

BIOLOGICAL OBSERVATION ON THE POND SMELT, HYPOMESUS OLIDUS (PALLAS), IN LAKE KOGAWARA, AOMORI PREFECTURE, JAPAN II. EARLY LIFE HISTORY OF THE FISH

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SMELT, *HYPOMESUS OLIDUS* (PALLAS),
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II. EARLY LIFE HISTORY OF THE FISH**

By

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Introduction

The pond smelt, *Hypomesus olidus* (Pallas), reaches the adult stage and spawn at the end of one year after hatching. In most lakes, such O-age group usually comprises the main part of commercial catches.

The annual production of fry in the lake, however, varies greatly as was described in Lake Kogawara, Aomori Prefecture (Sato, 1950). Therefore it is the most important to keep the production of the fries above a certain level in order to stabilize the annual commercial catch. For the sake of maintenance of such the required amount of annual production of fries of pond smelt, the early life history of the fish must be known.

I have already reported on the spawning habits of pond smelt in Lake Kogawara (Sato, 1950). Here will be reported the early life history of the pond smelt in Lake Kogawara.

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Materials and Methods

Early larvae of pond smelt were collected at shallow waters along shore line of Lake Kogawara several times in May of 1949 and 1950 in order to examine early life history. The net was specially prepared for the collection. It was cone-shaped, 3 meters long with a diameter of 1 m. at the mouth. Two third of the net was of silk mosquito-net cloth of 64-cm². mesh. And for the tail part,

one third of the net, silk bolting cloth with 225-cm². mesh was used. Hauling was made horizontally at the rate of about 1 km. per hour. When, in June, the larvae of pond smelt reached 25 mm. long and over, the collection was made by use of the boat seine net with the bag net of 25-cm². mesh at shallow waters along shore line. The collections were continued through the year, once every month or so. The samples of early larvae, fries and youngs thus collected provided the material for study of the growth of fish, population density and also its distribution. The contents of alimentary tracts were also examined to determine the food of fish at different stage of growth. Fluctuation of the amount of plankton in the lake was also observed once a month. For the plankton collection, a plankton net of silk bolting cloth with 6,400-cm². mesh was used. The hauling was made vertically from the bottom, 23 m. in depth, to the surface at the station indicated in Fig. 1.

Observation

I. Life History of the Early Larva

a). Appearance of larvae and their distribution

It has been already reported (Sato, 1950) that the spawning of pond smelt in Lake Kogawara was usually the most active from the beginning to the middle of April. According to Higurashi (1927), the egg of pond smelt hatched out on the 28-33rd day after fertilization, at 8-9°C of water temperature. The average water temperature of Lake Kogawara in April and through out May is close to this temperature. Therefore it can be expected from Higurashi's data that, in Lake Kogawara, the hatching occurs mainly from the beginning to the middle of May. Actually the early larvae of pond smelt were collected in Lake Kogawara at expected period of the season in both 1949 and 1950 as is seen in Table 1. The larvae, just hatched as well as those grown up to 10 mm., were collected at the region near the spawning ground. The area was shallow water less than 10 m. in depth along shore line where some hydrophytes such as *Ranunculus aquatilis* L., *Myriophyllum verticillatum* L., *Ruppia rostellata* Koch and *Potamogeton crispus* L. were grown, on which pond smelt laid their eggs.

Table 1. Collections of the early larvae of pond smelt by net hauling (100-500 m. in distance).

Date	No. of hauls	No. of larvae per haul	No. of eggs per haul
May 9, 1949	4	1-13	0
May 18, 1949	2	15-24	0
May 8, 1950	4	1-2	0-3
May 9, 1950	5	1-5	0-1
May 16, 1950	6	0-7	0
May 17, 1950	9	1-2	0

