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Intertidal Fishes from the Shandong Peninsula, China

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ABSTRACT This study was conducted to investigate the species composition and distribution patterns of intertidal fishes from the Shandong Peninsula, China from August 2006 to September 2007. The collected fishes were composed of 28 species, belonging to 21 genera, 14 families and 6 orders. Among them, the family Gobiidae was most abundant in both the number of species and individuals, while two species including *Hexagrammos agrammus* and *Sebastes schlegelii* were caught in large quantities of young fishes. In this study, *Sebastes koreanus* and *Porocottus leptosomus* known as Korean endemic species so far were collected in the Shandong Peninsula, therefore it should be revised that these two species were distributed on the North Yellow Sea and owned by both China and Korea.

Key words : Intertidal fishes, distribution, Shandong Peninsula

INTRODUCTION

Recently, the coastal water pollution in the North Yellow Sea has threatened the survival of many marine organisms, especially has more damage to the intertidal fishes. Although intertidal fishes play important roles in the food-chain of the coastal ecosystem, the studies about them have often been overlooked because of their small size, secretive nature and little commercial or edible value. For the fishes in the East China and Yellow Sea, Yamada *et al*. (2007) reviewed 480 species, Lee (1994) confirmed 389 species based on the published materials from Korea and China, nevertheless there have been still no studies on intertidal fishes in China, it is urgent to fill up the blank of studies on this field.

Geographically, the Shandong Peninsula is situated in the same latitude as the middle Korean Peninsula. Due to the common influences from the Yellow Sea, the coast of the Shandong Peninsula and west coast of Korea show the similar environmental conditions which are essential factors to form the resemblant ichthyofauna (Tian *et al*., 1993). In Korea, several new species of intertidal fishes have been recorded for the past few years, but it still lacked enough evidences from the opposite side of the Yellow Sea to support their results. This study may provide the proper evidences to them and verify whether that could be convinced or not.

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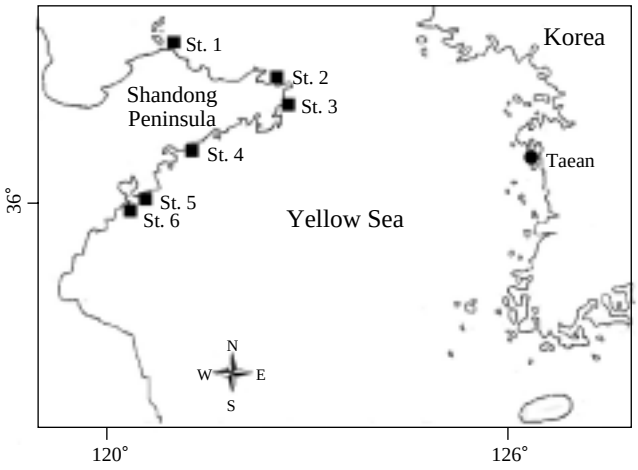

Fig. 1. Map showing the sampling sites in the Shandong Peninsula. St. 1: Penglai, St. 2: Weihai, St. 3: Rongcheng, St. 4: Haiyang, St. 5: Qingdao, St. 6: Huangdao.

MATERIALS AND METHODS

Six sites of the intertidal areas in the Shandong Peninsula were chosen for sampling, including Penglai, Weihai, Rongcheng, Haiyang, Qingdao and Huangdao (Fig. 1). Samplings were carried out by four times separately in August 2006, February, April and September 2007. The collecting tools included a stake net (5×5 mm) and scoop net (1×1 mm). Collected fishes were put into 1

liter bottles, fixed with 10% formalin, and taken back to the laboratory of Faculty of Marine Life Science in Kunsan National University (KNUM) for identification. The identifications of samples followed Nakabo (2002) and Kim *et al*. (2005).

