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The Reproductive Biology of Por's Goatfish (*Upeneus pori* Ben-Tuvia & Golani, 1989) from the Benghazi Coast, Eastern Libya, Mediterranean Sea

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ABSTRACT
This study aimed to determine the reproductive biology of *Upeneus pori* along the Benghazi coast, Mediterranean Sea, eastern Libya, by contrasting the present findings with those of previous investigations. This involved figuring out fecundity, length at initial sexual maturity, gonado somatic index, and sex ratio. Monthly samples of *Upeneus pori* were collected from commercial trawl captures in the Mediterranean Sea off the coast of Benghazi between January and December 2024. The overall sex ratio for *Upeneus pori* was 1: 1.24 (M: F). At 50% maturity, *Upeneus pori* males measured 10.1cm in length, while females measured 10.2cm. The spawning behavior was analyzed based on the gonad somatic index. The highest GSI values for both males and females were recoreded from March till July. *Upeneus pori* spawned during the spring and summer season. Approximately 60 mature ovaries were used to estimate *Upeneus pori's* absolute fecundity. The mean absolute fecundity ranged from 6791 ± 566 to 70285 ± 3426 with an average of 39118 ±1447, and the average fish length varied from 9.5 to 17.4cm.

INTRODUCTION

An essential part of fish biology is the study of fish reproduction, which has been successful in resolving a number of issues related to fishery management, including spawning stock determination. Utilizing available data based on reproductive traits and environmental change may help us better explain observed oscillations in reproductive output and estimate recruitment **(Kraus *et al.*, 2002; Uibein, 2007)**.

Family Mullidae or goatfish are one of the most lucrative and expensive fish families in Libya and are primarily targeted by trawl fishing. They account for more than 13% of all trawl landings in Libyan Mediterranean waters **(Elbaraasi *et al.*, 2019)**.

The Mediterranean Sea is home to four of the six taxa in the family Mullidae: *Mullus, Upeneus, Pseudupeneus*, and more recently, *Parupeneus* **(Golani, 1994)**.

Libyan Mediterranean demersal fisheries primarily target three dominant species of the family Mullidae: *Upeneus pori, Mullus barbatus*, and *Mullus surmuletus* **(Elbaraasi *et al.*, 2019)**.

Since the Suez Canal linked the Mediterranean and the Red Sea in 1869, many Indo-Pacific fish species have adapted to the Mediterranean **(Golani, 1998; Kasapidis *et al.*, 2007)**. The Por's goatfish, *Upeneus pori*, is one of these species **(Karachle *et al.*, 2004; Golani *et al.*, 2007)**. In 1950, Kosswig made the first observation of the Por's goatfish, *U. pori*, in Iskenderun Bay, Turkey. It is thought to have been successfully established in the Mediterranean Sea since its original discovery as *U. pori*, particularly off the coasts of Egypt **(El Sayed, 1994)** and Turkey's Levantine Coast **(Gucu *et al.*, (1994)**.

Furthermore, *U. pori* has been discovered on Mediterranean Sea beaches in Libya **Ben-Abdallah *et al.* (2004**) and Tunisia **(Ben Souissi *et al.*, 2005; Azzouz *et al.*, 2010)**. The Por's goatfish is a subtropical species that lives in the Western Indian Ocean, which extends from the Red Sea to southern Oman, according to **Ben-Tuvia and Golani (1989)**. This commercially important demersal species mainly inhabits muddy and sandy substrate up to 50 meters below the surface **(Cicek & Avsar, 2011)**. Trawls are also commonly used to catch it in shallow waters between 10 and 40 meters.

According to recent research by **El-Drawany (2013)**, Lessepsian fish species like *U. pori* and *Upeneus moluccensis* are crucial to commercial fishing along Libya's southern Mediterranean coast. Few efforts have been made to provide a thorough description of the biology and ecology of Por's goatfish. Except for a few studies **(Golani & Galil, 1991)** that provide some information on its feeding habits, the majority of the species' current information focuses on its range. **Golani (1994)** examined the niche distinction between native and colonial goatfishes on Israel's Mediterranean coast.

MATERIALS AND METHODS

Ethics approval

The animal studies adhered to the norms and criteria set out by ARRIVE (https://arriveguidelines.org/). The Faculty of Fish Resources at Suez University, Suez, Egypt, authorized all operations following the IACUC (Approval number SUEZ Sci_IRB: 08/09/2025/25).

Between January and December 2024, samples were taken from fishing trawlers off the coast of Benghazi in the eastern Libyan Mediterranean Sea (Fig. 1). A total of five hundred *Upeneus pori* specimens were analyzed.

