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Life History and Environment of *Aurelia aurita*

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Abstract

We investigated the seasonal occurrence, growth, age, and life history of *Aurelia aurita* in the Taniyama area of Kagoshima Bay, also some of the environmental factors such as the specific gravity, pH and the temperature, influence the appearance of *Aurelia aurita* in the surface layer. The size of an individual depends on environmental factors. In contrast the number of branching points of radial water vascular canals increasing with time, independently of environmental factors, and therefore could be used as an age index.

By using age index, the population of *Aurelia aurita* sampled may consist a mixture of two cohorts. The assumption may be that the life span of *Aurelia aurita* is up to two years.

By examining all stages of the life history of *Aurelia aurita* in Kagoshima Bay and comparing it with that of other locatives, it is found that the life form of *Aurelia* varies with their environmental circumstances. We suggest that how the habitat influence the life history in *Aurelia* should now be reviewed.

Key words: *Aurelia aurita*, Environment, Growth, Age, Water vascular system, Populations, Life cycle.

Introduction

The Scyphozoan *Aurelia aurita* is seen commonly in cosmopolitan waters. It has alternation of generations, between a sexual planktonic generation and an asexual benthic generation.

There are many ecological reports of the medusa stage in north Europe, north America and Japan. It was reported by MÖLLER (1980), YASUDA (1971), HAMNER and JENSSEN (1974), OLESEN (1994) and OMORI et. al. (1995) that *Aurelia* medusae grew in size and matured from early spring to summer and then the medusa size regressed. They suggested two reasons for that phenomenon; one is senescence of medusae after spawning and the other is the invasion of a new generation of young medusae. However, morphological characters, aging and mortality of medusae were not referred to and the reasons for size regression phenomena have never been proved.

The aim of this study is to clarify the life history of *Aurelia aurita* in Kagoshima Bay. We investigated seasonal occurrence, growth, maturation, aging and their environmental factors. In the laboratory, we studied the organ differentiation of canal system of medusa in cultures.

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Materials and Methods

I. The morphogenesis of medusae cultured in the laboratory.

Ephyrae used in this experiment were liberated from polyps in the laboratory by Kakinuma's method (KAKINUMA, 1975).

Experiments were carried out between mid-June and mid-September 1993. The range of room temperature was from 20 to 27°C. Ephyrae and metephyrae were cultured in tall-glass petri-dishes, 9 cm diameter, 12 cm high, filled with 500 ml filtered sea water. In order to supply oxygen and keep organisms from sinking to the bottom of the vessel, we made circular water flow by air lift using a piece of a acrylic tube 1 mm in diameter and 20 cm in length. Cultures were fed with excess of *Artemia* sp. larvae and old culture sea water was replaced with fresh sea water once a day. Young medusae were transferred to a glass medusa rearing tank devised by Michihiro Tabata, 25 cm diameter and 20 cm high, filled with 7 ℓ filtered sea water. They were also fed with excess *Artemia* sp. larvae once in a day and old sea water was replaced with fresh sea water every three days. Larger medusae were then cultured in a 60 cm wide tank with 40 ℓ filtered sea water.

For these jelly fish measurements of size (mm, diameter), wet weight (g) and the number of water vascular canal radial branches were taken every 7 to 10 days. The water vascular system branches and elongates from the margin of umbrella, so we counted the maximum number of branching points of radial canals (Fig.1 KAKINUMA et al., 1993).

