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First record of F_2 hybrid striped bass (Morone chrysops ♀ × Morone saxatilis ♂ × Morone chrysops ♀ × Morone saxatilis ♂) in Kemer Dam Lake

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Abstract: The morphometric and meristic characters of 2 F_2 hybrid striped bass (*M. chrysops* ♀ × *M. saxatilis* ♂ × *M. chrysops* ♀ × *M. saxatilis* ♂) from the family Moronidae are described. Two specimens were caught from Kemer Dam Lake. The body of the F_2 hybrid striped bass was elongated, moderately compressed, and scaly. Dorsal surface and sides were silver and black to olive-gray, and the abdomen was white in color. Four or 5 longitudinal broken stripes ran above the lateral line to the caudal fin. The stripes were less visible behind the pectoral fins and below the lateral line. The bodies of the F_2 specimens were deeper than 1/4 the fork length. The 2 dorsal fins were separated entirely. The first dorsal fin had 8–9 spines, and the second dorsal fin had a spine and 13–14 soft rays. The caudal fin was slightly forked. The anal fin had 3 spines with 12–14 soft rays. One tooth patch was present on the anterior of the tongue. According to our results, the fish were F_2 hybrid striped bass offspring of F_1 hybrid striped bass, which can reproduce naturally in Turkey. Morphological criteria showed that the F_2 hybrids tended to resemble white bass (*M. chrysops*).

Key words: F_2 progeny, hybrid reproduction, hybrid striped bass, Kemer Dam Lake, *Morone* sp.

1. Introduction

Hybrid striped bass are propagated artificially by crossing anadromous striped bass (*Morone saxatilis* Walbaum, 1792) and white bass (*Morone chrysops* Rafinesque, 1820), which are native to the east coast of North America and the Mississippi River, respectively (Hodson, 1989; Kohler et al., 2001). Studies have been performed on culturing hybrid striped bass since the mid-1980s; the resulting hybrids grow faster, adapt to fish feeds readily, and are more resistant to diseases than their parents (Kohler et al., 2001). Hybrid striped bass have great potential for food-fish aquaculture in the United States and they possess desirable culture attributes, such as being euryhaline, rapid growth, disease resistance, and an appetizing taste (Liu et al., 1998). Interspecific hybrids can also enhance recreational angling opportunities (Scribner et al., 2001). Countries such as Canada, Israel, Taiwan, China, Italy, Portugal, France, Germany, and Turkey are interested in the culture of hybrid striped bass (Liu et al., 1998; Nitzan et al., 2001; Güner et al., 2007). The cross between a female striped bass (♀ SB) and a male white bass (♂ WB) is referred to as a palmetto bass, and it is known as the 'original hybrid' (*Morone saxatilis* ♀ × *Morone chrysops* ♂) (Bayless, 1972; Kerby and Harrell, 1990); it is preferred because its eggs are larger, its larvae can eat formulated diet early, and it exhibits better growth and survival rates than striped bass (Tuncer et al., 1990). The hybrids grow at faster rates than their parents during the first 2 years of culture (Kohler et al., 2001). However, white bass females are easier to work with than striped bass females and are more readily available (Kerby and Harrell, 1990). The 'reciprocal hybrid' of male striped bass (♂ SB) and female white bass (♀ WB) is known as sunshine bass (*Morone chrysops* ♀ × *Morone saxatilis* ♂), which has the most promise for aquaculture (Harrell et al., 1990; Mylonas et al., 1996; Bartley et al., 2001; Mylonas and Zohar, 2001).

As an anadromous species, striped bass can spend its whole life in freshwater and is popular for stocking reservoirs used for angler fishing (Dettmers et al., 1998). Because of their predatory characteristics, striped bass are used for the biological control of unwanted fish species such as tilapia, which reproduce intensely in environments in Israel (Milstein et al., 2000), as well as shad (*Dorosoma* spp.) and *Nematalosa* sp. (Dettmers et al., 1998).

Morone species are not native to inland Turkish waters, but fish farmers prefer to culture hybrid striped bass (*Morone chrysops* ♀ × *Morone saxatilis* ♂). Small quantities of F_1 hybrid striped bass fry (around 0.5–1 g live

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weight) were imported into Turkey by 2 private fish farms between 1999 and 2000. The first of these fish were stocked in earthen ponds in the Muğla-Savran region, while the others were stocked in net cages in Kemer Dam Lake (Figure 1) in Aydın-Bozdoğan for growing. A study of the culture potential of hybrid striped bass was conducted in Kemer Dam Lake between May 2000 and August 2003. Approximately 2000 F_1 hybrid striped bass (age 1+) with a mean live weight of 367 g escaped through net tears in 2001 (Güner et al., 2007). It is known that, unlike many fish hybrids, all F_1 Morone crosses can be reared to maturity and induced to spawn in hatchery conditions (Harrell et al., 1990; Liu et al., 1998; Güner et al., 2003). F_1 hybrid striped bass are oviparous fish, and spawning occurs in spring when the water temperatures reach 15–20 °C in Turkey. The gonadosomatic index of both sexes increases from October and reaches a peak in May, after which it decreases to the basal level. About 90% of the male F_1 hybrids reach sexual maturity at 1 year and the females at 2 years. Spawning is induced by the stripping method, and 2.74% survival was obtained with F_2 hybrid striped bass (*M. chrysops* ♀ × *M. saxatilis* ♂ × *M. chrysops* ♀ × *M. saxatilis* ♂) larvae after 32 days in controlled conditions (Güner et al., 2003).