Both total length (TL) and total weight (to the closest cm) were measured.

Sex ratio

The monthly percentage of males to females (M: F) was used to calculate the sex ratio. To determine whether the sex ratio deviates significantly from 1:1, the chi-square test was employed at the 0.05 significance level.

Gonado- somatic index (GSI)

De Vlaming and Chapman (1982) developed the following formula to calculate the gonado-somatic index (GSI):

$$GSI = 100 \times G/W$$

Where, W stands for body weight and (G) for gonad weight.

Length at first sexual maturity(L_{50})

The length at which 50% of *Upeneus pori* reach sexual maturity was calculated by fitting the percentage maturity against mid lengths **(King, 1995)**.

Fecundity

About 60 *Upeneus pori* specimens were carefully removed during the breeding season. The ovaries were cleaned, weighed to within 0.01 grams, and then preserved in 4% formalin. Three sub-samples of each ovary were weighed to the nearest 0.01g. Each sub-sample was placed in a Petri dish with a drop of distilled water, and the eggs were then counted using a binocular microscope (X16).

According to **Bagenal (1978)**, the following formula was used to determine the absolute fecundity:

Total Fecundity = Number of Eggs in Subsample × Gonad Weight/Subsample Weight

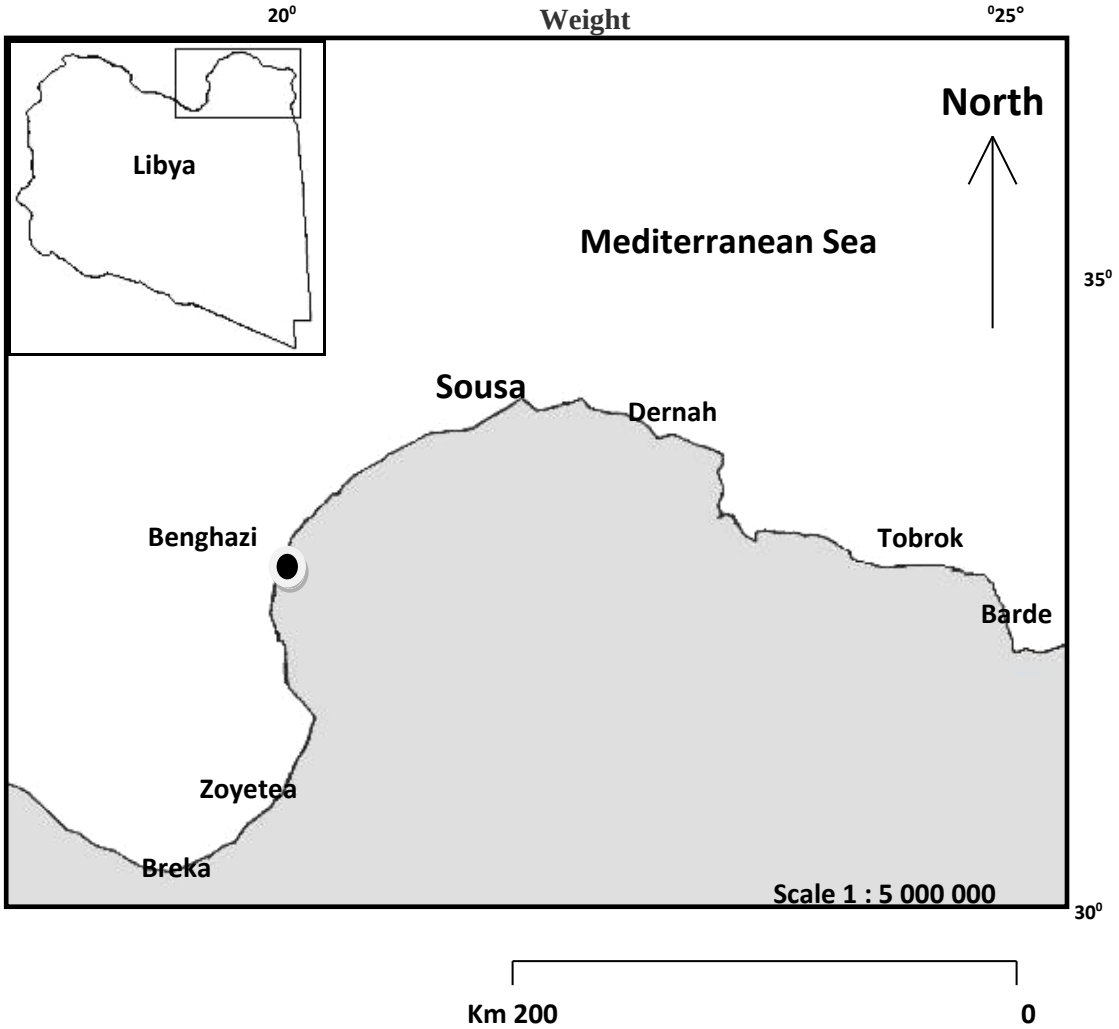


Fig. 1. Map displaying the collecting location on the eastern Libyan Mediterranean coast near Benghazi

