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# Some Aspects of the Reproductive Biology of the Swimming Crab, *Ovalipes punctatus* (De Haan), in Sendai Bay and its Adjacent Waters

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## Summary

The reproductive biology of the swimming crab, *Ovalipes punctatus* (De Haan), in Sendai Bay and its adjacent waters was investigated from 1975 to 1977. The results are summarized as follows.

1. The crabs of both sexes grow up to 50–65 mm in carapace width in their first year and females and males grow up to 70–90 mm and 80–95 mm in their second year, respectively. The biological minimum size of the crab is estimated to be 45 to 50 mm in carapace width and its life span is appraised to be 2–2.5 years for both sexes.

2. Spawning in this region lasts for about two months from mid-September to mid-November. The main spawning ground seems to be situated in the comparatively offshore region at the depth of 40–60 m. The main spawners are 2-year-olds with their mode at 75–80 mm in carapace width, partly supplemented by 1-year-olds. Duration of the egg-carrying period is estimated to be about 20 days. The number of eggs of a 2-year-old is 300,000–700,000.

3. The life of the swimming crab consists of five developmental stages, i.e., egg, larval, young, immature, and adult.

4. Immature crabs of both sexes mainly inhabit nearshore regions and sexual segregation is found at their adult stage; the females and males inhabit offshore and nearshore, respectively.

The swimming crab, *Ovalipes punctatus* (De Haan), is captured by small trawl nets and bottom gill nets in Sendai Bay and its adjacent waters. The fishing is carried out mainly from May to December. This crab with local names as "aka-gani" or "watari-gani", is edible, and its commercial price at fish markets is comparatively high. Thus, this crab is one of the important resources for the coastal fisheries in this region where crustacean resources are very scanty.

Whereas some features of the ecology of the crab have been reported by Kamei (1), Onuma (2) and Akimoto (3) an intensive study is needed to make clear their whole life history.

The present research especially aims at obtaining more fundamental knowledge

regarding the crab's reproductive biology, as a foundation for explicating the mechanisms of the population fluctuation of this crab inhabiting the region from Sendai Bay to off northern Fukushima Pref.

## Materials and Methods

The ecological surveys were carried out at Haragama Fish Market, Fukushima Pref., twice or three times a month from May 1975 to December 1977 on carapace width, sex, ovigerous or not, and fishing localities of trawl-caught crabs. Data were not available for July and August because of closed season.

The carapace width was defined as the distance between the 4th and 5th tooth on the anterolateral borders of carapace and measured to the nearest 0.1 mm with calipers.

In order to comprehend the living conditions of the crab in the area close to land, similar surveys were carried out for the samples caught by bottom gill nets