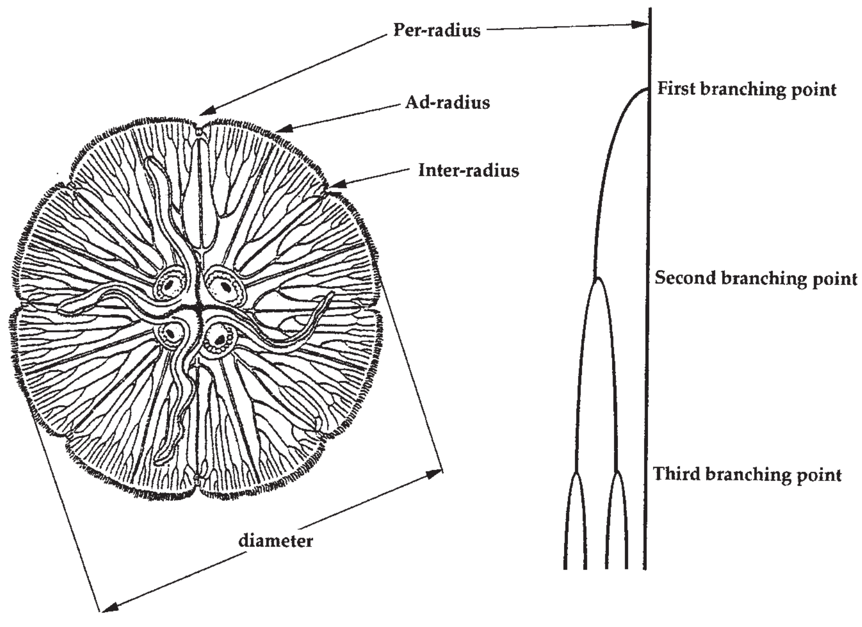

Fig. 1 The methods of measurement of medusa diameter and counting the number of branching points.

II. Ecological study of medusae at the Taniyama area in Kagoshima Bay

Between December 1993 and December 1994, three stations around the Taniyama area in Kagoshima Bay at the southern end of Kyushu Island, Japan were surveyed every 10 days (Fig. 2). Sampling was done using a 45 cm diameter plankton net with a mesh size of 2 mm. Within 2hr. after sampling, live medusae caught in the field were observed and measured. Data includes medusa diameter (mm), wet weight (g), the number of water vascular branches, maturation of gonad and the presence of planulae in the brood sacs on the oral arm. Environmental factors taken at each sampling points were as follows: weather condition, water transparency, temperature, pH, specific gravity and salinity measurement in day time, and the settled volume of plankton caught by oblique haul towed 6 to 10 m

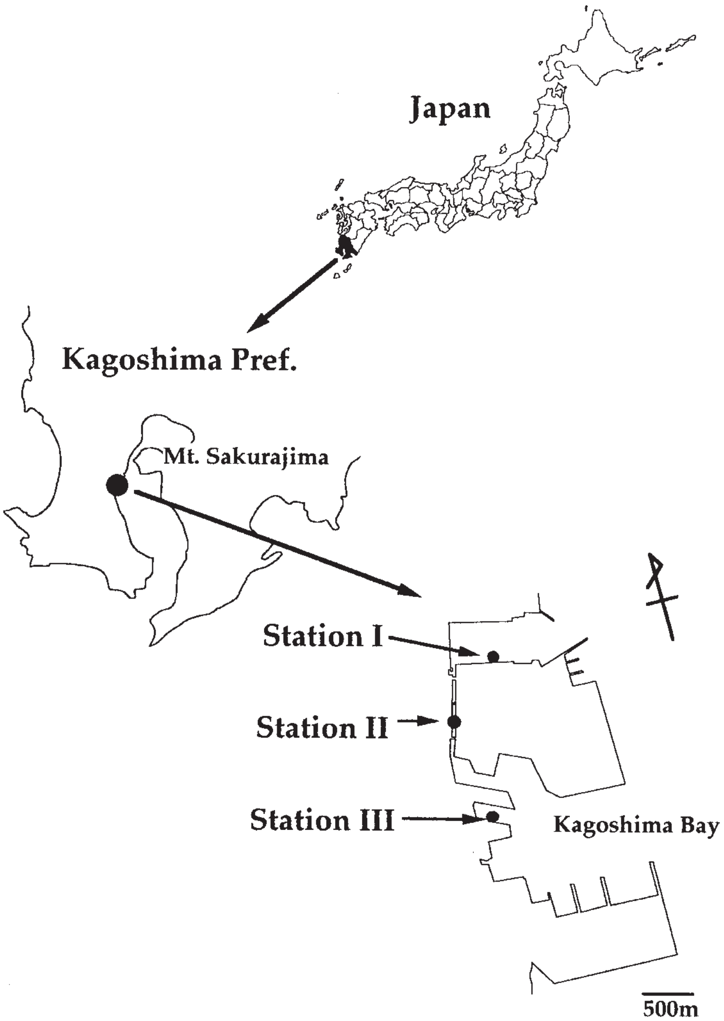

Fig. 2 The location of investigated station at the southern end of Kyushu island, Japan

using a 30 cm diameter plankton net with a mesh size of 50 μm.

