COLONIZATION PATTERN OF HYDROZOA ON SEVERAL SPECIES OF SARGASSUM

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COLONIZATION PATTERN OF HYDROZOA ON SEVERAL SPECIES OF *SARGASSUM*

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Epiphytic Hydrozoa are very abundant on the thalli of large, spreading and shrub-like brown algae at Asamushi and its neighbourhood. One species may occupy the whole thallus, or several species coexist. These animals have similar modes of life and consequently interspecific relationships must be severe on thalli where more than two species coexist in the range of possible contact. Certain species have their own respective colonizing positions on the alga, while some of the Hydrozoa attach to the various parts of the thallus and are able to extend their colonies over the entire thallus.

Reporting on the distribution pattern of several species of epiphytic Hydrozoa on two species of *Sargassum*, Katô *et al.* (1961) suggested that the interspecific coaction among them resulted in the modification of the normal location of colonization and in a decrease in colony size or in the number of living polyps. They continued experimental work on the mechanisms of interaction by rearing two species together in a Petri dish (Katô *et al.*, 1962, 1963, 1964). It is obvious that when two species are kept in a closed universe and left till they come into contact with each other, some coaction does occur. It must be much more severe where the requirements of both forms are similar or overlap.

In the present paper the distribution pattern of the epiphytic Hydrozoa on several species of *Sargassum* will be dealt with to test the application of their results to the field condition.

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COLLECTING AREA AND METHOD

Several species of *Sargassum* were sampled at various localities near Asamushi. Ôura, located about 5 km southwest of Asamushi, is a sheltered baylet with a well

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developed *Zostera marina* belt where several species of Hydrozoa, among which *Clytia edwardsi* is dominant, and hydromedusae such as *Gonionemus oshoro* and *Cladonema uchidai* are abundant. Along the somewhat sheltered boulder beach where various species of algae are growing, *Sargassum confusum* and *Sargassum thunbergii* were sampled. Tsuchiya, a moderately exposed rocky shore, is the place where the major part of the field work on the epiphytic Hydrozoa has been done (Nishihira, 1965, etc.). At Tsuchiya *Sargassum hemiphyllum*, *Sargassum confusum*, *Sargassum tortile* and *Sargassum thunbergii* were examined. At Yunoshima islet about 1 km off the Marine Biological Station only *Sargassum confusum* was collected. Higashitaki, located on the opposite side of the Natsudomari Penninsula, has a rocky shore with luxuriant algal growth. There, *Sargassum confusum* and *Sargassum thunbergii* were sampled.

All of the algae examined are of more or less similar form. The short and somewhat stout stalk arises from the conical or filamentous holdfast and then divides into several main branches or ramifications which bear many small branches (and further smaller branches) with abundant laminae, air bladders and receptacles (in the fruiting seasons).

After the collection in the field, the colonization of the Hydrozoa was examined in the laboratory. The length of the branches were measured and the length about which the colony adhered was measured as the index of colony size. The measurement was done according to each 10 cm of the main branch from base to the distal part. The degree of colonization was expressed in percentage value for each stratum or level (100 × length of branches hydrorhiza adhered/total length of branches).

RESULTS AND DISCUSSION

1. *Distribution pattern of Coryne uchidai*

Several stumps of *Sargassum* spp. were colonized with *Coryne uchidai* with or without other species. These algae were collected from the localities aforementioned. The colony bearing thalli are usually those growing infralittorally. All algae collected were fully grown and in good condition for the observation.

