

RESEARCH ARTICLE

**Determination of batch fecundity of garfish,
Belone belone, in the northern Aegean Sea**

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Abstract

This study reports the batch fecundity (BF) and oocyte diameters of *Belone belone* from the Aegean Sea (Izmir and Candarli Bays). A total of 51 female specimens of garfish were collected from January to December 2003. Oocyte diameters (n = 12140) of *B. belone* ranged from 0.063 to 3.5 mm, concentrating between 0.063 and 1.5 mm. The fish weight – BF relationships according to both hydrated oocyte and oocyte size frequency methods were $BF = - 0.3794 W + 192.22$ ($R^2 = 0.037$) and $BF = 5.165 W - 55.21$ ($R^2 = 0.218$), respectively. Mean oocyte numbers in the ovaries were 4144 ± 604 with varied from 662 to 15962. Maximum BF was 2130 (mean: 670 ± 97) in hydrated oocytes, and 8189 (mean: 1667 ± 559) in large oocytes. There was no linear relationship between BF and fish weight according to determination coefficients.

Keywords: Garfish, *Belone belone*, oocyte diameter, batch fecundity, Aegean Sea.

Introduction

The garfish, *Belone belone*, is distributed in the eastern Atlantic and Mediterranean Sea. Three subspecies were recognized by Collette and Parin (1986); *B. belone belone* in the Northeast Atlantic, occurring especially from France northwards; *B. belone euxini* in the Black Sea and Sea of Azov; and *B. belone gracilis* in the Mediterranean.

The garfish is epipelagic and lives solitarily or in small groups usually near the surface. It feeds on small schooling fish (Golani *et al.* 2006). According to FishBase (<http://www.fishbase.org/>), maximum recorded length and weight of the garfish is 93 cm TL and 1300 g, respectively (Froese and Pauly 2013).

Russell (1976) described that the eggs of *B. belone* were demersal, spherical with 3.0-3.5 mm in diameter, unsegmented yolk, membrane with filamentous and no oil globule. Spawning of large eggs, attached to vegetation and floating objects by sticky threads, occurs in coastal waters from May to June in the British Isles; February-May in Algeria, April-September in the Black Sea (Collette and Parin 1986; Golani *et al.* 2006).

Although there are some researches on reproductive biology of garfishes in all over the world (Rosenthal and Fonds 1973; Goldberg and Pizzorno 1985; Dorman 1989, 1991; Korzelecka-Orkiz *et al.* 2005; Hughes and Stewart 2006), there is a gap in the Aegean Sea. There has been a unique biological study, which also defines some reproductive properties of garfish in Izmir Bay, the Aegean Sea (Uçkun *et al.* 2004).

Recently, a new species (*B. svetovidovi*) of *Belone* was reported by Meriç and Altun (1999) for the Aegean Sea. According to our observations, *B. belone* and *B. svetovidovi* are using the same habitat for both feeding and reproductive activities in the same season (in late spring and early summer). This study reports some reproductive aspects such as oocyte numbers and diameters and determining the batch fecundity of *B. belone* in the Northern Aegean Sea.

Materials and Methods

A total of 51 female specimens of *B. belone* were collected from purse-seiners in northern Aegean Sea (Izmir and Çandarlı Bays) between January 2003 and December 2003 (Figure 1).

Mature gonads (n=51) of female specimens [total lengths ranged from 31.1 cm (32.4 g) to 58.4 cm (256.2 g)] were obtained and fixed in 4% formaldehyde solution. Maturity was assessed according to Gunderson's (1993) scale: stage I: immature, stage II: resting, stage III: developing, stage IV: ripe and stage V: spent. However, no gonads in stage V were observed in this study.

The batch fecundity (BF) was estimated by the "oocyte size frequency" (n=15) and the "hydrated oocyte" (n=36) methods (Hunter *et al.* 1985). According to gravimetric sampling (Holden and Raitt 1974), eggs were thoroughly washed and spread on blotting paper to dry in the air. Totally 2.0 g (\pm 0.1 g) oocytes from the gonads were counted in a Petri dish and their diameters were measured under a stereo microscope (10 x 1.5) with micrometric ocular (the measuring unit; 0.0625 ± 0.001 mm). Oocytes greater than 1.0 mm in diameter were assumed as "large oocytes".