In this study, we determined the morphometric and meristic characters of 2 F_2 hybrid striped bass belonging to the family Moronidae. The F_2 specimens were recorded as offspring of F_1 hybrid striped bass, which can reproduce naturally in inland Turkish waters (Kemer Dam Lake), where no Moronidae members exist naturally.

2. Materials and methods

Two F_2 specimens (Figure 2) were caught from Kemer Dam Lake (37°33′N, 28°32′E) (Figure 1) using gill nets during June 2004. The fish were fixed in 4% formaldehyde solution after capture. The morphometric measurements and meristic characters of these specimens are shown in the Table. For each specimen, we counted or measured the meristic and morphometric characters. Measurements were made using a ruler within ±0.1 mm. The fish were weighed to the nearest 0.1 g using an electronic balance. The morphometric characters were measured as described by Harrell et al. (1990).

3. Results

The 2 specimens from Kemer Dam Lake had live weights and total lengths of 99 and 109 g and 20.2 and 20.3 cm, respectively. Condition factors of the specimens were calculated as 1.20 and 1.30. The ages of the captured fish were estimated as 1+. The bodies were elongated, moderately compressed, and scaly. The dorsal surfaces and sides were silver and black to olive-gray, and the abdomen was white in color. Four or 5 longitudinal broken stripes ran above the lateral line to the caudal fin. The stripes were less visible behind the pectoral fins and below the lateral line. The 2 dorsal fins were separated entirely. The first dorsal fin had 8–9 spines, and the second dorsal fin had a spine with 13–14 soft rays. The caudal fin was slightly forked. The anal fin had 3 spines and 12–14 soft rays. The teeth were small, in bands on the jaws, vomer, and palatines, while 1 tooth patch was present on the anterior of the tongue (Table).

Figure 1. Map of Kemer Dam Lake in the western part of Turkey.

Figure 2. F_2 hybrid striped bass (*M. chrysops* ♀ × *M. saxatilis* ♂ × *M. chrysops* ♀ × *M. saxatilis* ♂) specimens.

4. Discussion

The Morone hybridization program was initiated in the 1960s to produce fish with preferred characteristics, including the size, longevity, food habits, and angling qualities of striped bass and the adaptability of white bass to exotic environments (Bayless, 1972; Harrell et al., 1990).

Table. Morphometric and meristic characteristics of F_2 hybrid striped bass (*M. chrysops* ♀ × *M. saxatilis* ♂ × *M. chrysops* ♀ × *M. saxatilis* ♂) caught from Kemer Dam Lake, F_1 hybrid striped bass (*M. chrysops* ♀ × *M. saxatilis* ♂), white bass (WB) (*M. chrysops*), and striped bass (SB) (*M. saxatilis*). S: Specimen. F_1, WB, and SB from Harrell et al. (1990), Woods (2005), and Güner et al. (2007), respectively.

Morphometric and meristic characteristics	F_2 (S1)	F_2 (S2)	F_1	WB	SB
Total length (cm)	20.2	20.3	53		
Live weight (g)	99	109	1309		
Fork length (cm)	19.2	19.3			
Standard length (cm)	16.6	16.7	46		
Body height (cm)	5.5	5.3	11.5		
Head length (cm)	5.2	4.8	11.4		
Preorbital length (cm)	0.9	1	3.4		
Eye diameter (cm)	0.7	0.7	1.7		
1st dorsal fin	VIII–I	VIII–I	IX		
2nd dorsal fin	14	13	I–13	12–13	12
Anal fin	III–14	III–12	III–11	12–13	9–11
Pelvic fin	I–4	I–4	I–6		
Pectoral fin	9	9	12		
Lateral line scales	54	56–57	50	52–58	50–70
Scales above lateral line	7–8	7–8	10	7–9	9–13
Scales below lateral line	14–15	14–15	16		
Teeth on tongue	1 patch	1 patch	2 patches	1 patch	2 patches

In particular, the reciprocal of the original cross, ♀ WB × ♂ SB, has considerable potential for world aquaculture (Liu et al., 1998). However, some studies have reported that hybrids could have escaped from fish farms into the wild environment accidentally (Innal and Erk'akan, 2006; Güner et al., 2007; Innal, 2012; Safner et al., 2013). Hybrids are reproductively viable in the wild (Woods et al., 1995), and the reproductive viability of Morone hybrids means that they can reproduce naturally in wild environments (Lueckenhoff, 2011). There is concern that they could reproduce or backcross with either or both of the parental species (Muoneke and Maughan, 1991).

