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Population structure of the bluespotted cornetfish *Fistularia commersonii* (Osteichthyes: Fistulariidae) in the eastern Mediterranean Sea

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The bluespotted cornetfish, *Fistularia commersonii*, has established in a few years a large population in the Mediterranean Sea and is considered among the most spectacular Lessepsian fish invaders. This work estimated the essential population structure of the species in the eastern Mediterranean off the coast of Lebanon. A total of 1073 individuals were sampled between 2005 and 2009. Fish size ranged from 19.2 to 113.1 cm L_T and the most frequent size class was 55 cm L_T. Weight-length relationship was described by the equation $W_G = 1.066 \times 10^{-4} L_T^{3.4063}$, showing a positive allometric growth; the overall sex ratio did not deviate significantly from 1:1 throughout the sampling period. The size range and number of individuals examined in this study could be considered representative of the population living in the eastern Mediterranean and provides basic data that can be used in specific studies that aim to understand the biology and ecology of this invasive fish in the new environment.

Key words: *Fistularia commersonii*, Lessepsian migration, invasive species, Lebanon.

INTRODUCTION

The construction of the Suez Canal in 1869 removed a major biogeographic barrier, and the Mediterranean and Red Seas were artificially connected. This passage resulted in the incursion of Indo-Pacific biota into the Mediterranean, a process termed Lessepsian migration (Por, 1978). The ichthyofaunal profile of the eastern Mediterranean Sea, and especially of the Levantine sub-basin, has been severely affected by Lessepsian migration (Mavruk & Avsar, 2008; Galil, 2009; Zenetos, 2010; Zenetos *et al.*, 2010).

During the last decade, the bluespotted cornetfish, *Fistularia commersonii* Rüppell, 1838, was recorded for the first time in the eastern Mediterranean (Golani, 2000). Contrary to the general pattern of colonization in which a small exotic population gradually increases with time (Golani & Ben-Tuvia, 1989), *F. commersonii* displayed an explosive growth pattern and rapidly expanded westwards. It stretched out its range into most of the Mediterranean Sea in a few years (e.g., Corsini *et al.*, 2002; Azzurro *et al.*, 2004; Garibaldi & Orsi-Relini, 2008; Kara & Oudjane, 2008; Bodilis *et al.*, 2011).

Except for its dietary habits and feeding behaviour (Corsini *et al.*, 2002; Takeuchi *et al.*, 2002; Nakamura *et al.*, 2003; Kalogirou *et al.*, 2007; Bariche *et al.*, 2009; Takeuchi, 2009), most aspects of the biology and ecology of *F. commersonii* have not been studied. Different authors have stressed on the importance of further investigations into the life history and biological traits of the species in order to decipher the reasons and have a better understanding of its unprecedented success (Kalogirou *et al.*, 2007; Kara & Oudjane, 2008; Psomadakis *et al.*, 2008; Bariche *et al.*, 2009). However, basic information concerning the population structure of this invader in the Mediterranean Sea is lacking.

The aim of the current study was to provide essential information on population structure, namely (1) general descriptive statistics, (2) length-frequencies,

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(3) weight-length relationships, and (4) sex ratios for the species in the eastern Mediterranean.

MATERIALS AND METHODS

Sampling of *F. commersonii* was carried out in the easternmost part of the Mediterranean, along the coast of Lebanon, during two intervals. Fish (n = 812) were collected from October 2005 to November 2006, and additional samples (n = 261) were acquired from April to December 2009. They were purchased directly from fishermen who used beach seines as well as fixed and encircling trammel nets. Significant effort was made to have a maximum of size classes and a random sampling in 2005-2006 but not in 2009. The 2005-2006 samples were used for the length-frequency distribution and for comparisons of population parameters between sexes, as well as for sex ratios. Data from all specimens (2005-2006 and 2009) were pooled for descriptive statistics and weight-length relationships. Total length (L_T) was measured to the nearest mm and gutted weight (W_G) to the nearest 0.01 g. The fat accumulated along the vertebral column was not removed and was included in the gutted weight measurements.

