# The Biological Production Process of a Mysid (Archaeomysis kokuboi) in the Slope of a Sandy Beach

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# The Biological Production Process of a Mysid (*Archaeomysis kokuboi*) in the Slope of a Sandy Beach

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## Summary

A mysid, *Archaeomysis kokuboi* have a large standing crop in the slope of the sandy beaches of surf zones all year round. In order to make clear the functional role of the ecosystem of the surf zone, the authors investigated the biological production in the course of the life history of the *A. kokuboi*. Judging from the interval between the appearance of the young and the transition of the larval stages in the marsupium, the mysids reproduce almost all year round except in the period from late January to early March. The reproductive cycle is 26-30 days from November to January and 15-22 days from April to July. Moreover, seeing the growth curves of the population estimated by laboratory experiment and the size frequency distribution of female mysids carrying embryo, it is clear that the growth of individuals in the population released after April is faster than the growth of individuals in the population released from November to January. The individuals in the population released after April take part in the reproduction during from June to July in smaller body size than the individuals in the population released from November to January.

It is well known that sandy beaches are a nursery ground for the larval and juvenile fish dwelling in the shallow sea area. They play a functional role in the purification of coastal sea water. In the community of the sea coast deeper than 5 m in depth, genus *Acanthomysis*, occupy an important niche as a key species in the productive structure of the biological community (1, 2). However, in the slope of the sandy beaches of the surf zone shallower than 5 m, the structure and function in the biological production system of the community has not yet been cleared. In the surf zone, the abundance of genus *Acanthomysis* is low, however, the abundance of genus *Archaeomysis* is high. In regard to genus *Archaeomysis*, Matsudaira *et al.* (3) studied precisely about a life cycle of *Gastrosaccus vulgaris* NAKAZAWA and Takahashi *et al.* (4) reported on the distribution of genus *Archaeomysis*. But the biological production process of genus *Archaeomysis* has

not been studied yet. Therefore, in order to make clear the functional role of the ecosystem of the surf zone, the authors investigated the biological production in the course of the life history of *A. kokuboi*.

## Materials and Methods

*Sampling*

Research was conducted at Yuriage beach, near the mouth of the Natori River from 1993 to 1995 (Fig. 1). The biological production process of *A. kokuboi* couldn't be made clear by investigating at a month interval in 1993. Therefore, further research was undertaken almost every day from November to December and at a week interval from January to July. Survey station was selected in a place surrounded by a break water with due regard to the stability of the situation of the sand slope in the surf shore.

As *A. kokuboi* burrow in the surface layer (0-3 cm) of the sand slope, the sand of the surface layer was gathered, by means of a shovel, onto the slope after the sea water retreated. The sand was put through a sieve (0.4 mm in mesh) and the mysids were separated from the sand. In the place soaked in water, which is a lower place than the break point of the wave, the mysids were collected by the use of a scoop net (0.4 mm in mesh). The mysids thus collected were fixed with a solution of 10% formalin at once.

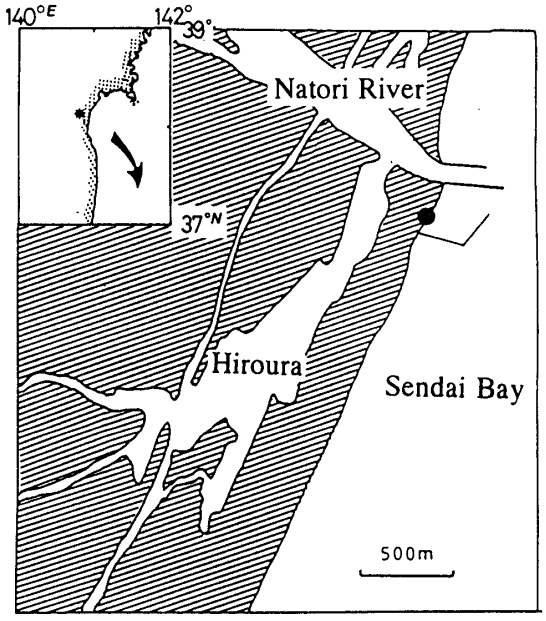


FIG. 1. Map showing the station of sampling performed in the Yuriage beach, near the mouth of the Natori River.

