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SOME ASPECTS OF THE BIOLOGY OF THE NIBBLERS, *GIRELLA PUNCTATA* GRAY (PERCOIDEI: KYPHOSIDAE) FROM THE NORTHERN COASTAL WATER OF TAIWAN

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Sin-Che Lee and Chao-Shen Huang (1981). Some aspects of the biology of the nibblers, *Girella punctata* Gray (Percoidei: Kyphosidae) from the coastal water of Taiwan. *Bull. Inst. Zool., Academia Sinica* **20**(1): 17-29. The biology of *Girella punctata* Gray from a rocky shore of the northern Taiwan was studied. *G. punctata* is an omnivorous species feeding on both algae and zooplanktons, mostly copepods and shrimp mysis larvae. Morphologically, incisor-like teeth, filterable gill-rakers and long intestine also indicated its omnivorous nature. Age was determined from the occurrence of rings on scale which formed between April and May every year, immediately after the physiological stress while gonadal maturation between February and March. *G. punctata* attained at least, an age of 13 years in male and an age of 12 years in female. The growth equation of the fork length (L_t) was $L_t=391.3(1-e^{-0.2182(t+0.445)})$ for male and $L_t=378.4(1-e^{-0.2121(t+0.4894)})$ for female and that of total weights $W_t=1483.94(1-e^{-0.2182(t+0.445)})^{3.4283}$ in male or $W_t=1369.89(1-e^{-0.2121(t+0.4894)})^{3.417}$ in female. The growth rate of male was slightly faster than that of female, and the growth curves of both sexes for Taiwan population were generally higher than those for the Japanese population. Breeding occurred between February and March in Taiwan and the females spawned only once each season. Estimated absolute fecundity based on 6 fully mature females varied from 23641 to 336158 eggs, among them 23641-141714 transparent ripe eggs were shedded per spawning.

Geographically, the nibblers, *Girella punctata* Gray, occurs from the southern Hokkaido coast of Japan southward to East China Sea, Taiwan, Pescadores, Hongkong and Batan Island of northern Philippines. It occurs with *G. melanichthys* and *G. mezina* in the rocky coast with abundant algal growth. In Taiwan area, the adults tend to aggregate during winter and early spring. The youngs may be found in the tide pools in summer. Morphologically, *G. punctata* is more similar to its sibling species *G. mezina* than *G. melanichthys*. The general feature of *G. punctata* may be distinguished from *G. melanichthys* by having more gill-rakers (40-49 *vs* 32-41), relatively larger scales and lack of black opercular margin while it may be separated from *G. mezina* by the lack of yellowish vertical band on body side[11].

So far, little of its general biology has been studied except some information on gonadal maturation[13] and age and growth[14] of the Japanese populations from Sasebo Bay.

This paper describes the biology of *Girella punctata* obtained from monthly samples from the northern coast of Taiwan during the period

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between September 1977 to December 1978. Compare their resulted data with those of the Japanese populations is also made.

MATERIALS AND METHODS

A total of 241 adults and 5 juveniles were collected near Keelung, northern Taiwan during the period between September 1977 to December 1978.

The fork length, from tip of snout to the end of caudal fin fork, was measured to the nearest 1 mm, and the wet body weight to the nearest 0.1 g.

About 10–15 non-regenerated scales under the pectoral fin were removed. Scales were cleaned with 5% KOH for 24 hours and stained with Menon's solution for 24 hours and finally mounted on micro slide with glycerine jelly. Scales were examined by means of Nikkon profile projector. The scale morphology and methods of measurement are shown in Fig. 1.

Age determination was based on the number of annual rings on the scale. All fish were grouped according to their ages: A fish in its first growing season (*i. e.*, without any ring on the scale) belongs to age 0 group and a fish in its second growing season was said to be a member of age group 1 and so on. The rate of the marginal growth of scale (α) was obtained from $\alpha = R - r_n / r_n - r_{n-1}$[14], where R indicated scale radius and r_n, radius for ring n. Growth curves were derived from the equation $L_t = L_\infty(1 - e^{-k(t-t_0)})$.[17,18]

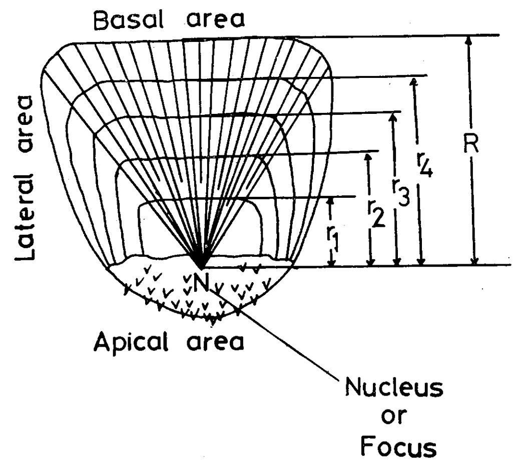

Fig. 1. The scale diagram of *Girella punctata* Gray (R, scale radius; r_i, radii of rings).