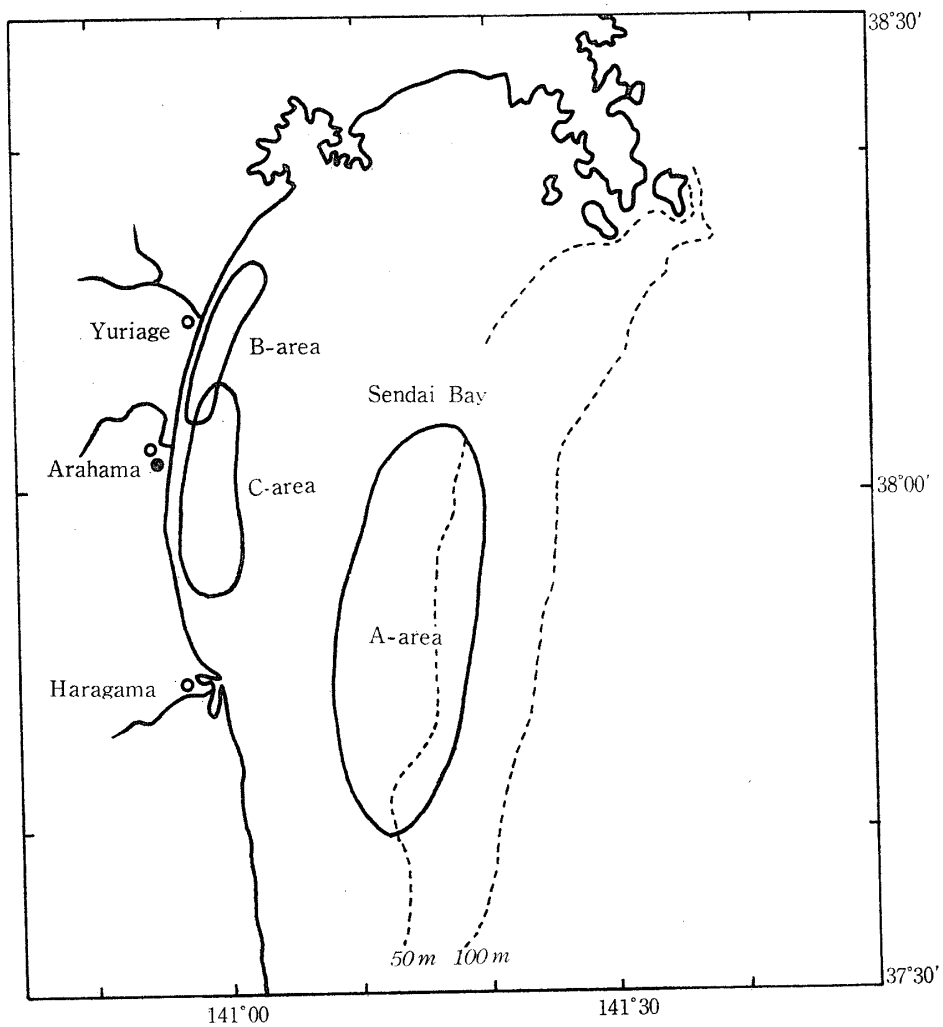


FIG. 1. Area surveyed.

at two stations, i.e., Yuriage, Miyagi Pref., for May-September 1975, and Arahama, Miyagi Pref., for May-November 1976.

The small trawlers operated in the area from the central Sendai Bay to off northern Fukushima Pref. at the depth of 40–80 m (Fig. 1 A-area), while the bottom gill net boats executed their fishing close to the land at the depth of 5–40 m (Fig. 1 B, C-area).

In order to estimate the duration of the egg-carrying period of the crab, ovigerous females were reared in October and November 1976. The crabs taken by the bottom gill nets off Haragama and Yuriage were carried to the two 200-liter tanks of the Fisheries Laboratory of Tohoku University at Onagawa Town, Miyagi Pref. Nine crabs carrying eggs (seemingly newly spawned from their appearance) were used. The tank water temperature was 16–20°C similar to that in the crab's environment.

The number of eggs carried by the five crabs were estimated by the following method; i) all the eggs are cut off from the pleopod and weighed, ii) a subsample about 0.1 g is removed, weighed exactly, disjoined into separate eggs in a laboratory dish filled with sea water and counted, and iii) the number of eggs is obtained by multiply the subsample egg number by the ratio of the carried egg weight to the subsample weight. Operations i) and ii) are repeated three times for each sample, to calculate a mean.

## Results

*Seasonal Changes in Carapace Width*

Figs. 2 and 3 show the frequency distributions of carapace width of the crabs caught in 1975 and 1976.

On the assumption that the carapace width at each molting stage is distributed normally, the carapace width was distinguished among molting stages using Harding's method (4). Mean carapace width at each molting stage by sex is shown in Table 1.

In the present report the molting stage groups distinguished are named for convenience as I～VI-stage groups in progressive order according to their mean carapace width. Since small-sized crabs under 40 mm in carapace width were scarecely obtained in the course of the survey, the absolute stage number is uncertain.

Fig. 4 shows the month-to-month change in the frequency distribution of the carapace width in female crabs by area in 1976.

A-area (offshore): The catches by small trawlers were composed of II～V-stage groups through the fishing season, and the relative proportion among them changed seasonally. In May and June the proportions of II, III, IV, and V-stage groups were 35.2, 24.2, 30.5 and 11.1 percent, respectively, whereas from September to November III-stage group occupied 74.5 percent of the whole and II, IV and V-

