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**STUDIES ON THE REPRODUCTION OF THE SAURY,  
*COLOLABIS SAIRA* (BREVOORT), OF THE  
PACIFIC COAST OF JAPAN**

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The saury, *Cololabis saira* (Brevoort), of the Pacific Coast of Japan had been believed to spawn when the fish migrate southwards in late autumn and winter, beginning at Kinkasan in October, Bōshū in November, Kishū from December to February and ending at Kyūshū in May.<sup>3)4)7)8)</sup> In 1949, the research boat "Fusa Maru" investigated the distribution of the larval fish at various localities in the offshore region of Tohoku (North-Eastern) Sea of Japan, and collected an abundant larval saury from 6 to 80 mm. in body length in the area within 37 degrees to 43 degrees N. latitude and 141 degrees to 155 degrees E. longitude, during the period from May to August.<sup>6)</sup> Judging from the occurrence of the small larvae just hatched in these seasons, the saury are supposed to spawn in late spring and summer as well as in late autumn and winter.

The mature fish of the saury were collected for study in all seasons for the period from May, 1951, to April, 1952 at various districts along the Pacific Coast of Japan. The study on these material has established some evidences concerning the reproduction of the saury. And the distribution of the larval saury originated from the northward migrating spawners in the Tohoku Sea in spring and summer of 1950 and 1951 has also been confirmed.

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### Materials and Methods

The materials of the spawners consisted of approximately 1800 individuals collected during the period from May 20th, 1951, to April 16th, 1952, covering the region from off Hokkaido, in the north, to Muroto of Shikoku, in the south, along the Pacific Coast of Japan. For each sample, which was preserved in 10 per cent formaline, the date and locality of capture, gear used, body length (from the tip of the snout to the end of the vertebra), body weight and gonad weight, were recorded. The ova was measured after the method of Dr. F. N. Clark (1934),<sup>1)</sup> which she used in the investigation of the sardine ova.

Test measurements were made of ovarian eggs from the anterior, central and posterior portion of an ovary. No differences in the relative number of eggs in each size group were found in any of these portions. Consequently a 0.2-gram sample through the central portion of both ovaries was taken and all eggs larger than 0.2 mm. in diameter were counted.

The samples of eggs and larvae from the Tohoku Sea Region were collected on the occasions of the oceanic investigations made by Tohoku Regional Fisheries Laboratory in spring and summer of 1949, 1950 and 1951. All samples and the records of the date and locality of collections were offered by the courtesy of the above agency. The number of larvae was 352 in all. They were all collected by the usual larva net. The localities of capture covered the region from Hokkaido, in the north, to off Chōshi, in the south. But we could not figure the relative abundance of larvae by year from the samples.

### Maturity of Ovarian Eggs

The diameter frequency of the eggs of each fish was arranged in order to demonstrate the growth from the immature stage to maturity, according to the location of the largest mode in the diameter frequency of the eggs from each fish as shown in Fig. 1. At the beginning of maturity a batch of ova in the immature group began to grow. When the first batch of ova had attained about 1.0 mm. in diameter, a second batch was separated from the immature group and began to grow. Three modes at about 1.0, 1.4 and 1.9 mm. were observed in practically all the frequency distribution of egg diameter from the mature ovary. After the first batch of ova had reached about 1.9 mm. in modal value, it was discharged out of the ovary. At the same time the second batch whose modal value were 1.4 mm. began rapid growth to the full grown eggs. While a second batch of eggs was ripening, there still remained in the oviduct a few

ripe ova which had not been extruded at the previous spawning. It is clear from these facts that the individual saury spawn more than once in a breeding season.

The ratio ( $\times 10^4$ ) of the gonad weight against the cube of body length for each fish was calculated and shown in Fig. 1. The ratio (G. I.) was 0.1-0.3 in the immature stage and gradually increased as the maturity advanced until 5.0 in the full grown ovary. Thus the ratio correlates with the maturity of gonad and can be taken as an index to show the degree of maturity. The time and locality of spawning were investigated by using this index (c.f. spawning season).

