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Fecundity of the blotched picarel, *Spicara maena* (Linnaeus, 1758) from Oran Bay (Western Mediterranean Sea)

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Abstract
The fecundity of the blotched picarel *Spicara maena* from the western Mediterranean (Oran Bay) was assessed by the volumetric method. Total length (TL) of studied females varied between 91 and 140 mm (mean ± SD: 111.9 ± 10.6 mm). Estimates of total potential annual fecundity varied from 16,750 to 28,125 oocytes per individual (mean ± SD: 21,404.7± 2,698.8). Relationships between total potential fecundity (*F*) and TL, total weight, gonad weight were established using the multiplicative regression model and a high significant correlation was found in all the cases.

Keywords: Blotched picarel; *Spicara maena*; Sparidae; fecundity; Oran Bay.

1 | INTRODUCTION

The fecundity of a fish is defined as the number of eggs that are likely to be laid during a spawning season (Bagenal and Braum 1978). The reproductive potential is an important biological parameter that plays a significant role in evaluating the commercial potentials of fish stocks (Gómez-Márquez 2003). Also, fecundity is an important aspect of the reproductive biology of species which must be understood to manage the species concerned including exploration of aquaculture potentials. The fecundity-size relationship has been used principally as a rapid means of predicting the fecundity of fish stocks when the length distribution is known (Dulčić *et al.* 1998).

The fecundity and its relation to body size make it possible to estimate the potential of egg output (Chondar 1977) and the potential number of offspring in a season and reproductive capacity of fish stocks (Qasim and Qayyum 1963). Variations in number of oocytes emitted seen from year to year, and over decades, reflect the amelioration or deterioration of the habitat in relation to the individual fish (Nikolskii 1969).

Spicara maena (Linnaeus, 1758) is a commercial species inhabiting in the Mediterranean, Black Sea, and along the European and African coast of Atlantic, from Morocco to Portugal and Canary Islands (Fischer *et al.* 1987) and very frequent on the western Algerian coast (Figure 1). This species commonly inhabits over posidonia beds and sandy or muddy bottoms, and distributes up to 100 m depth (Soykan *et al.* 2010). *S. maena* feeds primarily on zooplankton (Froese and Pauly 2017). It is often caught at depths ranging from 100 to 150 m (personal observation), by trawl or trammel net, most commonly used fishing techniques (Kadari 1984).

Published works on *S. maena* focused on several aspects including growth, feeding habits or mollecular differentiation (Dulčić *et al.* 2000; Ciçek *et al.* 2007; Ismen *et al.* 2007; Karakulak *et al.* 2007; Altinagac *et al.* 2009; Imsiridou *et al.* 2011; Minos *et al.* 2013; Cengiz *et al.* 2014; Karachle and Stergiou 2014; Saygili *et al.* 2016a, 2016b) but investigations on reproductive biology of this species are very limited and reported only from the Turkish waters (Ciçek *et al.* 2007; Soykan *et al.* 2010) and Adriatic Sea (Matic-Skoko *et al.* 2004).

However, in Algerian waters works are limited to the study of feeding habits of *S. maena* (Harchouche *et al.* 2009). Therefore, the present study aims to estimate the fecundity of this species for the first time in relation to total length, total weight and gonad weight to help comparative studies in the Mediterranean.

2 | METHODOLOGY

Specimens of *S. maena* (*N* = 2,638) were caught by trawlers operating in Oran Bay located on the North West of Algerian coasts (West Mediterranean Sea) situated between "Pointe de l'Aiguille" and "Cap Falcon" (35.95°N – 0.65 °E) (Figure 1) at depths ranging between 100 and 150 m between April 2002 and June 2003 and only 64 mature females (stages III and IV) were taken for fecundity estimation.

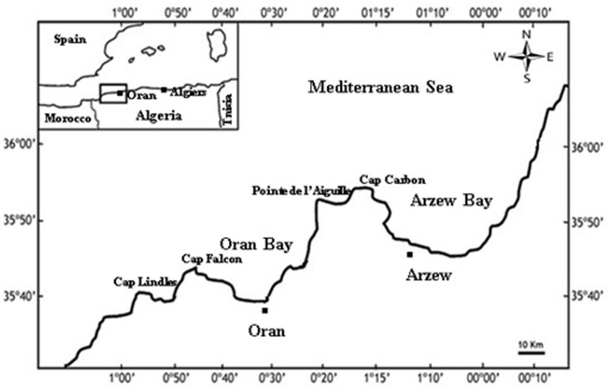

FIGURE 1 Map of the study area (Oran Bay)

The sex of individuals was determined macroscopically after opening the abdominal cavity and stages of maturity were classified according to colour, shape, vascularization and the volume occupied in the abdominal cavity as follows (Harchouche 2006, adapted): I, immature; II, resting; III, ripe; IV, ripe and running; V, spent (Table 1). Fork length (TL) was measured with an ichthyometer to the nearest mm, total weight (Wt) to the nearest g and gonad weight (Wg) to the nearest 0.01 g using a precision balance.

