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THE AGE AND GROWTH OF RED SEA BREAM IN PESCADORES ISLAND

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ABSTRACT

K. H. Chang and S. Chen (1972) *The age and growth of red sea bream in Pescadores Island.* Bull. Inst. Zool., Academia Sinica **11**(2): 11-19. The age of the red sea bream, *Chrysophrys major* TEMMINCK & SCHLEGEL, was determined by means of scale reading of 489 specimens, collected from water of Pescadores Island from July 1970 to December 1971. The scales between the 13-15 lateral line and the pectoral fin were chosen as the representative ones. The ring was formed once a year during November to January. For the growth of the fish, the von Bertalanffy's equations are given as follow:

$$FL_t = 982.72\ (1 - e^{-0.077(t+1.097)})$$

$$W_t = 14083\ (1 - e^{-0.077(t+1.098)})^{2.64866}$$

The growth curve was mostly followed by the progression of length of mode of length composition data. Though the growth rate 0.077 was smaller than East China and Yellow Sea.

The red sea bream, *Chrysophrys major* TEMMINCK & SCHLEGEL, is a demersal fish, distributed among Japan, Korea, China, Taiwan, Southeast Asia[1] and Hawaii[9]. Using long-liner or hand-liner, the Taiwanese caught the red sea bream from rocky bottom of the entire coast of Taiwan and the Pescadores Island.

The red sea bream is one of the most economically important fish in Taiwan. Its biological information is wanting and its production is somewhat unstable. The present report provides age data, in conjunction with length and weight measurements, which are invaluable in studying stock composition, age at maturity, life span, mortality, growth and production which are important in the study of population dynamic.

There were reports about age and growth of the red sea bream, such as Ebina[4-7], Wang[17], Murakami & Shindo[11], Akazaki[1], Murakami & Okada[12] etc. Most of them determined the age and growth by means of scale reading. The present study adapted the same method to determine the growth pattern of the red sea bream in Taiwan. Comparisons of the present results with other previous investigations are made.

MATERIALS AND METHODS

The study was based on data from 489 specimens collected monthly by hand-liner from July 1970 to December 1971 in water around Pescadores Island.

The red sea bream has ctenoid scales. Their appearance is typically pentagon, with feeble ctenii on the apical area. Eight to ten grooves (radii) radiate from the focus to the margin of the covered part. Around the focus, there are many ridges. Change in the growth pattern may affect the distribution of the ridges. The annuli are formed during the alternative periods of fast and slow growth. The feature serving as principal indicator of the annuli is the transparent circuli space between ridges of a unstaining scale and the dark red color ring in a stained preparation.

Scale varies in size and shape in accordance with its position. The scales between the 13–15 lateral-line and the pectoral fin were employed exclusively for age determination, because they have the smallest coefficient of variation and the largest scale size. In addition their shape is symmetrical and their rings are distinct and easy to be recognized.

Six scales were removed from each specimen. The scale was stained in Menon's solution for at least 24 hours and mounted on slides with glycerine. Scales were examined through Nikon Profile Projector (modal 6ct) at the magnification of 10. Measurements of radius of scale (R) and the radius of each annulus (r_n) were made. The radius of the scale in millimeter was measured from the focus to the basi-lateral angle. Body length of fish was measured to the nearest millimeter, body weight in grams was obtained with balance.

RESULTS

1. The results of age determination:

The determined age from 390 samples was listed according to the length class with 25 mm