Result and Discussion

I. The morphogenesis of medusae cultured in the laboratory

The relationship between the number of branches and the number of days show logarithmic growth (Fig. 3 $B = 3.590 \log D - 2.462$ $r = 0.969$; B = the number of branching points, D = days after ephyrae liberated from strobilae). At 10 days the first branching point appeared. Then at 18 days the second appeared. At 34 days the third branching points appeared, and after 63 days the forth ones appeared (Fig. 3). The most striking part in Figure 3 was that the medusa size decreased by their environmental factor or their physiological conditions (Fig. 3 arrows), however the number of branches continued to increase. So it is the best way to take the number of branches to indicate their aging.

II. Ecological study of medusae at the Taniyama area in Kagoshima Bay

We found the habitat of polyps at station II. Station II is located in a channel where most of the vessels and floating piers were anchored. No polyps were seen on the side of floating piers or the wharf. They are seen only on the undersurface of floating piers. These floating piers were made of polystyrene. The polyps were attached non randomly. Most of them were seen attached to solitary ascidians, Balanus, *Mytilus edulis*, polychaetae tubes and amphipod tubes (Table 1). These polyps advanced to strobilae from December to March, afterwards the life style changes from benthic polyp stage to planktonic medusa stage.

Table. 1 Substrates of *Aurelia aurita* polyps.

Substrates under the surface of floating pier	Polyps present
Solitary ascidians	++
Colonial ascidians	−
Barnacle (Balanus)	+
Bivalves (*Mytils edulis*)	+++
Polychaeta tubes	+
Amphipod tubes	+++
Bryozoans	−
Actiniarians	−
Hydroids	−
Sponges	−
Phaeophyseae	++
Other algae	−

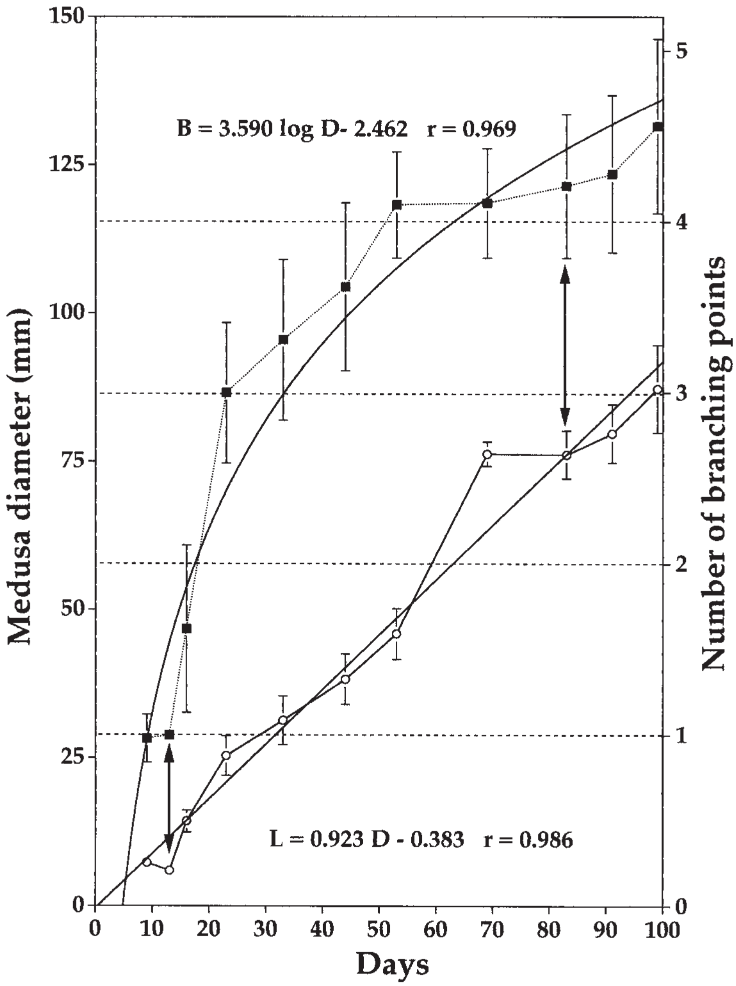

Fig. 3 The growth of *Aurelia aurita* medusa in the laboratory.
Open circle shows size (diameter). Closed squares shows the increasing number of water vascular branching points. The error bar shows S.D.
(B: the number of branching points, D: days, L: medusa diameter)

