Animal Cells and Systems 12: 305-311, 2008

Animal Cells
and
Systems

http://www.AnimalCells.or.kr

Age and Growth of the Mudskipper, *Scartelaos gigas* (Perciformes, Gobiidae) from Korea

Kyeong Dong Park, Jin Koo Kim[1,*], Dae Soo Chang[2], Joo Il Kim[3], and Chul Woong Oh[1]

Korea Inter-University Institute of Ocean Science, Pukyong National University, Busan 608-737, Korea; [1]Department of Marine Biology, Pukyong National University, Busan 608-737, Korea; [2]Fisheries Resources Research Team, NFRDI, Busan 619-705, Korea; [3]South Sea Fisheries Research Institute, NFRDI, Yeosu 556-823, Korea

Abstract: Age and growth of the mudskipper, *Scartelaos gigas* were investigated using the second actinost bone of the pectoral girdle, based on an analysis of 560 individuals collected from the mud flats in south west Korea. Specimens were collected semimonthly from March to September of 2003. Actinost and ring radii of each ring group showed a direct one-to-one relationship, with ring radius increasing in tandem with actinost radius. Monthly change in the marginal indices showed that ring formation occurred between May and July (mainly June), being supported by the monthly change in the gonadosomatic (highest in June) and hepatosomatic (lowest in July) indices. Because the species has not been found since November, when air temperature was less than about 10°C, it is thought to enter to hibernation. Therefore, it was suggested that the two new actinost rings may appear a year: one during the spawning season (May-July) and another during hibernation (since November). Although the growth of *S. gigas* must be limited to short periods each year from March to April and from August to October, its growth rate was considerably fast. The von Bertalanffy growth parameters of *S. gigas* were TL_∞=179.36 mm, K=0.78 year^{-1}, t_0=−0.7762, and age-length key were TL_1=134.3 mm, TL_2=158.6 mm, TL_3=169.1 mm, TL_4= 175.0 mm.

Key words: *Scartelaos gigas*, age, growth, mudskipper

Scartelaos gigas (family Gobiidae) is known to have been distributed only in Korea and China (Murdy, 1989; Kim et al., 2005a; Kuo and Shao, 1999; Randall and Lim, 2000). In Korea, its habitat is very restricted to the mud flats of the south west and the west south coast (Kim et al., 2005a). In Korean mud flats, there are several fishes such as *Apocryptodon punctatus*, *Mugilogobius abei*, *Acanthogobius flavimanus*, *Periopthalmus modestus*, *Boleophthalmus pectinirostris*, *S. gigas*, etc, of which, *B. pectinirostris* and *S. gigas* are commercially important species, being used as the ingredients of favorite foods (Kim et al., 2005b). Accordingly, there has been a lot of reports concerning *B. pectinirostris*, such as early life history (Koga et al., 1989a), distribution of fish larvae (Yuzuriha and Koga, 1990; Koga and Baba, 1991), ecology of young fish (Yuzuriha et al., 1990), reproductive ecology (Koga et al., 1989b; Chung et al., 1991), inhabitation ecology (Ryu, 1991; Ryu et al., 1995) and age and growth (Washio et al., 1991; Jeong et al., 2004; Kim and Jeong, 2007), however, the ecology of *S. gigas* has been poorly known yet.

The mud flats has a great value in economic and ecological aspects with purification function for various pollution flew into the sea and a habitat or spawning ground of fishes, crustaceans, cephalopods, gastropods, etc. (KORDI, 1999). Therefore, it has been increasing the importance of the mud flats in the aspect of ecology and species diversity in the world. In Korea, there are extensive mud flats, especially in the west coast, may be due to the wide range of tide in those area, 4.0-9.3 meters (Lee et al., 2003). The mud flats in the west south coast are about 2.4% of Korea's territory and approximately 83% of whole mud flats in the west coast (MOMAF, 1998). However, it has been rapidly decreased about 25% of the mud flats due to the coastal reclamation and/or environmental pollution for the past 10 years (Lee et al., 2003).

In recent years, the amount of *S. gigas* as well as *B. pectinirostris* has been decreased due to overfishing and destruction of a spawning burrow by traditional catch method so it has been raised the importance of species conservation and appropriate fisheries management of the two mudskippers (Kim et al., 2005b). Especially, with a limited habitat, it needs diverse researches for conservation strategies of *S. gigas* to prevent its local extinction.