Table 1. Number of intertidal fishes collected from the Shandong Peninsula, China

Orders	Families	Genera	Species
Mugiliformes	1	2	2
Atheriniformes	1	1	1
Beloniformes	1	1	1
Scorpaeniformes	3	3	6
Perciformes	6	12	16
Pleuronectiformes	2	2	2
6	14	21	28

RESULTS

1. Species composition of intertidal fishes from the Shandong Peninsula

The fishes collected from the Shandong Peninsula were identified into 28 species, 21 genera, 14 families and 6 orders (Table 1). Among them, the order Perciformes had the largest amount of 16 species, 12 genera and 6 families, the family Gobiidae was most abundant

Table 2. Species composition based on seasons from the Shandong Peninsula, China

Classification	Number of individuals				Sampling sites	Total length (mm)
	2006. 08	2007. 02	2007. 04	2007. 09		
Mugilidae						
Chelon haematocheilus				5	St. 2.5	56～68
Mugil cephalus	29				St. 1.2.6	41～63
Atherinidae						
Hypoatherina bleekeri	8				St. 1	23～41
Hemiramphidae						
Hyporhamphus sajori	1				St. 2	122
Scorpaenidae						
Sebastes koreanus	3		1	8	St. 2.5	32～88
Sebastes longispinis			1		St. 5	58
Sebastes schlegelii	19			10	St. 1.2.5.6	44～84
Hexagrammidae						
Hexagrammos agrammus		3	27		St. 2.5.6	42～137
Hexagrammos otakii	1		3		St. 2.5.6	56～139
Cottidae						
Porocottus leptosomus		1	2		St. 2	50～54
Sparidae						
Pagrus major	5				St. 1.2	45～71
Stichaeidae						
Ernogrammus hexagrammus	1				St. 2	42
Pholididae						
Pholis crassispina	3		2	7	St. 1.2	57～133
Pholis nebulosa	6		3		St. 2.3.5.6	36～203
Ammodytidae						
Ammodytes personatus		1			St. 2	33～70
Blenniidae						
Omobranchus elegans	3			4	St. 2.5.6	110
Gobiidae						
Acanthogobius flavimanus	24			1	St. 1.2.5.6	28～138
Chaenogobius annularis	37			1	St. 5.6	29～54
Chaenogobius gulosus			27	1	St. 5.6	53～118
Favonigobius gymnauchen	1				St. 6	54
Gymnogobius urotaenia			1		St. 3	110
Luciogobius guttatus	1		2	2	St. 2.3.5	23～59
Synechogobius hasta	1				St. 2	134
Tridentiger barbatus	1				St. 6	95
Tridentiger bifasciatus	10				St. 1.2	12～36
Tridentiger trigonocephalus	20	6	11	28	St. 1.2.3.5.6	19～90
Paralichthyidae						
Paralichthys olivaceus	1				St. 2	116
Pleuronectidae						
Pleuronichthys cornutus				1	St. 2	95

in both species and individuals. Most specimens were young fishes, the sizes were ranging from 5 cm to 10 cm in total length, some specimens of *Hexagrammos agrammus, H. otakii, Hyporhamphus sajori* and *Ammodytes personatus* were more than 10 cm, whereas the gobiid fishes were mostly less than 4 cm.

2. Distribution patterns of intertidal fishes in Shandong Peninsula

Species composition on different seasons indicated that 11 species were collected in April, 20 species in August, 11 species in September and 4 species in February (Table 2). The specimens collected in spring presented the similar diversity with the ones in early autumn, although the abundance of them were both lower than those collected in summer. For some visitors that spent part time of their lives in the intertidal in spring and summer, intertidal zone seemed to be a nursery ground, such as *Mugil cephalus, Pagrus major, Hexagrammos agrammus* and *Pleuronichthys cornutus* which usually disappeared in winter. Only few resident species could be observed through the entire year, including *Tridentiger trigonocephalus, Luciogobius guttatus, Sebastes koreanus* and *Pholis crassispina*.

