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VERTEBRAL COUNT AND GROWTH OF JAPANESE ANCHOVY, *ENGRAULIS JAPONICUS* TEMMINCK AND SCHLEGEL

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Japanese anchovy, *Engraulis japonicus* Temminck and Schlegel, is one of the most important neritic fishery resources in Japan and its annual yield amounts to 225,000 gramtons on an average, occupying 5% or a little less of the total yield of Japanese clupeoid fishes (Pacific herring excluded). Anchovy has a wide range of distribution in the Japanese waters from South Sakhalin and Hokkaidô in the north to Kyûshû in the south, although it is very common in the South Japan region and also on the south coast of Korea. Anchovy fishery takes place nearly all year round in the southern fishing ground and the peak of the season seems to be in winter. However, in the northern grounds the fishing season is rather shortened and its peak is shifted gradually towards summer.

Body length frequency polygon reveals three major modes. The whitebait group occupies the smallest mode under 50 mm, the medium sized group the medium mode from 50 to 90 or 100 mm and the large sized group the largest mode above 90 or 100 mm. The whitebait groups are present nearly all year round in such southern seas as around Kyûshû and on the southern Pacific coast, becoming scarce in winter on the northern Japan Sea coast and on the Pacific coast north from Cape Inubô, but they are never recorded around Hokkaidô and Sakhalin even in summer.

Probably due to the selective power of fishing gear and also due to the long duration of the spawning season, the whitebait

groups show no remarkable seasonal change in size and, in addition, the occurrence of eggs and larvae are so scattered in time and space that it is very difficult to make any accurate statement regarding its life history. Previously T. Nishikawa (1901) found two peaks in the occurrence of eggs and larvae in Suruga Bay and considered that the Japanese anchovy could spawn in winter and also in summer. Two peaks were also noted in the fishing season of whitebait groups off Aki in Tosa Bay as is shown in Table 1.

Table 1. Seasonal change in catch of whitebait group off Aki in Tosa Bay.

Month	Aki		Month	Aki		Susaki 1939
	1938	1939		1938	1939	
January	31294	1197	July	—	3180	4520
February	25144	30413	August	44843	2944	1028
March	13875	31883	September	31538	8366	25778
April	5963	25973	October	25541	27870	151992
May	14606	35824	November	13245	23355	31185
June	5963	39443	December	9420	13354	?

The whitebait groups are composed not only of the larvae of anchovy, but also of sardine (*Sardinia melanosticta*) and of Japanese murray (*Etrumeus microps*) in addition to several neritic fishes. The larval composition of whitebait groups varies seasonally and locally (Table 2).

Table 2. Seasonal change in the composition of whitebait group.

Locality	Date	Composition (%)			Anchovy		
		S	M	A	no.	*l* mm	*w* mg
Susaki	I 12, '37	—	—	100	—	—	—
,,	—, '38	7	5	88	—	—	—
,,	II 15, '37	51	22	27	—	—	—
,,	—, '38	93	2	5	278	32	15
Aburatsubo	28, '37	24	17	59	405	32	10
Susaki	III 12, '37	91	1	8	—	—	—
Aburatsubo	15, 〃	92	2	6	29	30	7
Yoshida	19, 〃	96	—	4	9	30	11
Totoro	IV —, '38	69	10	21	—	—	—

