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Food and Feeding Habits of the European Anchovy (*Engraulis encrasicolus*) (Linnaeus, 1758) Inhabiting Port Said, Mediterranean Coast, Egypt

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ABSTRACT

The present study aimed to investigate the feeding biology of *E. encrasicolus* in the Egyptian Mediterranean coast at Port Said, Egypt. A total of 750 specimens of the European anchovy *Engraulis encrasicolus* (Linnaeus, 1758) were randomly sampled on monthly basis from March 2020 to February 2021 from the fish landing site at Port Said Mediterranean coast. The fish diet composition was formed of crustaceans (49.3%), followed by polychaetes (27.1%), phytoplankton (12.7%) and fish parts (11.0%). Crustaceans and polychaetes were found all year around and in all fish length groups. Phytoplankton disappeared in December, January and February. Fish parts disappeared in March and April. Crustaceans, polychaetes and fish parts increased with the increase in fish size, while phytoplankton decreased with the increase in fish size. In the present study, the maximum feeding activity was recorded during winter (75.8%) and the minimum in summer (32.0%).

INTRODUCTION

The European anchovy *Engraulis encrasicolus* (Linnaeus, 1758) is considered as the most common species of family Engraulidae in the eastern Mediterranean. Mainly, it is a coastal marine species forming large schools when entering estuaries, lakes and lagoons, especially during spawning **(Whitehead *et al.*, 1988)**. Recently, the target species was joined in The IUCN Red List of Threatened Species **(IUCN, 2020)**.

Anchovies are commonly the dominant pelagic fish species in coastal upwelling areas all over the world. Their fishery economic importance is well recognized due to its abundance in pelagic ecosystems **(Blaxter & Hunter, 1982; Bakun, 1996**; **Lleonart & Maynou, 2003)**.

The European anchovy is a small pelagic fish which occurred in the Mediterranean Sea and along the eastern coast of the Atlantic ocean. It is the most important pelagic small fish in the Egyptian fisheries; it includes nearly 45% of the overall trawling marine small fish **(FAO, 1996)**.

Ecologically, anchovies play a significant role in the food chain of pelagic environment, either as a prey or consumer levels **(Bulgakova, 1992; Tudela & Palomera, 1997; Palomera *et al.*, 2007)**. Anchovy is the main food for some greatly commercial demersal and/or pelagic fishes **(Karachle & Stergiou, 2017)**. Recently, most studies on the

trophic ecology of the anchovy species in the Mediterranean Sea have been done without mentioning its importance in the pelagic ecosystem.

Anchovies are distributed all over the world's oceans, mainly concentrated in temperate waters while rare or absent in extremely cold or warm seas **(Tudela & Palomera, 1997). Plounevez and Champalbert (2000)** reported that anchovy feeding habit is mainly diurnal. It may be crepuscular **(James, 1987)** or nocturnal **(Bulgakova, 1992)**. Most of them are filter feeders on zooplankton, while few are piscivorous **(Bone & Marshall, 1982)**.

Therefore, the aim of the present work was to investigate the feeding biology of *E. encrasicolus* in the Egyptian Mediterranean coast at Port Said. These data would be valuable for those who are involved in the and management of fisheries and aquaculture of *E. encrasicolus.*

MATERIALS AND METHODS

Samples collection

750 specimens of *Engraulis encrasicolus* (Fig. 1) were randomly sampled over a period 12 months (from March 2020 to February 2021) from the fish landing site in Port Said on the Mediterranean coast. Fish samples were dissected to study the monthly and annual variations in diet composition, feeding intensity and their relationship with the different length groups.

Fig. 1. *Engraulis encrasicolus* collected from Egyptian Mediterranean coast in Port Said

Samples analysis

Fresh fish were dissected, the gut was removed and preserved in 5% formalin The stomach was opened, and its contents were emptied in Petri dish. Degree of fullness was visually evaluated and classified to seven categories according to the method of **Pillay (1952)** as empty, trace, quarter full (a%), half full, three quarters, full and completely full (b%). Food items were examined by a binocular microscope and then identified to the smaller taxonomic unit as possible. A list of general diet composition was recorded, and the quantitative analysis of food items was performed using points of assessment **(Hyslop, 1980)**.

RESULTS

1. Annual diet composition

Results indicated that crustaceans were the main prey item in the diet of *E. encrasicolus*, followed by polychaetes, phytoplankton and fish parts.

