Egyptian Journal of Aquatic Research (2016) xxx, xxx–xxx

HOSTED BY

ELSEVIER

National Institute of Oceanography and Fisheries

Egyptian Journal of Aquatic Research

http://ees.elsevier.com/ejar
www.sciencedirect.com

FULL LENGTH ARTICLE

Sexual maturity, spawning activity, sex ratio and fecundity of two Mullidae species dwelling the Gulf of Suez, Red Sea

Manal M. Sabrah [a,*], **Rasha A. Heneish** [a], **Magdy E. Alwany** [b], **Mohammed I. Ahmad** [b]

[a] *National Institute of Oceanography and Fisheries (NIOF), Fisheries Dep., Egypt*
[b] *Faculty of Science, Marine Science Dep., Suez Canal Univ., Egypt*

Received 17 February 2016; revised 12 March 2016; accepted 29 April 2016

KEYWORDS

Gulf of Suez;
Mullidae;
Upeneus guttatus;
Upeneus pori;
Reproductive biology

Abstract *Upeneus guttatus* and *Upeneus pori* are the most common Mullidae species inhabiting the Gulf of Suez and mainly caught by the trawl fisheries. Reproductive biology of the two species was studied during the fishing period from September, 2013 to May 2015. The monthly gonad maturity development and the monthly gonado-somatic index (GSI) sequence of *U. guttatus* and *U. pori* revealed prolonged spawning activities throughout spring and summer seasons. The sex ratio was 1:2 for the two species in favor of females; it differed statistically from the expected 1:1 (X^2 = 65.4 in *U. guttatus* and 70.4 in *U. pori*). The length at which 50% of the population attains sexual maturity (L_{m50}) is 11.35 ± 0.32 and 11.47 ± 0.25 cm for males and females respectively in *U. guttatus*, where it was 10.56 ± 0.21 cm in males and 10.60 ± 0.18 cm in females of *U. pori*. Absolute fecundity increased as the fish length and weight increases. Observed absolute fecundity ranged from 142,925 ± 5621 to 86,940 ± 3364 eggs for the length range of 12.0–18.0 cm in *U. guttatus* and from 8773 ± 560 to 71,400 ± 3219 eggs in total lengths of 11.0–16.0 cm for *U. pori*, with a low value of standard error ranging between 0.28% and 4.9% in both species and high correlation coefficient (R^2 > 0.96).

Introduction

Family Mullidae has many common names including goat fish or the Red Mullets, it forms the most commercially and economically important bottom trawl species distributing along the Gulf of Suez, it is highly valued as a food and has a high local market price. Goatfishes are found throughout tropical and temperate waters of the Atlantic, Pacific and Indian Oceans, including the Red, Mediterranean and Black seas. They are coral reef dwellers, small to medium-sized with two widely-spaced dorsal fins (Bray, 2012). Goatfish are characterized by a unique feature that they have a pair of barbels on the hyoid arch that referred to behavioral adaptations (Kim, 2002). As a result of the special feeding behavior, goatfishes

* Corresponding author.
E-mail address: manal_sabrah@yahoo.co.uk (M.M. Sabrah).

Peer review under responsibility of National Institute of Oceanography and Fisheries.

http://dx.doi.org/10.1016/j.ejar.2016.04.007

have great importance in food chains and in the whole ecosystem as they participate in the re-suspension of bottom sediments and nutrients into the surrounding water area causing attraction of other fish species (Uiblein, 2007; Rajan et al., 2012). Mullidae is represented in the Suez Gulf by four genera, Upeneus, Parupeneus, Mulliochthys and recently the Mediterranean endemic genus Mullus that have migrated to the Suez Gulf (Sabrah, 2015 and Ahmad et al., 2016). The genus Upeneus is the most dominant. In the Suez Gulf 5 species of the genus Upeneus were recorded genetically, namely *Upeneus guttatus*, *U. vittatus*, *U. tragula*, *U. pori* and *U. moluccensis* (Uiblein and Heemstra, 2010). All these species are tropical and subtropical that migrated to the Mediterranean Sea via the Suez Canal (Golani and Ritte, 1999). Very little is known about the reproductive strategy of the most common *U. guttatus* and *U. pori*, the only relevant studies addressing the biological characteristics of some upeneus species in Egypt were conducted by Sabrah (2006) and Sabrah (2007) on *U. japonicas* and Sabrah and El-Ganainy (2009) on *U. vittatus*, *U. tragula* endemic the Suez Gulf. In Turkey, Ismen (2006) studied the age, growth, mortality and reproduction of *U. pori*. Motomura et al. (2012) recorded *U. guttatus* for the first time in Japan. While El-Drawany (2013) in Lybia coast and Ramadan and El-Halfawy (2014) in the Mediterranean Coast, Egypt; studied the fishery and the reproductive biology of *U. pori* Çiçek (2015) studied the sustainability and gear selectivity of *U. pori* in Turkey.

Goals: Most of the Egyptian marine fish resources are over-exploited specially the Gulf of Suez. Information on the maturation and spawning is to establish basic knowledge on the reproduction of the most economic goatfish in relation to fisheries in order to promote sustainable exploitation of these marine resources for getting the maximum stock biomass.

Materials and methods

Sampling area

Samples of the Red Mullets (Mullidae) were collected from the commercial bottom trawling boats operating in the Gulf of Suez (Fig. 1) and landing at Attaka fishing port during the period from Sep. 2013 to May 2015 (data from two fishing seasons). The Gulf of Suez fishery is seasonal, generally starts from 1st September throughout the end of April every year. Samples of May, 2015 were brought from the artisanal boats that used small trawl fishing units and operating with licenses during the Gulf closed season.