Susaki		1, 〃	—	1	99	—	—	—
Fukuoka		7, 〃	—	98	2	—	—	—
Aburatsubo		11, '37	44	—	56	219	27	5
Yoshida		14, 〃	81	—	19	32	36	—
Owase	V	28, '38	18	—	82	82	35	—
Aburatsubo		10, '37	2	—	98	446	35	20
Yoshida		10, 〃	24	1	75	375	29	10
Hamada	VI	4, '36	—	93	7	—	—	—
Ezumi		9, 〃	94	5	1	—	—	—
Yoshida		10, '37	—	—	100	259	24	5
Susaki		12, 〃	5	5	90	—	—	—
Hi-no-Misaki		27, '36	43	55	2	—	—	—
Hamada		28, 〃	74	1	25	—	—	—
Aburatsubo	VII	1, '37	82	7	11	51	25	4
Yoshida		8, 〃	—	—	100	228	49	55
Kasumi		8, '36	66	26	8	—	—	—
Fukuoka		9, '38	38	4	58	—	—	—
Aburatsubo	VII	6, '37	—	31	69	230	22	—
Aburatsubo		16, '37	—	58	42	211	24	7
Yoshida	IX	22, 〃	—	—	100	821	27	8
Aburatsubo	X	23, 〃	—	3	97	541	30	—
〃		10, 〃	—	2	98	319	33	19
〃		28, 〃	—	56	44	186	25	4
Susaki	XI	15, 〃	72	20	8	—	—	—
Aburatsubo		18, 〃	—	71	29	189	26	5
Yoshida		28, 〃	—	—	100	420	32	14
Aburatsubo		29, 〃	—	79	21	30	32	12
Kasumi	XII	1, '36	—	—	100	—	—	—
Susaki		15, '37	—	72	28	18	—	11
Aburatsubo		20, 〃	—	40	60	198	33	19

S: sardine, M: murray, A: anchovy.

The sardine of whitebait stage (less than 50 mm in length) is generally prevalent among the catch during the first half of a year and the murray of whitebait stage during the latter half. Nevertheless, the anchovy of whitebait stage is always prevalent, being especially abundant from early spring to autumn. The vernal peak in the occurrence of whitebait groups seemed to be associated with the prevalence of the larvae of sardine and anchovy and on the other hand the autumnal peak with dominance of

larvae of murray and anchovy along the Pacific coast. Apparently from the occurrence of the whitebait groups, anchovy can be considered to spawn twice a year.

Anchovy of the Mediterranean Sea (*Engraulis encrasicholus*), ranging from 80 to 160 mm in average length, is generally smaller than the anchovy on the Atlantic coast of Europe. It seems probable that spawning takes place in summer and again in winter, although egg-production is usually far larger in amount in summer than in winter. Among the Australasian anchovies (*E. australis*), there exist many different races at different localities, considered from the occurrence of eggs and larvae. They are liable to occur densely in such localitles as on the coast from New South Wales to Queensland, from Victoria coast to Tasmania, around the New Zealand, on the south coast and also on the southwest coast of Australia. The specimens measured in any locality range from 40 to 130 mm in total length and 70-80 mm groups are generally prevalent everywhere. Mature anchovies are recorded both in summer and in winter. In several respects, the Australasian anchovies closely resemble the Japanese anchovy.

Based upon the vertebral count, which has been used in the study of race, the present authors could divide anchovy collections around Japan into two different groups and then easily trace seasonally the growth process of each group. At first, vertebral count was made for whitebait collections in 1936 and 1937, which were preserved in formalin (Table 3).

Table 3. Vertebral count of whitebait group.

Locality	Date		Mean	No.	No. of vertebrae			
					44	45	46	47
Yoshida	V	10, '37	45.41	104	2	59	41	1
Aburatsubo		17, 〃	45.29	103	3	67	33	
〃	VIII	16, '36	45.16	104	6	71	25	
Sodegaura		27, 〃	45.16	124	8	92	26	
Aburatsubo	IX	23, '36	45.17	104	3	80	21	
〃	X	10, 〃	45.06	101	12	71	18	
Sodegaura		14, '37	45.10	117	12	81	24	
Totoro	XI	10, 〃	45.09	117	8	91	18	

Note: hypural included.

The significance in the difference of numbers of vertebrae between any two collections is tested with chi-square method under the assumption that both collections will follow the same variation law in the number of vertebrae. When P-value, known from chi-square value, is higher than 0.05, the difference indicated is nonsignificant and both collections are considered to belong to the group of the same origin. On the other hand, when P-value is less than 0.05 or 0.01, the difference is highly significant and both collections are probably different from each other.

The differences of the vertebral numbers between the Aburatsubo collection in May (45.29) and any one of the Aburatsubo collections in August (45.16), in September (45.17) and in October (45.06) are all indicated as highly significant. However, all the collections after August in different localities and in different years are not significantly different from each other, as P-values are always higher than 0.05 (Table 3). Accordingly, the number of vertebrae seems to vary seasonally, but neither locally nor annually. To prove this conclusion, many anchovy samples were collected from different localities in different seasons since 1943 (Fig. 1). The details of measure of body proportion and the vertebral count are given in Tables 4 and 5.