Weight-length relationships were calculated by regression analyses, with a hypothesized power function of the form $W_G = aL_T^b$, where a and b are regression parameters. Analysis of variance (ANOVA) tables of regression were assessed for the highest F-values indicative of the best regression, as well as r^2 and standard error of b (SE*b*). The resultant slopes and intercepts for the two sampling periods, as well as between the sexes, were compared using Student's t-tests (Zar, 2009). Length-frequency histograms were constructed with individuals grouped into 5 cm size class intervals (20 = 15.1-20 cm L_T; 25 = 20.1-25 cm, etc.). Normality was tested by using the non-parametric Kolmogorov-Smirnoff test (Zar, 2009). Female and male L_T and W_G were compared using Student's t-tests as well as non-parametric Mann-Whitney tests (in case of deviations from normality). Sex ratios were analysed using χ^2 goodness-of-fit tests against an expected ratio of 1:1 (females:males). They were calculated by month and for the whole duration of the study as well as across L_T, with the data divided into size classes. Statistical tests, including curve-fitting, were performed using SPSS for Windows (16.0.0), or Microsoft® Excel 2007.

RESULTS

A total of 1073 individuals were collected and examined during the study periods. L_T ranged from 19.2 to 113.1 cm [64.7 ± 19.6 cm; mean ± standard deviation (s.d.)], and W_G from 3.2 to 1159.6 g (202.5 ± 170.4 g). Mean L_T of females (68.1 ± 19.7 cm) was significantly higher than that of males (59.5 ± 18.2 cm) during the study periods ($p < 0.01$). Similarly, females were also significantly heavier (236.6 ± 185.6 g and 150.5 ± 128.2 cm, respectively; $p < 0.01$). Distributions for sexed or total individuals (n = 812) were both not normally distributed ($p < 0.05$). The most frequent size class was 55 cm. Descriptive statistics are summarized in Table 1 and length-frequency distributions represented in Figure 1.

Weight-length regressions were highly significant between fish weight and total length ($p < 0.05$). The slopes and intercepts of the weight-length relationships between the two sampling periods were not significantly different ($p > 0.05$), and hence data were pooled for all individuals (Fig. 2). The overall weight-length relationship equation for *F. commersonii* from Lebanon is $W_G = 1.066 \times 10^{-4} L_T^{3.4063}$ (SE*b* = 0.011). Conversely, the slopes were significantly different between males and females when evaluated separately (Fig. 2, $p < 0.05$), with males having a slightly steeper slope than females (b = 3.39 and 3.35, respectively).

TABLE 1. Descriptive statistics for *F. commersonii* specimens from the coast of Lebanon (eastern Mediterranean). n: number of individuals; L_T: total length in cm; W_G: gutted weight in g

	n	Mean (s.d.)	Range
2005-06			
♀ L_T	424	60.34 (19.22)	26.6-112.4
♂ L_T	388	57.64 (17.81)	19.2-100.1
L_T (all)	812	59.05 (18.59)	19.2-112.4
W_G (all)	812	137.40 (124.31)	3.17-730.4
2009			
♀ L_T	222	82.83 (9.66)	48.3-113.1
♂ L_T	39	78.55 (9.58)	61.7-99.9
L_T (all)	261	82.19 (9.75)	48.3-113.1
W_G (all)	261	383.04 (157.27)	48.59-1159.6
Pooled			
♀ L_T	646	68.07 (19.71)	26.6-113.1
♂ L_T	427	59.55 (18.24)	19.2-100.1
L_T (all)	1073	64.68 (19.58)	19.2-113.1
W_G (all)	1073	202.48 (170.43)	3.17-1159.6

