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On the Shrimp Fishery and Biology of *Solenocera prominentis* KUBO (Decapoda, Penaeidae) in Kagoshima Bay

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Abstract

This study was conducted to gather imformations about shrimp fishery and the observation of histology of the ovarian eggs, spawning season including age and growth of *Solenocera prominensis* KUBO, one of the most important shrimp species in Kagoshima Bay. It was observed that the shrimp resource of this bay was being depleted. And from histological and maturity index observations revealed that the highest peak of spawning season of *S. prominentis* occured during October and November. In the commercial stocks, two groups were found, one the 0 age group and the 1 age group. This shrimp probably has a life-span of about two years and they spawn twice in their life. Females were found to be larger than the males in size.

Introduction

Shrimps fishery is among the most important fishing activities in Kagoshima Bay. During the period from April 1968 to March 1969 the commercial landing of shrimps from this bay amounted to 104 tons approximately. In these landings composed of different shrimps species, *Solenocera prominentis* KUBO (Fig. 1) is of great economic value by virtue of its larger size and demand in the market. Nevertheless little is known about the biological aspects of this species. In Japan life history and biology of shrimps belonging to Family Penaeidae have been done by many biologists, but few works were done on the biology and histology of ovarian eggs, such as the works of Hudinaga (1942)[1], Oka and Shirahata(1965)[2], In Kagoshima Bay, Urita (1942)[3] investigated the shrimps in 1942, however his work was confined to the taxonomy and the distribution of shrimps.

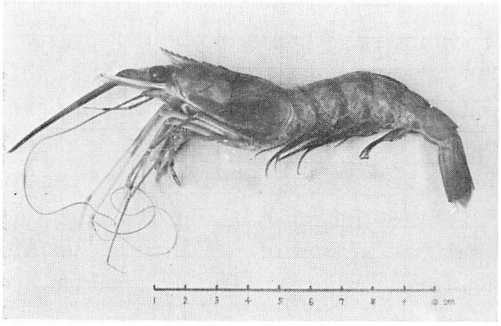

Fig. 1. *Solenocera prominentis* KUBO

This study was taken up with the view of investigating shrimps fishery and the lesser known biological aspects of *S. prominentis* such as the histology of ovarian eggs, spawning season, age and growth.

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Material and Methods

Shrimps were caught monthly by the "Nansei Maru" (44.6 gross tons), a training ship belonging to the Faculty of Fisheries Kagoshima University, from May 1969 to November 1970, using a small type of Danish seine. The seine used for this purpose made of synthetic fiber net (Nylon and Cremona) had the head rope of about 39 m long with 20.1 mm mesh size on the wing and 17.8 mm mesh size on the body and cod-end.

Fishing was done once or twice a month in day time between 10 a.m. and 2 p.m. Fishing grounds of depth ranging from 130 to 230 m were chosen to emulate the commercial fishermen and for safety of the net. Each fishing operation lasted for about an hour and after the net was hauled up the cod-end was opened. The total catch of shrimps was weighed and then *S. prominentis* was separated from the rest and weighed separately. Shrimp sampling was done at random and the samples were preserved in 10 % formalin and transported to the laboratory in the Faculty of Fisheries, Kagoshima University. The samples were weighed individually and the carapace length was measured. Besides, shrimp samples and data of shrimp landings were also obtained from Kanoya (Furue) Fishing Co-operative for this study.

Commercial Shrimp Fishery

In Kagoshima Bay the commercial fishing boats from many ports operate in the area with depth ranging from 130-230 m. Rich fishing grounds are considered to have a depth of about 150-180 m with flat and soft bottom sediments. The size of commercial boats is ahout 3-5 gross tons with an engine of about 15-20 h.p.. The net used is called "one boat small Danish seine" or "kogata kisen sokobiki ami" in Japanese. This net has a head rope of about 37.5 m and 23 mm of the mesh size at the cod-end.