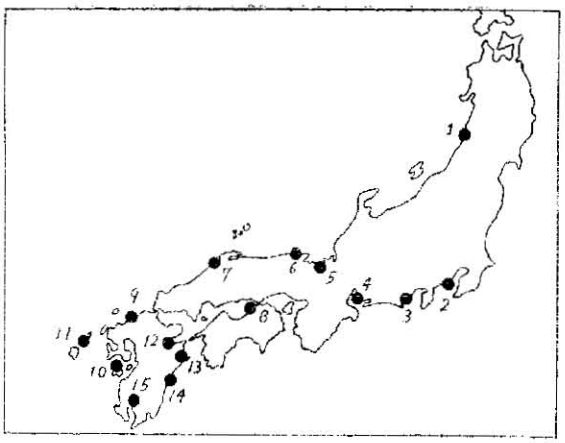

Fig. 1. Local stations where anchovy samples were collected. 1. Sodegaura, 2. Aburatsubo, 3. Yoshida, 4. Toyohama, 5. Miyazu, 6. Kasumi and Hi-no-Misaki, 7. Hamada and Ezumi, 8. O-Sima, 9. Ai no-Sima, Fukuoka, Karadomari and Fukae, 10. Tomioka, 11. Goto-Aoe, 12. Beppu, 13. Kamae, 14. Totoro, 15. Kagoshima

Table 4. Seasonal change in size and weight of Japanese anchovy.

Locality	Date		No.	Total length range	Total length 1 mm	Body l. mm	Head l. mm	Body weight mg	Sex-factor
Kamae	I	—, '45	61	96—130	111.2	92.1	—	65.8	
,,	IV	24, 〃	50	96—130	112.1	95.7	—	38.5	
,,	IV	—, 〃	39	111—155	134.3	101.3	—	116.0	
Tomioka	VIII	9, '46	40	81—100	87.2	75.0	—	23.0	
Ai-no-Sima	IX	—, '45	34	96—150	111.0	95.9	—	81.5	
,,	XI	22, 〃	53	101—146	112.3	92.4	—	86.7	
Beppu	X	28, '46	200	29—121	76.9	63.8	—	24.9	2.245
,,	XI	5-25, 〃	302	62—120	72.5	61.3	—	23.0	1.247
,,	I	6, '47	340	56—85	69.5	58.1	—	18.9	1.817
,,		15, 〃	300	44—79	66.6	55.9	—	16.1	3.038
,,	II	4, 〃	460	37—76	63.7	52.4	—	16.3	2.405
,,		24, 〃	348	70—108	84.2	68.9	—	34.4	1.274
,,	III	3, 〃	414	40—93	78.3	61.5	—	27.3	1.000
,,		17, 〃	148	60—95	79.8	65.3	—	29.7	0.973
,,		30, 〃	207	65—97	81.4	66.5	—	32.9	0.731
,,	V	24, 〃	148	87—132	103.4	86.1	—	71.4	0.615
,,		19, 〃	162	105—139	125.1	103.8	—	108.4	0.844
Tomioka	IX	6, '46	32	82—107	93.2	78.3	—	34.4	0.688
,,	X	—, 〃	66	89—112	98.9	88.0	—	49.2	
,,	I	8, '47	269	33—96	46.6	38.9	—	62.0	
Kitazaki	I	7, '47	331	57—108	93.0	78.0	—	50.6	1.482
,,		29, 〃	705	47—110	66.6	54.9	—	18.2	2.082
Totoro	X	14, '43	70	26—65	40.9	34.5	9.4	4.1	
,,		21, 〃	128	26—46	34.2	28.5	7.5	2.5	
,,		28, 〃	99	28—59	41.1	34.0	9.2	4.0	
,,		30, 〃	58	37—65	50.0	47.9	11.6	6.8	
,,	XI	2, 〃	37	40—63	50.3	42.0	11.5	6.6	
,,	XII	3, 〃	162	24—44	33.2	27.6	7.4	2.2	
,,		8, 〃	186	25—46	36.9	30.3	8.4	2.7	
,,		20, 〃	116	25—46	32.4	27.3	7.1	2.1	
,,		26, 〃	19	49—84	56.9	47.4	13.7	9.3	
,,		26, 〃	82	25—46	35.2	29.1	7.7	2.4	
,,		28, 〃	134	25—46	34.5	28.7	7.8	2.5	
,,	I	16, '44	68	34—50	41.8	34.0	9.3	3.7	
,,		19,	124	30—74	40.6	33.2	9.2	3.7	
,,		20, 〃	106	31—48	40.2	32.6	9.0	3.4	
,,	IX	1, '47	241	37—69	51.2	43.4	12.6	6.9	
Miyazu	XII	3, '47	670	22—48	30.8	25.8	6.5	1.8	
,,		31, 〃	260	24—53	37.8	31.7	8.6	3.2	
,,	I	14, '48	428	30—57	46.3	39.0	10.3	5.1	
Gotô	X	15, '47	620	22—41	29.4	25.1	6.2	1.5	
Ô-Sima	I	13, '48	280	66—98	—	81.1	22.3	47.0	1.028
Toyohama	XII	1, '47	450	66—114	88.8	74.9	21.5	41.8	0.902
Fukae	XI	12, '47	140	38—72	52.6	44.0	12.5	7.9	
Kasumi	X	8, '36	101	39—84	—	57.2	16.9	18.6	
,,		〃 〃	135	25—47	33.6	27.6	7.1	2.1	