RESULTS AND DISCUSSION

Sex ratio

Of the 500 sexed *Upeneus pori* specimens, 223 were males, accounting for 44.6% of the total, while 55.4% were females. The sex ratio was one male for every 1.24 females. Females outnumbered males during the entire study period, based on monthly changes in the sex ratio of *Upeneus pori* collected from the Benghazi coast between January and December 2024. The overall sex ratio was 1: 1.24, as shown in Table (1).

This outcome supported the findings of **Ramadan and El-Halfawy (2014)**, who noted that the female *Upeneus pori* dominated the samples.

According to the current survey, April had the highest proportion of females (56.8%), followed by May (55.9%), June (57.4%), August (57.6%), and November (60.6%). As a result, women dominated the current study during every month and time period. These results are almost identical to those of **Ismen (2006)** and **El-Drawany (2013)**

Similar to the results of the current study, in Iskenderun Bay, Turkey, **Ismen (2006)** reported a male to female ratio of 1.0:1.09. The chi-square value (X2= 70.05; *P*< 0.05) showed a statistically significant difference between the sexes.

Table 1. From January to December 2024, the *Upeneus pori* Benghazi coast in eastern Libya showed monthly changes in the sex ratio

		Males		Females		
Month	**No. of fish**	**No.**	**%**	**No.**	**%**	**Sex ratio**
Jan. (2024)	**41**	19	46.3	22	53.7	**1 : 1.16**
Feb.	**35**	16	45.7	19	54.3	**1 : 1.19**
Mar.	**32**	15	46.9	17	53.1	**1 :1.13**
Apr.	**37**	16	43.2	21	56.8	**1 : 1.31**
May	**59**	26	44.1	33	55.9	**1 : 1.27**
Jun.	**54**	23	42.6	31	57.4	**1 : 1.35**
Jul.	**55**	25	45.5	30	54.5	**1 : 1.20**
Aug.	**33**	14	42.4	19	57.6	**1 : 1.36**
Sep.	**35**	16	45.7	19	54.3	**1 : 1.19**
Oct.	**44**	20	45.5	24	54.5	**1 : 1.20**
Nov.	**33**	13	39.4	20	60.6	**1 : 1.54**
Dec.	**42**	20	47.6	22	52.4	**1 : 1.10**
Total	**500**	223	44.6	277	55.4	**1 : 1.24**

Length at first sexual maturity(L_{50})

Length at first maturity is defined as how long it takes to become sexually mature in fisheries research, L_{50} is a crucial metric that aids in establishing the ideal mesh size and minimum legal size that might be required to preserve the appropriate spawning

stock and guarantee that the mature individuals have at least one spawning. The male and female *Upeneus pori* reached their first sexual maturity at length group of 8.5 – 9.4cm by 44.9 and 41.2%, respectively, as shown in Figs. (2, 3). Male *Upeneus pori* were 10.1cm long and females were 10.2cm long at 50% maturity. The first-year age at first sexual maturity was the same for both studies, but the estimation of length at first sexual maturity varied considerably. The duration required to attain sexual maturity The minimum legal size and ideal mesh size that may be required to maintain the appropriate spawning stock and guarantee that the mature individuals have at least one spawning are determined by L_{50}, a crucial parameter in fisheries research. Figs. (2 and 3) demonstrate that 44.9 and 41.2% of male and female *Upeneus pori*, respectively, attained their first sexual maturity at length group (8.5 – 9.4cm).

At 50% maturity, *Upeneus pori* males measured 10.1cm in length, while females measured 10.2cm. The estimation of length at first sexual maturity varied significantly between the two studies, despite the fact that the first-year age at first sexual maturity was the same.