In Kagoshima Bay, ephyrae appeared from early January to middle March 1994, Metephyrae from late February to early April, and medusae from late February. In Fig. 4, the time of occurrence of this species in plankton form is very different in different localities, because of difference in their environment. Fig. 5 shows the differences in salinity and temperature ranges of environmental factors for *Aurelia aurita* it reveals that *Aurelia aurita* has the ability to adapt itself to various environmental factors and could change its life style with its environment. The specific gravity, pH and water temperature influence the presence of medusae in the surface layer as shown by Fig. 6. In the upper right graph (pH / temperature), the cross mark in the clear circle within the medusa occurrence range corresponds to the same mark in the upper left graph (pH / specific gravity), that the

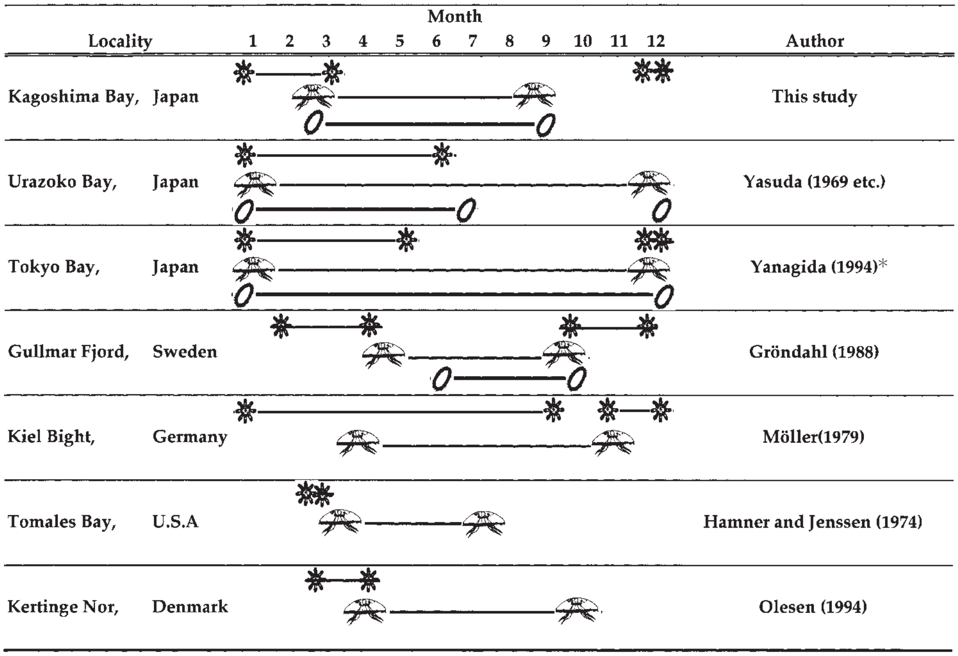

Fig. 4 The times of occurrence of *Aurelia aurita* in different localities.

: Planulae : Ephyrae : Medusae *Personal communication

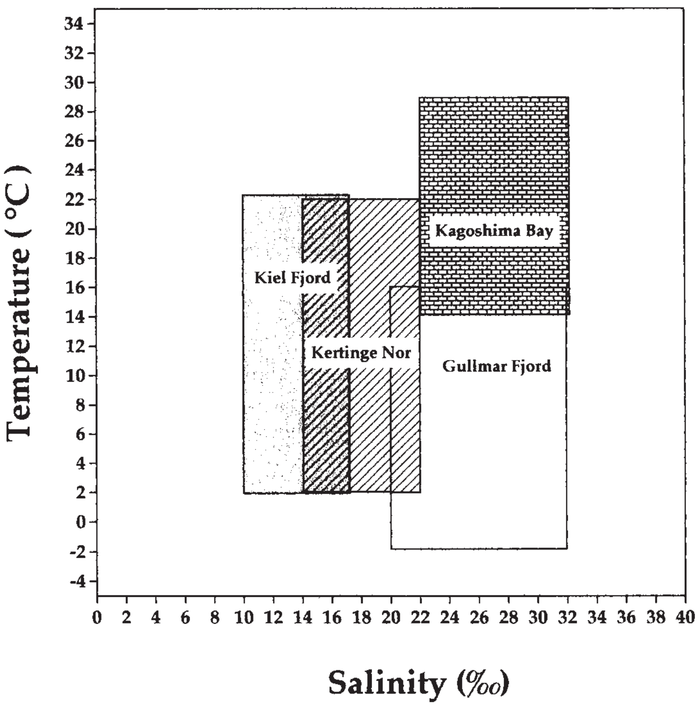

Fig. 5 The differences in range of temperature and salinity as environmental factor for *Aurelia aurita* in different localities.