21 species were totally collected at Weihai, more than 16 species at Qingdao, far more than that at other sites. Some cold-temperature species occurred at Weihai while more gobiid fishes were caught at Qingdao, because of influence from the coast current of north Yellow Sea, which caused the surface water temperature at Weihai is averagely 4˚C lower than that at Qingdao. The types of intertidal zones at Weihai are the combinations of sandy beaches, gravel and rocky shores, so habitat partitioning could form high diversity and abundance of intertidal fishes here. In contrast, Qingdao is mainly characterized by tidal pools with sea grass mass, *Sebastes koreanus, S. schlegelii, S. longispinis, Pholis crassispina, P. nebulosa* and gobiid fishes were respectively abundant in these areas.

The dominant species collected from the Shandong Peninsula included *Mugil cephalus, Sebastes schlegelii, Hexagrammos agrammus, Pholis crassispina, P. nebulosa, Ammodytes personatus, Acanthogobius flavimanus, Chaenogobius annularis, C. gulosus* and *Tridentiger trigonocephalus*. The dominant family is Gobiidae with *A. flavimanus* and *T. trigonocephalus* abundant in the sandy areas, Luciogobius guttatus in the gravels, *C. gulosus* in the rocky shores. Although the sculpins were generally known as a representative species in the intertidal zones, only one species *Porocottus leptosomus* was collected in the studying areas.

3. Redescriptions of unrecorded species in China

Three species of family Scorpaenidae including *Sebastes koreanus, S. longispinis*, and *S. schlegelii* were collected in this study. The genus *Sebastes* was considered to be distributed in the northwestern Pacific and contain 10 species in China (Yamada *et al*., 1995; Jin, 2006), thus the present study will add two species of *S. koreanus* and *S. longispinis* to this genus as first records in China. *S. longispinis* is obviously different from other rock fishes by owning broad white vertical band on caudal fin base, the Chinese name is proposed here as baibanweipingyou (白斑尾平鮋) accordingly. Redescriptions of *Sebastes koreanus* and the other Korean endemic species *Porocottus leptosomus* are shown as below.

Sebastes koreanus Kim and Lee, 1994

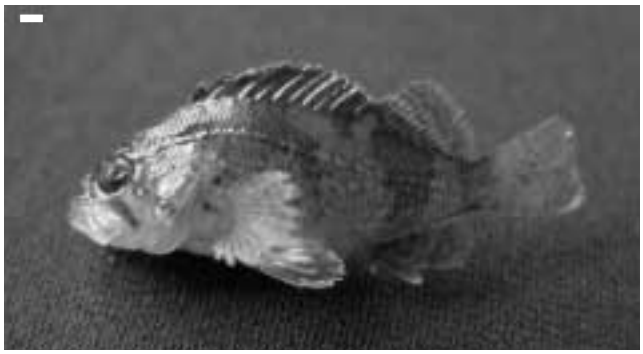

Fig. 2. *Sebastes koreanus* from Weihai, Shandong Peninsula, China, 29.1 mm SL, KNUM 1781.

Material examined. KNUM 1781～1783, 27.0～29.1 mm SL, Yuanyaozui, Weihai, 10th Aug. 2006; KNUM 1784, 57.5 mm, Badaguan, Qingdao, 16th Apr. 2007; KNUM 1785～1788, 36.7～49.8 mm, Jinhaiwan, Weihai, 16th Sept. 2007; KNUM 1789～1792, 31.4～71.8 mm, Badaguan, Qingdao, 15th Sept. 2007.

Description. Dorsal fin XIV, 12～13; anal fin III, 6; pectoral fin 16; caudal fin rays I, 12, I. All soft rays branched. Lateral line pores 30～31. Body depth more than 35% of its length. Head length 41% in standard length, 1.1 in predorsal length. Mouth terminal, jaw equal, eye large, orbit diameter same as snout length, and 1.6 in interorbital width. Caudal peduncle very short, its length 1.3 in depth. First and second dorsal fins jointed, last spine longer than the one in front of it, length of the third spine of anal fin 92% in the second one (Table 3). Pelvic fin originating posterior to anterior base of first dorsal fin.