Sampling strategy

In the laboratory Mullidae specimens were identified and separated into different species (as it constitutes more than 10 species belonging to four different genera). Our study is based on two species of genus Upeneus (*U. guttatus* and *U. pori*), as it is the first time to evaluate the reproductive pattern of these species in the Gulf of Suez. Total length was measured to the nearest 0.1 mm for each sample. Total weight and ovary weight were recorded to the nearest 0.01 g. Sex was determined by examination of gonad either by the visual assessment or under a binocular microscope. Spawning season was estimated based on the availability of gonad maturation during the study period and the monthly gonado-somatic index (GSI). Maturity stage was evaluated in different months, based on the scale described by King (1982) with some modifications. Maturity stages were classified into six stages, (I) Immature, (II) Developing/Recovery, (III) Maturing, (IV) Ripe, (V) Running/Spawning and (VI) Spent according to their development. The monthly gonado-somatic index was calculated according to (De Viaming et al., 1982) formula: (GSI = gonad weight/-total body weight × 100). For determining the size at sexual maturity (L_m) for males and females in each species, the percentage frequency of immature and mature fish during the period of gonad maturation (March to September) was used to group the fish into 1 cm length group, then the maturity curves (King, 1995) were fitted to estimate the size at L_{m50}. Absolute fecundity was estimated by gravimetric method, based on counting ova number in a known weight from 35 gravid females collected during the spawning months. The observed absolute fecundity (F) in each sample was estimated according to the equation:

$$F = \text{Ovary weight}/\text{sample weight} * \text{no. of ripe eggs in sample}$$

The relationships of absolute fecundity with total length of the two species were done by the least square equation (Holden and Raitt, 1974) as: $F_{abs} = a\ L^b$. The relationship between absolute fecundity and corresponding weight represented by a linear regression with an equation of:

$$F_{abs} = a + bWt$$

Results

The present study is based on 659 fish samples of *U. guttatus* with a length range of 9.0–19 cm TL (211 males, 413 females and 35 juvenile or immature). 476 fish samples of *U. Pori* ranged in total length from 9.0 to 16 cm (130 males, 304 females and 42 juveniles). There were no observed ripe males or females smaller than 9.5 cm through all the collected samples.

Mullidae species composition

Family Mullidae from the Gulf of Suez constituted more than 10 species which belong to four genera. Genus Upeneus is the most widely distributed Red Mullets in the Suez Gulf. It constitutes a high proportion of *U. guttatus* (35.8%), *U. tragula* (34.2%), while *U. vittatus*, (17.7%) and *U. pori* (10.5%) framed a relatively low proportion. The other Mullidae species constituted about (1.8%), (Fig. 2).

Sex ratio

Samples of length group 8.0–8.9 and some of length group 9.0–9.9 couldn't be distinguished as male or females so they were grouped as immature or juveniles. The grand average of sex ratio during the study period showed percentage of 33.8% and 66.2% (1:2) in *U. guttatus* and found to be 30% and 70% (1:2.3) in *U. pori* for males and females respectively. The overall sex ratio M:F was 1:2, which deviate significantly from the expected ratio 1:1 in favor of females in both species, ($P < 0.05$, $X^2 = 65.4$ in *U. guttatus* and $X^2 = 70.4$ in *U. pori*). Monthly sex ratio confirmed the expected 1:1 during

Please cite this article in press as: Sabrah, M.M. et al., Sexual maturity, spawning activity, sex ratio and fecundity of two Mullidae species dwelling the Gulf of Suez, Red Sea. Egyptian Journal of Aquatic Research (2016), http://dx.doi.org/10.1016/j.ejar.2016.04.007

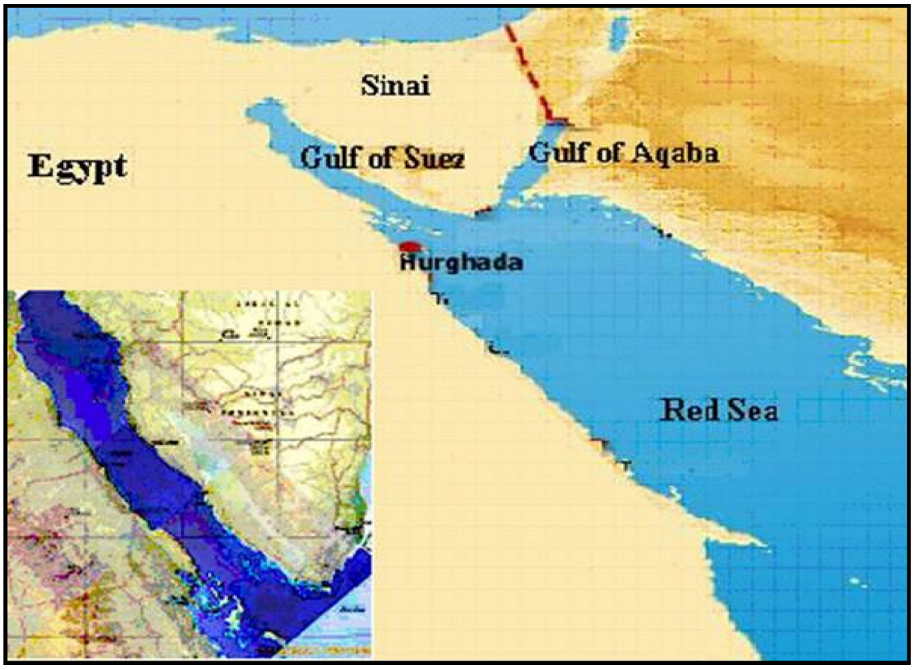

Figure 1 Gulf of Suez fishing area.

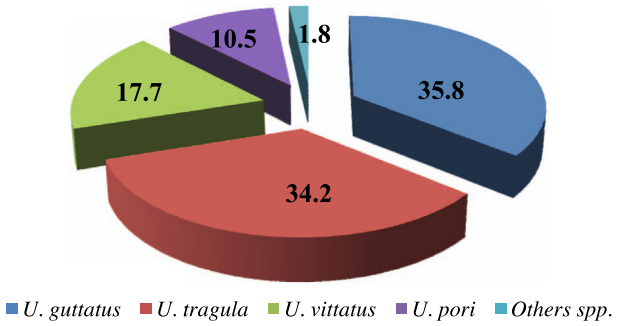

Figure 2 Family Mullidae species composition at the Gulf of Suez during the study period.