The number of eggs spawned by each fish in one spawning was estimated in thirty females of matured condition by counting all eggs larger than 1.6 mm. in diameter (Table 1). The

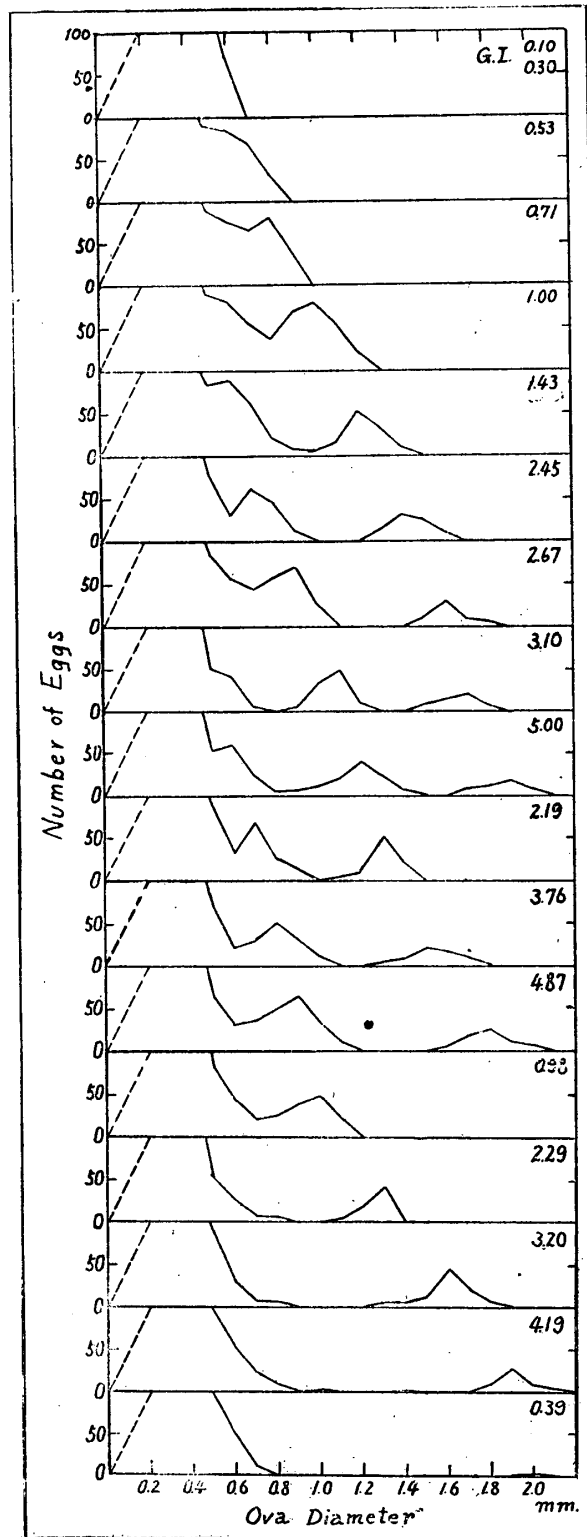


Fig. 1. Ova diameter frequency polygons showing the growth of eggs to maturity. Materials collected along the Pacific Coast of Japan for the period from May 20, to Dec. 15, 1951. "G. I." shows the ratio  $\times 10^4$  of the gonad weight against the cube of body length.

Table 1. Number of matured ovarian eggs larger than 1.6 mm. in diameter at each spawning of saury.

Date	Locality	Body length(mm.)	Body weight (gr.)	Gonad weight (gr.)	Gonad index	No. of eggs
May 20, 1951	Shigedera	271	135	9.7	4.89	2384
"	"	290	163	10.5	4.31	2504
"	"	292	148	10.2	4.10	1873
May 22, 1951	Numazu	283	133	9.5	4.19	1873
"	"	283	135	6.1	2.69	820
"	"	291	126	12.4	4.62	2280
"	"	291	147	9.4	3.82	1221
"	"	292	140	10.2	4.10	2478
"	"	294	145	11.1	4.37	2118
"	"	295	145	13.3	5.18	2759
"	"	295	161	9.4	3.66	1390
"	"	296	140	8.8	3.39	975
"	"	296	145	8.6	3.32	1940
"	"	298	140	9.3	3.51	1550
"	"	299	145	10.3	3.85	1368
June 5, 1951	Tateyama	291	132	9.4	3.81	2318
"	"	300	135	8.6	3.19	1194
July 16, 1951	Oya	301	152	13.6	4.99	2920
"	"	321	161	14.3	4.32	2201
Jan. 20, 1952	Kishū	263	95	6.2	3.41	994
"	"	270	100	8.6	4.37	1564
"	"	272	111	7.0	3.48	765
"	"	275	106	4.7	2.26	633
"	"	280	118	8.2	3.74	602
"	"	287	130	5.8	2.45	758
Jan. 31, 1952	Kishū	265	101	—	—	1075
"	"	277	95	—	—	952
"	"	282	110	—	—	468
"	"	290	112	—	—	653
"	"	291	126	—	—	1036