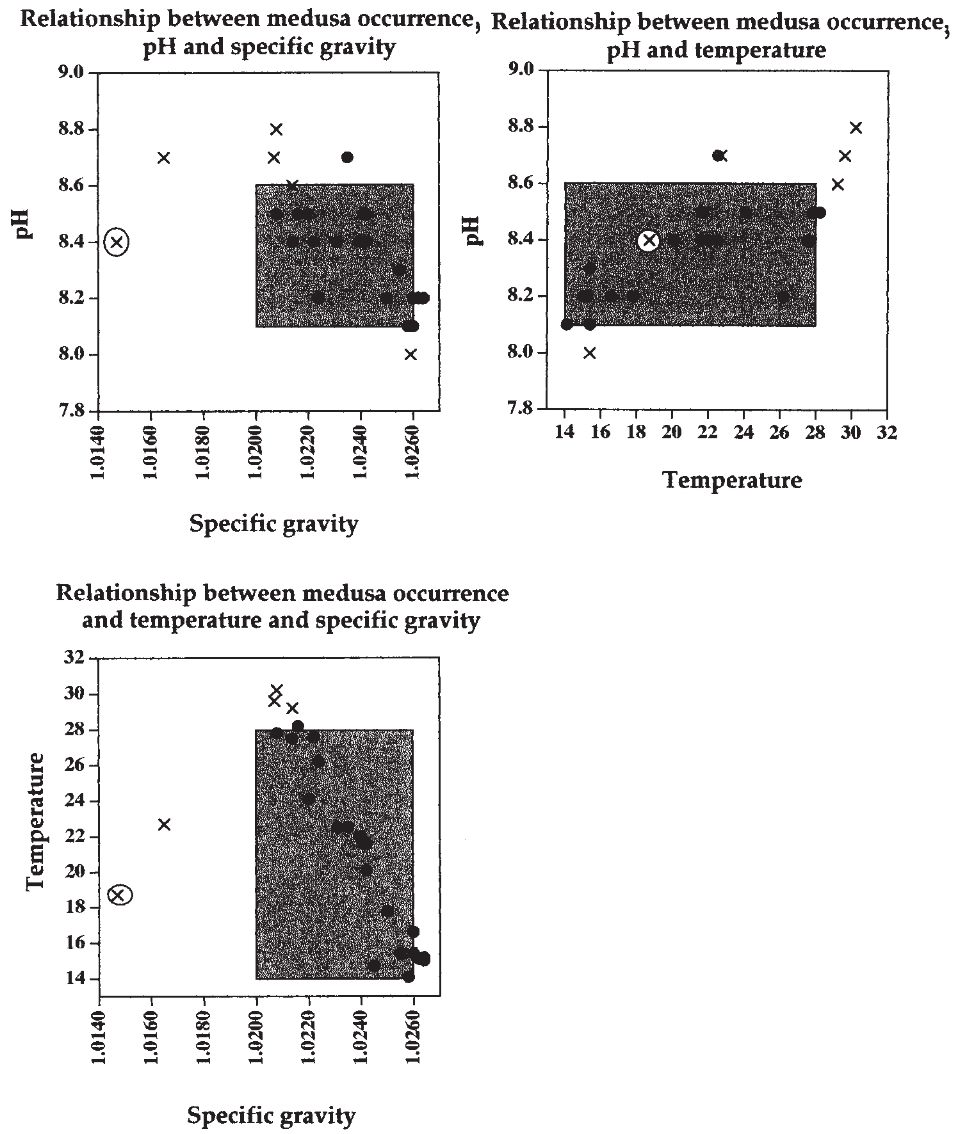

Fig. 6 The environmental range of medusa occurrence.
A closed circle (●) indicates medusa occurrence. A cross (×) indicates no occurrence. The stippled area is the range of environmental factors for medusa occurrence (Specific gravity 1.0210 ～ 1.0260, Water temperature 14 ～ 28 ℃, pH 8.1 ～ 8.6).

specific gravity mesurement is very low as also observe in the lower left graph (temperature / specific gravity). These three environmental factors, i.e., temperature, specific gravity and pH have the greatest influence on the occurrence of medusae.