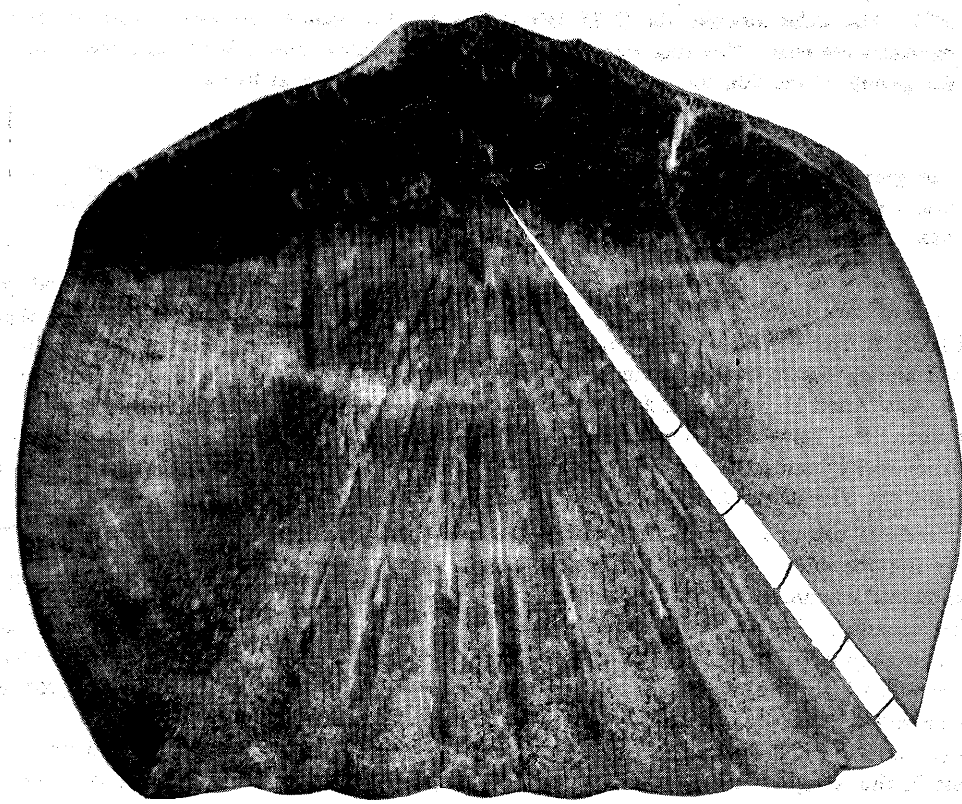

Fig. 1. Photographs of the scale of red sea bream showing the rings.

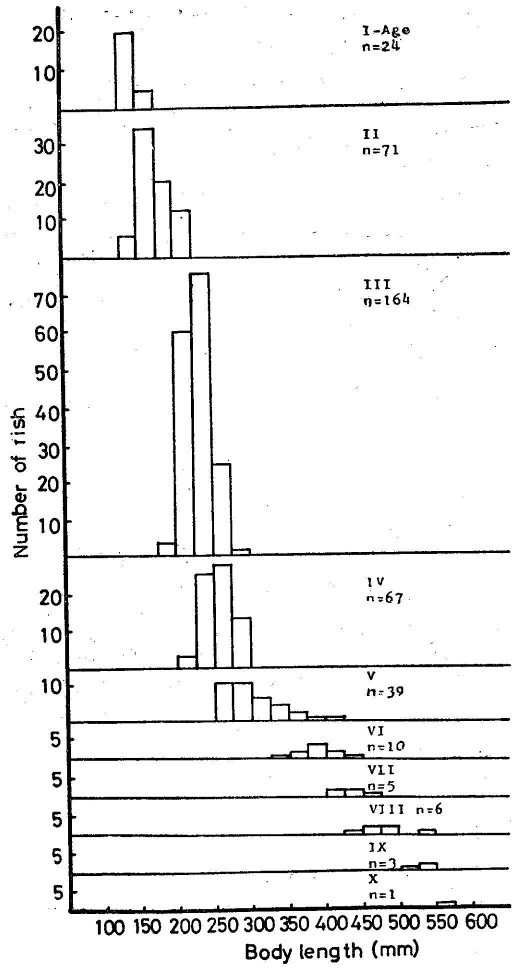

Fig. 2. The length distribution of each age group.

intervals. In Fig. 2 the length composition of each age group is shown and there is obvious overlap of the length distribution between each age group. The wide range in length of each age and the great overlap of adjacent age groups indicate a high degree of individual variation in growth rate.

2. Length-weight relationship:

Length and weight information on fish, aside from its significance in biological studies, are useful in population analysis, for converting length to weight(8).

The equation $W=aL^b$, where L is body length, and a, b are constants, was assumed to express the relation of length to weight.

Examination of the plot of length-weight data revealed no significant difference between monthly samples.

Thus the general length-weight relationship was established by combining all of the data. The length-weight relationship of 489 specimens is:

$$W=2.4210\times10^{-4}L^{2.64866}\ldots\ldots(\text{I})\quad r=0.99332$$

The correlation coefficient (r) of 0.99332 indicated a high degree of relationship and predictability between length and weight.

