Fecundity of Morocco Dentex *Dentex maroccanus* Valenciennes, 1830 Distributed in Izmir Bay (Central Aegean Sea of Turkey)

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A R T I C L E   I N F O

A B S T R A C T

In this study, the reproductive properties of the *Dentex maroccanus* species distributed in the Aegean Sea were determined. A total of 439 fish were collected during the period from December 2012 to March 2014 from the commercial fishers who seasonally hunt in the Foça-Mordoğan region (İzmir, Turkey) were examined. After the measurement of the total lengths and body and gonad weights of the fish samples in the laboratory, their sexes were identified, which revealed that 140 of the samples were male, 206 of the samples were female and 93 of the sample were undetermined. The female:male ratio was 1.5:1. The 5-point maturity phase discrimination method developed by Holden and Raitt for maturity stages in 1974 was macroscopically examined for female and male fish specimens. A total of 16 ovaries, which were determined to be at the 3rd and 4th stages of maturity according to the method, were used to determine fecundity. The gonadosomatic index values that were calculated based on the seasons revealed that the reproductive period of the species was summer (2.87) and autumn (2.10). The first maturation length for the species was 13.4 cm. Estimates of total fecundity varied between 74252 and 201187 eggs (mean: 123263±44586). There was an exponential relationship between fecundity and total length as $F = 10.643L^{3.111}$. The diameter of the mature eggs ranged from 0.49 mm to 0.67 mm (mean: 0.59±0.06 mm).

Introduction

The Sparidae family is represented by 10 genera and 21 species in the Turkish seas (Bilecenoğlu et al., 2014) and the total hunting amount is 5000 tons, which adds up to 2.9% of the total fish production in Turkey (TUIK, 2016). The Pagellus, Pagrus and Dentex genera of the Sparidae family is made up of breams and *Dentex maroccanus*, known as Morocco Dentex, is a species from the Dentex genus (Froese and Pauly, 2015). The species mostly distributes in the northern regions from Bay of Biscay in the Atlantic Ocean to Gulf of Guinea and lives at depths of 50 m to 200 m in the Atlantic Ocean and of about 250 m in the Mediterranean Sea. The species is distributed especially on rocky bottoms in coastal waters and its reproductive season in the Atlantic Ocean is spring and summer, whereas it is spring in the Mediterranean Sea (Whitehead et al., 1986).

There are limited studies on the reproductive properties of the *D. maroccanus* species. In their elaborate study on the biology of the species in the Safi region of Morocco, Lamrini and Bouymjjane (2002) examined the ratio of the sexes and first maturation length and carried out the determination of the reproductive season using the gonadosomatic indexes (GSI) and reproductive properties

such as fecundity. Mohdeb and Kara (2014) made mention of some of the reproductive properties of the species distributed in the Algerian coasts, which include the sex ratio, determination of the reproductive season, and first maturation length. In Turkey, in their study on the biology of the species living in Saroz Bay (the North Aegean Sea), Gül et al. (2014) determined the reproductive properties such as sex ratio, determination of the reproductive season, first maturation length, fecundity, and relationship between fecundity and length.

The reproduction studies in fishery biology focus on females because of by far the greater effect of egg count on offspring production (Murua and Saborido-Rey, 2003). Thus, the information about the fecundity, i.e., egg yield, length at reproductive maturity, duration of the reproductive season, and sex ratios of the females is of great importance in the studies on the management model for the regulation and control of the fishery industry and population dynamics and help further our knowledge of the status of the stocks (Murua et al., 2003; Huppell and Sullivan, 2000). The management model for the regulation and control of the fishery industry is important in population dynamics.

In this study, reproduction parameters such as the sex ratio, reproductive season, first maturation length, egg yield and its relationship with total length, and diameters of mature eggs of the species distributed in the Central Aegean Sea were determined. In addition to the only study on the reproductive properties of the species in the Turkish seas (Gül et al., 2014), this study reveals the egg diameter and other related values of the species. In ichthyoplankton science, egg diameter is one of the most important criteria used in the identification of the species. Especially the eggs of the species from the Sparidae family are quite similar and difficult to distinguish. Although, after fertilization, the eggs swell as a result of the water intake due to osmotic pressure, the mature eggs in the ovarium give, albeit little, information about the egg diameter of the species. However, there were no findings on the egg diameter of the species thus far. Today, in stock assessment studies, research about eggs and larvae are prevalently used (Somarakis et al., 2004; Somarakis et al., 2006; Stratoudakis et al., 2006; Murua et al., 2010; Taylan and Hossucu, 2016). Therefore, this study is believed to contribute to the stock assessment and fishery management of the species.

