Life History of Atherinid Fish of Western Part of Seto Inland Sea-II Age Determination of *Allanetta bleekeri*

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Abstract: Early growth and age determination of *Allanetta bleekeri* were chiefly examined by the scale characters and these values coincide well with Walford's and Bertalanffy's growth formulae. According to the latter formula, the present species shows the following growth equation ; $\ell_t = 166.1\{1-e^{-0.1015(t-0.5240)}\}$. Compared with the related species, *Allanetta bleekeri* is smaller in size, and takes more time to attain the same size.

1. Preface

The present report deals with the growth and age determination of the silverside, *Allanetta bleekeri*, based on the scale examination. This species is one of the common atherinid fishes found from the Suo Nada area of eastern part of Yamaguchi Prefecture (Fig. 1). Similar data of the related species, *Hypoatherina tsurugae*, with which *A. bleekeri* was compared in this report, will be published in the next paper.

2. Materials and methods

The larvae and juveniles were collected from Suo Nada area (Fig. 1) from July to September, 1983 and kept in outdoor ponds ($5\times2\times0.5$ m) of Tana Marine Biological Laboratory, Shimonoseki University of Fisheries. The development of the first scale and the circule formation on scales were examined on these material.

A total of 82 specimens, 31.0-124.3 mm in total length (TL), were used for the examination of age determination. The hibernating larger specimens, more than 80 mm in TL, were collected together with *Engraulis japonicus* from Hirao-Bay by small-scale midwater trawl for that fish from May to July in 1983 and rather smaller 0-year specimens were collected from the same area from Sep-

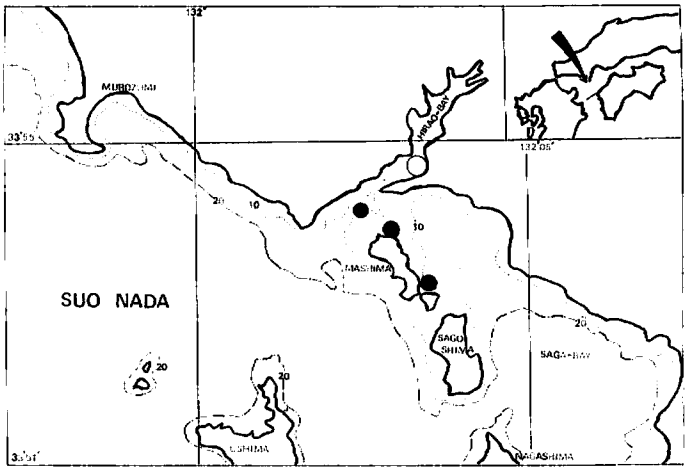

Fig. 1. Map showing the collecting sites of the larvae (●) and the juveniles (○) of *Allanetta bleekeri*.

tember to November (Fig. 1). The scales examined were collected from the dorsal side of trunk of each fish. They were stained by methylen blue solution and ordinally measured under Nikon Profile Projector (Nikon V24) (Fig. 2).

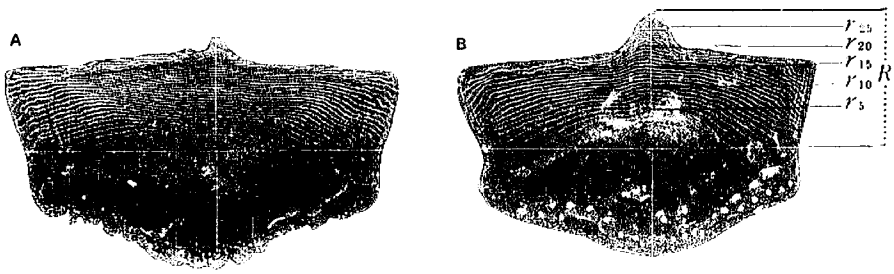

Fig. 2. Scale of silverside, *Allanetta bleekeri*, (A) and *Hypoatherina tsurugae* (B), showing the difference of scale-shape and measuring items of covered part. "R" is the scale size, which is a distance from the focus to the proximal end of scale, and "rn" means number of "n"th ring or circulus and also the distance from the focus to "n"th ring or circule.

