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On the fecundity of the bogue *Boops boops* (Linnaeus, 1758) in the Turkish Aegean Sea

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ABSTRACT

Objective: To determine the fecundity of *Boops boops* (*B. boops*) from Aegean Sea coast of Turkey.
Methods: A total of 470 specimens of *B. boops* were collected monthly from November in 2008 to October of 2009 in Izmir Bay (central Aegean Sea). Total length and total weight of each fish were measured and the maturity stages of gonads were determined. About 30 mature ovariums were taken to determine fecundity and oocysts were counted by using gravimetric method.
Results: About 210 were females (44.7%) and 226 males (48.1%) while 34 (7.2%) were hermafrodite in terms of sexuality with sex ratio (female: male) of 0.93:1.00. The fecundity of the bogue was assessed by the gravimetric method with 30 ovaries from females between the total length of 19.6 and 27.6 cm [(mean: 23.5 ± 2.1) cm]. Estimates of total fecundity varied between 33 072 and 66 123 oocytes (mean: 49 008 ± 8 826) and fecundity–total length, fecundity–weight relationships were expressed as :$F = 8207.6e^{0.075TL}$, $F = 30297e^{0.003TW}$ respectively.
Conclusions: The results of the study will contribute to the reproductive biology of *B. boops* and will be useful for management of fisheries.

1. Introduction

The bogue, *Boops boops* (L., 1758) (*B. boops*), is a teleost belonging to the Sparid family. It is an important species in the Mediterranean Sea and geographically distributes from Norwegian to Angolan coasts along the east Atlantic and from Mexican Gulf to Caribbean Sea as well as in the Mediterranean and Black seas[1].

B. boops is captured across all Turkish seas, mainly in Aegean Sea all the year round and regularly presented to local fish markets. The total production amount of the species in Turkish seas is 2 226.2 tones, 1 662.2 of which comes from the Aegean Sea[2]. An efficient fisheries method is necessary to protect natural sources and ensure their sustainability. It is of great importance that knowledge of biological studies be reconfirmed in terms of optimal economic evaluation of present stocks. Most studies on age and growth biology of *B. boops* have been conducted in the Mediterranean region over the last 30–35 years[3-10]. However, the studies regarding its reproduction are very limited[6,11-13]. Reproduction studies are given great importance in recent years especially the ones concerning the maintenance of the continuity of fish stocks and a good fisheries management. Sex ratio studies provide information to the presentation of male and female fish in a population. It states the proportion of male and female fish in a population and indicates the dominance of sex of fish species in a given population. Sex ratio also constitutes basic information necessary for the assessment of the potential of fish reproduction and stock size estimation in fish population[14]. An important aspect of reproductive biology is fecundity which gives information on the number of eggs in the ovary before the next spawning season[15]. Studies on fecundity of fish species are pertinent and useful for systematics in racial studies related to total population estimation and productivity[16].

However, there has not been any studies on the reproductive biology of the species in Turkish coasts. In this research that we conducted to the end, certain reproductive features of bogue such as spawning amount and egg size were identified for Izmir Bay, one of the major fishing areas in the Aegean Sea. It is hoped that the information obtained from this study will contribute to our knowledge of the reproductive biology of *B. boops* and will be useful for management of fisheries.

2. Materials and methods

In total, 470 specimens of *B. boops* were collected monthly from November in 2008 to October in 2009 in Izmir Bay (central Aegean Sea). Samples were obtained from commercial fishermen who generally use gill nets, trammel nets and gill net-trammel net combination to capture fish. Captured fish were placed in iceboxes and transported to the laboratory where total length of each fish

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was measured to the nearest millimetre, and total weight of each specimen was measured with a digital balance to an accuracy of 0.01 g. The maturity stages of gonads of female individuals were based on 8 development stages[17] (Table 1). According to previous study[10], the reproduction period of the bouge species in the Izmir Bay was late winter and early spring. The maximum gonadosomatic index value was 5.121 (February) for male individuals and 4.500 (February) for female individuals. According to these results, 30 ovariums from mature female individuals in the reproductive stage were fixed in 4% formalin solution to determine fecundity. Sub–samples were taken, accounting for 2%–5% of the ovary weight, eggs were counted by using gravimetric method and egg diameters were measured with Olympus SZ60 model binocular microscope. Only oocytes between 530 and 740 µm were considered as mature. After oocysts were counted with gravimetric method, the following formula was used to calculate the total egg count in ovarium:

Fecundity = Weight of ovary × Number of eggs in the sample/ weight of sample[17].

