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Fecundity of blotched picarel, *Spicara maena* L. (Teleostei: Centracanthidae), in the eastern central Adriatic Sea

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We studied the fecundity of Spicara maena *L. collected in the eastern central Adriatic Sea at the peak of the spawning period (from 16 September to 10 October). Due to protogyny, females up to a total length of 20.0 cm were observed. Absolute fecundity varied from a minimum of 42140 eggs for two-year-olds to a maximum of 80509 for three-year-olds. The mean oocyte diameter ranged 1.68-1.92 mm. The relationships between absolute fecundity and total weight and length of the females were best described by the following exponential equations:* $F_l = 33.4\ TL^{2.6}$ ($r^2 = 0.933$) *and* $F_w = 560.2W_t + 15874$ ($r^2 = 0.693$). *There was no significant correlation between oocyte size and maternal size.*

Key words: fecundity, *Spicara maena*, Centracanthidae, eastern Adriatic

INTRODUCTION

The blotched picarel, *Spicara maena* L. (Centracanthidae), is a common fish in the Adriatic Sea. It occurs also in the Mediterranean and Black Seas, in the Atlantic Ocean from Portugal to Morocco, and in the Canary Islands (JARDAS, 1996). Published literature on the biology and ecology of this species is limited to some morphological and meristic data (SALEKHOVA, 1979), length-weight relationships (PETRAKIS & STERGIOU, 1995; DULČIĆ & KRALJEVIĆ, 1996), age, growth, and mortality (DULČIĆ *et al*., 2000). This preliminary study contributes information on the reproductive biology of blotched picarel by reporting the first data on the fecundity of the species. *S. maena* is a protogynous hermaphrodite (LEPORY, 1960; REINBOTH, 1962; JARDAS, 1996; DULČIĆ *et al*., 2000). Females mature at 13 cm as they approach the age of two years (JARDAS, 1996; DULČIĆ *et al*., 2000).

MATERIAL AND METHODS

Samples were collected from beach seine nets (22 mm mesh when stretched) by professional fishermen, three times during the blotched picarel spawning season from 16 September to 10 October 1996, in the eastern central Adriatic (Fig. 1).

From the total sample of 573 adult specimens, 238 were females. Gonads were examined to determine the sex and reproductive stage of