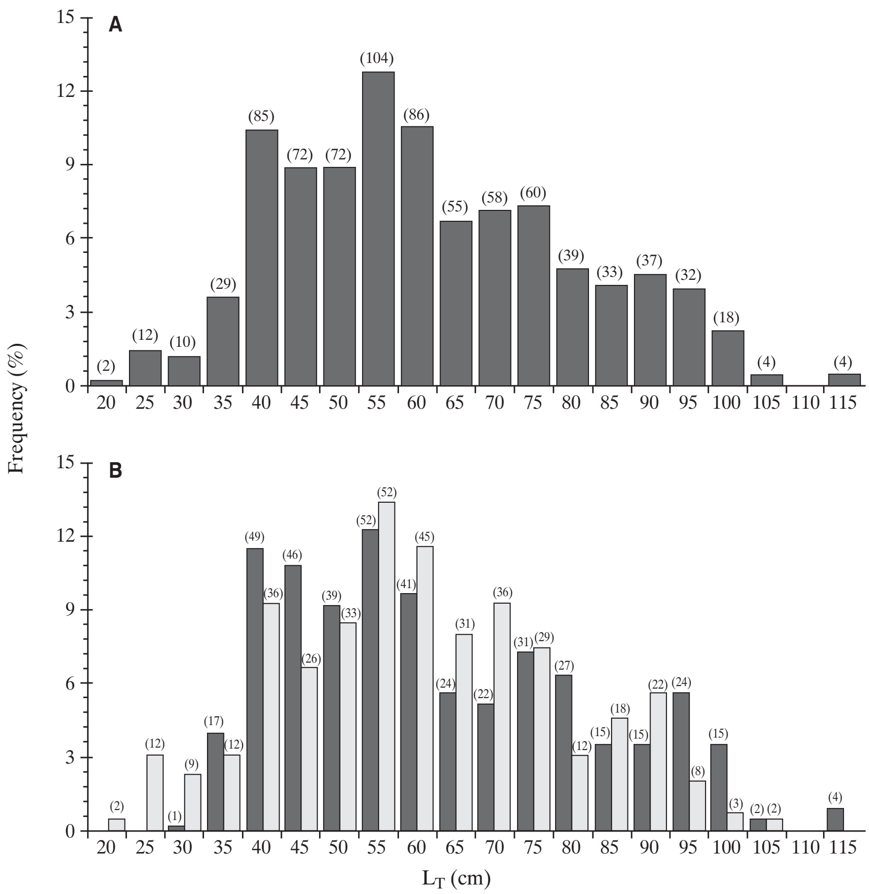

FIG. 1. Length-frequency distributions of *F. commersonii* collected from the coast of Lebanon (eastern Mediterranean). (a) All individuals, (b) females in black; males in grey. Number of fish individuals (n) is in brackets.

The overall population sex ratio did not deviate significantly from 1:1 (1.1:1, $p > 0.05$). Similarly, sex ratio did not show any deviations from 1:1 throughout the 14 months in 2005-2006, except for the month of March 2006 (1.7:1; n = 91), in which females slightly dominated ($p < 0.05$) (Fig. 3A). The female *vs* male distribution across size classes was not significantly different from 1:1 ($p < 0.05$) except for the 45 (1.8: 1; n = 72), 80 (2.3:1; n = 39), 95 (3:1; n = 32), 100 cm (5:1; n = 18) and 115 cm (4:0; n = 4) size classes, which were dominated by females and for the 25 (0:1; n = 12) and 30 cm (0.1:1; n = 10) size classes, which were dominated by males (Fig. 3B).

DISCUSSION

The size range and number of individuals analysed throughout the study were large enough and the results can be extrapolated to the population living along the coasts of the eastern Mediterranean Sea. The largest individual examined (113.1 cm) is in line with maximum sizes recorded from the Mediterranean in previous studies (Kalogirou *et al.*, 2007; Bariche *et al.*, 2009), and is probably very close to the maximum size the species can reach in the Mediterranean Sea. A substantially larger size (160 cm) has been reported from the Indo-Pacific, indicating that the species might grow larger in its native tropical realm (Fritzsche & Schneider, 1995). The species might have encountered some limiting factors in the Mediterranean Sea (e.g., low seawater winter temperature); alternately, smaller maximum sizes in the Mediterranean might be related to the reduced genetic diversity encountered in the individuals that invaded the Mediterranean (Golani *et al.*, 2007). In fact, it was shown that a severe genetic bottleneck occurred in the Mediterranean due to colonisation by two mitochondrial haplotypes (Golani *et al.*, 2007). Another explanation might be that maximum length reported in the literature from the Indo-Pacific is not very accurate.

The smallest *F. commersonii* specimen collected in the course of this study (19.2 cm) was probably very close to the size at settlement for the species. This conclusion was based on the extensive sampling effort in this study as well as on active underwater search