November and May in *U.* guttatus and during September, March and May in *U. pori* (Tables 1 and 2). In respect to the length distribution of males and females in *U. guttatus* and *U. pori* samples, females were predominant in all length groups and they were bigger in size than males in *U. guttatus* (Fig. 3). Sex ratio showed highly significant values in large length groups from 14.0 to 17.0 cm (X^2 ranged from 6.3 to 32.0, $P < 0.05$) of *U. guttatus* (Fig. 3), the rest of the length groups exhibit no significant differences (X^2 ranged from 1.1 to 3.6, $P > 0.05$). On the other hand sex ratio between length groups of *U. pori* differs significantly from the theoretically expected ratio of 1:1 always in favor to females(X^2 ranged from 10.2 to 29.0, $P < 0.05$ with a length range of 11.0 to 16.0 cm), (Fig. 3).

Table 1 Monthly variations in sex ratio of *Upeneus guttatus* from the Gulf of Suez.

Month	Total No. of Fish	Male		Female		Sex ratio	X^2
		No. of Fish	%	No. of Fish	%	M/F	
Sep.013	41	10	24.4	31	75.6	1:3.1	10.8*
Oct.	75	12	16.0	63	84.0	1:5.3	34.7*
Nov.	72	36	50.0	36	50.0	1:1	0
Dec.	95	20	21.1	75	78.9	1:3.8	31.8*
Jan.	42	14	33.3	28	66.7	1:2.0	4.6*
Feb.	82	27	32.9	55	67.1	1:2.0	9.5*
Mar.	88	36	40.9	52	59.1	1:1.4	2.9
Apr.	46	18	39.1	28	60.9	1:1.6	2.2
May 015	83	38	45.8	45	54.2	1:1.2	0.6
Total	624	211	33.8	413	66.2	1:1.96	65.4*

* Highly significant at 95% confidence limit.

Please cite this article in press as: Sabrah, M.M. et al., Sexual maturity, spawning activity, sex ratio and fecundity of two Mullidae species dwelling the Gulf of Suez, Red Sea. Egyptian Journal of Aquatic Research (2016), http://dx.doi.org/10.1016/j.ejar.2016.04.007

Table 2 Monthly variations in sex ratio of *Upeneus pori* from the Gulf of Suez.

Month	Total No. of Fish	Male		Female		Sex ratio	X^2
		No. of Fish	%	No. of Fish	%	M/F	
Sep.013	55	27	49.09	28	50.91	1:1	0
Oct.	43	6	13.95	37	86.05	1:6.2	21*
Nov.	80	8	10.00	73	90.00	1:9.1	64*
Dec.	42	5	11.90	37	88.10	1:7.4	23*
Jan.	22	7	31.82	15	68.18	1:2.1	2.9
Feb.	31	10	32.26	21	67.74	1:2.1	4.7*
Mar.	59	27	45.76	32	54.24	1:1.2	0.4
Apr.	30	10	33.33	20	66.67	1:2	8.3*
May 015	72	30	41.67	42	58.33	1:1.4	2.0
Total	434	130	30.0	304	70.0	1:2.3	70*

* Highly significant at 95% confidence limit.

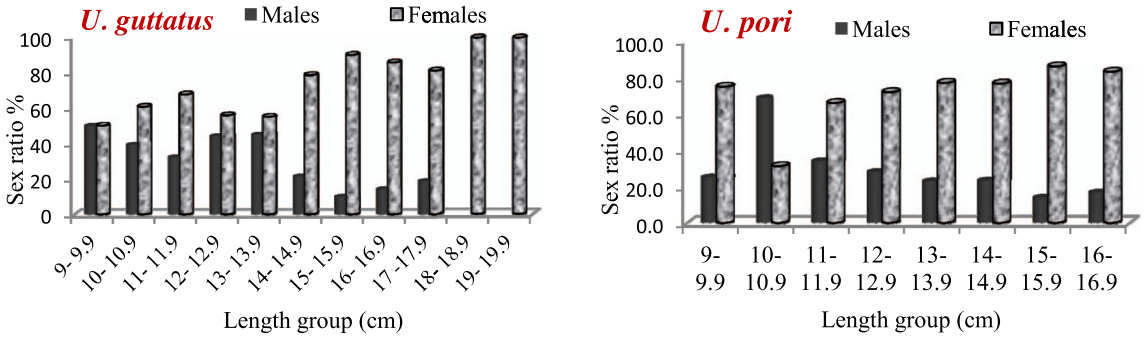

Figure 3 Sex ratio evaluation by length groups (cm) for *U. guttatus* and *U pori*.

Monthly variations in maturity stages

The percentage distribution of the different Maturity stages over the investigated period is shown in Figs. 4 and 5 for *U. guttatus* and *U. pori* respectively (males and female). The results indicated an extended spawning period from May to September in *U. guttatus* and from May throughout the summer season for *U. pori* (during the closed season). Immature fish (stage I) were not encountered in the maturation stages. The developing/recovery (Stages II) of *U. guttatus* was found throughout the study period, with a high ratio during December, January and February. March (spring) is the period in which the gonad begins maturing again (stage III) with a relatively high proportion >25% of the total samples and increasing by >50% in May. Ripe (stage IV) appears by a small proportion during April and May >15% and <25%. Spawning/Running individuals (stage V) appeared for the first time in September (>30%), while the spent fish (stage VI) appear by higher proportions during October and November with >50%. With respect to *U. pori* (males and females), it took the same gonad maturation trend in *U. guttatus* with slight differences. As the stage III appear with a peak in March and April, while stages IV and V showed high abundance in April and May, whereas stages V and VI appeared by a considerable amount in September and October.