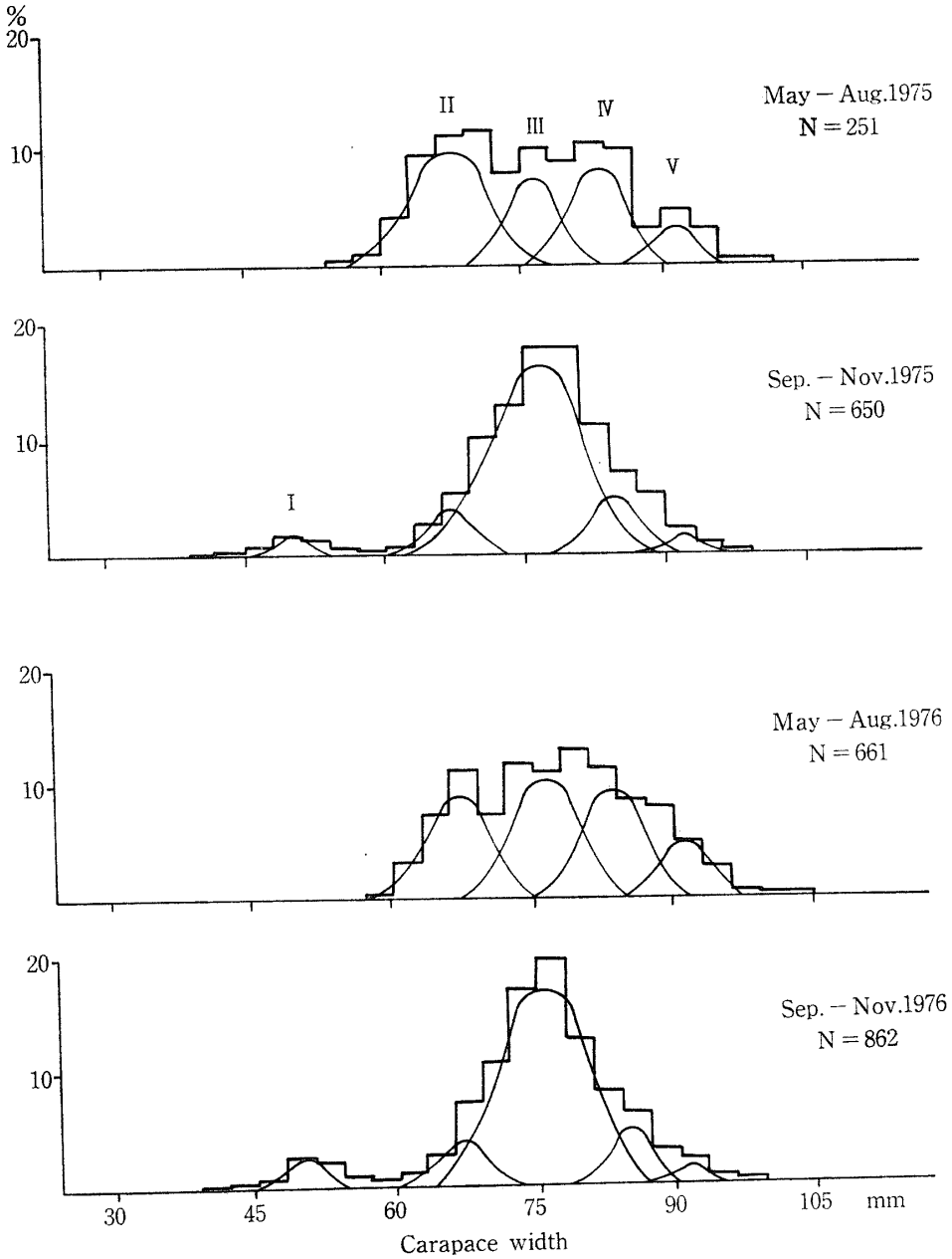


**Fig. 2.** Frequency distributions of carapace width of females by season. The normal curves show the molting stage groups distinguished with Harding's method.

stage groups reduced their proportions to 10.1, 12.3 and 4.1 percent, respectively.

C-area (nearshore): From May to August large crabs corresponding to II~V-stage groups were caught. In September smaller I-stage group appeared in the place formerly occupied by the larger groups and its mode of carapace width was 50.6 mm.

Fig. 5 shows the month-to-month change in the frequency distribution of the carapace width in male crabs by area in 1975.

B-area (nearshore): Samples obtained from May to August were mainly

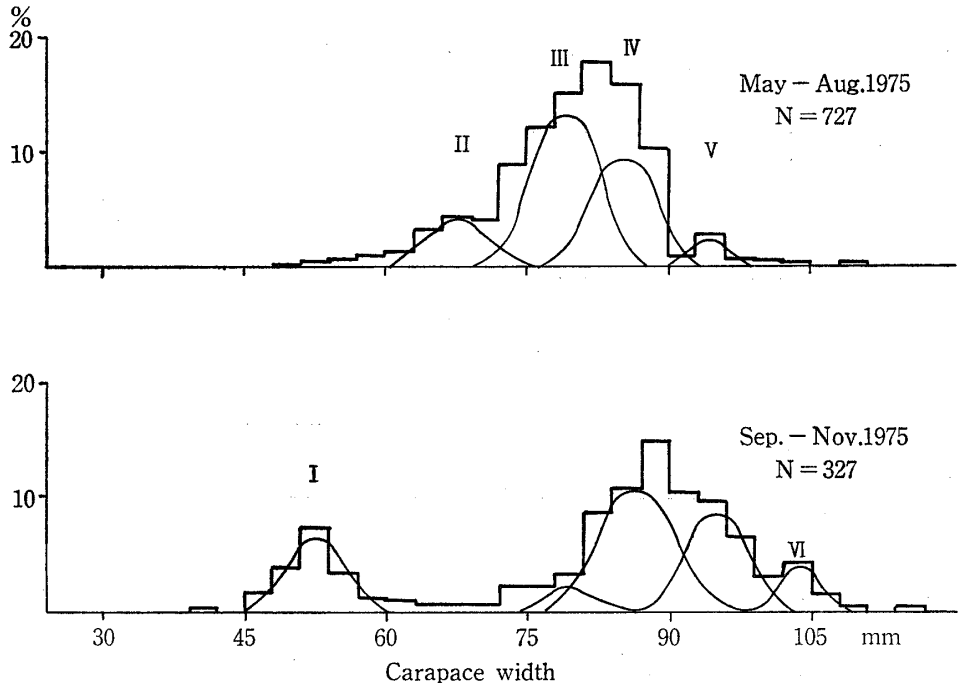


FIG. 3. Frequency distributions of carapace width of male by season. The normal curves show the molting stage groups distinguished with Harding's method.

