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Temporal Distribution of the Japanese Mantis Shrimp *Oratosquilla oratoria* Larvae during Transition from Good Catch Period to Poor Catch Period in Tokyo Bay, Japan

Jun Ohtomi[1]*, Hironori Kawazoe[1], and Toshio Furota[2]

Key words : larva, larval stage, temporal distribution, mantis shrimp, *Oratosquilla oratoria,* Tokyo Bay.

Abstract

Commercial catch of the Japanese mantis shrimp *Oratosquilla oratoria* (Stomatopoda, Squllidae) in Tokyo Bay was high during 1980s (good catch period), but dropped dramatically around 1992 and continued to be low during the 1990s (poor catch period). The major peak of larval abundance of *O. oratoria* appeared in June/July during the good catch period, while it appeared in August/September during the poor catch period. In the present study, we examined the temporal distribution of *O. oratoria* larvae during the transition from good catch period to poor catch period in Tokyo Bay. The larvae occurred from June to November, with a minor peak in July and a major one in September. The appearance of this major peak in September was considered to be an indication of the coming poor catch period. All of the eleven larval stages were collected during the research period. Stage-III larvae that were the first phase of pelagic life were numerically dominant. The propelagic-stage larvae (stages I and II) occurred only from June to September, while the larvae in the final stage of the planktonic phase (stage XI) occurred from July to November. Total duration of the larval phase was estimated to be one to two months.

The Japanese mantis shrimp *Oratosquilla oratoria* (Stomatopoda, Squillidae) is one of the most important target species mainly for small-scale trawlers in various part of Japan including Ishikari Bay, Sendai Bay, Tokyo Bay, Ise Bay, the Seto Inland Sea and Hakata Bay[1)]. In Tokyo Bay, the catch of *O. oratoria* showed a dramatic rise and fall in the past decades, with little or no catch during 1970 to 1973. Afterwards, around 1978, a recovery of the catch was recorded and the catch continued to be relatively high during 1980s, but dropped dramatically around 1992 and continued to be low during 1990s. Therefore, the 1980s was defined as recovery and good catch period and the 1990s was defined as poor catch period for *O. oratoria* in Tokyo Bay[2)].

By the examination of the change in composition of the market size categories of *O. oratoria* using monthly catch data from 1977 to 1989 and evaluation of the fishing intensity to the stock based on the fisheries and biological parameters determined previously, Ohtomi and Shimizu[3)] suggested that the fishing intensity was at around the optimal level during the late 1970s and 1980s. In that paper, however, they also suggested the necessity to keep

[1] 鹿児島大学水産学部資源育成科学講座 (Department of Aquatic Resource Science, Faculty of Fisheries, Kagoshima University, 4-50-20 Shimoarata, Kagoshima 890-0056, Japan)
[2] 東邦大学理学部生物学科 (Department of Biology, Faculty of Science, Toho University, 2-2-1 Miyama, Funabashi, Chiba 274-0072, Japan)
* Corresponding author, Email: ohtomi@fish.kagoshima-u.ac.jp

watching of future progress of the fishery. After 1990s, Kodama *et al.*[4] observed the decrease in the size at first maturity and they believed its positive relationship to the decrease in stock size as seen in other crustacean species[5,6].

In order to clarify the mechanism of stock fluctuation of *O. oratoria* and take appropriate fisheries management measures, it must be required to study larval ecology because the dynamics including dispersion and mortality during the period of planktonic phase is a critical factor of fluctuation of the adult stock. Nakata[7] examined the spatiotemporal distribution of *O. oratoria* larvae during the good catch period, whereas Shimizu[8] and Kodama *et al.*[4] examined the temporal distribution of the larvae during the poor catch period and observed the difference in the peak season of larval abundance between the two periods. In the present study, we examined the temporal distribution of *O. oratoria* in each larval stage during the transition from good catch period to poor catch period, using samples collected from September 1990 to September 1991.