When several species colonized one alga together each species occupied a rather definite part on the thallus. In the case shown in Fig. 1A, *Orthopyxis platycarpa* was the most abundant Hydrozoa, *Coryne* was next in abundance and *Sertularella miurensis* was rarest, each of which occupied respectively 30, 3 and 0.3 per cent of the thallus. *Orthopyxis* distributes over the whole stratum though the percentage of colonization increases towards the distal part of the alga. *Sertularella* is also more abundant on the distal half yet it tends to decrease where the former species is abundant. *Coryne*, the athecate hydroid, appears from the 60 cm level

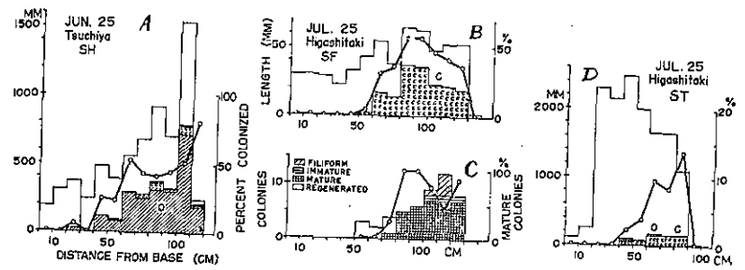

Fig. 1. Colonization pattern of several species of Hydrozoa on *Sargassum hemiphyllum* (A), *Sargassum confusum* (B, C) and *Sargassum thunbergii* (D). O: *Orthopyxis platycarpa*, C: *Coryne uchidai* and *M*: *Sertularella miurensis*.

upwards with heavy colonization at the distal part of the thallus.

Sertularella miurensis consists of small colonies, which suggests that the colonies are younger being ones soon after the settlement on the alga. Katô *et al.* (1961) observed the distribution of the species on the thallus of *Sargassum tortile*, where the nature of colonization and quantitative relation between *Orthopyxis* and *Sertularella* was inverse. The *Sertularella* zone was wide-spread over the whole stratum though the zone of *Orthopyxis* was restricted to the middle and distal part of the thallus.

Taking into consideration the fact that *Sargassum tortile* is the most preferable alga for the larval settlement of *Sertularella miurensis* and *Sargassum hemiphyllum* is most preferably colonized with *Orthopyxis platycarpa* (Nishihira, 1965, 1968c), the exchange of the attaching nature between both species may be acceptable. However, in that case the stratum of *Coryne* colonization was invariablly restricted to the distal half of the thallus. The colonization of the branches (namely ratio of the number of branches colonized to the total number of branches) is 60 per cent in *Orthopyxis*, 20 per cent in *Coryne* (at the level of 80 cm, about 70 per cent) and 4 per cent in *Sertularella miurensis*. The overlapping of the colonies on the branches were seldom seen, and this suggests the contradictory colonization.

Although it very rare, there were some algae supporting only *Coryne*. It must be important to examine these algae to consider the particular colonizing position of *Coryne uchidai*. *Sargassum confusum* growing infralittorally and *Sargassum thunbergii* growing in a shallower part but not emerging above water even at low tide, were examined at Higashitaki. In *Sargassum thunbergii* the attaching position of *Coryne* was not different from that on the two other species mentioned before, namely, it attached on the distal half of the thallus (Fig. 1D). Small colonies of *Orthopyxis* attached on the middle part of the thallus but it was negligible and no contact between both species was recognized. Also on *Sargassum confusum*, *Coryne* was restricted to the upper half of the thallus

even when no other species coexisted. At Higashitaki species other than *Coryne* were very few at the time of collection. Several thalli examined showed the same tendency in the colonization of *Coryne*. The representative one is shown in Fig. 1B. It colonized all strata from the 60 cm level upward. The ratio of the branches colonized was 100 per cent except at the uppermost stratum (where it was 50 per cent, but the branches there were very short) and thus it seems to colonize the whole length of the branches of the 60 cm level upward. Thus the colonization of the present species is restricted to the upper half of the thallus when it colonizes with or without other species.