*To whom correspondence should be addressed.
Tel: +82-51-629-5927; Fax: +82-51-629-5931
E-mail: taengko@pknu.ac.kr

Therefore, this study aimed to estimate age and growth of *S. gigas*, which has been reduced by indiscreet mud flats reclamation, environmental pollution and overfishing, as the basic data for species conservation and appropriate fisheries management.

MATERIALS AND METHODS

A total of 560 specimens were obtained by fishermen, 1-3 times a month on Jeung-do Island, south west coast of Korea from March to September 2003 (Table 1). Specimens were caught by hand catch or fishing by fishermen, who slide over the mud in a sleigh at low tide. Total length (TL) was measured to the nearest 0.1 mm using a vernier caliper and its weight of body, gonad and liver were measured to the nearest gram for all specimens using an electronic balance.

Age determination was conducted using the second actinost bone in shoulder girdle supporting a pectoral fin, being followed by methods of Washio et al. (1991) and Jeong et al. (2004). The second actinost bone after removing a flesh was observed under the microscope with an image analysis equipment (Image-Pro Plus, version 4.5). We measured distance one side from the focus to each ring, its boundary being a transition point from translucent zone to opague zone. To estimate ring formation time, the marginal index (MI) was calculated as follow; $MI=(AR-r_n)/(r_n-r_{n-1})$.

Where AR is distance from the focus to the external edge of actinost, r_n is distance from the focus to the internal edge of n^{nd} ring, and r_{n-1} is distance from the focus to the internal edge of $n-1^{nd}$ ring (Fig. 2).

To clarify if ring is appropriate for age determination, the interconnectivity between actinost radius and ring radius in each ring group was examined. In addition, it assumed its reproductive cycle to check the time of ring formation. For that, it examined monthly change of gonadosomatic index (GSI) and hepatosomatic index (HSI).

Difference in slope of linear regressions of log-transformed total length and body weight was investigated by analysis of covariance (ANCOVA) with Tukey-like test using SAS program (version 7.0) to examine the difference of growth between sexes.

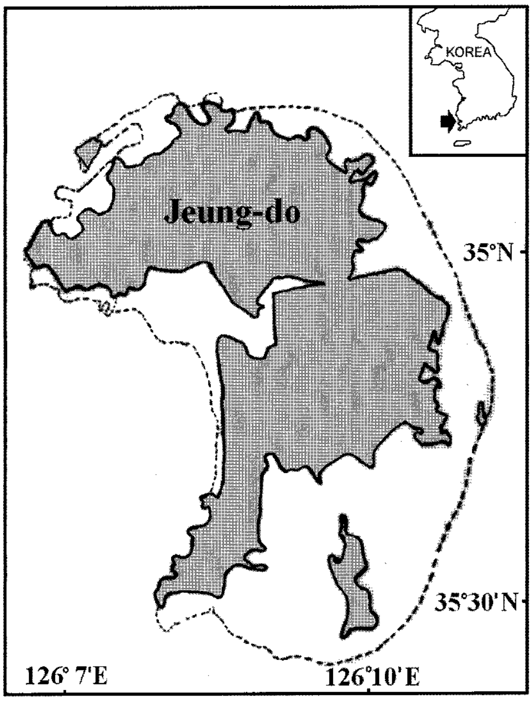

Fig. 1. Map showing the sampling area for *Scartelaos gigas*. Dotted line is mud flat area.

Table 1 Sampling data for *Scartelaos gigas* collected from Korea in 2003

Date Month/day		Number of specimens		Total length (mm)	
		Female	Male	Female	Male
March	23 th	17	13	134.5-201.2	144.3-191.6
April	17 th	22	18	127.1-186.1	132.5-180.6
	30 th	18	18	118.8-182.4	124.8-180.4
May	12 th	32	18	149.0-195.5	162.1-190.1
	28 th	24	26	132.4-192.0	133.6-189.0
June	10 th	28	31	134.4-189.5	136.8-186.6
	25 th	35	14	137.4-192.5	125.6-192.1
July	7 th	6	4	149.4-188.2	141.9-188.8
	15 th	18	21	116.4-181.9	115.8-188.8
	31 th	35	18	131.2-186.1	111.6-170.6
August	13 th	26	26	142.4-186.1	141.4-185.9
	26 th	16	4	135.1-193.5	128.1-151.4
September	9 th	7	13	152.9-182.1	124.7-180.9
	21 th	21	31	139.4-192.2	130.4-194.1

