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AGE AND GROWTH OF *GIRELLA MELANICHTHYS* (RICHARDSON) (PERCOIDEI: KYPHOSIDAE) FROM NORTHERN TAIWAN[1]

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Sin-Che Lee and Jung-Ti Chang (1981) Age and growth of *Girella melanichthys* (Richardson) (Percoidei: Kyphosidae) from northern Taiwan. *Bull. Inst. Zool., Academia Sinica* **20**(2): 21-27. Age of *Girella melanichthys* is determined by scale reading of 154 fish cellcted monthly from northern coast of Taiwan during the period from September 1977 to April 1980. One ring is laid down on each scale during April and May each year which is coincidently after the spawning season of the fish. Ages range from 2^+ to 9^+ years in the samples of northern Taiwan, among them, 4^+ years is the most abundant age group (29.8%).

Growth curves expressed either in length or weight have been drawn according to von Bertalanffy's growth equation:

$$FL_t = 562.2\ (1 - e^{-0.09094(t+0.8862)}) \text{ or}$$
$$W_t = 3539.23\ (1 - e^{-0.0994(t+0.8862)})^{2.9833}$$

The possible cause of ring formation on scales and the comparison of growth curves with those of *G. punctata* are also discussed.

The distribution of *Girella melanichthys* ranges from the southeastern coast of Japan to the East China Sea and northern Taiwan where a small school of fish may be found as far south as the southern part of Taiwan Strait between Pescadore Islands and Tainan in the summer.

Work on ageing the fish has not been published elsewhere. It is desirable to increase our knowledge of ageing and growth patterns of this species as base line information for future fishery surveys of such a commercial potential. Since the check marks on the scale are clearly visible, it has been considered a suitable structure for age determination. The problem of interpretation in relation to the possible cause of ring formation are discussed. The present paper also compares growth pattern with that of *G. punctata*.

MATERIALS AND METHODS

A total of 154 adults (94 males and 60 females) collected from the northern coast of Taiwan between Shimen, Taipei County and Tashi, Ilan County, by gill nets during the period from September 1977 to April 1980, and an additional lot of 72 juveniles collected from tide pools near Keelung City during January through December 1975 and June through November 1977, were used in this study.

The treatment and measurements of fish specimens and the method of the examination of scales were carried out as Lee and Huang[6]. The growth rate α of the marginal region on

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the scale was estimated from the formula $\alpha = R - r_n / r_n - r_{n-1}$, where R is scale radius and r_n is the radius of ring n (Fig. 1).

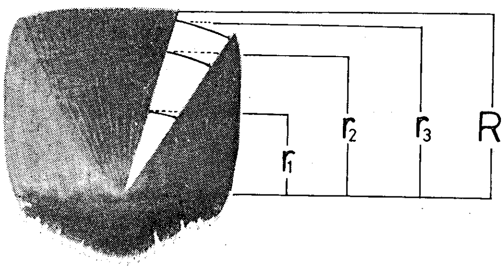

Fig. 1. External feature of scale showing three well differentiated annual rings.

RESULTS

The external features of the scale of this species are almost identical with that of *G. punctata*[6] (Fig. 1). In order to determine the validity of the use of scales for ageing *G. melanichthys*, the correlation between scale radius (R) and ring radius (r_i) of each ring group was calculated (Fig. 2). The presence of a strong positive correlationship ($p<0.01$) confirmed that the radius of the nth ring was proportional to the radius of the scale. In other words, rings were formed reguarly, otherwise they could be false marks.

Although determination of the number of check marks laid down each year was difficult to interpret, however, it may be predicated from the seasonal pattern of the mean growth rate of scale margin shown in Fig. 3. The lowest α level in April suggested that the ring was probably formed only once in April-May each year immediately following the breeding season (February-March) of the species. Therefore, the age of this fish could be determined by accessing annual rings on scales using the appearance of celarily differentiated check marks.

Ages of 154 adults from the northern coast ranged from 2^+ to 9^+ years. They were dominated by the age group 4^+ (29.8%) and followed in order by 5^+ (18.18%), 3^+ (16.23%) 6^+(8.44%), 8^+ (7.79%), 9^+ (3.25%) and 2^+ (0.65%).