It is possible to attribute the peculiar pattern of the present species to that the larval settlement occurs only on the upper part of the thallus or to that only those that settled on the upper part survive after random settling on the whole levels of the thallus. To know which is the case the age of the colonies was examined (Fig. 1C). The youngest colonies just after metamorphosis from the settled larvae have a particular kind of tentacles, namely the filliform tentacles (Kakinuma, 1960). Those colonies with filliform tentacles are seen in the upper part of the thallus with immature ones, while the mature colonies are more wide spread, and the regenerated old colonies are found on the middle part of the thallus, the lowermost portion of the distribution range. The facts seem to show that the larvae settle onto the upper half of the thallus and this seems responsible for the definite distribution pattern of the species. The larva of the present species is photopositive at least in the early phase of the swimming stage. The settling position seems to be decided by the behavior of the larvae. The larvae may swim up to the water surface and when they come into contact with the alga the swimming phase may be shortened. The following phase of crawling may result in the crawling on the alga and finally they may settle on the irregular surfaces such as buds and origin of branches, etc. (Nishihira, 1968b). The alga is bent horizontally at low tide and thus the upper half of the thalli is exposed to the strong illumination while the lower half is very dark especially in the *Sargassum* forest. In the dense forest the undergrowing algae were very poor according to the low intensity of illumination.

2. *Distribution pattern of Sertularella miurensis and Orthopyxis platycarpa*

Observations of the thalli bearing only *Orthopyxis platycarpa* revealed that the Hydrozoa is able to extend over the entire thallus within the range where the desiccation and some other severe factors associated with emergence do not disturb the survival of the Hydrozoa. As shown in Fig. 4c, the colonization ratio in *Sargassum confusum* is 95 per cent in average, and 98 per cent of the branches carry the colonies. The thallus must be covered entirely by Hydrozoa soon after the observation. In fact, in the levels 50–110, the colonization was 100 per cent.

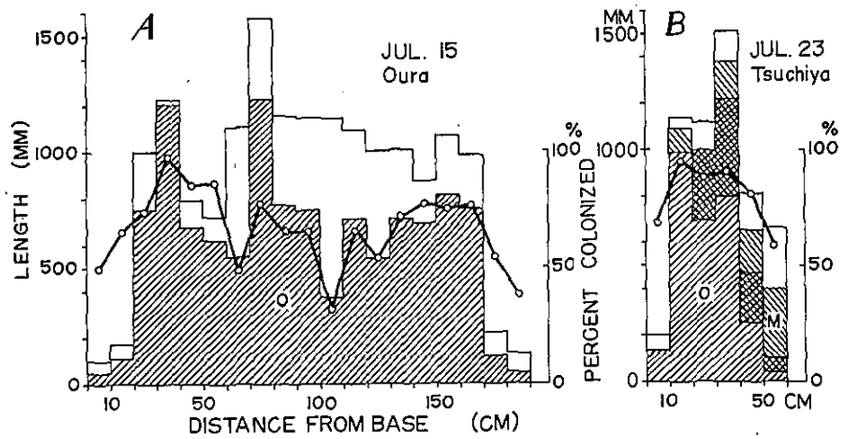

Fig. 2. Colonization of *Orthopyxis platycarpa* (O) and *Sertularella miurensis* (M) on *Sargassum thunbergii*.

It is also seen in *Sargassum thunbergii*. Normally this alga forms a dense carpet intertidally, but the continuous underwater growth is occasional and in such situation the alga carries luxuriant colonies (Fig. 2A). As already mentioned, the similar phenomenon was seen in *Sargassum hemiphyllum* (although it coexisted with other Hydrozoa, Fig. 1A also shows such pattern). It was impossible to collect any thallus of *Sargassum tortile* bearing only *Orthopyxis* since this alga always carries *Sertularella miurensis* in great abundance. From the time of young shoot, this alga is colonized with *Sertularella miurensis* and because this association continues thereafter (Nishihira, 1968c), *Orthopyxis* and other Hydrozoa never cover the entire thallus of *Sargassum tortile*. But there are no evidences that these Hydrozoa cannot colonize the whole thallus of the present alga in the absence of *Sertularella miurensis*. On the contrary it seems to be reasonable to consider that they can.