TABLE 1. *Average Carapace Width by Sex at the Molting Stages Distinguished with Harding's Method.*

| Molting stage | Carapace width | |
|---|---|---|
| | Female | Male |
| | mm | mm |
| I | 50.6 | 52.3 |
| II | 67.2 | 68.0 |
| III | 77.1 | 79.3 |
| IV | 84.0 | 86.2 |
| V | 92.5 | 94.4 |
| VI | — | 103.5 |
| Maximum | 102.8 | 115.2 |

composed of II ~ V-stage groups. The negative distortion of the frequency distribution of carapace width tended to reduce with time. Apparent change from the larger size groups over 60 mm in carapace width to the smaller I-stage group was also observed in the male.

A-area (offshore): Though the male specimens were a few in the A-area they were mainly composed of the groups beyond II-stage inclusive and IV and V-stage groups occupied the large proportion from September to November.

*Seasonal Change in Sex Ratio*

Fig. 6 shows the seasonal change in the proportion of females by area, showing that they occupied 70–90 percent in A-area while the proportions were 20–30 percent in B and C-area in the period from May to August.

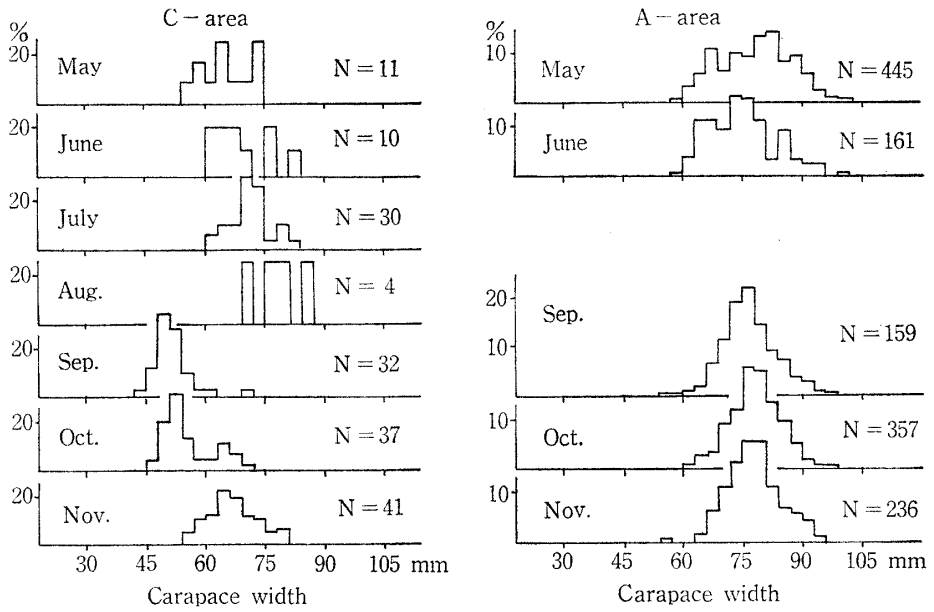


FIG. 4. Month-to-month change in the frequency distributions of carapace width of females by area in 1976.

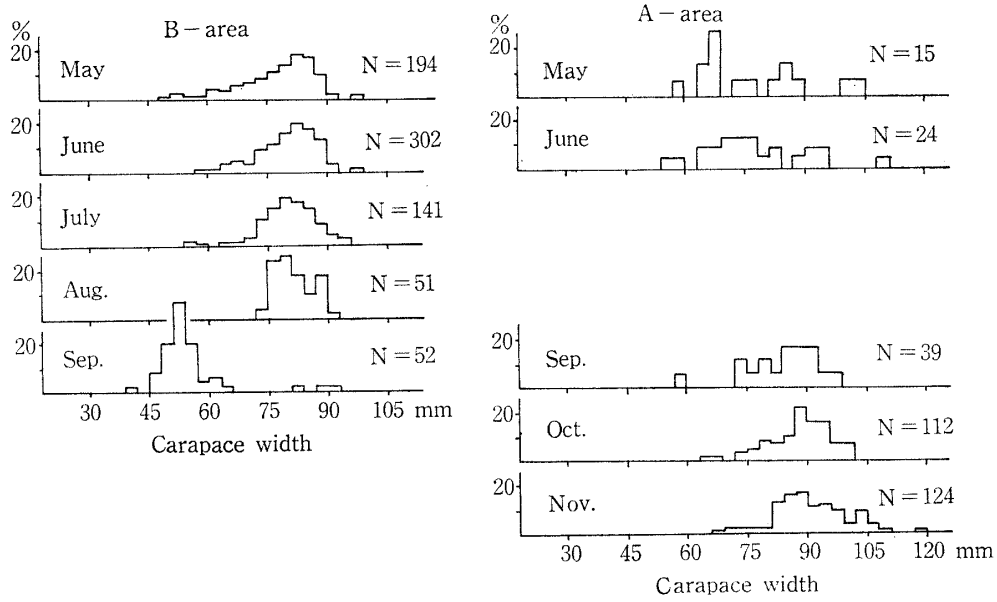


FIG. 5. Month-to-month change in the frequency distributions of carapace width of males by area in 1975.

Unevenness in the proportions of both sexes was found only for the older groups over II or III-stages inclusive.