Table 5. Results of the vertebral counts for Japanese anchovy.

Locality	Date		Mean no. of vertebrae	Size	Number of vertebrae						Sum
					42	43	44	45	46	47	
Kasumi	X	8, '36	45.05±0.49	W	—	—	13	102	20	—	135
Totoro		14, '43	45.03±0.59	W	—	1	8	49	12	—	70
,,		21, 〃	45.12±0.53	W	—	—	11	90	27	—	128
,,		28, 〃	45.14±0.53	W	—	—	8	69	22	—	99
,,		30, 〃	45.19±0.54	W	—	—	4	39	15	—	58
,,	XI	2, 〃	45.14±0.53	W	—	—	2	29	5	1	37
,,	XII	3, 〃	45.12±0.48	W	—	—	10	122	30	—	162
,,		8, 〃	45.11±0.53	W	—	1	13	135	37	—	186
,,		20, 〃	45.08±0.49	W	—	—	10	87	19	—	116
,,		26, 〃	45.11±0.46	W	—	—	5	80	16	—	101
,,		28, 〃	45.07±0.47	W	—	—	10	104	20	—	134
,,	I	19, '45	45.12±0.59	W	—	—	12	88	21	3	124
,,		20, 〃	45.12±0.56	W	—	—	11	71	24	—	106
Kamae	VIII	9, '45	45.07±0.35	L	—	1	9	46	17	—	73
Tomioka	I	8, '46	45.02±0.62	M	—	—	33	176	55	1	265
Beppu	I	6, '47	45.07±0.56	M	—	2	41	221	69	—	333
,,		7, 〃	45.14±0.54	M	—	—	28	229	73	—	330
,,		15, 〃	45.02±0.62	M	1	1	43	198	50	2	295
,,	II	4, 〃	45.06±0.55	M	—	1	53	312	81	—	447
,,		24, 〃	45.12±0.55	M	—	—	37	236	74	2	349
,,	III	3, 〃	45.12±0.53	M	—	—	36	282	85	—	403
,,		17, 〃	45.15±0.52	M	—	—	10	102	32	—	144
,,		30, 〃	45.12±0.54	M	—	—	19	145	41	1	206
Gotô-Aoe	X	15, 〃	45.05±0.60	W	—	6	78	419	116	1	620
Fukae	XI	12, 〃	45.16±0.62	W	—	—	14	92	31	3	140
Miyazu	XII	3, 〃	45.14±0.60	W	—	12	84	428	141	5	670
,,		21, 〃	45.06±0.61	W	—	2	35	169	54	—	260
,,	I	14, '48	45.06±0.52	M	—	1	42	314	71	—	428
Kagoshima	XI	4, 〃	45.00±0.70	M	—	1	—	7	2	—	10
Kasumi	X	8, '36	45.32±0.61	M	—	—	8	53	40	—	101
Kamae	I	—, '45	45.31±0.56	L	—	—	2	23	14	—	39
,,	IV	20, 〃	35.39±0.65	L	—	1	8	56	18	—	83
Ai-no-Sima	IX	—, 〃	45.33±0.33	L	—	—	1	12	8	—	21
,,	XI	22, 〃	45.65±0.28	L	—	—	—	14	14	3	31
Tomioka	VIII	24, '46	45.35±0.54	M	—	—	2	8	6	1	17
,,	IX	6, 〃	45.44±0.50	M	—	—	—	18	14	—	32
Beppu	X	28, 〃	45.33±0.60	M	—	—	7	124	61	6	198
Karadomari	I	29, '47	45.21±0.54	M	—	—	43	465	184	1	693
Beppu	V	24, 〃	45.43±0.54	L	—	—	13	93	40	2	148
,,	VI	19, 〃	45.32±0.61	L	—	—	11	87	63	1	162
Totoro	IX	1, 〃	45.26±0.60	W	—	—	15	154	67	5	241
,,	X	25, 〃	45.26±0.58	M	—	—	19	189	91	3	302
Toyohama	XII	1, 〃	45.25±0.56	M	—	1	21	295	130	3	450
O-Sima	I	3, '48	45.27±0.63	L	—	2	13	181	75	9	280
Kagoshima	XI	4, 〃	45.36±0.72	L	—	—	—	28	14	—	42
,,	XII	8, 〃	45.36±0.72	L	—	—	4	21	15	2	42