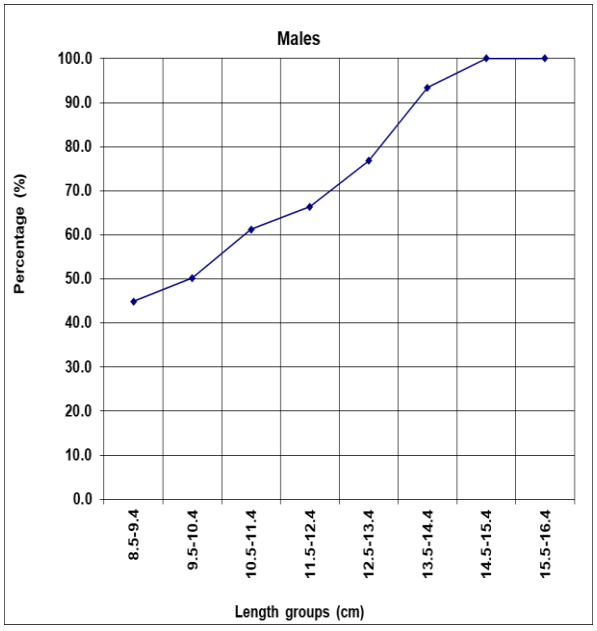


Fig. 2. The length at first sexual maturity of male *Upeneus pori* from the eastern Libyan coast of Benghazi between January and December 2024

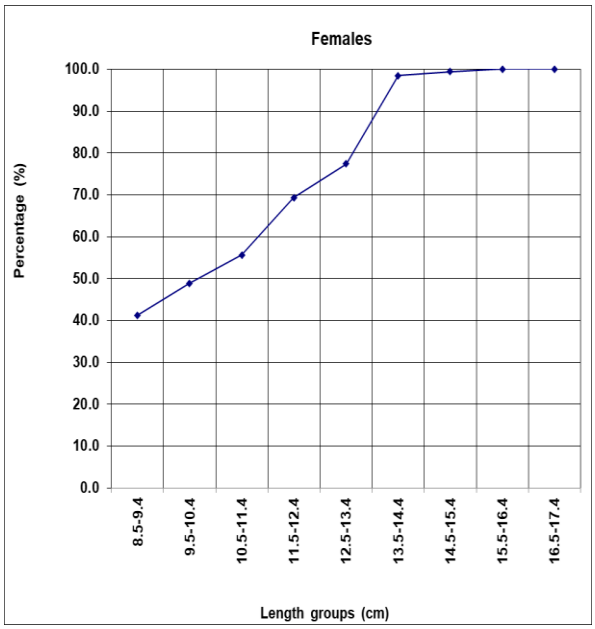
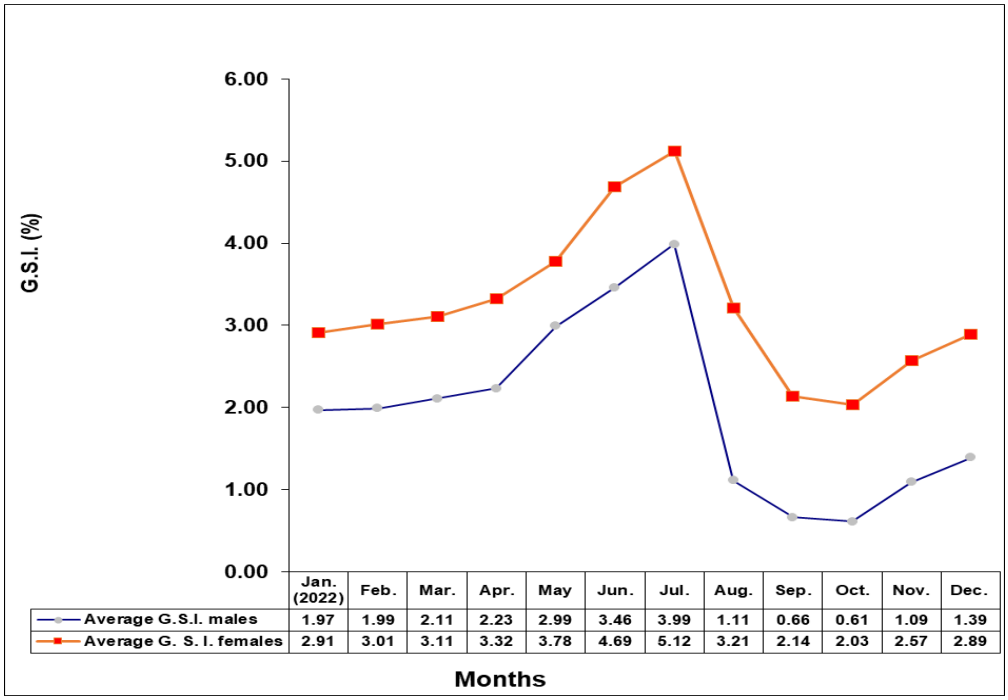


Fig. 3. The length at first sexual maturity of female *Upeneus pori* from the eastern Libyan coast of Benghazi between January and December 2024

Gonado-somatic index (GSI):

The spawning season of *Upeneus pori* took place close to the end of spring and summer because the male and female GSI peaked in May (2.99 and 3.78), June (3.46 and 4.69), and July (3.99 and 5.12). The GSI then declined, with October exhibiting the lowest values for both females (2.03) and males (0.61) (Fig. 4).

