STUDIES ON THE POPULATIONS OF THE FLATFISHES IN SENDAI BAY II AGE, GROWTH AND SPAWNING OF KAREIUS bicoloratus (BASILEUSKY)

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II AGE, GROWTH AND SPAWNING OF *KAREIUS bicoloratus* (*BASILEUSKY*)

By

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It is necessary to determine the biological properties of each unit population for an understanding of various trawl-caught fish resources. This paper is an attempt, following the first report, to study the biology of one member of the trawl-caught flatfishes in Sendai Bay. It is hoped to be of some value in the future to management of coastal trawling fisheries in Japan.

"Ishigarei" *KAREIUS bicoloratus* (*Basilewsky*), is known to occur in coastal waters of Japan from Hokkaido to Seto Inland sea, where fishing operations are usually carried on in waters of 10 to 50 fathoms in depth. The annual catch in Sendai bay which is made principally by trawlers amounts to over 100 tons.

The larvae and juvenile samples for the study were taken from Matsushima Bay during the time from May to November 1949, using a small beach seine and a larva net. The adult fish were collected at the Yuriage Fish Market or on board twice or three times a month during a period from April, 1950 to February, 1951.

Before proceeding further we should like to express our hearty thanks to the members of Fish Market of Yuriage Cooperative Association for their kind cooperation in obtaining samples and for statistical records of landings. We especially indebted to Prof. T. Imai of Tohoku University for reading the manuscript and to late Mr. R. Okamato for valuable advice. We express our hearty thanks to all.

Age-determination

As this plaice has no scales on the body surface except a few irregular scale-discs, the age determination was made by the otolith ring. The period

of annulus formation was determined by observing the marginal development of otolith throughout a year. During the seasons from spring to late summer the otoliths taken from all specimens of 10mm. to about 500mm. in standard length show an opaque growth zone at their margine. Towards the end of August about half (48%) of them turn their margine to a translucent resting zone and from the end of September (Sept. 24th) all of the otoliths enter into the resting stage. The resting period lasts until the following February, when it turns into the subsequent growing period. Thus the translucent rings of the otolith are formed once a year and at a definite season, so that these rings are annuli and can be relied upon for determining age.

The resting and growing stages of otoliths coincide with the annual growth cycles of the body, which show a rapid growth from March through September followed by a retarded growth until the month of February (Fig. 1.) This retardation of growth occurs during the time when the surrounding water temperature is maximum in September and then gradually goes down with the lapse of time towards winter.

The stomach contents of 362 specimens examined for a one year period consisted mainly of sand-launce (*Ammodytes personatus*) and various species of gammarus (Table 1). Empty stomachs were found only during the period from late November through December when spawning activity was at its height. Except this short period the stomach contents show no remarkable variation either in quality and in quantity, throughout a year. Thus it is apparent that the retardation of growth which occurred during the period from September through February is not due to the amounts or kinds of food ingested.

The formation of annual ring on the otolith or the resting stage of growth was found to be correlated with the maturation of the gonad. As an index to show the degree of maturation, the ratio of gonad weight as against cube of body length for each individual was computed (c.f. "Spawning"). In August the relative weight of the gonad was minimum and it was from September on that the gonad began to develop as shown in Table 4. About two months after spawning had finished, the growth of the body began again. It is, therefore, possible that the slow growth occurring in fall may be due to the consumption of metabolic energy for the gonad development rather than for the body growth. The fact agrees with the case of slender halibut, *Limanda angustirostris*[3], and lemon sole[4]. Even though in the case of fishes younger than I age group, a similar gonad development to that of the adult was observed. And in this case unspawned sex products are probably reabsorbed by the tissue of the gonad.

Table 1. Stomach Contents of *Kareius bicoloratus*, estimated in Percenstages of Number of Fish, classified according to the Main Food Items ingested, to the Total Number examined, Sendai Bay, 1950-1951.