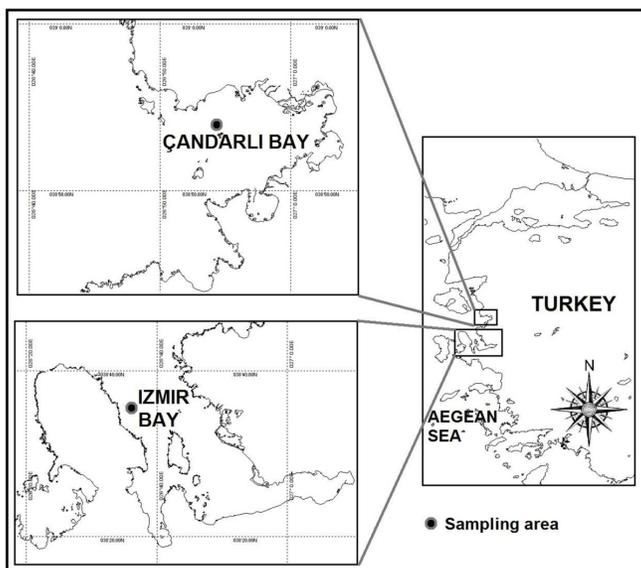


Figure 1. The map of the study areas

Fish (gonad free) weights (W) – BF relationships according to both methods were computed by linear regressions, where BF is batch fecundity (number), W is body weight (g), and a , b , c and d are constants. Means were given with standard error (\pm SE).

Results and Discussion

Oocyte diameters ($n = 12140$) of *B. belone* ranged from 0.063 to 3.5 mm, concentrating between 0.063 and 1.5 mm (Figure 2).

The fish weight – BF relationships according to both hydrated oocyte and oocyte size frequency methods were $BF = -0.3794W + 192.22$ ($R^2 = 0.037$) and $BF = 5.165W - 55.21$ ($R^2 = 0.218$), respectively (Figure 3). The number of oocyte in the ovaries varied from 662 to 15962 (mean: 4144 ± 604). Maximum BF was 2130 (mean: 670 ± 97) in hydrated oocytes, and 8189 (mean: 1667 ± 559) in large oocytes. There was no linear relationship between BF and fish weight according to the determination of coefficients.

The garfishes are multiple-spawner fish, spawning more than once during a reproductive season. There are several batches (most probably 3, as evidenced by oocytes of different size found in different parts of the ovary) (Goldberg and Pizzorno 1985; Korzelecka-Orkizs *et al.* 2005). Indeed, we observed various sizes of oocytes in the present study. Occurrence of the hydrated and larger

oocytes throughout the sampling period indicated that the garfish was a typical batch spawner and the reproduction might be continuous during the whole year with some peaks. However, the most abundant hydrated and larger oocytes, even the largest oocyte (3.5 mm) together in the same ripe gonads, were found in May. Therefore, the peak of the spawning is determined to be May.