3. The relation between the body length and the scale length:

A curvilinear regresion was applied to express the body-scale relationship.

As in $W-L$ relationship, there is no significant difference among monthly samples. We combine all data and obtaine an equation as below:

$$L=50.265+10.360R+1.4R^2\ \cdots\cdots\cdots\cdots\cdots(\text{II})$$

4. Back calculation of the body length at the time of ring formation:

The averaged ring radii of each ring group are calculated as:

r_1	r_2	r_3	r_4
4.497	6.285	7.894	9.227
r_5	r_6	r_7	r_8
10.865	11.865	12.695	13.148

Based on those averaged values of ring radii obtained and equation (II) the calculated body length at the time of ring formation (L_n) were computed. In order to compare the results with other previous studies, those calculated body length were converted to fork length by equation $FL=1.145\ L+1.539$. The results are shown as:

FL_1	FL_2	FL_3	FL_4
144.857	196.971	252.688	307.125
FL_5	FL_6	FL_7	FL_8
377.240	425.069	468.062	492.167

5. Walford's graphic test:

The results of age determination can be confirmed by applying the Walford's graphic method.

Plotting r_{n+1} against r_n, the regression line is shown as below:

$$r_{n+1}=2.581+0.981r_n \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \text{(III)}$$

With the same method, when plotted FL_{n+1} against FL_n, the linear equation is obtained as:

$$FL_{n+1}=72.511+0.926FL_n \cdots\cdots\cdots\cdots\cdots\cdots \text{(IV)}$$

$$FL_\infty=982.720 \text{ mm}$$

The slope of this line was 0.926. The asymptotic length, FL_∞, is the point where the line cuts the 45 degree diagonal from the origin.

Since above two regression lines both have intersection with the 45 diagonal, the measured ring radius and calculated fork length formed periodically is then confirmed.

6. Growth in length and weight:

Applying the von Bertalanffy equation

$$FL_t=FL_\infty(1-e^{-k(t-t_0)})$$

where:

FL_t = the fork length at t age

t = age

FL_∞ = maximum fork length

K = growth parameter

t_0 = the age when fork length equal to zero

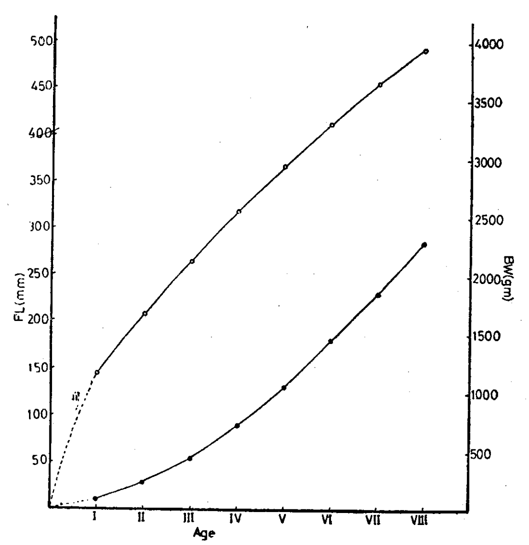

Fig. 3. The growth curves of body length and body weight.

Those parameters are estimated as below:

$$k=-\ln b$$

$$t_0=t+1/k\{\ln[(FL_\infty-FL_t)/FL_\infty]\}$$

Thus the growth equation of the red sea bream is obtained as:

$$FL_t=982.720(1-e^{-0.077(t+1.097)}) \cdots\cdots\cdots \text{(V)}$$

Based on equation (V) and equation (I), the growth in weight equation is estimated as below:

$$W_t=14083(1-e^{-0.077(t+1.098)})^{2.64866} \cdots\cdots \text{(VI)}$$

The curves of growth in length and growth in weight are shown in Fig. 3. Since the samples were all above I age, the estimated growth curve could not be illustrated from those under I age[4].

7. The time of ring formation:

We can use the ring as an indicator of age determination only because the ring formation is periodical. The time of ring formation was predicted by calculating the monthly changes of the marginal increments. Marginal increment is: $(\alpha)=[R-r_n/(r_n-r_{n-1})]$. The results showed in Fig. 4, the monthly changes of (α) dropped down abruptly in November and persisted through Janurary, indicated the ring was formed once a year during November to January.