Materials and Methods

O. oratoria larvae were collected monthly using a plankton net (50 cm mouth diameter, 170 cm length and 0.497 mm mesh) during daytime from September 1990 to September 1991 in Tokyo Bay (Fig. 1). Sampling surveys were conducted at 15 stations of which location and water depth were shown in Table 1.

Two procedures, slope towing and bottom horizontal towing, were adopted. For slope towing, the net was fixed on the stopper and descended and ascended repeatedly between the sea surface and 1.0 m above the bottom for about 5 minutes with a horizontal speed of about 0.5 m/second. In bottom horizontal towing, after the net descended freely along a guide rope stretched with a 15 kg depressor, the angle of the guide rope against the sea surface was kept at 45° and the net was towed at about 0.5 m above the bottom for about 5 minutes with a speed of about 0.5 m/second. Volume of water

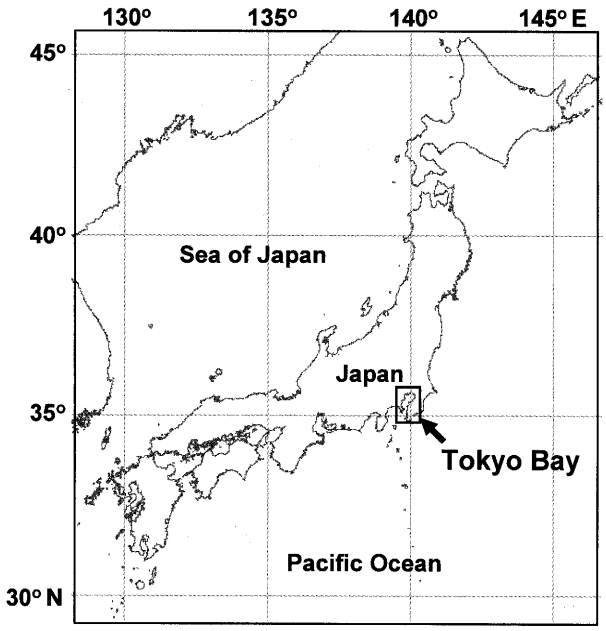

Fig. 1 Location of the study site (Tokyo Bay).

Table 1 Location and water depth of the 15 sampling stations in Tokyo Bay

Station	Location		Water depth (m)
	Latitude	Longitude	
1	35° 38' N	139° 59' E	8
2	35° 36' N	140° 03' E	6
3	35° 35' N	139° 51' E	8
4	35° 34' N	139° 55' E	15
5	35° 34' N	139° 57' E	15
6	35° 33' N	139° 58' E	15
7	35° 33' N	139° 49' E	12
8	35° 30' N	139° 51' E	25
9	35° 28' N	139° 54' E	20
10	35° 28' N	139° 46' E	22
11	35° 26' N	139° 47' E	30
12	35° 24' N	139° 49' E	14
13	35° 26' N	139° 42' E	24
14	35° 23' N	139° 45' E	20
15	35° 22' N	139° 46' E	17

sampled was recorded with a flow meter.

Individuals collected in the present study were fixed with 10% seawater formalin. Larval stage was defined for all individuals with microscopic observation of external morphology following Hamano and Matsuura[9]. Larval density was calculated as the number of larvae collected/volume of water filtered (m^3). In the present study, samples collected at each sampling station in the same month were pooled in order to examine the monthly change in the mean larval density in the bay.

Results

Total number of planktonic larvae of *O. oratoria* collected during the research period was 5,333 (1,934 for slope towing and 3,399 for bottom horizontal towing). Monthly change in the mean density of the larvae was examined for both towing methods (Fig. 2). The larvae occurred from June to October for slope towing, and from June to November for bottom horizontal towing. A minor peak and a major peak of the occurrence respectively appeared in July and September for both towing methods.

