

Scale Characteristics of Hybrids between Female Red Seabream, *Pagrus major* and Male Black Seabream, *Acanthopagrus schlegelii*

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We described the scale characteristics of induced hybrids between female red seabream (*Pagrus major* Temminck et Schlegel) and male black seabream (*Acanthopagrus schlegelii* Bleeker), and of their parental species. The external scalar morphology of induced hybrids showed intermediate characters compared to those of the parental species. The mean number of primary apical grooves and lateral line scales was 10.5 ± 2.6 and 49.5 ± 0.5 , respectively, in induced hybrids, which also showed intermediate meristic characters compared to those of the parental species ($P < 0.01$). The meristic characters used in this study may be useful parameters for the identification of genotypes of these seabream species.

Key words : black seabream, induced hybrid, red seabream, scale characteristics

Introduction

Artificial hybridization as a genetic breeding technique has been used as a tool to improve aquaculture productivity through heterosis in fish (Chevassus, 1983; Park *et al.*, 1997a, b, 2003; Kim *et al.*, 2005). In an attempt to obtain better phenotypes, several fish hybrids have been produced in Korea, including hybrids of olive flounder (*Paralichthys olivaceus*) and spotted flounder (*Verasper variegates*; Kim *et al.*, 1996); rainbow trout (*Oncorhynchus mykiss*) and coho salmon (*O. kisutch*; Park *et al.*, 1996); rainbow trout and cherry salmon (*O. masou*; Park *et al.*, 1997a); and mud loach (*Misgurnus mizolepis*) and cyprinid

loach (*M. anguillicaudatus*; Park *et al.*, 1997b; Park and Kim, 2000).

Red seabream (*Pagrus major* Temminck and Schlegel, 1843) and black seabream (*Acanthopagrus schlegelii* Bleeker, 1854), which belong to the Sparidae in the Perciformes, are distributed from Korea and Japan to the East China coast. In Korea, these fish are very popular and valuable sport fish, and are also available as aquaculture fish (Choi *et al.*, 2002). Thus, both species are economically important. To gain hybrid vigor between red and black seabream for increased productivity, hybrids between female red and male black seabream have been produced (Murata *et al.*, 1995, 1997; Kim *et al.*, 2005; Park *et al.*, 2006). Subsequent cytogenetic analyses of hybrids of female red and male black seabream

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have been performed (Park *et al.*, 2004).

Several studies of the characters of hybrid fish have been conducted to compare their biological characteristics with those of the parental species, e.g., shape and number of scales and fins, number of vertebrae and bones, position of the eyes, shape of the mouth, and the ratio of the weight of each organ to the body weight (Bhowmick *et al.*, 1981; Dunham *et al.*, 1982; Krasznai and Máráin, 1982). However, few studies have reported on scale morphology. The scales in the same species are almost uniform in their shape and structure, and can therefore, be used as a key characteristic for species classification. Annuli on the surfaces of scales are also used to estimate fish age and identify populations (Gritsai, 2002). This study was performed to assess the suitability of scales for species identification and population differentiation in hybrids between red and black seabream.

Materials and Methods

Hybrids between female red and male black seabream were produced following the method of Kim *et al.* (2005). In May 2001, seabream hybridization was carried out at the National Fisheries Research and Development Institute (NFRDI), Korea, to obtain hybrids using ten mature female (34.88 ± 2.98 cm total length [TL], 630.35 ± 138.70 g body weight [BW]) and eight mature male (33.96 ± 2.61 cm TL, 624.45 ± 125.97 g BW) red seabream, and ten mature female (28.53 ± 1.51 cm TL, 424.86 ± 57.72 g BW) and five mature male (26.30 ± 1.10 cm TL, 349.18 ± 39.64 g BW) black seabream. We established three groups, i.e., pure red, pure black, and hybrid seabream. Hatched larvae of the three groups were maintained at 5.0 mL L^{-1} dissolved oxygen (DO), $7.6 \sim 8.2$ pH, $32.21 \sim 33.32\%$ salinity, and 20°C water temperature.