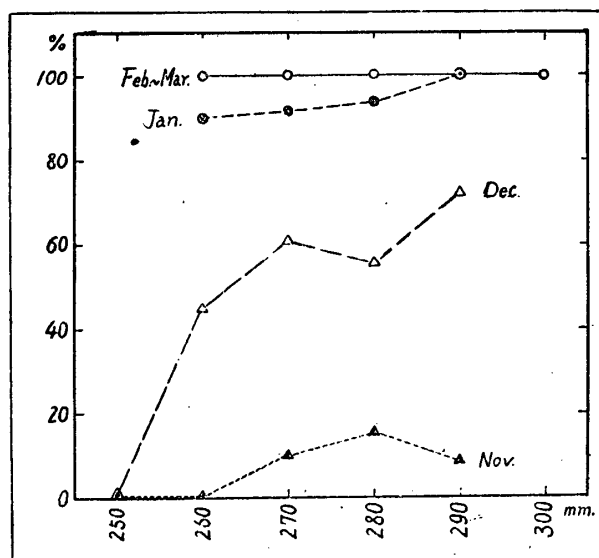
number of eggs spawned at one time varied from the minimum of 500 to the maximum of 3,000. The females caught in Kishū in winter had less eggs than those caught in the Suruga Bay in spring.

#### Size at First Maturity

All females with the gonad index higher than 1.0 were considered maturing and classed in the group that would spawn in the breeding season. Percentages of sauries maturing in ten millimeters of length during each one month interval are presented in Fig. 2. About 50 per cent of the females of the body length from 255 to 265 mm. were matured in December, and 90 per cent in January and practically all in February. The larger fish matured earlier than the smaller fish and remained at spawning condition over a longer time interval.

The samples from the Tohoku region for the period going from October to

Fig. 2. Percentages of sauries maturing in each ten millimeters of length during each one month interval. Samples collected at Ōshima and Kishū in 1951-1952.



December were caught by the Bōke-ami (pole lift net) using the fishing light, while the samples from the South region Ōshima, Kishū and Muroto, for the period going from December to April were by the drift net. Because of the difference in the selectivity of two gears the fish smaller than 254 mm. in length were not collected in the latter region. The maturation of the fish smaller than 254 mm. in the South region was not detected within the samples of commercial catch.

#### Time and Locality of Spawning

The time and locality of spawning of the saury were determined by investigating the seasonal variation of the gonad index (the ratio  $\times 10^4$  of the gonad weight against the cube of the body length) of each fish collected throughout the year from May, 1951, to April, 1952. Fig. 3 shows the seasonal changes of the range and the mode of the gonad index of the samples, classified according to the size and the date of capture separately for each sex.

The gonad index of the fish of over 270 mm. in length showed large values (1 - 5) in May, June and July, during which months the fish migrated northward along the Pacific Coast of Japan from the Suruga Bay to the Tohoku Sea Region. These mature fish which were caught by the set-nets in the Suruga Bay amounted to more than 180 tons in May and June, 1951. The eggs were sampled at the same time of the capture of the spawners in the Suruga Bay.

Spent fish and the immature group were dominant in samples collected in September near the Hokkaido region. The gonad index of the fish larger than 250 mm. gradually increased from October on, when the fish migrate southwards