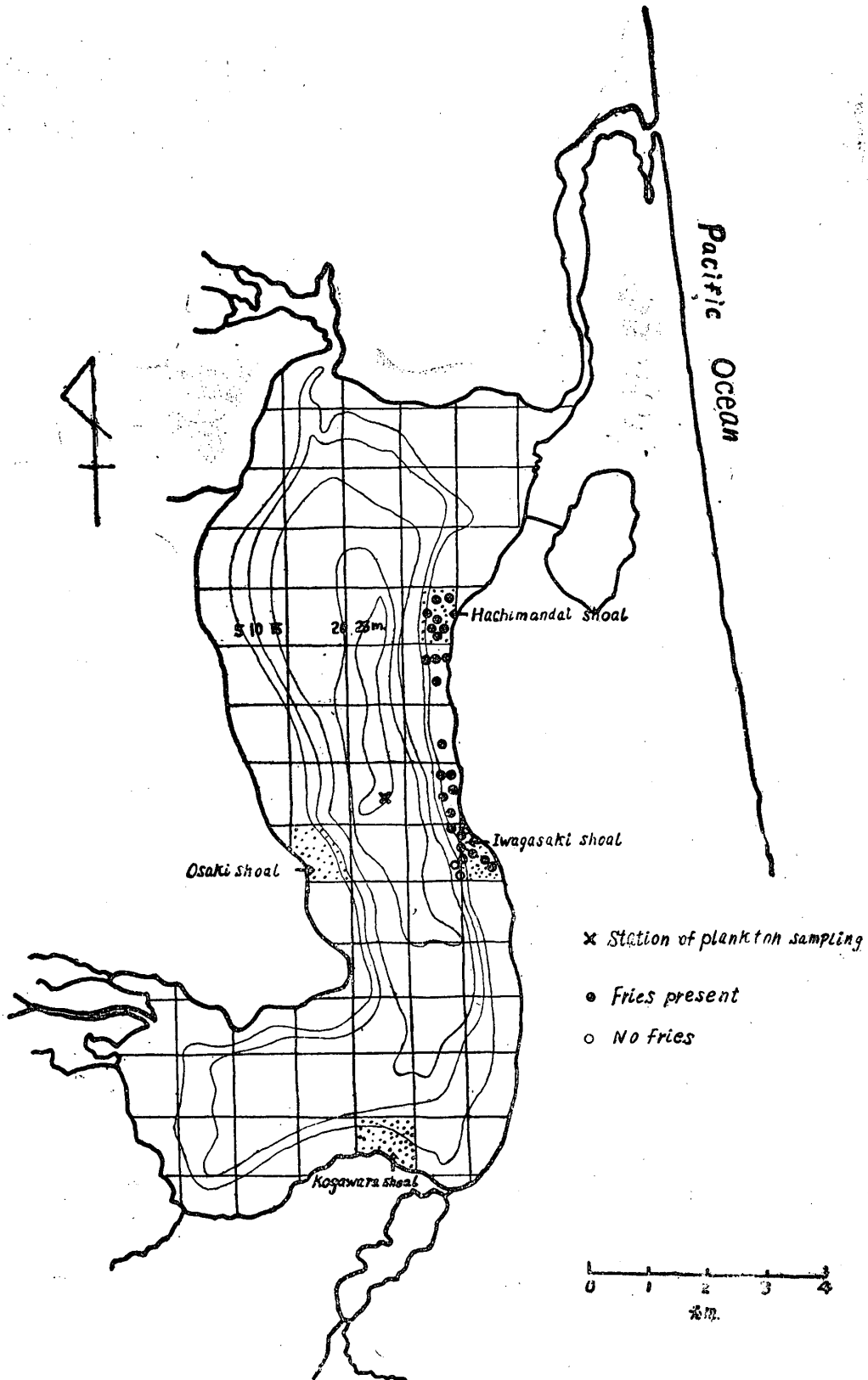


Fig. 1. Location of samplings of early larvae of pond smelt and the station of plankton sampling in Lake Kogawara.

No larvae were collected in the deeper water, over 10m. in depth, as is seen in Table 1 and Fig. 1.

b). Growth

Distribution of length frequency of the early larvae at different dates of collection is shown in Table 2. From the figure, it can be seen that a large number of the larvae of pond smelt grew to 8-10 mm. by May, in two weeks after hatched.

Table 2. Percentage distribution of length frequency of the early larvae of pond smelt at different dates of collection.

Date of collection	No. of fish	Percentage frequency of length					
		5-6mm	6-7mm	7-8mm	8-9mm	9-10mm	10-11mm
May 9, 1949	21	24	76	0	0	0	0
May 18, 1949	39	5	18	15	46	16	0
May 8, 1950	4	0	75	25	0	0	0
May 9, 1950	20	5	65	30	0	0	0
May 16, 1950	11	9	45	9	9	28	0
May 17, 1950	9	11	33	23	34	0	0

c). Feeding habits

The results of observation on the contents of alimentary tracts of the early post-larvae were shown in Fig. 2. In the figure, the occurrence of various food organisms is expressed by percentage of larvae in which each food organism was found. As it was found that frequent occurrence was parallel with the larger amount of ingestion, the figure may be taken as to express the relative importance of each kind of food organisms at different stages of larval development.