Stomach content analyses were expressed either by using the points method and the occurrence method recommended by Hynes[8]. For the points method, 40 points were given by visual observation when the stomach was full. All the points gained from each food item was summed and then expressed as % of total points of the food of all the fish examined. For the occurrence method, the occurrence of a food item was expressed as:

$$\frac{\text{No. fish eating one particular food item}}{\text{Total no. fish examined with food in stomachs}} \times 10^2.$$

Gonads were weighed to the nearest 0.01 g and the gonad index (GI) was calculated from $GI = \frac{GW}{BW} \times 10^3$ [9]. Oocytes were measured along their long axes with the aid of an ocular meter. Total number of eggs in late ripening and ripe stages contained in the ovaries of the fish was estimated by subsampling method[12].

RESULTS

Feeding habits

(a) *Alimentary tract*: Alimentary tract has developed some adaptive features for particular type of feeding. Mouth of this species is small and slightly protrusible. Vomer, palatines and tongue are toothless while the pharyngeal bones are furnished with villiform tooth patch. Each jaw has 1–3 rows of imbricated slender incisor-like tricuspid teeth for scraping sea algae on rocks. The left first gill arch has 40–49 comb-like gill rakers. Stomach is of short caecal type. Intestine is rather long, 1.12–2.19 (mean 1.6) times of body length and *S* shaped. Pyloric caecae are short and about 80–84 in numbers.

(b) *Diet composition*: Among 241 adults collected, 193 fish were used to examine stomach contents. The results of the analysis are given in Table 1. Algae were the main food items and followed in order by copepods and shrimp mysis larvae. Algae were taken more often between February and July, shrimp mysis larvae in August and September and the copepods in November and December (Fig. 2).

The stomach contents may be categorized into the following 3 groups: (1) Zooplanktons such as *Sagittta*, cladocerans, copepods, amphipods (part), stomatopod alima larvae, *Lucifer*, different developmental stages of crab and shrimp larvae, (2) various red, brown and green algae, and (3) commensal organisms associated with the algae such as hydroids, gastropods, cirripeds, isopods, caprellid amphipods, young stomatopods, crabs and shrimps. Trace of sand grain was also observed.

TABLE 1.
Food organisms found in the 191 stomachs of *Girella punctata* Gray, expressed either in % points or % occurrence

Food organisms	% points	% occurrence
Foraminiferans	0.01	0.52
Hydroids	0.18	3.14
Polychaetes	0.42	4.19
Unidentified worms	0.08	0.52
Gastropods	0.06	1.05
Crustaceans		
Cladocerans	0.01	0.52
Copepods	24.10	69.64
Cirripeds: Lepadidae	4.79	15.18
Isopods	0.08	1.57
Amphipods: Oxycephalidae, Gammaridae and Caprellidae	1.69	23.56
Stomatopods: Squillidae (juvenile)	0.07	0.52
Alima larvae	0.17	2.62
Shrimps: *Lucifer*	1.04	7.85
Segestes zoea	0.03	0.52
Shrimp mysis larvae	15.46	45.55
Other juvenile shrimps	0.08	0.52
Porcellana larvae	0.01	0.52
Crabs: Zoea	0.06	1.05
Phyllosoma	0.03	0.52
Juvenile	0.26	2.62
Chaetognaths: *Sagitta*	0.87	4.19
Tunicates: Larvacea	0.35	1.57
Thaliacea	2.14	5.76
Pisces: Fish larvae	1.29	15.71
Fish scales	0.08	1.05
Undetermined eggs	0.03	0.52
Diatoms	0.67	18.85
Algae: Green (mostly Ulvales), brown and red algae	31.84	71.20
Plant detritus	0.18	2.09
Underermined fragments	13.11	49.21
Sand	0.71	5.76
Total points	3603.50	

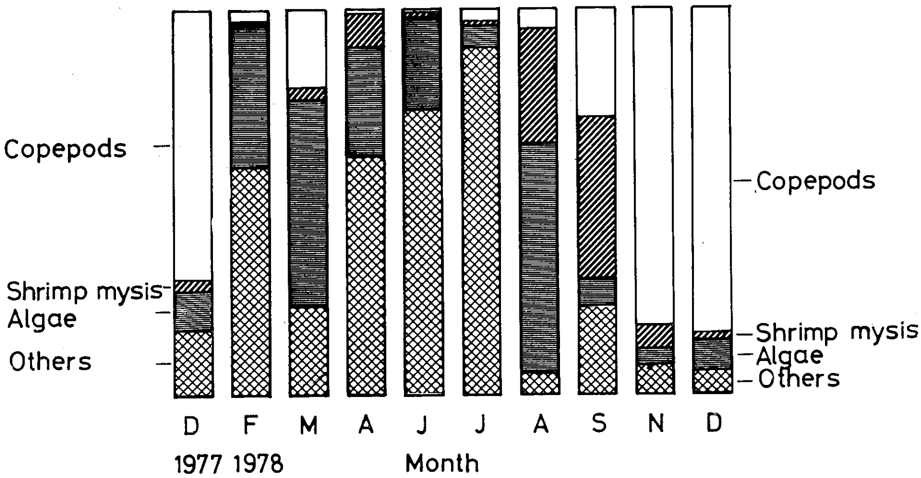

Fig. 2. Monthly changes of diet composition (% total points) of *Girella punctata.*

In some cases, algae confined to the lower half (pyloric portion) of stomach while planktonic food confined to the upper half (cardiac portion) of stomach. It revealed an interesting feeding behaviour of *Girella punctata*, which, scraping algae earlier and switching to zooplankton at a later time of the day. From the above results, this species may be considered as an omnivorous fish.

