

First report of abnormal body coloration in *Sebastes koreanus* (Actinopterygii: Perciformes: Sebastinae)

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Abstract

This study reports the first record of abnormal coloration in *Sebastes koreanus* Kim et Lee, 1994. The specimen (163.4 mm standard length and 197.3 mm total length) was collected from the Yellow Sea in South Korea in July 2021. The whole body of the specimens was red, and all fins also had red coloration while the slight dark red pattern under the eyes and dark spot on the opercula were similar to normal *S. koreanus*. It also showed a similar dotted pattern on the pectoral fins with a normal specimen.

Keywords

abnormal coloration, new maximum size, *Sebastes koreanus*, Yellow Sea

Introduction

Color variations have been reported in several fish species. They appear in both natural and aquaculture fishes (Muto et al. 2016) but are frequently found in flatfishes reared in aquaculture environments (Venizelos and Benetti 1999; Macieira et al. 2006; Burton 2010). In the natural environment, several fish species, such as pricklebacks (*Dictyosoma rubrimaculatum* Yatsu, Yasuda et Taki, 1978), skates (*Raja montagui* Fowler, 1910; *Raja brachyura* Lafont, 1871; and *Raja clavata* Linnaeus, 1758), angel sharks (*Squatina californica* Ayres, 1859), and rockfishes (*Sebastes trivittatus* Hilgendorf, 1880; *Sebastes chrysomelas* (Jordan et Gilbert, 1881); and *Sebastes pachycephalus* Temminck et Schlegel, 1843)} have also been reported to have sporadic albinism (Ball et al. 2013; Lewand et al. 2013;

Muto et al. 2013; Escobar-Sánchez et al. 2014; Kwun et al. 2016; Muto et al. 2016) while *Cephalopholis fulva* (Linnaeus, 1758) and *Lethrinus nebulosus* (Forsskal, 1775) have shown melanisms of body coloration (Simon et al. 2009; Jawad et al. 2013). Albinism is a genetic abnormality that reduces melanin biosynthesis, resulting in partial or total lack of body color, typically producing a golden-orange color. Melanism is the presence of excessive amounts of pigment in tissues and skin, and it is a phenomenon in which dark patterns appear on the body color (Simon et al. 2009; Jawad et al. 2013; Escobar-Sánchez et al. 2014).

Sebastes koreanus Kim et Lee, 1994 belongs to the genus *Sebastes*, of which approximately 110 species are known worldwide, with more than 30 species found in the North Pacific (Yu et al. 2015; Nelson et al. 2016). Rockfishes (subfamily Sebastinae) often show variations

in body coloration according to their habitat, which causes difficulties in species identification based only on body morphology (Kai et al. 2011; Kai and Nakabo 2013). Recently, genetic analysis was further developed to reduce errors in taxonomic classifications and to find patterns of various intraspecific body colorations (Narum et al. 2004; Hawkins et al. 2005). It has also become possible to distinguish taxonomic variations of rockfishes at the species level by combining body color and genetic analyses. For example, *S. pachycephalus* has been divided into two species according to color pattern and the presence or absence of scales under the dorsal fin (Kai et al. 2011; Kai and Nakabo 2013). In addition, *Sebastes inermis* Cuvier, 1829 has been divided into three morphotypes according to the pattern of body color and the number of pectoral fin rays (Kai and Nakabo 2002, 2008). As described above, body color is often used as a taxonomic key to distinguish species in the subfamily Sebastinae. The normal body color of *S. koreanus* is speckled with dark brown and light ivory, and there is no significant color variation among individuals (Kim and Lee 1994; Fang et al. 2015). This species is distributed in the Yellow Sea off the Korean and Chinese coasts, with a relatively narrow distribution range (Choi and Yang 2008; Murdy 2010; Fang et al. 2015). Biological and ecological studies of *S. koreanus* inhabiting Korean waters have only reported on the morphological development of egg and juvenile fishes (Park et al. 2015; Yu et al. 2015).

In this study, a single specimen of *S. koreanus* was collected by fishing on the western coast of Korea, but its body size was considerably larger, and its color was unusually different from usual *S. koreanus* specimens. We aimed to confirm if the specimen was *S. koreanus* and to study whether there are intraspecific color variations in *S. koreanus* through morphology and molecular analyses. Consequently, this study reports the first abnormal body coloration *S. koreanus* collected from the western waters of Korea.

Methods

A *Sebastes koreanus* specimen with a total length (TL) of 197.3 mm was collected from Ongdo (36°38'49.81"N, 126°0'30.56"E) in the coastal waters of Taean Province, western Korea (Fig. 1). Sampling was conducted at a depth of approximately 13 m during the daytime via fishing on 16 July 2021. Immediately after capture, the sample was frozen with seawater and transported to the laboratory. In the laboratory, an image of the specimen was taken. Body measurements were recorded following Hubbs et al. (2004), measuring both standard length (SL) and TL. The specimen was measured to the nearest 0.1 mm using a digital Vernier caliper. The specimen was then preserved in 5% formalin for

24 h and was later transferred to 70% ethanol for further analyses.