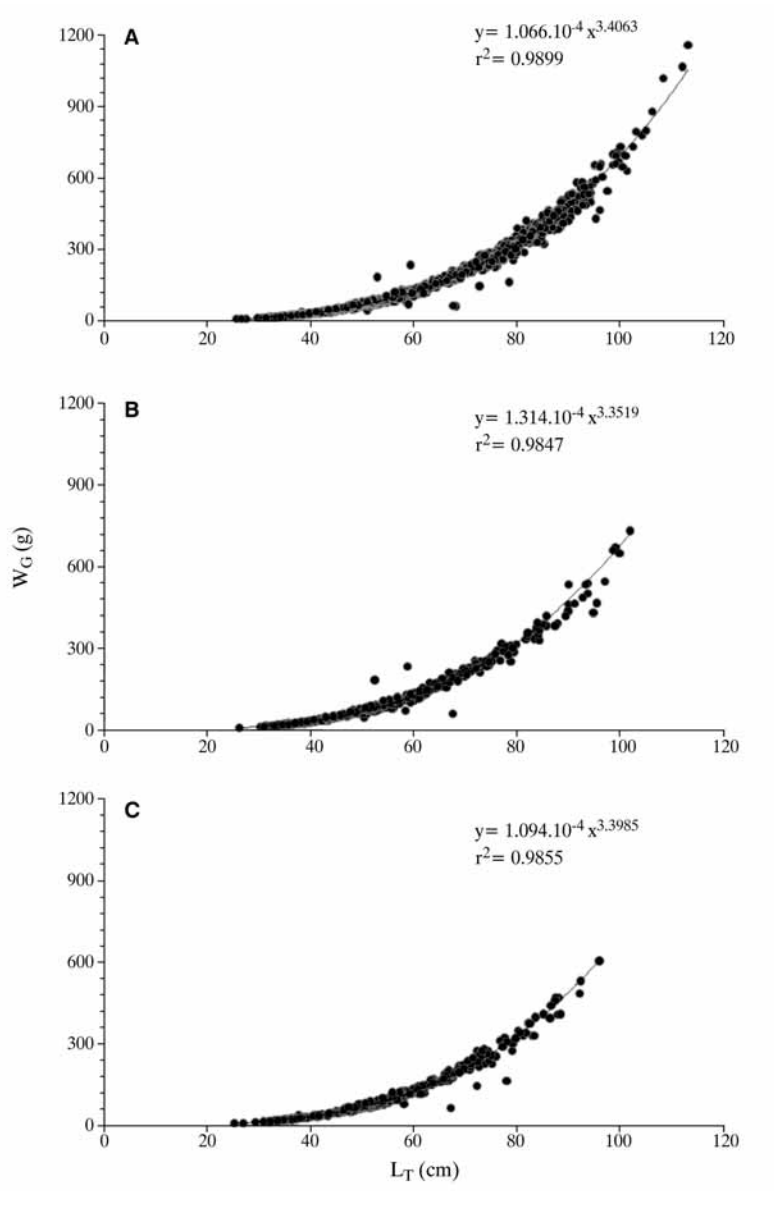

FIG. 2. Weight-length relationships of *F. commersonii* from the coast of Lebanon (eastern Mediterranean). (A) All individuals combined (n = 1073), (B) females (n = 424) and (C) males (n = 388).

for smaller individuals ever since the species was first recorded in the Mediterranean. The smallest individuals were caught in the month of November and no information regarding size at settlement or nurseries for this species is available in the literature.

Length-frequency distributions were not normally distributed for the sexes separately or for all individuals grouped together. Possible causes behind this deviation from normality are unclear and could be due to some hidden sampling biases. Females were larger in size than males ($p < 0.01$) but the mean values of L_T from the 2005-2006 were, however, not significantly different ($p > 0.05$). This is due to the fact that the 2009 sampling was not random, as we were targeting specifically larger individuals. Based on the sampling method used and the number of individuals examined, it is expected that the size classes collected in this study are representative of the size structure of *F. commersonii* in the eastern Mediterranean. These sizes also coincide with the size structure of cornetfish landings in the Lebanese fishery, as all individuals were directly purchased from fishermen's catches. Despite that, the minimum marketable size is around 60 cm L_T and smaller specimens are usual-