For fecundity estimates, the volumetric method was employed, ovaries were labelled and dropped in Gilson's fluid, a preservative and dissociative solution (100 ml 60% alcohol, 800 ml water, 15 ml 80% nitric acid, 18 ml glacial acetic acid, 20 g mercuric chloride) (Stéquert and Ramcharrun 1995). The ovaries were shacked periodically to help loosen the ovarian tissue and ensure rapid penetration of the preservative. After 48 hours in preservative, the eggs can be completely liberated from the tissues by vigorous shaking (Holden and Raitt 1974). Eggs were cleaned and put in a measuring cylinder and made up to a known volume with water.

TABLE 1 Macroscopic description of *Spicara maena* gonads

Stage	*Description*
I: Immature	Transparent or pale pink small filamentous gonads, (invisible oocytes).
II: Resting	Pale pink to light orange firm ovaries; some oocytes can be visible through ovarian membrane.
III: Ripe	Usually orange clear then dark more developed and less firm gonad; the visible oocytes confer a grainy aspect of the ovary.
IV: Ripe and running	Voluminous very vascularised ovary occupying the entire abdominal cavity with a very thin ovarian membrane; the hyaline eggs are visible and are emitted with a simple pressure exerted on the abdomen.
V: Spent	The ovary is flaccid, vascularized; the colour is red-pink with the typical general appearance of an empty bag.

Subsamples were then taken by shaking the container until all the eggs are evenly distributed through the water; a subsample of known volume was picked-up with a Stempel pipette (Holden and Raitt 1974), and the number of eggs in the subsample was counted with a Dollphus box under a binocular microscope (G×16). Only oocytes with diameter between 200 and 760 µm were considered as mature (Harchouche 2006) corresponding to eggs in stage III (ripe: vascularized light orange ovary occupying almost the abdominal cavity with visible oocytes conferring a granular aspect to the gonad) and stage IV (ripe and running: voluminous vascularized orange ovary occupying all the abdominal cavity containing hyaline eggs that can be easily expulsed by simple pressure on the abdomen).

Given the very soft and fragile characteristics of gonadal tissue, only 64 females from 2,638 specimens were taken for fecundity estimation during April–June of the sampling period corresponding to the reproduction period of the species (Harchouche 2006, Soykan *et al.* 2010). The degree of association between fecundity with total length (TL), total weight (TW) and gonad weight (GW) was assessed by the coefficient of determination (R^2); statistical significance level was estimated by a *t*-test using Excel 2016© software.

We used the multiplicative regression model ($y = ax^b$) modified with the logarithmic function then measures were log-transformed in order to eliminate any effect of 'scale', to keep relations linear and their variances comparable (Froese 2006). The equation can be expressed as:

$$\text{Log } F = b \text{ Log } X + \text{Log } a,$$

where *F* is the fecundity, *X* is TL, TW or GW; *a* is the intercept of the regression and *b* is the regression coefficient.

3 | RESULTS AND DISCUSSION

Of 2,638 specimens of *S. maena* collected, 120 were male and 2,610 were female and sex ratio was 1:20.98 (male to female) was in favour of female during all months of the sampling period. Given the gonads fragility, only 64 gonads were considered for the fecundity estimation ranging from 16.9 to 26.3 cm TL (mean ± SD: 206.6 ± 19.9 cm) weighing 63.5 to 234.2 g (mean ± SD: 110.0 ± 37.6 g) with gonadal weight of 1.2 to 6.1 g (mean ± SD: 3.1 ± 1.2 g). Potential fecundity (*F*) ranged from 19,875 to 49,125 (mean ± SD: 29,448.9 ± 8,198.1), the value of SD can be explained by the biometric variation of the specimens. Added to this, the volumetric method is subject to considerable bias because it is very difficult to get all the eggs evenly distributed throughout the measuring cylinder (Holden and Raitt 1974).

Table 2 and Figure 2 show the relationships between total potential fecundity and TL, TW and GW obtained from the application of the multiplicative regression model. The significance test (*t*-test) calculated for the regression coefficient of the relationship between fecundity and TL, TW and GW of *S. maena* was higher than tabulated *t*-value ($t = 3.46$, $df = 62$) confirming high correlation.