*Seasonal Change in Incidence of Ovigerous Females*

Generally the crabs have the nursing habit in which the eggs laid adhere to the hairs on the pleopods between spawning and hatching. This period is called the

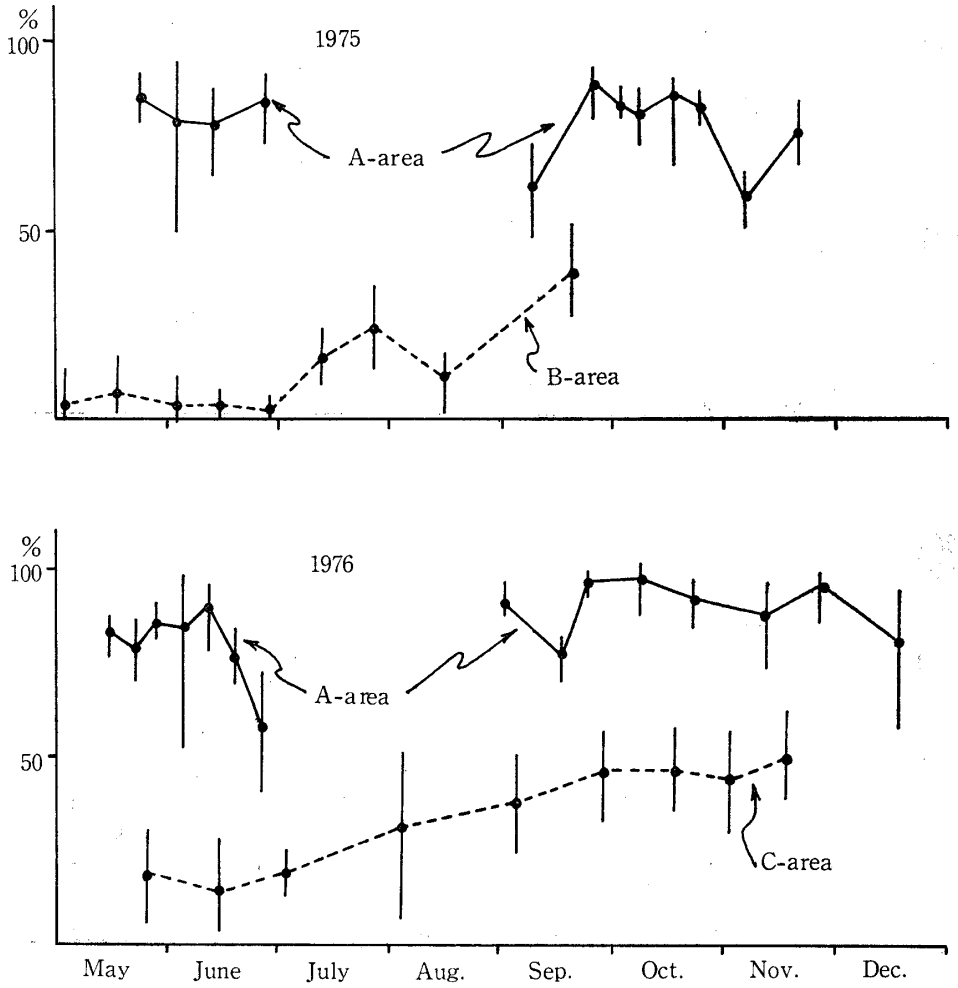


FIG. 6. Seasonal changes in the proportion of the females by area. The vertical bars denote the 95% confidence limits.

egg-carrying period and the females in this situation are called ovigerous females.

Fig. 7 shows the seasonal change in the proportion of the ovigerous females in A-area in 1975–1977. Most ovigerous females occurred from September to November, reaching a maximum in mid-October, i.e., 78.3 percent, 86.4 percent and 77.8 percent in 1975, 1976 and 1977, respectively.

Though a few ovigerous females were found in May and June every year, the incidence was 10–20 percent, very low compared with that from September to November. The ovigerous females of I or II-stage groups occurred most abundantly from September to November 1976 in C-area, showing an incidence of 21.2 percent.

*The Frequency Distribution of Carapace Width of the Ovigerous Females*

It is shown in Fig. 7 that most ovigerous females appeared from September to November. Fig. 8 shows the frequency distributions of carapace width of the ovigerous females in A-area in 1975–1977, indicating that most spawners belong to III-stage group.