Age and growth

The scale of *Girella punctata* is a pentagonal-shaped ctenoid with numerous spinules at the apical area and with variable numbers of radial grooves radiating out from the focus (Fig. 1).

From the monthly changes in mean values of the rate of the marginal growth of scale (α) (Fig. 3), the lowest α value in May suggested that rings were mostly formed between April and May. The ring formed annually immediately after the spawning season in this species.

Because of the scale ring formed annually and the existence of good fit between scale radius (R) and ring radius (r_i) for each ring group (Figs. 4–5), the scale reading can be used for age determination for *G. punctata.*

Among 141 males and 100 females collected from the coastal waters, their ages ranged from 3^+ to 13^+. Fish of age groups 1^+ and 2^+ were not obtained in this study. In additions, 5 specimens of age-group 0 with 63–88 mm in fork length were collected from the tide pool. Body lengths between age groups revealed somewhat overlapping (Fig. 6).

The regression equation between fork length (L) and scale radius (R) obtained separatively for each sex were:

$$L = 44.1 + 26.52R \text{ (male)} \quad (r = 0.95) \qquad (1)$$

$$L = 43.1 + 26.02R \text{ (female)} \quad (r = 0.97) \qquad (2)$$

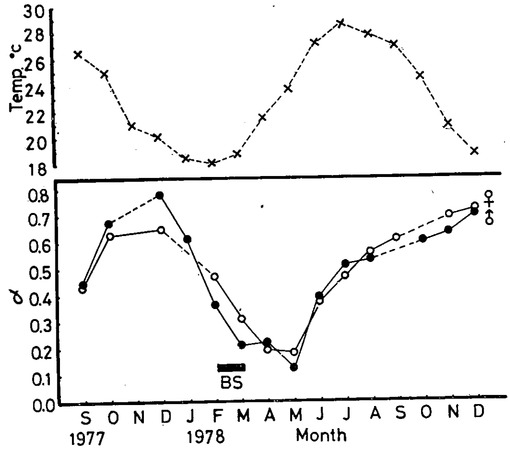

Fig. 3. Monthly changes in the rate of marginal growth of scale (α) of male (•) and female (◦) *Girella punctata*, with surface temperatures and timing of breeding season (BS) included.

