

Zoogeography and Systematics of Shallow Water Marine East Asian Fishes

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1. INTRODUCTION

Examples of marine fishes from East Asia were first studied by colleagues of Carl von Linnaeus in the 18th Century. Carl P. Thunberg, one of the best-known students of Linnaeus, visited Japan to collect plant and animal specimens whilst a naturalist employed by Vereenighde Oost Indische Compagnie. Through the agency of the latter, Martin Houttun received and later described (Houttun, 1782) 42 fish species from Japan. In the middle of the 19th Century, many other Japanese fishes were described by Temminck and Schlegel (1843~1850) and Richardson (1846). However, the culmination of these early studies were the comprehensive works of Jordan, Tanaka and Snyder (1913) and Jordan and Metz (1913), whereby almost all of the fishes of Japan and Korea became known to the western world.

The marine fish fauna in the shallow waters of East Asia is basically comprised of warm and cold water fishes. This was initially recognized by Tanaka (1931), who demonstrated biogeographical boundaries between northern and southern fishes along the Sea of Japan and Pacific coasts. Later, Nakabo (2002) divided the marine fish fauna of East Asian waters into 17 areas, according to habitat characteristics and water temperatures. In this paper, relationships between the zoogeographic areas and systematics of shallow water fishes are discussed.

2. SHALLOW WATER REEFS

Area 2.1-Subarctic-rocky-reef fishes

This area includes the Pacific coast from Tohoku District northward to the Kurile Islands, Sea of Japan coast northward from Tsugaru Strait, Okhotsk Sea coast of Hokkaido, and the coast of Primorsky Krai northward from Chongin. Resident fishes include *Sebastes*, *Hexagrammos*, Cyclopteridae, *Liparis*, *Chirolophis*, *Stichaeus*,

Anarhichas orientalis and Pholidae, which are distributed in the Okhotsk and Bering Seas across to the northern Pacific coast of North America.

Area 2.2-Pohai and Yellow Seas-rocky-reef fishes

These include *Hemilepidotus villosus*, *Sebastes schlegelii* and *Sebastes koreanus*, the last-mentioned being endemic (Kim and Lee, 1994). All species have cold-water origins, the population of *Hemilepidotus villosus* being well separated from that of northern Japan.

Area 2.3-Temperate area-rocky-reef fishes

This area extends from southern Hokkaido southward to northern and western Kyushu along the Sea of Japan coast, and southward to eastern Kii Peninsula along the Pacific coast, the Seto Inland Sea, Tsushima Islands, Cheju Island and the southern coast of the Korean Peninsula. Resident fishes include *Sebastes*, *Hexagrammos otakii*, *H. agrammus*, *Dictyosoma burgeri*, *D. rubrimaculatum*, *Pholis nebulosa*, *P. crassispina*, *Pseudoblennius*, Embiotocidae (*Ditrema* and *Neoditrema*) and *Pterogobius*, all being endemic.

Most of the fishes listed here have North Pacific cold water origins. For example, shallow water *Sebastes* have their origins in the North Pacific, having subsequently speciated in East Asian waters separately from those off the Pacific coast of North America (Kai *et al.*, 2003). Among the former, the *Sebastes inermis* complex have been recently recognized as comprising *S. inermis*, *S. ventricosus* and *S. cheni*, endemic temperate-water rocky-reef fishes (Kai and Nakabo, 2002, 2008; Kai *et al.*, 2002).

Some of the temperate-water fishes have related species or genera distributed along the Pacific coast of North America, viz. Embiotocidae and *Hexagrammos*, as pointed out by Ekman (1953). Embiotocidae has warm-water origins and is believed to be related to Chichlidae and Pomacanthidae (Mabuchi *et al.*, 2007). In addition, *Ditrema temminckii* has recently been recognized as comprising three distinct taxa, *D. temminckii temminckii*, *D.*

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temminckii pacificum, and *D. jordani* by Katafuchi and Nakabo (2007). *Pterogobius* (Gobiidae) clearly has Indo-West Pacific origins.

Furthermore, Pacific Ocean and Sea of Japan populations have been found for *D. temminckii*, *Pterogobius zonoleucus* and *P. elapoides*, corresponding to coasts adjacent to the Kuroshio and Tsushima Currents (Katafuchi and Nakabo, 2007; Akihito *et al.*, 2008).

