Ecological Studies on Gobid Fish, *Acanthogobius lactipes* (Hilgendorf) —I. Spawning

Toru Takai

1. Preface

The ecology of *Acanthogobius lactipes* from the Japanese waters has little been known. More than 30 years ago, Dotsu[1] reported the life history of this species around Kyushu, which was only report so far known. Every summer from 1970, the author has examined fisheries biology of this species, especially spawning behavior and early life history, in the Suo Nada area of eastern part of Yamaguchi Prefecture, in order to know the relationship between the present species and other predator fishes living in bay area of the Seto Inland Sea. The present report deals with the size and age of the parent fishes of *Acanthogobius lactipes* and their spawning behavior during the reproductive season.

2. Materials and Methods

The materials examined for total length of the parent fishes and their age determination were as follows: one was those, which were caught from their spawning nest during the low tide, and the other was material collected by a towing net (length 15 m, height 2 m, mesh size 1.7mm) from neighborhood area (Fig. 1). The age determination (growth) was analyzed by number of ridge, which was formed on lateral part of an exposed portion of the scale, and by the distance from the focus, measured under Nikon Profile Projector (Nikon V 24) (Fig. 2). Relationships between scale length and number of ridge, and total length and number of ridge were based on the scales obtained monthly from live specimens, which were hatched in late June and reared at an outdoor pond until end of December.

For the examination of spawning nest, about 50 pieces of roofing tiles (collectors) already prepared and other natural substances such as stones and wood pieces on tidal flat were inspected carefully. The sex of the parents, their total length, the structure of spawning nest, the size and number of egg masses, their developmental stages and water temperature of the nest were also examined. The spawning and hatching times were examined individually at the special spawning nest under marked tiles during the day at low tide.

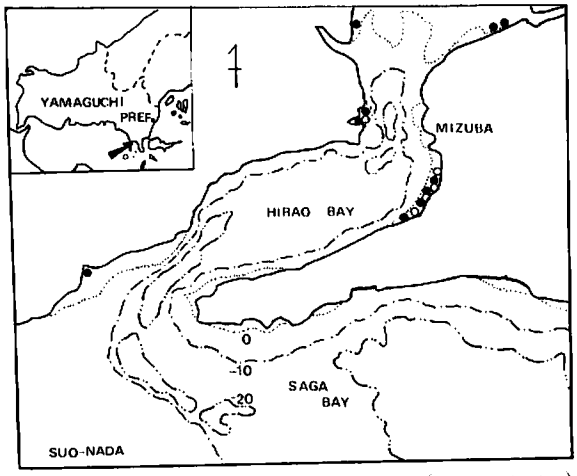

Fig. 1. Location of sampling stations (solid circle) for *Acanthogobius lactipes* around Hirao Bay, Seto Inland Sea.

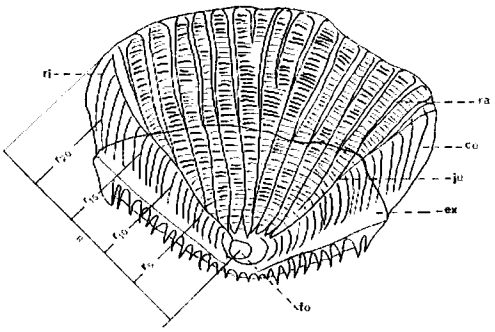

Fig. 2. Scale of *Acanthogobius lactipes*, showing portion for measurments. R, radius; CO, covered portion; f, focus; ju, juncture; ri, ridge.

3. Results

3・1. Parents

3・1・1. Sex, size and fatness : The compositions of total length and weight of the parents fishes collected from spawning area and its neighborhood during mid-spawning season, from mid July to early August, were shown in Figure 3 and Table 1. The total length of males varied from 48.0 to 88.0mm and the average was 73.90 ± 0.98mm, and females were 53.0—79.4mm in total length and their average was 69.9 ± 1.52mm. The size, in which the fishes was most frequently appeared, was 69.0—81.0mm in male (65.2%), 69.0—78.0mm in female (57.9%). Proportion of the large fishes, more than 78.0mm was 35.7% in male, and 10.5% in female, and therefore, the large specimens were usually male.

