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Reproductive Biology of *Fistularia commersonii* (Rüppell, 1838) from the Eastern Mediterranean Region, Alexandria, Egypt

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ABSTRACT

This study is the first to examine the reproductive aspects of the non-indigenous species *Fistularia commersonii* in the Mediterranean Sea, specifically in Egyptian waters. Monthly variations in maturity stages indicated a prolonged spawning season lasting six months, from June to December. The highest gonado-somatic index (GSI) values were recorded in July, with females averaging 7.768 ± 3.568 and males 0.826 ± 0.261, showing multiple peaks during the season. The highest average hepato-somatic index (HSI) also occurred during the spawning season. The overall sex ratio was F= 1:1.16, showing no significant difference between the sexes ($\chi^2 = 3.756$; df = 1; $P > 0.05$). However, during spawning, the Chi-square test revealed a significant difference ($\chi^2 = 5.538$; df = 1; $P < 0.05$), with a sex ratio of 1:1.26 for females to males. The length at first sexual maturity (Lm) was 55.215cm total length (TL) for males and 60.0cm TL for females. The reproductive load was determined to be 0.405 for males and 0.441 for females. Absolute fecundity (Fa) ranged from 76,167 to 281,325 for lengths between 60.0 and 100.0 cm TL, with a relationship expressed as Fa = 1.9812 $L^{2.55}$ ($R^2 = 0.947$). Relative fecundity (Fr) varied between 1,269 and 2,813 ova per unit length of the fish in centimeters, with the relationship described as Fr = 1.9812 $L^{1.55}$ ($R^2 = 0.864$). Ova diameter ranged from 0.3 to 3.0mm (mean = 1.00 ± 0.605), displaying a poly-modal distribution. This reproductive study revealed multiple spawning events and a prolonged, indefinite spawning period. With its high fecundity rate and extended spawning season, *Fistularia commersonii* has become the most dominant non-indigenous species in the Egyptian Mediterranean Sea.

INTRODUCTION

The bluespotted cornetfish, *Fistularia commersonii* **(Rüppell, 1838)**, belongs to family Fistulariidae (Order: Syngnathiformes) **(Fritzsche, 1976)**. It was first reported in the Mediterranean Sea in 2000 **(Golani, 2000)**, and it has subsequently proliferated to become one of the most impactful non-native lessepsian species in the Mediterranean Sea **(Streftaris & Zenetos, 2006)**, causing the greatest rate of spreading in the Mediterranean with estimates ranging from 1000 to 1500km per year **(Azzurro *et al*., 2013)**. Adult lessepsian immigrant mobility and larval dispersal are thought to have been the most likely means of *F. commersonii's* secondary expansion throughout the Mediterranean **(Azzurro *et al*., 2013)**.

F. commersonii is a bottom-swimming fish that is primarily found in shallow coastal areas, with a typical depth range of 1 to 50 meters and an occasional depth of 130 meters. It is found mostly on soft bottoms next to reefs as well as along rocky and coral reefs **(Fritzsche, 1976)**. **Azzurro *et al*. (2013)** reported that it favors regions with low concentrations of chlorophyll-a and high salinity, and it can be found on sandy bottoms or above sea grass meadows in its invaded range in the Mediterranean Sea (**Kalogirou *et al*., 2007)**. This fish has some economic relevance in local markets in several locations of the eastern Mediterranean due to its growing abundance and tasty flesh **(Corsini-Foka *et al*., 2017)**.

In the Egyptian Mediterranean waters, *F. commersonii* specimens are caught by trawlers at depths from 40 to 60m, and this species is also caught by purse-seine **(Farrag *et al*., 2014; Ragheb, 2022)**. It was first recorded near Alexandria in 2001 **(Halim & Rizkalla, 2011)**, and its morphometrics **(Ragheb, 2022)**, length-weight relationships and condition factors were studied **(El-Samman & Ragheb, 2023)**, and its age and growth were documented.

Regarding *F. commersonii's* reproductive biology, the scientific literature contains only a limited number of incomplete and sparse observations about the cornetfish reproduction. Of those, **Azzurro *et al*. (2004)**, **Fiorentino *et al*. (2004)** and **Pais *et al*. (2007)** evaluated just one single ovary of *F. commersonii*, whereas later **Psomadakis *et al*. (2009)** examined seven ovaries and four testes. Only **Saad and Sabour (2010)** from the Syrian coast, **Bariche *et al*. (2013)** from the shores of Lebanon, **Bashir and Elbaraasi (2014)** from the coast off Benghazi, Libya, and **Kondylatos *et al*. (2024)** in Rhodes, Greece, gave some reproductive knowledge of *F. commersonii*, depending on numbers. The aim of the present work was to determine some reproductive aspects, including sex ratio, gonadosomatic index, reproductive load, length at first sexual maturity, and fecundity for *F. commersonii* in the Egyptian Mediterranean water.

MATERIALS AND METHODS

Monthly random samples of *F. commersonii* were collected from the commercial catches of the fishing area extending west of Alexandria, from Sidi Kirayr to Al-Hamam, between October 2017 and March 2019. There were no samples caught in April 2018 or April 2019. The samples were collected from the landed catch of trawlers.

In the laboratory, for each fish sample, the total fish length (TL) excluding the length of the filament was measured to the nearest centimeter. Gutted body weight (W) was recorded to the nearest gram, while liver weight (LW) and gonad weight (GW) were measured to the nearest 0.01 gram. The sexes of the fish were determined, and the ovaries of ripe females were preserved in a 10% formalin solution.