The earliest post-larvae, less than 7 mm. in length, fed on rotifera such as *Keratella aculeata* and *Polyarthra platyptera*, and subsequently on other rotifer, *Asplanchna sp.* These rotifers seem to be the most desirable food for the earliest larvae of pond smelt because of its suitable size for ingestion and possibly of its digestibility. As it has been already proved by Sato (1950) that unicellular algae are not suitable as food for the larvae, ingestion of rotifers by early larvae is the essential factor for their growths. The food studies of early larvae, less than 7 mm. in length revealed that the alimentary tracts of 78 per cent of larvae in 1948 and of 76 per cent, in 1950 were empty. While in the artificial rearing pond no larva showed empty tracts (Sato, 1950 and 1952). Such difference seems to be due to the difference in density of food organisms between natural lake and artificial pond, because amount of rotifers was less than 25,000 per m³. in Lake Kogawara in both springs of 1949 and 1950, while it was 300,000 per m³. or over in the artificial pond. Soon after the larvae grew to over 7 mm. in length, they

began to take a naupli. As the larvae grew, other food organisms such as *Bosmina coregoni* and *Sinocalanus tenelus* were taken as main food organisms. On these organisms the larvae continued to grow. When they reached 20 mm. and over and the comblike gill rakers developed, they began to take zooplanktons selectively from unicellular algae. Kokubo (1949) have also reported the same result from an analysis of stomach contents of pond smelts, of 25 mm. to 40 mm. in length, collected from Lake Kogawara. Such feeding habits are similar to the results found in the artificial rearing experiment (Sato, 1950 and 1952).

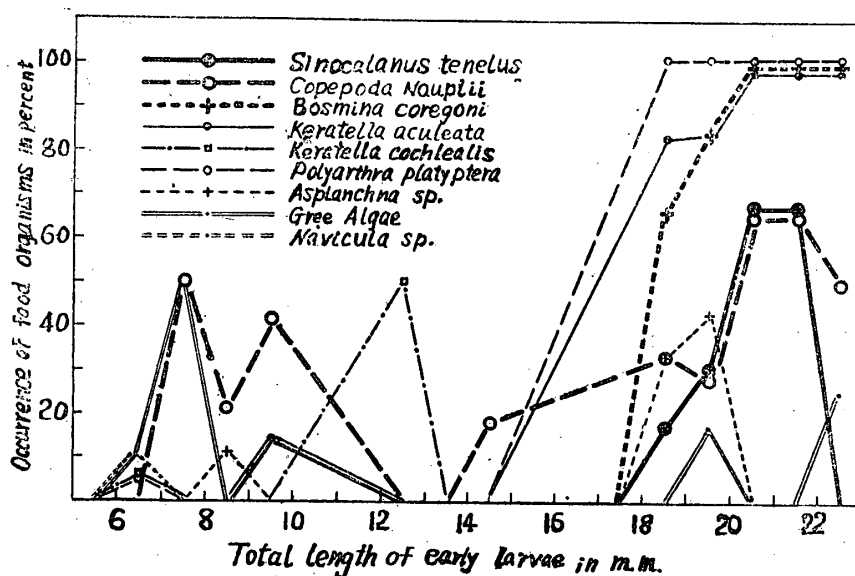


Fig. 2. Percentage of occurrence of various food organisms in the alimentary tracts of early larvae at various stage of development.

