J. Fish. Sci. Tech., 7(3), 136-140, 2004

JOURNAL OF
FISHERIES SCIENCE
AND TECHNOLOGY

Maturation and Spawning of Robust Tonguefish (*Cynoglossus robustus* (Soleidae; Teleostei)

Gun Wook Baeck[1] and Jae Won Kim[2]*

[1]*Department of Oceanography, Pukyong National University, Busan 608-737, Korea*
[2]*Department of Marine Biology, Pukyong National University, Busan 608-737, Korea*

We examined the ovaries of 312 robust tonguefish (*Cynoglossus robustus*) collected each month from January to December 2001, off the coast of Yeosu, Korea.The samples were used to investigate robust tonguefish reproductive activity. Monthly changes in the gonadosomatic indexindicated that spawning peaked between June and August. Fish size at first spawning was 15-19 cm total length (TL). Over 50% of female fish 25-29 cm TL were sexually mature, and this rose to 100% for female fish 35-39 cm TL. The tonguefish spawned four or more times during the spawning season. Most females commenced spawning in their second year. The relationship between total length (cm TL) and fecundity (F) was F=528646Ln(TL)-1E+06.

Key words: Maturation, Spawning, *Cynoglossus robustus*, Yeosu

Introduction

Robust tonguefish (*Cynoglossus robustus*) is found on sandy and/or muddy bottoms, at a depth of 20 to 85 m, from southern Japan to the South China Sea, and in the Yellow Sea (Menon, 1977; Masuda et al., 1984; Nakabo, 1993). They are distributed widely along the Pacific coasts of southern Japan and from the northern Yellow Sea to the southern East China Sea, spending winter months west and south of Cheju Island, Korea (Yamada et al., 1986). Robust tonguefish are especially predominant in the coastal waters of Yeosu area, and it has high commercial value as food.

Several species of tonguefish, including robust tonguefish (*C. robustus*), three-lined tonguefish (*C. abbreviatus*) and red tongue sole (*C. joyneri*), are targeted by commercial bottom trawlers in the region (Yamada et al., 1986; Inaba, 1988; Lee, 1989; Kim and Choi, 1994).

Despite its economic importance and relative abundance among the fishes of coastal western and southern Korea, there has been very little studies are on maturation and spawning of robust tonguefish. Choi et al. (1995) and Ochiai (1959) provided only limited data about maturation and spawning in this species. The present study addressed this need by investigating the gonadosomatic index (GSI) and spawning season, first maturation and sex ratios, distribution of egg diameter and ovarian developmental stage, fecundity of robust tonguefish off the coast of Yeosu, Korea.

*Corresponding author: kjw01@hanmail.net

Materials and Methods

Robust tonguefishspecimens were caught by commercial bottom trawlers off the coast of Yeosu, Korea. Monthly collections of scores of robust tonguefish between January and December 2001 provided a total of 312 specimens. They were fixed in 10% buffered formalin immediately after collection. For all specimens, the total length (TL, in cm to the nearest (mm) and body weight (BW), in g to the nearest (0.1 g) were recorded. The gonads were removed from the fish and fixed in 10% buffered formalin. The gonadosomatic index (GSI) was calculated using the following equation:

$$GSI\ (\%)=(GW/BW)\times 10^2$$

GW: gonad weight (g)
BW: body weight (g)

After rapid washing in water, ovaries were fixed in Bouin's solution. Following dehydration through graded concentrations of ethanol, ovaries were embedded in paraffin blocks. Sections 4-5 μm in thic-

kness were stained with Mayer's hematoxylin and 0.5% eosin. Oocyte diameters were examined using an Olympus Video Micrometer (VM-10). Fecundity was estimated gravimetrically, by weighing a piece of the central portion of an ovary.

Results and Discussion

Gonadosomatic index (GSI) and spawning season

Monthly changes in female robust tonguefish GSI are presented in Fig. 1. The GSI peak occurred in July, and the lowest value was observed in December. Previous investigations of the GSI of robust tonguefish, three-lined tonguefish, and red tongue sole have placed their spawning seasonsfrom June to August, from March to May, and from June to August, respectively (Ochiai, 1959; Choi et al., 1995). In terms of spawning season, there is no difference between robust tonguefish from the southern Pacific coasts of Japan (Ochiai, 1959) and the Korean populations. Interestingly, although the spawning seasons of two *Cynoglossus* species appear to occur simultaneously (robust tonguefish and red tongue sole), spawning in the co-occurring, congeneric three-lined tonguefish happens earlier in the year. This temporal diversification in spawning season may enable early life stages of the three-lined tonguefish to avoid competition with congeneric larvae and juveniles.