Macroscopic identification of maturity stages was based on the criteria set by **Bariche *et al*. (2013)**, with some modifications. Six maturity stages were recognized for both males (M) and females (F): immature (stage I), maturing (stage II), nearly ripe (stage III), ripe (stage IV), spawning (stage V), and spent (stage VI).

The reproductive potential of the *F. commersonii* population was determined from the study of sex ratio (F: M). The sexual activity was studied through addressing the gonad-somatic index (GSI) using the formula: GSI = (GW / W) *100, where GW is the gonad weight in g, and W is the gutted body weight in g. The hepato-somatic index (HIS) was calculated using the formula: HSI = (LW / W) *100, where LW is the liver weight in g, and W is the gutted body weight in g. The reproductive load was calculated as a ratio of L_m/L_∞ **(Cushing, 1981)**, where L_m is the length at first sexual maturity, and L_∞ is the asymptotic length of *F. commersonii* population. The length, at which first sexual maturity was reached (L_m) for both sexes, was estimated as the length when 50% of individuals were matured and reached the nearly ripe stage of maturation. The used L_∞ was as L_∞= 136.194cm **(Ragheb *et al*., 2024)**.

Fecundity and ova diameters are determined by fish with developed ovaries in stage IV and those of high GSI in stage V of maturation. A precision eyepiece micrometer was utilized at a magnification of 32 x for diametric measurements of the ova obtained, and data were expressed in millimeters. The fecundity (F) estimation was done according to the Simpson dry method **(Simpson, 1951; Baxter, 1959; Bridger, 1961)**. The eggs were liberated from the ovarian tissue, and then weighed to the nearest milligram. Three sub-samples of eggs were taken and weighed to the nearest 0.01 gram, and the average number of eggs in these sub-samples was counted. Absolute fecundity (Fa) and relative fecundity (Fr) were estimated to assess the reproductive potential of the fish.

Absolute fecundity was defined as the total number of mature ova present in each individual during the spawning season, while relative fecundity was calculated by expressing the number of ripe eggs in relation to the fish's total length.

To model the relationship between fish length (L) and both absolute and relative fecundity, a power function, F = aL^b, was employed, where F represents fecundity; L denotes fish length in centimeters, and 'a' and 'b' are constants. All data analyses were performed using Microsoft Office Excel 2010.

RESULTS AND DISCUSSION

Reproductive biology is essential for assessing and managing fish populations **(Froese, 2004)** since the stock reproductive features are necessary for effective management strategies **(Morgan, 2008)**. Furthermore, it is a critical link in the fish's life history **(Ragheb, 2016)**. In the present study, out of a total of 746 fish specimens collected during the period of study, only 334 were females, 386 were males, and the remainders were unsexed.

1- Gonad morphology and differentiation of sexual maturity stages

Depending on the description of **Pais *et al*. (2007)** and **Bariche *et al*. (2013)**, *F. commersonii* has one ovary that consists of two united lobes separated by a longitudinal septum of connective tissue. Furthermore, **Bariche *et al*. (2013)** described that the only notable deviations from the characteristic morphology of teleost reproductive organs is distinguished by the longitudinal confluence of the bilateral lobes and the protracted configuration of the gonads, which exhibits a notable correspondence with the overall body morphology. In the present study, the macroscopic examination of *F. commersonii* gonads clarified that the two lobes of ovaries or testes were bonded together for the majority of their length and just extremely loosely at their posterior end. They expand antero-dorsally over the digestive tract and in maturing individuals, they occupy nearly the entire length of the body cavity; whereas in immature individuals, they only reach roughly half of the abdominal cavity in males and three-quarters in females. Studying the monthly fluctuations in the stages of reproductive maturity makes it clear that *F. commersonii* is characterized by a remarkably protracted spawning season, spanning from June to December, during which both males and females exhibit synchronized reproductive activity, with a peak of spawning in September for males (78.95%) and females (86.96%). The lowest percent of spawning was observed in November for males and females. The males and females of *F. commersonii* started their reproductive cycle in October, whereas the immature stage began to appear in the catch from October for both sexes to March for males and to June for females, with a high percentage in November for both sexes (79.21% for males and 79.66% for females). The monthly fluctuations in the various stages of reproductive maturity for both male and female *F. commersonii* individuals from the Egyptian Mediterranean waters are represented in Table (1).

2- Sex ratio

Sex ratio is one of the characteristics influencing a population's reproductive potential **(Marshall *et al*., 2006)**. Developing a nuanced understanding of the intricate relationships between fish populations and their environmental context is essential for informing effective conservation and management strategies that promote the long-term sustainability of these populations **(Oliveira *et al*., 2012)**.

Table 1. Monthly variations of maturity stages for males and females *F. commersonii* from the Egyptian Mediterranean waters

