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Feeding ecology of *Mullus barbatus* and *Mullus surmuletus* off the Egyptian mediterranean coast

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Abstract
The present work describes the feeding habits of the two-dominant species of family Mullidae; red mullet, *Mullus barbatus barbatus* Linnaeus, 1758 and striped red mullet, *Mullus surmuletus* Linnaeus, 1758 caught off the Egyptian Mediterranean coast throughout the period from January to December 2016. A total of 322 specimens of *M. barbatus* and 289 of *M. surmuletus* were investigated. The index of relative importance (IRI) indicated that Polychaeta was, for *M. barbatus*, the most important food item in all seasons with an average of 26.86%, followed by Decapoda, Amphipoda and Mysidacea. While, in the case of *M. surmuletus*, Mysidacea was the most preferred food item in all seasons with an average of 34.02%, then Amphipoda and Decapoda. According to the previous results, it can be inferred that the two Mullid species; *M. barbatus* and *M. surmuletus* from the Egyptian Mediterranean waters are specialist zooplanktivorous.

Keywords: feeding habits, *M. barbatus*, *Mullus surmuletus*, Egyptian mediterranean coast

1. Introduction
The knowledge of the food and feeding habits of a fish helps in finding out the distribution of a fish population and a thorough survey of literature indicates that such knowledge is highly essential for successful management of a fishery and such studies are undoubtedly important in any fisheries research program [1].

Family: Mullidae (Goatfish) is one of the most valuable and highly priced fish families in Egypt that are mainly exploited by trawl fishery since it shares with about 10% of the total trawl landings in the Egyptian Mediterranean water. Four out of the six genera of family Mullidae are present in the Mediterranean Sea; Mullus, Upeneus, Pseudupeneus and recently Parupeneus [2, 3, 4, 5]. The two-dominant species of family Mullidae, *Mullus barbatus* and *Mullus surmuletus*, are among the major target species of the Egyptian Mediterranean demersal fisheries [6].

The Egyptian Mediterranean waters extend for about 1100 km from west to east comprising different environmental features, where the seabed is flat, mostly muddy to sandy along the middle and eastern coast, whereas it is rocky in the western area [7]. Given that these varied environmental characteristics created different sets of food items to consume by fish species, feeding habits of family Mullidae are therefore affected by the availability of food items especially it uses seabed to detect food items as it is distinguished by having barbels covered with taste buds [8]. During the day-time, many goatfishes form large, inactive (non-feeding) schools that can change their coloration to match that of the ambient environment. By night, the schools disperse for bottom feeding.

Food and feeding habits of the two Mullus species were the main idea of several studies conducted from specimens caught off different Mediterranean areas [9, 10, 11, 12]. However, these two species did not have the same interest in the Egyptian Mediterranean, since we couldn't find any article dealing with the feeding habits of *M. barbatus* or *M. surmuletus* from the Egyptian Mediterranean water.

Therefore, this work aimed at providing a detailed description of the feeding habits of the two species *M. barbatus* and *M. surmuletus* off the Egyptian Mediterranean Sea that could help in providing basis for understanding trophic levels and interactions in the aquatic food web of the study area.

2. Materials and Methods

Samples were collected onboard fishing trawlers from two different areas off the Egyptian Mediterranean coast throughout the period of January to December 2016 (Fig. 1). A total of 322 *M. barbatus* and 289 *M. surmuletus* were examined.

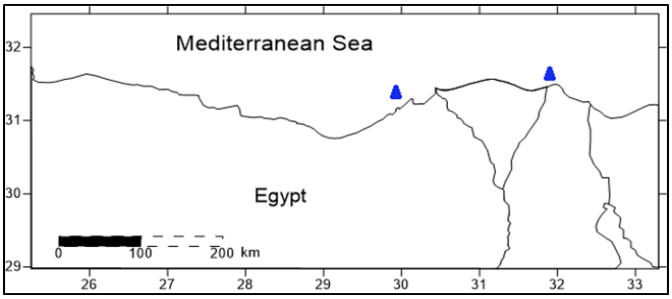

Fig 1: A map shows the fishing areas of the two sampling locations off the Egyptian Mediterranean coast

Total length (TL) was recorded to the nearest cm, and total weight to the nearest g. Males and females were separated. The stomach contents of fresh specimens were removed, examined, and weighed. The preys were removed, sorted, and identified to the lowest possible taxonomic level using keys and fields [13, 14, 15].

