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ECOLOGICAL STUDIES OF EPIPHYTIC HYDROZOA[1]

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The range of ecological distribution of organisms is usually restricted to a certain part within the potential range decided by their tolerance to abiotic environmental factors. This actual range results from the interactions between the organisms and the physicochemical environmental factors, and other oragnisms as competitors, predators and prey. The mechanisms involved in this range are of great interest. The ecological distribution of epiphytic Hydrozoa have been studied and the following is a brief description of the results obtained.

Based on an extensive survey on the substrata of the polyp stage, the Hydrozoa were classified into three groups, namely those which do not colonize algae, those which colonize algae and other objects and those which occur only on algal thalli. The last group may not be distinct. Some species are indifferent to substratum, while others are highly restricted to particular substratum. Extreme examples of the latter are some commensal hydroids, the distribution of which is completely within the range of their host animals. Among the Hydrozoa of the second and third categories, most species have their preferred algae and consequently their ecological distribution is likely to be in good accordance with that of their respective preferable alga or plant. The Hydrozoa can be easily cultured in a Petri-dish on a diet of brine shrimp, which shows that their attachment to particular algae is not necessary for survival in the physiological sense.

The investigation of the ecological distribution of epiphytic Hydrozoa on the Tsuchiya coast by means of the transect method clearly showed that the distribution of Hydrozoa was highly influenced by that of algae, mostly several species of Sargassaceae which were known to be the preferred algae. Several hydroids showed marked preferences for particular weeds and consequently good accordance in ecological distribution with their respective preferable algae. Vertical and horizontal distribution of several species of Sargassaceae and *Zostera*, and their epiphytic Hydrozoa were analyzed with respect to the nature of the bottom and

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tidal level. Each hydroid has a different distribution center along the two gradients showing good correlation with that of a particular weed. For example, *Sargassum tortile* grows below the ELWST line and supports abundant *Sertularella miurensis*, *Sar. hemiphyllum* flourishes around the low water mark and is colonized by *Orthopyxis platycarpa*, and *Sar. thunbergii* grows in the lower midlittoral zone and carries abundant *Sertularella* sp. These algae occur on the rocky shore. On the stones embedded in the sand *Coccophora langsdorfii* colonized by *Amphisbetia pacifica* is abundant and on the sandy bottom *Zostera marina* develops, its blades colonized heavily by *Clytia edwardsi*. Thus, the investigation is directed to the mechanism of the establishment of these particular associations between Hydrozoa and weeds. The simplest hypothesis is that only those larvae that settled on a particular alga survived though settlement occurred uniformly or at random on various algae according to the environmental factors at the growing sites of the algae. But in practice, the Hydrozoa are found on particular algae even when there are many algal species growing intermingled, which fact suggests the algal selection by the settling larvae. Recently various invertebrate larvae have been shown to have an ability to discriminate between suitable and unsuitable substrata and to postpone their settlement or metamorphosis until they come into contact with a suitable one. The concept of random or indifferent settlement seems to be inadequate.

The emersion effects must be of great importance specially for animals which are delicate and susceptible to desiccation. As with some other intertidal animals the upper limit of the distribution of Hydrozoa in the intertidal zone may be decided by their tolerance to severe environments associated with emersion. Consequently, the assumption that the ecological distribution of epiphytic Hydrozoa is decided by the algal selection of the settling larvae should be limited to the infralittoral zone. Since the larva of *Ser. miurensis* is of the creeping type, dispersal is concentric from its center in the area of larval production, but the larvae disperse rather widely according to the water movement even to the sandy bottom where no algae occur and to the intertidal zone. During the low tide there is no chance for the larvae to invade the midlittoral zone and thus the larval supply may be less. Even so, if the settled larvae survived and grew, many colonies of *Ser. miurensis* would be observed (for example *Ser. miurensis* on small *Sar. tortile* in a tide pool). The range is decided in relation to the tolerance of the animals and is variable according to the seasonal change of the low tide level. Actually it was observed that *Ser. miurensis* attaching to *Sar. tortile* in the upper fringe of the distribution range died from the emersion effects especially in April, when the lowest low water occurs in the daytime. In the winter months it occurs in the night and seems not to influence the Hydrozoa. Outside the possible range, even suitable algae do not support Hydrozoa. Within the

possible range of survival, the algal selection by the settling larvae was suggested.