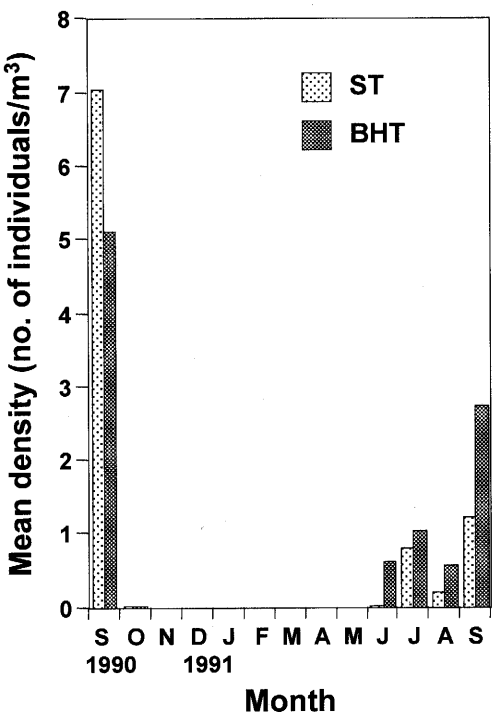

Fig. 2 Monthly changes in the mean density of *Oratosquilla oratoria* larvae collected by slope towing (ST) and bottom horizontal towing (BHT) in Tokyo Bay from September 1990 to September 1991.

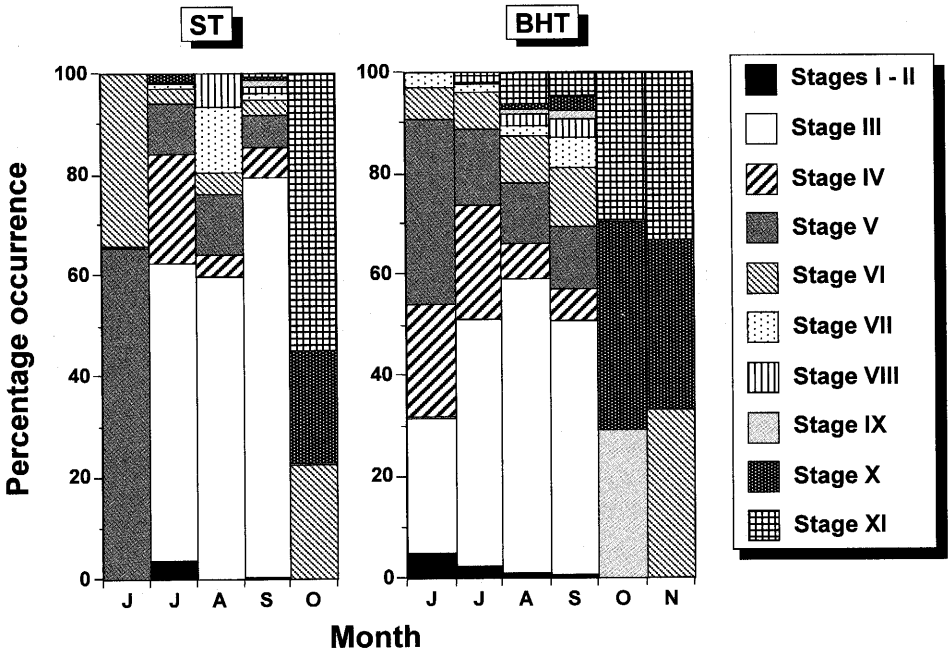

Fig. 3 Monthly changes in percentage occurrence of *Oratosquilla oratoria* in each larval stage collected by slope towing (ST) and bottom horizontal towing (BHT) in Tokyo Bay from September 1990 to September 1991. Data of September was shown as average in 1990 and 1991. No individual occurred During December 1990 to May 1991.

The density in September was considerably different between 1990 and 1991 especially for slope towing.

All of the eleven larval stages were included in our samples. Monthly changes in the percentage occurrences of the larvae in each stage are shown in Fig. 3. Stage-III larvae that were the first phase of pelagic life[9] were numerically dominant especially from July to September, with the ratio of 60-80% and 50-60% for slope towing and bottom horizontal towing, respectively. Propelagic stages, I and II[9], occurred only from June to September, while stage-XI larvae that is the final stage of the planktonic phase occurred from July to November. The larvae collected during the latest two months, October and November, were in stage VI or later.