Note: W—whitebait group, M—medium sized group, L—large sized group.

On seeing the frequency distribution of the average numbers of vertebrae within the range from 45.00 to 45.65, there occur two modal groups, that is, the lower modal group ranging from 45.06 to 45.15 and the higher one from 45.31 to 45.35, both groups being separated by the range from 45.16 to 45.25. Among eighteen collections in 1947, the Gotô-collection (October 15) is selected as a standard and the differences in the average numbers of vertebrae between the standard collection and any one of other seventeen collections are tested with the chi-square method (Table 6). Disregarding the size of fish and the date of collection, the differences are always indicated as nonsignificant between the collections with the vertebral numbers less than 45.20, while they are highly significant between the standard and all the collections with the vertebral numbers greater than 45.20

Table 6. Chi-square test for the differences in the vertebral numbers with the standard collection in Gotô.

Locality	Group	Average length (mm)	Average vert. no.	n	χ^2	P
Beppu	M	70	45.07	3	0.7742	>0.8
,,	M	92	45.14	2	5.9109	>0.05
,,	M	67	45.02	4	2.7883	>0.5
,,	M	64	45.06	3	2.6799	>0.30
,,	M	84	45.12	3	3.4464	>0.3
,,	M	78	45.12	2	5.4370	>0.05
,,	M	80	45.15	2	5.4166	>0.05
,,	M	81	45.12	3	2.6911	>0.3
Fukae	M	53	45.16	3	7.6095	>0.05
,,	W	31	45.14	4	5.5916	>0.2
Miyazu	W	38	45.06	3	0.7222	>0.8
Karadomari	M	67	45.21	3	27.1545	0.01
Beppu	L	110	45.43	3	92.1087	>0.01
,,	L	125	45.32	3	32.5536	>0.01
Totoro	W	43	45.26	3	30.4927	>0.01
,,	M	73	45.26	3	470.8733	>0.01
Toyohama	M	82	45.25	4	328.2798	>0.01

Note: W: wheitebait group, M: medium sized group, L: large sized group.

Treated together the collections in Beppu Bay from January to May, 1947, the body length frequency polygon reveals two major groups (Fig. 2). 70 mm (medium sized) group of lower mode is

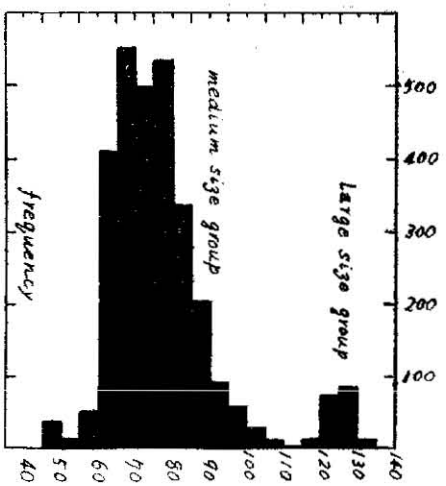

Fig. 2. Body length frequency polygon of anchovies caught in Beppu Bay from January to May, 1947

less in the number of vertebrae than 125 mm (large sized) group. The difference of the vertebral numbers between these two groups is indicated highly significant (Table 7).