In the case of *Sertularella miurensis*, the thallus seems to be colonized entirely. On *Sargassum confusum* (Fig. 3) the percentage colonization is fairly low in the lowermost level, but the ratio increases upward up to 100 percent. On the level of 10 cm, the branches colonized were 50 percent, and it takes a rather long time to be colonized entirely but at the levels of 20–60 cm all the branches were colonized and thus they must soon be colonized entirely. Consequently the present Hydrozoa may be able to cover the entire thallus of *Sargassum confusum*. The larval settlement was observed not only in the upper part of the thallus but also in the lower parts, consequently the further settling on the lowermost level is possible. In *Sargassum hemiphyllum*, there were observed occasionally the thalli carrying *Sertularella miurensis* only; in these cases full colonization is sometimes observed. Even *Sargassum thunbergii* carries a large quantity of

Hydrozoa when it grows in the sublittoral zone, in such case *Sertularella miurensis* occasionally colonizes the upper part of the plant. In the figure presented, *Orthopyxis* dominated over *Sertularella miurensis* in abundance but there are many cases of *Orthopyxis* only to *Sertularella* only. Of course the algae in the normal habitat carry characteristically *Sertularella* sp. on their proximal portion. In *Sargassum tortile*, as mentioned before, it was impossible to collect thalli free from colonization of *Sertularella miurensis*. Occasionally *Orthopyxis* and/or *Coryne* and some other Hydrozoa attach to this alga, but they are very scarce in comparison with the bryozoans, *Bowerbankia imbricata* and *Amathia distans*. As shown by Katô *et al.* (1961) there were some thalli carrying several Hydrozoa together. Even in these situations *Sertularella miurensis* always dominates over all the other Hydrozoa on this alga. *Orthopyxis* is rather common, *Coryne uchidai* is occasional but is always restricted to the upper half. When several species coexist on one thallus they seldom overlap.

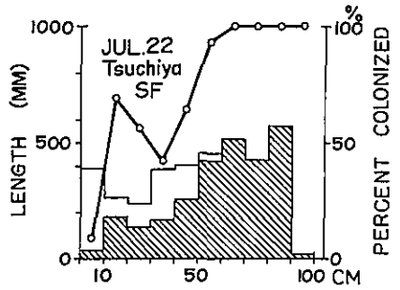

Fig. 3. Colonization of *Sertularella miurensis* on *Sargassum confusum*.

Clytia edwardsi covers the whole length of the older blades of *Zostera marina* (Nishihira, 1968d).

It is conceivable that *Sertularella miurensis* and *Orthopyxis platycarpa* are able to cover the entire thallus when they occur in continuous submergence without other species. *Clytia delicatula* and *Obelia geniculata* are likely to extend their colonies over the whole thallus when they alone colonize the thallus. When they coexist on the same thallus they show the tendency to avoid each other. Thus the larval settlement and colony growth thereafter are important in determining the distribution pattern on the thallus. And further, as demonstrated by Katô *et al.* (1962) there must be some dominant species which exterminate other subordinate ones in the process of propagation. As stated by them there have been no field observations on the problem. At Ôura, *Sargassum confusum* bearing *Bougainvillia* sp. was observed in abundance, so an observation was made on the effect of *Bougainvillia* sp. on other species on the same thallus.

3. *The effect of Bougainvillia sp. on other species*

At the sheltered boulder beach at Ôura, a luxuriant forest of *Sargassum confusum* is developed and most of these algae bore small colonies of *Bougainvillia* sp. in addition to the rather abundant colonies of other species in June. The most abundant species was *Clytia delicatula*. *Orthopyxis platycarpa*, *Obelia geniculata* and *Coryne uchidai* were occasional. Several algal stumps were sampled at random from the uniform growth of the forest, and an example on a alga is shown in Fig. 4 A, which shows that *Clytia* is distributed from the base to the distal part of the plant rather uniformly as stated by Katô *et al.* (1961) and more colonies colonize the central stratum. *Orthopyxis* and *Obelia* occupy their own distribution areas or portions and *Bougainvillia* sp. occupies the levels of 80–130