Month	Males						
	N	Immature %	Mature %	Nearly ripe %	Ripe %	Spawning %	Spent %
Jan	57	54.39	38.60	3.51	-	-	3.51
Feb	18	-	11.11	77.78	11.11	-	-
Mar	57	31.58	26.32	29.82	12.28	-	-
Apr	-	-	-	-	-	-	-
May	22	13.64	22.73	45.45	9.09	-	9.09
Jun	27	33.33	7.41	18.52	18.52	22.22	-
Jul	18	-	-	22.22	11.11	66.67	-
Aug	13	-	7.69	-	15.38	76.92	-
Sep	18	-	-	5.56	16.67	77.78	-
Oct	24	4.17	25.00	8.33	4.17	50.00	8.33
Nov	101	79.21	13.86	0.99	-	5.94	-
Dec	31	22.58	6.46	12.90	3.23	54.84	-
Month	**Females**						
	N	Immature %	Mature %	Nearly ripe %	Ripe %	Spawning %	Spent %
Jan	60	11.67	75.00	5.00	-	-	8.33
Feb	2	-	-	100.00	-	-	-
Mar	68	14.71	67.65	17.65	-	-	-
Apr	-	-	-	-	-	-	-
May	20	15.00	60.00	25.00	-	-	-
Jun	32	6.25	21.88	53.13	9.40	9.38	-
Jul	20	-	-	10.00	25.00	65.00	-
Aug	9	-	-	11.11	22.22	66.67	-
Sep	23	-	-	8.70	4.35	86.96	-
Oct	28	10.71	-	17.86	32.14	25.00	14.29
Nov	59	79.66	11.86	-	-	6.78	1.69
Dec	13	15.38	15.38	7.69	-	61.54	-

For the total sample, males are slightly more than females, and the aggregate sex ratio (F: M) was obtained as 1:1.16, and the value of the Chi-square analysis demonstrated an insignificant variation (χ^2 = 3.756; df = 1; P > 0.05). According to Table (2), the fluctuations of sex ratio on a monthly basis (F:M) of *F. commersonii* show that only the months of February, November, and December have a significant difference between sexes at 1%, where males predominate the females, and the values of the Chi-square test were χ^2 = 12.800, 11.025, and 7.364 for these months, respectively. On the other hand, the sex ratio during months of spawning and out of spawning (Fig. 1) also showed a predominate of the males than the females. During the months of spawning from June to December, the sex ratio (F: M) was 1:1.26 (N = 184 for females and N = 232 for males), and the value of the Chi-square analysis indicate a statistically significant result (χ^2 = 5.538; df = 1; $P < 0.05$), whereas the sex ratio out of spawning (Fig. 2), from January to May, showed that the females were slightly equal to the males (N = 150 for females and N = 154 for males) (Sex ratio F:M = 1:1.03), with insignificant variation according to the Chi-square value (χ^2 = 0.053; df = 1; $P < 0.05$).

The present sex ratio (M: F = 1:0.87) agrees with those of **Bariche and Kajajian (2012)** (M: F = 1:1.10) for *F. commersonii* from the shores of Lebanon since they are not statistically significant, suggesting that the population was in a balanced state. Although **Bashir and Elbarassi (2014)** reported that males predominated over females (M: F = 1:0.69) in the coast off Benghazi, Libya. Moreover, their results disagreed with the present study results, where the sex ratio of Lebian population was statistically significant.

On the other hand, the predominant of females than males was statistically significant in the Iskenderun Bay, Turkey (M: F = 1: 1.43) **(Ergüden *et al*., 2022)** and in Rhodes, Greece, where the sex ratio was estimated at M: F = 1:1.33 **(Kondylatos *et al*., 2024)**.

It is clear that the sex ratio showed differences depending on the region and researcher. It may also be due to differences in sample size and sampling period **(Martins & Haimovici, 2000)**. The discrepancy in sex ratio can be attributed to the influence of biological activities such as reproduction, which can alter behavior and determine capture susceptibility. Genetic differences in the population may also be a potential influence **(Oliveira *et al*., 2012)**.

Table 2. Monthly variation of sex ratio for *F. commersonii* from the Egyptian Mediterranean water

Month	Females		Males		F : M	Chi- square value
	N	%	N	%		
Jan	60	51.28	57	48.72	1 : 0.95	0.077
Feb	2	10.00	18	90.00	1 : 9.00	12.800**
Mar	68	54.40	57	45.60	1 : 0.84	0.968
Apr	-	-	-	-	-	-
May	20	47.62	22	52.38	1: 1.10	0.095
Jun	32	54.24	27	45.76	1 : 0.84	0.424
Jul	20	52.63	18	47.37	1 : 0.90	0.105
Aug	9	40.91	13	59.09	1 : 1.44	0.727
Sep	23	56.10	18	43.90	1 : 0.78	0.610
Oct	28	53.85	24	46.15	1 : 0.86	0.308
Nov	59	36.88	101	63.13	1 : 1.71	11.025**
Dec	13	29.55	31	70.45	1 : 2.38	7.364**
Total	**334**	46.39	**386**	53.61	**1 : 1.16**	**3.756**

** Significant at 0.01

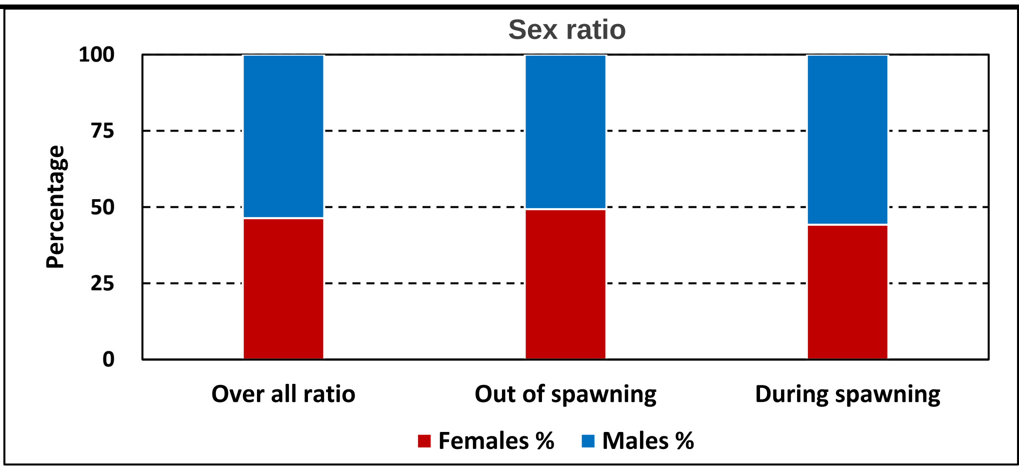

Fig. 1. Variations of sex ratio during and out of spawning for males and females *F. commersonii* from the Egyptian Mediterranean waters