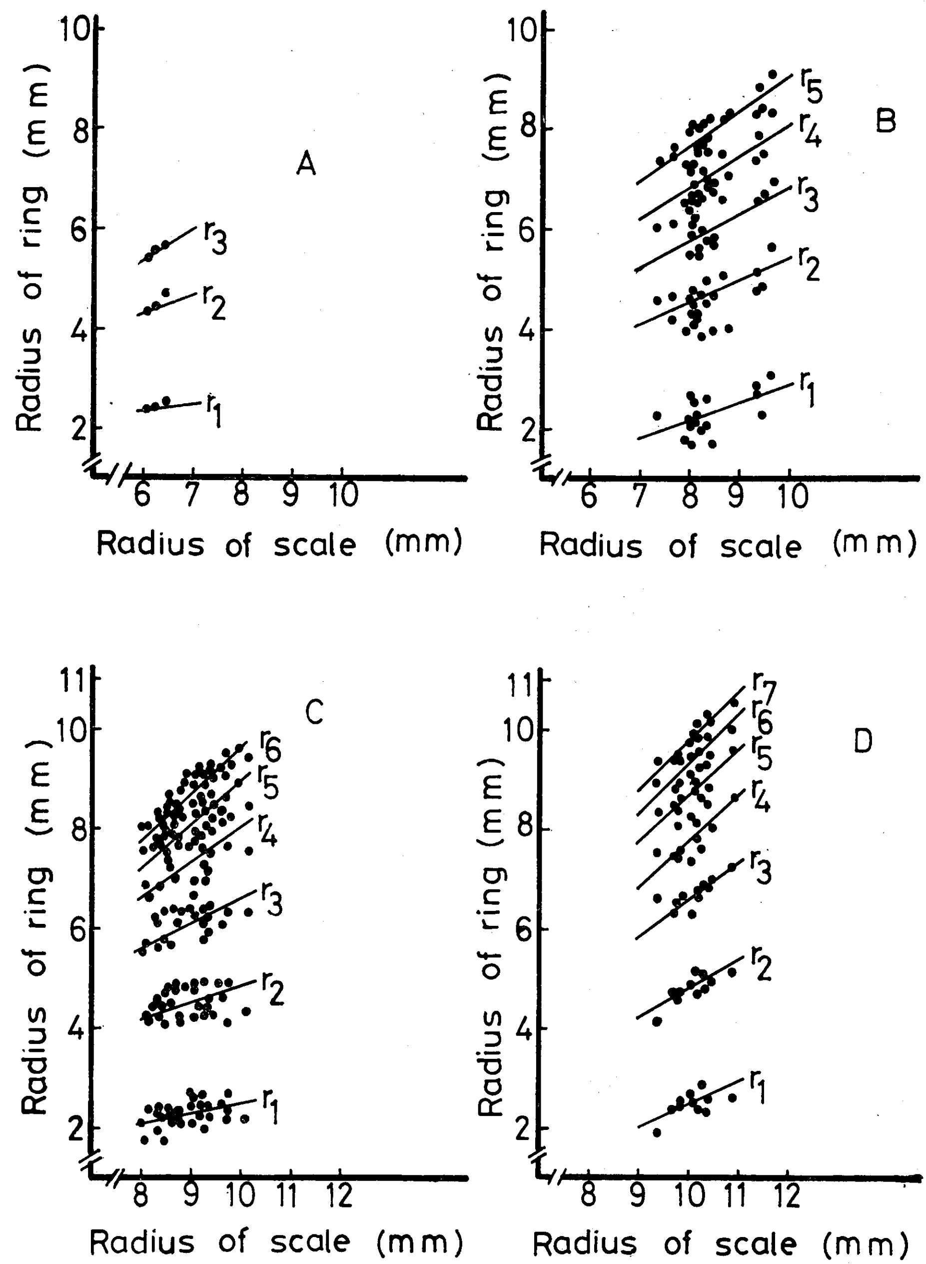

Fig. 4. The relationship between radii of rings (r_i) and scale radius (R) in three (A), five (B), six (C) and seven (D) ring groups of male *Girella punctata*, with highly significant coefficient in each regression line.

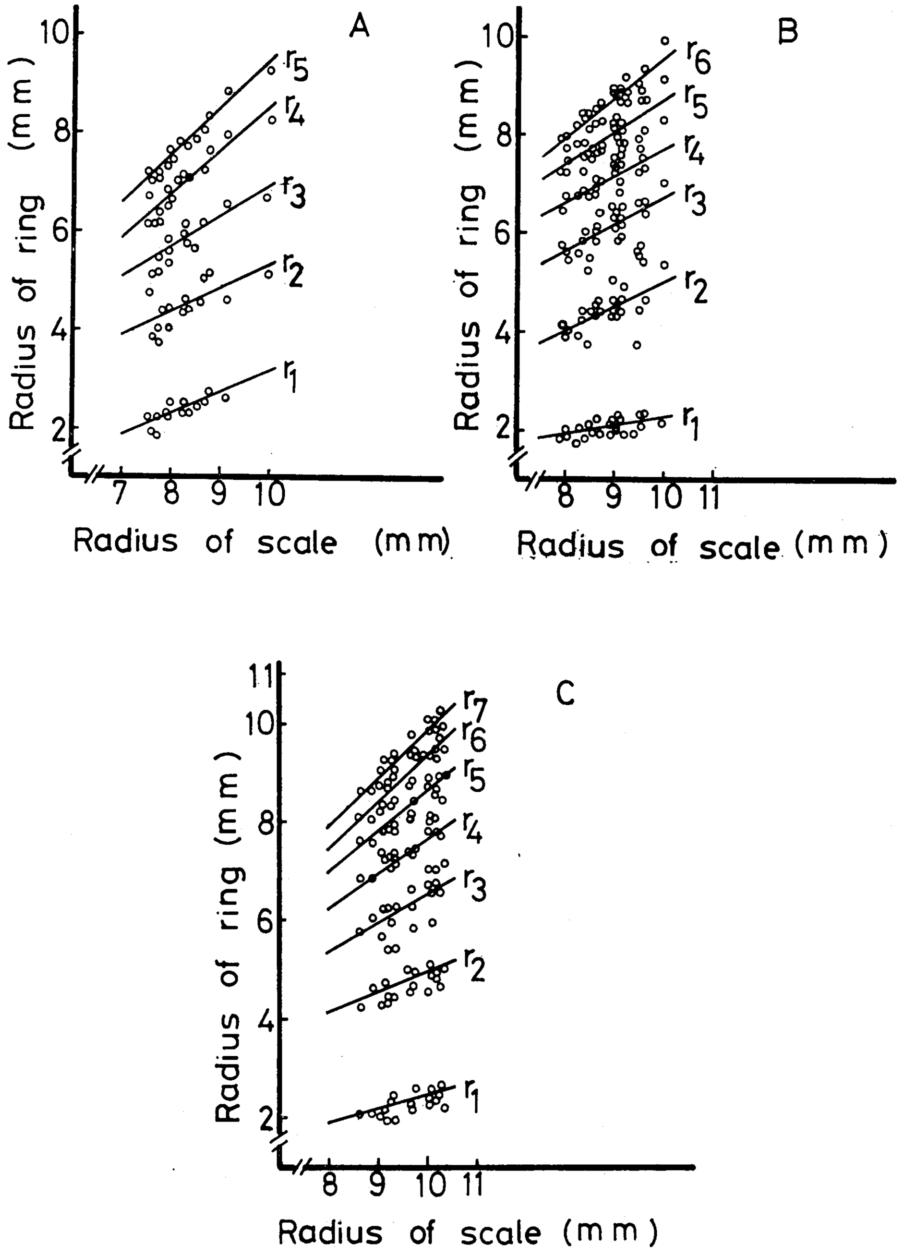

Fig. 5. The relationship between radii of rings (r_i) and scale radius (R) in five (A), six (B) and seven (C) ring groups of female *Girella punctata*, with highly significant coefficient in each regression line.