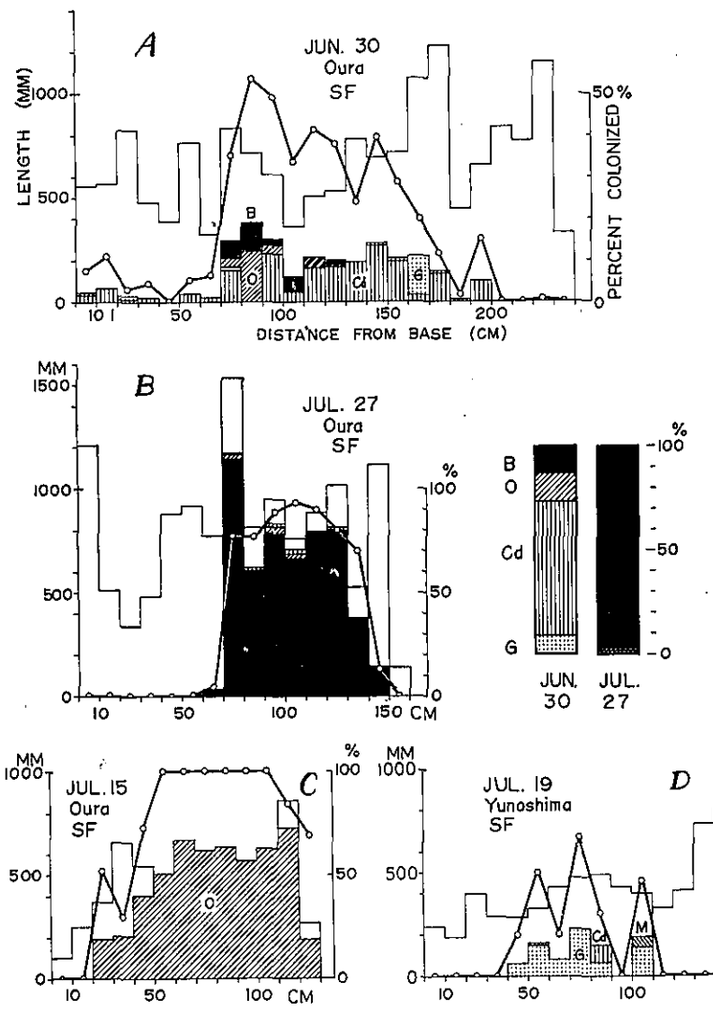

Fig. 4. Distribution of several species of Hydrozoa on *Sargassum confusum*. B: *Bougainvillia* sp., O:*Orthopyxis platycarpa*, G:*Obelia geniculata*, M:*Sertularella miurensis* and Cd:*Clytia delicatula*. Notice the influence of *Bougainvillia* sp. on the extinction of the subordinate species.

Table 1.
Co-existence of *Sertularella miurensis* and *Orthopyxis platycarpa* on the thallus of *Sargassum hemiphyllum* growing in a quadrat (25×25 cm) at Hadakajima.

Species	No. of thalli observed in four samples			
	s. 1	s. 2	s. 3	s. 4
S. miurensis only	28	20	11	8
Orthopyxis only	18	24	13	10
Both species	17	18	4	2
Neither species	3	5	1	8
Totals	66	67	29	28
Coefficient of association	0.712	0.756	0.455	0.466
χ^2	13.195	8.804	13.062	3.331
Probability	<0.001	<0.01	<0.001	<0.1

cm. Among thecate species there was no overlapping with each other but between *Clytia* and *Bougainvillia* there was some overlapping at the levels of 110–130 cm. All of the species were in healthy condition except the colonies of *Clytia* covered with *Bougainvillia*. Both *Sargassum confusum* and *Sargassum thunbergii* carried good colonies of *Orthopyxis*. The alga colonized with several species of Hydrozoa except *Bougainvillia* was required as a control but it was not possible to collect such thallus. But *Sargassum confusum* collected on July 19th at Yunoshima, a small islet located between Asamushi and Ôura, carried *Obelia* and *Clytia* in good condition.