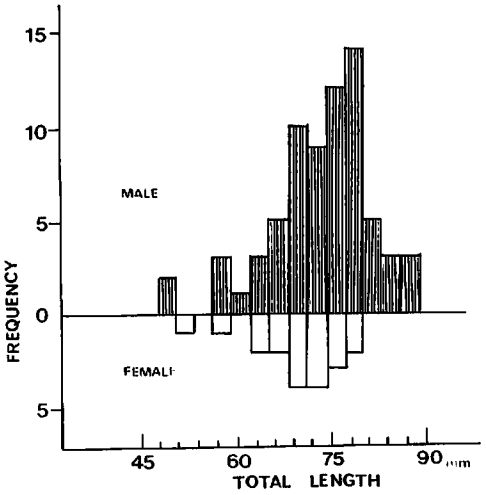

Fig. 3. Size composition of mature fishes of *Acanthogobius lactipes* collected from Hirao Bay.

Table 1. Fatness of parent fish of *Acanthogobius lactipes* in spawning season. TL, total length, BW, body weight; f, fatness($BW/TL^3 \cdot 10^3$); N, number of specimens. A and B, survey areas shown in Fig. 1.

Items		Male			Female		
		TL(cm)	BW(g)	f	TL(cm)	BW(g)	f
A	*n*	58	57	57	17	17	17
	Range	4.80~8.80	1.06~6.0	4.05~20.50	5.30~7.94	1.02~3.89	6.37~10.62
	Mean ±S.D.	7.38±0.84	3.19±1.07	7.84±2.47	7.06±0.67	2.88±0.49	8.18±0.91
B	*n*	12	12	12	2	2	2
	Range	6.10~8.57	1.28~5.27	5.21~9.56	6.37~7.57	2.18~3.43	7.91~8.43
	Mean ±S.D.	7.44±0.98	3.23±1.20	7.55±1.47	6.97	2.81	8.17
A+B	*n*	70	69	69	19	19	19
	Range	4.80~8.80	1.0~6.0	4.05~20.50	5.30~7.94	1.02~3.89	1.02~3.89
	Mean ±S.D.	7.39±0.82	3.20±1.10	7.79±2.32	6.99±0.66	2.87±0.78	2.87±0.78

The average fatness was larger in female (8.18±0.25mm) than in male (7.79±0.28mm). The relationship between total length (L, mm) and weight (W, g) were

$$W = 1.048L - 45.47 \quad \text{in male,}$$

$$W = 1.047L - 44.55 \quad \text{in female.}$$

There was no significant difference between them (Fig. 4).

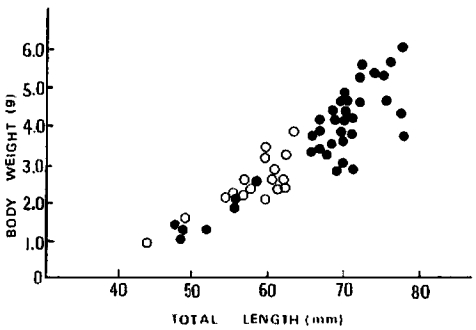

Fig. 4. Relationship between total length and body weight of *Acanthogobius lactipes*. Solid circle, male; open circle, female.

3・1・2. Age: Using the ridge on exposed part of scale, the scale length (r_i) was determined as a distance from the scale focus to each ridge (Fig. 2). The relationship between number of ridge (n_i) and scale length was shown in Fig. 4. The average scale lengths at the average value of each ridge such as 5, 10 or 15, were shown in Table 2.

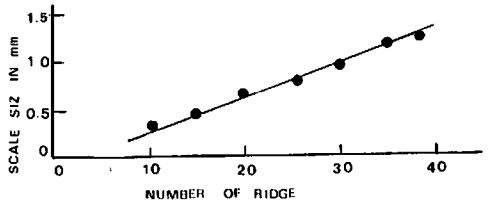

Fig. 5. Relationship between size in radius and number of ridges in exposed portion of scale of *Acanthogobius lactipes*. For detailed measurement see Fig. 2.

Table 2. Radius (r_i) of marking ridges of scale and calculated total length (L') of *Acanthogobius lactipes*.