II. *Life History of the Fry and Young*

a). *Distribution and density*

Sampling of fries of pond smelt was made in the shallow waters along the lake shore by the boat seine net. 30 samplings were made during the period from 15 th to 30th of June, 1948 and large number of fries were collected. The fries, 25-40 mm. in length, were well spread over the water less than 10 m. in depth along the lake shore as can be understood from Fig. 3, and the maximum density was 2,500 fries per 100 m. at points 13 and 15. The fries, however, were found mostly in waters of the spawning ground and its neighbourhood as is shown in the figure. The average number of density of the larvae within each section in which spawning ground was included such as shoals of Osaki shoal (Section I), Kogawara shoal (Section X), Iwagasaki (Section XII) and Hachimandai shoal (Section XV) were 1,800, 2,500, 2,500 and 1,600 per 100 m². respectively, and

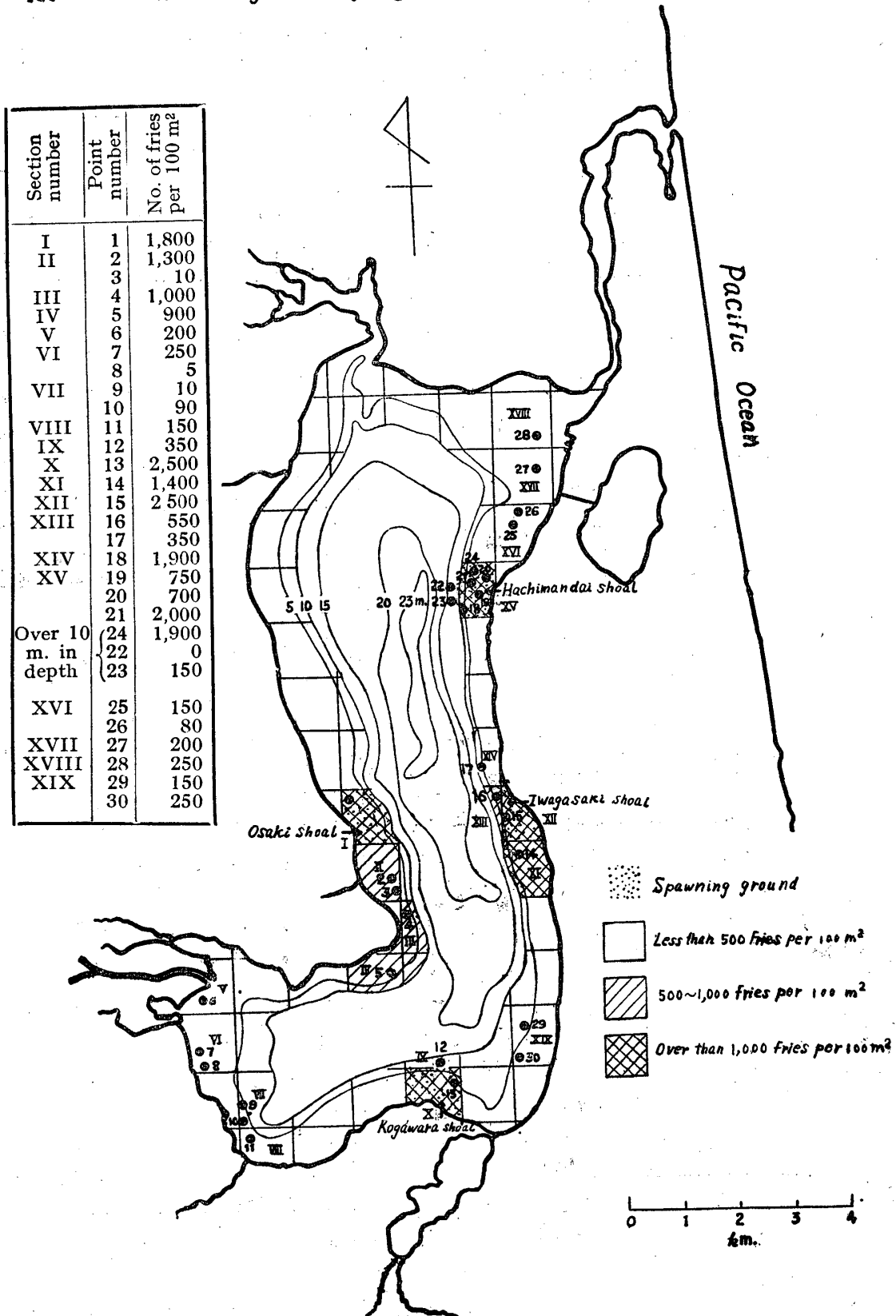
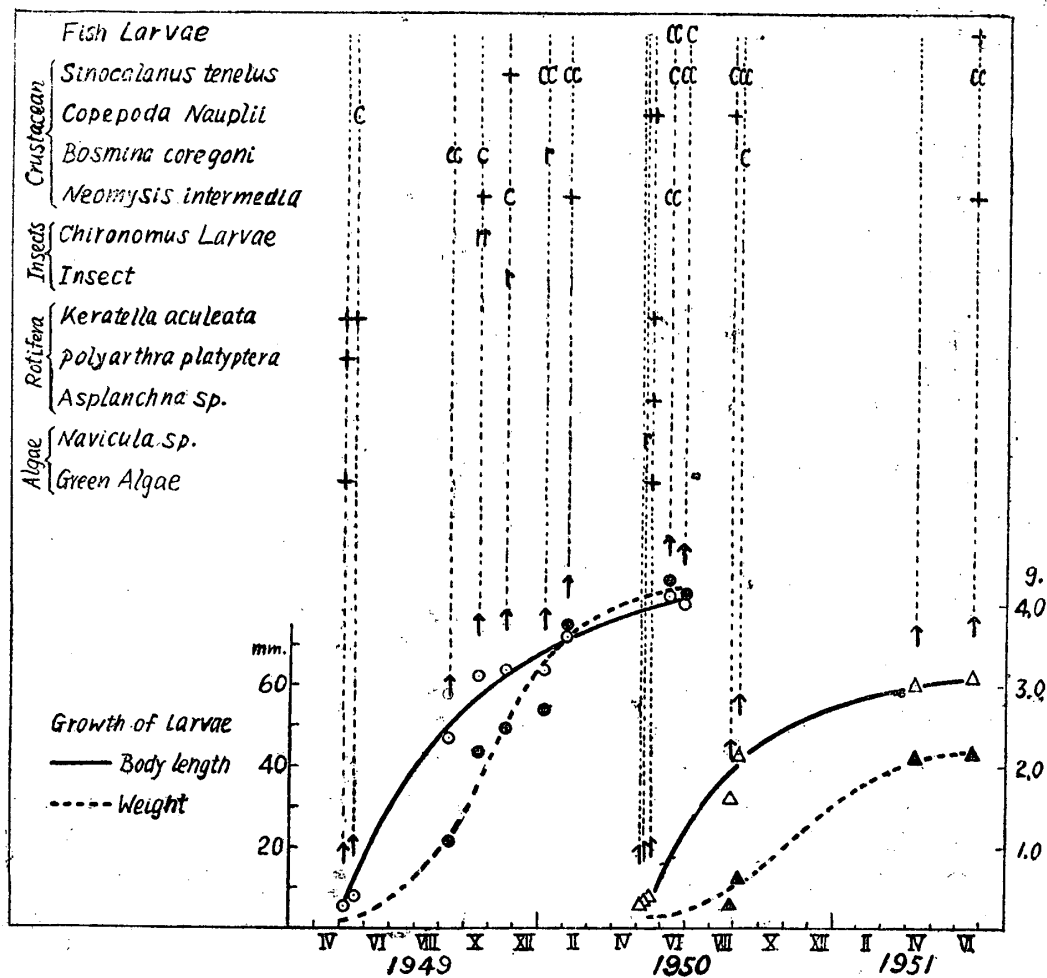