The *Chi*-square (χ^2) test was used in order to determine whether there was a statistically significant difference between the female-male ratio. To establish the relationship between fecundity and total lenght and total weight, $y = ae^{bx}$ regression model was used.

3. Results

It was found in the research that out of 470 examined bouge, 210 were female (44.7%), 226 were male (48.1%) and 34 were hermaphrodite (7.2%). Total length of all *B. boops* specimens ranged from 11.3 to 27.9 cm. The weight distribution of specimens varied between 12.1 and 261.8 g. The sex ratio (female: male) of the sampled specimens was 0.93:1.00. *Chi*–square test (χ^2) was performed to determine whether there were statistically differences in ratio between female and male and the difference was determined in autumn and spring (Table 2). In this study, only two stages of gonadal development were observed in female *B. boops*, which were stages IV and V (Table 1).

The total length of 30 mature females (20 in winter, 10 in spring) examined ranged from 19.6–27.6 cm (mean: 23.5), while the total weight ranged from 78.5–260.2 g (mean: 152.7). The total fecundity varied between 33 072–66 123 (mean: 49 008) (Table 3). Fecundity–length and fecundity–weight regression equations can be expressed as follows: $F = 8207.6e^{0.075TL}$ ($R^2 = 0.79$), $F = 30297e^{0.003TW}$ ($R^2 = 0.71$) (Figures 1 and 2). Fecundity–body length and fecundity–body weight were positively correlated. However, the relationship of fecundity and size of *B. boops* revealed that fecundity was more related to body length than to body weight. In our study, oocytes with a diameter between 0.53–0.74 mm (mean: 0.60) were considered as mature.

Table 1

Stages of gonadal developments of *B. boops*.

Stages	State	Macroscopic characteristics of ovaries and testes
I	Virgin	Sexual organs are very small, situated close to vertebral column. Testis and ovary are transparent, colourless or grey. Eggs are not visible to naked eye.
II	Maturing virgin	Testis and ovary are translucent, grey–red. Length of gonads is 1/2, or slightly more, of length of ventral cavity. Individual eggs can be seen with magnifying glass.
III	Developing	Testis and ovary are opaque, reddish with blood capillaries, occupying about 1/2 of ventral cavity. Eggs are visible to naked eye as whitish granular material.
IV	Developed	Testis is reddish–white, with no milt produced under pressure. Ovary is orange–red. Eggs are clearly discernible, and opaque. Testis and ovary occupy about 2/3 of ventral cavity.
V	Gravid	Sexual organs fill ventral cavity. Testis is white, with drops of milt produced under pressure. Eggs are completely round, and some already translucent and ripe.
VI	Spawning	Roe and milt run under slight pressure. Most eggs are translucent with few opaque eggs left in ovary.
VII	Spent	Not completely empty, and no opaque eggs are left in ovary.
VIII	Resting	Testis and ovary are red and empty. A few eggs are in state of resorption.

Table 2

Seasonal variation of females.

Season	Total	% of females	χ^2 calculated	*P* value
Summer	40	52.50	0.05	$P < 0.05^*$
Autumn	47	82.98	10.01	$P > 0.05$
Winter	120	60.00	2.40	$P < 0.05^*$
Spring	229	34.06	11.60	$P > 0.05$
Annual	436	48.17	0.29	$P < 0.05^*$

*: Statistically significant difference in ratio between female and male.

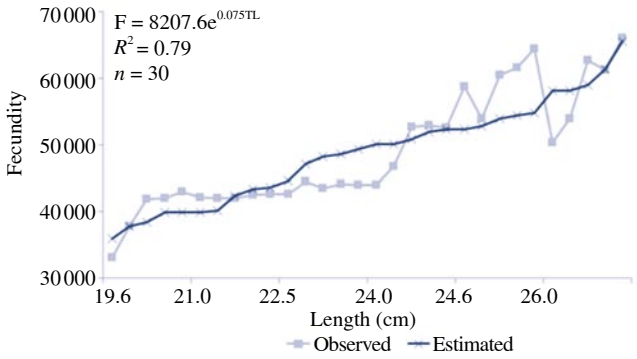

Figure 1. Relationship between fecundity and length for *B. boops*.