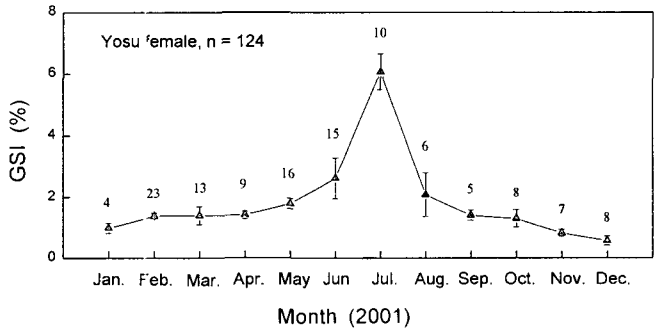

Fig. 1. Monthly change in the gonadosomatic index of robust tonguefish.

First maturation and sex ratios

First spawning occurred at 15-19 cm TL. Over 50% of female fish 25-29 cm TL were sexually mature, and this rose to 100% for female fish 35-39 cm TL (Table 1). Female robust tonguefish can spawn in their first year, but most spawn for the first time in their second year (Table 1; Baeck 2003). By comparison, Ochiai (1959 and 1966) reported that both robust tonguefish and three-lined tonguefish attained first sexual maturity in their third year in the Pacific Ocean, off southern Japan. In this region fast-developing robust tonguefish may achieve sexual maturity from the second year after birth (Ochiai, 1959 and 1966).

Table 1. Percentage of immature and mature females of robust tonguefish within size classes for spawning season

Total length (cm)	Females		
	n	Immature %	Mature %
10-14	6	100	-
15-19	14	92.86	7.14
20-24	18	72.22	27.78
25-29	11	45.45	54.55
30-34	7	14.29	85.71
35-39	5	-	100
Total	61		

Table 2 shows the monthly variation in sex ratios of adult robust tonguefish. The sex ratio does not differ significantly from 1:1.17 throughout the year ($p>0.01$).

Table 2. Monthly variations in sex ratios of robust tonguefish

Month (2001)	Female (ind.)	Male (ind.)	Total (ind.)	Sex ratio (F/(F+M))
Jan.	4	3	7	0.57
Feb.	23	21	44	0.52
Mar.	14	17	31	0.45
Apr.	9	11	20	0.45
May	16	14	30	0.53
Jun.	18	22	40	0.45
Jul.	24	28	52	0.46
Aug.	13	16	29	0.45
Sep.	10	14	24	0.42
Oct.	9	11	20	0.45
Nov.	8	9	17	0.47
Dec.	8	10	18	0.44
Total	124	144	312	0.46

Ovarian developmental stage

There arefive stages in oogenesis in the robust tonguefish: early growth, late growth, mature, ripe, and resting/degeneration.

Early growth

The early ovariesare small with thin ovarian walls. The small cells stain strongly with haematoxylin, and have a very dense and compact consistency. One