*Observation and measurement of samples*

A carapace length of mysids was measured because a body of mysids is bent, with fixation, by the use of formalin. Moreover, observation of the embryo in the marsupium is carried out using a stereoscopic microscope to make the reproduction cycle clear. According to the criterion of the development of the embryo described by Mauchline (5), embryo were divided into three stages as follows.

Stage I. The early embryo, at first egg-like but later with rudiments of antennae and abdomen developing. It is still within the egg membrane which is shed at the end of this stage.

Stage II. The larva has hatched from the egg membrane by puncturing it with the abdomen. The antennae and thoracic appendages develop during this stage and the eyes become pigmented. This stage terminates in a molt.

Stage III. The molted larva now has the eyes on stalks. No lith is present in the developing vesicle of the statocyst in the uropods. This stage also terminates in a molt that takes place as, or shortly after, the larvae are released from the marsupium.

*Methods of laboratory experiment*

(1) Development process of embryo

Female mysids, carrying Stage I larvae, were selected from samples brought to the laboratory and kept them alive. For investigating the influence of temperature in the development of the embryo, aquariums were set up at a water temperature of 10, 15, 20 and 25°C. And four beakers of 100 ml were set up in the aquarium as shown in Fig. 2. The mysids selected were reared in them, one to every four beakers. The inside of a mysid's marsupium can be observed easily

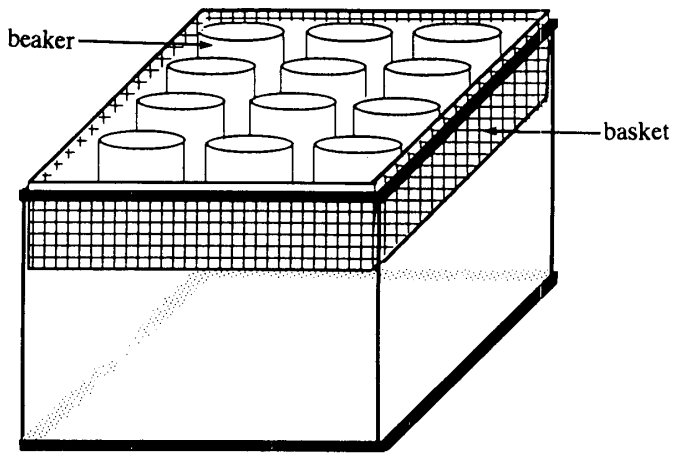


FIG. 2. An aquarium used in the laboratory experiment. Beakers of 100 ml in a basket are set up in the aquariums keeping the water temperature at 10, 15, 20 and 25°C.

with the naked eye because their marsupium is clear when they are alive. The development of their embryo was observed with the naked eye in detail on the basis of the above-mentioned criterion.

Moreover, an experiment was carrid out to estimate from the period of releasing to spawning. Female mysids, carring stage III larvae just before releasing, were selected and they were kept in an aquarium set up at a temperature of 15°C till they released. Five female mysids which released young at the same time, were put in a plastic vessel of 5 *l* together with five mature males and the vessel was put in an aquarium set up at a temperature of 15°C. This experiment was continued until the next molt because spawning and molt take place at the same time in mysids.

(2) Growth process of released young

On the other hand, this experiment was carried out to make clear the growth process until the released young grow up. Female mysids carrying stage III larvae just before releasing were selected and they were kept in a beaker of 500 ml set up at a temperature of 15°C till they released. Eight beakers of 100 ml were set up in aquariums at a water temperature of 10, 15, 20 and 25°C for the purpose of investigating the influence of temperature on growth. Young released from a female mysid were reared in them, one to every eight beakers. The young were fed with artemia nauplius 1-3 days after birth. On the basis of intake of the artemia per day, estimated from preliminary experiments, enough artemia was fed once a day. Their cast-off skins were gathered and their telson length were measured because it is difficult to measure directly the total length of mysids while alive. These data were adopted by allometric equation between telson length and carapace length and growth curves for carapace length were obtained.