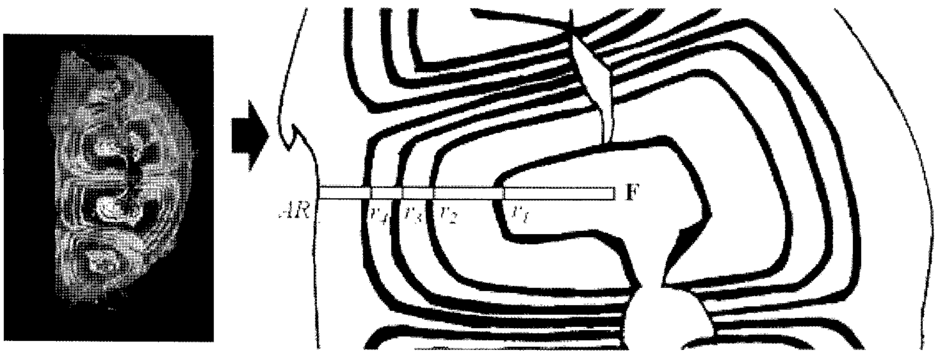

Fig. 2. Actinost diagram for age determination of *Scartelaos gigas*. F, Focus; AR, Actinost radial size; r_n Radius to the n-th mark.

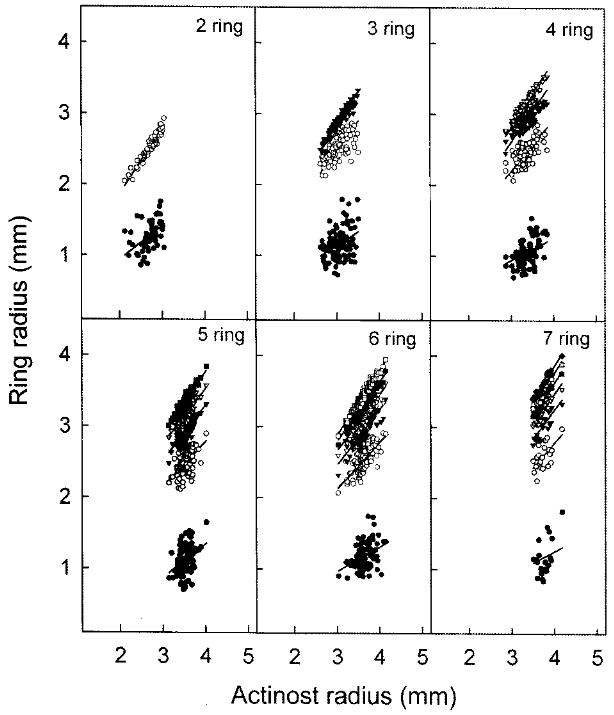

Fig. 3. Relationship between actinost and ring radii of *Scartelaos gigas*.

Total length by age was estimated with a back calculation method by applying estimated ring radius at the time of ring formation to linear regression equation of total length and antinost radius. The growth parameters were obtained by applying back calculated total length in each age, to von Bertalanffy's growth formula (von Bertalanffy, 1938).

$$TL_t = TL_\infty\{1-\exp[-K(t-t_0)]\}$$

Where TL_t is total length at age t, TL_∞ is the asymptotic fork length, K is the growth coefficient (yr^{-1}), t_0 is the hypothetical age when the fork length is zero.

RESULTS

Actinost ring formation

To determine whether a ring in actinost bone is appropriate for age character, the relationship between actinost radius and ring radius was examined in each ring group. As a result, every ring radius was increased in proportion to the length of actinost bone, showing positive relationship. As the number of ring is increased, each ring seemed to overlap little by little with close ring radius, but there was a constant interval to discriminate those (Fig. 3). To estimate a ring formation time and frequency, we examined monthly change of marginal index (MI). It was high value until April, decreased in May, minimum in June and then increased in July (Fig. 4). It was assumed that ring formation occurred between May and July, main ring formation occurred in June. The two ring individuals were found between March and April, suggesting the first ring to be formed in winter season.

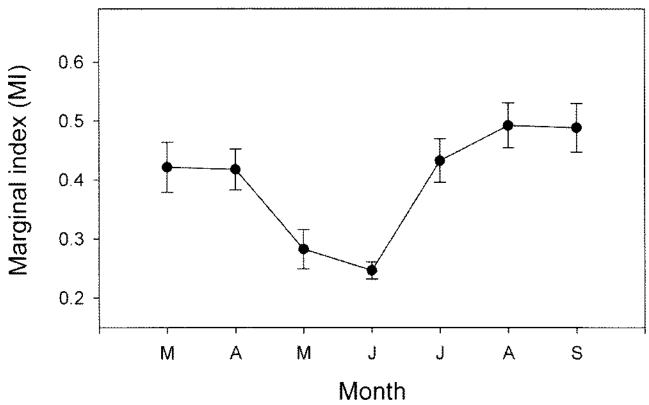

Fig. 4. Monthly change in the margin indices of *Scartelaos gigas*. Solid circles and bars indicate average and standard error, respectively.