To compare scales of the hybrids and parental species, 18 red, 23 hybrid, and 20 black seabream were sampled from each culture tank, fixed in 10% formalin, and then washed in tap water to remove the formalin from the body surface. Scales were removed from the head, body, and tail of fish from the three groups. The scales were immersed in 0.5% KOH (Sigma, USA) to remove attached epithelial tissue and pigment to produce a clean profile of the scales; these scales were then washed with secondary distilled water

and stained for 1 h in 0.05% alizarin red S (Sigma, USA). To clean the surface of the scales, scales obtained from the three groups were left in glycerol (Sigma, USA), which was replaced once, for 3 days.

The scales were observed and measured under an optical microscope (Axiostar plus, Zeiss, Germany) and the external characteristics were photographed under a stereomicroscope (Stemi DV4, Germany) using a $40\times$ digital camera. Primary apical grooves were counted in 45 samples taken from each body part (head, body, and tail) of each fish. The numbers of lateral line scales from the anterior margin of the pectoral fin to the anterior margin of the caudal fin were also counted. Significant differences in the mean number of primary apical grooves and the mean number of lateral scales among the three groups were analyzed using one-way analysis of variance (ANOVA; $P < 0.01$).

Results and Discussion

All scales of the head, body, and tail of red, black, and hybrid seabream contained pigment on the outer margin of the scale surface. All three groups had ctenoid scales with ctenii, as is common in most teleosts. The shapes of the scales were similar among the three groups, although the scales differed in size (Fig. 1). As shown in Fig. 1, the external shape of each scale was slightly round to square in red seabream and round in black seabream. The external shape of the scale in hybrids was intermediate, i.e., roundsquare, compared to those of the two parental species. Suzuki (1963) reported that in hybrids produced by crosses and back crosses of female minnows *Gnathopongon elongatus elongatus* and male *G. japonicus*, the external shape of the scales was more similar to that of the male parental species.

The annuli and annual rings on the scale surface were observed more clearly in red seabream than in black seabream and hybrids, whereas the focus was observed in all three groups. Annuli on the scales of black seabream were found on the surface, but the foci were rarely observed. The characteristics of the annuli and foci in the hybrids were similar to those of black seabream. The number of primary apical grooves on the scales of red, black, and hybrid seabream was 7.6 ± 1.4 , 11.1 ± 3.0 , and 10.5 ± 2.6 , respectively

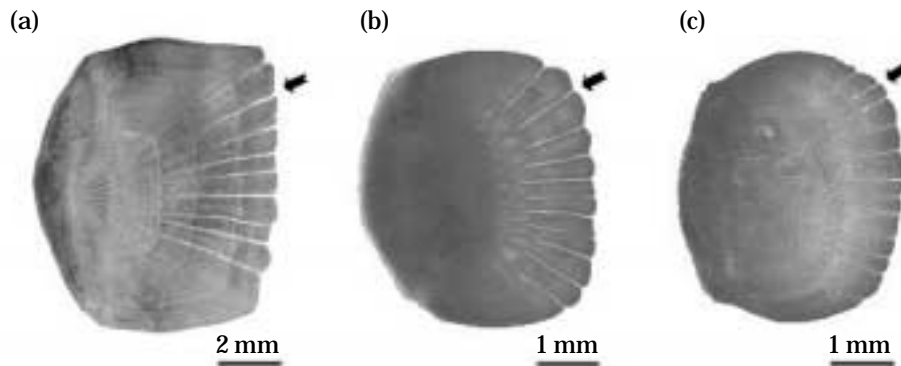


Fig. 1. Morphology of the scales in the red seabream (a), the hybrid (b) and black seabream (c). Arrows indicate primary apical grooves in the scale.