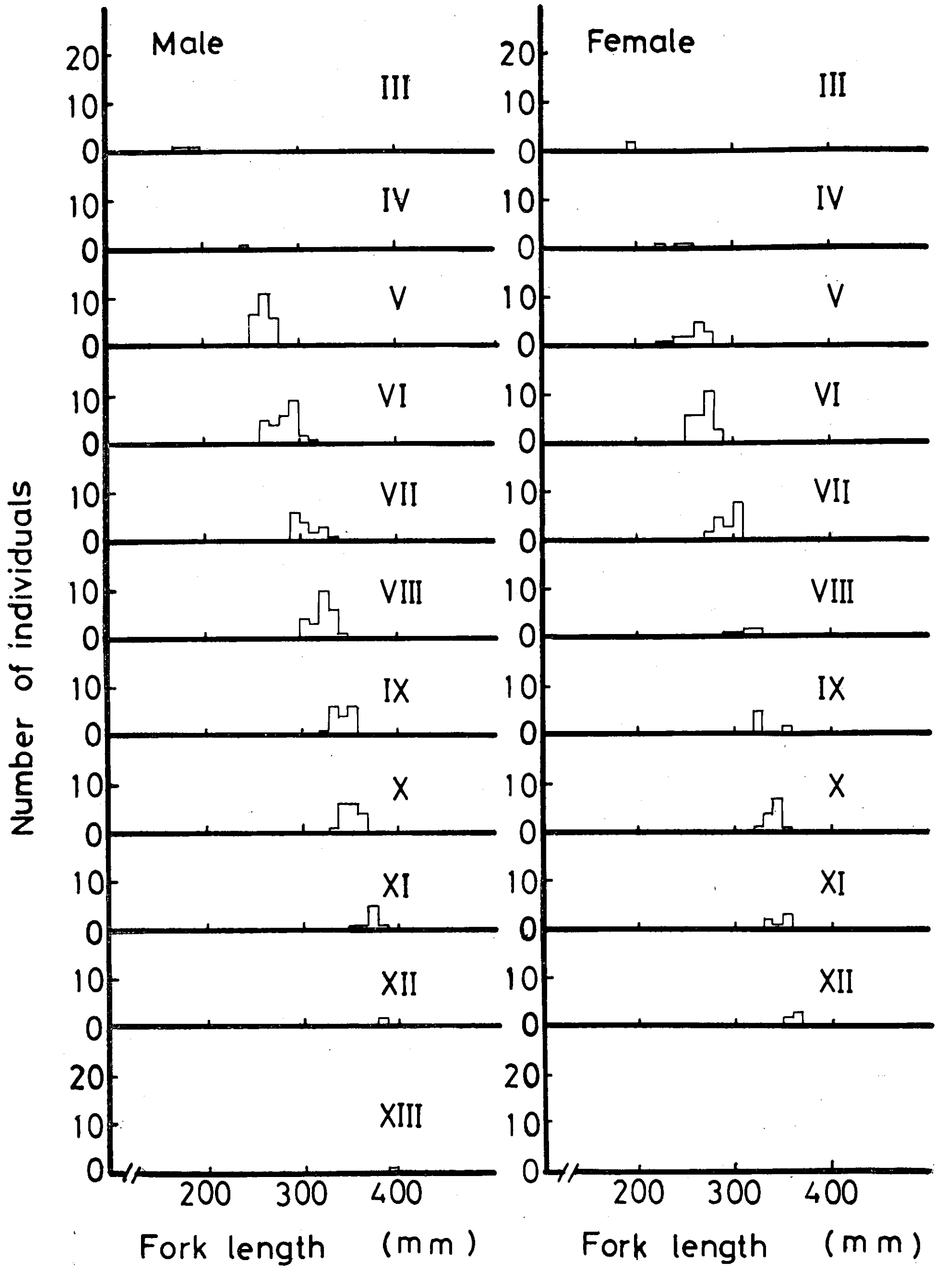

Fig. 6. Length-frequency histograms for each age group in *Girella punctata*.

When substituting mean ring radii in Tables 2 and 3 for the R in the above two equations, the theoretical back calculated fish length at the time of ring formation was tabulated in Table 4.

Following the Walford's graphic method[19], the regression equations between L_t and L_{t+1} were established from the data in Table 4.

$$L_{t+1}=76.7023+0.8040L_t \text{ (male)} \quad (r=0.99) \qquad (3)$$

$$L_{t+1}=72.3152+0.8089L_t \text{ (female)} \quad (r=0.99) \qquad (4)$$

TABLE 2.
Mean ring radius measured for each age group of male *Girella punctata*

Age group	Sample size	Mean ring radius (mm)												
		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}	r_{13}
3	3	2.45	4.55	5.59										
4	1	2.30	4.60	6.22	7.50									
5	25	2.36	4.60	6.08	7.08	7.99								
6	27	2.28	4.54	6.17	7.31	8.43	8.77							
7	16	2.50	4.85	6.68	7.86	8.69	9.30	9.84						
8	24	2.17	4.53	6.26	7.47	8.43	9.16	9.81	10.35					
9	17	2.21	4.54	6.30	7.49	8.50	9.31	9.91	10.47	10.91				
10	17	2.38	4.62	6.39	7.64	8.61	9.33	10.00	10.56	10.10	11.35			
11	8	2.09	4.53	6.28	7.66	8.66	9.46	10.19	10.84	11.31	11.79	12.16		
12	2	2.09	4.57	6.00	7.15	7.87	8.59	9.39	10.10	10.79	11.24	11.57	11.95	
13	1	2.77	5.46	7.11	8.23	8.91	9.50	10.10	10.62	11.02	11.57	11.97	12.21	12.48
Mean $\bar{r}_t$		2.33	4.67	6.28	7.54	8.45	9.18	9.89	10.49	11.00	11.49	11.91	12.08	12.48