3. Results and discussion

3・1 Appearance and development of scale (Fig. 3 a – f)

About ten scales were first appeared on central part of lateral side of the caudal portion of larvae, 11.0 -12.0 ㎜ in TL (Fig. 3 a). Then, the scales were increased in number, and in a larva of 13.2 ㎜ a series of about 30 scales were lined on central part of lateral side (Fig 3 b). In 15.6 ㎜ larva these lateral

scales were increased in number as to about 40 and additional two lines composed of about 30 scales were arranged at upper and lower sides of this lateral scales line (Fig. 3 c). In larva of 16.7 mm in TL the lateral scales extended anteriorly to the pectoral fins, of which those from the base of caudal part to the middle of trunk were partly overlapped each other. Other 7 scales were newly appeared at the base of anal fin (Fig. 3 d). In larva of 19.3 mm in TL three lines of overlapped scales were observed in lateral part of body (Fig. 3 e). In larva of 19.8 mm in TL lateral surface was almost all covered by overlapped scales, except for posterodorsal part of the opercular and ventral part of the pectoral fins (Fig. 3 f).

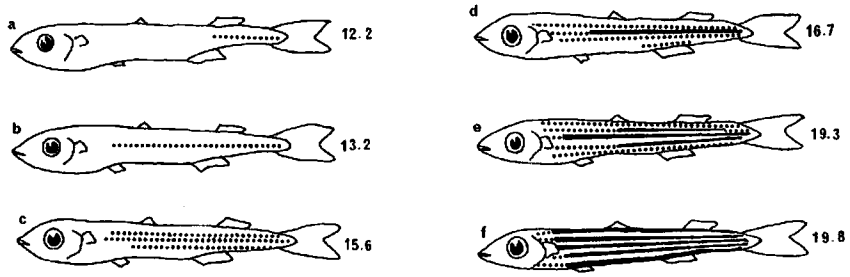

Fig. 3. Schematic figure of the scale development of *Allanetta bleekeri*. a: 11.0–12.0 mm in TL, b: 13.2 mm in TL, c: 15.6 mm in TL, d: 16.7 mm in TL, e: 19.3 mm in TL, f: 19.8 mm in TL. Black spot shows isolated or incomplete scale and black line shows series of completed or covered scale.

Masterman[1] mentioned that the relationship between the total length (L) and number of scales (N) was shown in the following equation.

$$Ln = (L/N - C/N)\ Nn + C$$

Where $L = kN$, and C meant the total length of larvae, when the first scales were appeared.

Adopted this equation to *A. bleekeri*, $C = 16.5$ mm. On the other hand, in the related species, *H. tsurugae*, $C = 14.1$ mm.

3 · 2 Formation of circule

Changes of circule formed on covered portion of scales were shown in Fig. 4 and Table 1. As shown in these data, number of circule (N) was linearly related with days (D). In young stage of *A. bleekeri* 6.5 circule were monthly formed, while in *H. tsurugae* monthly circule were 4.3.

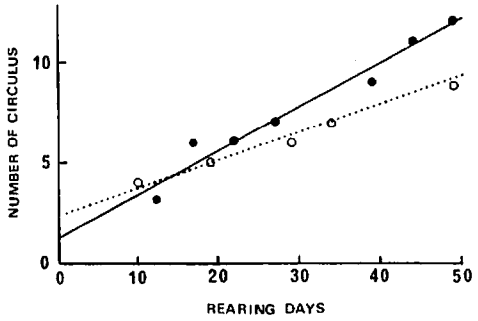

Fig. 4. Change of the circule with growth of rearing larvae. Total length of rearing larvae at the beginning of experiment is 20.0 = 0.35 mm (see, Fig.2, f).
●, *Allanetta bleekeri* ; ○, *Hypoatherona tsurugae*.