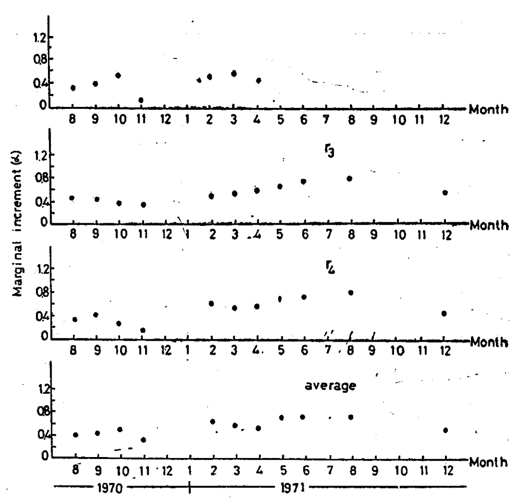

Fig. 4. The monthly changes of the marginal increments.

8. The monthly modal length:

The growth curve can be examined from the progression of length of mode of length composition data. The body length frequency distribution was shown in Fig. 5. The growth curves derived from equation (V) and the modal length of the samples are both plotted in accordance with months (Fig. 6). The observed modals fit well with the predicted values.

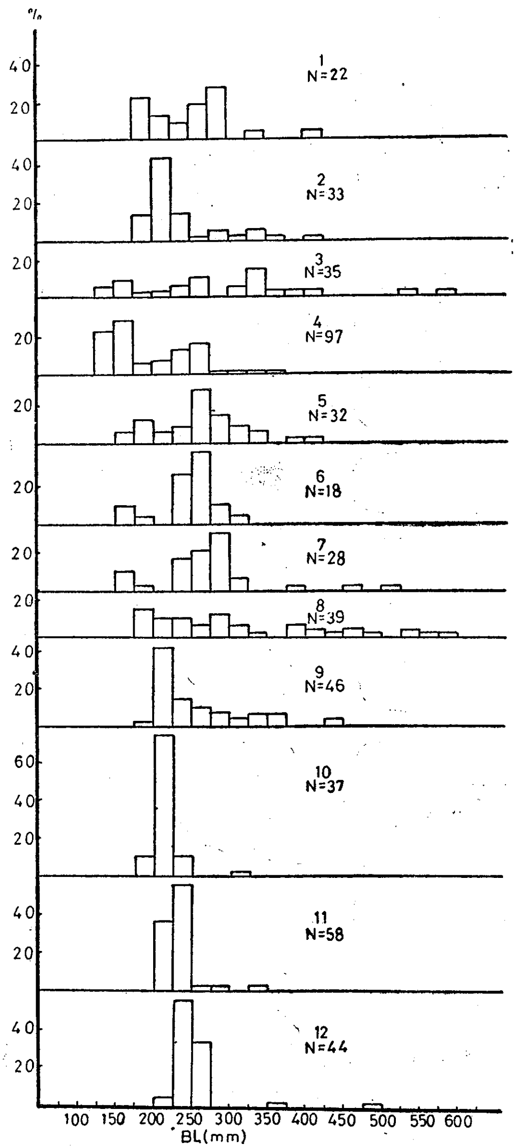

Fig. 5. The body length freguency distribution.

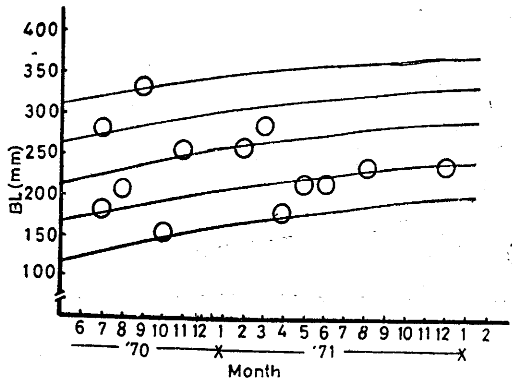

Fig. 6. Monthly modal length of the red sea bream.
○: the monthly modal length
solid lines: the estimated growth curve.