Fig. 3. Densities of the fries of pond smelt by section in Lake Kogawara at the end of June, 1958.

these of adjoining sections of spawning ground were also from 350-1,400. While that of other sections was from 50 to 1,000 per 100 m². From the average number of fries of pond smelt within each section on shallow water less than 10 m. in depth along the lake shore, the total population in the lake was estimated. If we apply the density figure of the nearest section to those where no sampling was made, it is estimated that there were over 320 millions of fries in 32 km². of shallow waters of less than 10 m. in depth. However the total population estimated here may be less than the actual one, because total catch of O-age group of pond smelt in 1948 fishing year was roughly 450 millions.

b). Growth

The collection of pond smelt by boat seine net was carried once a month continuously for two full years, from 1949 to 1951, at the same station as



cc abundant, c frequent, + common, r rare, rr very rare.

Fig. 4. Growth curve and change of stomach contents of pond smelt at different stages of growth in Lake Kogawara.

plankton collection. The rate of growth is illustrated in Fig. 4 by plotting the mean length and weight against date. When the fish reached 30 mm, in length, usually at the end of June, they attained adult form in the dimensional proportion of the body as well as in body organs. In 1949 they grew to 70 mm. in average body length and 35 g. in weight by the time of spawning, just one year after hatching. While those of 1950 group reached only 60 mm. in average body

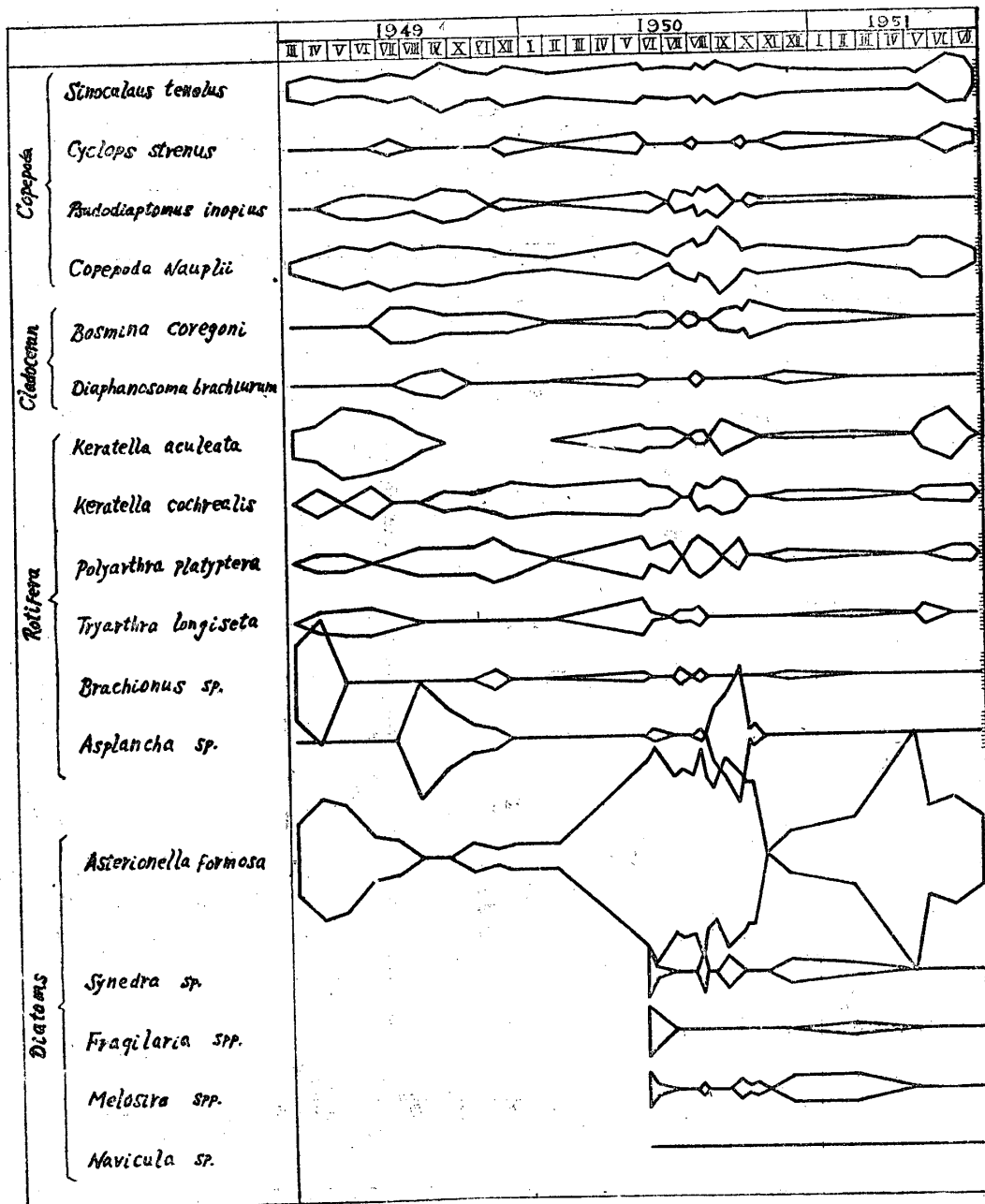


Fig. 5. Seasonal fluctuation of the amount of plankton organisms in Lake Kogawara. Unit per m³ by sphere-curve method (Lohman, 1908).

length and 20 g. in weight. Thus growth of pond smelt differs by years.