Table 1. Change of total length and circulus with growth of rearing larvae of *Allanetta kleekeri* and *Hypoatherina tsurugae*. (D: Rearing period, days, n : number of specimens examined, N : number of circule)

No. of experiment	*Allanetta bleekeri*						*Hypoatherina tsurugae*					
	D	n	Total length (mm)		Circule		D	n	Total length (mm)		Circule	
			Range	Mean	N	Mean			Range	Mean	N	Mean
1	12	4	22.0-24.0	23.0	1-3	2.25	10	9	22.0-27.0	23.8	2-4	2.67
2	17	4	22.0-30.0	26.5	2-6	4.25	19	8	23.0-30.0	27.3	3-5	4.13
3	22	4	20.0-29.0	26.4	3-6	4.50	29	10	23.0-35.0	30.7	2-6	5.30
4	27	5	21.0-32.0	26.6	2-7	4.40	34	12	32.0-37.0	34.3	5-7	5.58
5	39	1	37.0	37.0	9	9.0	39	6	36.0-42.0	37.5	6-9	7.0
6	44	1	40.0	40.0	11	11.0	49	6	35.0-41.0	37.7	7-9	8.0
7	49	1	41.0	41.0	12	12.0	–	–	–	–	–	–
	$N = 0.218\ D + 1.186$						$N = 0.142\ D + 2.412$					

3・3 Growth and age

Scales size (R), which is a distance from the focus to the proximal end of scale, number of circule (N) and total length (L) of hibernating adults and 0-year subadults of *A. bleekeri* were shown in Table 2 and Fig. 5. Three formulae of relationships between scale size (R) and number of circule (N), total length (L) and scale size (R) and total length (L) and number of circule (N) were shown in the equation nos. 1, 2, and 3 of Table 3, respectively. These results were referred to Walford's formula[2], and then the relationship between distance from

focus to one circule (r_n) and the following circule (r_{n+1}) was calculated, as shown in no. 4 equation of Table 3. It showed that the growth rate between circule was nearly constant. Then, based on the formula between the total length (L) and scale size (R) (equation no. 2 of Table 3), the equation for the calculated total length (ℓ_n), in which stage the circule "r_n" was formed, is shown in no. 5 of Table 3. Based on the calculated total lengths of each stage (ℓ_n : ℓ_3, ℓ_4, ℓ_8, ℓ_9) and refereed to the equation nos. 6 and 7 of Table 3, Bertalanffy's[3] maximum total length (ℓ_∞) and the value of α were obtained; $\ell_\infty = 163.7$, and $\alpha = 0.0972$. Using the equation nos. 8 and 9 of Table 3 and the calculated total lengths of ℓ_2 and ℓ_3, the initial growth time (t_0) of Bertalanffy's formula[3] was obtained; $t_0 = -0.5156$.

On the other hand, using the formula of the relationship between ℓ_{n+1} and ℓ_n (equation no. 5 of Table 3), Walford's ℓ_∞ and value of α were also obtained; $\ell_\infty = 168.5$ and $\alpha = 0.1057$. Based on these values and calculated total lengths of ℓ_2 and ℓ_3, the above mentioned Bertalanffy's to was again calculated