The fishing is carried out all year round except in June which is forbidden by the regulation of Kagoshima Prefecture as this month is considered to be the spawning season of the shrimps in this bay. Generally the fishermen operate in the three important fishing grounds of the inner bay and middle bay (Fig. 2). On investigations it was found that most of the fishing boats with the main purpose of catching *S. prominentis* operate in the middle bay during spring and summer and in the inner bay during autumn and winter. These fishing boats fish 5 times a day from the early morning till afternoon (about 2 p.m.) and land their catches on that day at the fishing co-operatives in this bay. Kanoya Fishing Co-operative is one of the largest fishing co-operatives for shrimp landing and as the majority of shrimps caught in this bay are landed at this co-operative data of shrimp landings from this co-operative were chosen as representative of commercial shrimp fishery in this bay.

The seasonal change of total shrimp catch and the catch per haul from April

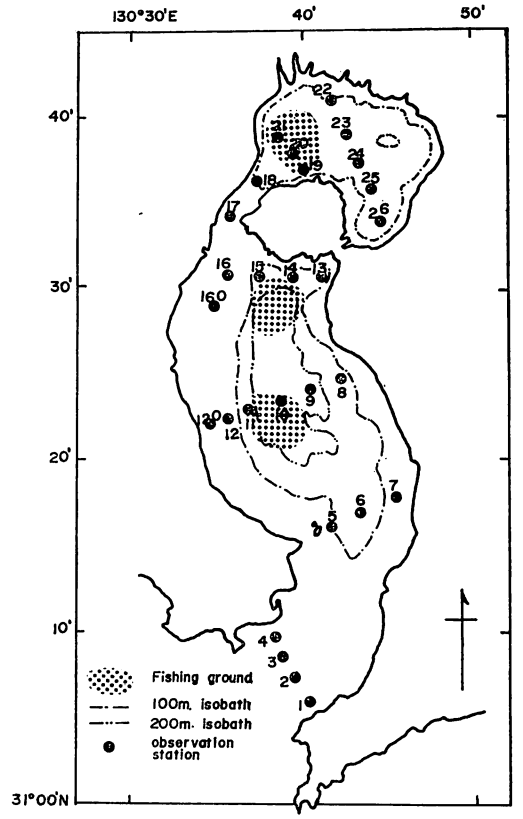

Fig. 2. Shrimp fishing grounds and oceanographic observations in Kagoshima Bay.

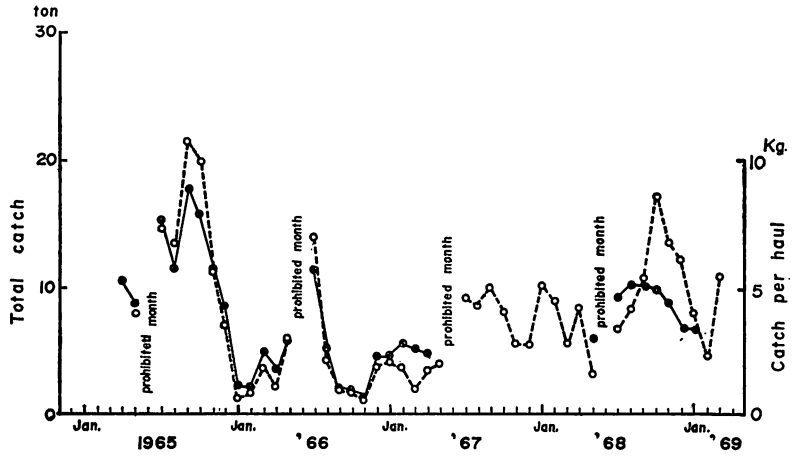

Fig. 3. Monthly change of total shrimp catch and catch per haul of shrimps landing at Kanoya Fishing Co-operative (1965 to 1969). Open circle : Total catch, Closed circle : Catch per haul

1965 to March 1969 are shown in Fig. 3, it can be seen that the peak of the catch in each year occured mostly in summer and autumn and minimum in winter. The catch per haul was estimated by the following formula:-

$$\text{Catch per haul} = \frac{\text{Monthly total catch}}{\text{No. Boat} \times \text{No. Day} \times 5}$$

here "5" is the number of operations per day per fishing boat. From the figure, in 1965 the maximum catch per haul was 8.6 kg in October, 6 kg in September of the following year and decreased to 5 kg in October 1968. Fig. 4 shows the seasonal fluctuations of *S. prominentis* and other shrimp species, in autumn the catch of *S. prominentis* was very high while that of the other species was very low. The other species was very high in spring at which time the catch of *S. prominentis* was very poor.