Table 7. Chi-square test for the difference of the numbers of vertebrae between the medium and large sized groups collected in Beppu Bay from January to May, 1947.

Group	Range (mm)	Average vert. no.	No.	Number of vertebrae					
				42	43	44	45	46	47
70 mm	35—115	45.16	2370	1	4	250	1605	504	6
125 mm	116—140	45.34	32				22	9	1

$n = 2$, $x^2 = 17.99$, $P < 0.01$

Accordingly, the anchovy collections are divided into two groups, one of which possesses the average number of vertebrae lower than 45.20 and another that higher than 45.20. From Table

3. it is easily known that the groups with lower vertebral number are present as the whitebait group mainly in autumn and also as medium sized group in spring. On the other hand, the groups with higher vertebral number appear as whitebait group in spring and as medium sized group from summer to autumn. The large sized groups are of the group with higher vertebral number in winter, while they are of that with lower number in summer. Considered from the occurrences of these two groups, all groups with higher vertebral number will be originated from the offsprings spawned in winter and those with lower vertebral number from the offsprings in summer. Here, the groups with higher vertebral number may be called as the winter offspring group and those with lower number as the summer offspring group.

For each of different offspring groups, the total collections of a separate year and grand total collection of all years are given in Table 8. Among the same offspring groups, the differences of the numbers of vertebrae between the grand total collection and any total collection of each separate year are nearly always indicated as nonsignificant ($P > 0.05$), except the summer offspring group in 1943 ($P < 0.01$). Therefore, the annual variation in the number of vertebrae is considered nonsignificant among the same offspring group. On the contrary, the differences of the vertebral numbers between the different offspring groups of all years also of any separate year, except 1945, are always highly significant. The differences in the numbers of vertebrae are certainly considered seasonal in nature rather than annual and geographical (Tables 8 and 9).

Table 8. Chi-square test for the differences between the grand total collection and each total collection of a separate year.

Years	Average no. of vertebrae	No.	Number of vertebrae						n	χ^2	P
			42	43	44	45	46	47			
1936	45.05	135	—	—	13	102	20	—	2	2.7773	>0.2
1943	45.11	1091	—	2	81	804	203	1	3	12.3466	>0.01
1944	45.12	230	—	—	23	159	45	3	3	6.9360	>0.05
1945	45.07	73	—	1	9	46	17	—	2	1.2674	>0.5
1946	45.02	265	1	—	33	176	55	1	2	0.9031	>0.8
1947	45.08	4197	—	24	478	2833	847	14	4	3.5093	0.3
1948	45.07	439	—	2	42	321	73	—	2	6.4213	>0.02
All years	45.09	6430	1	29	680	4441	1260	19	—	—	—

1936	45.32	101	—	—	8	53	40	—	2	4.7620	>0.05
1945	45.27	174	—	1	11	105	54	3	2	0.6610	>0.7
1946	45.35	247	—	—	9	150	81	7	2	2.9115	>0.2
1947	45.24	1996	—	1	122	1283	575	15	3	3.5090	>0.1
1948	45.29	364	—	—	17	230	104	11	3	7.2489	>0.05
All years	45.26	2882	—	2	167	1821	854	36	—	—	—

Table 9. Chi-square test for the differences of the same year classes.