Monthly variation in Gonado-Somatic Index (GSI)

The monthly mean values of GSI for *U. guttatus* (males and females) (Fig. 6) started to increase slowly from March to May and reaching its peak value in September. The highest mean GSI values for males (0.718 ± 0.155) and females (3.054 ± 1.819) were seen in September, while the minimum values were demonstrated in January and February. The appearance of the gradual increase in GSI indicates that spawning activities takes place at the summer months (closed season). The monthly variations in GSI of *U. pori* (Fig. 6) revealed that it reached its mean maximum value in May (2.89 ± 2.119 for males and 3.569 ± 1.982 for females), while a sudden decrease occurred in September (0.617 ± 0.034 in males and 0.935 ± 0.173 in females) This sequence proved that the spawning activity of *U. pori* occurred by spring and summer months (see Fig. 7).

Spawning period

Samples used for this study covered nine months, (September–May), as there were no available data during the closed season (spring–summer). Analysis of the monthly variation in the GSI and the sequence of maturity stages development for males

Please cite this article in press as: Sabrah, M.M. et al., Sexual maturity, spawning activity, sex ratio and fecundity of two Mullidae species dwelling the Gulf of Suez, Red Sea. Egyptian Journal of Aquatic Research (2016), http://dx.doi.org/10.1016/j.ejar.2016.04.007

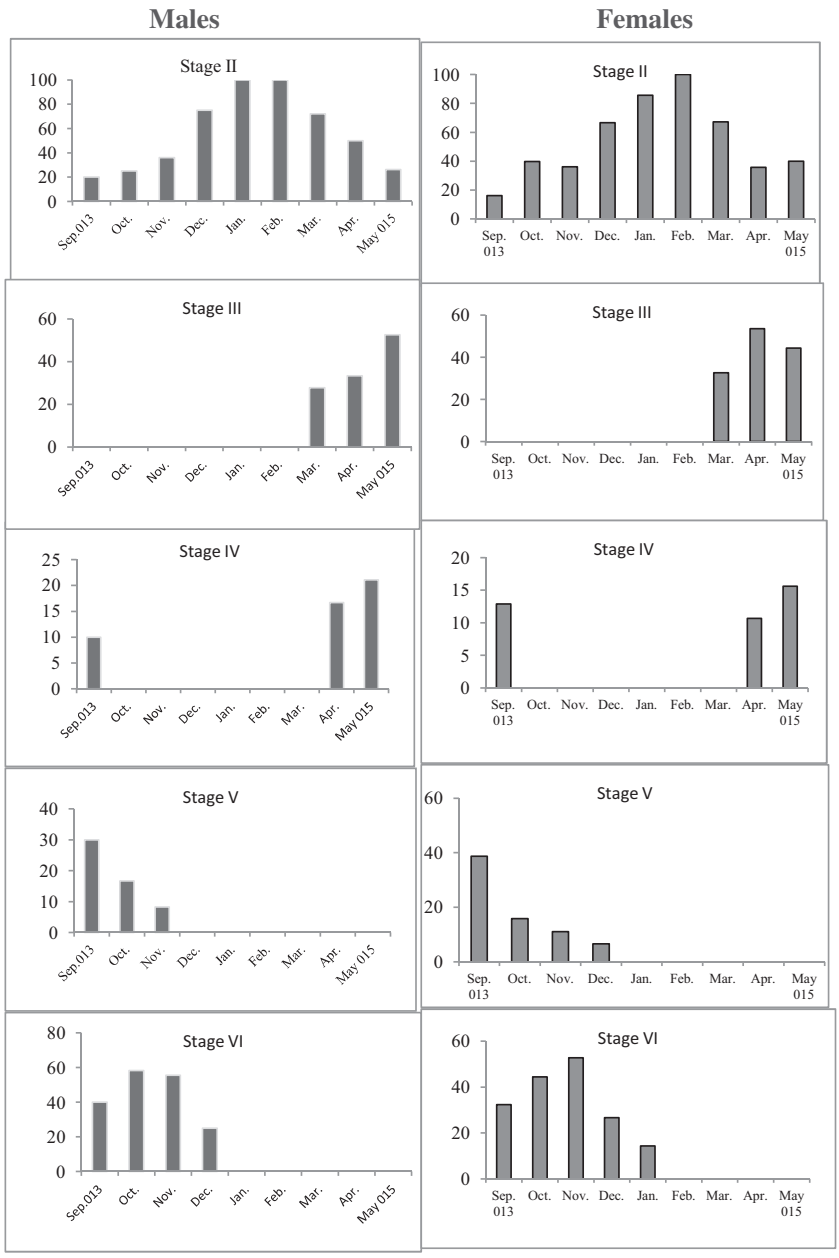

Figure 4 Monthly variations in maturity stages of *U. guttatus* from the Gulf of Suez.

and females of *U. guttatus* revealed that GSI increased considerably from March until May, while highest values were demonstrated during September, which indicates that *U. guttatus* spawns during summer. On the other hand GSI of *U. pori* was increased from March toward May and attained its minimum value in September, besides that inferred from the month1y variations in the maturity stages and the occurrence of the ripe gonads in May, while the spent appeared in September, October and November. These reveal that *U. pori* spawns during spring, extending to early summer seasons.

Size at sexual maturity (L_m)

During the spawning months (March to September) 64 males and 110 females of *U. guttatus*, while 64 males and 84 females of *U. pori* were considered to estimate the size at first sexual maturity. The estimated L_{m50} was found to be mediated between 11.0 and 11.9 in males and females of *U. guttatus* with a mean length of 11.35 ± 0.28 in males and 11.47 ± 0.25 in females. With regard to *U. pori*, L_{m50} values ranged between 10.0 and 10.9 cm with a mean length of 10.56 ± 0.21 for males and 10.6 ± 0.18 for females. *t*-test revealed that there was no significant difference between sexes in the two species ($P > 0.05$).

Fecundity

Absolute fecundity of *U. guttatus* and *U. pori* was estimated based on 35 ovaries of gravid females from each species, which were taken during the spawning months.