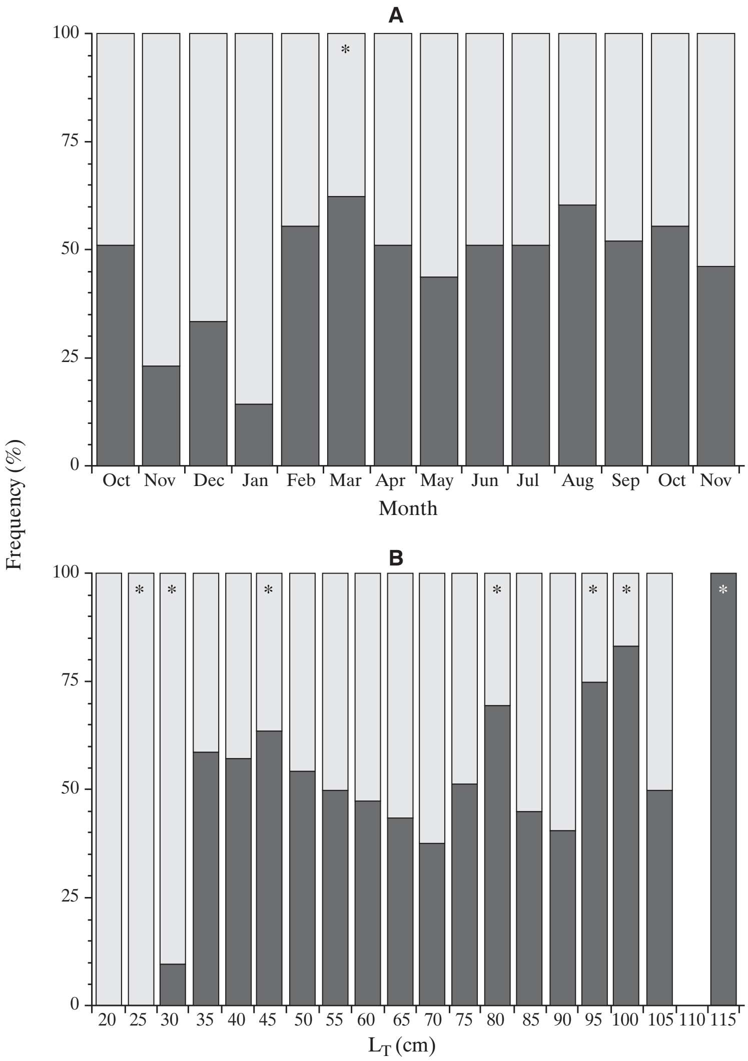

FIG. 3. Sex ratio variations across months (A) and size classes (B) in *F. commersonii* from the coast of Lebanon. Females (black); males (grey). Significant differences from 1:1 ($p < 0.05$) are denoted with an asterisk.

ly discarded after capture.

Values of the regression coefficients (b) in the weight-length relationships were greater than 3 for all individuals as well as for each gender taken separately (Fig. 2). As in most fish species, this indicated that growth in *F. commersonii* was positively allometric; fish body becomes more rotund as length increases (Ricker, 1975; Anderson & Neumann, 1996; Froese, 2006). The regression parameters of the weight-length relationship presented here for *F. commersonii* from the coast of Lebanon are comparable to those from the South-East Aegean (b = 3.37 – Kalogirou *et al.*, 2007), and higher than that from Turkey (b = 2.50 – Erguden *et al.*, 2009). There was a significant difference between female and male weight-length relationships ($p < 0.05$) and the slightly steeper slope recorded in males (Fig. 2C) indicated that the two sexes did not grow in a similar way. Weight-length relationships are lacking in the literature for the species in its native environment.

The overall sex ratio of *F. commersonii* did not differ from the hypothesized 1:1 ratio, which indicated a well-balanced population in the eastern Mediterranean. The monthly percentages were more or less well-balanced between males and females, except in November, December, and January, where there was a low sample size and a skew towards males (n = 13, 9, and 7, respectively). The monthly sex ratio deviated from 1:1 only in March and no other deviations were recorded (Fig. 3A). Across size classes, sex ratio was consistently balanced in the sample (1:1; $p < 0.05$) except for some sizes (Fig. 3B). A possible cause for this variation is unequal growth rates and mortality between males and females (Turner *et al.*, 1983; Lowerre-Barbieri *et al.*, 1996; Fogarty & O'Brien, 2009), and needs to be explored with growth data. Such information exists neither in the native nor in the Mediterranean range of the species distribution.

An alien species is considered invasive when its population size increases exponentially, and when its geographical range extends rapidly (Occhipinti-Ambrogi & Galil, 2004). Within a few years since its first sighting in the Mediterranean, *F. commersonii* has been increasingly acquiring economic importance in the eastern Mediterranean Sea (Bariche, 2011). This is certainly due to the fact that it has a white palatable flesh, no "spines" and the fact that consumers eventually got used to its uncommon elongated flute-like shape.

During the last decade, *F. commersonii* successfully established itself in most parts of the Mediterranean. All alien species have an impact upon arrival into their new environment, which might not always be possible to assess or measure (Carlton, 2002). In the case of *F. commersonii*, there is a growing necessity to assess its impact on the native Mediterranean marine ecosystem.

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