Year	n	χ^2	P
1936	2	18.1966	<0.01
1945	2	4.2638	>0.1
1946	2	22.0603	<0.01
1947	4	100.3590	<0.01
1948	2	26.6076	<0.01
All years	4	191.9838	<0.01

C. L. Hubbs (1925) found the males of northern anchovy (*Engraulis mordax mordax*) to have a slightly higher vertebral number (45.77) than the female (45,65), although he considered the difference (0.12 excess for the males) to be "of probable but hardly certain significance" The sexual dimorphism in vertebral number was found highly significant for the elasmobranch (*Spinax niger*) by R. C. Punnett (1901) and also for capelin (*Mallotus villosus*) by J. L. Hart (1937). Although the sex factor (the number of females divided by that of the males) varies seasonally in considerable extent (0.6−3.0), the differences of the numbers of vertebrae are always nonsignificant among the same collection as is shown in Table 10.

Table 10. Comparison of the numbers of vertebrae between the males and females.

Locality	Date	Sex factor	Average number of vertebrae		Excess for male	Significance
			male	female		
Beppu	X 28, '46	2.25	45.34±0.64	45.34±0.61	±0.00	no
,,	XI 5-25, '46	1.25	45.24±0.66	45.26±0.58	−0.02	no
,,	I 6, '47	1.82	45.02±0.61	45.09±0.58	−0.07	no
Karadomari	I 7, '47	1.48	45.13±0.55	45.12±0.50	+0.01	no
Beppu	I 15, 〃	3.04	45.02±0.57	45.08±0.62	−0.06	no

,,	II	4, 47	2.41	45.03±0.54	45.06±0.50	−0.03	no
,,		24, 〃	1.27	45.10±0.57	45.12±0.57	−0.02	no
,,	III	3, 〃	1.00	45.10±0.52	45.15±0.53	−0.05	no
,,		17, 〃	0.97	45.10±0.54	45.15±0.52	−0.05	no
,,		30, 〃	0.73	45.15±0.58	45.09±0.49	+0.06	no
Kamae	IV	24, 〃	1.37	45.17±0.55	45.00±0.63	+0.17	yes
Beppu	V	24, 〃	0.62	45.20±0.54	45.18±0.66	+0.02	no
,,	VI	19, 〃	0.69	45.32±0.62	45.35±0.57	−0.03	no
Mean			1.53	45.16±0.58	45.15±0.66	+0.01	no

There occur in the same direction the significant differences between the groups of different offsprings everywhere, but, on the contrary, there exist no significant differences between the groups of the same offspring even in different localities. Therefore, the geographical variation is unrecognizable in the number of vertebrae. However, all groups of the same offspring are not considered to belong to a unit population all around Japan, as anchovies are liable to occur densely in some different localities. The race of anchovies must be determined based upon the variation in some other morphometric characters.

The seasonal change in body length are shown graphically in Fig. 3, where the groups of winter offspring with higher vertebral number than 45.20 are indicated with black circles and those of summer offspring with lower vertebral number than 45.20 with white circles. The whitebait groups of summer offspring appear a little already in August and are dominant from September to December. Some of them attain the medium size above 50 mm in November, although the medium sized groups of summer offspring become prevalent after succeeding January till March and they attain the large size above 100 mm in May and June.

On the other hand, the medium sized groups of winter offspring are generally prevalent from August till December and some of them attain the large size above 100 mm in November. The large sized groups of winter offspring appear abundantly in the next February and March. The medium sized groups of winter offspring and the whitebait groups of summer offspring occur together from late summer to early winter on one hand and the medium sized groups of summer offspring and the large sized groups of winter offspring are present together from early winter

till spring as was observed in Beppu Bay in 1947 (see Fig. 2). After late spring till summer, the medium sized groups of summer offspring occur together with the whitebait groups of winter offspring. The same sized groups of different offsprings are never found together in any season and in any locality.