Area 2.4-Temperate area - rocky-reef fishes with warm water origins

This area includes the Sea of Japan coast of Niigata Prefecture southward to northern and western Kyushu, the Pacific coast of Sendai Bay southward to southern Kyushu, the Seto Inland Sea, Tsushima Islands, Cheju Island, southern coast of the Korean Peninsula, and the coast of southern China from Taiwan-Fujian southward to Tonking Bay, the overall area closely approximating to the "Japan Region" of Briggs (1974). Fishes of the region, with warm-water Indo-Pacific origins, include *Myliobatis tobijei*, *Conger japonicus*, *Syngnathus schlegeli*, *Hippocampus coronatus*, *Pterois lunulata*, *Sebastes*, *Lateolabrax*, *Epinephelus septemfasciatus*, *E. akaara*, *Apogon kinesis*, *A. semilineatus*, *Parapristipoma trilineatum*, *Hapalogenys*, *Sparus sarba*, *Acanthopagrus schlegelii*, *Chaetodon modestus*, *Goniistius*, *Chromis notata*, *Rhyncopelatus oxyrhynchus*, *Girella punctata*, *Oplegnathus fasciatus*, *Pseudolabrus sieboldi*, *Semicossyphus reticulatus*, *Choerodon azurio*, *Sphyaena pinguis*, *Sphyaena japonica*, *Petroscirtes breviceps*, *Siganus fuscescens* and *Rudarius ercodes*. Among them, *Conger japonicus*, *Hippocampus coronatus*, *Acanthopagrus schlegelii*, *Goniistius*, *Chromis notata*, *Oplegnathus fasciatus*, *Rudarius ercodes* and *Stephanolepis cirrhifer* are not distributed off the South China Sea Chinese coast, whereas *Nemipterus virgatus*, *Chaetodon modestus*, *Siganus fuscescens*, *Pterois lunulata*, *Epinephelus septemfasciatus*, *Sparus sarba*, *Sphyaena pinguis* and *Petroscirtes breviceps* are widely distributed in the West Pacific or Indo-West Pacific.

Area 2.5-Temperate to subtropical area - rocky-reef fishes

This area includes the Pacific coast of southern Japan from Boso Peninsula southward to southern Kyushu and the coast of southern China from Taiwan-Fujian southward to Tonking Bay. The fishes typically have warm-water Indo-West Pacific or Indo-Pacific origins. Many are endemic to the Pacific coast of southern Japan from Boso Peninsula southward to southern Kyushu, *viz.* *Platyrrhina sinensis*, *Narke japonica*, *Dasyatis izuensis*, *Myripristis kochiensis*, *Scorpaenopsis cirrosa*, *Lates japonicus*, *Lateolabrax latus*, *Decapterus maruadsi*, *D. muroadsi*, *Leiognathus rivulatus*, *Gerres equulus*, *G.*

microphthalmus, *Hapalogenys sennin*, *Oplegnathus punctatus*, *Calotomus japonicus*, *Prionurus scalprum*, *Sphyaena iburiensis* and *Ostracion immaculatus*. Fishes endemic to the overall area include *Lutjanus ophuysenii*, *Chaetodon nippon*, *Girella leonina* and *Pseudolabrus eoethinus*. *Ophisurus macrorhynchus*, *Seriola dumerili*, *Pseudocalanx dentex*, *Upeneus tragula*, *Parupeneus chrysopleuron*, *Pempheris* and *Sphyaena obtusata* are widely distributed in the Indo-West Pacific or to the tropical Atlantic.

Among the species endemic to the Pacific coast of southern Japan, *Sphyaena iburiensis* forms a clade with *S. pinguis*, widely distributed in the Indo-West Pacific (Doiuchi and Nakabo, 2005, 2007). Accordingly, *S. iburiensis* may have speciated in East Asian waters from a common ancestor with *S. pinguis*. *Gerres equulus* and *G. microphthalmus* both have relatives in Southeast Asian waters (Iwatsuki *et al.*, 1999, 2002), along with *Hapalogenys sennin* (Iwatsuki and Nakabo, 2005).

Some fishes of Area(s) C and/or D, *viz.* *Girella* and *Pseudolabrus*, show anti-equatorial distribution, having temperate region relatives in the Southern Hemisphere. Furthermore, East Asian *Girella* and *Pseudolabrus* may have evolved from Southern Hemisphere stock (Yagishita and Nakabo, 2000, 2003; Mabuchi and Nakabo, 1997; Mabuchi *et al.*, 2004). *Hapalogenys* and *Oplegnathus* also have anti-equatorial distribution (Hoese *et al.*, 2006).