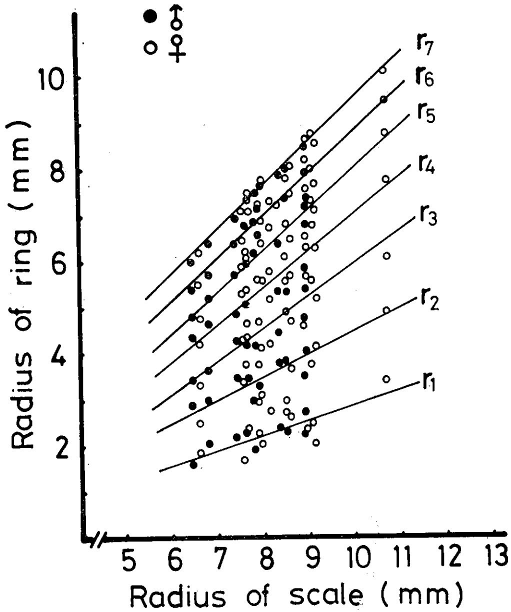

Fig. 2. Relationship between ring radius (r_i) and scale radius (R) for 24 seven-ringed fish:
$r_1 = -0.2583 + 0.3164\,R$ ($r=0.76$**);
$r_2 = -0.4661 + 0.5003\,R$ ($r=0.84$**);
$r_3 = -1.1941 + 0.7181\,R$ ($r=0.89$**);
$r_4 = -0.9732 + 0.8058\,R$ ($r=0.93$**);
$r_5 = -0.9119 + 0.8950\,R$ ($r=0.94$**);
$r_6 = -0.4307 + 0.9209\,R$ ($r=0.97$**);
$r_7 = -0.0752 + 0.9581\,R$ ($r=0.99$**).
All the above correlation coefficients are significant at 1% level.

The length distribution of fish in the sample was bimodal or multimodal but the length ranges of the component age groups overlapped considerably (Fig. 4). 72 juveniles from tide pools belonged to age group 0^+.

A plot of the scale radius (R) against fork length (FL) of adult fish of each sex shown in Fig. 5 indicated a linear relation. The regression lines of both sexes were then combined since no apparent differences was found between sexes and applied to the subsequent data.

The resultant regression equation was:

$$FL = 19.1001 + 36.0995\ R\ (r=0.93) \quad (1)$$

When the regression line (Fig. 5) was extrapolated ($R=0$), the theoretical 19 mm FL at the time of the first appearance of scale wa