Material and Method

In the study, a total of 439 fish were collected from the commercial fishers hunting seasonally in Foça-Mordoğan, İzmir, Turkey, during the period from December 2012 to March 2014. In the laboratory, total length measurements of the fish samples were performed using a 0.1 cm-interval fish measuring board; following the body and gonad weight measurements using a 0.01 g-sensitivity Scaltec electronic scales, sex determination was macroscopically carried out. To determine whether there were statistically significant differences between female and male fish, the chi-square (χ^2) test was performed. The gonad development of the female fish was determined following the 5-point maturity stage distinction method proposed by Holden ad Raitt (1974) (Table 1).

To determine fecundity, 16 ovaries at the 3rd and 4th stages of maturity from the summer season were fixed in a 4% formalin solution. Subsamples were collected from the ovaries by taking 2-5% of the ovaries by weight and the oocytes were counted using the gravimetric method.

Total fecundity was calculated by referring to the total oocyte count in the ovarium and using the $F= (n \times G)/g$ formula (Valladolid and Przybylski, 2008). In the gonadosomatic index calculation to determine the reproductive season, the $GSI= (BW-GW)/GW \times 100$ formula (King, 1995) was used in which BW represents the body weight and GW represents the gonad weight. Length at first maturity (Lm) was calculated according to the method of King (1996), size at maturity was defined as the size at which 50% of individuals were mature. An L50 computer program, performed with the LogLog function, was used to determine the length at 50% maturity (İlkyaz et al., 1998).

Results

Of a total of 439 fish samples collected during the study, 140 were male, 206 were female, and the sex of 93 fish samples were undetermined. The female: male ratio was 1.5: 1. According to the chi-square (χ^2) test, ($\chi^2=0.83<\chi^2_{t0.05}=3.85$, $P<0.05$) there were no statistically significant differences between female and male fish samples.

The gonadosomatic index values according to the seasons revealed that the reproductive period of the species was summer and autumn (Fig. 1). The length at first maturation of the species was 13.4 cm.

The length of the female fish that were used to determine fecundity was 16.6-22.3 cm (19.5±1.7) and fecundity was 74252-201187 eggs (123263±44586). There was an exponential relationship between fecundity and total length as $F= 10.643L^{3.111}$ and the results revealed that the fecundity increased as the female fish grew (Fig. 2). The diameter range of the mature eggs was 0.49-0.67 mm (0.59±0.06 mm).

Discussion

In the study carried out in İzmir Bay, of the 439 fish samples, 31.89% were male, 46.93% were female and 21.18% were undetermined. The sex ratios reported by some studies from around the world and Turkey were 69% female, 30% male and 1% undetermined (Lamrini and Bouymajjane, 2002); 50% female, 47% male and 3% undetermined (Mohdeb and Kara, 2014); 82% female and 18% male (Gül et al., 2014).

Table 1 A five-point maturity scale for partial spawners (Holden and Raitt, 1974)

Stage	State	Description
I	Immature	Ovary and testis about 1/3rd length of body cavity. Ovaries pinkish, translucent; testis whitish. Ova not visible to naked eye.
II	Maturing virgin and recovering spent	Ovary and testis about 1/2 length of body cavity. Ovary pinkish, translucent; testis whitish, more or less symmetrical. Ova not visible to naked eye.
III	Ripening	Ovary and testis is about 2/3rds length of body cavity. Ovary pinkish-yellow colour with granular appearance, testis whitish to creamy. No trans- parent or translucent ova visible.
IV	Ripe	Ovary and testis from 2/3rds to full length of body cavity. Ovary orange-pink in colour with conspicuous superficial blood vessels. Large transparent, ripe ova visible. Testis whitish- creamy, soft.
V	Spent	Ovary and testis shrunken to about 1/2 length of body cavity. Walls loose. Ovary may contain remnants of disintegrating opaque and ripe ova, darkened or translucent. Testis bloodshot and flabby.
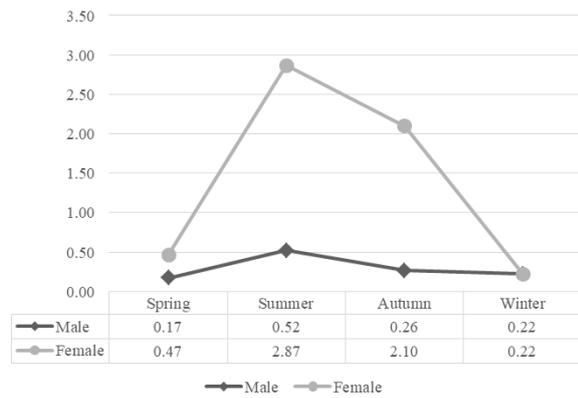
Figure 1 Seasonal variation of GSI in females and males