Maturity and fecundity

Gonadosomatic index (GSI) and hepatosomatic index (HSI) were examined to estimate the spawning period and survival strategy in preparation for hibernation. In female, GSI showed its low value until April, increase in May, maximum in June, and sudden decrease after July. In male, it showed its low value until April, increase in May, maximum in June and gentle decrease after that (Fig. 5).

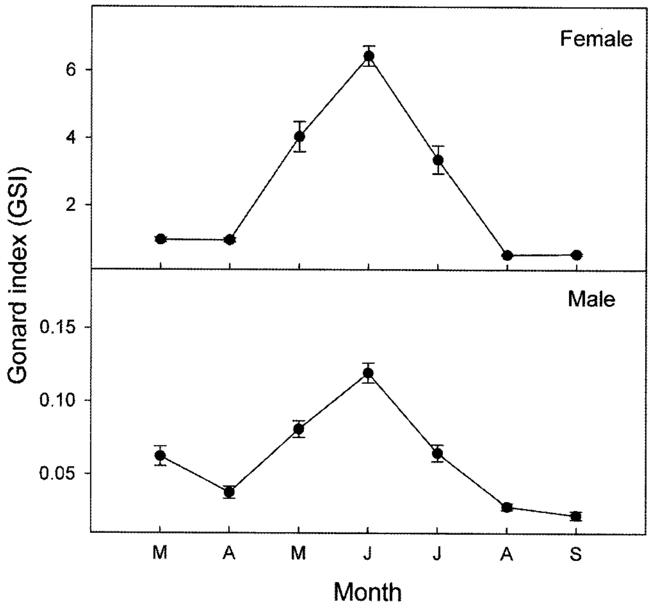

Fig. 5. Monthly change in the gonadosomatic indices of *Scartelaos gigas*. Solid circles and bars indicate average and standard error, respectively.

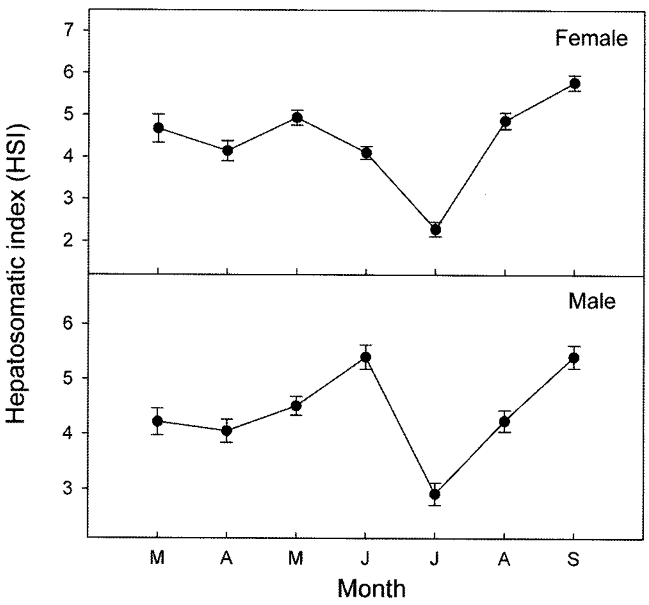

Fig. 6. Monthly change in the hepatosomatic indices of *Scartelaos gigas*. Solid circles and bars indicate average and standard error, respectively.

Therefore, spawning period was estimated between May and July, main spawning time was June, which was consistent with ring formation time. In female, HSI showed its high value until June, decrease after that and minimum in July. In male, HSI was low in April, maximum in June and minimum in July (Fig. 6). Estimated fecundity (F) during the spawning period ranged from 1,362 to 18,368 eggs (n=21, 116.0-193.1 mm TL), and tended to increase with size. There was a statistically significant non-linear