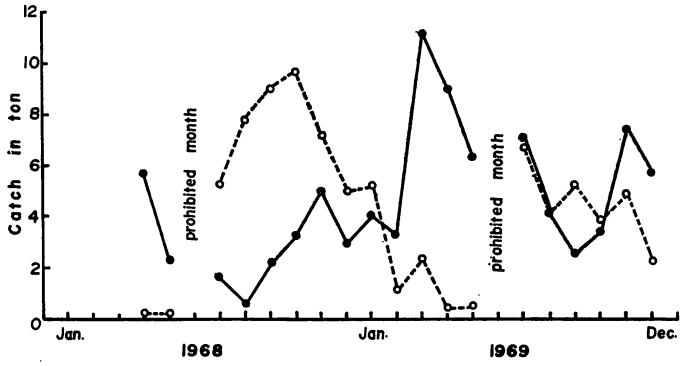

Fig. 4. Fluctuation of *S. prominentis* and other shrimp species in 1968 and 1969. (Data from Kanoya Fishing Co-operative).
Open circle: *S. prominentis*, Closed circle : Other species

Water Temperature and Salinity

Water temperature and salinity were obtained from the oceanographic observation stations in the inner bay (St. nos. 18-21) at a depth of 100 m and in the middle bay (St. nos. 9-11) at a depth of 200 m.

From Fig. 5, the range of water temperature in the inner bay in 1969 was 15.0-16.9°C and 13.4-16.8°C in 1970. The maximum temperatures for the two years were in November and January while the minimum were in April and May respectively. In the middle bay the range of temperature in 1969 was 14.8 to 15.3°C and in 1970 was 14.1-16.2°C. The maximum temperatures of these two years were in November and January respectively and the minimum of both years was in April.

From Fig. 6, the salinity of the inner bay in 1969 and 1970 were 33.20-34.00 ‰ and 33.70-34.40 ‰ respectively. In the middle bay the salinity in 1969 and 1970 were 34.32-35.24 ‰ and 33.66-34.95 ‰ respectively.

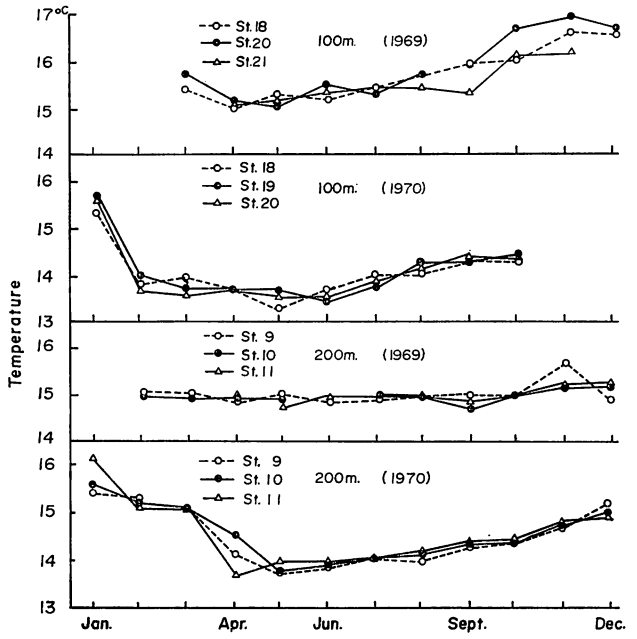

Fig. 5. Monthly variation of water temperature of the fishing grounds from January 1969 to December 1970.