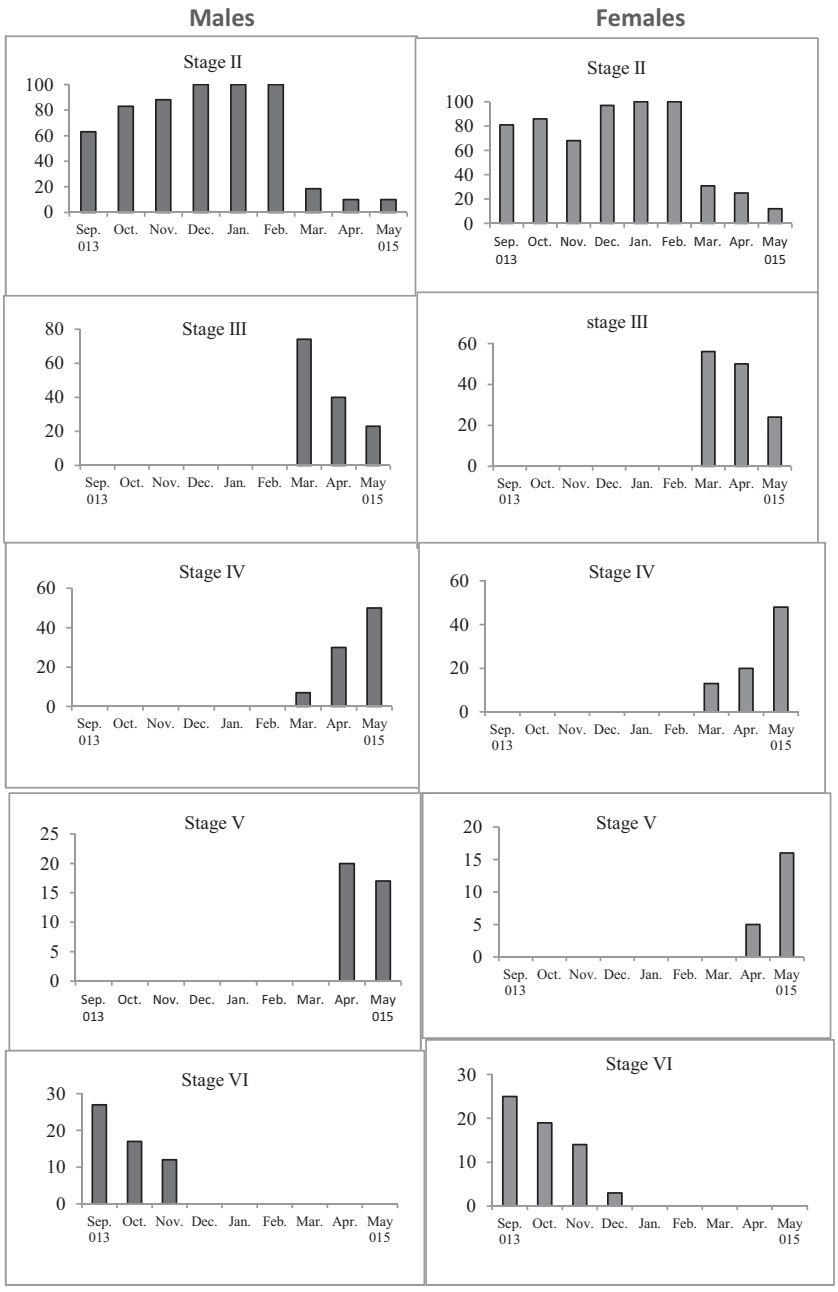

Figure 5 Monthly variations in maturity stages of *U. pori* from the Gulf of Suez.

Absolute fecundity-total length relationship

Females sample of *U. guttatus* ranged in total length from 12.0 to 18.4 cm, while *U. pori* ranged from 11.5 to 16.2 cm (Figs. 8 and 9). Absolute fecundity was varying from 14,295 ± 5621 to 86,940 ± 3364 eggs and from 8773 ± 560 to 71,400 ± 3219 eggs in *U. guttatus* and *U. pori* respectively. It is evident that fecundity increases as the fish grows in length and the value of correlation coefficient ($R^2 > 0.97$) revealed a strong correlation between absolute fecundity and fish length. According to the following equations the relationship exhibited a linear relationship for both species.

$$F = 12661\,(L) - 145290, r^2 = 0.99\,(Guttatus)$$

$$F = 12628\,(L) - 137715, r^2 = 0.96(Pori)$$

Absolute fecundity –total weight relationship

The relation between average absolute fecundity and total weight indicated a linear relationship with high correlation (>0.96) in both species based on the following equation: F = 1488 Wt – 17219, $r^2 = 0.97$ (*U. guttatus*) and F = 1710L – 14686, $r^2 = 0.99$ (*U. pori*). It was evident from Figs. 8 and 9 that fecundity increased as the fish grows in

Please cite this article in press as: Sabrah, M.M. et al., Sexual maturity, spawning activity, sex ratio and fecundity of two Mullidae species dwelling the Gulf of Suez, Red Sea. Egyptian Journal of Aquatic Research (2016), http://dx.doi.org/10.1016/j.ejar.2016.04.007