Field observations in the breeding season of *Ser. miurensis* and field experiments, transplantation of several species of algae into the same place, showed that the larvae of *Ser. miurensis* shows a marked algal selectivity. Abundant larvae settle preferentially on *Sar. tortile*, and to a less extent on the other species of *Sargassum*. Some red algae received a few larvae but the green algae were scarcely settled. These figures are closely related to the field observations except that *Sar. thunbergii* received some larvae. The reason for this has already been discussed. Almost all larvae settled on the buds, the origin of laminae, branches and air bladders, namely on concave irregular surfaces as is widely seen in various species of sedentary animals. The question, thus, is what is the cause of the algal selectivity; what factor of the preferred alga is responsible for the heavy settlement? The number of settled larvae could not be explained by only the amount of surface area of the algae. The degree of branching or the irregularity of thallus, though important, cannot explain satisfactorily the suitableness of *Sargassum*. A brief discussion about the factors influencing the settlement of the larvae has been given.

The algal selection was also tested in the laboratory using *Coryne uchidai*, the larvae of which have a swimming phase. The results were similar to the observations in the field. In this case, *Sar. thunbergii* received many settled larvae though it usually does not bear this hydroid. Adding cut pieces of *Sargassum* promoted the larval settlement to a great extent, though the cut pieces of *Ulva pertusa* did not show such promoting effect. From this a chemical substance in *Sargassum* was considered to promote settlement. This was heat stable, water soluble and effective even in solution. The extract of an unfavourable alga, *Ulva*, did not show the promoting effect and that of *Symphiocladia latiuscula* seemed to be harmful. The effective extract was not necessarily restricted to the species of *Sargassum* but was also seen in another brown alga, *Dictyopteris divaricata*. This alga usually did not carry *Coryne*. The reason for this discrepancy is not yet fully explained. The larvae seemed not to show positive chemotaxis but were promoted to settle when they came into contact with an effective concentration of extract. As was reported by many authors in various invertebrates, the settlement of hydrozoan larvae such as *Clytia edwardsi*, *Tubularia mesembryanthemum* and *Plumularia undulata*, may be influenced by filmed surfaces. This was suggested from investigations on the distribution pattern of these Hydrozoa on the blades of eel-grasses. A certain sere in the succession of the aufwuchs might be suitable for the settlement, but it was not known why *Clytia* preferred the blade of *Zostera marina*.

The most abundant hydroid near Asamushi is *Ser. miurensis* and the most abundant alga is *Sar. tortile*. These two species constantly show a marked association. Consequently particular attention was paid to them, and the dynamics of natural populations of *Ser. miurensis* was investigated. The algal selection of the larvae of *Ser. miurensis* was highly stable seasonally. *Sargassum tortile* was the most preferable, *Sar. hemiphyllum* was the next most preferable followed by *Sar. confusum* and *Sar. thunbergii*. The general tendency is similar to the results obtained in summer. This stability of algal preference may result in limiting the habitat of this species continuously to a definite site on the shore. There were two prominent peaks in August and November in the seasonal trend of the settling larvae. This first peak was made by the larvae from the old mature colonies on the thalli which appeared in the previous summer. This larvae-producing population soon declined with the old thalli, which resulted in decrease of larval settling in October.

The seconds peak in November may be caused by the larvae from newly matured colonies on the new thalli of the same year. The relation between the high water temperature and season of the displacement of old thalli by the young ones, the behaviour type of the larvae and the stability in algal preference may guarantee the continuous and constant association between *Ser. miurensis* and *Sar. tortile.*

Sertularella miurensis shows sympodial growth and an exponential increase in the biomass at least in the earlier phase of colony growth. There were two exponentially increasing phases, one from September to November, another from January to March, each of which seems to correspond to the growth of the colonies originating from the larvae settled in the summer and autumn peaks. The growth of the colonies was analyzed from several points of view.

The role of the abundant population (ca. 1000 g/m^2 in dry weight) of *Ser. miurensis* in the *Sar. tortile* forest is of great interest in relation to the bioeconomy of the algal forest community.

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