TABLE 3.
Mean ring radius measured for each age group of female *Girella punctata*

Age group	Sample size	Mean ring radius (mm)											
		r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9	r_{10}	r_{11}	r_{12}
3	2	2.51	4.36	5.63									
4	2	2.15	3.70	5.47	6.57								
5	14	2.41	4.48	5.89	6.97	7.77							
6	26	2.18	4.47	6.06	7.14	7.92	8.62						
7	18	2.26	4.74	6.33	4.47	8.29	8.92	9.43					
8	6	2.15	4.59	6.55	7.64	8.56	9.25	9.80	10.17				
9	8	2.37	4.68	6.64	7.85	8.76	9.28	9.97	10.37	10.88			
10	13	2.30	4.37	5.98	7.23	8.36	9.14	9.92	10.48	10.95	11.38		
11	5	2.12	4.05	5.62	6.93	8.01	8.88	9.59	10.21	10.84	11.34	11.77	
12	5	2.38	4.79	6.29	7.64	8.58	9.23	9.90	10.40	10.74	11.16	11.54	11.94
Mean $\bar{r}_t$		2.28	4.42	6.05	7.27	8.28	9.06	9.77	10.33	10.85	11.29	11.65	11.94

TABLE 4.
The back calculated fork length (mm) of the fish at the time of ring formation. L_{1-13} represents fork length at time 1-13

	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}
Male	105.8	168.0	210.7	244.1	268.3	287.5	306.4	322.3	335.9	348.7	359.7	364.5	375.1
Female	102.5	158.2	200.5	232.3	258.6	278.8	297.3	311.8	325.5	336.9	346.3	353.7	—

The asymptotic lengths of male (L_∞= 391.3 mm) and female (L_∞'=378.4 mm) were derived from the above regression lines which intercepted 45° diagonal lines. The constant, K, 0.2182 (male) and 0.2121 (female) were obtained from the formula $K=-\ell_n b$ (b, the slope in the equations 3 and 4). The theoretical age at the begining of growth, t_0, -0.4445 (male) and -0.4894 (female) were obtained from $t_0=t+\frac{1}{K}\ \ell_n\ \frac{(L_\infty-L_t)}{L_\infty}$.

The von Bertalanffy's growth equations[17,18] in lengths were:

$$L_t=391.3\ (1-e^{-0.2182(t+0.4445)})\ \text{(male)} \quad (5)$$

$$L_t=378.4\ (1-e^{-0.2121(t+0.4894)})\ \text{(female)} \quad (6)$$

The growth curves in lengths (Fig. 7) were based on equations 5 and 6.

The length-weight relationships were as follows:

$$W=1.9203\times10^{-6}\ L^{3.4283}\ \text{(male)} \quad (7)$$
$$(r=0.99)$$

$$W=2.127\times10^{-6}\ L^{3.417}\ \text{(female)} \quad (8)$$
$$(r=0.99)$$

The growth equations in weights were then transformed by combining the equations (5)-(8), thus

$$W_t=1483.94\ (1-e^{-0.2182(t+0.4445)})^{3.4283}\ \text{(male)} \quad (9)$$

$$W_t=1369.89\ (1-e^{-0.2121(t+0.4894)})^{3.417}\ \text{(female)} \quad (10)$$

The growth curves in weights (Fig. 8) were drawn on the basis of equations 9 and 10.

Futhermore, by applying the formula $t=\frac{Kt_0+\ell_n n}{K}$, where n=3.4283 and 3.417 in the equations 9 and 10, respectively. The time of maximal growth of this species was then estimated as 5.2 years for male and 5.3 years for female after their hatching.

Reproduction

Of the 241 fish examined, 141 were males and 100 females, giving a sex ratio of 1.41:1.00.

The seasonal change in gonad development was observed by calculating the monthly mean gonad index for each sex. The highest gonad

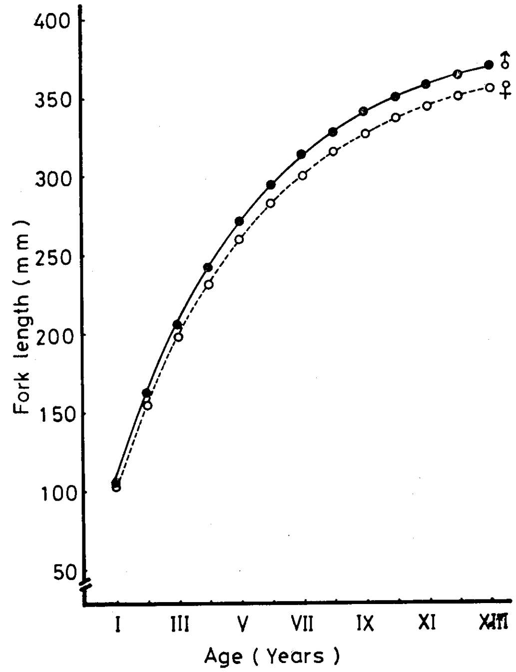

Fig. 7. Growth curves drawn by plotting the back calculated fork length (mm) for ages of male (•) and female (∘) *Girella punctata*.