## Results and Discussion

*Reproductive cycle*

It is necessary to coincide the growth and maturity process of the population with the appearance of the released young in order to make clear the reproductive cycle of the population of mysids in an area. As comparatively bigger mysids are caught in the water's edge all year round, it is possible to pursue the growth and maturity process of mysids by tracing the transition in size composition. Therefore, the reproductive cycle of the population was estimated by means of coupling the result of the field observation with the rearing experiment in laboratory.

(1) Appearance of young

Fig. 3 shows the size composition of mysids caught on the sand slope when the sea water retreats. The carapace length of mysids sampled in this place are more than 1 mm. This phenomenon is observed all year round. On the other hand, the carapace length of mysids sampled in the sea water, 50 cm in depth, are 0.7-

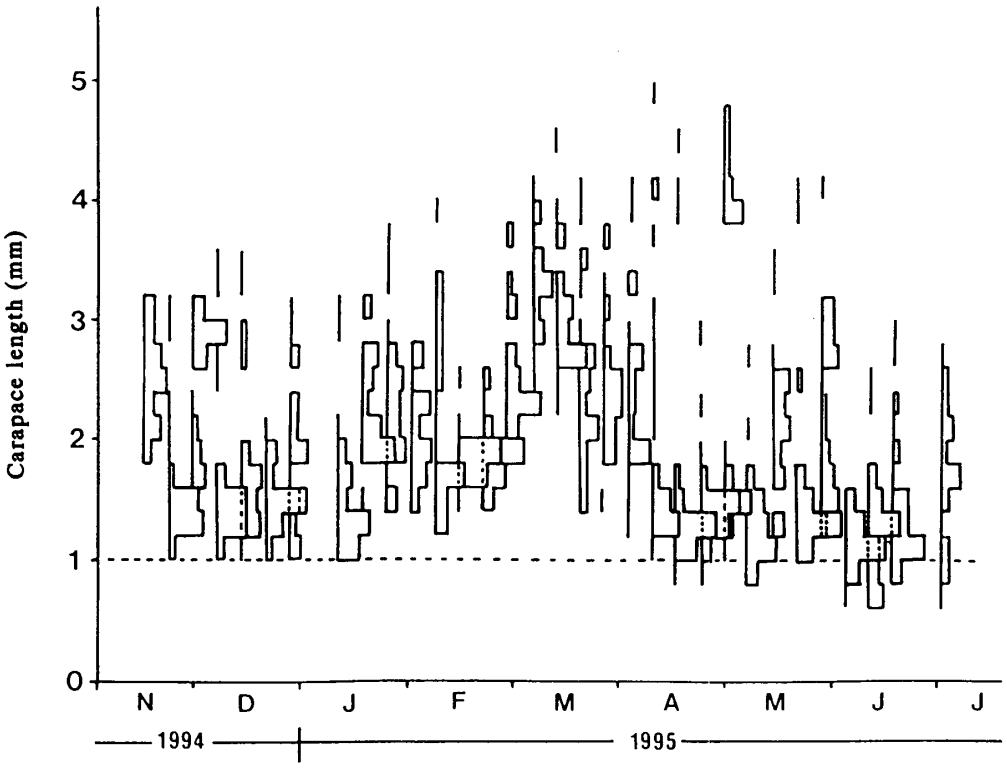


FIG. 3. Carapace length frequency distribution of *A. kokuboi* sampled on the sand slope when the sea water retreats. Broken line indicates the maximum carapace length (1 mm) of young just released.

1.3 mm in length as shown in Fig. 4. Most of the young (0.7-0.9 mm) just released appear from November 18-21, December 11-15, January 8.