3- Gonado-somatic index (GSI)

The gonado-somatic index (GSI) is an indicator for the sexual cycle of fish species and is widely used to determine the spawning period of a fish species **(Nikolsky, 1963; Plaza *et al*., 2007)**. The data in Fig. (2) clarify that females have higher average values of GSI than males. The GSI results confirmed that this species exhibits an extended spawning season with a main peak that starts in June and terminates by late October, then fluctuations of the GSI with two other peaks in December and February for both sexes. The highest average value of GSI was obtained in July to be 7.768 ± 3.568 for females and 0.826 ± 0.261 for males. Then it decreased in August for both sexes. After that, another increase was obtained in the months of September, October, December, and February for both females and males, with a sharp drop in November and January.

According to **Saad and Sabour (2010)**, the GSI for *F. commersonii* in the Syrian coast showed that males and females followed the same pattern, and it spawned from the second half of May until early August, attaining its peak during June. As noted by **Bariche *et al*. (2013)**, female gonado-somatic index (GSI) values for *Fistularia commersonii* began to develop in April, reaching their maximum in August. In contrast, male GSI increased from June to September, coinciding with the peak GSI observed in females. Reproduction was still occurring throughout November, despite a decline in GSI for *F. commersonii* along the shores of Lebanon.

Bashir and Elbarassi (2014) reported that GSI values for *F. commersonii* from the Libyan coast off Benghazi showed distinct peaks, with maximum values recorded in August for females and September for males. **Kondylatos *et al.* (2024)** found that the highest GSI occurred in summer, followed by autumn for *F. commersonii* in Rhodes, Greece.

Certain individuals may experience delayed maturation within the annual cycle or potentially undergo a secondary spawning event, provided environmental conditions are conducive; this phenomenon exhibits a consistency across multiple-spawner species, a pattern that corroborated by the present findings, as well as those of **Marino *et al*. (2001)**, **Moore *et al*. (2007)**, and **Bariche *et al.* (2013)**, thereby underscoring its pervasive presence within this taxonomic species. On the other hand, fluctuations in the gonado-somatic index (GSI) corresponded with sea surface temperature and salinity **(Bariche *et al*., 2013)**. Spawning activity occurs when water temperatures reach 22°C, which aligns with the annual average temperature of 23.2°C recorded for the Mediterranean Sea in the study area **(Alprol *et al*., 2021)**. This phenomenon helps explain the extended duration of the spawning season for *Fistularia commersonii* in Egyptian Mediterranean waters.

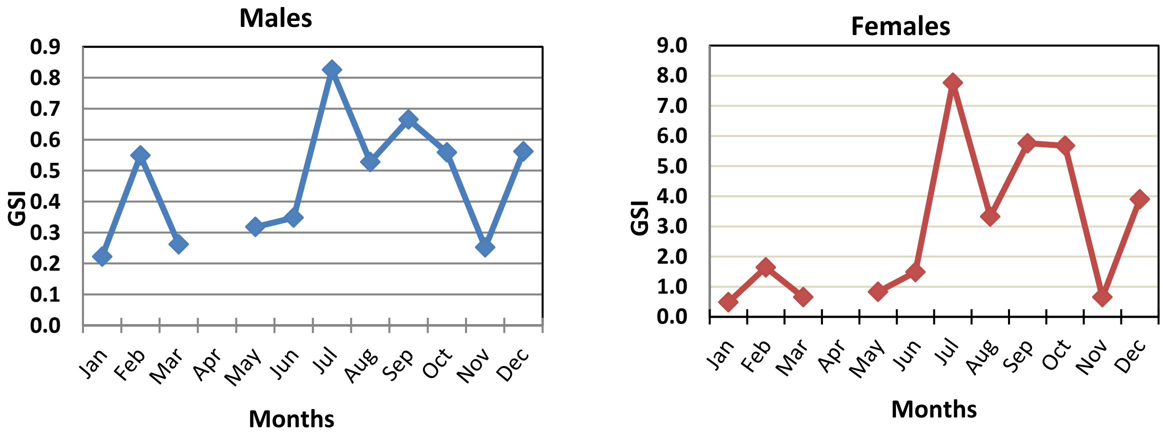

Fig. 2. Monthly variation of GSI for both males and females of *F. commersonii* from the Egyptian Mediterranean waters

4- Hepato-somatic index (HSI)

The hepato-somatic index (HSI) constitutes a prominent indicator of the energy reserves stored in the liver, which is in relation to the metabolic health of the fish.

Compared to males, females had higher average HSI values. The highest average value of HSI was obtained from June to October for both sexes (Fig. 3), but it decreased in July for males and in August for females through this obtained period. After that, another increase was obtained in the months of January for males and in December for females, with a drop in other months.