DISCUSSION

1. The interpretation of annual ring:

The interpretation of ring is critical to the age determination. In AKAZAKI'S work[1], the annual ring was a thin transparent zone appearing on the scale and looked like a white circular ring from the photographic print. SHINDO[14] studied the yellow sea bream and reported that the annual ring could be recognized between a transparent zone and a dark zone. Although yellow sea bream and red sea bream both belong to the family sparinae[8], MURAKAMI & OKADA[12] considered there were no such zones on the scale of red sea bream. Yet the annual ring was determined by the disorder ridges continuing from basal area to lateral area. The interpretation of annual ring in the present study was based on the transparent circular space between adjacent ridges. It was similar to those two worker's. Furthermore there were high correlation between the $R-r_n$ of each ring group. The older the fish is, the higher the coefficient of correlation and the larger the slope of those regression line are. This reveals the measured R and r_n are trusty. In general, the older the fish is, the more difficult the interpretation of the annuli is. The problem is complicated by the presence of false rings and regenerated scales often found in older fish. Therefore there

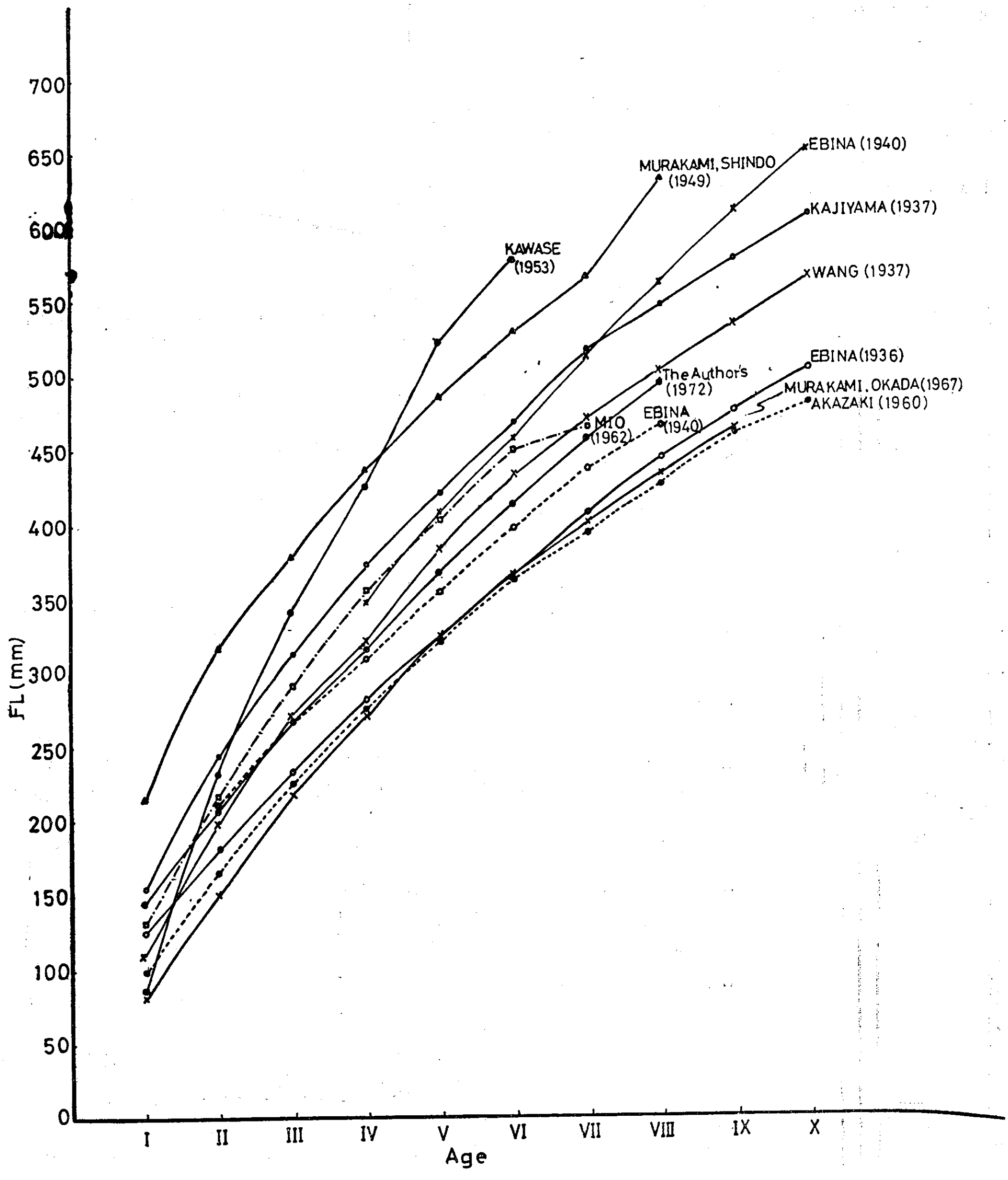

Fig. 7. Comparison of the growth curve of the red sea bream.

are only 390 samples could really be used in age determination. The percentage of readable scale is 79.8.