Specimens	r_i						
	r_5	r_{10}	r_{15}	r_{20}	r_{25}	r_{30}	r_{35}
1	0.19	0.30	0.43	0.61 0.65(21)			
2	0.19	0.32	0.49	0.64	0.79	0.94 1.00(33)	
3	0.15	0.25	0.40	0.55	0.71	0.84 1.09(33)	
4	0.15	0.31	0.48	0.67	0.84 0.93(28)		
5	0.18	0.30	0.44	0.64	0.80	0.96	1.11 1.22(38)
Mean	0.17	0.30	0.45	0.62	0.79	0.91	1.11
L' (mm)	19.6	25.3	32.0	39.6	47.1	52.4	61.3

Of the material examined, selected 10 specimens each, 48.0—88.0mm in male and 55.0—76.0mm in female, the relation between scale length (S) and total length (L) were calculated.

$$S = 0.0225\,L - 0.270$$

Based on this formula, the calculated total length (L') at the time when the scale was formed was shown in Table 2.

Above-mentioned results of growth pattern and number of scale ridge of adults fishes collected at the spawning season showed that the parent fishes were thought to be about one year old population.

3・1・3. Maturation and ovarian eggs : Based on 18 female specimens collected at the spawning season, the maturity factor[23] ($M_f = W_o / W \cdot 10^2$) was shown in Table 3. W_o was weight of ovary (g), W was body weight (g). The maturation started at 6.0 in this factor.

Table 3. Maturity factor of female of *Acanthogobius lactipes* in spawning season. BW, Body weight (g) ; OW, ovary weight (g) ; Mf, maturity factor (OW/BW $\cdot 10^2$).

Items	BW(g)	OW(g)	Mf
n	18	18	18
Range	1.02~3.89	0.03~0.42	1.03~12.66
Mean±S.D.	2.85±0.79	0.21±0.10	7.62±2.87

The relationship between ovary weight (W_o) and total length (L) was as follows (Fig. 6)

$$W_o = 0.4862\, L^{0.0785}$$

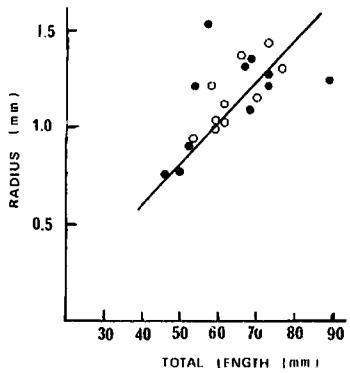

Fig. 6. Relationship between scale size in radius and total length of *Acanthogobius lactipes*. Open circle, male; solid circle, female.

The gonad condition factor of the female population ($KL = GL/L$, where GL was ovary length) was 0.12—0.25 (0.20 on average) in specimens ranged under the above-mentioned total length (Table 4). Judging from the gonad condition factor (KL), the matured specimens were more than 0.18. This showed the ovary length attained 18% of total length.

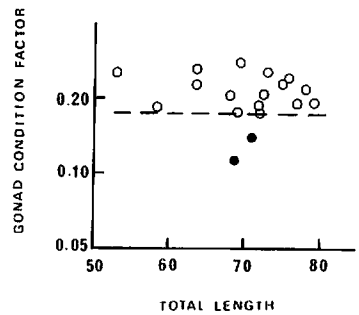

Fig. 7. Relationship between ovary weight and total length of *Acanthogobius lactipes*.

The ovary was mixed with large matured eggs and small immature eggs. The former was the first spawning eggs, 0.41—0.71mm in diameter and the latter was the secondary spawning eggs, 0.14—0.24mm.

The matured ovarian eggs (E_n) were calculated as 1349—4441 in number and 2554.4±200.9 on average. The following relationship with the total length (L) was established approximately (Table 4).

$$E_n = 596.95\,L - 1643.47$$

Table 4. Number of ovarian eggs of *Acanthogobius lactipes* collected from the spawning room. Parentheses show length of ovary in mm.