Remarks. Kim and Lee (1994) compared 10 specimens of *Sebastes koreanus* with *S. hubbsi* and *S. longispinis*, and described that it was an endemic species of genus *Sebastes* in Korea. Some results on proportional measurement in this study differs from the original des-

Table 3. Proportional measurements of *Sebastes koreanus*

	Holotype	Paratypes	Present study	
		Munyae	Range	Mean
Standard length (mm)	130.4	118.2 ~ 139.5	27.0 ~ 71.8	–
No. of specimens	1	4	12	–
Proportional measurements (% SL)				
Head length	42.4	39.6 ~ 40.7	39.3 ~ 43.0	40.9
Snout length	11.9	9.7 ~ 11.7	10.0 ~ 13.4	11.2
Orbital diameter	11.7	10.5 ~ 10.8	10.7 ~ 12.5	11.4
Interorbital width	6.2	4.2 ~ 5.2	7.4 ~ 8.0	7.4
Length of upper jaw	18.8	16.8 ~ 18.9	16.2 ~ 19.4	17.8
Predorsal length	36.2	33.9 ~ 35.1	31.7 ~ 40.0	36.6
Body depth	41.2	38.4 ~ 40.9	33.6 ~ 37.3	35.5
Pectoral fin length	26.1	28.0 ~ 31.7	27.0 ~ 33.3	30.3
Pelvic fin length	24.2	21.6 ~ 24.0	22.0 ~ 24.8	23.2
1st dorsal spine	7.0	5.9 ~ 7.3	5.2 ~ 6.7	6.0
3rd dorsal spine	13.1	9.6 ~ 12.4	12.9 ~ 14.1	13.3
2nd dorsal soft-ray	14.9	15.8 ~ 16.3	16.3 ~ 17.5	16.7
1st anal spine	9.6	7.9 ~ 8.5	6.3 ~ 9.1	7.5
2nd anal spine	18.3	14.5 ~ 17.5	14.7 ~ 19.8	16.0
3rd anal spine	15.3	12.5 ~ 15.0	13.5 ~ 16.0	14.7
Length of caudal peduncle	16.2	16.8 ~ 18.2	11.6 ~ 15.1	13.8
Depth of caudal peduncle	10.7	9.9 ~ 11.1	9.1 ~ 12.0	10.7

criptions, mostly due to a wide range of body sizes: the specimens in this study were all young fishes, standard length was much shorter than the specimens from the previous description, in addition *S. koreanus* is deep-bodied fish, so that the ratio of body depth in standard length of young fishes was smaller than that of adults.

Porocottus leptosomus Muto, Choi and Yabe, 2002

Fig. 3. *Porocottus leptosomus* from Weihai, Shandong Peninsula, China, 39.4 mm SL, KNUM 1778.

Material examined. KNUM 1779, 39.8 mm SL, Xiaoshidao, Weihai, 1st Feb. 2007; KNUM 1777 ~ 1778, 39.7 ~ 41.7 mm, Yuanyaozui, Weihai, 17th Apr. 2007.

Description. Dorsal fin VI-18 ~ 19; Anal fin 13; Pectoral fin 15; Pelvic fin I, 3. Soft rays of all fins except for middle rays of caudal fin unbranched. Body compressed, body width 76% in body depth. Caudal peduncle short, compressed, its length 2 in depth. Head small, head length 35.5% in standard length. Snout short, bluntly pointed, its length 93% in orbital diameter. Interorbital space narrow, concave, its width 53% in orbital diameter (Table 4).

Two pairs of cirri on dorsal surface of head. A single filamentous cirrus on distal tip of each dorsal fin spine. First dorsal fin originating slightly anterior to anterior tip of opercular flap. First and second dorsal fins jointed by a low membrane. Last ray of second dorsal fin broadly connected with caudal peduncle by a terminal membrane. Pelvic fin originating slightly anterior to anterior base of first dorsal fin. Proximal part of terminal ray of anal fin connected with caudal peduncle by a narrow membrane. Body brightly green, because of adaptation to habitat background of eelgrass. Body with five dark bands: one below first dorsal fin, three below second dorsal fin, and one on caudal peduncle.