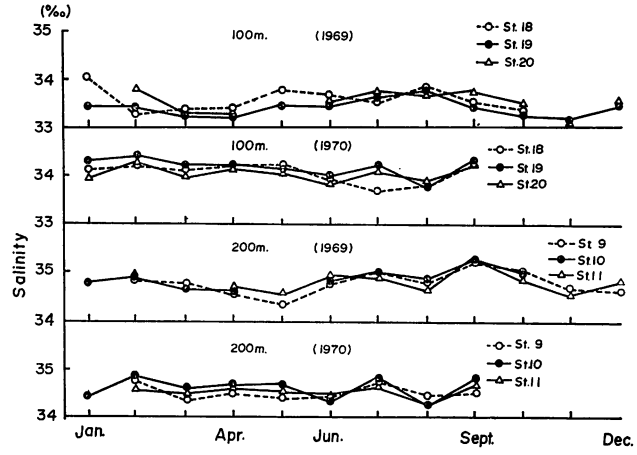

Fig. 6. Monthly variation of salinity of the fishing grounds from January 1969 to September 1970.

Histology of Ovarian Eggs

The ovaries used in this study were colected from July to December 1969. The ovaries were weighed and fixed in Buin's fluid for 24 hours and then preserved in 70 % alcohol. For microscopic observation a small portion was taken usually from the cephalothorax and embedded in parafin and after which 8-10 microns

sections were cut. These sections were stained with Delaphield's haematoxylin and eosin.

The stages of development of the ovarian eggs of *S. prominentis* were identified according to the degree of maturation following the lines adopted by Oka and shirahata (1965)[2], Oka (1967),[4] and Tuma (1967)[5]. The stages of developing eggs are shown in Plate I

(1) Nucleolus stage: The ova are small and densely stained blue with haematoxylin. The diameter of an ovum is about 0.05 mm.

(2) Pre-yolk stage: The diameter of an ovum is larger than 0.05 mm. The nucleus is small and has nucleoli arranged in the periphery. The ooplasm is stained blue with haematoxylin.

(3) Early yolk-globule stage: At this stage the nucleoli are linked together like a chain. The yolk globules stained blue by haematoxylin are found in the cytoplasm. The diameter of ova is about 0.07-0.1 mm.

(4) Late yolk-globule stage: Most of the ova of this stage are stained red with eosin. The diameter of an ovum is about 0.15 mm. At this stage the jelly like substance begins to appear in the peripheral parts of the ovum.

(5) Pre-mature stage: The ova become larger and having diameter of about 0.15-0.17 mm. The nucleus and the nuclear membrane disappear and the jelly like substance spreads inward.

(6) Autolysis stage: The ova that cannot be spawned are degenerated and absorbed by the body. During the autolysis the follicle cells increase, vacuoles coalesce with each other and enlarge their sizes while the ova degenerate.

Spawning Season

Monthly change of the stages of ovarian eggs were observed and the result was shown in Fig. 7. In July only Nucleolus stage and pre-yolk globule stage were found, in August about 10 % of ovarian eggs were in Premature stage and from this month the percentage of this premature stage was gradually increased. The highest percentage of premature eggs was 50 % in November and December, however in December the others 50 % of the ovarian eggs were in Autolysis stage.

The maturity index of this species is shown in Fig. 8. This index was calculated by the following formula: —

$$\frac{OW}{BW-OW} \times 100$$

in which OW is the ovarian weight, and BW is the body weight. It can be seen from the figure that in August the range of the maturity index was very wide, but the average was very low. The average of maturity index was gradually increased and reached the highest peak in October and was still very high in November and after that it decreased sharply in December.