The spawning season begins by the end of March and lasts until the middle of July, according to previous research **(Ismen, 2006; El-Drawny, 2013; Ramadan & El-Halfawy, 2014; Sabrah *et al.*, 2016)**. These outcomes are consistent with those conclusions. To guarantee ideal conditions for fish larval growth and survival, *Upeneus pori* fertility is timed to coincide with the summer peak of zooplankton abundance **(Winemiller & Rose, 1992; Fernandez de Puelles *et al.*, 2003)**. Larval growth is encouraged by warmer summer temperatures and stable water columns that shield feeding areas **(Sabates *et al.*, 2007)**.



	Jan. (2022)	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Average G.S.I. males	1.97	1.99	2.11	2.23	2.99	3.46	3.99	1.11	0.66	0.61	1.09	1.39
Average G. S. I. females	2.91	3.01	3.11	3.32	3.78	4.69	5.12	3.21	2.14	2.03	2.57	2.89

Fig. 4. From January to December 2024, the gonado-somatic index of male and female *Upeneus pori* from the Benghazi shore in eastern Libya varied monthly

Fecundity

Fisheries, population dynamics, and the food supply all depend on an understanding of fish fecundity. In the current investigation, the ripe eggs were used as the basis for counting the more developed egg groups and calculating fecundity. To estimate fecundity, specimens were collected during the spawning season. When evaluating the commercial potential of fish stocks, fecundity a biological indicator of reproductive potential—is a crucial consideration **(Gomez-Marquez *et al.*, 2003)**.

Fecundity and its relationship to female size allow for estimation of the reproductive capacity of fish populations **(Qasim & Qayyum, 1963)**, the number of potential offspring in a season, and the potential for egg production **(Chondar, 1977)**. Based on their overall range, the ripe females in this study were separated into size classes at intervals of 0.9 cm. The fecundity of the fish increased with length (Table 2). According to the current study, the mean absolute fecundity ranged from 6791 ± 566 to 70285 ± 3426 with an average of 39118 ±1447, and the average fish length ranged from 9.5 to 17.4 cm. **Sabrah *et al.* (2016)** found that the average absolute fecundity for *U. pori* in the Gulf of Suez, Egypt, was 8773± 560 to 71,400±3219 eggs with total lengths of 11.0–16.0 cm. This result is nearly identical to theirs.

Table 2. Relationship between female *Upeneus pori* fertility and total body length (cm) from January to December 2024 in Benghazi, eastern Libya

Total length (cm)		No.	Absolute Fecundity		
Range	Average		Minimum	Maximum	Average
9.5-10.4	9.9	**9**	6651	6948	**6791 ± 566**
10.5-11.4	11.1	**11**	7443	8290	**7759 ± 645**
11.5-12.4	11.9	**12**	9231	10317	**9612 ± 869**
12.5-13.4	12.9	**8**	11238	15690	**13329 ± 1123**
13.5-14.4	14.1	**7**	32789	44398	**37289 ± 1345**
14.5-15.4	14.9	**6**	41167	65390	**53257 ± 2432**
15.5-16.4	16.1	**4**	61298	70786	**68786 ± 3123**
16.5-17.4	17.1	**3**	64333	74888	**70285 ± 3426**
		60			**39118 ±1447**

CONCLUSION

The reproductive biology of *Upeneus pori* in the Mediterranean Sea, eastern Libya, along the Benghazi coast, is described here for the first time. This study includes fecundity, gonado-somatic index, sex ratio, and length at initial sexual maturity, providing the basic information needed for replication and stock size estimation. Fecundity data can be used to determine the number and timing of recruitments. Closed fishing seasons and minimum landing size, which are linked to length at first sexual maturity, are key components of the management strategy. The study found that *U. pori* spawned in late spring and summer along the Benghazi coast.

Author Statement

Karima Momen Al-Mabrouk[1]: Data curation, Project administration, Funding acquisition, Methodology, Software, Writing- original draft, Writing – review& editing.

Ahmed S. Abd El-Naby[2]: Data curation, Project administration, Funding acquisition, Methodology, Software, Writing- original draft, Writing – review& editing.

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