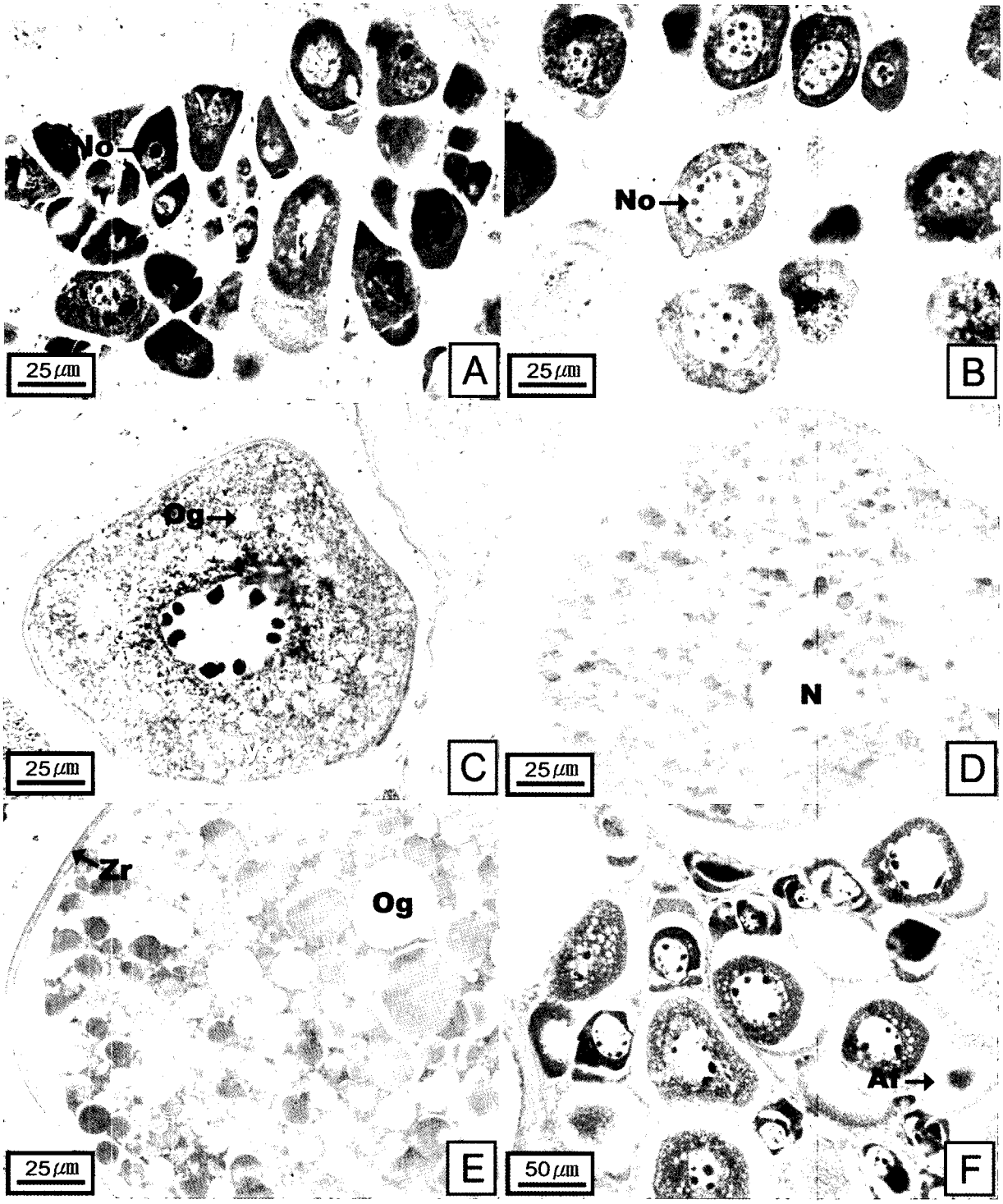

Fig. 2. Photomicrographs of developmental stage of ovary in the robust tonguefish (*Cynoglossus robustus*). A, Early growing stage. Note the oogonia and oocytes with chromatin nucleolus; B and C, Late growing stage. Showing many nucleoli distributed along the periphery of the nuclear membrane and some of oil globules in the cytoplasm; D, Maturing stage. Note the breakdown of germinal vesicle; E, Ripe stage. Showing the oil globules and zona radiata of ripe oocytes; F, Resting and degenerating stage. Note atretic follicle after spawning and degnerating oocytes. Abbreviations: Af, atretic follicle; Eyg, Eosinophilic yolk granules; N, nucleus; No, nucleolus; Og, oil globule; Zr, Zona radiata.

or two nucleoli are clearly visible in the nucleus (Fig. 2A). Oocyte diameters range from 10-15 μm. Ovaries at this early growth stage were most frequently observed from January to February.

Late growth

There are many nucleoli distributed along the periphery of the nuclear membrane and some oil globules and eosinophilic yolk granules in the cytoplasm (Fig. 2B, C). Oocyte diameters range from 50-150 μm. Ovariesat this late growth stage were most frequently observed from March to April.

Mature

The ovarian wall is considerably thickened in vascular areas. Some basophilic stain is apparent in oocyte cortical cytoplasm (Fig. 2D). Oocyte diameters range from 250-350 μm. Ovaries at this mature stage were most frequently observed from April to May.

Ripe

Ovarian wall thickness is regular. Zona radiata and a layer of follicle cells are visible within each oocyte. And the entire cytoplasm was filled with many yolk globules and oil globules which scattered in cytoplasm (Fig. 2E). Oocyte diameters range from 400-500 μm. Well-developed and ripe ovaries were most frequently observed from June to August.

Resting/degeneration

The ovarian wall is quite thick. Atretic structures are present, indicating that the gonad is in a phase of resorption (Fig. 2F). Degenerating oocytes are present (Fig. 2F). These ovaries, considered recently spawned, were most frequently observed from September to December.