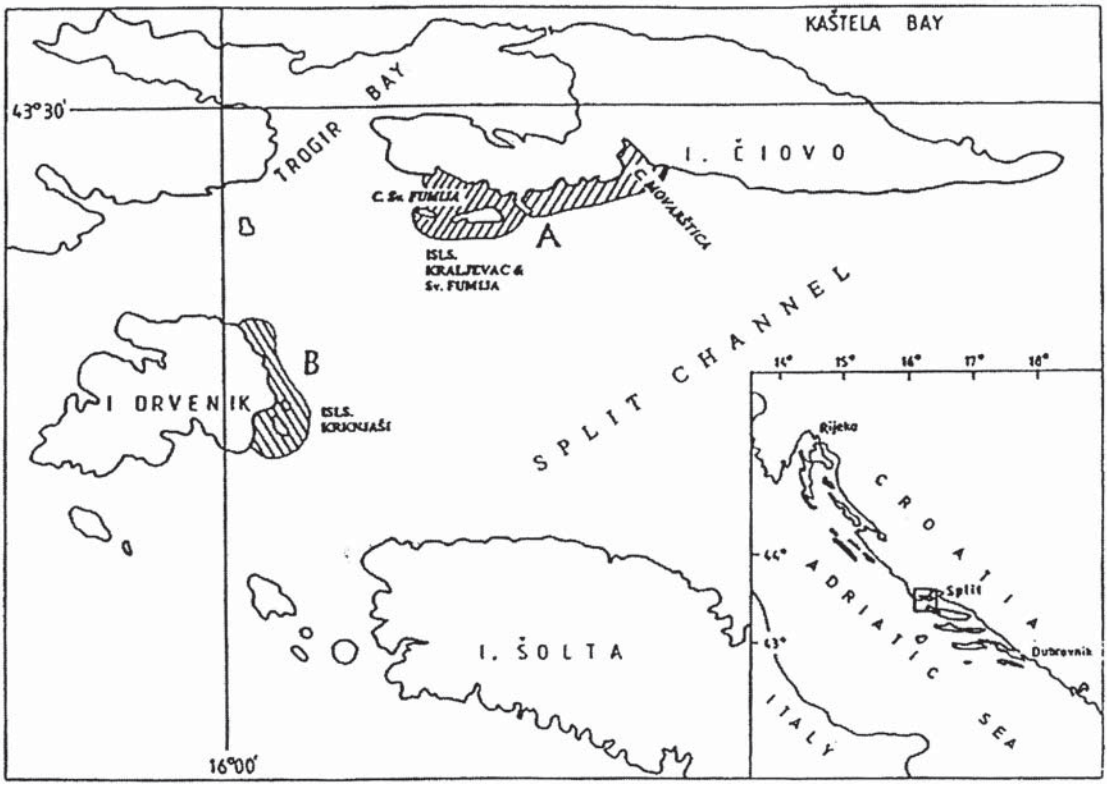

Fig. 1. Sampling areas in the eastern central Adriatic Sea (A – southern coast of Čiovo Island from cove Mavarštica to cove Sv. Fumija including Kraljevac and Sv. Fumija Islets; B – eastern coast of Veli Drvenik Island including Krknjaši Islets

the females. Total length of the females was measured to the nearest 0.1 cm and gross weight was measured to the nearest 0.1 g. Age was determined by scale reading (using a binocular microscope Reichert at 40x and 60x magnification), based on annulus counts and information regarding the spawning season (from mid-September to mid-October; VIDALIS & TSIMENIDIS, 1996; DULČIĆ *et al*., 2000). A gonad maturity stage was assigned to each specimen using the sexual development classification and criteria proposed by NIKOLSKY (1976).

Ovaries were immersed in GILSON'S fixative (SIMPSON, 1951) for two to three months. This solution not only preserves oocyts, but also breaks down the intraovarian connective tissues after several weeks without damaging the ova. To allow better penetration of the fixative and facilitate membrane breakdown, the ovaries were frequently shaken. After three months of preservation, the ovaries were washed thoroughly in cold water. Oocyte diameters were measured using a binocular microscope fitted with an eyepiece micrometer.

Only gonads with mature and hydrated oocytes (stage V-VI, spherical, transparent, easily visible to the naked eye, with blood capillaries on the surface due to the breakdown of the folicule membranes, and easily released after light pressure) were used for fecundity analysis. Seventy-four females (31.1%) had mature oocytes. Fecundity was determined for both maturing gonads by dividing the number of oocyts in three subsamples (each of 0.1 g, measured to the nearest 0.0001 g with an electronic analytical balance) by the weight of the whole gland. Earlier investigations showed that three tissue samples per ovary of some fish species are adequate to obtain good precision, and that the location of the subsamples within the ovary does not affect the estimate (SANZ & URIARTE, 1989), as we confirmed by analysis of

variance (F = 2.51, p>0.05). Three subsamples from one ovary of each fish showed high homogeneity (F = 2.76, p>0.05), and their mean value was used in further estimations. We weighted the same ovaries and their sample sections to the nearest milligram on a METTLER balance to make gravimetric determinations. This method involved weighting a known number of mature ova and proportionally computing the total number of oocyts in both ovaries by the following formula: Fecundity = wt of the ovary x no. of oocyts wt^{-1} of the sample. Relative fecundity was estimated as the number of oocyts per g body weight.

The multiplicative (power) regression model was used to establish relationships between total potential fecundity (F) and total length (TL), gonad weight (Wg), and age.

RESULTS

Total length of the 74 females with mature oocytes ranged 13.5-20.0 cm (mean 18.29±1.048 cm). Age ranged 2-3 years. Sixty-three females were three years old with oocyts in stages V-VI. The oocytes of two-year-old females were mainly in stages III-IV (68.9%). Total weight ranged 58.74-119.40 g (mean 87.21±14.313 g). The ripe ovaries occupied the greatest part of the body cavity and were orange. The two ovaries of a single female were almost equal in length and size. Gonad weight fluctuated 7.23-21.73 g (mean 14.06±3.409 g).

Total mean potential fecundity per fish ranged from 42140 oocyts for the smallest mature female (15.7 cm) to 80509 oocyts for the largest (20.0 cm; mean 64.730±9634.2). The mean mature oocyte diameter ranged from 1.68 mm (TL = 17.6 cm) to 1.92 mm (TL = 17.8 cm). There was no significant correlation between the mean number (r^2 = 0.268) or diameter (r^2 = 0.137) of the mature oocytes and total length of the females (Fig. 2).

