フサコケムシの群体成長に対する低塩分海水の影響

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The Effect of Low Salinity on the Early Growth of a Bryozoan *Bugula neritina* in the Sea and Laboratory*1,2

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Colonies attached to glass slides were suspended in the sea. They were also immersed in low salinity waters once for one or two hours or repeatedly for one, two or six hours once a day to examine the effects of salinity changes on growth. The effect was also examined with a culture method in beakers using water of various salinity (33.7, 31.0, 27.9, 24.1 and 18.1‰), with colonies on glass slides with *Rhodomonas* as food.

Exposure to fresh water for even a short time caused severe damage to the animal, but salinities higher than 9‰ were not injurious for their further growth. Colonies repeatedly exposed to seawater lower than 20‰ will not grow to be a mature colony. If the seawater has a salinity higher than 25‰ they might grow to a mature stage and in salinities higher than 30‰ they grow well.

Studies on the effect of various environmental factors on the growth of *Bugula neritina* colonies are important if this species is to be a useful indicator of some environmental factors in coastal and inlet waters. Such studies are also necessary to gain fundamental knowledge for the prevention of attachement of the colony as a fouling animal.

The effect of water temperature on the early growth of the animal on glass slides suspended in the sea was discussed in a previous paper.[1] SOULE *et al.*[2] studied the effect of environmental factors on the distribution of bryozoans in outer Los Anegels Habor. They showed that *B. neritina* was abundant in the waters of higher salinity than *B. californica,* but the range of salinity which the animal requires remains unknown.

We have established a method to culture the animal under laboratory conditions,[3] so the effect of individual components of environmental factors can be separately examined in laboratory. Here, we report on the effect of low salinity on the early growth of the colony in the sea and under laboratory conditions.

Materials and Method

Many larvae of *B. neritina* can be obtained and made to attach to glass slides by the methods described in the previous paper.[1] Such colonies attached to glass slides were used for experiments in the sea and under laboratory conditions.

In the Sea

Six glass slides, each with one or two attached larvae, were fitted on test-plate frames.[1] So the total number of attached larvae per test-plate frame ranged from six to 12. Sixteen test-plates put in plastic cages were suspended 1 m below the surface in the sea.

We examined the effect of low salinity on growth in two ways. On the sixth day from the start of suspension in the sea, six test-plates were immersed in 30 *l* tanks containing the low salinity water (18.1, 9.1 and 0‰) for either one or two h. The colonies had increased to about 10 in the mean zooid number by this time. After the period of immersion, they were returned to the sea, and suspended further for 10 days. One test-plate remained in the sea throughout the experiment as a control. The water temperature and salinity in the sea averaged 22.2°C and 32.9‰, respectively, throughout the experiment.

On the fifth day after the start of suspension in the sea, three test-plates were immersed in the tanks containing the test waters (33.7 as control, 23.7 and 18.5‰) for one h, and six test-plates were also immersed in the test water for two or six h. After the immersion, they were returned to the sea. Each immersion was repeated daily from the fifth to the 13th day except for the ninth day. The water temperature and salinity in the

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sea averaged 21.1°C and 33.7‰, respectively, throughout the experiment.

The first experiment was carried out in Omura Bay and the second was in Nomo Inlet near Nagasaki City.

Under Laboratory Conditions

We can culture *B. neritina,* with *Rhodomonas* sp. as food, in the laboratory as well as in the sea.[3] The colonies were cultured with *Rhodomonas* sp. at 10,000 cells/m*l* in a 1 *l* beaker containing 800 m*l* of filtered seawater of different levels of salinity (33.7, 31.0, 27.9, 24.1 and 18.1‰). *Rhodomonas* was grown at about 27‰ at 22±1°C. as a monoculture.[3]

Six days after the start of the culture, all the colonies in five beakers with five to 11 colonies on two glass slides were cultured in normal seawater of 33.7‰. Then, the salinity of the seawater in each beaker was periodically changed to the defined level (Fig. 5). These culture experiments were carried out at 19, 22 and 25°C.

In the experiments in the sea and under laboratory conditions, the zooid number of all colonies was counted every day or every few days. The intrinsic rate of the increase of the zooid number of the colony was calculated and tested for statistical significance with the student t-test.

Results

In the Sea

The growth of the colonies immersed in the low salinity waters for one or two h are shown with that of the control, 32.9‰ (Fig. 1). The colonies immersed in fresh water for one or two h were all dead just after immersion. In both experiments, the colonies decreased their growth rate just after immersion in 9.1‰ compared with that of the sea. Although the reduction in the growth rate by the two h immersion was more drastic than that for one h, both colonies recovered their growth rates by the 13th day (Fig. 1). The growth of the colonies immersed in 18.1‰ for one or two h showed no difference from that of the control.