From the results of these two observations it may be assumed that the spawn-

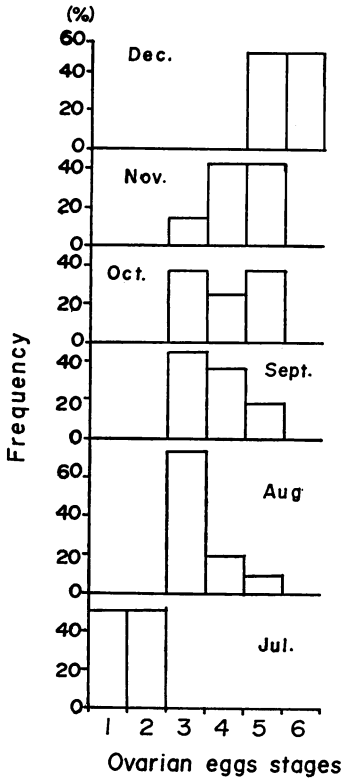

Fig. 7. Changes in the stages of ovarian eggs during July and December 1969.

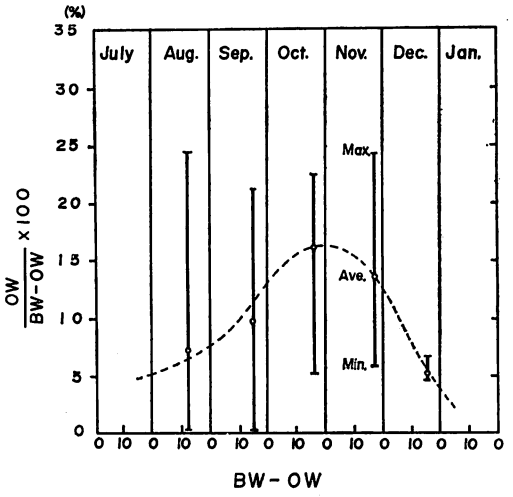

Fig. 8. Monthly change of maturity index of *S. prominentis* from August to December 1969.

ing season of *S. prominentis* begins in August and the highest peak might be during October and November and the end of the season might be in December or January.

Age and Growth

1) Length frequency distribution

A class interval of 10 mm was set as a convenient value for carapace length and histograms of the length frequency distributions of male and female from commercial stock observed in every month beginning from May 1969 to March 1971 are shown in Figs. 9 and 10 respectively. In Fig. 9 it appears that from May 1969 there were two groups on the basis of size of carapace, a small size group (0 age group) having mode of 18.5 mm and a large size group (1 age group) having mode of 28.5 mm. The 0 age group grew and attained the mode of 26.5 mm in September, thus taking about 5 months for an increase of 8 mm in the carapace length. The 1 age group grew up at a slower rate and was not found in the catches after October when they reached the maximum size of 38.0 mm. Fig. 10 shows the length frequency of female, here too, a small size group (0 age group) could be distinguished from a large size one. The 0 age group having a mode of 18.5 mm in May and they continued growing and reaching a mode of 32.5 mm in September. The growth during 5 months was about 14.0 mm. The 1 age group appeared in a small number having a mode of about 34.5 mm and very scarce in

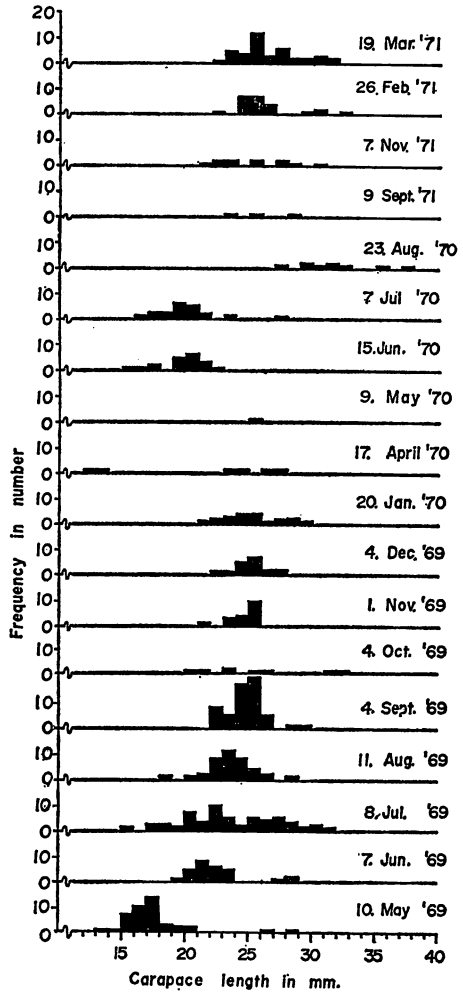

Fig. 9. Length frequency distributions of male, *S. prominentis* from May 1969 to December 1971.