The relationship between total potential fecundity (F) and length (TL) was $F_{TL} = 33.4TL^{2.601}$ (r^2 = 0.933). The relationship between total potential fecundity and total weight (Wt) was F_{Wt} = 560.2Wt + 15874 (r^2 = 0.693). The relationship between total potential fecundity and gonad weight (Wg) was $F_{Wg} = 412Wg^{0.175}$ (r^2 = 0.905). The relationship between total potential fecundity and age (A) was $F_A = 41000A^{0.436}$ (r^2 = 0.205). Regression analysis showed that fecundity estimation exponentially increased

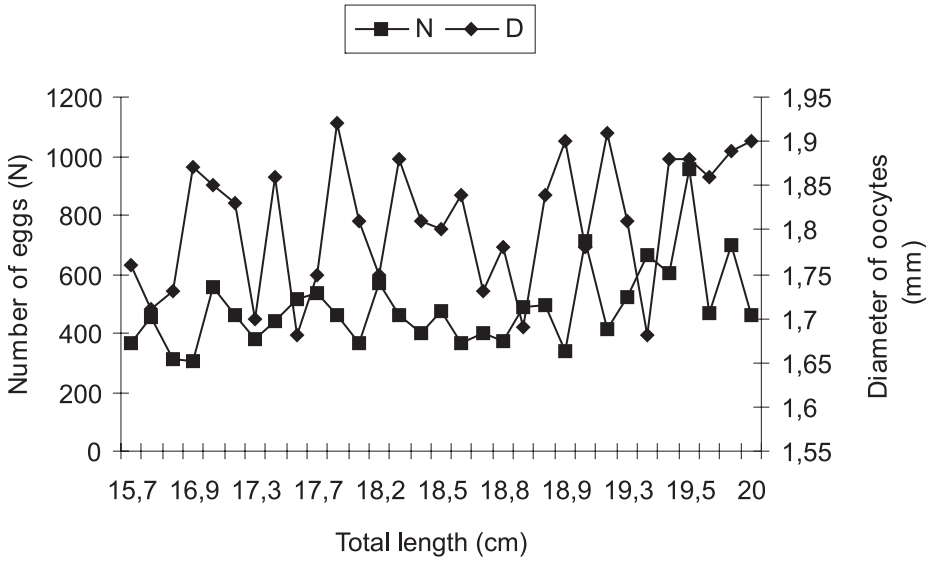

Fig. 2. The relationships between mean number of oocyts (N) and diameter of mature oocytes (D) and total length of S. maena *females*