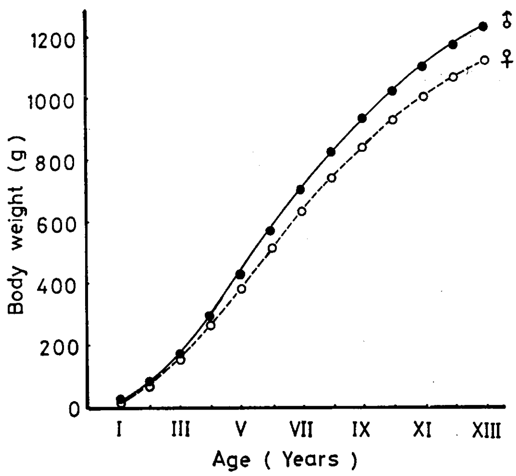

Fig. 8. Growth curves drawn by plotting back calculated weight (g) for ages of male (•) and female (◦) *Girella punctata.*

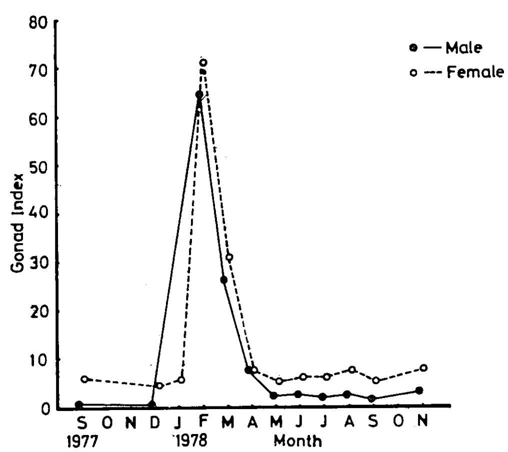

Fig. 9. Monthly changes in gonad indices of male (•) and female (◦) *Girella punctata.*

index (Fig. 9) and the presence of ripe ovaries in February and March, suggested that spawning takes place during these two months.

Fig. 10 showed the maturity of gonad started from the earliest immature stage (Fig. 10 A) through developing stage (Fig. 10 B), ripe (Fig. 10 C) to the spent stage (Fig. 10 D, E). From the polymodal size frequency distribution of oocytes appeared in a ripe ovary (Fig. 10 C), it revealed that there is a group of smaller

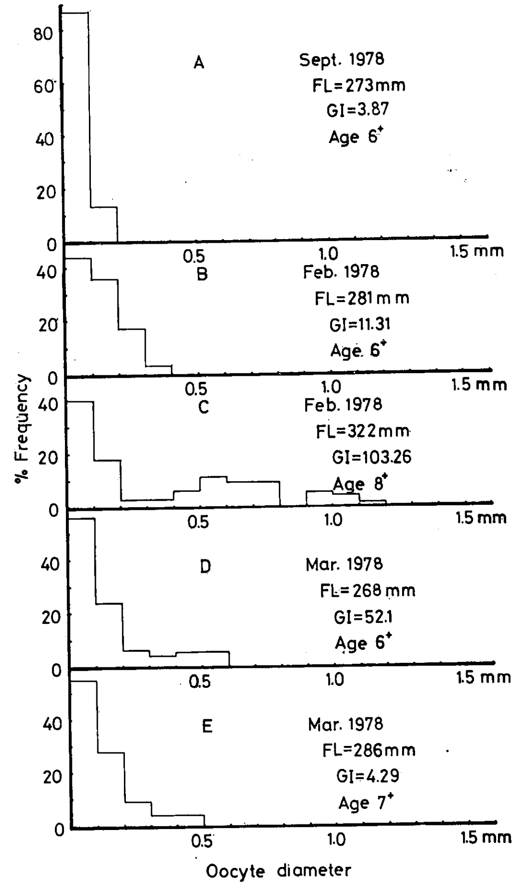

Fig. 10. Percentage size-frequency distribution of oocytes at the gonad maturity stages of immature (A), developing (B), ripe (C) and spent or recovering (D, E) of *Girella punctata.*

oocytes, 0.4–0.8 mm and another group of larger oocytes 0.9–1.2 mm. However, according to the study of Mizue and Mikami[13], this species spawned only once in a season. The smaller oocytes remained until the spawning season of the following year.

The absolute fecundity estimated by counting 6 fully mature females, ranged from 23641 to 336158 ripe and late ripening eggs, among them 23641–141714 transparent ripe eggs were shedded per spawning. It was found that the estimations of fecundity varied considerably. The relationship between fecundity and fish size was not obtained due to limited number of ripe ovaries available for the study.