(2) Larval stages in the marsupium

Fig. 5 shows the weekly frequency of the distribution of the larval stages in the developmental process. Few female mysids, carrying embryo in marsupium appear during the period from late January to early March. For that reason, it may be thought that mysids don't reproduce this period. Seeing the transition from the stage I to stage III, we can understand the feature of the reproductive cycle in mysids. From the observation of the tendency of weekly distribution in stages, it is difficult to find the continuous transition in stages. However, watching only stage III, we can easily find some periods in the high frequency of that stage, namely, in the middle of November, December, January, April, early May, late May and the middle of June. These periods almost coincide with the periods when the young apper. Assuming that intervals of these periods are reproductive cycles, the seasonal variations of the cycles are observed as follows, namely, 26-30 days from November to January and 15-22 days from April to July.

Fig. 6 describes the daily transition of each stage from the middle of Novem-

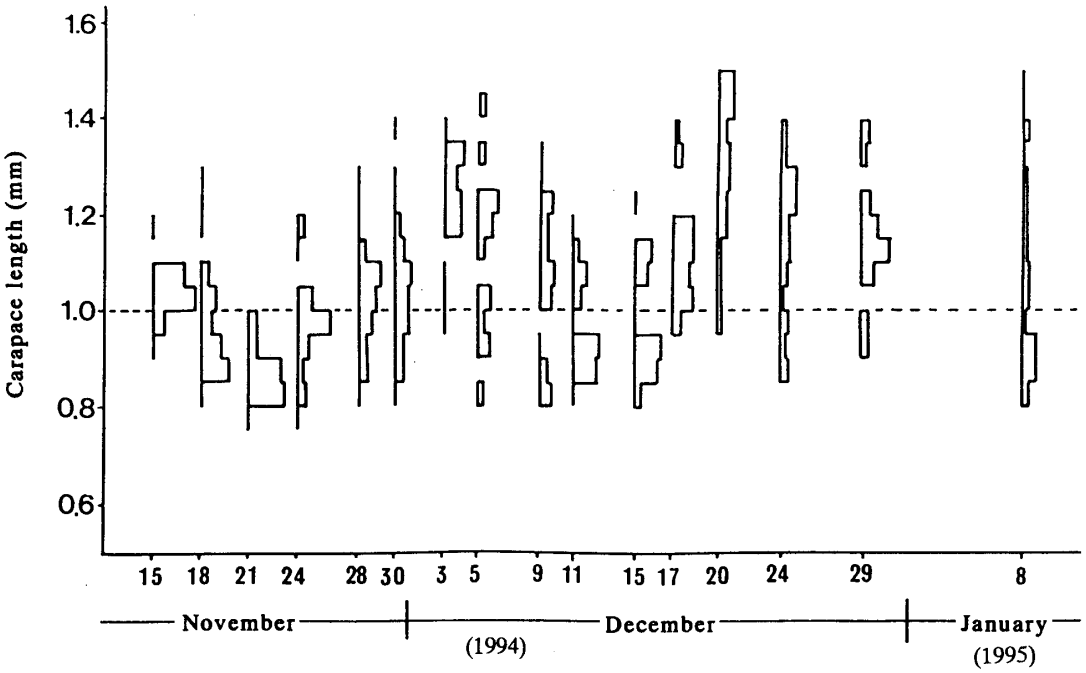


FIG. 4. Carapace length frequency distribution of *A. kokuboi* sampled in the sea water 50 cm in depth. Broken line indicates the maximum carapace length (1 mm) of young just released.