Discussion

In Tokyo Bay, commercial catch of *O. oratoria* was high in the middle 1980s (good catch period), but dropped dramatically around 1992 and continued to be low during 1990s (poor catch period)[2]. As the results of sampling survey during the good catch period, from May 1983 to April 1984, the planktonic larvae of *O. oratoria* occurred from June to December with a peak from middle June to late July[7]. While in the poor catch period, from 1992 to 1998, the larvae occurred from late May or early June to late October with a minor peak in middle July and a major peak from late August to early September[8]. According to Kodama *et al.*[4], in 2002, the larvae occurred from June to October and the larval abundance was considerably high in August and September as compared with that in June and July. As suggested by the previous authors[2,4], larval abundance of *O. oratoria* was high from June to July and low from August onward during the good catch period, whereas it was high from August to September and low before July during the poor catch period.

The spawning season of *O. oratoria* has been estimated to continue from April to August with two peaks from April to May and from July to August in Tokyo Bay[10]. Larger females ($\geq$ 10 cm in body length) matured and spawned at the first peak, whereas smaller females (8 to 10 cm in body length) spawned at the second peak in addition to some larger females[10]. The peak of larval abundance in June/July and that in August/September have been considered to correspond to the first peak and second peak of spawning, respectively[2]. Kodama *et al.*[4] concluded that disappearance of the peak of larval abundance in June/July was caused by a substantial decrease in the stock size of large individuals.

In the present study, we examined the temporal distribution of *O. oratoria* larvae using the samples collected during the transition between good catch period and poor catch period, from 1990 to 1991. As the results, the larvae occurred from June to

Table 2 Summary on results of the study on the occurrence of *Oratosquilla oratoria* larvae in Tokyo Bay

Study period	Condition of fishery	Larval occurrence		Author(s)
		Period	Peak	
1983-1984	Good catch	June-December	Middle June-late July	Nakata[7]
1990-1991	Transition	June-November	July (minor) and September (major)	Present study
1992-1998	Poor catch	Late May-late October	Middle July (minor) and late August-early September (major)	Shimizu[8]
2002	Poor catch	June-October	August-September	Kodama *et al.*[4]

November with a minor peak in July and a major peak in September. Results of the previous studies on the larval occurrence conducted in Tokyo Bay are summarized in Table 2 including the results of the present study. It was considered that the major peak of larval abundance had already shifted from June/July to August/September in the transition period. This shift of the peak may have been an indication of the coming poor catch period.

The difference in the actual value of larval density between September 1990 and the same month of 1991, which suggested annual fluctuation in larval abundance, was greater at slope towing than at bottom horizontal towing (Fig. 2). This is probably caused by higher ratio of stage-III larvae, which were potentially more dominant than larvae in later stages in the sea, in slope towing than in bottom horizontal towing (Fig. 3). All of the eleven larval stages of *O. oratoria* occurred in the present study. The larvae in the terminally additive stages[9,11] also occurred in Yuya Bay, Japan[12]. However, they did not occur in Tokyo Bay throughout the research period. The larvae in the propelagic stages, I and II, which were just after hatching, occurred from June to September, while the larvae in stage XI, which were just before metamorphosis and settlement, occurred from July to November. Therefore, total duration of the larval stages of *O. oratoria* in Tokyo Bay was estimated to be one to two months that was around the same as the duration observed for the laboratory-birth individuals[9]. The period when the settlement occurred was estimated to continue from July to November, by the occurrence of the larvae in the final stage.

Juveniles after the metamorphosis and settlement has been considered to grow up to around 5 cm in body length before the recruitment occurring from November onward[13,14]. For the appropriate stock management of *O. oratoria* in Tokyo Bay, it is also desirable to assess the abundance of juveniles that succeeded in settlement, along with determination of the factors leading the decrease of large individuals.

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