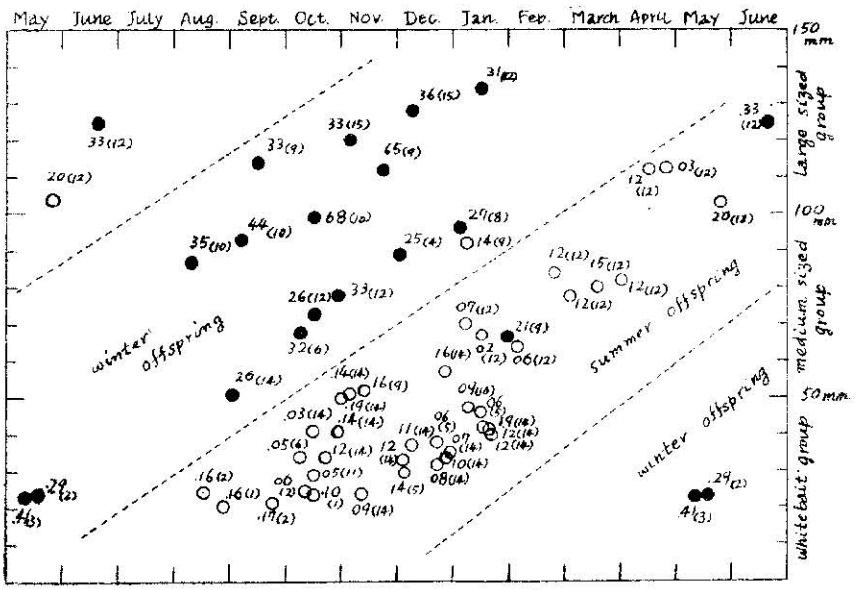

Fig. 3. Seasonal change in body length with refference to the average number of vertebrae and the locality. ●: winter offspring, ○: summer offspring, number: for example. $03_{(12)}$, indicates average number of vertebrae 45.03 of the collection in St. 12 (Beppu as shown in Fig. 1).

The larvae, hatched out either in winter or in summer, are observed as whitebait group from 20 to 50 mm in body length during the first six month period and as the medium sized group from 50 to 90 or 100 mm during the following six month period. The large sized groups above 90 or 100 mm in body length are of a year old, but only a little one and a half or more years old. From scale reading for European anchovy, the body length l_1 is calculated as 80–120 mm, l_2 as 140–170 mm, and l_3 as 160–200 mm respectively. Groups of one and two years old are generally dominant, but those older than two years rather scarce (Alex.

Meek, 1916). Differing from this statement, anchovy in the Zuiderzee grows more rapidly (H. C. Redeke, 1939). Anchovy enters the Zuiderzee in April from the North Sea and spawns in June and July. In a little less than three days at a temperature varying from 14° to 17°C, the larvae hatch out and grow rapidly during summer, reaching an average length of 90 to 100 mm in October, then the young anchovies leave the Zuiderzee, but the greatest part, about 80%, come back again next spring as nearly ripe fish and spawn, being then one year old and having grown to an average length of about 150 mm, the remaining 20% consisted of individuals of two or exceptionally three years. During the first one year, the growth process of the anchovy of the Zuiderzee resembles much that of the Japanese anchovy. The Atlantic anchovy of North America (*E. mitchilli*) is 70 mm in body length on an average and spawns only in summer from June to August. The northern anchovy (*E. mordax mordax*) of the Pacific coast of North America is generally smaller than 150 mm in body length and spawns in winter off South California. American anchovies on both coast resemble the Japanese anchovy in size, but differ in the spawning habit from the latter.

The annual yield of anchovy in Japan fluctuates remarkably every year, because the young anchovies are caught as whitebait group already in two or three months after hatching out and also as medium sized group in seven or eight months. The unfavourable spawning in one season effects the catches of these small anchovies, as it cannot be easily compensated by the favourable spawning in the next season within a year. The fluctuation in catch was within the range from 1 to 4.4 off Aki in Tosa Bay (Table 11), where the anchovy fishery takes place throughout the year. Nevertheless, the range of fluctuation will be far more remarkably wide in the fishing grounds, where the fishery takes place during only a part of a year.

Table 11. Fluctuation in catch off Aki in Tosa Bay.

Year	Catch in value	Year	Catch in value	Year	Catch in value	Year	Catch in value
1920	¥ 26124	1925	¥ 23023	1930	¥ 20150	1935	¥ 17596
1921	32579	1926	36344	1931	19800	1936	48108
1922	34321	1927	35755	1932	20730	1937	44183
1923	37503	1928	36238	1933	22932	1938	52202
1924	29423	1929	37750	1934	50909	1939	77782

As some of the medium sized groups of half a year old are already provided with ripe gonads, the Japanese anchovy can grow not only rapidly but also reproduce vigorously. Therefore, anchovy resource can stand against the present intense fishing and show no decreasing trend in catch anywhere, except the remarkable fluctuation.

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