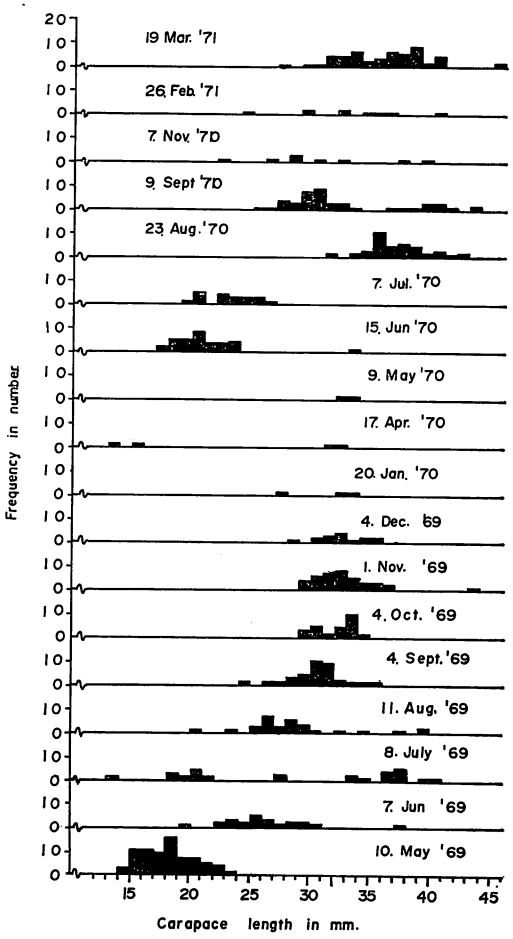

Fig. 10. Length frequency distribution of female, *S. prominentis* from May 1969 to December 1971.

November when they attained the size of about 45.0 mm in carapace length. In both figures it can be seen that in the next spring (April 1970) new small size group appeared in the commercial catches and they became larger in number while the older age group seemed to be decreased.

The frequency distributions of male and female during the entire period (May 1969-July 1970) of investigation are shown in Fig. 11. These two graphs show clearly that there were two distinct groups. For the male, the small size group (0 age group) having the range of carapace legth 13.0-21.0 mm and the large size group (1 age group) having 18.0-33.0 mm. For the female, the carapace length of the small size group (0 age group) ranged from 13.0-27.0 mm while that of

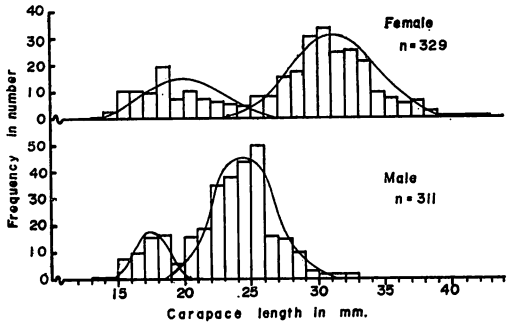

Fig. 11. Length frequency distribution of males and females, *S. prominentis*, caught during entire period from May 1969 to July 1970.

the large size group (1 age group) was 23.0-43.0 mm.