The rise in the hepato-somatic index (HSI) during the reproductive peak can be linked to the liver's crucial roles in energy regulation and the synthesis of reproductive proteins. As the primary storage organ for glycogen and lipids, the liver mobilizes these reserves to meet the increased metabolic demands associated with gonad maturation and egg production, often resulting in a temporary enlargement of the liver **(Cerda *et al*., 1996; Zin *et al*., 2011)**. In addition, the liver is instrumental in producing vitellogenin, a protein that is vital for egg yolk formation, which further contributes to the elevated HSI during the reproductive season **(Singh *et al*., 2008)**. Physiological adaptations, such as the enlargement of liver cells, may also take place as fish prepare for spawning. Together, these factors highlight the liver's essential role in supporting successful reproduction in fish, showcasing its ability to adapt to the heightened metabolic demands during this critical time **(Zin *et al*., 2011)**.

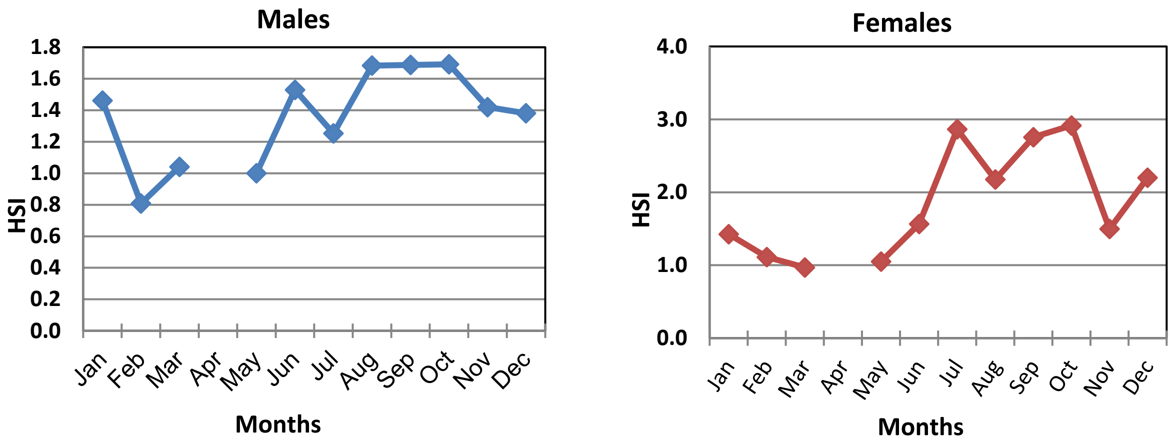

Fig. 3. Monthly variation of HSI for both males and females of *F. commersonii* from the Egyptian Mediterranean waters

5- Length at first sexual maturity and reproductive load

At the point at which 50% of fish were matured and reached the stage of maturation nearing ripeness for males and females, the length at first sexual maturity (L_m) was determined as L_m = 55.215cm for males and L_m = 60.0cm for females (Fig. 4). It is apparent that males achieved first sexual maturity at a lesser length than females.

The present results were in agreement with those of **Saad and Sabour (2010)**, **Bariche *et al*. (2013)** and **Kondylatos *et al*. (2024)**, as males reach sexual maturity before females. **Saad and Sabour (2010)** showed that the first sexual maturity (L_m) of *F. commersonii* of females and males were 57.5 and 56.0cm SL, respectively; **Bariche *et al*. (2013)** determined that the L_m was 65.4cm TL for the females and 54.7cm TL for the males; and **Kondylatos *et al*. (2024)** estimated the L_m as 69.07cm TL for females and 59.58cm TL for males.

On the other hand, the observed difference in length at first maturation between this study and previous ones is likely due to environmental factors such as unstable hydrological systems, fishing pressure, or adaptive behavior **(Lévêque, 1997; Mazzoni & Petito, 2011; Ragheb, 2016)**.

The reproductive load of *F. commersonii* was determined as 0.405 for males and 0.441 for females, based on a previously computed L_∞ of 136.194cm. According to **Pauly (1984)**, the reproductive load typically ranges from 0.4 to 0.9. The data reflect a noteworthy correlation between the size of the individuals and their reproductive output. Values that hover near the lower threshold of the reproductive load could signify the influence of various environmental or biological factors on reproductive strategies, including resource availability and individual health status **(Jensen & Gross, 2004)**. These insights emphasize the critical need to comprehend the relationship between reproductive strategies and growth dynamics **(Pauly, 1984)**, as such understanding is essential for assessing the sustainability of *F. commersonii*. Future investigations should aim to elucidate the implications of these reproductive loads on population dynamics and management strategies, particularly considering the potential impacts of environmental fluctuations and fishing pressures that could threaten the reproductive health of this species.