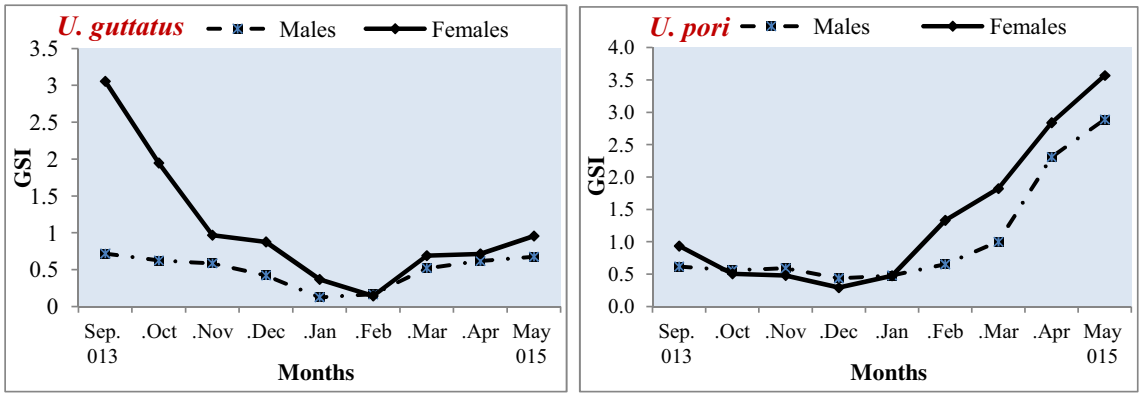

Figure 6 Monthly variations in Gonado–Somatic Index (GSI) of *U. guttatus* and *U. pori* from the Gulf of Suez.

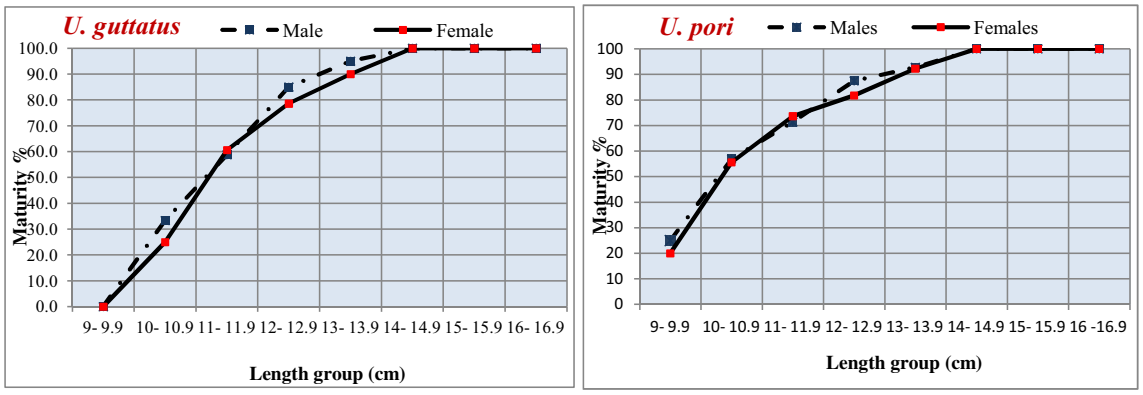

Figure 7 Size at first sexual maturity of *U. guttatus* and *U. pori* from the Gulf of Suez.

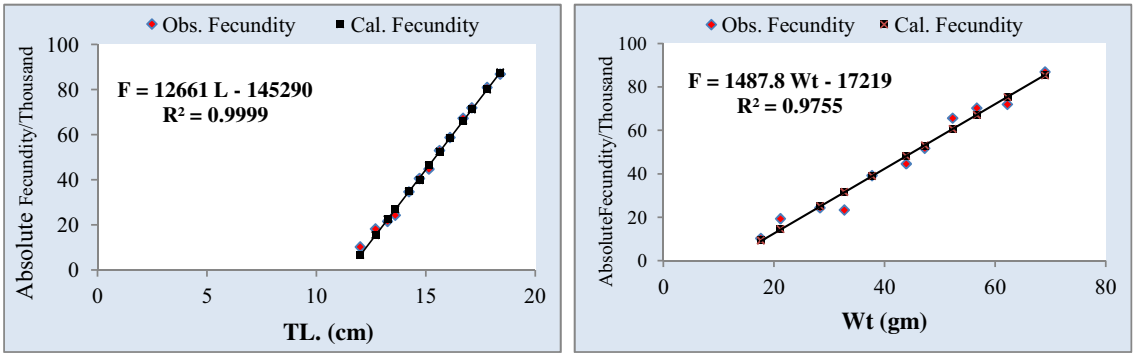

Figure 8 Mean observed and calculated absolute fecundity per length (cm) and per weight (Wt) groups of *Upeneus guttatus* from the Gulf of Suez.

weight. The absolute fecundity of *U. guttatus* ranged from 10,320 ± 505 to 86,940 ± 650 eggs for fish weight ranging from 17.6 to 69 gm, whereas it ranged from 14,510 ± 6167 to 74,800 ± 1838 eggs for fish weight ranging from 17.7 to 54.0 gm in *U. pori*, with average standard errors ranging between 1.6% and 3.3% in both species.

Discussion

Sex ratio, maturity, gonado-somatic index and the size first sexual maturity are essential tools for effectively estimating the reproductive potential of a population. In the current study females were dominant along the study months and in all length groups than males and there was a significant difference in sex ratio ($P < 0.05$) from the expected 1:1. It was noticed also that the percentage of females was higher than males by about 2/3 during our study and the ratio of males to females decreases as the fish length get longer. According to Wahbeh (1992), Yousif and Sabrah (2004) and Cherif et al. (2007), the predominance of females may be connected with the high catch ability for females than in males, or due to the high mortality of females, as they are more vulnerable to the fishery.