2) Length-weight relationship

The weight of any animal may be considered a function of its length (Roundsefell and Everhart) (1959)[6]. For shrimp, carapace length was found to be as reliable a measure of size as over all length or volume (Dall) (1958)[7] and Hall (1962)[8] used the following formula to express the relation between length and weight

$$W=kC^a$$

where W is the body weight, C is the carapace length, k and a are constants. This equation expresses the curvilinear relation and could be re-written in its log form to transform the curve into a straight line as follows: —

$$\log W=\log k+a \log C$$

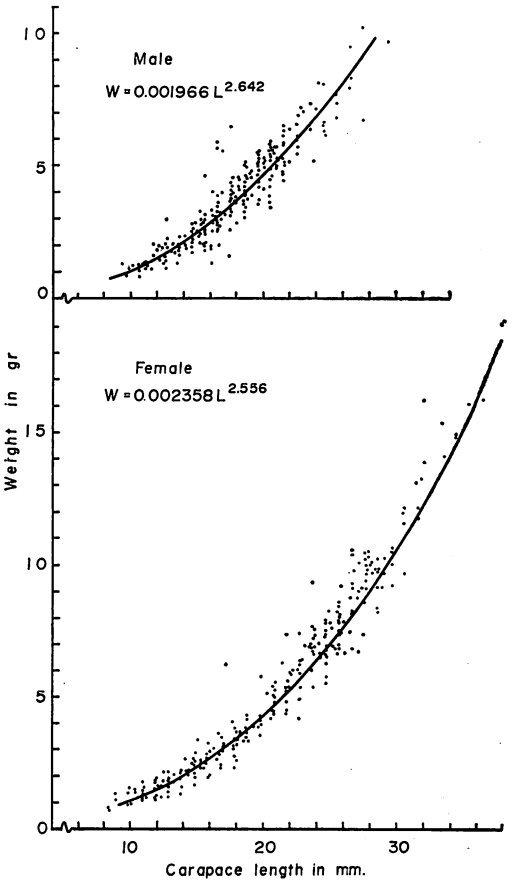

Fig. 12. The relationship between carapace length and body weight of male (above) and female (below), *S. prominentis*.

The body weight of each sex was ploted against the carapace length and a curve was drawn through the points (Fig. 12). By using the above equation the length-weight relationship of *S. prominentis* of each sex is as follows: —

$$\text{Male: } W=0.001966\ C^{2.664}$$
$$\text{Female: } W=0.002358\ C^{2.556}$$

Comparing the size of both sexes, female is larger than male.

Discussion

Considering the results of this investigation on shrimp fishery of this bay, it seems that the shrimps natural resource is being depleted. This may be due to many factors such as overfishing and fishing during spawning season.

S. prominentis is mainly caught in the mid bay area during spring and summer and in the inner bay during autumn and winter. It might be that the shrimp migrates from the deeper area of the middle bay to the shallow area of the inner bay during autumn and winter. And from the results of the observations on the monthly change of ovarian eggs and maturity index, this shrimps has spawning season in autumn and the peak of spawn was found in October and November.

From the observatios on the structure of ovaries and development of ovarian eggs of this shrimp revealed that they are similar to those of other Penaeidae, however the color of the ripe ovaries is deep orange. The diameter of the ovarian eggs ranges from 0.05-0.17 mm and these eggs are classified as small type eggs among the other Penaeidae.

Comparing the spawning season of this species with those of the other Penaeidae in Japan, this shrimp has the spawning season later than most of Penaeidae, such as *Penaeus japonicus* (1955)[9] and *Metapenaeus joyneri* (1955).[10] Concerning the environmental factors of Kagoshima Bay the water temperature (at the bottom layer) may have some effects on the spawning period of this species, as it can be seen that during autumn (September to December) the water temperature, of the fishing grounds, especially in the inner bay has a tendency to rise and reach a maximum in January. This condition might be suitable for the mother shrimps to spawn.

As for the age and growth of *S. prominentis*, there were two age groups in the commercial stocks *i.e.* the 0 age group and the 1 age group. The first group may becomes 1 age group and the second group becomes 2 age group in autumn of the following year and they spawn and the older might die afterwards. In April of every year 0 age group recruits to the commercial stocks. Considering the life-span of this species which may be about 2 years and they spawn twice in their life.