Crustaceans represented 49.3% in *E. encrasicolus* stomach during the study period (Fig. 2). They were classified to Ostracoda, Copepoda, Cladocera, Amphipoda and shrimps. Polychaetes formed the second food item represented by 27.1% of all food items, followed by phytoplankton (12.7%) which was classified to 6 genera, *Amphora, Cyclotella, Navicula,*

Nitzchia, *Pleurosigma* and *Synedra*. Fish parts, which constituted 10.9% of all stomach content, were composed of fish eggs, scales, bones and fish larvae.

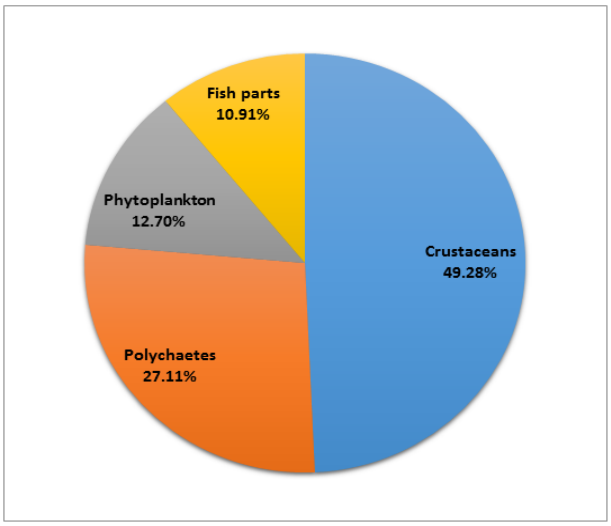

Fig. 2. Diet composition of *Engraulis encrasicolus*

2. Monthly variation in diet composition

Crustaceans and polychaetes were recorded as the major food items allover the study period (Table 1), whereas phytoplankton was entirely absent in December 2020, January and February 2021. Moreover, fish parts disappeared completely in March 2021 and April 2021.

Table 1. Monthly variations in diet composition of *Engraulis encrasicolus*

Months	No.	Food items			
		Crustacean	Polychaetes	Phytoplankton	Fish parts
Mar.(2020)	62	57.2	38.3	4.5	A
Apr.	66	59.5	27.7	12.8	A
May	69	58.1	24.7	8.1	9.1
Jun.	65	41.2	34.4	7.9	16.5
Jul.	77	33.6	30.6	15.9	19.9
Aug.	74	29.3	28.7	26.7	15.3
Sep.	58	36.9	26.8	22.4	13.9
Oct.	49	36.3	23.3	24.8	15.6
Nov.	39	32.1	16.1	29.3	22.5
Dec.	53	69.5	23.3	A	7.2
Jan. (2021)	75	67.9	27.3	A	4.8
Feb.	63	69.8	24.1	A	6.1
Average	750	49.3	27.1	12.7	10.9

Notes: Data expressed as percentage, (A) = Absent food item in month

3. Feeding habit in relation to fish size

The total length of the studied anchovy population ranged from 3.5 to13.4cm. It was classified into 10 classes with 0.9cm interval (Table 2). There was a significant correlation between prey size and fish size. Crustaceans and polychaetes were recorded as main food items in fish stomachs of different length groups. Percentage of these prey items together with fish parts increased as the fish size increased. On the other hand, it was noticed that phytoplankton decreased with the increase in fish size .

Crustaceans were present in all size groups; they increased from 35.6% in size class 3.5- 4.4cm to 63.4% in size class 12.5-13.4cm. Polychaetes increased from 20.5% (in size

class from 3.5 to 4.4cm) to 25.9% (in size class from 12.5 to 13.4cm), whereas it decreased from 43.9% (in size class from 3.5 to 4.4cm) to 7.1% (in fishes with size class ranged from 10.5 to 11.4cm). On the other hand, polychaetes disappeared completely as food item in fish stomach of sizes from 11.5 to 13.5cm. Fish parts eaten by fishes of size class 6.5 - 7.4cm were represented by 5.7% and increased in the larger size classes recording the highest percentage (10.7%) in both length groups (11.5- 14.4cm and 12.5-13.4cm).