The colonies immersed in the waters of 23.7 and 33.7‰ for one h exponentially increased the zooid number at the same rate (Fig. 2). On the other hand, the colonies immersed in 18.5‰ had a low intrinsic rate of growth from the fifth to the 13th day as compared with that of 33.7‰ ($p < 0.05$). The colonies immersed in 18.5 and 23.7‰

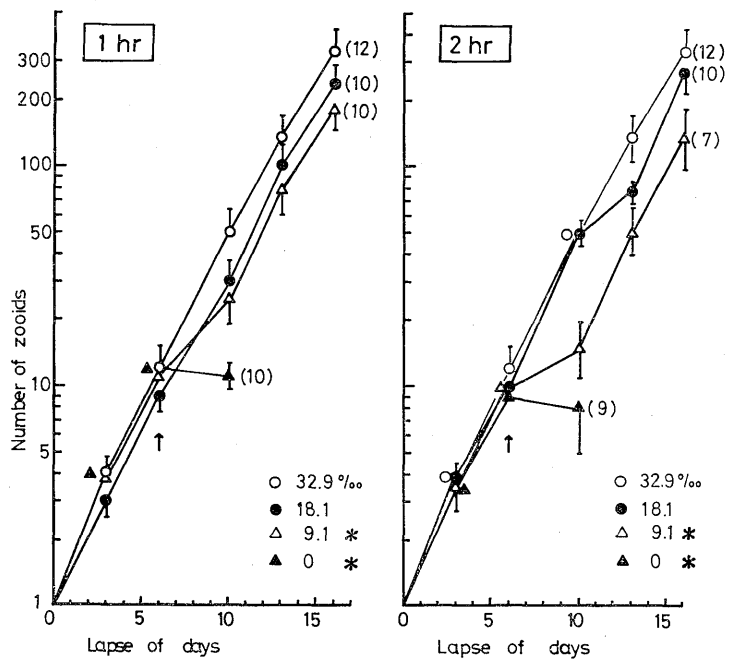

Fig. 1. Growth of *Bugula neritina* in the zooid number per colony immersed once in the water of various salinities for one or two h. The arrow indicates the immersion of the colonies. The number in parentheses and the bars indicate the number of colonies employed in each experiment and the standard deviation, respectively. *: The intrinsic rate of the increase of the zooid number per colony was significantly different from that of the control (32.9‰).

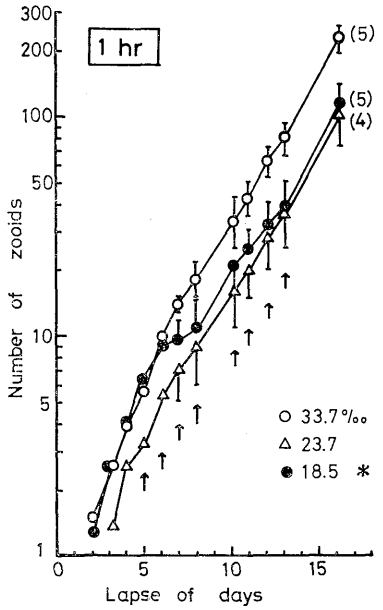

Fig. 2. Growth of *Bugula neritina* in the zooid number per colony immersed eight times in the water of various salinities for one h a day. The arrows indicate the immersion of the colonies. The number in parentheses and the bars indicate the number of colonies employed in each experiment and the standard deviation, respectively. *: The intrinsic rate was significantly different from that of the control 33.7‰).

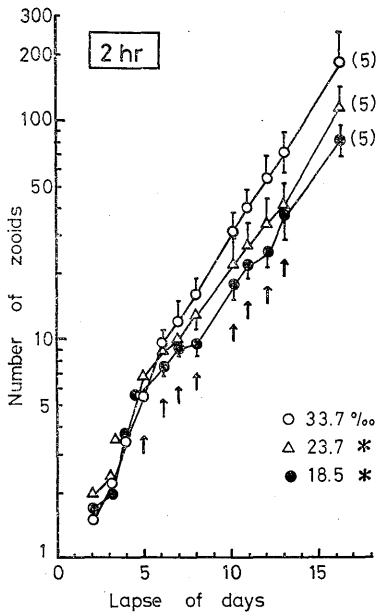

Fig. 3. Growth of *Bugula neritina* in the zooid number per colony immersed eight times for two h. Explanation of symbols is the same as in Fig. 2.