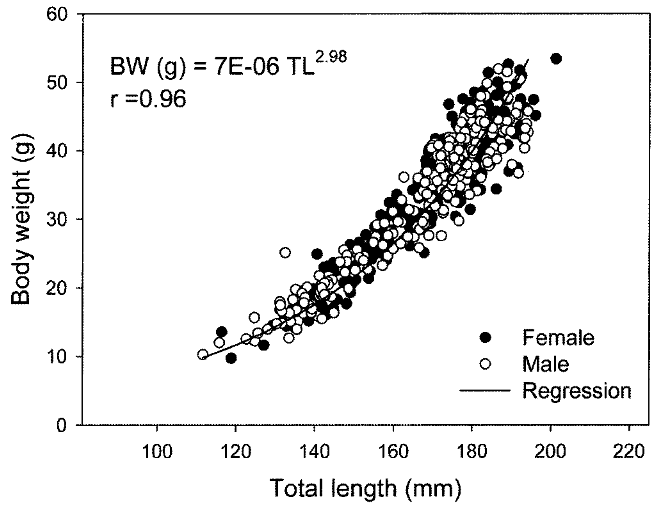

Fig. 7. Relationship between total length and body weight of *Scartelaos gigas*.

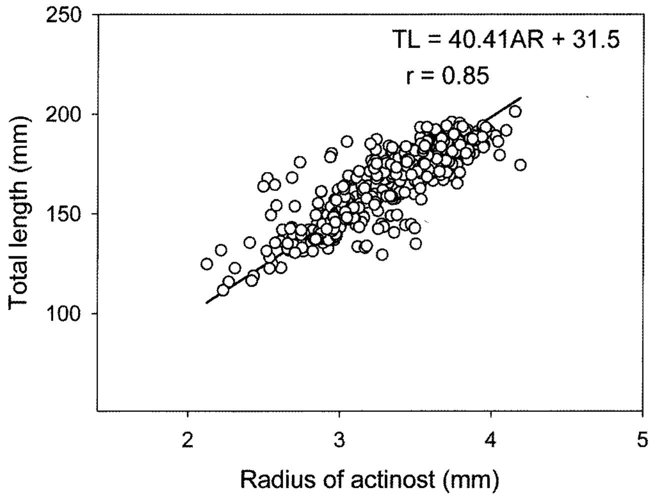

Fig. 8. Relationship between actonost radius and total length of *Scartelaos gigas*.

relationship between fecundity and total length, $F=0.0001TL^{3.46}$ ($r=0.63$, $P<0.01$).

Growth

The relationship between total length (TL) and body weight (BW) was expressed as following equation; $BW=7E\text{-}06TL^{2.98}$ ($r=0.96$, $P<0.01$) (Fig. 7). There was no difference in relative growth between sexes (ANCOVA, $P>0.05$).

The relationship between total length (TL) and actinost radius (AR) was $TL=40.41AR+31.5$ ($r=0.85$, $P<0.01$) for combined sexes (Fig. 8). Accordingly, the back calculated total length at the time of ring formation was obtained by applying them to a relationship between actinost radius and total length (Table 2, 3).

Growth parameters such as TL_∞, K, t_0 were determined by the growth formula for the age-length key (von Bertalanffy, 1938). For von Bertalanffy's growth parameters,

Table 2 Mean ring radii on the actinost of *Scartelaos gigas*

Ring group	R	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	Remark*
1										Hibernation
2	2.70	1.27	2.52							Spawning
3	3.05	1.16	2.52	2.89						Hibernation
4	3.37	1.05	2.47	2.94	3.16					Spawning
5	3.55	1.13	2.50	2.95	3.18	3.36				Hibernation
6	3.63	1.18	2.54	2.95	3.16	3.32	3.46			Spawning
7	3.68	1.16	2.57	2.97	3.17	3.31	3.45	3.55		Hibernation
8	3.85	1.18	2.68	2.96	3.18	3.31	3.46	3.59	3.70	Spawning
Mean	3.40	1.16	2.54	2.94	3.17	3.33	3.46			

*indicate the formation time of the exterior ring

Table 3 Mean and back–calculated total length of *Scartelaos gigas*

Age (year)	Number of individual	Mean ring radius (mm)	Back-calculated total length (mm)	Mean total length (mm)
1	163	2.54	134.24	140.53
2	203	3.17	158.86	167.62
3	162	3.46	169.47	179.08
4	10	3.7	175.17	183.69

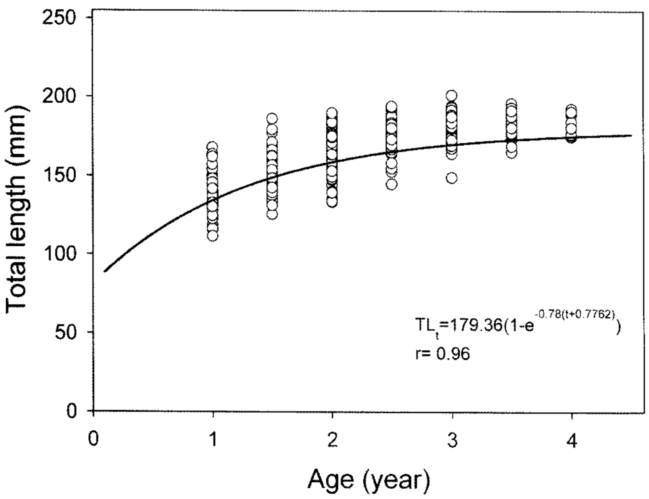

Fig. 9. Von Bertalanffy's growth curve for total length of *Scartelaos gigas*. Open circles indicate total length.