Age of Fish	Date	IV-13	IV-25	V-10	V-26	VI-13	VI-26	VII-9	VIII-23	IX-16	IX-24	X-9	X-23	XI-17	XI-26	XII-8	XII-22	I-8	I-29
II	No. of fish	9	3	14	18	15	7	24	23	28	8	16	12	13	17	20	15	25	18
	Main food items																		
	Sand launce	55	0	21	66	0	30	46	47	7	25	6	33	15	47	0	0	8	35
	Gammarus	22	66	36	0	80	0	0	4	40	0	0	0	0	0	0	0	0	7
	the others	0	0	7	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
	Empty	22	33	36	33	20	70	54	47	50	75	94	66	85	53	100	100	92	57
III	No. of fish	3	2	0	5	4	11	5	1	1	4	6	5	4	4	6	2	4	10
	Main food items																		
	Sand launce	33	0	—	40	0	18	20	100	100	50	33	20	20	0	0	0	25	50
	Gammarus	33	50	—	0	75	0	0	0	0	0	0	0	0	0	0	0	0	0
	the others	0	0	—	20	25	0	0	0	0	0	0	40	40	0	0	0	0	0
	Empty	33	50	—	40	0	82	80	0	0	50	66	40	40	100	100	100	75	50

Table 2. The Standard Lengths of the Juveniles taken at Matsushima Bay and Sendai Bay, 1949-1951.

Date	IV-20	V-4	V-21	V-28	VI-3	VI-13	VII-14	VIII-1	VIII-18	IX-5	X-7	XII-11
No. of fish	78	50	24	58	60	16	14	8	17	12	1	9
Mean (mm.)	20.4±0.59	21.8±3.39	27.1±0.83	30.1±1.17	31.7±0.87	37.5±8.91	49.6±9.05	53.9±7.11	61.1±8.30	78.7±0.75	105.0	100.3±0.52

Growth

The larval fish after hatching in December come close to the beach and shortly after metamorphosis which occurs for the most part during the months of January and February, they attain 10mm. in standard length. Fish of 10 to 30mm. in standard length can be found abundantly in March along the shore line of fine sand in sheltered places such as Matsushima Bay.

Feeding on small crustaceans and polychaetes, the larval fish attains 20mm. in average length in May and through a rapid increase from late spring to summer it reaches about 60mm. in August (Table 2). During the months of September and October the growth rate shows down considerably. The fish which reached 90-100mm. in length in October gradually leave the beach and are caught at times by the trawl net operating in Sendai Bay.

Fig. 1 shows a graphic illustration of the rate of growth which were computed by plotting the mean lengths against age according to the month of capture separately for each sex. The growth curve, fitted by eye, shows no apparent difference between the sexes until the first year, when the differential growth rate by sex become eminent with advancing age. The female grows more rapidly than does the male of the same size after the first year.