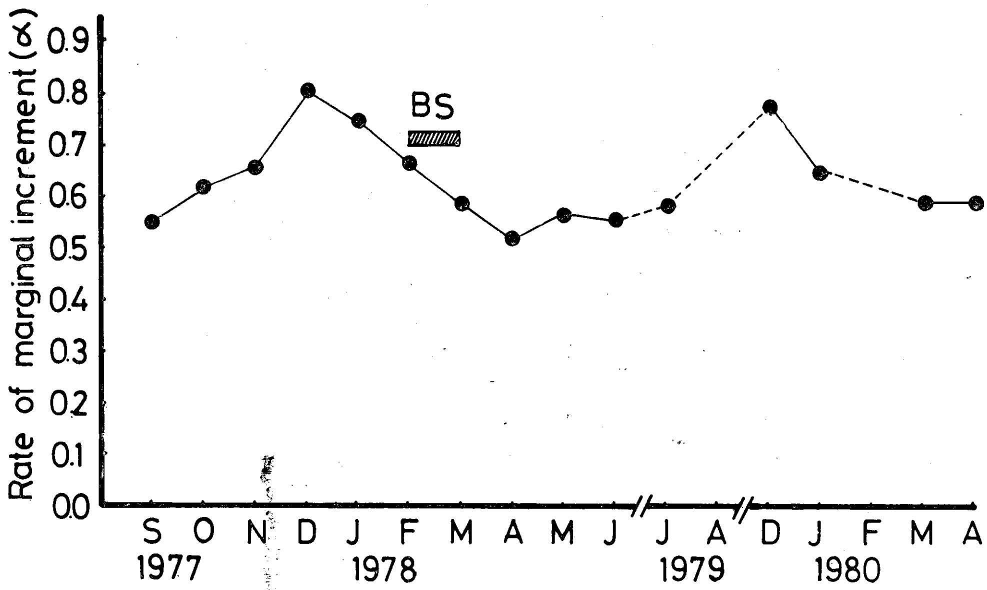

Fig. 3. Monthly changes of mean marginal growth of the scale (α) of 154 fish, with an indication of timing of breeding season (BS).

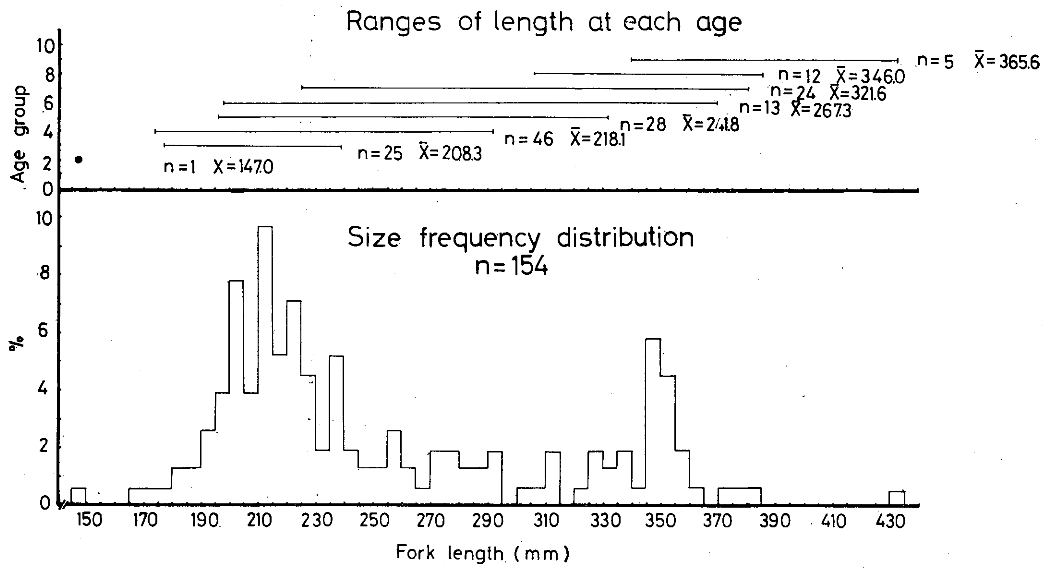

Fig. 4. Size frequeucy distribution and ranges of length at each age.

estimated from the intercept of the line upon the body length axis, which was close to the estimation from the following equation for 72 juveniles:

$$FL = 19.9701 + 36.5728\ R$$

When the mean radius in Table 1 was substituted for R in the equation (1), the results of the back-calculated body lengths at the time of ring formation were then given in Table 2. By applying the Walford's graphic method[7], the