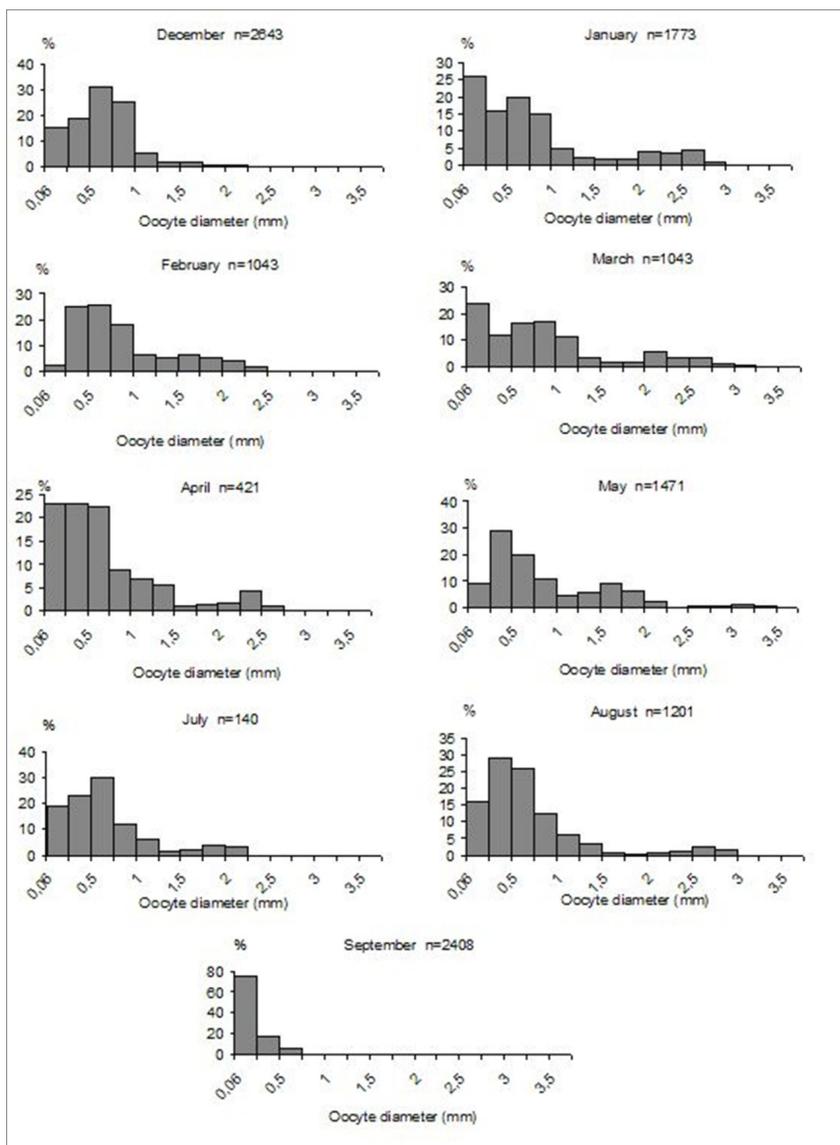


Figure 2. Distribution of oocyte diameters in monthly samplings of *B. belone*

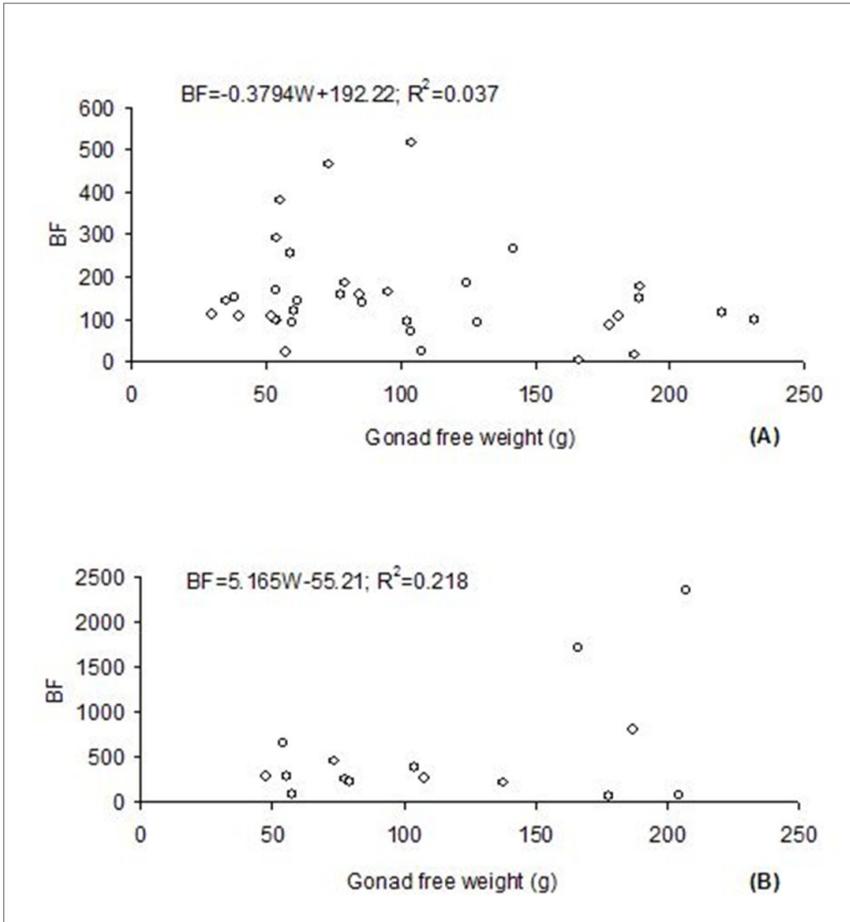


Figure 3. The fish weight – BF relationships [(A) hydrated oocyte, n = 36; (B) oocyte size frequency, n = 15] in *B. belone*

Collette and Parin (1986) reported that *B. belone* spawns from May to June in the British Isles; February-May in Algeria and April-September in the Black Sea. Dorman (1989, 1991) reported that spawning of the species occurred from early to late June for Southern Ireland, and from May to June for the Western coast of Sweden and from August to September for the Baltic Sea. Along the Dutch and German coast of the North Sea, spawning period of the garfish was primarily in May and June (Rosenthal 1970; Rosenthal and Fonds 1973). Yüce (1975) stated that the spawning season of this fish in the Sea of Marmara was extended from mid April to end of August. In the Aegean Sea, the maximal seasonal GSI values for garfish were found as winter and spring and the spawning period starts from late March and early April (Uçkun *et al.* 2004).