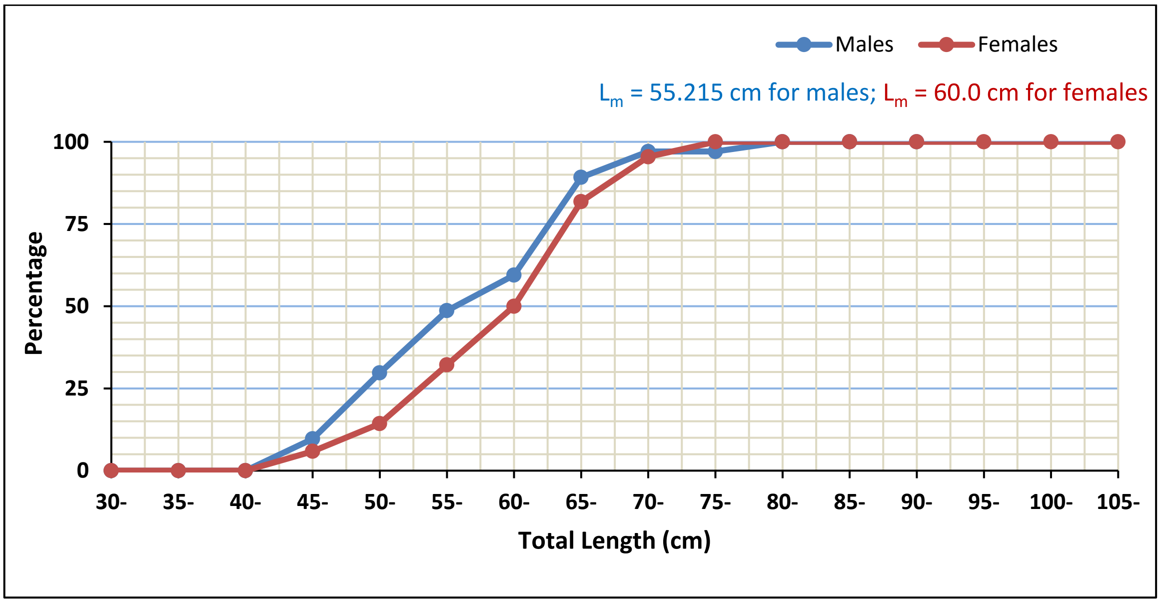

Fig. 4. Percentage distribution per length of maturing males and females of *F. commersonii* from the Egyptian Mediterranean waters

6- Ova diameter

The spawning mode is clearly elucidated through egg diameter measurements taken during the spawning season. Like other fish species, the ovaries of female *Fistularia commersonii* contain a stock of small, transparent, or undeveloped (immature) eggs, which periodically develop into mature eggs. This stock provides a portion that matures during the breeding season.

The characteristics of the spawning season can be revealed through percentage data on egg sizes. The diameter of *F. commersonii* eggs ranged from 0.3 to 3.0mm, averaging 1.00 ± 0.605mm. The highest peak in ova diameter was recorded within the range of 0.3 to 0.8 mm, accounting for 54.19% of the total measured ova, indicating a significant presence of immature eggs.

Subsequent peaks in ova diameter were also observed. As shown in Figure 5, the distribution of oocyte diameter is poly-modal, suggesting that this species undergoes multiple spawning events and has a prolonged, indefinite spawning period.

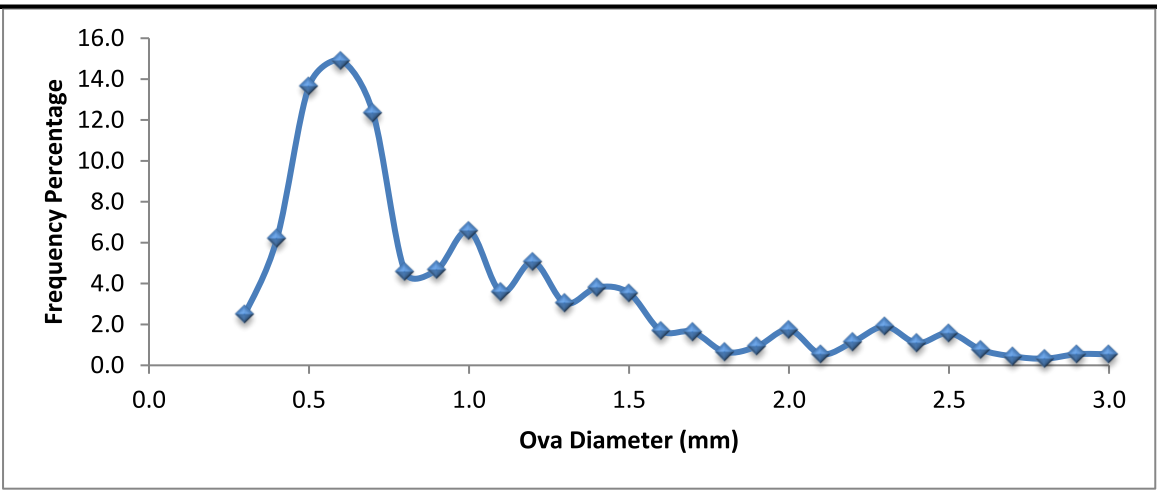

Fig. 5. Frequency distribution of ova diameter of *F. commersonii* from the Egyptian Mediterranean waters

7- Fecundity

The study of fish biology and population dynamics hinges on a comprehensive understanding of fecundity **(Hunter, 1992)**. The present study revealed an absolute fecundity range of 76,167 to 281,325 oocytes for *F. commersonii*, corresponding to a length range from 60.0 to 100.0cm TL. The nexus between absolute fecundity and fish length is clarified by a pronounced curvilinear. The equation representing this relationship is as follows: $F_a = 1.9812\ L^{2.55}$ ($R^2 = 0.947$). The value of the exponent b = 2.55 reflects that the ova diameter change is significant with the increase in fish length. From Table (3), it is clear that the fecundity increases as fish length increases. Regarding the relative fecundity, it was found to range between 1269 and 2813 ova per unit fish length (cm). The rapport between relative fecundity and fish length is depicted as: $F_r = 1.9812\ L^{1.55}$ ($R^2 = 0.864$). According to **Saad and Sabour (2010)**, high relative fecundity values support rising recruitment and young fish populations.

In general, due to the high fecundity rate and the prolonged reproductive cycle, this species has emerged as a non-indigenous in the Mediterranean Sea, its proliferation rendering it a formidable occupant of this marine ecosystem.