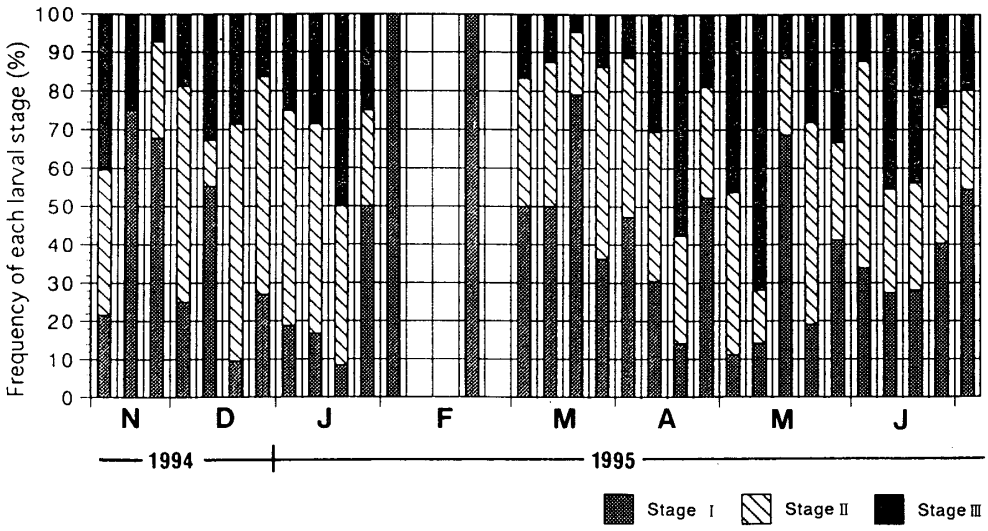


FIG. 5. Weekly frequency distribution of larval stages in developmental process.

ber to late December. From the observation of the tendency of daily distribution in stages, we can find the continuous transition in stages. During the 10 day period from November 22 to December 1, the frequency of the stage I is high. During the 6 day period from December 2 to December 7, the frequency of the stage II is high. During the 6 day period from December 8 to December 12, the

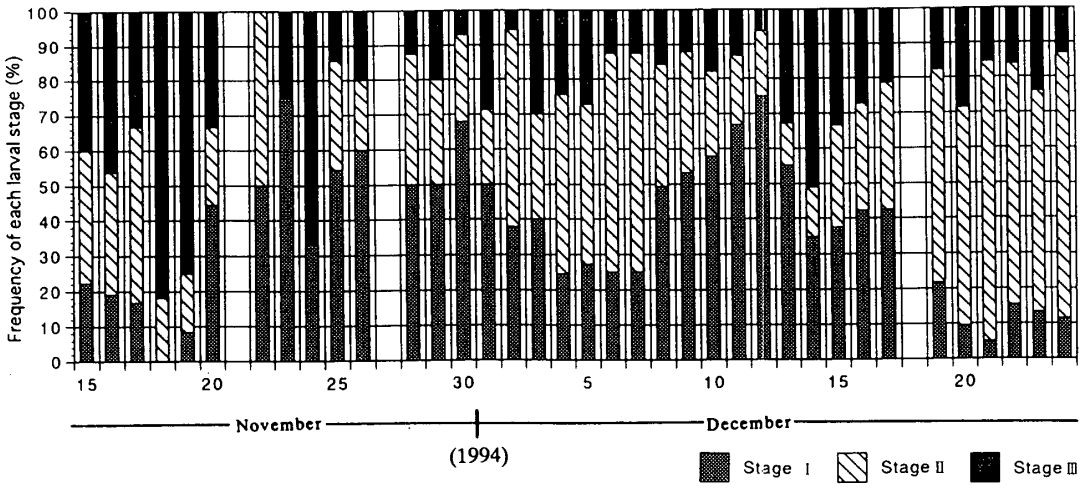


FIG. 6. Daily frequency distribution of larval stages in developmental process.

frequency of the stage I is high. During the 4 day period from December 13 to December 15, the frequency of the stage III is relatively high. It seems that another group spawning in December 8, because of the high frequency period of Stage II returns to stage I again. In other words, the period of stage I is from November 22 to December 1, the period of stage II is from December 2 to December 12 and the period of stage III is from December 13 to December 15. Accordingly, the period from spawning to releasing is estimated at about 24 days in summation of the period of the stages from November 22 to December 15.

(3) The period of each larval stage estimated by the rearing experiment.