the nonlinear regression analysis was adopted. As a result, we obtained TL_∞ (179.36 mm), K (0.78 yr^{-1}), t_0 (−0.7762), accordingly, the von Bertalanffy's growth formula was TL_t =179.36 {1−exp[−0.78(t+0.7762)]} for combined sexes. It showed high total length at age 0 and then rapid growth curve until age 2, gentle curve thereafter, and sudden slowdown from age 3 (Fig. 9).

DISCUSSION

We used the second actinost bone as an age character, because otolith of *S. gigas* tends to be easily broken.

Monthly change of MI in *S. gigas* (Fig. 4) suggested a ring is formed during spawning season (May-July). It was suggested that the first ring is formed in winter season, based on the two ring individuals being found between March and April. This overall pattern was similar to that of *B. pectinirostris*, which was defined to have two new actinost rings each year, (June-July and October) (Jeong et al., 2004). Considering a spawning season (May-July) assumed by GSI of *S. gigas*, it seemed no individual forming a new ring from August. However, interestingly, there were some individuals forming a new ring in August and in September after that season. Those individuals were composed of relatively small sized fishes (less than 15 cm TL), assuming that small fishes participate to spawning later. According to the microscopic examination of reproductive tissues of *S. gigas*, Kim et al. (2005b) mentioned that both female and male can release eggs and sperms from May up to the middle of August and observed the evidence of egg and sperm release several times during spawning season. A spawning ring of *S. gigas* had very complicated pattern that its width was thick and there was slight growth line between rings. It may be related to multiple release of eggs or sperms (Kim et al., 2005b). Regarding such complicated pattern of spawning ring, Kim and Jeong (2007) hypothesized that not all fishes participate to spawning in the following year based on cohort separation of age 0 in each spawning time (cohort I, II and III). According to Kim and Jeong (2007), in *B. pectinirostris*, the cohort I hatched in June may rapidly grow so it may reach to the size of group maturity in June of the following year, but the cohort III hatched in August may release eggs or sperms partially in August of the following year or enter into hibernation

Table 4 Von Bertalanffy's growth parameters (TL_∞ and K) for five gobiids

Species	TL_∞	K	Age character	Source
Scartelaos gigas	179.4 mm	0.78	Actonost	This paper
Boleophthalmus pectinirostris	155.3 mm (M.)	1.39	Actonost	Jeong et al., 2004
	165.2 mm (F.)	1.07		
Gobius vittatus	50.1 mm	1.18	Otolith	Kovačić, 2006
Gobius paganellus	127.7 mm	0.89	Length-frequency	Azevedo & Simas, 2000
Gobius niger	166.6 mm	0.34	Otolith	Silva & Gordo, 1997

without spawning. However, like *B. pectinirostris* (see Washio et al., 1991; Jeong et al., 2004), main spawning season of *S. gigas* is from May to July, although Kim et al. (2005b) insisted that the spawning can be maintained until August based on reproductive tissue's observation, most of those may release eggs or sperms in the following year. In this study, it was not determined the formation of a hibernation ring. In the case of *B. pectinirostris* (see Washio et al., 1991; Jeong et al., 2004), it was reported that the hibernation ring was found in October, just before hibernation. *S. gigas* was observed in the mud flats by the end of October, accordingly, it was thought that the hibernation ring in *S. gigas* may be formed after October. Hence, our findings suggest that two actinost rings may appear each year; one during the spawning season, and another during hibernation.