c). Feeding habits

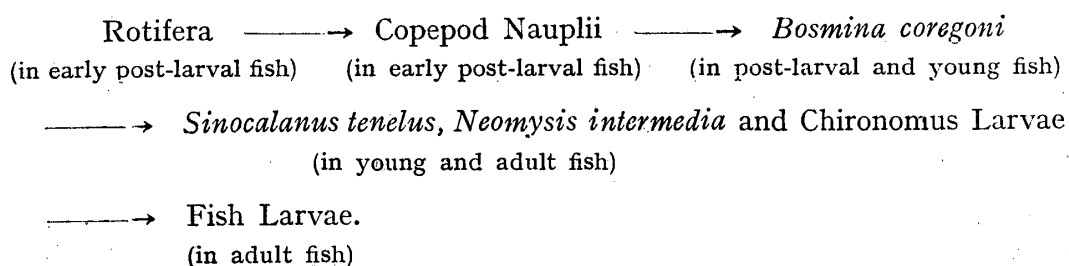
Stomach contents of the pond smelt at different stages of growth were also examined during two years, and the results are summarized in Fig. 4. In case of the young fishes, there was a predominance of a copepod, *Sinocalanus tenelus* and a mysis, *Neomysis intermedia* in their stomach. The stomach content was frequently composed entirely of only one species of food organisms. Some young fish ingested a cladocera, *Bosmina coregoni*, and a species of insect. Seasonal fluctuation of the amount of planktons was illustrated in Fig. 5. Among the planktons found in the alimentary tracts of pond smelt, rotifers such as *Polyarthra platyptera*, *Keratella cochrealis* and *Asplanchna sp.* were abundant in spring and summer. *Bosmina coregoni* of crustacea was abundant in the summer and autumn, and *Sinocalanus tenelus* and its naupli and *Neomysis intermedia* were found all the year around. These planktons were the main food of pond smelt at each season of their maximum abundance as indicated in Fig. 4.

The foods of adult pond smelt which finished their first spawning were found to be similar to the case of the young fish. Occasionally, however, particularly in the spring, larvae of fishes such as goby, ice fish and pond smelt were found in the stomach of pond smelt.

Conclusion and Discussion

In Lake Kogawara, the early larvae of pond smelt appear usually at the beginning of May. The early post-larvae, less than 7 mm. in length, fed on a rotifer, *Polyarthra platyptera*, besides unicellular algae and subsequently on other rotifers. This fact suggests that the rotifer is the most desirable food for the earliest larvae because of its suitable size for ingestion and possibly of its digestibility. The fact that the alimentary tracts of over 75 percent of early post-larvae, of 6 to 7 mm. in length, were empty seems to suggest that the amount of rotifer at this critical period is the limiting factor for the early growth of fries and consequently the amount of production. As the post-larvae grew, other food organisms such as naupli of copepod, *Bosmina coregoni* and *Sinocalanus tenelus* were taken successively. On these food organisms the larvae continued to grow. Such feeding habits is similar to the results observed in the artificial rearing experiment (Sato, 1950). The young pond smelt above 30 mm. in length with completed external characters fed primarily on zooplanktons such as *Sinocalanus tenelus*, *Neomysis intermedia* and *Bosmina coregoni*. A predominancy of *Neomysis intermedia* in the stomach of pond smelt has been reported in Lake *Kasumiga-ura* by Miyauchi (1934) and also in Lake Abashiri by Ishida (1949). Ishida (1949) had reported that *Sinocalanus tenelus* and *Bosmina coregoni* also occur in large numbers of pond smelt and that

of the content of stomach was usually composed of only one kind of these food organisms. Such facts were also frequently noticed in the present investigation in Lake Kogawara. Stomach contents of the adult pond smelt which passed spawning stage revealed that they often fed on several fish larvae including that of pond smelt. Therefore it can be expected that there may occur the consumption of larval pond smelt by adult ones to the extent of affecting the natural survival rate of the larvae. Such successions of these food organisms in the alimentary tracts of pond smelt, from early post-larval stage to full grown adult fish, can be indicated as follows.



Growth rate of the young of pond smelt was found to be different by years. Namely, the 1949 group reached 70 mm. in average body length at the first spawning season, while the 1950 group reached only 60 mm. in the same length of time. And such difference is more conspicuous in that of weight. The reason of the difference of the growth rate by year is being investigated now by the author.

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