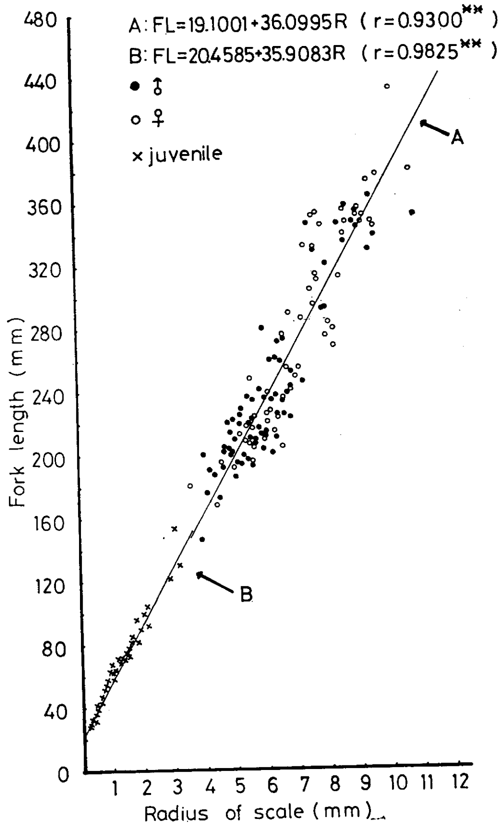

Fig. 5. The relationship between fork length (mm) and scale radius (R) of 154 adults (A) and 72 juveniles (B), each with highly significant correlation coefficient (r).

regression line in Fig. 6 was constructed according to the data of L_t and L_{t+1} in Table 2, the relevant regression equation was thereby obtained as:

$$L_{t+1}=53.190+0.905\ L_t \qquad (2)$$

The asymptotic value ($L_\infty=562.25$ mm FL) is given by the intercept of the regression line with the 45° diagonal line in Fig. 6. The approach of the Walford slope to the 45° slope in a straight line in all the plots indicated a good fit of each of the curves to von Bertalanffy's equation[8]. The value of $K=0.0994$ was obtained from the negative natural logarithm $(-l_nb)$ of the slope of the Walford line in equation (2). The theoretical age (t_0) at the commencement of fish growth was obtained from the formula $t_0=t+1/Kl_n(L_\infty-L_t)/L_\infty$, and the value t_0, -0.8862 was the means of each of the age groups from 2^+ to 9^+. The Bertalanffy's growth equation was then expressed as:

$$L_t=562.2\ (1-e^{-0.0994(t+0.8862)}) \qquad (3)$$

The weight-length relationship was noted below:

$$W=2.3568\times10^{-5}\ L^{2.9833}\ \text{(Fig. 7)} \qquad (4)$$

The growth equation in weights was obtained by the conversion from equation (4):

$$W_t=3539.23\ (1-e^{-0.0994(t+0.8862)})^{2.9833} \qquad (5)$$

The growth curve expressed either in length

TABLE 1.

Mean ring radii for each age group of *G. melanichthys*, with both sexes combined.

Age group	Sample size	Radius of ring (mm)								
		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9
2	1	2.36	3.69							
3	25	1.94	3.23	4.53						
4	46	1.98	3.16	4.14	5.06					
5	28	1.97	3.07	4.08	4.99	5.80				
6	13	1.98	3.09	4.07	4.97	5.67	6.51			
7	24	2.34	3.64	4.70	5.64	6.43	7.12	7.78		
8	12	2.19	3.68	4.80	5.71	6.57	7.35	8.01	8.56	
9	5	2.32	3.90	5.06	6.03	6.86	7.53	8.19	8.75	9.22
Mean (mm)		2.14	3.43	4.48	5.40	6.27	7.13	8.00	8.66	9.22

TABLE 2.
Back-calculated mean fork lengths (mm) for ages of *G. melanichthys* caught between September 1977 and April 1980.

Age group	Sample size	Back calculated fork length (mm)								
		L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9
2	1	104.30	152.31							
3	25	89.28	135.74	182.56						
4	46	90.40	133.03	168.70	201.91					
5	28	90.32	130.00	166.39	199.27	228.33				
6	13	90.47	130.50	166.06	198.33	223.93	253.96			
7	24	103.47	150.43	188.62	222.56	251.18	276.24	300.06		
8	12	98.19	152.05	192.38	225.34	256.38	284.54	308.26	328.08	
9	5	102.85	159.82	201.62	236.78	266.67	290.86	314.90	335.04	351.87
Mean (mm)		96.17	142.99	180.90	214.04	245.30	276.75	307.75	331.58	351.87