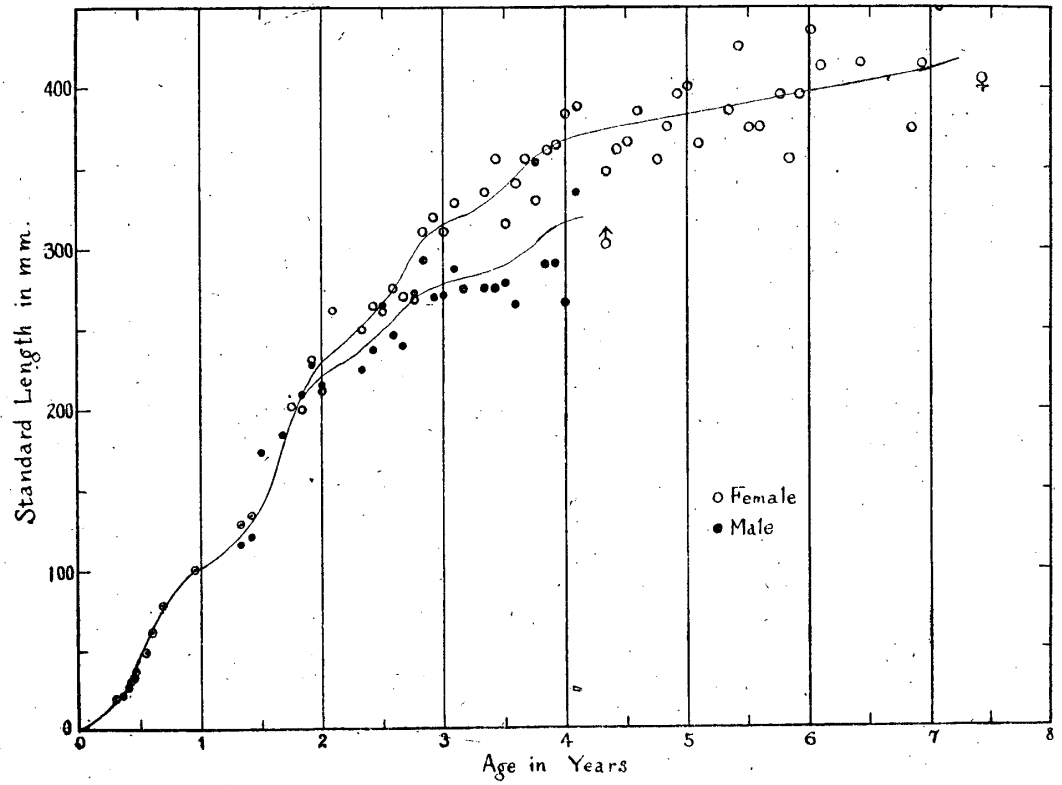

Fig. 1 Growth Rate of *Kareius bicoloratus*, from Sendai Bay, 1949-1951.

Male fishes older than four years of age were very rarely (only two individuals) found among all the samples (537 specimens in total number) taken from inshore and offshore regions in Sendai Bay, and from the spawning area where all the mature male and female come together. While among the females taken from the same localities, fish of six years of age and with a length over 500mm. was found.

Samples taken from the offshore region deeper than 20 fathoms in depth had better average sizes than those of the same age from the inshore region in all months of the year (Table 3). The faster growing fishes probably distribute more offshore than do the slower growing individuals of the same age. Among them, however, no significant differences in the racial characters, such as vertebral numbers and fin ray numbers, or the sex ratio could be detected.

Fig. 2 shows the relationship between weight and length of *Kareius bicoloratus* separately for the two sexes. The males larger than 250mm. in length lag noticeably in weight as against females.

Table 3. Average Body Lengths of Male and Female of two Years of Age from Inshore and Offshore Regions in Sendai Bay, 1950.

Month	Sex	Inshore	Offshore
April	♀	–	25.0
	♂	21.3	24.0
May	♀	24.6	28.0
	♂	21.2	26.3
June	♀	24.0	28.5
	♂	23.6	29.3
Sep.	♀	26.9	30.2
	♂	24.5	29.8
Dec.	♀	30.5	33.5
	♂	26.8	28.7

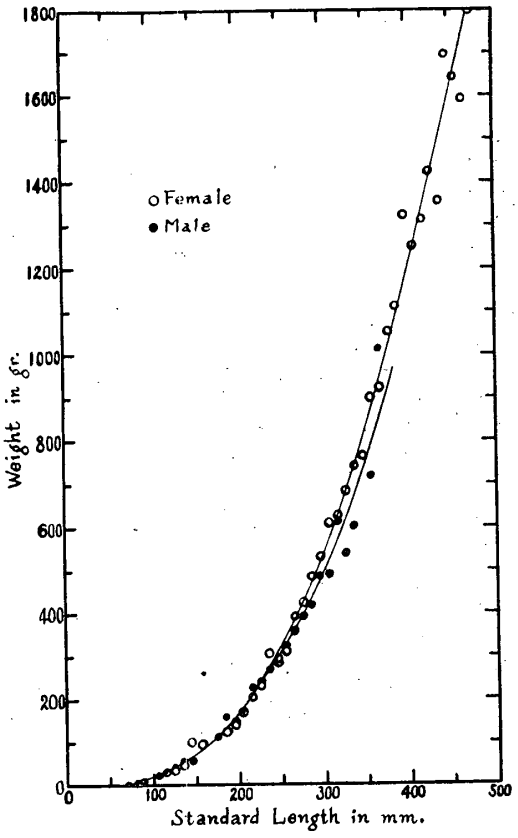

Fig. 2 Length-Weight Relationship of *Kareius bicoloratus*, Sendai Bay, 1949-1951.

Spawning

The degree of maturity of the gonads was expressed by the ratio of gonad weight to the cube of body length (Table 4). Because this ratio was highly correlated (+0.88) with the mean egg-diameters of each gonad of maturing and mature females examined in one hundred and one cases. Table 4 shows clearly that *Kareius bicoloratus* spawns but once a year at a definite and in a short period from late November through early De-

Table 4. The Ratio of Gonad Weight ×10,000 against Cube of Body Length of each Female classified according to the Date of Capture, in Sendai Bay, 1950-1951.