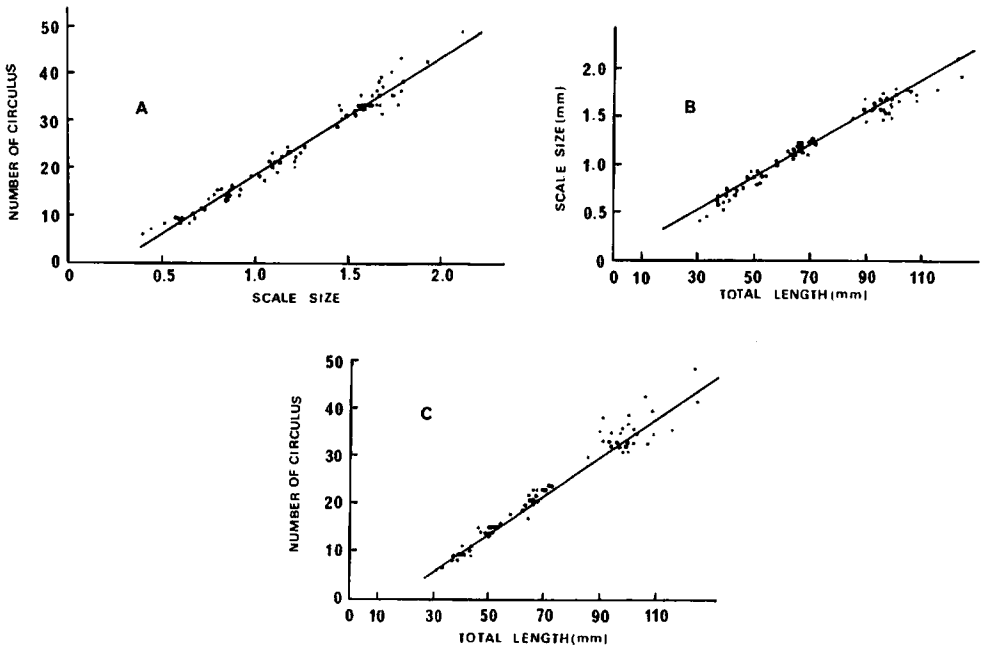

Fig. 5. Relationship between the scale size and number of circule (A), the totallength and the scale size (B) and the total length and number of circule (C) of *Allanetta bleekeri*.

Table 2. Total length, scale size and distance from the forcus to every 5 rings of scale of *Allanetta bleekeri*.

No. of specimen	No. of circulus	Total length (mm)	Scale size (R) (mm)	Distance from forcus to every 5 rings of scale (mm)								
				r_5	r_{10}	r_{15}	r_{20}	r_{25}	r_{30}	r_{35}	r_{40}	r_{45}
1	6	31	0.398	0.272								
1	7	33	0.443	0.278								
3	8	37-39	0.511-0.594	0.355								
5	9	37-43	0.568-0.674	0.341								
1	10	43	0.663	0.334	0.566							
2	11	40,44	0.724,0.709	0.362	0.588							
3	13	46-50	0.745-0.850	0.350	0.555							
5	14	47-51	0.775-0.914	0.352	0.559							
4	15	50-53	0.791-0.917	0.351	0.538	0.732						
1	16	54	0.872	0.348	0.523	0.713						
1	17	64	1.050	0.424	0.580	0.771						
2	18	58,58	0.974,1.027	0.372	0.558	0.736						
1	19	62	1.122	0.363	0.569	0.765						
2	20	63,66	1.095,1.213	0.355	0.542	0.727	0.929					
4	21	65-67	1.082-1.212	0.347	0.536	0.706	0.879					
2	22	64,67	1.142,1.219	0.345	0.541	0.716	0.900					
4	23	66-70	1.093-1.242	0.336	0.536	0.718	0.867					
2	24	71,72	1.264,1.175	0.326	0.508	0.686	0.861					
1	30	85	1.466	0.319	0.502	0.685	0.870	1.058	1.243			
3	31	97-99	1.489-1.683	0.337	0.542	0.750	0.957	1.144	1.352			
4	32	93-98	1.572-1.585	0.365	0.566	0.758	0.940	1.115	1.302			
8	33	90-106	1.450-1.762	0.347	0.541	0.738	0.932	1.126	1.318			
6	35	89-108	1.570-1.743	0.352	0.554	0.754	0.940	1.128	1.309	1.468		
2	36	97,115	1.651,1.781	0.351	0.554	0.752	0.941	1.136	1.326	1.517		
1	37	99	1.688	0.337	0.533	0.730	0.905	1.094	1.295	1.454		
2	38	90,101	1.667,1.792	0.343	0.544	0.740	0.937	1.114	1.278	1.435		
1	39	99	1.676	0.347	0.531	0.701	0.877	1.042	1.223	1.379		
1	40	108	1.732	0.371	0.559	0.745	0.928	1.110	1.281	1.454	1.613	
1	42	124	1.922	0.345	0.559	0.732	0.916	1.109	1.308	1.491	1.697	
1	43	105	1.784	0.335	0.536	0.735	0.927	1.114	1.319	1.477	1.644	
1	49	123	2.117	0.327	0.515	0.677	0.862	1.045	1.231	1.412	1.581	1.733
Average				0.347	0.547	0.732	0.916	1.117	1.305	1.461	1.634	1.733