The growth of *Bougainvillia* sp. about one month later is presented in Fig. 4B. It is uncertain whether the extinction of the colonies or the lack of the larval settlement is responsible for the absence of the colonies at the levels of 0–60 cm. The upper part of the thallus was cut and became shorter than that of the former example. It is obvious that the colonies of *Bougainvillia* increased extremely and on the contrary the other Hydrozoa were almost extinguished from the alga. The small colonies that still remained were those attached to the air bladders. Namely only the colonies which did not contact with *Bougainvillia* survived, which is noteworthy. From the level of 50 cm downwards the alga seems to have been free from colonization of Hydrozoa, this is because the Hydrozoa seem to survive where the colonization of *Bougainvillia* is lacking as shown before. Consequently the extinction of the thecate Hydrozoa in the central parts of the plant is considered to be caused by the luxuriant growth of the dominant Hydrozoa, *Bougainvillia* sp. It may compete with other species and over come all the other Hydrozoa as was seen in the Petri dish (Katô *et al.*, 1962).

Unfortunately further observation was not possible since *Bougainvillia* disappeared from Ôura in accordance with the start of the *Porphyra* cultivation in the baylet. This species was restricted to that baylet (Kakinuma, 1961; Nishihira, 1965). *Bougainvillia* is certainly the dominant species and is able to exterminate other species. But in the field condition the present species is very rare and thus the exinction of other species caused by the competition with *Bougainvillia* also seems to be very rare.

It is, of course, important to know the sequence of larval settlement to consider the coaction of these animals. Even when it is shown that the colony size is smaller in coexisting species, it can be attributed either to the younger age of the colonies or to the inhibition of the growth caused by the severe coaction between coinhabitants. In July to August a large number of larvae settle (especially those of *Sertularella miurensis*), and the upper part of *Sargassum tortile* at that time is less colonized with Hydrozoa. *Orthopyxis* usually occurs on the distal part of the thallus, thus the decrease in size of *Sertularella miurensis* cannot necessarily be attributed to the effect of the co-existing *Orthopyxis*. It was observed that the number of alga that received larval settlement of *Orthopyxis* is more when the number of settling larvae of *Sertularella* is less.

Although it is unknown whether it is an outcome of the coaction between co-existing species or the negative association between settling larvae, *Sertularella miurensis* and *Orthopyxis* are apt to be segregaged from each other. At Hadakajima, in front of the Marine Station, *Sargassum hemiphyllum* in a quadrat (25×25 cm) was collected in August, and colonization by the Hydrozoa was examined. The results are presented in Table 1, from which it is obvious that *Sertularella* and *Orthopyxis* are segregated from each other. It seems unlikely that it is the outcome of competition after the random settling of the larvae since not all of the thalli were occupied with only one particular species. In fact the actual overlapping of both species was very rare. It seems more likely to consider that the larvae of one species may avoid the sites already occupied by other species at the time of settling than that the result of competition is not uniform on all of the thalli.

It is necessary to observe continuously the coaction between these animals from the time of settlement of the larvae till the disappearance of the alga in the summer season.

SUMMARY

The distribution pattern of several Hydrozoa on the thalli of four species of *Sargassum* was observed. Both *Orthopyxis platycarpa* and *Sertularella miurensis*, and probably other species are able to cover the entire thallus when they colonize the alga without other species. When they coexist with other species on the same thallus the distribution tends to be restricted to certain portions according to the avoidance of the different settling larvae and the contradictory propagation of colonies of both species.

Coryne uchidai, having a similar nature as mentioned above, colonizes the distal half of the thallus in preference to other parts, and this may be attributed to

the selective settlement of the larvae on the distal half. The larva shows photopositive reaction at least in its early phase of the swimming stage.

Bougainvillia sp. dominates over other species as shown in the Petri dish (Katô *et al.*, 1962, 1963). In the field condition, the extinction of other species caused by the luxuriant growth of *Bougainvillia* sp. is actual. However, this phenomenon seems to be very rare because the present species is very scarce on the algal thalli.

The investigation of the coaction between Hydrozoa on the algal thalli requires observations from the time of larval settlement to the time of disappearance of the algae.

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