Age \ Date		IV-13	IV-25	V-10	V-26	VI-13	VI-26	VII-9	VIII-23	IX-16	IX-24	X-9	X-23	XI-17	XI-26	XII-8	XII-22	I-8	I-29
I	No. of fish	-	4	5	-	-	-	-	-	1	-	-	2	-	5	-	-	1	-
	Mean	-	8.0	9.0	-	-	-	-	-	7.0	-	-	7.0	-	6.6	-	-	16.0	-
II	No. of fish	3	-	5	10	5	4	11	9	12	3	11	3	4	11	11	3	2	4
	Mean	11.1	-	10.2	11.8	9.2	9.5	9.5	4.7	13.5	30.3	37.0	34.0	154.8	147.5	171.4	20.0	11.0	13.7
III	No. of fish	2	3	-	-	2	4	2	1	2	3	5	2	3	2	5	2	2	8
	Mean	13.5	15.3	-	-	10.5	14.0	20.5	7.0	20.5	38·7	48.6	42.5	157.3	197.0	291.0	89.0	16.0	15.9
IV	No. of fish	3	1	3	2	3	3	2	-	-	1	1	6	-	1	-	2	-	5
	Mean	14.0	10.0	16.7	24.0	12.7	30.0	30.0	-	-	26.0	38.0	49.8	-	95.0	-	108.5	-	16.2
V	No. of fish	1	3	-	-	1	-	-	1	-	2	-	1	-	-	1	-	1	3
	Mean	25.0	25.7	-	-	15.0	-	-	22.0	-	48.5	-	67.0	-	-	193.0	-	12.0	16.7

Table 5. Sex Ratio of the Samples taken from Matsushima Bay (juveniles,) Inshore, Offshore and Spawning Regions in Sendai Bay, 1949-1951.

Locality \ Age	%	0	I	II	III	IV	V	VI	Total
Matsushima Bay	No. of fish	39	-	-	-	-	-	-	-
	♀:♂	38.7:61.3	-	-	-	-	-	-	-
Inshore Region	No. of fish	-	46	119	16	11	3	2	197
	♀:♂	-	19.6:80.4	38.7:61.3	50.0:50.0	100:0	100:0	100:0	40.1:59.9
Offshore Region	No. of fish	-	-	101	41	15	10	1	168
	♀:♂	-	-	40.6:59.4	65.8:34.2	93.4:6.6	100:0	100:0	56.0:44.0
Spawning Region	No. of fish	-	23	62	17	7	2	3	114
	♀:♂	-	30.4:69.6	43.5:56.5	64.7:35.3	100:0	100:0	100:0	50.0:50.0

cember. Both males and females younger than one year of age show no indication of shedding sex products. The age at first maturity does not differ between sexes and also the spawning period does not differ by ages.

The spawning fishes seek shallow waters less than 20 fathoms in depth and spawn when the water temperature approached 13-14 degree C. The gonads of fish larger than 50mm. in standard length show clearly the morphological differences between sexes. Table 5 shows the sex ratio of the total samples taken respectively from Matsushima Bay (juveniles), inshore, offshore and spawning regions in Sendai Bay. As is clearly seen from Table 5, the sex ratio in the whole samples examined is close to fifty-fifty. However, among the fishes of one year and two years of age, females were almost one-third and one-half respectively of the number of males. The ratio was changed in the case of the females of three-years of age, whose number was about twice that of males and the males older than four years of age could only be seldom found.

If the distribution of males and females were uniform in the whole fishing regions concerned, the female fish survive longer than males, although the starting number of the former are fewer. And also the natural death rate of the male fish from three years to four years of age should be larger than that of the female. Such being the case the age-composition of the catch should be computed separately for the two sexes.

The age-composition of the spawning group in 1950, of which the amounts of commercial catch and fishing efforts are known, is shown in Table 6. The age groups which contribute to the recruiment of this plaice consist of fish older than two years of age in both sexes. The age-compositions of the samples examined month by month revealed that the commercial catch in Sendai Bay consists mainly of fish of two years of age.

Table 6. The Age Composition of the Spawning group, landed in Yuriage Fish Market during the period from late in November through early in December, 1950.

Sex \ Age	I	II	III	IV	V
Female	7	25	9	3	3
Male	16	32	5	0	0

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