In Kagoshima Bay, the growth of *Aurelia* medusa starts in January and by July they reach a peak diameter of 23 cm (Fig. 7). In Kiel Bight, Germany (MÖLLER, 1980), the species

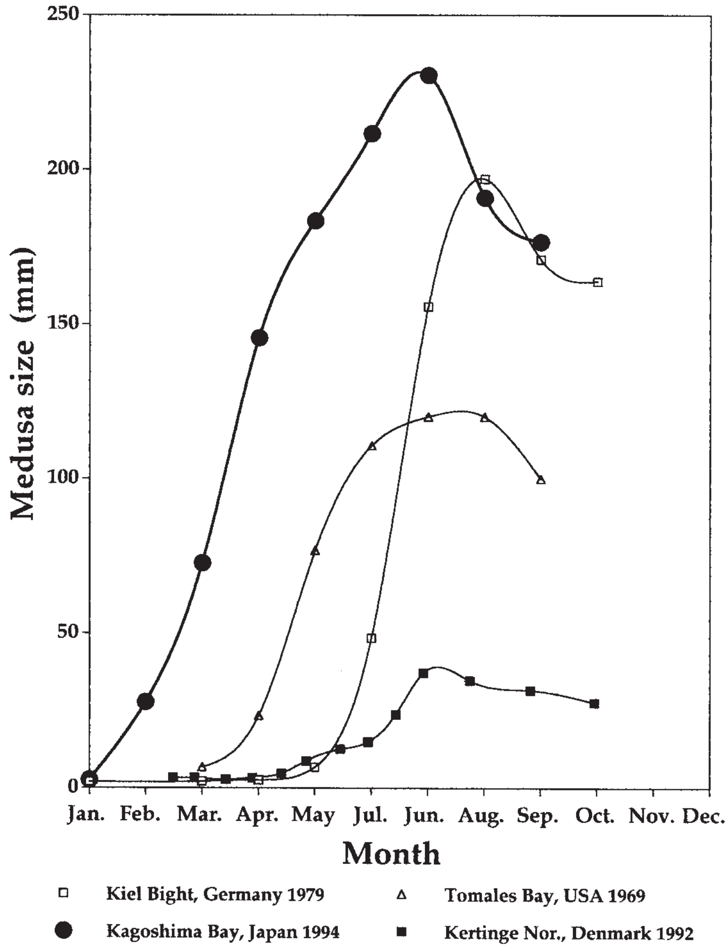

Fig. 7 The growth of *Aurelia aurita* medusae in different localities.

started growing in May and reached a peak diameter of 20 cm in August. In Tomales Bay, USA (HAMNER and JENSSEN, 1974), growth started in March and reached a peak of 12 cm by July. In Kertinge Nor, Denmark (OLESEN, 1994), growth started in April and reached a peak of about 4 cm in July (Fig. 8). These four curves, all show that the growth rates and medusa size decrease after summer. The reason why the curves differ is that ranges of environmental factors vary in different places where the jellyfish is present.

There is a scattering in the relationship between medusa diameter and the number of branching points of the radial canals (Fig. 8). For the given same medusa diameter, the number of water vascular system branching points varied from 4 to 8. For example, when there are 5 branching points, the medusa diameter ranges between 90 mm to 320 mm. The reason suggested is that environmental factors as well as physiological factors control the growth of medusae.

The monthly change of age composition of the *Aurelia* population was indicated by the