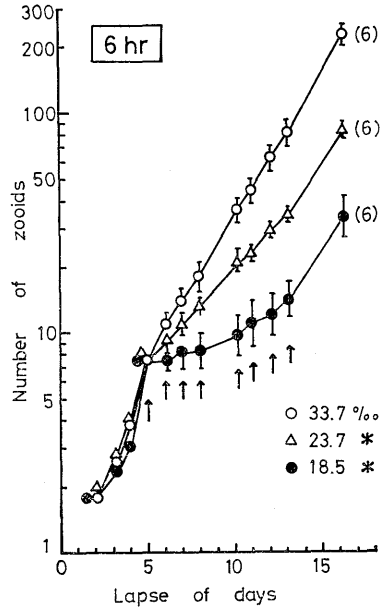

Fig. 4. Growth of *Bugula neritina* in the zooid number per colony immersed eight times for six h. Explanation of symbols is the same as in Fig. 2.

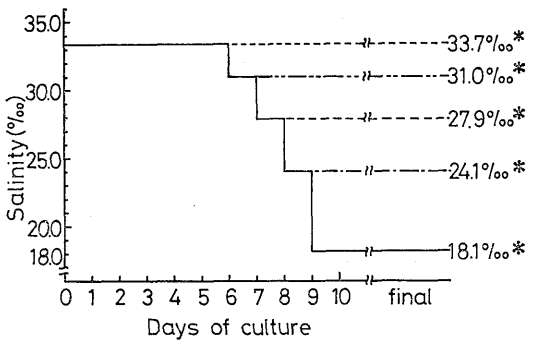

Fig. 5. Salinity change scheme of the laboratory culture. All colonies were cultured at 33.7‰ for six days and then transfered to less saline waters. Culture lasted 20, 19 and 13 days at temperatures of 19, 22 and 25°C, respectively. *: The final salinities of the culture water.

for two h had a significantly reduced growth rate during the period of the immersions as compared with that of 33.7‰ (Fig. 3). The colonies immersed in 23.7‰ for six h also decreased their growth rate. Although the growth rate in 18.5‰ was drastically reduced through the period of immersion, the colonies recovered their growth rates in the sea after the immersions (Fig. 4).

Under Laboratory Conditions

There was no difference in the growth rate be-

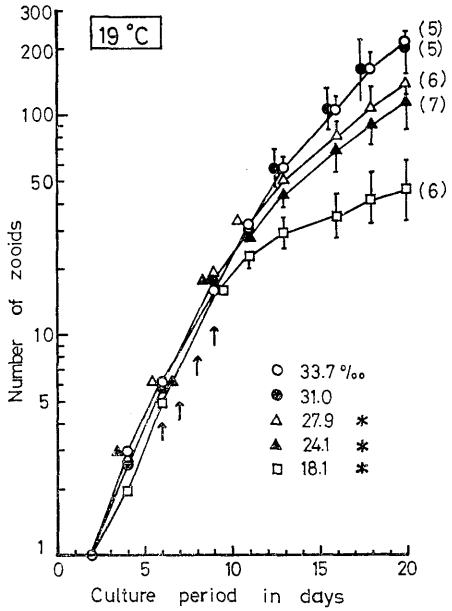

Fig. 6. Growth of *Bugula neritina* in the zooid number of colonies cultured in seawater of five different levels of salinity in a 1 *l* beaker at 19°C. The arrows indicate the changes in the salinity. The number in parentheses and the bars indicate the number of colonies and the standard deviation, respectively. *: The intrinsic rate nine of the first days was significantly different from that of the control (33.7‰).

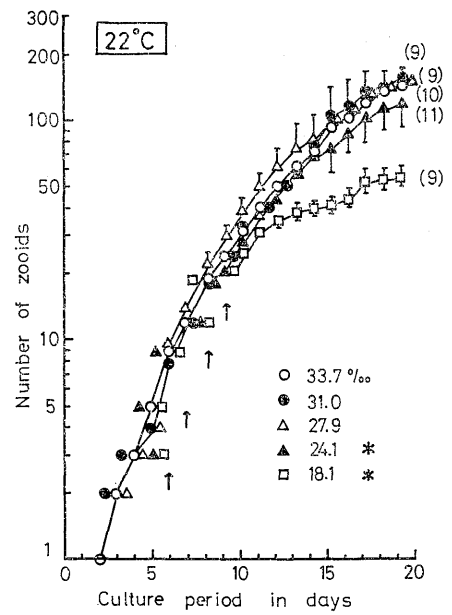

Fig. 7. Growth of *Bugula neritina* in the zooid number per colony cultured in seawater of five different levels of salinity at 22°C. The symbols are explained in Fig. 6.