Table 1 shows the period of each stage in various water temperatures. This experiment was carried out in order to demonstrate the reproductive cycle estimated by the use of fixed samples. Figures in this table are the average of the period of each larval stage of 4 mysids reared in 10 and 15°C and the average of the period of each larval stage of 3 mysids reared in 20 and 25°C. In Table 1, the

TABLE 1. *The period of the each larval stage in the marsupium and the total period in various water temperatures*

| Temperature (°C) | period (days) of | | | Total* |
|---|---|---|---|---|
| | Stage I | Stage II | Stage III | |
| 10 | 9 more | 13.8 | 10.2 | 33 more |
| 15 | 5 more | 6.0 | 5.8 | 16.8 more |
| 20 | 4 more | 3.7 | 3.7 | 11.4 more |
| 25 | 4 more | 3.3 | 2.0 | 9.3 more |

* Total shows a period of summation of the period of stage 1, stage 2 and stage 3.

total shows a period of summation of the period of stage I, stage II and stage III. The period of stage I couldn't be found because the observation was started in the middle of stage I. In 10°C, the period of stage I is more than 9 days, the period of stage II is 13.8 days, the period of stage III is 10.2 days and the total is more than 33 days. In 15°C, the period of each stage is half the period of 10°C and the total is more than 16.8 days, moreover, more than 11.4 days in 20°C and more than 9.4 days in 25°C.

On the other hand, in order to estimate the period from releasing to spawning, a rearing experiment was carried out. Three females out of five female mysids spawned after 4-5 days rearing. It seems that the period from releasing to spawning is 4-5 days. Therefore, the reproductive cycle of an individual female is estimated at 22 days in 15°C. If these results are applied to the field, the reproductive cycle is estimated at almost 20-40 days from November to December and April, 15-20 days from May to June. These results closely demonstrate the assumption mentioned above; the interval of appearance of the young and the transition of larval stages in marsupium.

*Growth process*

(1) Growth process in the laboratory experiment

It is difficult to estimate the growth of the populations by only tracing the

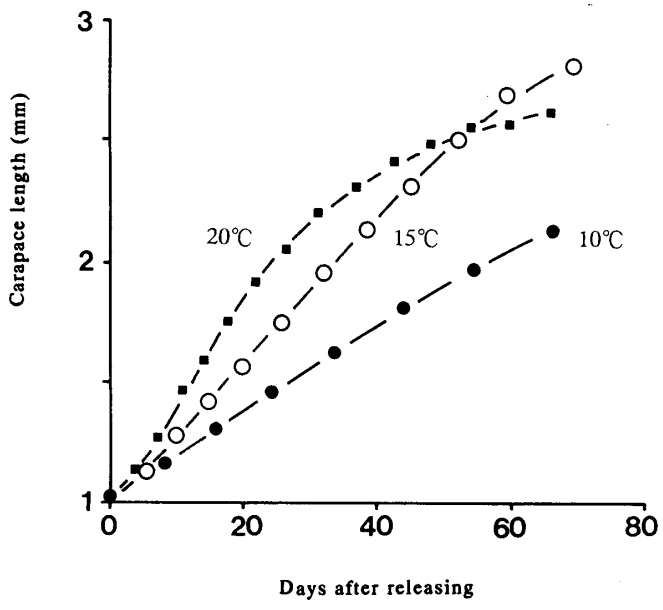


FIG. 7. Growth curves of *A. kokuboi* obtained in laboratory experiment in various water temperature. This figure shows the relationship between the days after releasing and the carapace length averaged individually in each temperature of 10, 15, 20°C. A growth curve in 25°C couldn't be obtained because a lot of young died. The closed circles show at temperature of 10°C, the open circles show at a temperature of 15°C and the squares show at temperature of 20°C.

transition of size composition in Fig. 3. Therefore, the growth of the populations was estimated by means of compiling the result of the growth curves obtained in laboratory experiment. The growth curves of *A. kokuboi* are shown in Fig. 7. This figure shows the relationship between the days after releasing and the carapace length averaged individually in each temperature of 10, 15, 20°C. A growth curve in 25°C couldn't be obtained because a lot of young die. In the water temperature of 10°C, young show linear growth. In 15°C, the young the size of 1.0–2.7 mm show linear growth, and thereafter the growth rate decreases. In 20°C, the young the size of 1.0–2.1 mm show linear growth and thereafter the growth rate decrease, but the young hardly grow after attaining the length of 2.6 mm. The growth rate during straight growth is about 0.016 mm/day in 10°C, 0.029 mm/day in 15°C and 0.040 mm/day in 20°C.