Table 1. Comparison of the number of primary apical groove and number of the scale in lateral line in red seabream, black seabream, and the hybrid

Genotype (n)	No. of primary apical groove	No. of lateral line scale
Red seabream (18)	7.6 ± 1.4 ^a	54.0 ± 2.0 ^a
Hybrid (23)	10.5 ± 2.6 ^{ab}	49.5 ± 0.5 ^{ab}
Black seabream (20)	11.1 ± 3.0 ^b	46.5 ± 0.5 ^b

Values indicate Mean ± SD. n=number of individual tested. Values in different letters in each column indicate significant differences ($P < 0.01$).

(Table 1). The hybrids showed intermediate characteristics compared to the parental species ($P < 0.01$). Our results corresponded to a report by Suzuki (1963), who showed that the number of primary apical grooves in hybrids produced via crosses and back crosses between minnows (*G. elongatus elongatus* and *G. japonicus*) was intermediate compared to that of the parental species. The number of scales along the lateral line in the hybrids was intermediate between both parental species ($P < 0.01$). In our study, the number of scales arranged along the lateral line in red seabream, hybrids, and black seabream were 54.0 ± 2.0 , 49.5 ± 0.5 , and 46.5 ± 0.5 , respectively. This pattern, in which the number of lateral line scales in hybrids was intermediate between the parental species, has also been reported in grass carp (*Ctenopharyngodon idella*), carp (*Cyprinus caprio*), and their hybrids, in which the number of lateral scales was 40.5, 11.4, and 33.8, respectively (Stanley and Jones, 1976). The hybrid was closer to grass carp than carp in the number of lateral line scales (Stanley and Jones, 1976). In another study, the number of lateral line scales in striped bass (*Morone*

saxatilis) and white bass (*M. chrysops*) and their hybrids were reported to be 59.1, 52.8 and 56.5, respectively (Harrel and Dean, 1988).

The morphological and meristic characteristics of hybrids of red and black seabream were intermediate to those of the parental species, or were more similar to one parental species (Park *et al.*, 2004, 2006). Hybrids between minnow and crucian carp, grass and big-head carp, and mud and cyprinid loach show intermediate characteristics between the two parental species for some morphometric traits, whereas other morphometric traits resemble only one of the parental species ($P < 0.01$; Krasznai and Márián, 1982; Kasama and Kobayasi, 1991; Park, 1992).

It has generally been reported that the characteristics of hybrids are intermediate between those of the parental species or are sometimes more similar to those of one parental species (Suzuki and Fukuda, 1973; Chevassus, 1983; Park *et al.*, 2004, 2006). In our study, some of the morphological, meristic, and morphometric characteristics of the scales in hybrids of red and black seabream differed from those of the parental species. Therefore, on the basis of our results, the number of primary apical grooves and the scale number of the lateral line, as well as the shape of the scales, may be used in the identification of red and black seabream, and may be used to differentiate among individuals under anesthesia, without having to sacrifice the fish.

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참돔, *Pagrus major* (♀)과 감성돔, *Acanthopagrus schlegelii* (♂)간
유도 잡종의 비늘 특성

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참돔, *Pagrus major* Temminck et Schlegel (♀)과 감성돔, *Acanthopagrus schlegelii* Bleeker (♂) 그리고 이들간 유도 잡종 개체의 비늘 특성을 조사하였다. 본 연구 결과, 유도 잡종 개체의 비늘 외형은 양친의 중간적인 특성을 나타내었다. 참돔과 감성돔의 primary apical grooves와 측선 비늘 수의 평균은 각각 10.5 ± 2.6 과 49.5 ± 0.5 를 나타내었으며, 유도 잡종의 평균 primary apical grooves 수와 평균 측선 비늘 수 역시 양친의 중간적 계수형질의 경향을 보였다 ($P < 0.01$). 본 연구에서의 계수형질은 본 연구 대상 어류인 돔류에서의 동정에 유용한 parameter로 사용될 수 있을 것이다.