Acknowledgement

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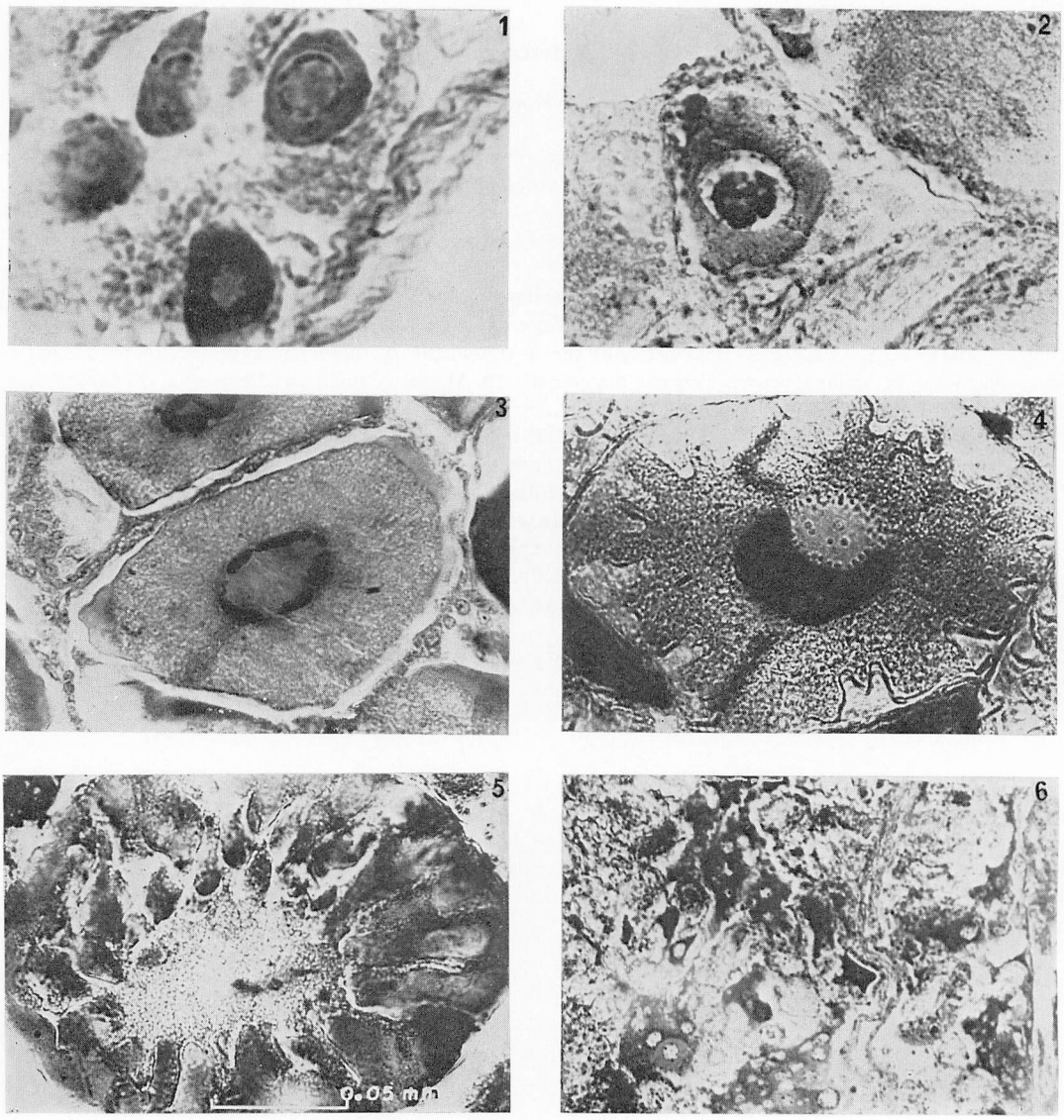
PLATE I



Microphotographs of cross-section of eggs of *Solenocera prominentis* KUBO.

Fig. 1. Nucleolus stage.
Fig. 2. Pre-yolk stage.
Fig. 3. Early yolk globule stage.
Fig. 4. Late yolk globule stage.
Fig. 5. Premature stage.