Remark. According to Muto *et al.* (2002), *Porocottus leptosomus* is distinguished from all other species of genus *Porocottus* except *P. minutus* in having a single filamentous cirrus on the distal tip of each dorsal fin spine. Most of results in this study agreed well with previous descriptions of *P. leptosomus*, except for preanal length and anal fin base length in standard length. But the sum of them in this study is 87.2, similar to that of 86.8, probably because the anterior origin of anal fin chosen in this study is lightly different from the original description. Additionally, Length of second dorsal fin base is obviously shorter than that from the previous description, 88% in the latter, the likely explanation is that there are only 16 dorsal fin rays for the specimens in this study, whereas there were 18 ~ 19 rays in the specimens of holotype and paratypes.

DISCUSSION

The sampling areas in the Shandong Peninsula comprise different intertidal types, including rocky shores, sandy beaches, gravel shores and mud flats. Rocky shores sustain more residents like the pricklebacks and gunnels, with the rock fishes occasionally abundant. Sheltered sandy beaches mainly distributing at Weihai and Haiyang are relatively homogeneous in terms of substratum, and fish species such as *Mugil cephalus* that swims fast and *Paralichthys olivaceus* which has flattened bodies are active in these zones. The gobies *Luciogobius guttatus*, *Chaenogobius gulosus* and *Tridentiger trigonocephalus* live in some gravel shores with sandy-mud substrate, while some mud hoppers could be observed at a mud flat which is located at Qingdao. Among six sampling sites, Weihai has the largest num-

Table 4. Proportional measurements of *Porocottus leptosomus*

	Holotype HUMZ	Paratypes (specimens)		Present study	
	172394	Range	Mean	Range	Mean
Standard length (mm)	43.4	30.7～45.6	–	39.1～41.8	–
Proportional measurements (% SL)					
Body depth	27.4	24.6～28.7	27.3	26.1～29.4	28.2
Body width	20.3	18.2～23.4	20.4	18.2～24.3	21.4
Head length	37.0	34.7～37.8	36.2	35.0～35.9	35.5
Snout length	9.4	9.2～10.8	9.7	9.5～10.3	9.8
Orbital diameter	11.6	10.4～12.0	11.0	10.3～10.7	10.5
Interorbital width	5.4	4.1～6.4	5.3	5.0～6.0	5.6
Length of upper jaw	15.3	14.1～15.9	15.0	14.2～15.7	14.9
Predorsal length	34.7	31.3～34.9	32.9	31.5～34.0	33.2
Prepelvic length	31.8	30.0～34.9	32.4	32.0～33.3	32.5
Preanal length	54.5	52.8～58.7	56.2	58.9～59.1	59.0
Length of caudal peduncle	14.4	14.9～17.4	15.8	14.6～15.3	15.0
Depth of caudal peduncle	7.1	6.4～7.9	6.9	7.0～7.9	7.4
Length of 1st dorsal fin base	19.6	16.7～22.2	19.3	17.9～22.1	19.7
Length of 2nd dorsal fin base	45.0	38.9～49.5	42.5	36.5～39.0	37.6
Length of anal fin base	31.4	27.5～34.5	30.6	27.4～31.3	28.7
Length of pectoral fin base	14.9	14.7～16.7	15.5	14.6～16.1	15.3
Pectoral fin length	34.1	30.5～34.3	32.8	31.0～34.7	32.4
Pelvic fin length	24.5	21.1～26.1	23.1	20.1～25.8	22.5
Caudal fin length	27.4	25.6～31.3	28.1	27.4～28.6	28.1

ber of fish species, most probably due to its various habitat partitioning.