Area 2.6-Subtropical area - coral and rocky reef fishes

This area includes the Ryukyu and Ogasawara Islands, the fishes being both tropical or subtropical and widely distributed in the Indo-West Pacific, *viz.* Lamnidae, Myliobatidae, Muraenidae, Serranidae, Apogonidae, Lutjanidae, Lethrinidae, Haemulidae, Pomacentridae, Chaetodontidae, Pomacanthidae, Labridae, Scaridae, *Neosynchiropus*, *Pterosynchiropus*, Gobiidae, Acanthuridae, Siganidae and Balistidae.

3. SANDY-MUDDY BOTTOMS ON CONTINENTAL SHELVES

Area 3.1-Subarctic area - demersal fishes

This area extends from the Pacific coast northward from Miyagi Prefecture to Hokkaido, and includes the northern Sea of Japan northward from both Tsugaru Strait and Ch'ōngin. The fishes include *Gymnocanthus*, *Hemilepidotus*, *Artediellus*, Agonidae (some species endemic to the region) and *Pleuronectes* (except *P. yokohamae*; some other species endemic). Fishes in the area are widely distributed throughout the Okhotsk and Bering Seas, through waters off Alaska to the northern Pacific coast of North America. *Cottiusculus* species and *Alcich-*

thys elongates are endemic.

Area 3.2-Temperate area - demersal fishes

This includes the Sea of Japan coast from southern Hokkaido, the Pacific coast from Miyagi Prefecture southward to the East China Sea, the Yellow Sea and the coast of China southward to Tonking Bay. The fishes, many of which are endemic to East Asian waters at the specific level, have Indo-West Pacific relatives.

Musterus, *Dipturus*, *Dasyatis akajei*, *Inimicus japonicus*, *Chelidonichthys spinosus*, *Lepidotrigla*, *Branchiostegus*, Sciaenidae (some species also widespread in the Indo-West Pacific), *Uranoscopus japonicus*, *Repomucenus*, *Amblychaeturichthys*, *Acanthogobius flavimanus*, *Trichiurus japonicus*, *Paralichthyidae*, *Cynoglossus*, and *Takifugu* are widely distributed in this region. However, *Okamejei*, *Conger myriaster*, *Saurida umeyoshii*, *Sirembo imberbis*, *Hoplobrotula armata*, *Lophiomus setigerus*, *Lophius litulon*, *Erisphex pottii*, *Platycephalus* sp. 1, *Platycephalus* sp. 2, *Ewynnis tumifrons*, *Sillago japonica*, *Cepola schlegeli*, *Acanthocephala krusensternii*, *Parapericis sexfasciata*, *Repomucenus huguenini*, *R. virgatus*, *R. valenciennesi*, *R. lunatus*, *R. beniteguri*, *R. ornatipinnis*, *Amblychaeturichthys*, *Acanthogobius flavimanus*, *Trichiurus japonicus*, *Engyprosope multisquamata*, *Pleuronichthys*, *Pleuronectes yokohamae* and *Heteromycteris japonica* are not distributed in the South China Sea along the Chinese coast. On the other hand, *Saurida macrolepis*, *S. wanieso*, *Cociella crocodila*, *Inegocia japonica*, *Nemipterus virgatus*, *Pagrus major*, *Upeneus japonicus* and *Engyprosope grandisquamata* are widely distributed in the Indo-West Pacific. Among these, *Dipturus*, *Okamejei*, *Pleuronichthys* and *Pleuronectes yokohamae* have North Pacific origins, the former two genera also including species in Australian waters.

Saurida umeyoshii is endemic to the Pacific coast of southern Japan and the East China Sea, and may have arisen from among the *S. undosquamis* group, which is widely distributed in the Indo-West Pacific (Inoue and Nakabo, 2006).

The two species of East Asian *Pleuronichthys* are endemic which implies their having speciated there, although having relatives off the Pacific coast of North America (Suzuki *et al.*, 2009).