(2) Estimation for the growth of populations from the laboratory experiment

Based on the water temperature obtained by field survey, the period from November to June was divided into three periods and the growth curves obtained

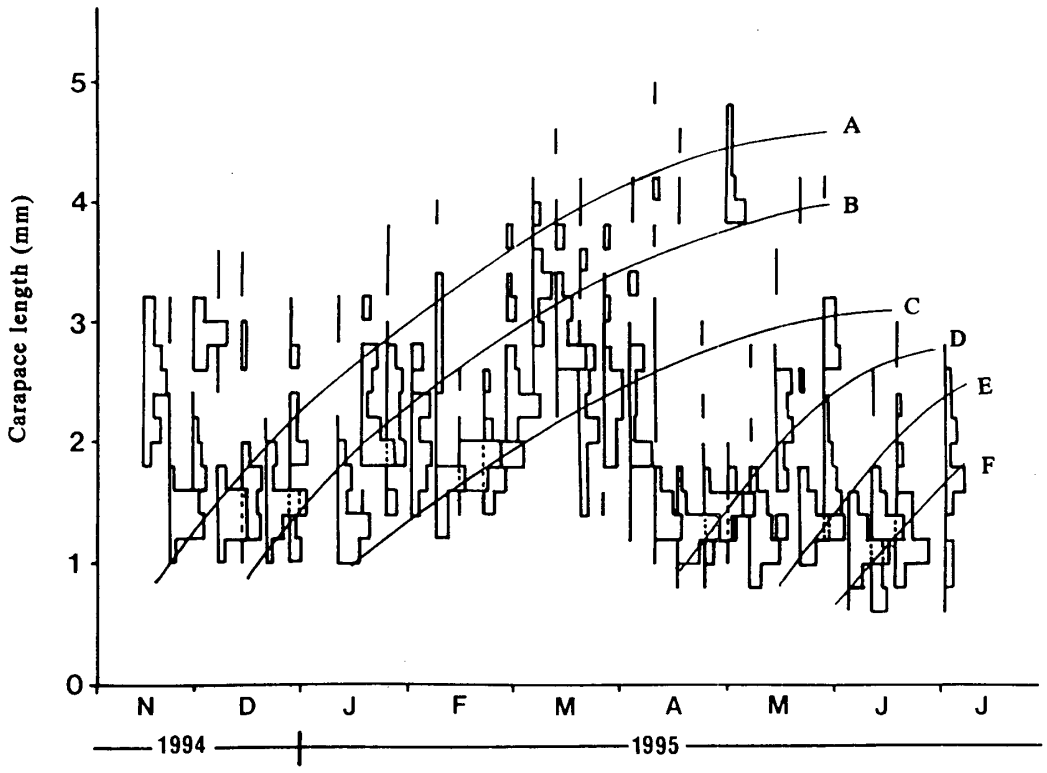


FIG. 8. Growth curves of populations estimated by the laboratory experiment. Basing on the water temperature obtained by field survey, the growth curve of 15°C was applied to the period during from November to December and April, the growth curve of 10°C was applied to the period during from January to March, the growth curve of 20°C was applied to the period during from May to June. Each growth curve expressed by a solid line was drawn on the base of the six cohorts named A-F in order of birth.