Table 3. Absolute and relative fecundity in relation with fish length for *F. commersonii* from the Egyptian Mediterranean waters

Total Length (cm)	N	Absolute fecundity		Relative fecundity / cm	
		Observed	Calculated	Observed	Calculated
60-	16	76167	69200	1269	1153
70-	8	103370	102602	1477	1466
80-	2	111274	144319	1391	1804
90-	2	206720	194993	2297	2167
100-	2	281325	255228	2813	2552

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Conflict of interest

The authors explicitly affirm that they are devoid of any discernible financial conflicts of interest or personal affiliations that could have potentially biased the research presented in this manuscript.

REFERENCES

Alprol, A.E.; Ashour, M.; Mansour, A.T.; Alzahrani, O.M.; Mahmoud, S.F. and Gharib, S.M. (2021). Assessment of water quality and phytoplankton structure of eight Alexandria beaches, southeastern Mediterranean Sea, Egypt. J. Mar. Sci. Eng., 9: 1328. https://doi.org/10.3390/jmse9121328

Azzurro, E.; Pizzicori, P. and Andaloro, F. (2004). First record of *Fistularia commersonii* (Fistularidae) from the central Mediterranean. Cybium, 28 (1): 72–74

Azzurro, E.; Soto, S.; Garofalo, G. and Maynou, F. (2013). *Fistularia commersonii* in the Mediterranean Sea: invasion history and distribution modeling based on presence-only records. Biol. Invasions, 15(3): 977–990.

Bariche, M. and Kajajian, A. (2012). Population structure of the bluespotted cornetfish *Fistularia commersonii* (Osteichthyes: Fistulariidae) in the eastern Mediterranean Sea. J. Biol. Res., 17: 74.

Bariche, M.; Kajajian, A. and Azzurro, E. (2013). Reproduction of the invasive bluespotted cornetfish *Fistularia commersonii* (Teleostei, Fistulariidae) in the Mediterranean Sea. Mar. Biol. Res., 9(2): 169–180.

Bashir, A.E. and Elbaraasi, H. (2014). Some biological aspects of the invasive fish *Fistularia commersonii* (Ruppell 1838) population in the coast off Benghazi, Libya (Doctoral dissertation, University of Benghazi)

Baxter, I.G. (1959). Fecundities of winter-spring and summer-autumn herring spawners. ICES J. Mar. Sci., 25(1): 73–80.

Bridger, J.P. (1961). On the fecundity and larval abundance of Downs herring. Fishery Invest. Lond., 23(1): 1–30**.**

Cerda, J.; Arana, de la G. and Fernández, J.L. (1996). Ovarian and liver responses to environmental stressors in fish. J. Fish Biol., 48(4): 738–747. https://doi.org/10.1111/j.1095-8649.1996.tb01454.x

Corsini-Foka, M.; Mastis, S.; Kondylatos, G. and Batjakas, I.E. (2017). Alien and native fish in gill nets at Rhodes, eastern Mediterranean (2014–2015). J. Mar. Biol. Assoc. U.K., 97(3): 635–642

Cushing, D.H. (1981). Fisheries biology: a study in population dynamics.

El-Samman, A. and Ragheb, E. (2023). *Fistularia commersonii* (Rüppell, 1838) (Pisces: Fistulariidae): Length-weight relationship and condition factors from the Egyptian Mediterranean waters (West Alexandria). Blue Econ., 1(2): 149–157. https://doi.org/10.57241/2805-2994.1014

Ergüden, D.; Gürlek, M. and Turan, C. (2022). Length-weight relationships of *Fistularia commersonii* Rüppell 1835 from the Northeastern Mediterranean Sea, Türkiye. Çanakkale Onsekiz Mart Univ. J. Mar. Sci. Fish., 5(1): 77–86.

Farrag, M.; Osman, A.; Akel, E. and Moustafa, M. (2014). Catch and effort of night purse seine with emphasis to age and growth of lessepsian *Etrumeus teres* (Dekay, 1842) in the Mediterranean Sea, Egypt. Egypt. J. Aquat. Res., 40(2): 181–190. https://doi.org/10.1016/j.ejar.2014.06.003

Fiorentino, F.; Giusto, G.B.; Sinacori, G. and Norrito, G. (2004). First record of *Fistularia commersonii* (Fistularidae, Pisces) in the Strait of Sicily (Mediterranean Sea). Biol. Mar. Mediterr., 11(2): 583–585

Fritzsche, R.A. (1976). A review of the cornetfishes, genus *Fistularia* (Fistulariidae), with a discussion of intrageneric relationships and zoogeography. Bull. Mar. Sci., 26(2): 196–204

Froese, R. (2004). Keep it simple: three indicators to deal with overfishing. Fish Fish., 5(1): 86–91

Golani, D. (2000). First record of the bluespotted cornetfish from the Mediterranean Sea. J. Fish Biol., 56(6): 1545–1547

Halim, Y. and Rizkalla, S.I. (2011). Aliens in Egyptian Mediterranean waters: A checklist of Erythrean fish with new records. Mediterr. Mar. Sci., 12(2): 479–490

Hunter, J.R. (1992). Fecundity, spawning and maturity of female Dover sole *Microstomus pacificus*, with an evaluation of assumptions and precision. Fish. Bull., 90(1): 101–128

Jensen, A.L. and Gross, D.R. (2004). Fish life histories: An overview. In Fish Physiology 23: 1–42. Elsevier

Kalogirou, S.; Corsini, M.; Kondilatos, G. and Wennhage, H. (2007). Diet of the invasive piscivorous fish *Fistularia commersonii* in a recently colonized area of the eastern Mediterranean. Biol. Invasions, 9: 887–896