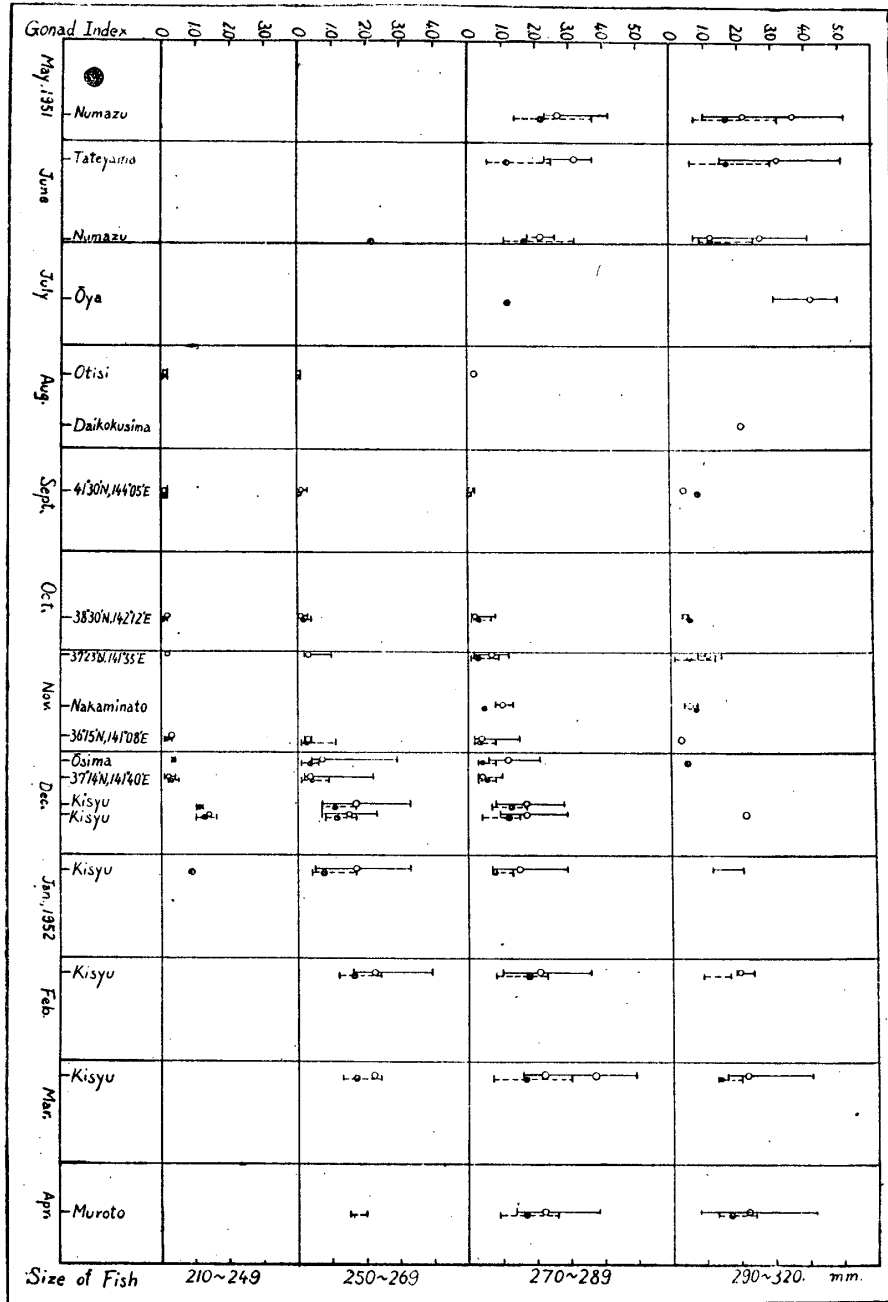


Fig. 3. Seasonal changes of the range and the mode (○ for female, ● for male) of the gonad index of the samples, classified according to the size and the date of capture separately for each sex. Materials collected along the Pacific Coast of Japan for the period from May, 1951, to April, 1952.

along the Pacific Coast of Japan from Hokkaido to the Tohoku region. Although maturing fish were not found among the samples of the commercial catch by the pole-lift net in the Tohoku region in the fishing season of 1951, larval sauries

of 7 - 16 mm. long were collected by the larva net off Miyako and Kinkasan in late October and November (c.f. Distribution of larvae). It is possible that the maturing fish, even if they were present in the fishing area, would not be abundantly caught by the pole-lift net with the fishing light. Therefore the gonad index of the samples obtained in the Tohoku region in November may be lower than they would be if we could obtain an unselected sample from the whole oceanic population. The samples, which were caught by the drift net, from Ōshima in December showed a high gonad index. Fishes in the same maturity condition occurred in catches by the drift net or gill net until the next April, covering the region from Ōshima to Muroto in Shikoku.