Please cite this article in press as: Sabrah, M.M. et al., Sexual maturity, spawning activity, sex ratio and fecundity of two Mullidae species dwelling the Gulf of Suez, Red Sea. Egyptian Journal of Aquatic Research (2016), http://dx.doi.org/10.1016/j.ejar.2016.04.007

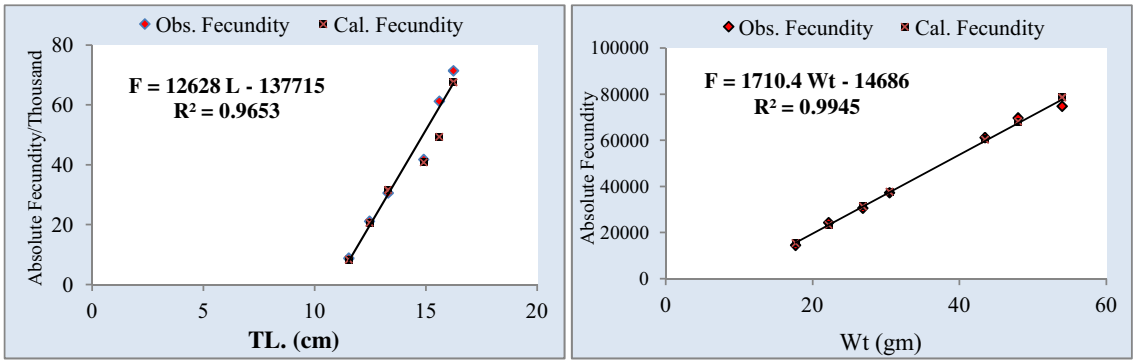

Figure 9 Mean observed and calculated absolute fecundity per length (cm) and per weight (Wt) groups of *Upeneus pori* from the Gulf of Suez.

Also, in some species males disappear or migrate to guard their eggs and juveniles in deep waters. Conover and Voorhees (1990) stated that differences of sex ratio in a given population tend to a balanced sex ratio through generations. Conover and Voorhees (1990) also indicated that high temperature observed during the late spawning may cause most of the recruited small fish produced to become males. Chakroun and Ktari (2006) reported an unbalanced sex-ratio in favor of females in some species, revealing that the natural mortality may be higher for males while the females may present a high vulnerability to the fishing gears.

Upeneus maturity stages were identified according to King (1982) with some modifications that are more suitable for Mullidae reproductive activity. Maturity stages were classified into six stages, Immature, Developing/Recovery, Maturing, Ripe, Running/Spawning and Spent. Monthly distribution of Maturity stages revealed that the maturing and ripe stages were recorded in March, April with a high peak in May for *U. pori* and in September for *U. guttatus*. A marked increase in gonado-somatic index (GSI) pattern for the two species in males and females from March to September synchronized with those of high percentage of matured fishes. This pattern is similar to other tropical fishes (Sadovy, 1996). These sequences probably suggested that *Upeneus* species from the Gulf of Suez are characterized by prolonged spawning activity extending from March along to early September (spring-summer spawner fish). These results are in agreement with the previous studies that recorded the same spawning time, by Ismen (2006) on Turkish *U. pori*, Sabrah (2007) on *U. japonicus*, Sabrah and El-Ganainy (2009) on *U. vittatus* and *U. tragula* from the Gulf of Suez. Tsikliras et al. (2010) concluded that the *U. Pori* is a late spring–early summer spawner. Pavlova et al. (2014) on *U. tragula* from Vietnam. El-Drawany (2013) in Lybia and Ramadan and El-Halfawy (2014) in the Mediterranean Coasts studied the reproductive biology of *U. pori* and concluded that spawning took place from April through June with peak activity in May. Emel'yanovaa et al. (2015) concluded that goatfishes are pelagic spawners and the maturity stages progression with the time of spawning of *U. tragula* took the same trends of that in Upeneus from the Suez Gulf.

Knowledge of the length at first sexual maturity of fish helps to predict harvestable size of the fish; hence it has great benefit in fishery management. Our results indicate that there were no ripe males or females smaller than 9.5 cm through all the collected samples. The results revealed that the size groups 10.0–10.9 cm and 11.0–11.9 cm were considered to be the length at first sexual maturity of *U. pori* and *U. guttatus* respectively, these lengths correspond to the end of the first year of their life in both species. The present results are confirmed by several authors, Sabrah (2007) and Sabrah and El-Ganainy (2009) concluded that first maturity of *Upeneus japonicus*, *vittatus* and *tragula* occurred in length range from 10.0 to 11.9 cm. El-Drawany (2013) and Ramadan and El-Halfawy (2014) pointed that the length at first sexual maturity was 10.0 to 10.9 cm in *U. pori*. The absolute fecundity of the two Upeneus species was calculated in relation to fish total length and total body weight, it showed that the absolute fecundity increases with the increasing of fish length and weight. The estimated absolute fecundity of *U. guttatus* seems to be close to that estimated by Sabrah (2007) on *U. japonicas;* the fecundity of *U. japonicas* as given by the last author ranged from 13,640 to 81,965 eggs in a length range from 11.0 to 19.6 cm.

Conclusion

The output of this study revealed that the spawning season of Upeneus species under investigation extends from March to September with peaks in May in *U. pori* and September in *U. guttatus*. To achieve sustainable utilization, minimum fishing size should be limited to at least 12 cm and protecting adult fish while they are spawning in spring-summer. Besides performance improvement spawner survival, likewise seasonal closure from March to September can provide better spawning chance for females and is considered to be a good fishery management tool for this fishery area.

Conflict of interest

There are no conflicts of interest.

References

Ahmad, M.I., Sabrah, M.M., Heneish, R.A., Alwany, M.E., 2016. DNA barcoding uncover Cryptic diversity in Goats fishes (family: Mullidae) across the Egyptian Red Sea and Mediterranean coasts. Pak. J. Biol. Sci. 19, 65–70.

Bray, D.J., 2012, Goatfishes, MULLIDAE, in Fishes of Australia, <http://www.fishesofaustralia.net.au/home/family/12> (accessed 09.12.2015).

Chakroun-Marzouk, N., Ktari, M.H., 2006. Caractéristiques de la reproduction et de la croissance pondérale relative de Pomadasys incisus (Haemulidae) du Golfe de Tunis (Reproduction and length-weight relation-ships of Pomadasys incises (Haemulidae) from Tunis Gulf). Cybium 30 (4), 333–342.

Cherif, M., Zarrad, R., Gharbi, H., 2007. Some biological parameters of the Red Mullet, *Mullus barbatus* L., from the Gulf of Tunis. Acta Adriat. 48 (2), 131–144.