	Spring	Summer	Autumn	Winter
Male	0.17	0.52	0.26	0.22
Female	0.47	2.87	2.10	0.22

$F= 10.643L^{3.111}$
$R^2 = 0.62$
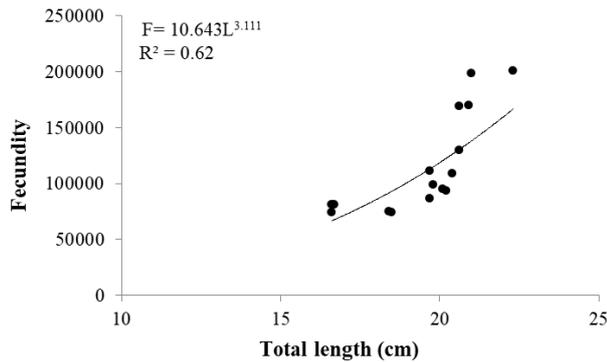
Figure 2 Fecundity-total length relationship of Dentex maroccanus

The previous studies revealed that the female fish were dominant, which agrees with the findings of this study. In this study, the female: male ratio was 1.5:1, while it was 1:0.9 in the study published by Mohdeb and Kara (2014) and 4.8:1 in the study published by Gül et al. (2014). The results reveal that female fish are dominant.

The findings both in this study and in other studies show that the reproductive season of the species is spring and autumn (Bauchot and Hureau, 1990; Lamrini and Bouymajjane, 2002; Mohdeb and Kara, 2014; Gül et al., 2014).

Gül et al. (2014) determined the first maturation length of females as 13.0 cm, which was found to be 13.4 cm in this study. The number of the studies on the egg yield of the species is quite insufficient. Gül et al. (2014) found that the fecundity of the species varied between 65.000 eggs and 362.000 eggs and determined an exponential relationship between fecundity and length ($F=0.981.L^{3.991}$) in Saroz Bay (Central Aegean Sea). The egg yield determined in this study was between 74.252 eggs and 201.187 eggs. There was an exponential relationship between fecundity and length ($F=10.643.L^{3.111}$). The difference between the fecundity values found in this study and the previous study was attributed to the length of the samples. Gül et al. (2014) used samples with a maximum length of 25. 2 cm, while the maximum length of the sample used in this study to determine fecundity was 22.3 cm. In their study, Lamrini and Bouymajjane (2002) determined a mean egg yield of 100 510 eggs. In this study, the mean egg yield was determined to be 123 263 eggs, which agrees with the results of the previous study.

The reproductive potential of a population is affected by many factors including spawning stock biomass (Bagenal, 1973; Myers and Barrowman, 1996), age and density of mature individuals (Alheit et al., 1983; Cardinale and Arrhenius, 2000), the ratio of the first and repetitive spawners (Evans et al., 1996; Trippel, 1998), the availability of food in the environment (Hislop et al., 1978; Hunter and Leong, 1981; Brooks et al., 1997), and sexual maturity length and age (Roof, 1981; Morgan and Hoening, 1997). Fecundity studies are of great importance in total population assessments, productivity and population dynamics studies, and the determination of the specific properties of the populations, subpopulations, and/or fish stocks (De Martini and Sikkel, 2006). Thus, fishery research increasingly includes these studies (Murua et al., 2003; Murua and Saborido-Rey, 2003; Trippel, 2003; Hutchings and Reynolds, 2004; Jacobsen et al., 2009).

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