Table 3

Results of the total length, total weight and fecundity estimates obtained for 30 individuals sampled.

Fish number	Total length (cm)	Total weight (g)	Fecundity
1	19.6	78.53	33 072
2	20.3	80.54	37 802
3	20.5	83.79	41 946
4	21.0	88.45	41 980
5	21.0	96.22	42 000
6	21.0	98.53	42 980
7	21.1	98.67	42 112
8	21.8	109.99	41 999
9	22.1	116.78	42 509
10	22.2	116.98	42 600
11	22.5	117.88	42 609
12	23.2	128.55	44 570
13	23.5	145.87	52 682
14	23.6	148.41	43 530
15	23.8	156.20	44 100
16	24.0	164.3	46 716
17	24.0	170.0	44 000
18	24.2	178.4	44 062
19	24.5	182.5	58 807
20	24.6	183.5	53 899
21	24.6	185.2	62 752
22	24.7	189.1	52 602
23	25.0	189.5	64 418
24	25.1	190.4	61 232
25	25.2	191.8	53 876
26	26.0	198.0	60 500
27	26.0	199.9	61 562
28	26.2	202.7	52 906
29	26.7	231.4	50 279
30	27.6	260.2	66123

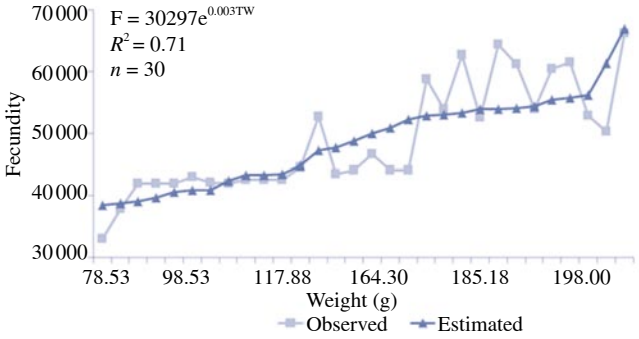

Figure 2. Relationship between fecundity and total weight for *B. boops*.

4. Discussion

The female: male ratio of bogue was estimated as 1.25: 1 by Livadas[18]. In most fish species in nature and produced under normal circumstances, the sex is determined genotypically by using gonadal sex determination. According to this mechanism, tiddlers' distribution of sex is almost equal to the ratio of 1: 1 (female: male[19]. In bogue population, numbers of females and males are usually similar. It is found the reproductive period to be February and April for both males and females by Hassan[20]; February and March[6]; February, March and April[12], which is similar to our findings.

In his study, the biological features of *B. boops* and *Boops salpa* species belonging to the Sparidae family were compared[20], and the fecundity in individuals belonging to *B. boops* species was investigated with total length between 13.0–22.0 cm and the total fecundity of the species was found to be 5 185–52 208 eggs. In a study that he conducted in the Mediterranean[12], it was found that the fecundity was 1 296–51 528 in 462 individuals with total length of 10.6–20.8 cm of *B. boops*. That is similar to our study. Gordo investigated the fecundity for *B. boops* species seen in Portuguese coast with 75 ovariums (total length between 14–36 cm) using volumetric method and found it to be 11 550–357 800[6], which is significantly higher compared to our study. This is due to the different methods used to determine fecundity.

In his study, El–Agamy, *et al.* determined these relationships as Fa = -61688 + 5037L, Fa = -12398 + 730.33W respectively (Fa is the absolute fecundity and L is the mean total length in cm and W is the mean weight in grams)[12], and identified eggs with a diameter between 0.51-0.68 mm as highly mature, which is similar to our study. In studies undertaken on some other species of the Sparidae family, similar results were observed by Hadj Taieb, *et al.* for *Diplodus vulgaris*; and by Talet Lotfi, *et al.* for *Pagellus acarne*[21,22].

Conflict of interest statement

We declare that we have no conflict of interest.

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