Table 3. Experimental equations for growth and age determination of *Allanetta bleekeri*.
(N : number of circule, R : scale size (mm), L : total length (mm),
r_n: distance from forcus to "n" th ring of scale,
ℓ_n: calculated total length having scale with "n" th ring)

No.	Equation
(1)	$N = 25.090\ R - 6.715$
(2)	$R = 0.0167\ L + 0.0003$
(3)	$N = 0.4220\ L - 6.975$
(4)	$r_{n+1} = 0.8996\ r_n + 0.2825$
(5)	$\ell_{n+1} = 0.8996\ \ell_n + 16.9052$
(6)	$54.8 = \ell_\infty (1 - e^{-a}) + 43.8\, e^{-a}$
(7)	$103.8 = \ell_\infty (1 - e^{-a}) + 97.8\, e^{-a}$
(8)	$32.7 = 163.7\ \{1 - e^{-a\ (2 - t_0)}\}$
(9)	$43.8 = 163.7\ \{1 - e^{-a\ (3 - t_0)}\}$
(10)	$32.7 = 168.6\ \{1 - e^{-a\ (2 - t_0)}\}$
(11)	$43.8 = 168.6\ \{1 - e^{-a\ (3 - t_0)}\}$
(12)	$\ell_t = 166.1\ \{1 - e^{-0.1015\ (t - 0.5240)}\}$

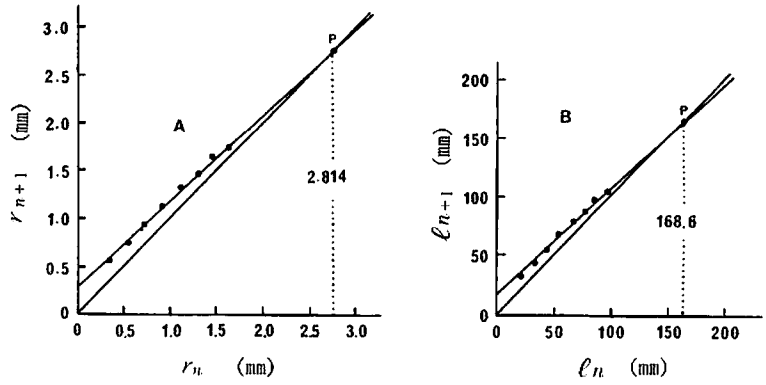

Fig. 6. Walford's growth transformation of the total length of *Allanetta bleekeri*, based on the figures in Table 2. P shows the maximum point of radius (A), calculated from the equation of no. 4 of Table 3 and the maximum total length (B), calculated from the equation of no. 3 of Table 3.

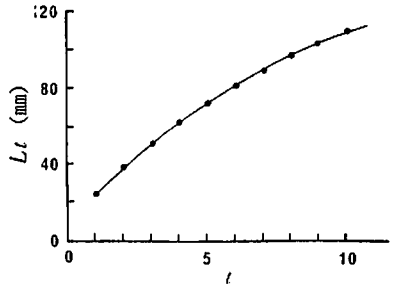

Fig. 7. Growth curve in total length of *Allanetta bleekeri* obtained by Bertalanffy's equation (no. 12 of Table 3).

(equation nos. 10 and 11 of Table 3) ; $t_0 = -0.5324$. Finally, Bertalanffy's growth formula was obtained by the means of these two values of ℓ_∞, α, and to (equation no. 12 of Table 3). The relationship between period (t) and total length (L) was shown in Fig. 6.

The duration (days) for the maturation of *A. bleekeri* was 174 -236 days calculated by the formula of relationship between the number of circule (N) and rearing days (D) and 186 -298 days from the calculation of the above mentioned growth equation (Table 3). While that of *H. tsurugae* was 204 -324 days and 174 -308 days, respectively.

References

1) A. T. Masterman : *Fish. Invest. Minis. Agr. Fish.*, **1**, (3), pp. 1-16 (1924).
2) L. A. Walford : *Woods Hole Biol. Bull.*, **90**, (2), pp. 141-147 (1946).
3) L. von Bertalanffy : *Human Biol.*, 10, pp. 181-213 (1938).