Knowledge of fecundity is regarded as an important contributor in understanding stock dynamics and obtaining basic biological information for use in stock assessments. Estimated fecundity for *S. maena* of Oran Bay was compared to other results found in the literature (Table 3).

Only a few articles are available in the literature concerning the biology of *S. maena* and more precisely dealing with reproduction and fecundity to allow us to compare our results.

However, in the current study, the mean number of oocytes in ovaries was 29,448 ± 8,198, with a range from 19,875 to 49,125 oocytes number and 16.9 to 26.3 cm of TL. The statistical analysis revealed that the relationships between fecundity and TL, TW and GW were found significant (all $P < 0.001$) and that the fecundity increases linearly with the increase ($0.92 < R^2 < 0.98$) of TL, TW and GW (Table 1) of specimens. The total weight related to absolute fecundity appeared to be the more appropriate parameter to estimate fecundity for *S. maena*.

Table 2 Relation between absolute fecundity (F), total length (TL), total weight (TW) and gonad weight (GW) of *Spicara maena* collected from the Oran Bay (Algeria)

Relationship	*Equation*	R^2	*t-test*
F vs TL	LogF = 1.3197 LogTL + 2.945	0.979	53.39*
F vs TW	LogF = 0.4216 Log TW + 3.794	0.986	64.80*
F vs GW	LogF = 0.4670 LogGW + 4.228	0.903	24.06*

*, significant relationship ($t = 3.46$, $df = 62$; $P < 0.001$)

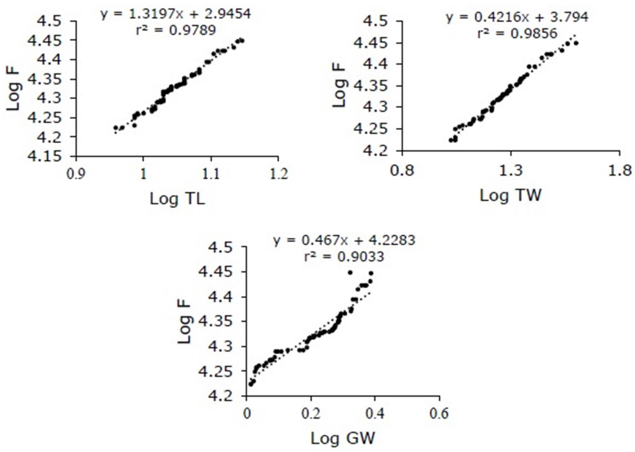

FIGURE 2 Relationship of total fecundity (*F*) to total length (TL; above left), total weight (TW; above right) and gonad weight (GW; below) of *S. maena* female

TABLE 3 Fecundity of *Spicara maena* given by different authors

Locality	*Fecundity* (range; mean±SD)	*N*	*Length (cm)*	*Source*
Eastern Adriatic Sea	42,140 – 80,509 (64,730 ± 9,634)	74	13.5–20	Matik-Skoko *et al.* 2004
Algiers Bay, Algeria	9,000 – 92,000 (30,960 ± 5,420)	42	11.5–18.5	Harchouche 2006
Oran Bay, Algeria	19,875 – 49,125 (29,448 ± 8,198)	64	16.9–26.3	Present study

Despite the difference in length range during sampling, our results were found similar to Harchouche (2006) who estimated fecundity of *S. maena* between 9,000 and 92,000 for a total length ranged from 11.5 to 18.5 cm. Matik-Skoko *et al.* (2004) estimated the fecundity between 42,140 and 80,509 with a mean fecundity equal to 64,730 eggs.

The variation of fecundity is very common in fish (Doha and Hye 1970; Kraus *et al.* 2000) and the number of eggs produced by an individual female is dependent on various factors like size and age (Lagler *et al.* 1967, Burt *et al.* 1988, Munro *et al.* 1990; Alam *et al.* 2012). In addition, some authors attribute these differences to food availability and /or quality in *S. maena* (Matik-Skoko *et al.* 2004). Several studies on genus *Gadus* revealed that temperature can affect the fecundity positively (e.g. Kjesbu *et al.* 1998, Kraus *et al.* 2000). Dulčić *et al.* (1998) compared fecundity in Sparidae family and concluded that fecundity oscillates considerably depend on the species and geographical location.

In conclusion, there is lack of data on reproductive biology of *S. maena* a commercially important species for the Mediterranean and Algerian fisheries. Further studies on the histological approach, first maturity, growth and exploitation status will be treated in order to determine details of the reproductive biology of the blotched picarel.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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CONTRIBUTION OF THE AUTHORS

FD & LBT fish specimen collection, fecundity estimation and data analysis; **LBT** manuscript preparation; **LBT & ABT** research supervision; **SMEAAA** provided laboratory facilities

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