Cynoglossus arel and *C. lida* from Indian waters spawn only once a year (Rajaguru, 1992). However, robust tonguefish from Korean waters may spawn four or more times during each season. Robust tonguefish have bigger oocytes than those of other tonguefish of the Pacific coasts of southern Japan (Ochiai, 1959).

Fecundity

The relationship between TL and fecundity of robust tonguefish was examined using specimens collected during the spawning season (Fig. 3). The equation F=528646Ln(TL)-1E+06 describes the regression line calculated for the relationship between TL and fecundity. Tonguefish spawning appears to take place mainly in deep waters (Seshappa and Bhimachar, 1955), and batch fecundity spawning times and spawning behavior have not yet been confirmed. According to this study, the fecundity of individual robust tonguefish females varied between 133,119 and 449,534 eggs.

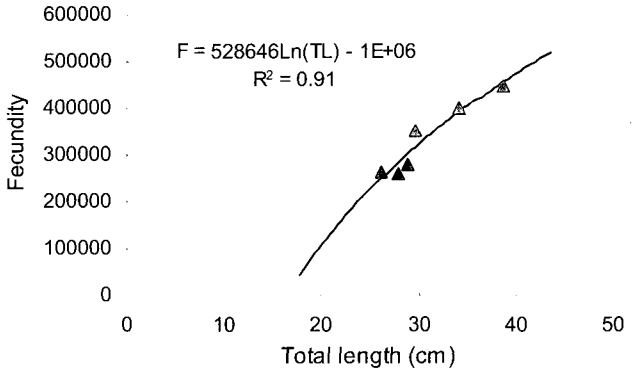

Fig. 3. Relationship between fecundity and total length (cm) for robust tonguefish.

References

Baeck, G.W. 2003. Comparative fisheries ecology on three tonguefish species, genus *Cynoglossus*, from the Yosu coast, Korea and the Seto Inland Sea, Japan. Ph.D. Thesis, Hiroshima Univ., pp. 129.

Choi, Y, I.S. Kim, B.S. Yu, U.Y. Jong and J.Y. Park. 1995. Biology of *Cynoglossus joyneri* Gunther in the West coastal water, Korea. Kor. J. Ichthyol., 7(1), 56-63.

Inaba, A. 1988. Fauna and Flora of the Seto Inland sea, Second Edition II. Mukaishima Marine Biological Station, Hiroshima Univ. Press, Hiroshima, pp. 475.

Kim, I.S. and Y.A. Choi. 1994. Taxonomic Revision of the Family Cynoglossidae (Pisces, Pleuronectiformes) from Korea. Bull. Kor. Fish. Soc., 27, 803-812.

Lee, T.W. 1989. Seasonal change of benthos fish from Chun Su-Bay. Bull. Kor. Fish. Soc., 22, 1-8.

Masuda, H., K. Amaoka, C. Araga, T. Uyeno and T. Yoshino. 1984. The Fishes of the Japanese Archipelago, Tokai University Press, Tokyo, pp. 437.

Menon, A.G.K. 1977. A systematic monograph of the tongue soles of the genus *Cynoglossus Hamilton Buchanan* (Pisces; Cynoglossidae). Smithson. Contr. Zool., 238, 1-108.

Nakabo, T. 1993. Fishes of Japan with Pictorial Keys to the Species, Tokai University Press, Tokyo, pp. 1474.

Ochiai, A. 1959. Morphology, Taxomomy and Ecology of the Soles of Japan, Tokyo University Press, Tokyo, pp. 236.

Ochiai, A. 1966. Study about Biology and Morphology of Cynoglossidae in Japan. Misaki Marine Biological Station, Tokyo Univ. Press, Tokyo, pp. 97.

Rajaguru, A. 1992. Biology of two co-occurring tonguefishes, *Cynoglossus arel* and *C. lida* (Pleuronectiformes: Cynoglossidae), from Indian waters. Fish.

Bull., 90, 328-367.
Seshappa, G. and B.S. Bhimachar. 1955. Studies on the fishery and biology of the Malabar sole, *Cynoglossus semifasciatus* Day. Indian J. Fish., 2(1), 180-230.
Yamada, U., M. Tagawa, S. Kishida and K. Honjo. 1986. Fishes of the East China Sea and the Yellow Sea. Seikai Regional Fisheries Research Laboratory, Kochi, pp. 501.

(Received April 2004, Accepted September 2004)