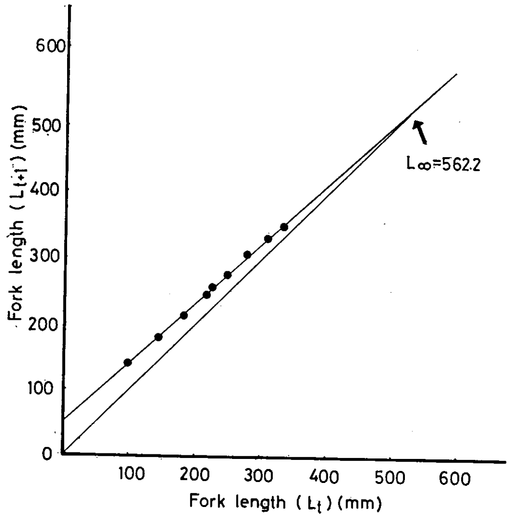

Fig. 6. Walford plots for *G. melanichthys* of combined sexes with final L_∞ drawn in.

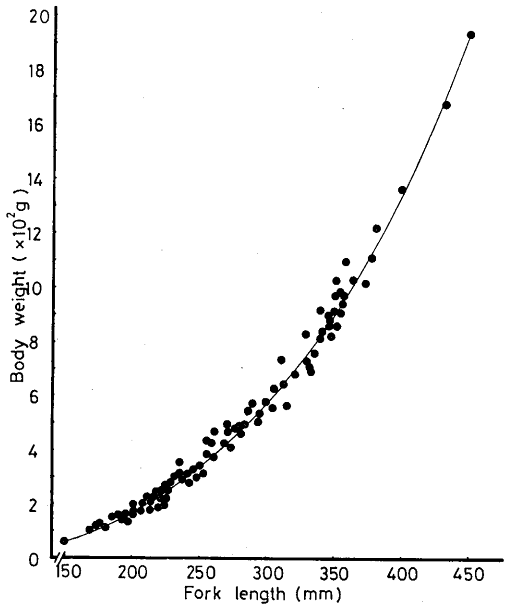

Fig. 7. Length-weight relationship of 154 adult fish. $W = 2.3568 \times 10^{-5} L^{2.9833}$

or weight (Fig. 8 and Fig. 9, respectively) was drawn according to the data in Table 3 while deriving from the equations (3) and (5) respectively by the use of the von Bertalanffy's model[8].

DISCUSSION

Because of small sample size, the use of length-frequency distribution for age determination of this species has been excluded. However, scale is a good bony structure for ageing. The presence of annual marks on the scales of temperate fishes is well documated while those of tropical fishes are often related to the process of gonad maturation or other external factors, for instance, lowered food intake during the period of low water level[1]. Because of the scarity of this species, the lower α value in September in addition to

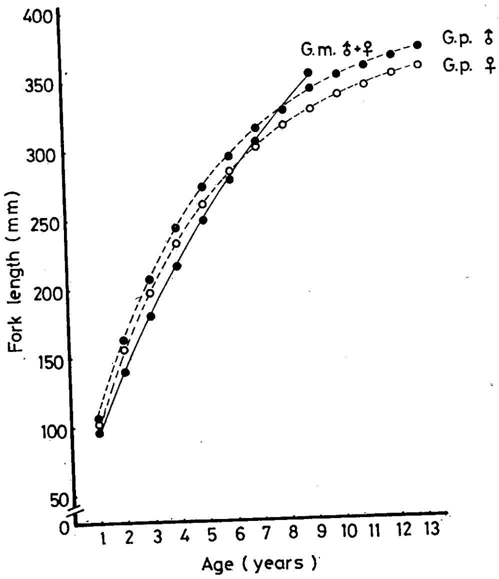

Fig. 8. Growth curves of *Girella melanichthys* (GM) and *G. punctata* (GP).

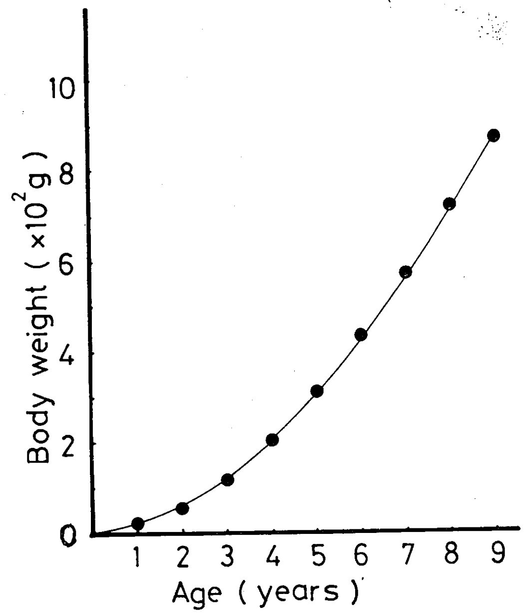

Fig. 9. Growth curve of *Girella melanichthys* expressed in weights.