Total length of *S. gigas* calculated by the von Bertalanffy growth function were 134.3 mm in age 1, 158.6 mm in age 2, 169.1 mm in age 3 and 175.0 mm of age 4. When comparing to total length of the Japanese *B. pectinirostris* (78-86 mm, age 1; 103-119 mm, age 2; 128-132 mm, age 3; see Washio et al., 1991), there was difference more than 1 year. In addition, total length of both male (132 mm, age 1; 149 mm, age 2) and female (121 mm, age 1; 150 mm, age 2; 160 mm, age 3) of the Korean *B. pectinirostris* (see Jeong et al., 2004) were smaller than those of *S. gigas*. *S. gigas* was also bigger than other gobiids, *Gymnogobius macrognathus*, *Gymnogobius* sp. 1 and *Gymnogobius* sp. 2 presented by Kim and Kim (2001), showing somewhat rapid growth pattern. In *S. gigas*, the theoretical maximum total length (TL_∞) was 179.4 mm and growth coefficient (K) was 0.78 yr^{-1}, being slightly slower than the Korean *B. pectinirostris* (TL_∞=155.3-165.2 mm, K=1.07-1.39 yr^{-1}, see Jeong et al., 2004), *Gobius vittatus* (TL_∞=50.1 mm, K=1.18, see Kovaèiè, 2006), or *Gobius paganellus* (TL_∞=127.7 mm, K=0.89, see Azevedo and Simas, 2000) but being relatively faster than *Gobius niger* (TL_∞=166.6 mm, K=0.34, see Silva and Gordo, 1997) (Table 4). It reported that the growth differences among species or localities, are mainly due to their habitat's water temperature (Park and Kang, 2007; Dunne, 1978). However, it assumed that, in the case of gobiids living in the intertidal zone, rather water temperature, the difference of diet opportunity due to inhabited environment changed by the range of tide might cause the growth difference (Azevedo and Simas, 2000). Jeong et al. (2004) mentioned that such growth difference between the Korean and Japanese *B. pectinirostris* might be due to difference in exposure time of mud flat. *S. gigas* comes out from its burrow to the surface of the mud flats at low tide and actively eats a diatom (Kim et al., 2005b). At full tide, it returns to its burrow to take a rest, which may be resulted in a very rapid growth, similar to *B. pectinirostris*. In addition, it was observed that *S. gigas* eats a diatom (Noda and Koga, 1990) very actively since August to prepare over winter regardless of fishermen's high intensive fishing. The active feeding behavior of *S. gigas* resulted in sudden increase of HSI after August (Fig. 6). In the view point of feeding ecology, *S. gigas* seems to be largely affected by air temperature, rather than water temperature. Compared occurrence of *S. gigas* to the change of air temperature in Mokpo area in 2002-2003, it was about 11°C that *S. gigas* first appeared in 23 March, about 20°C that GSI became peak in June, and less than about 10°C that it entered to hibernation (from November). Accordingly, it is suggested that *S. gigas* go to winter sleep under about 10°C.

S. gigas distributes only in the mud flats from the south west coast (e.g., Sin-an, Mu-an, Young-gwang) to the west south coast (e.g., Hae-nam, Jang-heung) of Korea, and China (Shanghai) unlike *B. pectinirostris* (Korea, Japan, China and Taiwan) (Murdy, 1989; Kim et al., 2005a; Kuo and Shao, 1999).

Especially, due to water temperature rising by global warming, the sea level is increased 3.1±0.7 mm a year from 1993 to 2003 (Bates et al., 2008), so it may cause a decrease of the mud flats in the world including Korea and Japan (Ariake Sea) in future, thereby significantly reducing biodiversity lived in the mud flats. Therefore, it is necessary to study various research fields to conserve species diversity in the mud flats.

ACKNOWLEDGMENT

Source of grant funded: Pukyong National University, National Fisheries Research & Development Institute

REFERENCES

Azevedo JMN and Simas AMV (2000) Age and growth, reproduction and diet of a sublittoral population of rock goby *Gobius paganellus* (Teleostei, Gobbidae). *Hydrobiologia* 440: 129-135.

Bates BC, Kundzewicz ZW, Wu S, and Palutikof JP (2008) Climate Change and Water. Technical Paper VI.

Bertalanffy L von (1938) A quantitative theory of organic growth (Inquiries on growth laws.). *Hum Biol* 10: 181-213.

Chung EY, An CM, and Lee TY (1991) Sexual maturation of the bluespotted mud hopper, *Boleophthalmus pectinirostris* (Linnaeus). *Bull Kor Fish Soc* 24: 167-176.

Dunne J (1978) Littoral and benthic investigation on the west coast of Ireland-IX (Section A: Faunistic and ecological studies). The biology of rock-goby, *Gobius paganellus* L., at Carna. *Proc Royal Irish Acad* 78B: 179-191.

Jeong SJ, Han KH, Kim JK, and Sim DS (2004) Age and growth of the blue spot mudskipper (*Boleophthalmus pectinirostris*) in the mud flat of southwestern Korea. *J Kor Fish Soc* 37: 44-50.