To compare molecular data, total genomic DNA was extracted from muscle tissue using 10% Chelex resin (Bio-Rad, Hercules, CA, USA). A portion of the mitochondrial cytochrome oxidase subunit I (COI) gene was amplified using universal primers (Ward et al. 2005). PCR was performed in a 30 µL reaction tube containing 3 µL genomic DNA, 3 µL 10 × PCR buffer, 2.4 µL 2.5 mM dNTP, 1 µL of each primer, 0.3 µL Ex-Taq DNA polymerase, and 19.3 µL sterile distilled H₂O using a thermal cycler (MJmini PTC-1148, Bio-Rad, Hercules, CA, USA). The PCR profile consisted of initial denaturation at 95°C for 5 min, followed by 34 cycles of denaturation at 95°C for 1 min, annealing at 50°C, extension at 72°C for 1 min, and a final extension at 72°C for 5 min. PCR products were purified using ExoSAP-IT (United States Biochemical Corporation, USA) and were sequenced using an ABI PRISM BigDye Terminator v.3.1 Ready Reaction cycle sequencing kit (Applied Biosystems Inc., USA) on an ABI 3730xl DNA Analyzer (Applied Biosystems Inc.). We compared our molecular data with the mtDNA COI sequences from other *Sebastes* species and one outgroup, *Sebastiscus marmoratus* (Cuvier, 1829) obtained from the GenBank (National Center for Biotechnology Information, www.ncbi.nlm.nih.gov). Sequences were aligned using ClustalW (Thompson et al. 1994) in BioEdit version 7 (Hall 1999). Genetic divergences were calculated using the Kimura 2-parameter (K2P) model (Kimura 1980) with Mega 6 (Tamura et al. 2013). Phylogenetic trees were constructed using the neighbor-joining method (Saitou and Nei 1987) in Mega 6 (Tamura et al. 2013), with confidence assessed based on 1000 bootstrap replications.

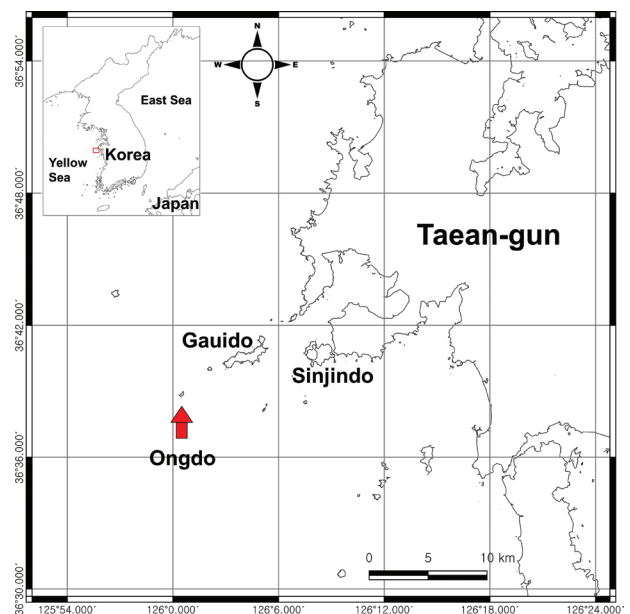


Figure 1. Map showing the sampling area of *Sebastes koreanus* in Ongdo, Taean-gun, Korea.

Results

Subfamily: Sebastinae Kaup, 1873 *Sebastes* Cuvier, 1829

Sebastes koreanus Kim et Lee, 1994

Korean common name: 황해볼락

Suggested English common name: yellow Korean rockfish

Figs 2, 3

Description. Body moderately compressed (Fig. 2). Strong spines on head. Large mouth and eyes large. Maxilla not reaching posterior margin of eye. Dorsal fin continuous, notched between 13th spine and 14th spine; soft part of dorsal fin length similar to spinous part length. Origin of anal fin same as origin of soft part of dorsal fin. Pectoral fin large; upper half rounded; rays of lower half thickened; origin of pectoral fin located on second spine of dorsal fin; posterior margin located on 11th spine of dorsal fin. Pelvic fin short; origin of pelvic fins located behind origin of pectoral fins. Pectoral and pelvic fins covered with skin and ctenoid scales near base. Caudal fin truncated. Lateral line sloping moderately downward above pectoral fin.

Dorsal fin rays XIV, 12; anal fin rays III, 6; pectoral fin rays 16; pelvic fin rays I, 5; lateral line pores 31. Proportions as percentage (%) of SL (163.4 mm): head length

37.6; head width 22.0; head depth 31.0; snout length 11.1; orbit diameter 9.1; interorbital width 6.5; body depth 39.0; body width 21.3; upper jaw length 16.8; pre-dorsal fin length 35.6; pre-anal fin length 74.4; pectoral fin length 29.9; pelvic fin length 24.5; 1st dorsal fin spine length 5.3; 2nd dorsal fin spine length 7.8; 3rd dorsal fin spine length 11.4; longest dorsal fin ray length 15.7; 1st anal fin spine length 7.0; 2nd anal fin spine length 16.1; 3rd anal fin spine length 14.0; caudal peduncle length 18.3; caudal peduncle depth 11.1.