Spawning must have occurred, therefore, between the time from October to the next August, when the fish migrated from Hokkaido toward the south and made a turn at Shikoku and Kyūshū,<sup>8)</sup> moving toward Hokkaido along the Pacific Coast of Japan.

#### Distribution of Eggs and Larvae

Fig. 4, 5 and 6 represent the distribution of eggs and larvae collected in the Tohoku region in 1949, 1950 and 1951 respectively. In 1949, five voyages were made for the period from May to August and the total number of the larval saury collected was 281 individuals with lengths ranging from 6 to 80 mm.

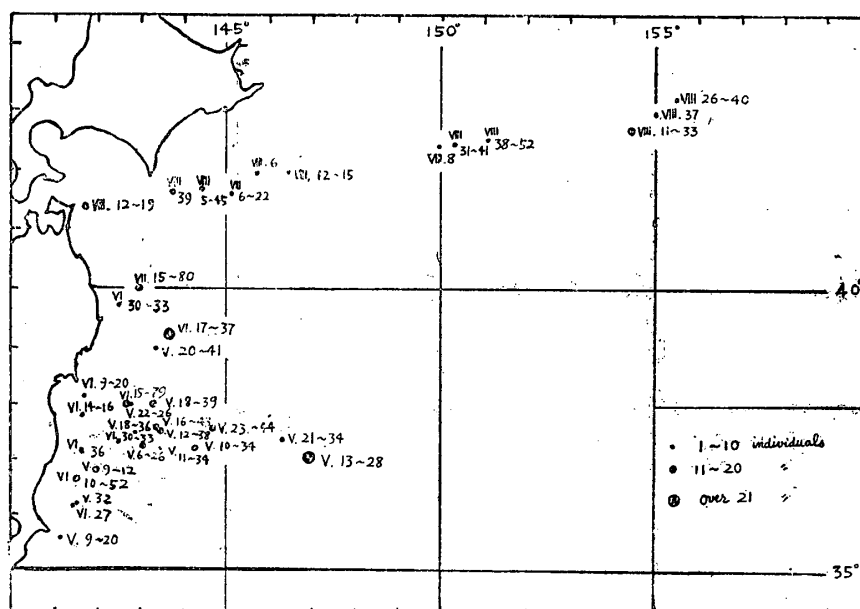


Fig. 4. Distribution of larvae of the saury collected in the Tohoku Sea Region for the period from May to August, 1949. The Roman figure indicates the month of capture and the Arabian figure indicates the range of body length in millimeter.



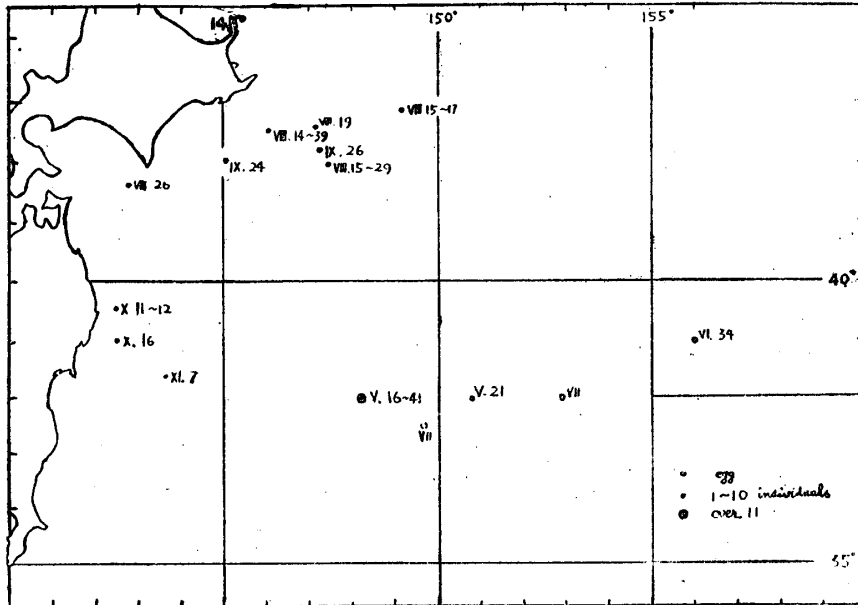


Fig. 5. Distribution of eggs and larvae of the saury collected in the Tohoku Sea Region for the period from May to November, 1950. The Roman figure indicates the month of capture and the Arabian figure indicates the range of body length in millimeter.