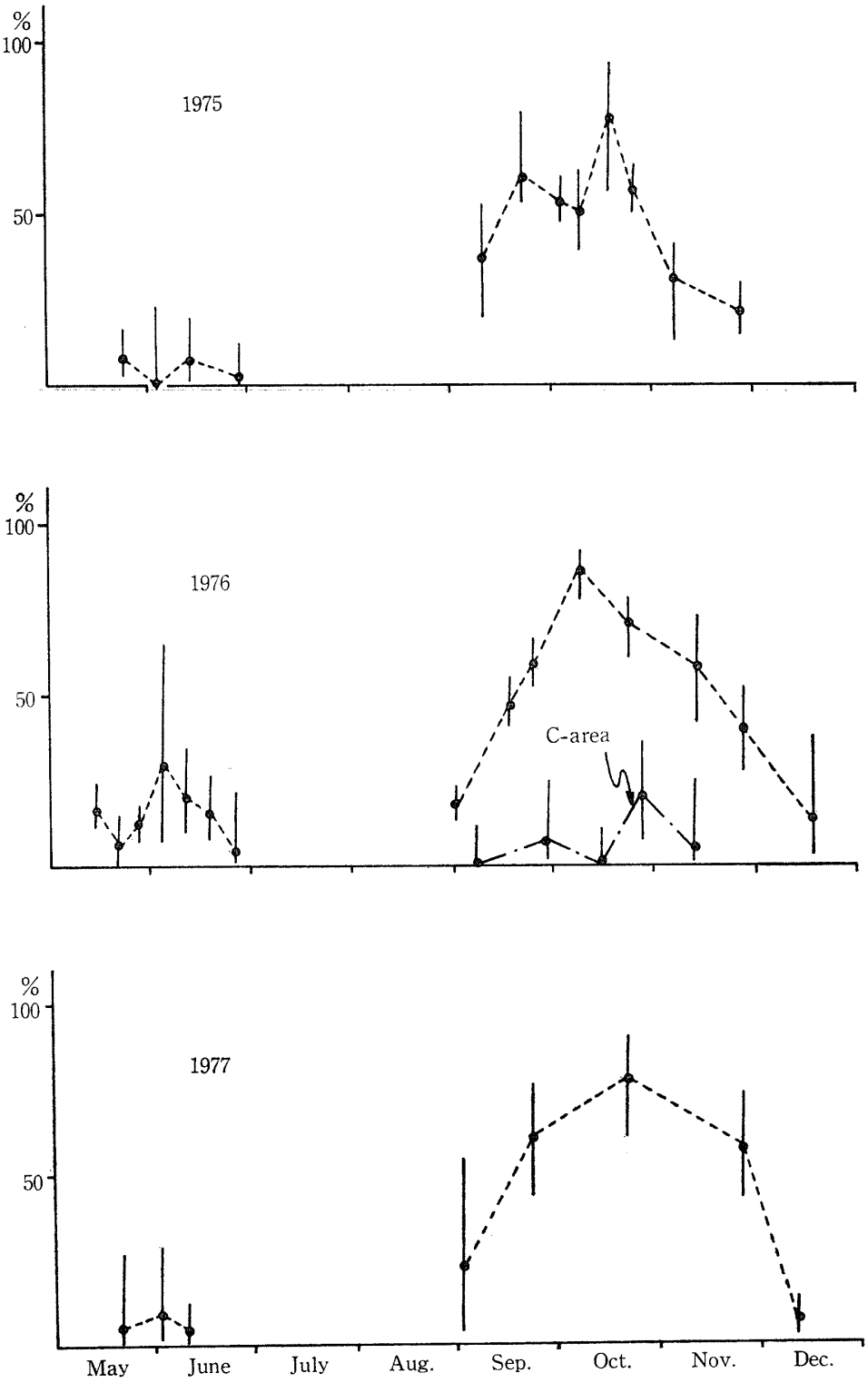


FIG. 7. Seasonal changes in the incidence of the ovigerous females in A-area by year. The vertical bars denote the 95% confidence limits.