In order to analyze food and feeding habits of the two species, we used some indices following [16, 17, 18]: (i) vacuity index (VI = number of empty stomachs/total number of stomachs × 100), (ii) percentage of frequency of occurrence (%F = number of stomachs containing prey i /total number of full stomachs × 100), (iii) percentage of numerical abundance (%N = number of prey i/total number of prey × 100), and (iv) percentage of gravimetric composition (%W = weight of prey i/total weight of all prey × 100).

To integrate the three previous percentages, we used the index of relative importance (IRI) of [19], as modified by [20]: IRI = %F × (%N + %W). Statistical differences ($P < 0.05$) in basic diet composition as a function of size and season were established by applying a c^2 test [21].

3. Results

3.1 Vacuity index

The percentages of vacuity index (VI) of *M. barbatus* and *M. surmuletus* are shown in (Fig. 2). The total percentage of vacuity index was 52.48% for *M. barbatus*, while it was 28.37% for *M. surmuletus*. The lowest value of vacuity index was recorded in April and July for both species as (44.6%, 45.7%) for *M. barbatus* and (18.5%, 25%) for *M. surmuletus*. While the highest values were attained in January and October.

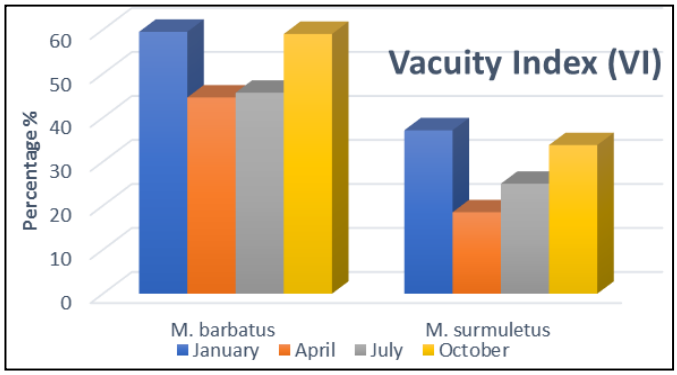

Fig 2: Vacuity Index (VI) of *M. barbatus* and *M. surmuletus* according to month

3.2 Overall description of stomach contents

The diet composition of *M. barbatus* and *M. surmuletus* is shown in (Table 1). The identification of stomach content according to the species level was not possible in most of the examined specimens, because of the high degree of digestion of the preys.

According the obtained results, Crustaceans; Mysidacea, Amphipoda and Decapoda were the dominant food items of the striped red mullet caught off the Egyptian Mediterranean coast. While Polychaeta constituted the highest percentage of the diet of the red mullet caught off the same area. Isopoda, Bivalvia, Echinodermata and Teleostei were less frequent items for both species.

Table 1: Diet composition of *M. barbatus* and *M. surmuletus* off the Egyptian Mediterranean coast.

Food item	*M. barbatus*				*M. surmuletus*			
	F%	N%	W%	IRI%	F%	N%	W%	IRI%
Mysidacea	15.53	9.54	7.62	2.67	62.01	29.78	24.89	33.97
Amphipoda	27.14	8.34	11.70	5.44	32.20	16.04	17.38	10.80
Decapda	33.21	10.90	12.84	7.89	22.73	15.47	16.09	7.19
teleostei	14.67	6.19	5.54	1.72	15.42	10.16	8.33	2.85
Polychaeta	56.26	28.61	19.15	26.86	12.24	8.13	7.31	1.80
Isopoda	2.93	7.60	5.97	0.40	10.07	5.15	6.46	1.15
Bivalvia	14.53	7.36	6.83	2.06	10.56	4.75	6.70	1.21
Echinodermata	8.07	4.80	6.83	0.94	10.74	7.04	6.25	1.42
Others	29.60	14.82	19.26	3.51	5.79	3.48	6.60	0.58

F%= percentage of frequency of occurrence, N%= percentage of numerical abundance, W%= percentage of gravimetric composition, IRI%= index of relative importance.

3.3 Index of Relative Importance (IRI)

The index of relative importance (IRI), which combines together the percentages of frequency of occurrence, numerical abundance and gravimetric composition, is one of the indices that allows an interpretation much more real for food by minimizing the misleading results caused by each one of these percentages separated. Therefore, we used this index to test the importance of each food item for both species according to season and sex as the following:

3.4 According to seasonal changes

The IRI of the food items of *M. barbatus* is shown in (Fig. 3). It was clear that the Polychaeta was the most important food item in all seasons with the highest percentage during the summer season with an average of 26.86%, followed by Decapoda, Amphipoda and Mysidacea. While, in the case of *M. surmuletus*, Mysidacea was the most preferred food item in all seasons with an average of 34.02%, then Amphipoda and Decapoda, as shown in (Fig. 4).