It was reported that F_1 hybrid striped bass fry (around 0.5–1 g live weight) were stocked in net cages during May 2000, and that they could reproduce by tank spawning or stripping when they reached >1309 g (Güner et al., 2003). Approximately 2000 F_1 hybrid striped bass escaped through net cages into the environment during the growing period in 2001 (Güner et al., 2007). Two specimens were caught from Kemer Dam Lake during June 2004 (Figure 2). The ages of the captured fish were determined as 1+. It was assumed that these specimens were F_2 offspring of F_1 hybrid striped bass (WB × SB), which escaped from fish farms into the environment and reached sexual maturity. SB × WB is the cross of ♀ SB and ♂ WB, and the palmetto bass is generated from this cross, whereas the reciprocal hybrid (♀ WB × ♂ SB) is the sunshine bass (Harrell et al., 1990). Muoneke and Maughan (1991) stated that the reproduction of SB × WB hybrids has been reported in natural habitats. Liu et al. (1998) demonstrated that F_1 hybrid striped bass (SB × WB) reared to maturity and fed dry commercial feed could be induced to spawn in captivity and produce viable F_2 progeny, which exhibited low hatching rates, a high level of morphological deformity, growth variability, and low larval survival. Similar results were obtained with the F_2 progeny of sunshine bass (WB × SB) by Güner et al. (2003). Harrell et al. (1990) indicated that the F_2 hybrids of palmetto bass × palmetto bass are less hardy than the F_1 or parental species, while their survival is generally poor and their growth rates are highly variable.

The appearance of F_2 hybrid striped bass is intermediate between striped bass and white bass. White bass and striped bass have 7–8 stripes on their bodies and the stripes run from the operculum along the sides of the body to the origin of the caudal fin. By contrast, the stripes of white bass are faint, and only one extends to the caudal fin. The stripes are distinct in striped bass and the F_1 hybrid, but are generally broken in the F_1 hybrid (Harrell et al., 1990). The F_2 hybrids more closely resemble white bass than striped bass and the F_1 hybrid parents in terms of stripes.

Hybrid striped bass share many morphological and meristic traits with both parental forms but are generally more similar to white bass (Muoneke and Maughan, 1991). The body of white bass is shorter and more strongly compressed laterally than striped bass, but is more deep and robust vertically (Woods, 2005). Williams (1976) stated that the ratio of the fork length relative to the body height is around 4.44 for striped bass, but 3.47 and 3.46 in white bass and hybrid, respectively. The bodies of the F_2 specimens were deeper than 1/4 the fork length, i.e. a ratio of 3.49–3.64. These findings show that the F_2 hybrid striped bass are similar to white bass and F_1 hybrids, but different from striped bass. By contrast, the F_2 hybrids are similar to white bass but different from striped bass and the F_1 hybrids in terms of the number of dorsal and anal rays, and scales (Table).

A common technique used to distinguish striped bass, white bass, and their hybrids is an examination of the basihyal tooth patches on the base of the tongue (Lueckenhoff, 2011). Striped bass and F_1 hybrid striped bass have 2 patches, whereas white bass have only 1 patch (Woods, 2005; Güner et al., 2007; Lueckenhoff, 2011). A single tooth patch is present on the anterior of the tongue in the F_2 hybrids. According to our results, all of the morphological criteria showed that the F_2 hybrids tended to resemble white bass.

Neither striped or white bass nor hybrid striped bass occur naturally in Kemer Dam Lake, nor were they were introduced into Kemer Dam Lake after 2000, and so the caught fish are considered to be F_2 hybrid striped bass. Thus, F_1 hybrid striped bass can reproduce naturally in Turkey (Kemer Dam Lake, Aydın) and generate viable F_2 offspring.

Escaped farmed fish can have negative impacts on the environment and wild populations of fish, whether they are native or exotic in the area where they are farmed (Myrick, 2002). Invasive species can modify food chains and habitats, displace native species, and disrupt economic systems (Parker et al., 1999; Mack et al., 2000). Patrick and Moser (2001) reported that hybrid striped bass compete for food aggressively with striped bass and may also compete for mates or spawning ground habitats. Because of their predatory characteristics, the potentially adverse impacts of the F_2 hybrids on Kemer Dam Lake's environment should be taken into consideration; surveys are required to confirm whether the F_2 hybrids have any effects on the natural fish populations. The possible spreading of the F_2 hybrids to other water bodies must be prevented.

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