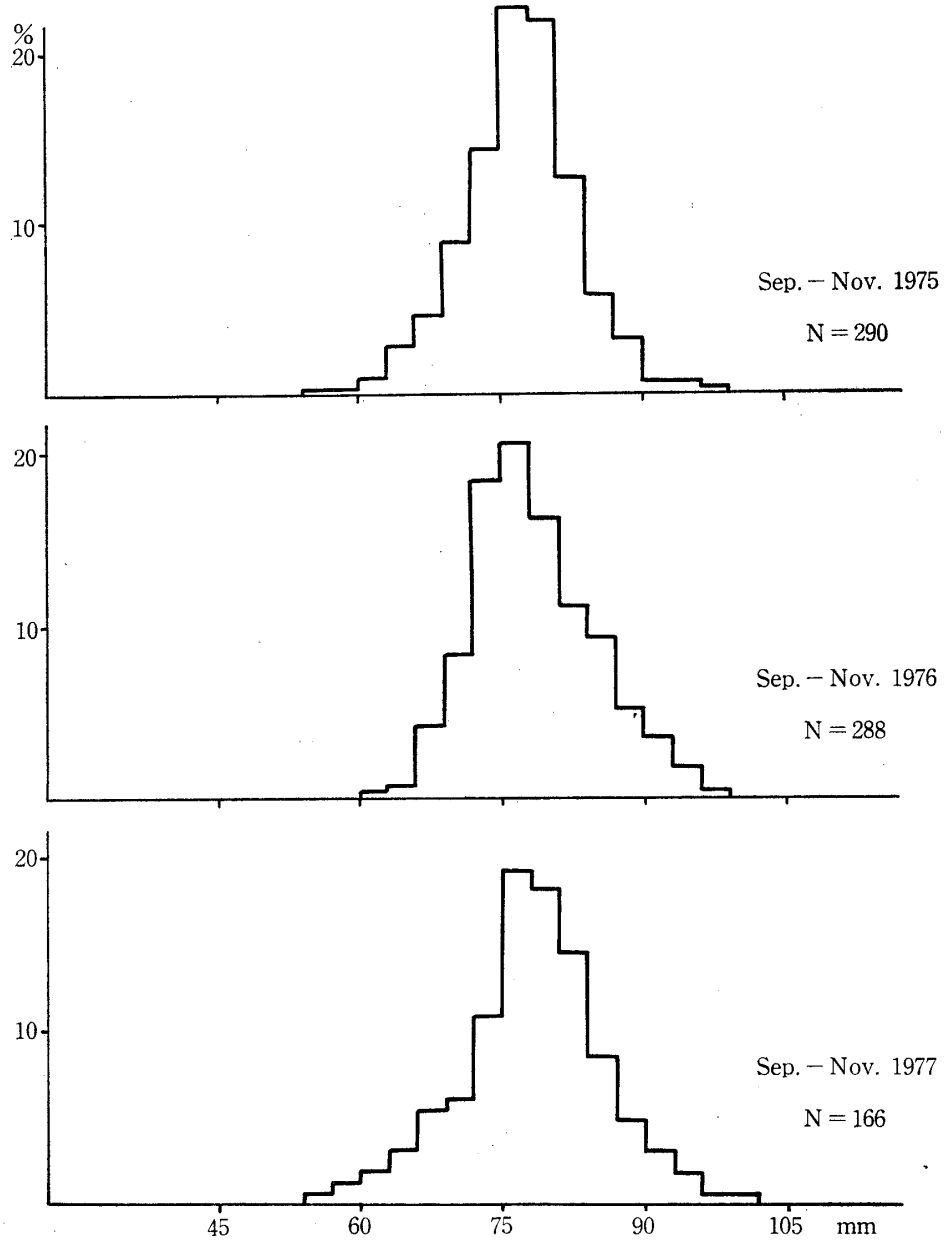


FIG. 8. Frequency distributions of carapace width of the ovigerous females from September to November by year.

Substantial differences in carapace width of the ovigerous females are not found between years and between months in a year.

The maximum and minimum carapace width of the ovigerous females were 100.4 mm and 49.7 mm, respectively.

*Duration of the Egg-carrying Period and the Fecundity*

Rearing experiments were conducted to clarify the duration of the egg-carrying period of this crab, as shown in Table 2.

The individual identification was made and a small amount of eggs were

TABLE 2. *Duration of the Egg-carrying Period.*

| No. | Carapace width | Experiment started at | Hatching commenced at | Hatching ended at | Days between spawning and hatching |
|---|---|---|---|---|---|
| | mm | | | | |
| 1 | 84.7 | Oct. 14 | Oct. 29 | Nov. 2 | 15-19 |
| 2 | 78.1 | | Oct. 28 | Oct. 31 | 14-17 |
| 3 | 77.9 | | Nov. 1 | Nov. 3 | 18-20 |
| 4 | 74.2 | Oct. 18 | Nov. 3 | Nov. 4 | 16-17 |
| 5 | 79.0 | | Oct. 29 | Nov. 1 | 11-14 |
| 6 | 83.6 | | Nov. 4 | Nov. 5 | 17-18 |
| 7 | 72.2 | | Nov. 4 | Vov. 6 | 17-19 |
| 8 | 77.7 | | Oct. 30 | Nov. 2 | 12-15 |
| 9 | 75.6 | | Nov. 5 | Nov. 8 | 18-21 |

TABLE 3. *Fecundity.*

| No. | Carapace width | Weight of batch | Fecundity per gr. | Fecundity |
|---|---|---|---|---|
| | mm | g | | $\times 10^5$ |
| 1 | 72.2 | 12.76 | 32613.3 | 4.161 |
| 2 | 84.3 | 25.34 | 28920.7 | 7.329 |
| 3 | 76.0 | 21.37 | 30432.0 | 6.503 |
| 4 | 74.1 | 10.91 | 29981.6 | 3.271 |
| 5 | 80.7 | 19.85 | 32404.1 | 6.432 |

removed from a crab twice or three times a day to be observed. There were some differences in development in a batch, not depending upon the location in the batch. Synchronism in hatching was not found, taking 1–4 days for all the eggs to hatch. Fecund ity is shown in Table 3.

## Discussion

As is evident from our observations the egg-carrying period lasts for about 20 days. Thus the period of high incidence of the ovigerous females may be regarded as the spawning season, though in some species spawning seasons are not able to be estimated from only the incidence of the ovigerous females because of their long-term egg-carrying periods.

Provided that spawning season is defined as the period when the incidence of the ovigerous females is over 50 percent, it lasts for about two months from mid-September to mid-November in this area.