Area 3.3-Pohai and Yellow Seas, and Ariake Bay

The fishes of this region include *Coilia mystus*, *C. nasus*, *Coilia ectenes*, *Setipinna tenuifilis*, *Thryssa kammalensis*, *Salanx ariakensis*, *Neosalanx reganius*, *Pampus echinogaster*, *Repomucenus koreanus*, *R. olidus*, *Boleophthalmus pectinirostris*, *Acanthogobius hasta*, *Chaeturichthys stigmatias*, *Odontamblyopus lacepedii* and *Cynoglossus lighti*. These demersal fishes are mostly endemic, although having warm-water Indo-Pacific rela-

tives. For example, *R. koreanus* is endemic to the Yellow Sea, but has relatives (*R. valenciennesi* and *R. luntus*) in Japanese waters (Nakabo *et al.*, 1987). *Repomucenus olidus*, common in brackish-water areas along the Yellow Sea coast and in Southeast Asian waters, is not distributed in Japanese waters (Nakabo and Jeon, 1985). *Setipinna tenuifilis* and *Thryssa kammalensis* are widely distributed in the Indo-West Pacific.

Salanx ariakensis is genetically and morphologically divided into two geographic populations between the southern Korean Peninsula and Ariake Bay, Japan (Kim *et al.*, 2006, 2007). However, most of the fishes of Ariake Bay are biologically separated from those of the Pohai and Yellow Seas.

Area 3.4-Southwestern coast of Korean Peninsula

Distributions of the coastal marine fishes of the Korean Peninsula fall into three areas, viz. the Yellow Sea coast (western coast), the Korean Peninsula southern coast (southern coast) and the Sea of Japan coast (eastern coast), based on the geographical distributions of the Korean marine fishes described by Kim *et al.* (2005). Fishes off the western coast correspond to Areas 2.2 and 3.3, those off the southern coast to Areas 2.3, 2.4, and 3.2, and off the eastern coast to Areas 2.1 and 3.1. *Hongeo koreana* is endemic to the southwestern coast of the Korean Peninsula (Jeong and Nakabo, 1997), that region not corresponding to any of the areas listed above. Although *H. koreana* belongs to the Tribe Rajini, its morphological characters differ significantly from other genera of the tribe (Jeong and Nakabo, 2009).

4. BIOGEOGRAPHICAL BOUNDARY ZONE BETWEEN NORTHERN AND SOUTHERN FISHES ALONG THE EAST COAST OF KOREA

The biogeographical boundary zone between “northern fishes” (Areas 2.1 and 3.1) and “southern fishes” (Areas 2.3, 2.4 and 3.2) along the east coast of Korea is near Heunghae and Yongil Bay. The fish fauna of Kang Won Do comprises mostly “northern fishes” (ca.70% of all) in the list of Ryu *et al.* (2005). On the other hand, the fish fauna of Ulsan westward to Wando comprises mostly “southern fishes” (ca.70~90% of all) in the lists compiled by Huh and Kwak (1998a, b), Huh and An (2000), An and Huh (2002), Han *et al.* (2002), Kim *et al.* (2002), and Kim *et al.* (2003). In Heunghae and Yongil Bay, “southern fishes” are 50 to 75% of all in the lists by Hwang *et al.* (1997), Han *et al.* (1997), Lee (1999), and Hong *et al.* (2008), which shows a boundary zone between “northern and southern fishes” of the eastern coast of Korean Peninsula.

As the southeastern coast of Korea is adjacent to the

Tsushima Current, the fish fauna there is similar to that of the Sea of Japan coast of Honshu, Japan. The boundary zone between “northern and southern fishes” along the Sea of Japan coast of Honshu is from Hamada, Shimane Prefecture northward to Aomori Prefecture (Nakabo, 2002). The number of “southern fishes” of the boundary zone is influenced by flux of the Tsushima Current. Accordingly, the number of “southern fishes” might have been varied year by year like 50% or 75% shown by Hwang *et al.* (1997), Han *et al.* (1997), Lee (1999), and Hong *et al.* (2008).

As well, the fish fauna of Ulleundo compiled by Myung *et al.* (2005) is similar to that of the Sado Island, Niigata Prefecture, Japan by Honma (1963). Although the Ulleundo is located off eastern coast of middle Korean Peninsula, the fish fauna there is strongly influenced by the Tsushima Current like the Sado Island.

5. REMARKS

The East Asian shallow water marine fish fauna essentially comprises fishes with warm- and cold-water origins, their geographic distribution conforming to 6 areas *sensu* Nakabo (2002), plus 1 area added here. However, their evolutionary histories differ, even within the same geographic areas, indicating considerable scope for further phylogeographic studies.

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