Specimens	TL (mm)	BW (g)	En		
			Right	Left	Total
1	75.7	3.43	1461(17.2)	1709(17.2)	3170
2	69.2	3.52	1342(17.1)	1512(13.6)	3054
3	72.5	3.24	1540(15.2)	1758(14.0)	3298
4	73.0	3.80	2160(17.0)	2281(18.0)	4441
5	75.0	3.00	1256(16.2)	1042(15.2)	2298
6	68.2	2.55	1183(13.9)	1263(13.0)	2446
7	72.0	2.82	978(13.5)	979(15.3)	1957
8	63.5	2.01	1161(15.2)	1213(14.0)	2374
9	53.0	1.02	726(12.4)	623(9.5)	1349
10	72.0	3.05	1096(13.0)	1349(13.2)	2445
11	79.4	3.60	1145(15.4)	1385(17.0)	2530
12	69.5	3.18	− (−)	− (−)	− (−)
13	69.3	2.12	617(12.5)	785(11.0)	1402
14	70.8	2.92	− (10.5)	− (9.5)	−
15	78.0	3.45	1234(16.5)	1350(18.3)	2584
16	58.5	1.58	708(11.0)	790(−)	1498
17	76.8	3.89	1574(14.8)	1715(15.0)	3289
18	68.8	3.13	− (8.0)	− (7.0)	−
19	63.7	2.18	1242(14.0)	1494(13.4)	2736
Range	53.0~79.4	1.02~3.89	617~2160	623~2281	1349~4441
Mean±S.D.	69.9±0.7	2.87±0.8	1226.4±385.5	1327.9±428.7	2554.4±803.8

3・2. Spawning

3・2・1. Spawning nest : The position of the spawning nest against the sea level was shown in Fig.8. The position is restricted to the intertidal flat, 0 — 5 hours exposed. Substratum of the spawning nest was muddy sand or sand, and usually underground water saturated to the substratum or more or less containing the underground water. Water temperature at low tide in late July was 26.9—29.6℃, chlolinity was 7.0—11.5‰, specific gravity (σ_{15}) was

12.76—20.86. The structure of the nest was summarized in Table 5. The entrance of the nest usually opened to the sea side or the main channel. The nest was circle or pear-shaped, with 1.0—3.3cm depth and 45—250cm² in wide and filled always with waters (Fig.9).

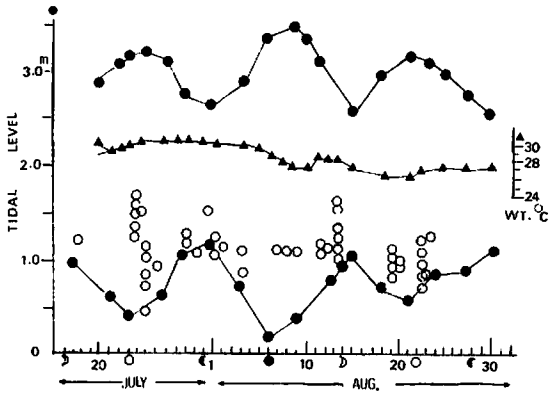

Fig. 8. Location of spawning rooms of *Acanthogobius lactipes* above 0 meter line.

Table 5. Number of attached eggs in egg mass of *Acanthogobius lactipes*.

Specimen	Area of egg-mass(cm²)	Number of eggs	Number of per cm²
1	25.12	1750	69.7
2	24.61	2441	99.2
3	20.35	3363	165.3
4	18.84	2842	150.8
5	17.38	3282	188.8
6	16.61	2289	137.8
7	13.65	2114	154.9
8	11.91	1994	167.2
9	10.99	1831	166.6
10	10.36	1922	185.5
11	9.67	335	34.6
12	9.42	2171	230.5
13	7.54	1638	217.2
14	5.31	729	137.3
n	14	14	14
Range	5.31~25.12	335~3363	34.6~230.5
Mean±S.D.	14.41±5.97	2050.1±806.1	150.4±51.6

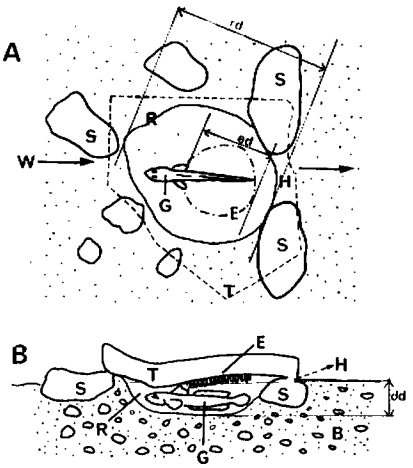

Fig. 9. Diagrammatic illustrations of spawning room of *Acanthogobius lactipes*. A, horizontal view of whole room; B, cross section of room; E, egg-mass; G, parent fishes; H, entrance of room, R, room; T, roof tile. ed, Diameter of egg mass; rd, diameter of room; depth of room.