DISCUSSION

Girella punctata has incisor-like teeth, filterable gill-rakers and long intestine and has adapted itself for feeding especially on algal and small animal food items. In the northern coast of Taiwan, marine algae exist throughout the year. However, they are more abundant during autumn (November) and early spring (March)[3] which coincide well with the seasonal abundance and distribution of the fish along rocky area. Because of its migratory spawning and feeding, *G. punctata* has numerous pyloric caecae which are correlated with the active species as Tominaga[16] stated that the active species have more pyloric caecae than those of inactive species. According to Yokota, *et al.*[20], the larvae of 6.15 mm standard length feed entirely on both larval and adult forms of copepods and phyllopods. Thus, *G. punctata* changes from a carnivorous in postlarval stage to an omnivorous in adults.

A ring is formed annually on the scale of this species. The precise mechanism of annulus formation is still uncertain, however, scale growth is considered to be correlated with the somatic growth of fish. The environmental factors such as temperature and food abundance have long been considered as major factors to influence the fish growth[5,15]. It seems that any environmental change may affect the physiological change of fish, for instance, changes in metabolic rate. However, annulus formation is also related to the seasonal physiological stress, particularily during gonadal maturation, resulting in the fluctuation of the levels of alkaline phosphatase deposition on scale since the alkaline phosphatase is involved in both protein synthesis and calcification of the osseous layer of fish scales. The reabsorption of calcium and protein for the maturation of gonad during the spawning season may produce a mark on the scale surface[1,4,6,7]. This may also occur in younger fiish. This study has

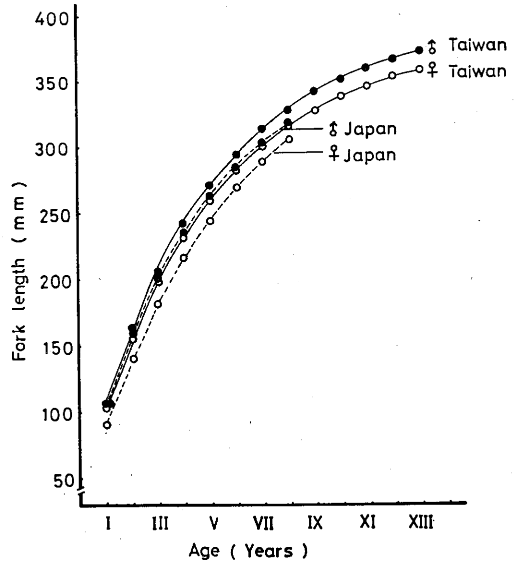

Fig. 11. Growth curves of *Girella punctata* of different origins.

also found that the breeding of *Girella punctata* occurs during the low temperature period, and the scale ring is formed at the commence of rising temperature. It is more likely that the physiological stress due to gonadal maturation is considered to be a reasonable causing of the retardation of growth. Like the Japanese population, growth rate of male is generally faster than that of female. The nature of growth curves (Fig. 11) in both sexes closely agrees with those observed for Japanese population by Mizue and Mikami[13]. There is a general tendency of higher growth coefficient K for both sexes in Taiwan population than those of Japan. For instance, the K value of 0.2182 of Taiwan population against 0.2105 for Japanese population in male and 0.2121 against 0.1852 in female are noted.

The spawning of Taiwanese population takes place (February–March) two months earlier than that of Japanese poulation (May) due to different temperatures between two regions. Similar trend has been found in *Chrysphrys major* whose spawning time is slightly delayed in the fish of northern Taiwan Strait than those in middle Taiwan Strait[2,10]. *Girella* *punctata* spawns only once during the spawning season, evidently from the rapid increase and sudden drop of gonad index[13]. The youngest fish with ripe eggs among the catch has been recorded as six years old. Unfortunately, 1^+ and 2^+ age group fish were not available and insufficient number of other age groups have been obtained for making more precise determination.

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臺灣北部沿岸瓜子鱲魚之生物學研究

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本文記述棲息於臺灣北部岩礁沿岸瓜子鱲魚之生物學研究。瓜子鱲爲雜食性魚類主食海藻及以撓足類與糠蝦期 (mysis) 幼蝦爲主之浮游性動物。形態上，本種魚類因具有纖長之絨毛狀門齒，可濾性之鰓耙及細長之腸部，足以適應其雜食之習性。年齡之判定係根據鱗片上年輪數之多寡而定。年輪經證實約形成於每年之 4～5 月間緊接着每年產卵期因生殖腺之成熟而引起魚體生理抑制之後。到目前爲止，由本研究結果得知年齡最高之雄魚爲 13 歲，雌魚爲 12 歲。成長式以體長（叉長 mm），表示則雄魚爲 $L_t=391.3(1-e^{-0.2182(t+0.445)})$，雌魚爲 $L_t=378.4(1-e^{-0.2121(t+0.4894)})$，若以體重 ($g$) 表示則雄魚爲 $W_t=1483.94(1-e^{-0.2182(t+0.445)})^{3.4283}$，雌魚爲 $W_t=1369.89(1-e^{-0.2121(t+0.4894)})^{3.417}$。成長速率，雄魚一般較雌魚爲快，且臺灣族羣之成長曲線無論雄性或雌性均略高於日本產者。產卵期通常在每年之 2～3 月間，抱卵數爲 23641～336158 粒之間（其中 23641～141714 粒爲透明之完熟卵），每季僅產卵一次，其產卵數卽爲上述之透明完熟卵數。