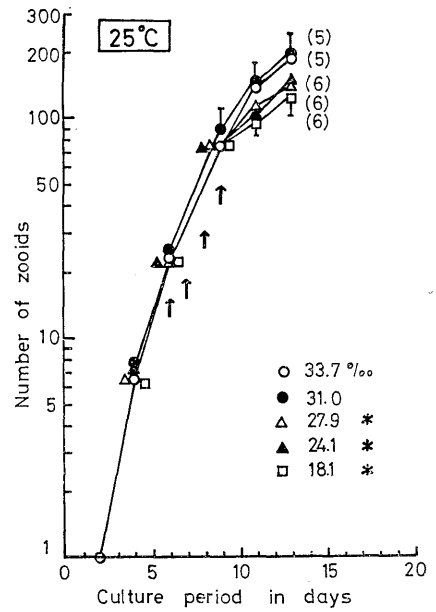

Fig. 8. Growth of *Bugula neritina* in the zooid number per colony cultured in seawater of five different levels of salinity at 25°C. The symbols are explained in Fig. 6.

tween the colonies cultured in 31.0 and 33.7‰ at 19°C (Fig. 6). The intrinsic growth rates of the colonies cultured in 27.9 and 24.1‰, were significantly lower than the control ($p<0.05$) in the last phase of culture. The colonies cultured in 18.1‰ had a greately reduced growth rate. Growth rates of the colonies at 22°C in 31.0 and 27.9‰ were almost the same as that of 33.7‰ (Fig. 7). But, there was a significant difference in the intrinsic growth rate between the colonies cultured in 33.7 and 24.1‰ ($p<0.05$) from the ninth to the 19th day. The growth rates of the colonies at 25°C in 31.0 and 33.7‰ were almost the same, but the intrinsic growth rates obtained, in 24.1, and 27.9‰, were significantly lower than that of the control (33.7‰, $p<0.05$) in the last phase (Fig. 8).

Discussion

B. neritina inhabits the coastal waters of temperate and tropical zones all over the world. The salinity of the water is one of the environmental factors that controls the distribution of the animal.[2,4] MAWATARI[5] pointed out that salinities lower than 18‰ were injurious and lower than 14‰ were almost always fatal to the larval life, but the effect of low salinity on colony growth was almost unknown.

In these experiments, the effect of low salinity on the early growth of the colony is examined. The experiments showed that the colony could not tolerate fresh water for even a short time (Fig. 1). Immersion in low salinity water of 9.1‰ for a period of one or two h resulted in temporary damage to the growth of the colony, but they could recover their growth rates soon after returning to the sea (Fig. 1). These results indicate that the lower limit of salinity for the colony to tolerate for a short time is less than 9‰.

The repeated immersions in low salinity water of 18.5‰ for six h a day drastically delayed the growth of the colony (Fig. 4). Although the colonies immersed in 18.5‰ for one or two h decreased their growth rate, they increased the zooid number almost exponentially (Figs. 2, 3). The colonies immersed in 23.7‰ showed exponential growth in the zooid number at slightly lower rates when compared with those in normal seawater (Figs. 2–4). KITAMURA and HIRAYAMA[6] reported that the life span of the colony in the sea was two to three months except in winter and did not exceed six months usually. They also reported that when the colony increased their zooid number to more than several thousands, the animal could release larvae to the sea. The results of the experiments suggest that if the colony was repeatedly exposed to the seawater of the salinity lower than 20‰ for several h a day, it might take a long time (more than three months) to become a mature colony of several thousand zooids, even in the summer season.

The colonies cultured in 18.1, 24.1 and 27.9‰ at 19°C decreased their growth rate compared with those of 31.0 and 33.7‰ (Fig. 6). Since the growth rate of the colony in 18.1‰ was very low, the colony might not grow to be sexually mature within six months. Although the colonies cultured in 24.1 and 27.9‰ had slightly decreased growth rates compared with that of 33.7‰, they might grow to the mature stage. The experiment showed that at salinities higher than 30‰, there were no harmful effects on the growth of the colony.

In the culture experiment at 22°C, the growth rates of the colonies in 18.1 and 24.1‰ differed from that of 33.7‰ (Fig. 7). However, there was no difference in the growth between the colonies in 27.9, 31.0 and 33.7‰. The intrinsic rate of increase of the zooid number from three to about 200 zooids in 33.7‰ (0.239) was low as compared with the rate (0.354) obtained in the previous study.[3] Since the culture of *Rhodomonas* was contaminated by large numbers of bacteria, we think that the reduction in the rate might be due to the difference in quality of the food.

From the results of these experiments in the sea and under laboratory conditions, we can summarize the effect of low salinity on the early growth of the colony. The exposure to fresh water, for even a short time, caused severe damage to the animal, but water of salinities higher than 9‰ is not injurious for their further growth. The colonies repeatedly exposed to seawater lower than 20‰ can not grow to maturity. If the seawater has a salinity higher than 25‰ they might be able to sexual maturity. In salinities higher than 30‰ they can grow well regardless of salinity differences.

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