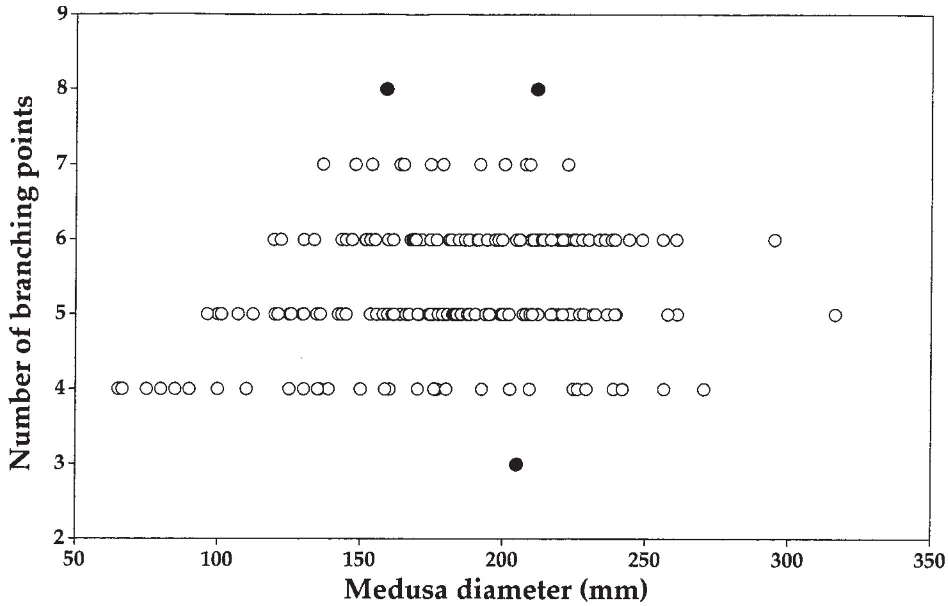

Fig. 8 The relationship between medusa diameter and the number of branching points of radial canal.

number of branching points and the maturity of medusae (Fig. 9). The results obtained show that the number of branching points ranged from 0 to 8. Considering these data (Fig. 9) together with unpublished observations on the organ differentiation with growth in laboratory cultures, it is possible that the *Aurelia* samples indicate a succession of two populations. In our samples it would have originated in 1993 and 1994. From the monthly changes in number of mature medusae in Fig. 9, it may be that the older the medusae is, the more accelerated the maturity of its gonad is. The number of older medusae (i.e. numerous branching points of radial canals) increased up to July but from August they began to disappear. Possibly by this time the 1993 population of medusae is being succeeded by the 1994 population. By summer, old medusae, which have more than 7 radial canal branching points, have no directional swimming ability and drifted by the wind and waves. During 1994, water temperature and the amount of planktonic food available increased from March, and reached a peak in June. At the same time, *Aurelia* medusae attached planulae increased from march, reached a peak in June and increased again slightly in September (Fig. 10). Considering the age of this population (i. e. the number of branching of radial canals, Fig. 3), it may be suggested that from March to April only the medusa population of 1993 released planulae, and after that, medusae reached more than 4 radial canal branching points in 1994 population also began to release planulae. So it may be that in Kagoshima Bay, *Aurelia* release planulae twice, both in the first summer and in the second summer. In that case mortality of medusae occurs over a period of 8 to 20 months. The life span is up to two years.

The importance fact described above is that we must consider not only the life cycle of