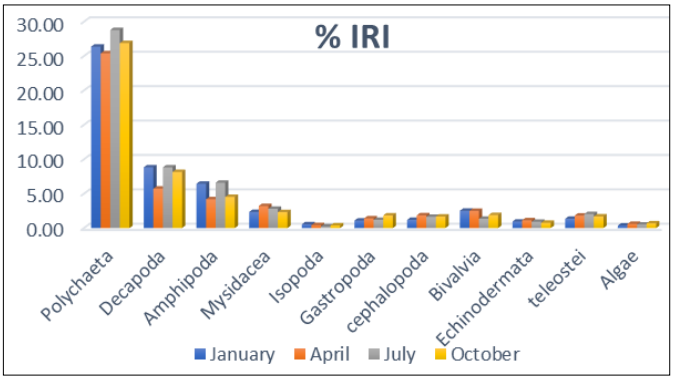

Fig 3: The IRI of food items of *M. barbatus* according to season

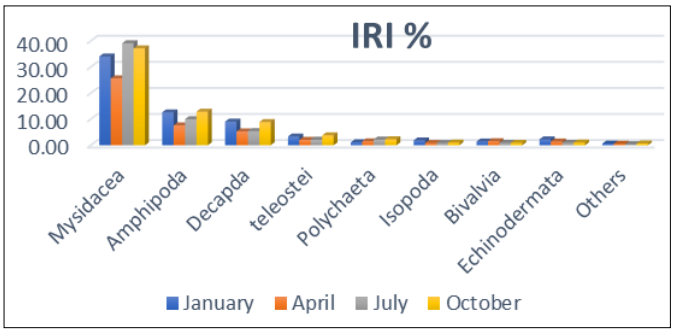

Fig 4: The IRI of food items of *M. surmuletus* according to season

3.5 According to sex

The IRI of food items for each species according to sex are shown in Figures (5 & 6). Results showed that males and females had the same trend of preferable food items as there were no significant differences between both sexes in each of the studied species. Mysidacea was the most preferred food item for *M. surmuletus*, while Ploychaeta was the most important for *M. barbatus*. Fig. (7) shows the average of IRI of food items of *M. surmuletus* and *M. barbatus* for the combined sexes in all months, that indicated the same trend of preferred food items for both species.