Total number of species collected in this study is close to that at Taean, west coast of Korea (Lim and Choi, 2000), which contained 27 species, 25 genera, 15 families and 6 orders. Comparing with species composition of tidepool fishes at Kunsan, west coast of Korea (Ryu and Choi, 1993; Choi *et al*., 2005), *Mugil cephalus, Tridentiger trigonocephalus, Synechogobius hasta, Favonigobius gymnauchen* and *Gymnogobius urotaenia* occurred in common. On the other hand, some species that had not been reported in China were collected in this study, especially for the genus *Sebastes* (Scorpaenidae), it was considered that there was a total of 10 species distributing in China (Zhu and Jin, 1965; Jin, 2006), less than 19 species of genus *Sebastes* from Korea (Kim *et al*., 2005).

The species of family Gobiidae were most abundant in this study, but still less than that of 19 species in the Bohai Bay (Liu *et al*., 1997), 15 species at Taean of Korea (Lim and Choi, 2000). *Luciogobius guttatus, Synechogobius hasta, Tridentiger barbatus* and *T. trigonocephalus* were commonly collected in the intertidal zones of three regions. Although the fishes in the Bohai Bay are usually considered as an extended part of ichthyofauna in the Yellow Sea (Tian *et al*., 1993), the assemblage of gobiid fishes between the Shandong Peninsula and Taean are much higher, the common species being 39.8% than that of 20.8% between the Shandong Peninsula and Bohai Bay. Especially, the dominant species in both the Shandong Peninsula and Taean, such as *Favonigobius gymnauchen, Chaenogobius annularis* and *C. gulosus* were not found in the Bohai Bay, showing the closer geological relationships between the former two.

Typically true resident intertidal fishes, such as the species of family Gobiidae, Pholidae and Blenniidae, are active emergers in a restrict area of intertidal zones permanently. Some deep-bodied fishes in families of Scorpaenidae, Hexagrammidae and Mugilidae usually occur in the intertidal as young fishes and migrate to the coast when growing up (Horn *et al*., 1999; Suda *et al*., 2002), thus they distribute more extensively in the Shandong Peninsula. The sculpin is also typical of intertidal fishes like *Hexagrammos agrammus, H. otakii* and *Pholis nebulosa* in which its color patterns match the background, for example, *Porocottus leptosomus* collected on green eelgrass at Weihai were in brightly green color, whereas those collected at Taean were maroon (Lim and Choi, 2000).

Additionally, *Sebastes koreanus* and *Porocottus leptosomus* should be revised as endemic species of the Yellow Sea but not of Korea, distributing on the intertidal zones in the Shandong Peninsula and west coast of Korea. The Chinese names, Huanghaipingyou (黃海平鮋) is proposed here for *S. koreanus* according to its Korean name Hwanghaebolnak, while zhaitijidufuyu (窄体棘杜父鱼) is for *P. leptosomus* with Jidufuyushu (棘杜父鱼属) for the genus *Porocottus* according to its feature of multifid cirrus on tip of each dorsal spine.

The limitation of this study lies in using the present sampling methods, for the fishes were collected in a relatively small number of both species and individuals,

at the same time, some problems like whether species abundance in the intertidal is higher at low tide or high tide (Suda *et al*., 2002) were not well studied by this study.

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중국 산둥반도의 조수웅덩이 어류상

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요 약 : 2006년 8월부터 2007년 9월까지 4회에 걸쳐 중국 산둥반도의 조수웅덩이로부터 어류를 채집하여 서식어종과 분포유형을 조사하였다. 조사기간 동안 채집된 어류는 모두 6목 14과 21속 28종이었고, 이 가운데 망둑어과 어류가 종수와 개체수에서 우점하였다. 모래지역에서 숭어와 가숭어, 문치가자미의 유어들이 주로 채집되었고, 자갈과 바위지역에서는 조피볼낙과 노래미의 유어 그리고 점베도라치가 우점하였다. 한편 지금까지 한국 고유종으로 알려진 고려실횟대와 황해볼낙이 본 조사 해역에서 채집되었다. 따라서 이 2종의 어류는 한국 서해안의 태안뿐만 아니라, 중국의 산둥반도에 서식하는 것이 확인됨으로써 황해 고유종으로 수정됨이 타당하다.

찾아보기 낱말 : 산둥반도, 조수웅덩이, 어류상