In the spawning season, since the incidence of the I and II-stage females in the nearshore regions was 21.2 percent at most, spawning was presumably done in the offshore regions at the depth of 40–60 m (5).

According to Kamei (1) spawning is carried on twice a year, September to October and January to April in Sagami Bay and Onuma (2) and Akimoto (3) observed long-term spawning from October to next April-June off Ibaraki and Fukushima Prefs., respectively.

In these studies the proportion of the ovigerous females was 5.3–26.2 percent in Sagami Bay, 20–50 percent off Ibaraki Pref., and under 5 percent off Fukushima Pref., considerably low in comparison with that of the present study. These differences may resulted from the insufficient survey of the main spawners distributed in the areas deeper than 40 m.

As seen above, most spawning occurred in the two months around October and another comparable spawning was not observed in spring.

In Fig. 9 growth curves were drawn in by eye for the carapace width in Sendai Bay. Akimoto (3) reported that the crabs 10 mm in carapace width in May grew to 30 mm in July, 40 mm in August, 55 mm in September and 65 mm in November. The crabs from B and C-areas, 55 mm in September and 65 mm in November presumably correspond to I and II-stage groups, respectively.

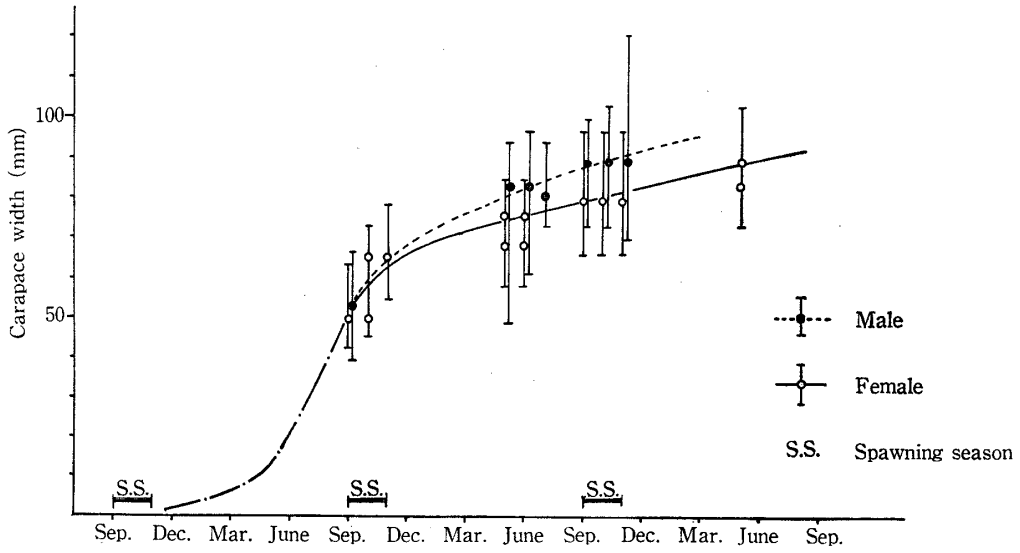


FIG. 9. Growth curves in carapace width in Sendai Bay, by sex. The vertical bars denote the carapace width range.

From Akimoto and Fig. 9, crabs in B and C-areas in September to November seems 1 year old born in the last autumn. The larger II ~VI-stage crabs taken in A-area nearly all the year round and in B and C-areas for April-August are estimated to be 2 years old.

As shown in Fig. 8, the main spawners are at III-stage and most of them are distributed in A-area, indicating that they are 2 years old. Some crabs spawn in their second year and they are at I and II-stages in B and C-areas.

The minimum carapace width of the ovigerous females sampled is 49.7 mm. Onuma (2) reported that the crabs over 45 mm in carapace width mature, showing that the biological minimum size may be 45–50 mm. Life span of the crab is appraised to be 2–2.5 years since the crabs older V and VI-stages in female and male, respectively, were not found.

In examining the previous and present studies, the whole life of this crab may preferably be divided into the five developmental stages as below.

1. Egg — From laying to hatching. Adhering to haris on the pleopods of mother crabs.
2. Larval — From hatching to settling on sea bed.
3. Young — After settling to 30 mm in carapace width. At this stage crabs acquire specific morphological features, without sexual distinction in pleopod.
4. Immature — 30–60 mm in carapace width. Morphologically indistinguishable from the adult. Secondary sexual characters disclosed and the form of pleopods sexually distinct.
5. Adult — Over 50–60 mm in carapace width.

The timing of settling is March to April, inferred from the growth curves (Fig. 9), indicating that the duration of the larval stage would be three to four months. The immature stage corresponds to the I and II-stages as shown in Table 1, being about one year from birth. At this stage the crabs evenly sexed are mainly distributed in the nearshore areas. II and III stages and above are the adults and conspicuous sexual segregation was found in the two years old adults.

In comparing Fig. 6 with Figs. 4 and 5, habitat segregation seems to occur between stages II and III, in other words, from immature to adult.

These are insufficient data however they suggest that the adult males stay in the nearshore region until July-August then move offshore for reproduction.

## Acknowledgements

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