Body generally orange, upper part of head faded yellow, with two slight dark red stripes behind and under eye (Fig. 2). Anterior and posterior parts of eyes faded yellow with bit of red. Dorsal side of body red and ventral side pale yellow. Membrane of spine dorsal fin interspersed with red dots on pale yellow background. Membrane of soft dorsal fin orange and tip pale yellow. Pelvic and anal fins red. Caudal fin dark red interspersed with tiny black dots. Front of pectoral fin red, but in middle and rear, red dots scattered on faded red background.

Remarks. Based on the analysis of the COI gene sequence (577 bp) of the presently reported specimen and the mtDNA COI region of *S. koreanus* registered in the NCBI, the genetic distance between the two individuals was found to be 0.002. The other four species in the genus *Sebastes* had genetic distances of 0.032–0.051 (Fig. 3).



Figure 2. Specimens of *Sebastes koreanus* with abnormal and natural body colorations between presently reported and previous studies, 197.3 mm total length, Ongdo, Yellow Sea, Korea. Scale bar = 5 cm.

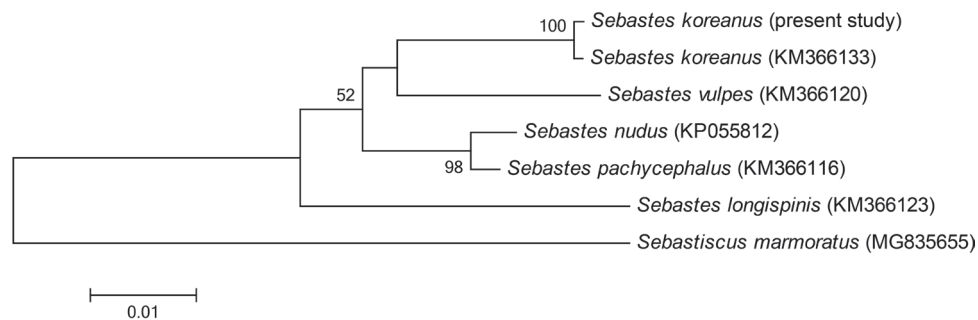


Figure 3. A neighbor-joining tree based on the partial mitochondrial DNA COI gene region using *Sebastes koreanus* (KI-OST_22_001) showing the relations among the four species of *Sebastes* and one outgroup (*Sebastiscus marmoratus*). Numbers at the branches indicate bootstrap probabilities in 10 000 bootstrap replications. Scale bar equals 0.01 of Tamura and Nei's distance (1993) with K2 parameter model. Abbreviation: COI, cytochrome oxidase subunit I.

Discussion

Sebastes koreanus is generally dark brown with dark stripes and tiny dark spots, four to five vertical patterns on the body side, small brown spots scattered on each fin, two stripes behind and below the eyes, one dark blotch on the opercula, interspersed black dots on the pectoral fins, and 14 dorsal fin spines (Kim and Lee 1994; Fang et al. 2015). In this study, a single specimen of rockfish showed a difference in body coloring from the normal *S. koreanus*. Its body was overall red without a black blotch on the opercula. The specimen was morphologically similar to that of *S. koreanus*, especially in the number of dorsal fin spines (i.e., 14 dorsal fin spines). The specimen also showed similar patterns on the body with two lines under the eyes and red dots on the pectoral fins, although the color was different from *S. koreanus* (i.e., red vs. black). The mtDNA COI region further demonstrated that the genetic difference between the presently reported specimen and *S. koreanus* was 0.002, indicating within-species variation. Therefore, this species can be identified as *S. koreanus*.

The abnormal body colorations of fishes are mainly due to the lack or excess of melanin, which causes albinism and melanism, respectively (Jawad et al. 2013; Muto et al. 2013). Such abnormal body color patterns of rockfish-

es have also previously been reported in *S. trivittatus* (see Muto et al. 2016). Overall, morphometrics were identical between the abnormal and normal specimens, and only the color form combinations were different. In the presently reported specimen, the black and brown colors of *S. koreanus* appeared as red and yellow, especially in the two lines under the eyes and in the scattered dots on the pectoral fins, which are important morphological traits of *S. koreanus*. Such abnormal body color in the presently reported specimen appears to be a form of albinism.

Sebastes koreanus showed a relatively narrow distribution range, inhabiting only the Yellow Sea off the Korean and Chinese coasts. This study collected a single specimen of *S. koreanus* and reported a color variation in *S. koreanus*, with the body having an unusually orange color.

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