would have been necessary to give valid results, sampling was discontinued at this level.

Barnacles from the lower half of the mussel zone were also sampled initially, but during the low tides in spring almost all of the lower mussel zone was removed for food, leaving only patches of mussels which were too small to bear barnacles. At this level barnacles are effectively absent from the rock surface, and for at least part of the year the mussel cover is almost 100% and many be several layers deep.

Results from the lower mussel zone from March to May were comparable with those from the upper half. With occasional exceptions, the samples taken in February and March of the uppermost barnacles were comparable with the samples from the upper level.

In general, at lower levels of the shore growth is more rapid, life spans are shorter and reproduction occurs earlier than at higher levels. While this is generally related to length of submergence, this is not the only factor involved. Such trends were demonstrated in *Balanus balanodies* (Moore 1935). Almost all of the lower samples of *C. challengeri* had settled either one or two summers previously and most if not all of these appeared to produce larvae. In no sample did all of the barnacles contain larvae, although one sample from the upper level in April and from the lower level in August showed all barnacles with either larvae, or eggs in the ovary.

The number of larvae produced is related to the size of the barnacle, and hence to age. This is complicated by the effects of crowding. Crowded barnacles of one level may be smaller than younger barnacles at a lower level, or less crowded ones at the same level. The effects of crowding and shore level on size and shape have been studied by Kato et al (1960). in *C. challengeri*. They showed that the growth form is characteristic of each level on the shore and is related to initial density and mortality at each level. There is an inverse logarithmic relation between shell height and shell base diameter.

There was no evidence of older individuals failing to produce larvae at any of the sampled levels as in *B. balanoides*. At both levels the barnacles spawned at least twice-probably three times at the lower level. Growth in shell size continues as either increase in height or basal size at all levels (Kato et al), and it is assumed that at least over the first few years larval production also increases. At lower levels the barnacles live for only one or two years, but produce larvae the summer after settlement, and spawn more often each season than at higher levels.

SETTLEMENT

Previous records of *C. challengeri* settlement at Asamushi are those of Hoshiai (1965) obtained during a study of the reformation of intertidal zonation after denduation of the rock surface. Areas of rock were denduded at several places near Asamushi including Hadakajima and Futagohana, as well as at Matsushima. All recorded settlements at Asamushi were in May, and occurred in 1959, 1960, 1961 and 1963. Settlement was also recorded at Matsushima in May 1957. Hoshiai reported settlement of *C. challengeri* both on areas cleared within a month prior to settlement and also on rocks cleared up to ten months previously.

Samples of embryos taken at Hadakajima in 1967 first contained mature larvae capable of hatching, in late March. From this it was expected that the first settlements would probably occur in April. Consequently a close watch was maintained over both cleared areas and undisturbed parts of the shore until May 20th. No settlement was observed. Observations on the ninth of June showed that a very light settlement had occurred a few days previously, but the maximum densities of newly-settled barnacles were less than $0.1/cm^2$. By the eighth of July the maximum density had reached $10/cm^2$ on the lowest rocks and mussels. In the central part of the barnacle zone densities were still less than $1/cm^2$. Further and better settlements occurred in August and September, and these again showed a gradient of decreasing density from low to high levels.

In contrast to the light settlements at Hadakajima, there were several heavy settlements of *C. challengeri* on the rocks forming the breakwater along the new bypass at Asamushi. Below Koyasan at the western end of the bypass a comparison of settlement on a mature natural rock reef with that on the newly-immersed rocks of the breakwater alongside showed that settlement was much heavier on the fresh surfaces. Settlement of *Mytilus edulis* was dense subtidally and in the lower part of the intertidal zone below the barnacles. *Ulva* was also abundant, but limpets were scarce, and the *Littorina brevicula* all less than five millimetres in diameter. By early august *C. challengeri* had settled over a band 80 cm deep, with both settlement density and carino-rostral diameter increasing from the upper limit down to just below the central portion (Table 1).

Density of newly-settled barnacles was most marked at the lower levels. Here on the mature surfaces barnacles other than freshly-settled ones, were effectively absent, and the freshly-settled specimens were denser than on the fresh surfaces. At the higher levels the presence of older barnacles on the mature surfaces limited settlement.

The effect of other organisms on barnacle settlement was well shown by a comparison of two sides of the same boulder. The shaded face had been abundantly settled by the bryozoan *Dakaria subovoidea* (previously known as *Watersipora cucullata*) whose colonies increased in diameter towards lower levels,

Table 1.
The percentage cover of *C. challengeri* (%CC) and *D. subovoidea* (%CD), and the settlement density (SD) and maximum basal carino-rostral diameter (CRD) of *C. challengeri* at ten centimetre intervals down three near-vertical rock faces at the Asamushi bypass.

	Mature reef surfacel							
	Highest level				owest level			
%CC SD/cm²	<10 0	10 < 1	70 < 1	80 < 5	80 < 5	70 10-20	40 10	40 10
	Sunny newly-immersed urface							
%CC SD/cm² CRDmm	<10 < 1 1.9	70 10-20 2.3	80 20-40 2.3	80 20-40 2.9	60 20-40 3.4	50 20-40 3.8	<10 < 5 4.0	<10 < 5 5.0
	Shaded newly-immersed surface							
%CC %CD		<10 30	<10 40	<10 60	<10 70	<10 80	<10 80	0 80

and below low tide level were often contiguous. There was also a general increase in the algal film, so that the rock surface was slippery to the touch. *Ulva* occurred intertidally here but was subtidaly only on the other sides of the boulder. On this shaded side the *C. challengeri* never reached 10% cover.