3・2・2. Spawning and hatching : The spawning was related to the tidal rhythm, because the spawning nest situated at the tidal flat, the spawning behavior seemed to be started at the high tide. In July, 1982 the marked experience showed that the spawning occurred during the high tide and the hatching occurred during the high tide also 4 days after spawning at 26.0—28.0℃.

The eggs spawned were attached as one layer egg mass with bottom of an covering substance (ceiling of the spawning nest). The egg mass was circle or oval, 5.31—25.12㎠ in area, of these the area of 5.0—9.9㎠ was 28.9%, that of 10.0—19.9㎠ was 55.3%, and that of more than 20.0㎠ was 15.8%. All egg masses examined were not subdivided, always constituted of a single batch. The number of eggs were ranged from 335 to 4347, 2304±196.7 on average, and 1500—2000 in mode.

4. Discussion

No distinct sexual differences of the total length in mid or late spawning seasons, in early July to early September, were observed. Of 16 paired fishes captured in their spawning nest, 11 pairs in mid spawning season showed the male was rather larger than the female, and 5 pairs in after spawning no significant size difference between male and female was not seen. These observations did not coincide with the results of Dotsu (1959), who mentioned that the pairs constituted with large and small fishes were dominant. In general the range of total length was larger in male than in female, but the females were nearly equal size. The fatness was also showed the same pattern, winder range in male, but no significant difference of mean fatness between male and female was shown.

Based on the ridge number on the exposed area of the scale and the total length, the present species attained and hibernated 19—23 ridges and bout 40mm in total length five months after hatching. After more 10 to 12 months, 30—40 ridges, 48—88mm in total length, the fishes matured and spawning.

The spawning nest is so-called a side cave type, which is an under space between stones or other hard substances and the substratum, always supplied with fresh sea water even at low tide. The position of the nest against the sea level was midlittoral and infralittoral zones, especially concentrated at the level between mean sea level and extreme low-water neaps. On the other hand, another sympatric gobid fish, *Rhinogobius pflaumi*, which was the same spawning season and spawning behavior as the present species, spawned at more lower place, mainly sublittoral, lower than the extreme low-water springs. Their spawning nests, therefore, were vertically separated from each other.

The degree of the ripeness and observation of the ovarian eggs showed that the developmental pattern of the present species belonged to the group synchronism[3]. However, it is necessary to reexamine the synchronism of this species, because no trace of eggs remained in the ovary of female just after spawning, no secondary addition of eggs to the egg mass spawned. Dotsu[1] reported that the large part of the ovary contained large yellowish eggs, which were divided into two groups, one was spherical, many in number and the other was oval, small in number. The latter type eggs only bore small oil globule and adhesive filaments and spawned separately from the former. The present observation showed the large eggs in matured ovary with entangled filaments but a small number of eggs without oil globule.

Dotsu and Tsutsumi[4]observed that some eggs in the spawning nest of *Pterogobius elapoides* became whitish and dead during the developmental course but no unfertilized eggs present. The present observation showed no unfertilized eggs and no dead eggs in *Acanthogobius lactipes*. In matured females the maturity factor was more than 6.0, their minimum total length was 6.35mm.

Dotsu and Tsutsumi[4] and Yamamoto and Yamazaki[3] separated the spawning behavior of *Pterogobius elapoides* and *P. zonaleucus* three phases, such as pre-spawning, spawning and post-spawning behavior. These behavior occurred continuously without interruption, of 7 marked pairs of *Acanthogobius lactipes*, three pairs were spawned in 24 hours, and 2 pairs spawned in 48 hours, then, the duration about spawning behavior of the male in the spawning nest was thought to be about 6 days.

References

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2) Kubo, I and Yoshihara, T.: Fisheries resources (revised edition), Kyouritsu Shuppan Co. Ltd., 482 p. (1969).

3) Yamamoto, K. and Yamasaki, F.: *Bull. Fac. Fish. Hokkaido Univ.*, **12**, pp. 2—7 (1961).

4) Dotsu, Y. and Tsutsumi, T.: *Bull. Fac. Fish. Nagasaki Univ.*, **8**, pp. 186—190 (1959).