In the present study, the smallest reproductively active female was measured 311 mm TL and its gonad (2.3 g) contained 111 hydrated oocytes. The oocyte diameters of garfish ranged from 0.063 to 3.5 mm, concentrating between 0.063 and 1.5 mm. The largest oocyte (3.5 mm) was measured in May. However, some oocytes with 3.38 mm in diameter were also observed between March and May. Uçkun *et al.* (2004) reported that the oocyte diameters (n=794) of garfish from the Izmir Bay ranged from 0.4 to 4.00 mm. Yüce (1975) informed that the diameters of garfish from the Sea of Marmara were between 0.3 and 3.7 mm. Korzelecka-Orkizs *et al.* (2005) measured that the diameters of the smallest and the largest eggs of *B. belone* were 2.95 and 3.70 mm, respectively (mean: 3.27 ± 0.15) in Gulf of Gdansk (Baltic Sea, Poland).

In the current study, the mean number of oocytes in ovaries were 4144 ± 604 , with the range from 662 to 15962. Maximum BF was 2130 (mean: 670 ± 97) in hydrated oocytes, and 8189 (mean: 1667 ± 559) in large oocytes. Uçkun *et al.* (2004) calculated that the average number of oocytes was 7780 with the range from 1066 to 20446. Yüce (1975) reported that the number of oocytes of garfish from the Sea of Marmara varied from 10196 to 48903. Dorman (1991) stated that the fecundity estimates ranged from 2193 to 10804 eggs per ripe ovary. Hughes and Stewart (2006) estimated that mean BF for eastern sea garfish (*Hyporhamphus australis*), and for eastern river garfish (*H. regularis ardelio*), and for snub-nosed garfish (*Arrhamphus sclerolepis*) in south-eastern Australia were 1498 ± 110 (range: 98 - 3449); 917 ± 36 (range: 102 - 2268) and 716 ± 104 (range: 20 - 2956) ripe oocytes per female, respectively. Although, these results were found similar, differentiation from Yüce (1975) might be recognized. As he did not describe exactly which oocytes he counted. The maximal gonad weight reported by Yüce (1975) was 3350 mg ($=3.35$ g), whereas, there was a maximum 47.5 g gonad weight in our study.

In the present study, there was no strong linear relationship between BF and fish weight due to several reasons. The eel-like body form of the garfish (we could not give fish length-BF relationship due to negative determination coefficient) and the sampled fish in the study probable partially spawn, namely, there can be some fish with full gonads.

In conclusion, there is lack of studies on reproductive biology of the garfish in the Mediterranean probably due to sampling difficulties. However, the garfish is commercially important species in Turkish marine waters, and the further studies such as histological examinations, first maturity length/age, etc. are essential in order to determine the reproductive biology of the garfish for sustainable fishing.

Kuzey Ege Denizi'nde zargana balığının (*Belone belone*) bir defada yumurtlama miktarının belirlenmesi

Özet

Bu çalışma, Ege Denizi'nde İzmir ve Çandarlı Körfezleri'nden elde edilmiş *Belone belone*'lerin bir defada yumurtlama miktarını (BF) ve yumurta çaplarını rapor etmektedir. Toplam 51 dişi zargana bireyi Ocak-Aralık 2003 tarihleri arasında toplanmıştır. *B. belone*'nin yumurta çapları (n=12140) 0,063 ve 1,5 mm yoğunlukla, 0,063'den 3,5 mm'ye değişmektedir. Balık ağırlığı-BF ilişkisi hem hidrate yumurta hem de yumurta büyüklüğü yöntemlerine göre sırasıyla $BF = - 0.3794 W + 192.22$ ($R^2 = 0.037$) ve $BF = 5.165 W - 55.21$ ($R^2 = 0.218$) şeklindedir. Ovaryumlarda ortalama yumurta sayısı 4144 ± 604 adettir (min. 662 – maks. 15962). Maksimum BF, hidrate yumurtalar için 2130 (ortalama: 670 ± 97), büyük yumurtalar için 8189 (ortalama: 1667 ± 559) adettir. Korelasyon katsayısına göre BF ve balık ağırlığı arasında lineer bir ilişki yoktur.

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