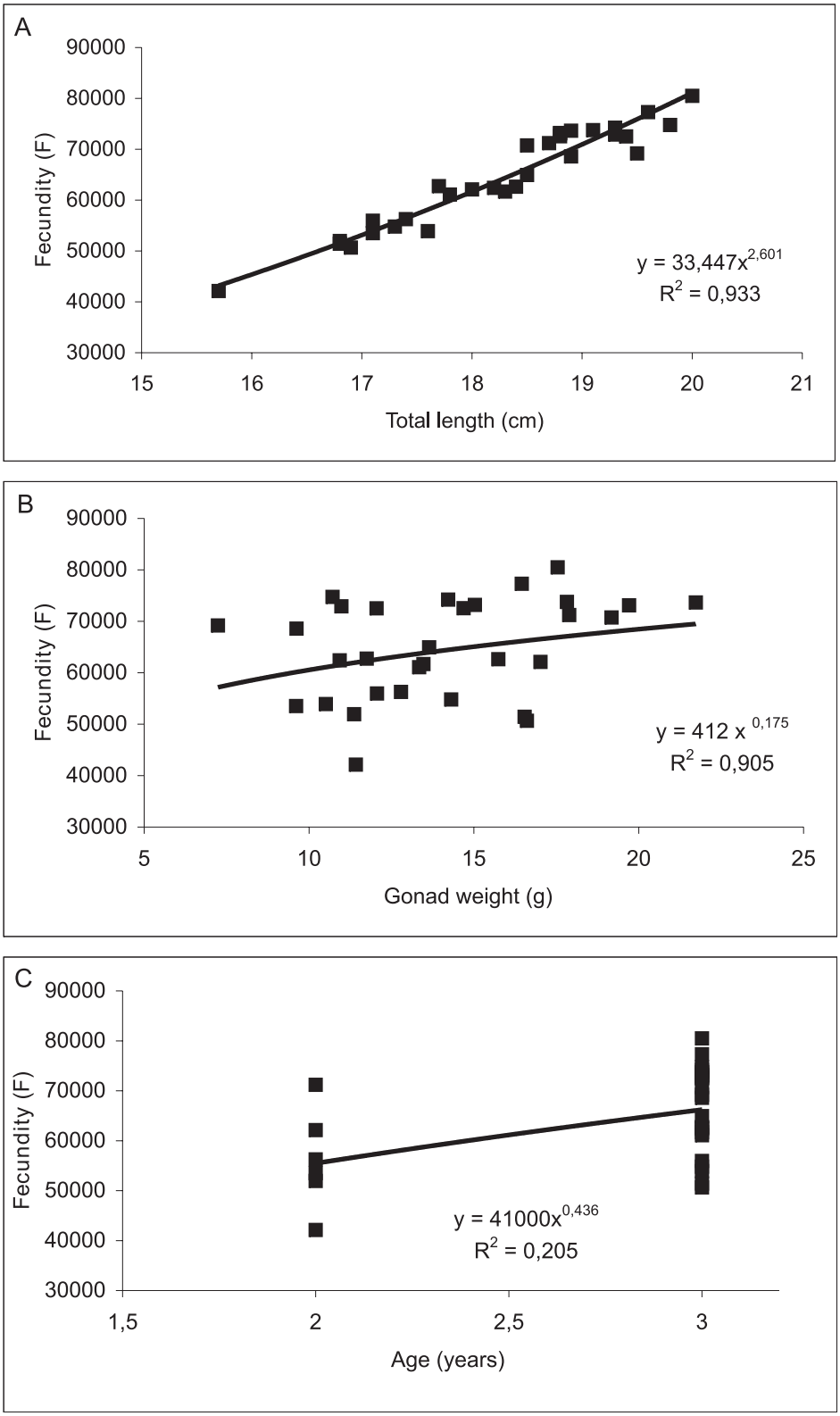

Fig. 3. The relationships between total potential fecundity and total length, total weight, and age obtained by application of regression models for S. maena *females*

with total length and gonad weight (Fig. 3). The differences among ages were not statistically significant. Relative fecundity appears almost constant, reaching a maximum of 9.56 oocyts per gram in the 19.5 cm length class.

DISCUSSION

Estimated annual fecundity is of great interest to fishery scientists as a critical parameter of stock assessment based on egg production (SAVILLE, 1964; LASKER, 1985) and as a basic aspect of fish biology and population dynamics. The abundance of a population as a component species in an assemblage is mainly determined by natural interspecific relationships with prey and predators and human impact. Fluctuations in the abundance of a population are not passive responses to changing environmental conditions; rather, they are active adaptations of the fecundity of a population and the quality of its reproductive products. The adaptation is achieved by changes in the reproduction pattern (NIKOLSKY, 1976). In general, fecundity may vary among spawning stocks or spawning areas in relation to fish condition and inversely with egg size (KOSLOW *et al*., 1995). Long-term reproduction is controlled by climatic changes that affect dynamics of water masses and organic production, as clearly demonstrated in anchovy (REGNER, 1996).

The findings of our study confirm the blotched picarel spawning period as found by JARDAS (1996) and DULČIĆ *et al*. (2000). Mature oocytes (stages V-VI) were discovered at the end of September and the beginning of October, which was probably the peak of the *S. maena* spawning season. DULČIĆ *et al*. (2000) also proposed that positive allometry (b = 3.12) in that period was caused by gonad maturity. But, the time of spawning of a species may vary between localities (BELL *et al*., 1992) and different authors have remarked on the ecological advantages (less risk of being predated upon by sea birds, fishes, etc.) of nocturnal spawning (HUBSON & CHESS, 1978).