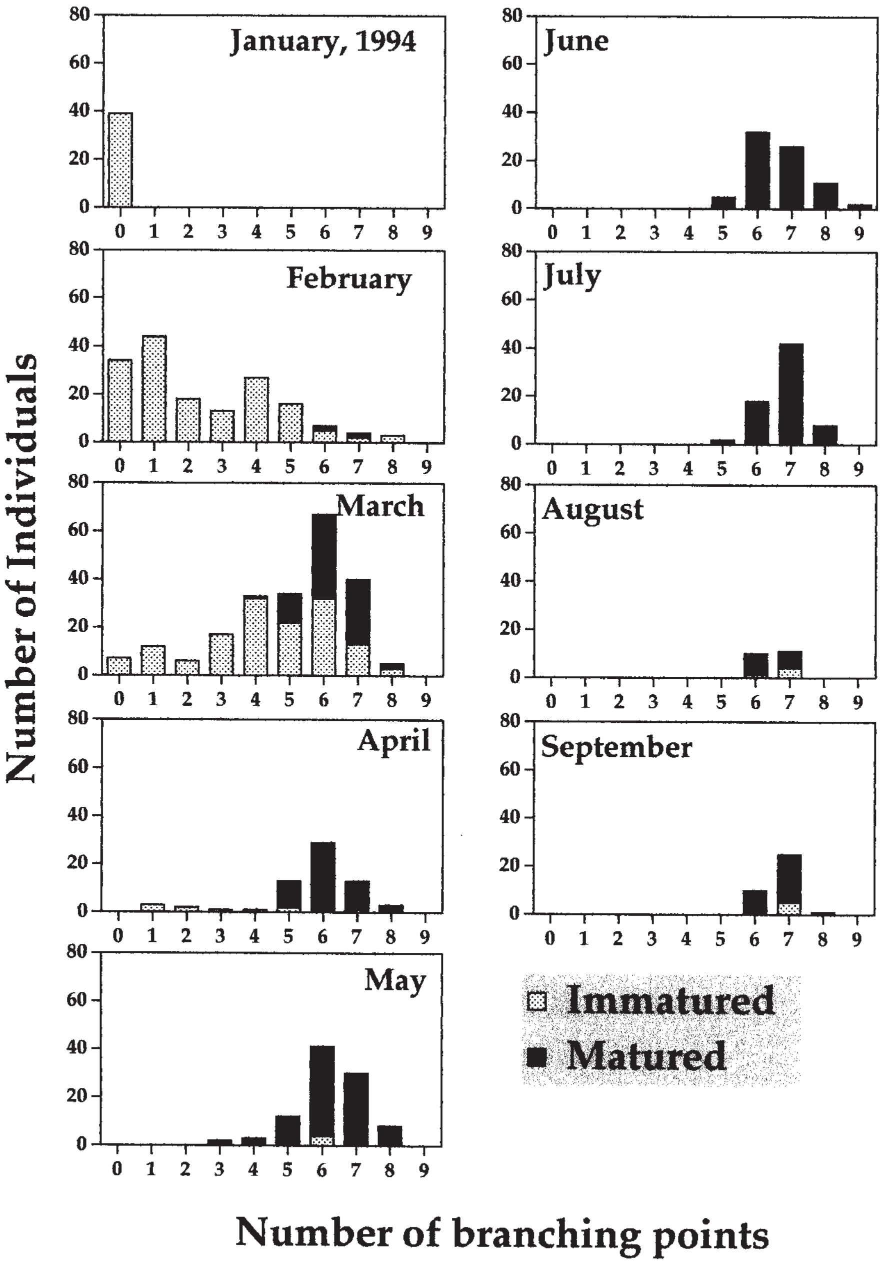

Fig. 9 The monthly changes of the age of the *Aurelia aurita* population and sexual maturating of medusa during 1994.

The aging was taken by the number of water vascular canal branching points. Dotted area indicates immature medusae. Black shows mature medusae with planulae.

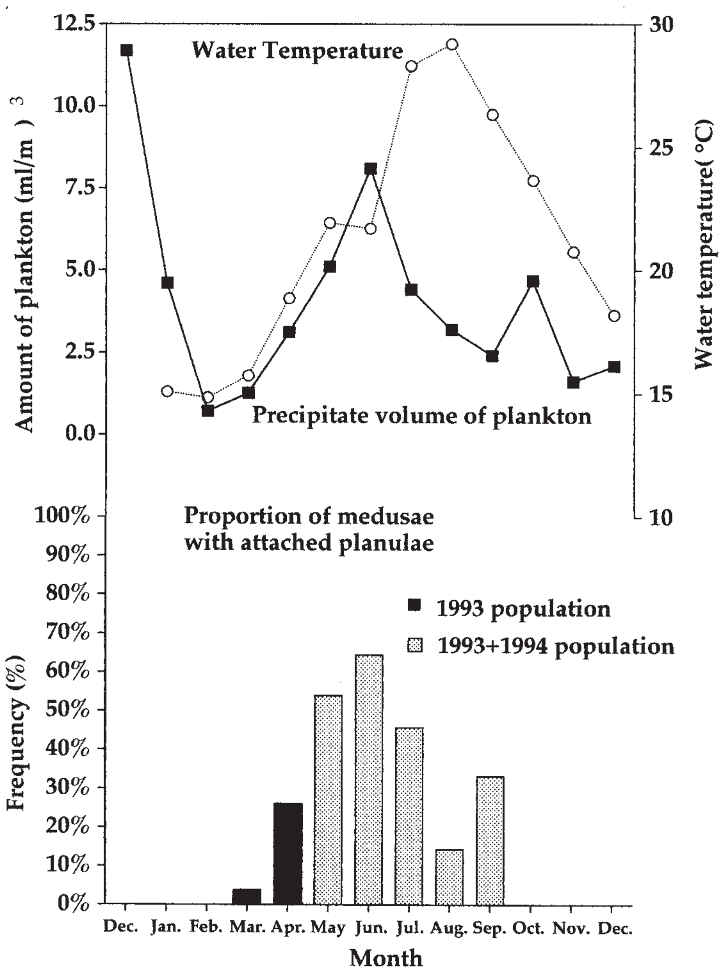

Fig. 10 Above: Seasonal change of water temperature and volume of plankton in 1994. Below: Seasonal change in the frequency of medusae with attached planulae in 1994.

Aurelia aurita, but also the life cycle including the environmental factors play an important role for the survival of *Aurelia* population.

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