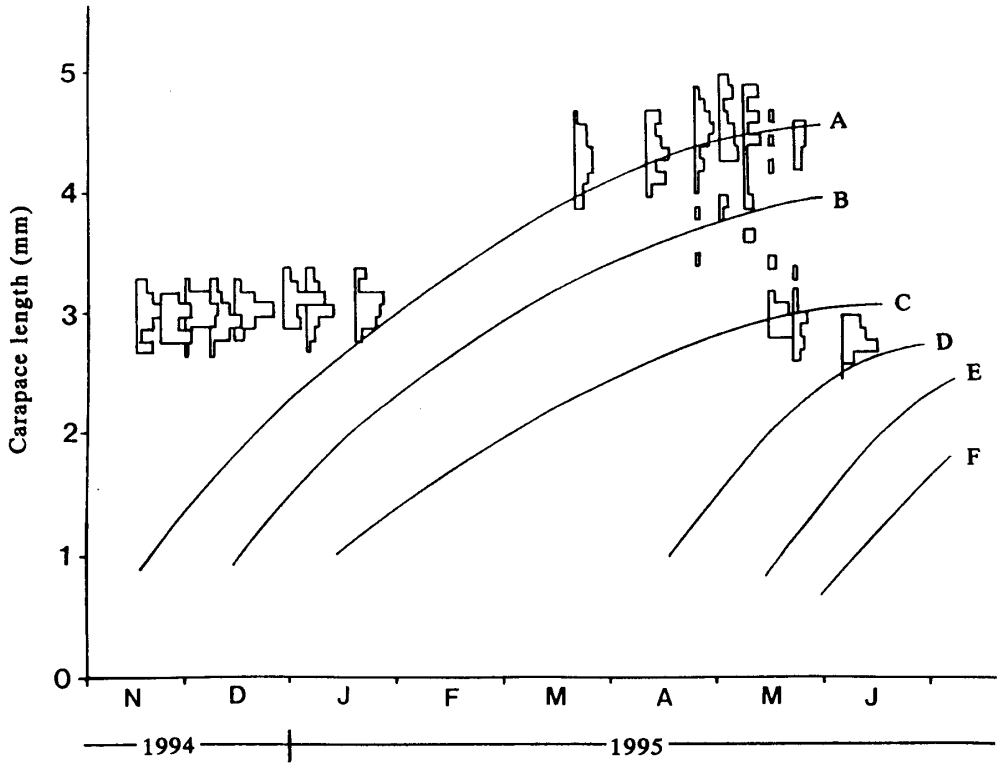


FIG. 9. Carapace length frequency distribution of female mysids carrying embryo in their marsupium. Each growth curve expressed by a solid line was drawn on the base of the six cohorts named A-F in order of birth.

by laboratory experiment were applied to the three periods. Namely, the growth curve of 10°C was applied to the period from January to March, the growth curve of 15°C was applied to the period from November to December and April, the growth curve of 20°C was applied to the period from May to June. Moreover, judging from the above-mentioned reproductive cycle, we could find six cohorts. Each growth curve was drawn on the base of the six cohorts named A-F in order of birth as shown in Fig. 8. Cohort A and B attain a body length of 4-5 mm and disappear late in May. Cohort C attains a length of 3 mm and disappears late in May. Cohort D attains nearly a length of 3 mm in about two months.

*Growth and reproduction*

Fig. 9 shows the size frequency distribution of female mysids carrying embryo in their marsupium. The carapace length of the female mysids is 2.7-3.4 mm from November to January, 3.9-4.7 mm late in March, 4.3-5.0 mm late in April, 2.6-3.4 mm in the middle of May and 2.5-3.0 mm early in June. Judging from the estimated growth curves, the group 3.9-4.7 mm in length late in March, connects to cohort A and B. The cohorts release their young and molt in the middle of April, and attain to 4.3-5.0 mm in length late in April and take part in the second

reproduction. That is, cohort A and B don't reproduce till late in March, but the groups grow up to the larger size and reproduce more young at a time, than other groups. It seems that the groups produce cohort D and E. Moreover, A group 2. 6-3.4 mm in length in the middle of May connects to cohort C and produce cohort F in the middle of May. As a group of smaller size appear in June, the group may be released in April by cohort A and B. That is, the group takes part in reproduction after two months of birth.

From the result mentioned above, it can be thought that *A. kokuboi* have a high productive potential. And primary production is done in the activity of the surf zone and the mysids feed on organisms such as diatoms and copepods produced in the surf zone, and convert the organisms into their body substances. That is why they have a large standing crop all the year round. Moreover, from the result of the analysis of the stomach contents of the coastal fish (1), there is some possibility that *A. kokuboi* occupy an important niche in the productive structure of the surf zone and play important role in connecting the flow of energy and materials to the neighboring subsystem in the shallow coastal sea.

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