Accurate determination of the fecundity of a fish is time-consuming. The problem is further complicated by the need to classify oocyts on the basis of maturity. The best approach is to determine the size of mature ova and determine the number of such ova by gravimetric-volumetric estimates or actual counts (DULČIĆ & KRALJEVIĆ, 1994), as we did to estimate the fecundity of 74 mature females. There was no positive correlation between mean mature oocyte diameter and length or weight of the blotched picarel female. Further, the minimum (1.68 mm) and maximum (1.92 mm) oocyte diameters were determined for females of 17.6 cm and 17.8 cm TL, respectively. The size-frequency distribution of the oocytes showed they were almost the same size in the ovary due to their simultaneous maturation (very low standard deviation, on average <0.069). This contributed to our earlier conclusion that *S. maena* is probably a determinate spawner and, therefore, its fecundity can easily be measured (DULČIĆ *et al*., 2000).

The estimated range of number of oocyts per female was very wide (42140-80509), confirming a common case that total fecundity depends on the length and weight of the female. Fecundity is responsive to food availability, so a time series analysis of fecundity provides insight into the state of the habitat and the stock (HORWOOD, 1990). We obtained relatively low fecundity that can be attributed to the relatively large size of the oocyts and appears to indicate relatively low mortality during the early life stages (ZELDIS, 1993). However, according to DULČIĆ *et al*. (2000), the natural mortality of blotched picarel is very high (M = 0.98), which in turn supports a low fishing rate of F = 0.20. But, they calculated mortality rates from a single sampling season, so estimates may be biased due to annual differences in year class strength and because PAULY's (1983) empirical equation was used.

As in other fish species (BAGENAL, 1978), the present study confirms that the absolute fecundity of *S. maena* increases with the length and weight of the female but, according to the regression correlation coefficient, it is better related to length. The fecundity of blotched picarel from the eastern mid-Adriatic varied at a rate proportional to the length at a power of about 2.6. This exponential value generally ranges 3-5 for Baltic cod (BOTROS, 1962), cod of

eastern Newfoundland (MAY, 1967), and Adriatic damsel fish (DULČIĆ & KRALJEVIĆ, 1994), but 2.20-3.36 for *Merlangius merlangus euxinus* from the Turkish Black Sea coast (ISMEN, 1995), and 2.69-3.91 for Arco-Norwegian cod (KJESBU *et al*., 1998). Many available data were not suitable for comparison because authors used different regression models (ELS & DAAN, 1974; KOSLOW *et al*., 1995).

DULČIĆ *et al*. (2000) estimated that the oldest male and female *S. maena* were 8 and 3 years old, respectively. The relationship between fecundity and age revealed higher fecundity in the third year, just before the change of sex, but it was not statistically significant. SIMPSON (1959) found that younger fish were relatively few in number at the beginning of the spawning season and concluded that older females arrived on the spawning ground and spawned earlier than younger ones. HORWOOD (1990) concluded by examination of age 2 and 3 *Pleuronectes platessa* that those with a higher modal size of the distribution of the diameters of vitallogenic eggs were neither longer nor more fecund than those with a lower modal size, and that the relationship is more strongly influenced by age than size of fish. The same author proposed that the reason for the later appearance of the younger females is that they are less physiologically advanced.

In addition to the obvious applications of estimating spawning biomass, this work provides insights into the reproductive biology of *S. maena*. The very wide range of total fecundity and relatively short breeding season indicate that energy reserves due to the availability of food and abiotic conditions in spawning areas may limit the number of spawnings and, hence, total fecundity.

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Fekunditet traglja, *Spicara maena* L. (Teleostei: Centracanthidae) u istočnom dijelu srednjeg Jadrana

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SAŽETAK

Proučavan je fekunditet traglja, *Spicara maena* L. uzorkovanog na istočnoj obali srednjeg Jadrana u vrhuncu mrijesta (od 16. rujna do 10. listopada). Ženke, uslijed protoginije, su utvrđene do ukupne dužine od 20,0 cm. Apsolutni fekunditet je kolebao od 42 140 kod drugog godišta do maksimalnih 80 509 u trećem godištu. Srednji je promjer oocita bio od 1,68 do 1,92 mm. Odnos između apsolutnog fekunditeta i ukupne dužine, odnosno ukupne mase, određen je slijedećim eksponencijalnim jednadžbama: $F_l = 33{,}4\ TL^{2.6}$ ($R^2 = 0{,}933$) i $F_w = 560.2W_t + 15874$ ($R^2 = 0.693$). Nije bilo značajne korelacije između veličine oocita i veličina ženki.

Ključne riječi: fekunditet, *Spicara maena*, Centracanthidae, istočni Jadran