Kim IS, Choi Y, Lee CL, Lee YJ, Kim BJ, and Kim JH (2005a) Illustrated book of Korean Fishes. Kyohak Publ Seoul, pp 420-443.

Kim JK and Jeong SJ (2007) Growth estimation of 0-aged blue spot mudskipper *Boleophthalmus pectinirostris* using length frequency data. *J Kor Fish Soc* 40: 50-52.

Kim JK, Sim DS, Chang JI, Choi JH, Park SY, and Oh CU (2005b) Fisheries study on mudskippers from the southern west mud flat of Korea. 2004 Report Natl Fish Res Dev Inst, pp 1-241.

Kim YJ and Kim JM (2001) Age and growth of three species of genus *Gymnogobius* from Korea. *Kor J Ichthy* 13: 237-247.

Koga H and Baba H (1991) Appearance and distribution of mudskipper's larvae and juvenile. *Bull Res Inst Shallow Sea Tideland* 5: 45-49.

Koga H, Noda S, Noguchi T, and Aoto I (1989a) Studies on artificial propagation of mud skipper *Boleophthalmus pectinirostris* (Linnaeus)-III. Hatching and larval rearing. *Bull Saga Prefect Ariake Fish Exp Stn* 11: 17-28.

Koga H, Noguchi T, and Kinoshita K (1989b) Studies on artifical propagation of mud skipper *Boleophthalmus pectinirostris* (Linnaeus)-II. Collecting eggs by artificial spawning nest and spawning condition. *Bull Saga Prefect Ariake Fish Exp Stn* 11: 9-16.

KORDI (1999) Study on efficient use and conservation of mud flats. 1999 Report in KORDI, pp 1-839.

Kovačić M (2006) Age structure, growth and mortality of the striped goby, *Gobius vittatus* (Gobiidae) in the northern Adriatic Sea. *Scientia-Marina* 70: 635-641.

Kuo SR and Shao KT (1999) Species composition of fish in the coastal zones of the Tsengwen Estuary, with descriptions of five new records from Taiwan. *Zool Stud* 38: 391-404.

Lee SW, Je JG, and Lee HS (2003) Tidal flat aspects of Yellow Sea area and conservation for migratory birds. *Kor J Eco* 17: 295-303.

MOMAF (1998) Mudflats of Korea, Seoul, pp 1-144.

Murdy EO (1989) A taxonomic revision and cladistic analysis of the Oxudercine gobies (Gobiidae: Oxudercinae). *Records of the Australian Museum Supplement* 11: 1-93.

Noda S and Koga H (1990) Studies on artificial propagation of mud skipper, *Boleophthalmus pectinirostris* (Linnaeus)-IV. Feed of young fishes. *Bull Saga Prefect Ariake Fish Exp Stn* 12: 1-6.

Park KD and Kang YJ (2007) Age and growth of black rockfish, *Sebastes schlegeli* in the Tongyeong marine ranching area in Korean waters. *Kor J Ichthyol* 19: 35-43.

Randall JE and Lim KKP (2000) A checklist of the fishes of the South China Sea. *Raffles Bull Zool Suppl* 8: 569-667.

Ryu BS (1991) Taxonomy and ecology of mudskipper, the subfamily gobionellinae (Pices, Gobiidae) from Korea. PhD thesis Chonbuk Natl Univ, pp 1-134.

Ryu BS, Kim IS, and Choi Y (1995) Ecology and life history of *Boleophthalmus pectinirostris* in Korea. *J Kor Fish Soc* 28: 316-324.

Silva MN and Gordo LS (1997) Age, growth and reproduction of the black goby, *Gobius niger*, from Obidos Lagoon, Portugal. *Cah Biol Mar* 38: 175-180.

Washio M, Tsutsui M, and Takita T (1991) Age and growth of the mudskipper *Boleophthalmus pectinirostris* distributed in the mud flat of the Midori River, Kumamoto. *Nippon Suisan Gakkaish* 57: 637-644.

Yuzuriha M and Koga H (1990) Ecological study of mud skipper *Boleophthalmus pectinirostris* (Linnaeus)-III. Apperence and disribution of larvae and juveniles. *Bull Saga Prefect Ariake Fish Exp Stn* 12: 15-20.

Yuzuriha M, Koga H, Yoshimoto M, and Baba H (1990) Ecological study of mud skipper *Boleophthalmus pectinirostris* (Linnaeus)-II. Ecology of young fish. *Bull Saga Prefect Ariake Fish Exp Stn* 12: 21-27.