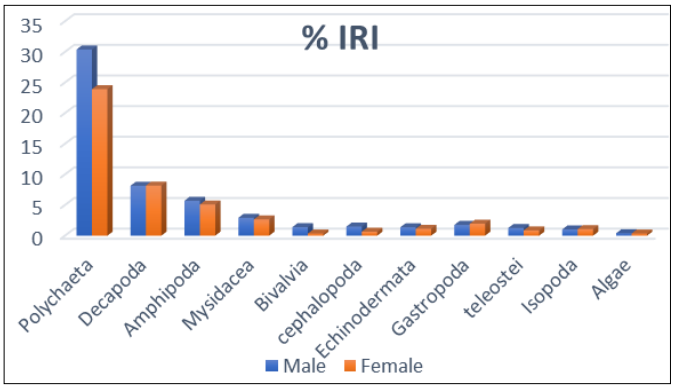

Fig 5: The IRI of food items of *M. barbatus* according to sex

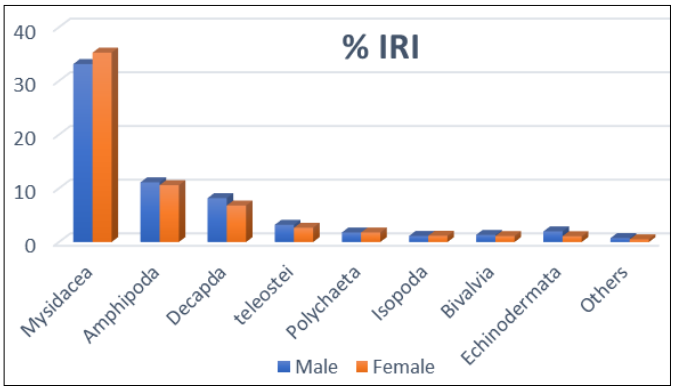

Fig 6: The IRI of food items of *M. surmuletus* according to sex

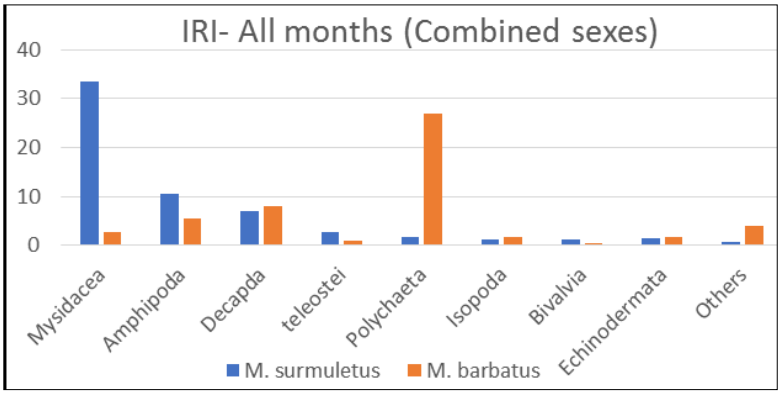

Fig 7: Average of IRI of food items of *M. surmuletus* and *M. barbatus* for the combined sexes in all months

4. Discussion

The presence of many benthic and epibenthic organisms of the gut content of *M. surmuletus* and *M. barbatus* caught off the Egyptian Mediterranean coast, such as mysids, decapods, polychaets and amphipods, implies that both species normally feed on zoobenthos. This study indicates that different trends are present between the two species in terms of the main preferred food item. In the case of the striped red mullet, it counts almost mainly on mysids, amphipods, decapods and teleostei, as well as a minor importance of polychaeta, isopoda and Echinodermata. This agrees with the findings of [22, 23].

On the other hand, Polychaeta was the most important food item for *M. barbatus*, followed by decapoda, amphipoda and mysidacea. This pattern was in agreement with the results of [22, 10, 23] who reported that the species mainly fed mainly on polychaetes, molluscs, echinoderms, and a bit less on teleosts. In the meantime, our results contradicted the findings of some studies in the Mediterranean such as [24] who noted that red mullet caught in the Gulf of Tunis fed on crustaceans (amphipods, decapods, and isopods) and less intensively on polychaetes and molluscs. Also, [25] reported that specimens from the Mediterranean coast of Morocco consumed amphipods, polychaeta, and bivalves while decapods, isopods and nematodes were secondary preys.

During spawning time, fish need more energy input in order to meet the reproduction requirements [26]. Accordingly, the present study revealed that, for both species, the lowest

percentage of vacuity index (VI) was attained during April and July that represent the spawning season of both species. These results were also in agreement with [27] who defined the vacuity index (VI) or empty stomachs' ratio, as an inverse indication of feeding intensity which vary according to variations in the abundance of fish, spawning time, seasonal changes in water temperature.

The feeding intensity of *M. barbatus* showed some seasonal changes. The main diet components of male and female of red mullet were polychaeta and some crustaceans like mysids, amphipoda and decapoda throughout the year in agreement with observations carried out on red mullet from the Gulf of Lions (northwestern Mediterranean) by [28]. This could be linked to prey availability in relation to the dynamics of the water masses in the region. Similar patterns were reported for Moroccan coast [25], the Gulf of Tunis [24], Spanish waters [29], and western Greece Sea [30].

The highest index of relative importance (IRI) of both species was attained during July. This might be interpreted as the environmental conditions were favorable and the food supply may be abundant enough to support the expanded fish community without competitive interactions [20], then the two Mullid species showed a tendency to feed more on their preferred items, taking into account that a kind of differential microhabitat utilization might exist among the two species and the associated fish species since none use barbels to assist in foraging and prey capture. Although both species use barbels to detect their prey items, *M. burbutus* dig deeper [31] and take a broad range of polychaeta species, which are their dominant prey [32]. That completely agrees with our findings as ploychaeta was, according to the seasonal IRI and for both sexes, the main eaten food item by *M. barbatus* in the area of study.

5. Conclusion

The present study has demonstrated that *M. barbatus* and *M. surmuletus* exhibit some degree of selectivity in their feeding habits since they exploit, almost exclusively, Polychaeta and Crustacean such as mysidacea, amphipoda and decapoda, respectively. Therefore, the two red mullet species; *M. barbatus* and *M. surmuletus* from the Egyptian Mediterranean waters are specialist zooplanktivorous.

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