Kondylatos, G.; Theocharis, A.; Charokopou, M.; Perakis, E.; Mavrouleas, D.; Kalaentzis, K.; Pafras, D. and Klaoudatos, D. (2024). Life-history traits of the bluespotted cornetfish *Fistularia commersonii* Rüppell, 1838 in Rhodes, Greece, with notes on the red cornetfish *Fistularia petimba* Lacepède, 1803. Hydrobiology, 3(3): 183–208. https://doi.org/10.3390/hydrobiology3030013

Lévêque, C. (1997). Biodiversity dynamics and conservation: The freshwater fish of tropical Africa. Cambridge University Press

Marino, G.; Azzurro, E.; Massari, A.; Finoia, M.G. and Mandich, A. (2001). Reproduction in the dusky grouper from the southern Mediterranean. J. Fish Biol., 58(4): 909–927

Marshall, C.T.; Needle, C.L.; Thorsen, A.; Kjesbu, O.S. and Yaragina, N.A. (2006). Systematic bias in estimates of reproductive potential of an Atlantic cod (*Gadus morhua*) stock: implications for stock recruit theory and management. Can. J. Fish. Aquat. Sci., 63(5): 980–994.

Martins, A.S. and Haimovici, M. (2000). Reproduction of the cutlassfish *Trichiurus lepturus* in the southern Brazil subtropical convergence ecosystem. Sci. Mar., 64(1): 97–105

Mazzoni, R. and Petito, J. (2011). Reproductive biology of a Tetragonopterinae (Osteichthyes, Characidae) of the Ubatiba fluvial system, Maricá-RJ. Braz. Arch. Biol. Technol., 42

Moore, S.E.; Hesp, S.A.; Hall, N.G. and Potter, I.C. (2007). Age and size compositions, growth and reproductive biology of the breaksea cod *Epinephelides armatus*, a gonochoristic serranid. J. Fish Biol., 71(5): 1407–1429.

Morgan, M.J. (2008). Integrating reproductive biology into scientific advice for fisheries management. J. Northwest Atl. Fish. Sci., 41: 37–51

Nikolsky, G.V. (1963). The Ecology of Fishes. Academic press, London& New York, p.352

Oliveira, M.R.; Costa, E.F.S.; Araújo, A.S.; Pessoa, E.K.R.; Carvalho, M.M.; Cavalcante, L.F.M. and Chellappa, S. (2012). Sex ratio and length-weight relationship for five marine fish species from Brazil. J. Mar. Biol. Oceanogr., 1: 2

Pais, A.; Merella, P.; Follesa, M.C. and Garippa, G. (2007). Westward range expansion of the Lessepsian migrant *Fistularia commersonii* (Fistulariidae) in the Mediterranean Sea, with notes on its parasites. J. Fish Biol., 70(1): 269–277

Pauly, D. (1984). Fish population dynamics in tropical waters: a manual for use with programmable calculators. ICLARM.

Plaza, G.; Sakaji, H.; Honda, H.; Hirota, Y. and Nashida, K. (2007). Spawning pattern and type of fecundity in relation to ovarian allometry in the round herring *Etrumeus teres*. Mar. Biol., 152: 1051–1064

Psomadakis, P.N.; Scacco, U.; Consalvo, I.; Bottaro, M.; Leone, F. and Vacchi, M. (2009). New records of the Lessepsian fish *Fistularia commersonii* (Osteichthyes: Fistulariidae) from the central Tyrrhenian Sea: signs of an incoming colonization? Mar. Biodivers. Rec., 2: e49.

Ragheb, E. (2016). Reproductive biology of catfish *Chrysichthys auratus*, Geoffroy Saint-Hilaire, 1809 (Family: Bagridae) from Damietta branch of the river Nile, Egypt. Egypt. J. Aquat. Res., 42(3): 349–356

Ragheb, E. (2022). Morphometric and meristic characteristics of the first record *Fistularia petimba* (Lacepède, 1803) and *Fistularia commersonii* (Rüppell, 1838) (Pisces: Fistulariidae) from the Egyptian Mediterranean waters (west Alexandria). Egypt. J. Aquat. Res., 48: 143–150

Ragheb, E.; El-Samman, A. and El-Betar, T. (2024). Age, growth and population aspects of *Fistularia commersonii* (Rüppell, 1838) from the Eastern Mediterranean region, Alexandria, Egypt. Egypt. J. Aquat. Res., in press.

Saad, A.A. and Sabour, W.G. (2010). Impact of invasive species on the biodiversity and fish stock; case study: *Fistularia commersonii* Rüppell, in the Syrian Coast. Rapp. Comm. Int. Mer Médit., 39: 652

Simpson, A.C. (1951). The Fecundity of the Plaice, &c.

Singh, R.; Prasad, R. and Singh, K. (2008). The role of the liver in fish reproduction. Fish Physiol. Biochem., 34(1): 89–100. https://doi.org/10.1007/s10695-007-9166-3

Sokal, R.R. and Rohlf, F.J. (1969). Biometry. Freeman and Company, San Francisco, CA, pp. 776

Streftaris, N. and Zenetos, A. (2006). Alien marine species in the Mediterranean—the 100 'worst invasives' and their impact. Mediterr. Mar. Sci., 7(1): 87–118.

Zin, A.M.; Robson, M.R. and Kwan, P.A. (2011). Physiological role of the liver in fish. Aquat. Biol., 12(1): 43–52. https://doi.org/10.3354/ab00321