The occurrence on mature surfaces of a main barnacle zone with barnacles of several year classes, and a lower part where newly-settled specimens occur alone or predominantly, has been seen in several places and may usually be related to seasonal changes in the level of algae.

At Yasuizaki on the east coast of the Natsudomari peninsula a visit in March showed a barnacle zone whose lower limit was abruptly bounded by a dense band of algae. In that area algae were dominant sub- and low-tidally, and the *C. challengeri* restricted to a few exposed rock faces, and the tops of boulders. Barnacles of several age groups occurred down to the junction with the algae.

A further visit in August showed that the upper algae limit had dropped at least 30 cm and a band of rock free of algae had been settled by *C. challengeri* at densities up to 45/cm². It appeared that the algae, which had settled on barnacles of the previous summer's settlement had been killed by the increased emersion and insolation during the lower daytime low tides in spring leaving bare rock to be settled again by barnacles in the summer. Such a cyclic phenomenon is related to the covering phenomenon of Hoshiai (1961), but is less stable and is repeated annually. A similar cyclic succession resulting in a mosaic of patches each at different stages in the succession has been seen on New Zealand shores (Luckens 1964, 1966).

The death of the *C. challengeri* was at first assumed to be mainly caused by smothering by algal holdfasts. However, observations at Hadakajima showed that under a dense cover of *Chondria crassicaulis* few barnacles were actually smothered, but in spring, with the death of the upper parts of the alga the barnacles became dislodged. Numerous *Mitrella tenuis* gathered to feed on the dislodged and still-living barnacles washed down to lower levels.

Where the barnacle zone is bounded below by a mussel zone, the barnacles usually settle also on the mussel shells. If the mussels are removed, the barnacles will settle on the denuded surface. Such a situation often occurs where mussels are collected for food. At Hadakajima much of the mussel zone is removed in spring, and in summer the *C. challengeri* settle on any areas free of mussels as well as on the mussels themselves. Subsequent settlement and growth of the mussels usually results in overgrowth of the barnacles. This in itself does not automatically kill the barnacles. However, a layer - or several layers - of mussels usually results in some accumulation of silt and detritus, and subsequently in the appearance of various infaunal species including worms. Accumulations of silt, and deoxygenation can both kill the barnacles, and at least one species of the flatworms occurring here is a barnacle predator. Those barnacles settled on top of the mussels show that increased submergence alone is not lethal to *C. challengeri*.

The help so willingly given in innumerable ways by Professor M. Kato of the Biological Institute, Tohoku University, and by Professor E. Hirai and the staff of the Asamushi Marine Biological Station throughout the work is gratefully acknowledged. The work was completed during the tenure of a Mombusho Scholarship.

SUMMARY

1. Mature larvae of *C. challengeri* were present in the mantle cavity from March to October at Asamushi.

2. Low level barnacles appeared to breed continuously, but the upper level barnacles showed two distinct breeding periods, during a season.

3. Although previous records of settlement at Asamushi were all in May, settlement during 1967 was from late May or early June to September with a probable peak in August.

4. Settlement was denser and more frequent at lower levels.

5. Seasonal distribution changes of the distribution of mussels and algae resulted in alteration of the lower limit of the *C. challengeri*.

LITERATURE CITED

HIRAI, E., 1963. On the breeding seasons of invertebrates in the neighbourhood of the marine biological station of Asamushi Sci. Rep. Tohoku Univ. Biol. 29: 369–375.

HOSHIAI, T., 1961. Synecological study on intertidal communities IV. An ecological investigation of the zonation in Matsushima Bay concerning the so-called covering phenomenon. Bull. Mar. Bio. Stat. Asamushi 10: 203–211.

——— 1965. Ditto VI. A synecological study on the intertidal zonation of the Asamushi coastal area with special reference to its reformation. Ibid. 12: 93–126.

KATÔ, M., K. HAYASAKA & T. MATSUDA, 1960. Ecological studies on the morphological variation of a sessile barnacle *Chthamalus challengeri*. I Changes of the external appearance introduced by the population density. Ibid. 10: 1–7.

——— 1960. Ditto II Constitutional characters of the *Chthamalus* population with special reference to the stratification of the *Chthamalus* zone. Ibid. 10: 9–17.

——— 1960. Ditto III Variation of the shell shape and of the inner anatomical features introduced by the population density. Ibid. 10: 19–25.

LUCKENS, P.A., 1964. Settlement and succession on rocky shores at Auckland. M. Sc. Thesis. University of Auckland, New Zealand.

——— 1966. Competition and predation in shore zonation at Leigh. Ph. D. Thesis. University of Auckland, New Zealand.

MOORE, H.B., 1935. The biology of *Balanus balanoides*. III The soft parts. Journ. mar. biol. Assoc. 20: 263–277.

UTINOMI, H., 1955. Studies on the Cirripedia of Japan. II Geographical Distribution. Bull. Biogeograph. Soc. Japan, 16–19: 113–123.

——— 1955. Ditto III Ecological evidences. Ibid.: 124–134.