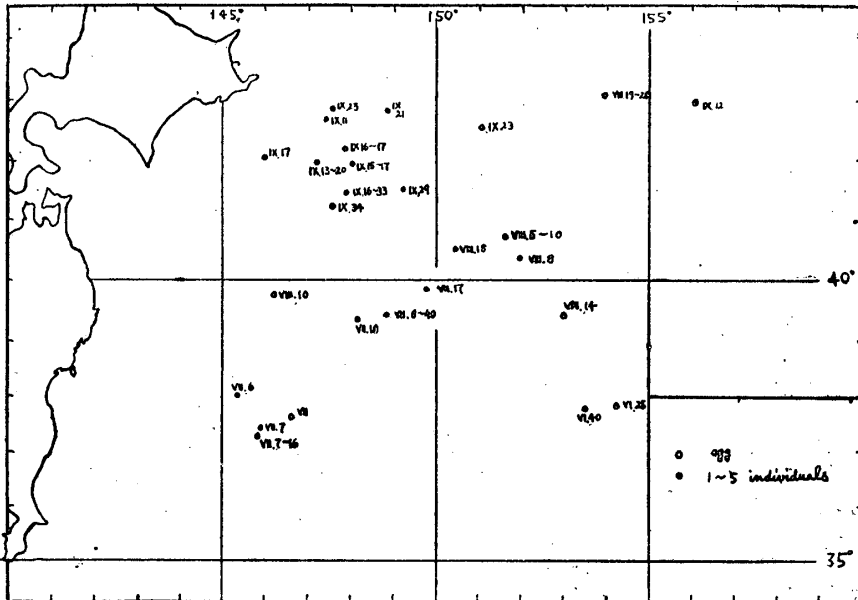


Fig. 6. Distribution of eggs and larvae of the saury collected in the Tohoku Sea Region for the period from May to September, 1951. The Roman figure indicates the month of capture and the Arabian figure indicates the range of body length in millimeter.

Thirty-five hauls of the larva net were made out of seventy-five trials during the whole course of the investigations. In 1950, thirteen voyages were made for the period from May to November and the total number collected was 34 individuals of length from 6 to 39 mm. In 1951, twelve voyages were made for the period from May to September and the total number collected was 37 individuals ranging from 5 to 40 mm. in length.

The collections of larvae in 1949 were much more abundant than those in 1950 and 1951. It was observed that much warmer water than normal prevailed off the Zyōban region in 1950 and 1951. Egg-masses of the saury with 230-350 eggs being entangled to a feather of bird were collected in early July of 1950 and 1951, at three localities within the region of 37°-38° N. lat. and 148°-153° E. long. Such fact suggests that the spawning occurred offshore to a distance over 500 miles from coast.

As seen from the figures the larval fish of the saury are widely distributed in late spring and summer in the Tohoku region within 37 degrees to 43 degrees N. latitude and 141 degrees to 155 degrees E. longitude. It is clear that these larval fish and eggs originated from the spring and summer spawners which migrated northward along the Pacific Coast of Japan.

The existence of the larvae just hatched in late October and November in the region off Miyako and Kinkasan shows that there must be present maturing fish as early as in October among groups migrating southward.

The pelagic eggs collected from the offshore region above mentioned were in various developmental stages from morula to the most advanced embryo. The eggs were rather ellipsoidal in shape with the major axis ranging from 1.82 to 2.23 mm. and minor axis from 1.78 to 2.00 mm. :- with the averages of 2.05 mm. and 1.87 mm. respectively. Kurakami (1914)<sup>2)</sup> measured the diameters of eggs of the saury collected in the west coast of Hokkaido, while Nakamura (1937)<sup>5)</sup> examined the eggs obtained in Chiba-Prefecture. Both results of the egg diameters were different from the present case, namely the former were high and the latter low. The spring spawners sampled in the west coast of Hokkido were usually very old fish while in Chiba-Prefecture, the autumn spawners consisted of young fish only. It was revealed that the diameters of the eggs from the younger spawners were smaller than those of the older females. Thus the diameters of eggs may differ by localities depending on the ages of spawning groups. The smallest specimens of larva was 5.3 mm. in total length which was collected in Kyūshū in Feb. 1950. The yolk of this larva was recognizable and the dorsal fin membrane occurred at a little posterior to the middle of the body.

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