2. The relation between the body length and the scale length:

The graph of body-scale data from 390 specimens seemed to indicate a linear relationship between the body length and the scale length. The straight line fitted by least squares to these data obtain the equation: $L = -56.056$

TABLE I
Results of the application of Walford's graphic method.
(Based on MURAKAMI & OKADA, 1967)

Author	Year	Locality	b	a	FL_∞(mm)	k
Ebina	1936	Izu	0.891	90	825	0.115
Wang	1937	Hiroshima	0.890	73	662	0.116
Ebina	1940	Hiuchinada	0.892	84	778	0.114
Ebina	1940	Saganoseki	0.891	56	514	0.115
Kawase	1953	Kii	0.887	110	973	0.120
Akazaki	1960	Wakasa Bay	0.893	76	710	0.113
Mio	1962	Northern Kyushu	0.873	103	803	0.136
Murakami & Okada	1967	East China & Yellow Sea	0.915	62	740	0.090
Okada	1970	East China & Yellow Sea	0.909	68	749	0.095
Present study	1972	Pescadores Is.	0.926	72	982	0.077

$+35.274R$, where L is the body length in mm and R is the scale length in mm. The test of significance of linear regression revealed that the linear regression was reasonable. But the intercept of -56.056 appears unreasonably to estimate the body length at scale formation.

A curvilinear body-scale relationship has been demonstrated by Thompson[15] by $L=a+bs+cs^2$, where a is the intercept on the abscissa. We also gave the $L-R$ relationship by curvilinear regression and obtain the equation as: $L=50.265+10.360R+1.4R^2$. The intercept of 50.265 appears reasonable well enough to approximate the size at scale formation. Furthermore, we also make a test of significance of curvillinear regression. The result indicated significant difference and the value of deviation from quadratic was smaller than that of deviation from linear. Thus we considered the equation of curvilinear regression of $R-L$ relationship is the best fit.

3. The time of ring formation:

In Japan, the time of ring formation varied according to the age group and the geographical difference. No doubt, the environmental changes may influence the physiological condition of the fish and modify the ring formation. The time of ring formation of those from Pescadores Island was estimated to be during Nov.-Jan. It is presupposed that the lowest water temperature in winter may cause the sudden increase of the gonad index[18] and the formation of rings.

4. Comparison of growth pattern:

Results of the application of Walford's graphic method were shown in Table I. According to MURAKAMI & OKADA[12], the growth patterns of this species are shown in Fig. 7 and divided into three groups as in Table II. In comparing with other previous investigations in Japan, the growth pattern of the red sea bream of Pescadores Island can be classified into the third group. Though the growth rate 0.077 is smaller than those in East China & Yellow Sea, they are still very close.

ACKNOWLEDGMENTS

We wish to express our appreciation to Dr. C. C. Huang for critically reviewing the manuscript. Grateful acknowledgment is also extended to the colleagues in the Laboratory of Fisheries Biology of the Institute.

REFERENCE

1. Akazaki, M. (1960) Growth and age of the sea

TABLE II

Comparison of growth pattern of the red sea bream

(Based on MURAKAMI & OKADA, 1967)

Growth pattern	Growth rate fast		Growth rate mediate				Growth rate slow				
Author	Murakami, Shindo (1949)	Kawase (1953)	Wang (1937)	Kajiyama (1937)	Ebina (1940)	Mio (1968)	Ebina (1936)	Ebina (1940)	Akazaki (1960)	Murakami, Okada (1967)	Present study (1972)
1st year	213	85	109	152		130	83		99	130	146
2nd year	317	231	199	244	210	218	150		165	182	208
3rd year	378	341	271	311	265	290	218		225	230	266
4th year	439	426	324	372	307	355	270	348	275	274	319
5th year	487	524	387	427	355	402	324	409	320	314	368
6th year	530	579	434	469	398	450	366	457	363	351	414
7th year	567		471	518	439	466	403	515	395	385	456
8th year	634		504	549	468		445	563	428	415	495
9th year			536	579			475	612	462	443	
10th year			567	609			501	653	484		
Sample size	142	101	446	unknown	30	385	56	26	1010	3767	390