TABLE 3.
The theoretical lengths and weights of *Girella melanichthys* derived from von Bertalanffy's growth equation.

Age group	L_t (mm)	W_t (g)
1	96.11	18.21
2	140.22	56.19
3	180.14	118.67
4	216.29	204.78
5	249.02	311.79
6	278.66	436.04
7	305.48	573.62
8	329.78	720.70
9	351.77	873.78

the lowest in April shown in Fig. 3 is probably due to the greater variance of a smaller sample. Small samples make it difficult to confirm the exact period of ring formation in *G. melanichthys*. Considering the possible link of gonad maturation to the timing of ring formation during April and May in the sibling species *G. punctata*[6], the similar breeding season of *G. melanichthys* in February and March may imply a similar ring formation period. The time for ring formation of both species is probably related to reproductive strain regarded as a part of physiological change as seen in *Chrysophrys major*[5], *Epinephelus diacanthus*[2], and *Sebastiscus marmoratus*[3] occurring in the same water. Among 154 adult *G. melanichthys*, only one female collected in February 1978, had ripe ovaries, but all the adult fish with unripe gonads also have clearily differentiated annual rings on their scales.

Evidently, annual rings are attributed to the seasonal cycle of retarded growth in association with the maturation of gonads in many mature fishes. In fact, the seasonal cycle of metabolic rhythm (or seasonal cycle of thyroid activity) is already established in immature or adolescent fish. It only differs in amplitude from that shown by spawning fish[4]. The similarity in the growth cycle may also aplicable to the unripe *G. melanichthys*.

The growth curve of *G. melanichthys* shown in Fig. 8 is slightly different from that of *G. punctata*. The estimated asymptotic length (L_∞) of this species is 562.25 mm *FL* which is far beyond 391.3 mm (male) or 378.4 mm (female) in *G. punctata.* It is not clear whether the great difference of asymptotic length between the two species is real or simply a result of sampling error in *G. melanichthys* due to the failure to catch larger specimens in the northern coast. The maximum age reached by *G. melanichthys* in northern coast does not exceed 9^+. In fact, the oldest sampled *G. melanichthys* of age 13^+ and 482 mm *FL* was collected in August 1980 from the southern Taiwan Strait between Pescadore Islands and Tainan coast. The more samples obtained the more accurate the expected growth picture. Growth of fish depends on a number of factors including water temperature, population density, quality of food, photoperiod and water turbidity. It is difficult to identify factors that account for the growth pattern of this species since environmental factors were not investigated during this study.

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臺灣北部沿岸黑瓜子鱲之年齡與成長

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年齡係根據 1977 年 9 月～1980 年 4 月間採自臺灣北部沿岸之 154 尾黑瓜子鱲之鱗片判讀的。鱗片上之年輪經估計約於每年之 4～5 月間亦即生殖季之後形成一次。所獲標本中，年齡組成之範圍包括 2^+ 歲至 9^+ 歲，其中以 4^+ 歲 (29.87%) 爲最多。除外在岩質潮池可發現到爲數可觀之 0^+ 歲幼魚。成長曲線以體長（尾叉長 mm）表示爲 $FL_t = 562.2\ (1-e^{-0.0994(t+0.8862)})$，若以體重 (g) 表示則爲 $W_t = 3539.23\ (1-e^{-0.0994(t+0.8862)})^{2.9833}$。鱗片上年輪形成之可能機制於文中略加討論，同時比較本種與其姊妹種瓜子鱲 (*Girella punctata*) 之成長曲線。