Çiçek, E., 2015. Bottoms trawl selectivity parameters of four fish species from Karataş coasts of Turkey in Northeastern Mediterranean Waters. Iran J. Ichthyology 2 (2), 79–86.

Conover, D.O., Voorhees, D.A.V., 1990. Evolution of a balanced sex ratio by frequency-dependent selection in a fish. Science 250, 1556–1559. http://dx.doi.org/10.1126/science.250.4987.1556.

De Viaming, V.G., Grossman, F.Chapman., 1982. On the use of gonado-somatic index. Comp. Biochem. Physiol. 73, 31–39.

El- Drawany, M.A., 2013. Some biological aspects of the Por's goatfish, (Family:Mullidae) from Tripoli Cost of Libya. Egypt. J. Aquat. Res. 39, 261–266.

Emel'yanovaa, N.G., Pavlov, D.A, Thi Bich, T.L., Thi Ha, V., 2015. Gonadal condition, sperm motility, and initial stages of embryonic development in freckled goatfish *Upeneus tragula* (Mullidae). J. Ichthyology 2015 (55), 240–250. http://dx.doi.org/10.1134/S0032945215020046.

Golani, D., Ritte, U., 1999. Genetic relationship in goatfishes (Mullidae: Perciformes) of the Red Sea and the Mediterranean, with remarks on Suez Canal migrants. Sci. Mar. 63 (2), 129–135.

Holden, M.J., Raitt, D.F., 1974. Manual of fisheries science. Part2. Methods of resource investigations and their application. FAO Fish. Tech. Pap. 115 (1), 214.

Ismen, A., 2006. Age growth and reproduction of the Por's goatfish, (*Upeneus pori*) Ben-tuvia and Golani, 1989 in Iskenderun Bay, the eastern Mediterranean. Turk. J. Zool. 30, 91–98.

Kim, B.-J., 2002. Comparative anatomy and phylogeny of the family Mullidae (Teleostei: Perciformes). Mem. Grad. Sch. Fish Sci. 49, 1–74. Hokkaido University.

King, M., 1995. Fisheries Biology, Assessment and Management. Blackwell Science Ltd, Oxford, UK, Fishing News Books.

King, P.A., 1982. The biology of some commercial and non-commercial fish species in the Galway Bay Area, west coast of Ireland (Unpublished Ph.D thesis). National University of Ireland.

Motomura, H., Yamashita, M., Itou, M., Haraguchi, Y., Iwatsuk, Y., 2012. First records of the two-tone Goatsh, *Upeneu guttatus*, from Japan, and comparisons with *U. japonicas* (Perciformes: Mullidae). Species Diversity 2012 (17), 7–14.

Pavlova, D.A., Emel'yanova, N.G., Thi Bich, T.L., Thi Ha, V., 2014. Reproduction of Freckled Goatfish Upeneus tragula (Mullidae) in the Coastal Zone of Vietnam. J. Ichthyology 54 (10), 893–904. http://dx.doi.org/10.1134/S0032945214100129.

Rajan, P.T., Sreeraj, C.R., Immanuel, T., 2012. The Goatfishes (Family Mullidae) of Andaman and Nicobar Islands. Rec. zool. Surv. India 111 (Part-3), 35–48.

Ramadan, A.M., El-Halfawy, M.M., 2014. Ovarian maturation and spawning season of Por's Goatfish *Upeneus pori* (Mullidae) from Mediterranean Sea, Egypt. J. Ichthyology 54, 905–912.

Sabrah, M.M., 2006. Population dynamics of *U. japonicus* (Houttuyn, 1782), family Mullidae, from the Gulf of Suez, Red Sea, Egypt. Egypt. J. Aquat. Res. 32, 334–345.

Sabrah, M.M., 2007. Some biological aspects of Red Mullet, *Upeneus japonicus* (Houttuyn, 1782) from the Gulf of Suez, Red Sea, Egypt. Egypt. J. Aquat. Res. 33, 222–234.

Sabrah, M.M., 2015. Fisheries biology of Red Sea Goatfish Parupeneus forsskali (Fourmanoir & Guézé, 1976) from the northern Red Sea Hurghada Egypt. Egypt. J. Aquat. Res. 41, 111–117.

Sabrah, M.M., El-Ganainy, A.A., 2009. Observation on biological traits of Striped Goatfish (Upeneus vittatus) and Freckled Goatfish (*Upeneus tragula*) from the Gulf of Suez, Egypt. World J. Fish Mar. Sci. 1 (2), 121–128.

Sadovy, Y.J., 1996. Reproduction of reef fishery species. In: Polunin, N.V.C., Roberts, C. (Eds.), Reef Fisheries. Chapman and Hall, London, pp. 15–59.

Tsikliras, A.C., Antonopoulou, E., Stergiou, K.I., 2010. Spawning period of Mediterranean marine fishes. Rev. Fish Biol. Fish 2010 (20), 499–538.

Uiblein, F., 2007. Goatfishes (Mullidae) as indicators in tropical and temperate coastal habitat monitoring and management. Marine Biol. Res. 2007 (3), 275288.

Uiblein, F., Heemstra, P.C., 2010. A taxonomic review of the Western Indian Ocean goatfishes of the genus *Upeneus* (Family Mullidae), with descriptions of four new species. Smithiana 11, 35–71.

Wahbeh, M.I., 1992. Aspects of the reproduction, biology and growth of two species (Mullidae) from Aqaba, Red Sea. Senckenbergiana Marit. 1992 (22), 255–264. no. 3/6.

Yousif, A., Sabrah, M.M., 2004. Catch ability of Red Mullet (Upeneus spp.) from North West, Red sea during autumn. Egypt. J. Aquat. Res. 30(B).

Please cite this article in press as: Sabrah, M.M. et al., Sexual maturity, spawning activity, sex ratio and fecundity of two Mullidae species dwelling the Gulf of Suez, Red Sea. Egyptian Journal of Aquatic Research (2016), http://dx.doi.org/10.1016/j.ejar.2016.04.007