bream, *Chrysophrys major*, caught in Wakasa Bay. Bull. Jap. Soc. Sci. Fish. **26**(3): 217–221.
2. Von Bertalanffy, L. (1938) A quantitative theory of organic growth. Human Biol. **10**: 181–213.
3. Chen, T. F. (1969) A synopsis of the vertebrates of Taiwan. 1, 548pp.
4. Ebina, K. H. (1936) On the growth of *Pagrosomus mator* T. & S. Bull. Jap. Soc. Sci. Fish. **4**(6): 411–414.
5. Ebina, K. H. (1937) On the stock of the Teleost, *Pagrosomus major* (T. & S.) I. The specimens obtained inside and outside the Inland Sea of Japan compared. Bull. Jap. Soc. Sci Fish. **6** (4): 179–181.
6. Ebina, K. H. (1938) On the stock of the Teleost, *Pagrosomus major* (T. & S.) II. The specimens obtained outside (Prefs. Wakayama and Tokusina) and inside the Inland Sea of Japan compared. Bull. Jap. Soc. Sci. Fish. **7**(3): 151–154.
7. Ebina, K. H. (1940) On the stock of the Teleost, *Pagrosomus major* (T. & S.) III. Bull. Jap. Soc. Sci. Fish. **8**(6): 295–297.
8. Lux, F. E. (1969) Length-weight relationships of six new England Flatfishes. Trans. Amer. Fish. Soc. **98**(4): 617–621.
9. Matsubara, K. (1955) Ichthyology. part II. 615pp.
10. Miyosi, K. (1938) A study of the stock of *Pagrosomus major* (T. & S.) landed at Hirosima. Bull. Jap. Soc. Sci. Fish. **7**(3): 149–150.
11. Murakami, S. and Shindo, S. (1949) Studies on the stocks of some economically important marine fishes caught around Amakusa. VI. On the snapper, *Pagrosomus major* (TEMMINCK & SCHLEGEL) of Amakusa. Bull. Jap. Soc. Sci. Fish. **15**(4): 158–160.
12. Murakami, S. and Okada, K. (1967) Studies on the fishery biology of the sea bream, *Chrysophrys major* TEMMINCK & SCHLEGEL, in the East China and the Yellow Seas-III. Age and Growth. Bull. Seikai Reg. Fish. Res. Lab. **35**: 23–38.
13. Snedecor, G. W. and Cochran, W. G. (1940) Statistical methods. 478pp.
14. Shindo, S. (1960) Studies on the Fisheries Biology of the Yellow Sea Bream (*Taius tumifrons*) from the East China Sea. Bull. Seikai Reg. Fish. Res. Lab. (20), 56–90.
15. Thompson, H. (1923) Problems in haddock biology with special reference to the validity and utilization of the scale theory. I. Rep. Fishery Bd. Scotl. for 1922, No. 5.
16. Walford, L. A. (1946) A new graphic method of describing the growth of animals. Biol. Bull., Woods Hole **90**:141–147.
17. Wang, Y. K. (1937) Some knowledge of the nature of stock of *Pagrosomus major* (T. & S.) in the Inland Sea of Japan. Bull. Jap. Soc. Sci. Fish. **6**(4): 175–178.
18. Wu, W. L. (1972) Studies on the maturity and fecundity of red sea bream in Taiwan. unpublished.
19. Yang, R. T. et al. (1969) A comparative study on the age and growth of yellowfin tunas from the Pacific and Atlantic Oceans. Bull. Far Seas Fish. Lab. (2), 1–20.

澎湖近海嘉鱲魚之魚齡與成長

張崑雄　　陳　　硒

本研究係自 1970 年 7 月至 1971 年 12 月在澎湖馬公以一支釣獲得之嘉鱲魚共 489 尾爲材料，取其第 13～15 側線鱗下方，胸鰭上方之鱗片研究年齡與成長。分析結果，輪紋每年在 11 至 1 月間形成一次。利用 von Bertalanffy 方程式求得尾叉長成長式爲：$FL_t=982.72(1-e^{-0.077(t+1.097)})$，體重成長式爲：$W_t=14083(1-e^{-0.077(t+1.097)})^{2.64866}$，此結果與日本各地研究者之結果非常相近。