Table 2. The diet composition of different length groups of *Engraulis encrasicolus*

Size classes (cm)	No.	Food items			
		Crustacean	Polychaetes	Phytoplankton	Fish parts
3.5-4.4	85	35.6	20.5	43.9	A
4.5-5.4	77	39.5	21.4	39.1	A
5.5-6.4	78	40.2	23.1	36.7	A
6.5-7.4	55	42.5	23.9	27.9	5.7
7.5-8.4	76	44.8	23.9	23.4	7.9
8.5-9.4	67	48.5	24.7	18.7	8.1
9.5-10.4	74	50.3	25.1	15.9	8.7
10.5-11.4	75	57.1	25.7	7.1	10.1
11.5-12.4	86	63.4	25.9	A	10.7
12.5-13.4	77	63.4	25.9	A	10.7

Notes: Data expressed as percentage, A: Absent food item in size class

4. Feeding intensity

Empty fish stomach or with food traces and quarter full stomach (ranked as a %) constituted 48.7% of the total specimens, whereas those stomachs of half full, almost full and full of food (ranked as b %) showed 51.4% of all examined fishes. Feeding activities of the entire population showed high percentage during winter (75.8%) and recorded a minimum value in summer (32.0%) (Tables 3, 4).

Table 3. Monthly variations in the intensity of feeding of *Engraulis encrasicolus*

Months	No.	The degree of distension of the stomach							
		Empty	Trace	1/4	a %	1/2	3/4	Full	b %
Mar.(2020)	62	6.2	A	39.9	46.1	13.7	10.1	30.1	53.9
Apr.	66	10.0	4.0	44.6	58.6	20.0	21.4	A	41.4
May	69	24.0	28.0	A	52.0	24.0	24.0	A	48.0
Jun.	65	26.4	22.9	26.3	75.6	8.9	A	15.5	24.4
Jul.	77	26.4	21.1	16.8	64.3	16.0	2.0	17.7	35.7
Aug.	74	9.2	29.0	26.0	64.2	20.0	10.2	5.6	35.8
Sep.	58	20.0	21.4	A	41.4	10.0	4.0	44.6	58.6
Oct.	49	24.0	24.0	A	48.0	24.0	28.0	A	52.0
Nov.	39	10.3	5.3	45.3	60.9	A	39.1	A	39.1
Dec.	53	12.4	1.2	A	13.6	11.1	48.1	27.2	86.4
Jan. (2021)	75	23.3	A	A	23.3	15.4	15.2	46.1	76.7
Feb.	63	20.0	10.2	5.6	35.8	9.2	29.0	26.0	64.2
Average	750				48.7±19.9				51.4±20.7

Notes: Data expressed as percentage, A: Absent food item in month

Table 4. Seasonal variations in the intensity of feeding of *Engraulis encrasicolus*

Seasons	No. of fish	The degree of distension of the stomach							
		Empty	Trace	1/4	a %	1/2	3/4	Full	b %
Spring	197	13.4	10.7	28.2	52.2	19.2	18.5	10.0	47.8
Summer	216	20.7	24.3	23.0	68.0	15.0	4.1	12.9	32.0
Autumn	146	18.1	16.9	15.1	50.1	11.3	23.7	14.9	49.9
Winter	191	18.6	3.8	1.9	24.2	11.9	30.8	33.1	75.8

Notes: Data expressed as percentage

DISCUSSION

Engraulis encrasicolus inhabiting the Mediterranean water in Port Said is omnivorous. They were found to consume four food items (crustaceans, polychaetes, phytoplankton and fish parts) with crustaceans as the major food group. This is in full agreement with the findings of **Bulgakova (1996)**, **Palomera *et al.* (2007)**, **Bacha and Amara (2009)** and **Mouna *et al.* (2018)**.

Bulgakova (1996) found that *E. encrasicolus* collected from the Black Sea is omnivorous which prefer to feed mainly on Copepoda and Cladocera. Anchovy can switch to other available food items as polychaetes, mysid, fish or larvae and phytoplankton which constituted about 80% of food items in some cases, when zooplankton biomass in the sea decreased. Results of the present study revealed that crustaceans, mollusks and fish (eggs and scales) constitute the main food of this species. **Mouna *et al.* (2018)** who studied stomach contents of *E. encrasicolus* in the central of the Moroccan coast coincides with the results of the present study. **Mariam *et al.* (2009)** stated that *E. encrasicolus* inhabiting the Suez canal is a plankton feeder with two main food items; mysedaca and polychaetes. On the other hand, **Mazlum *et al.* (2017)** studied the food composition of the *E encrasicolus* in the southeast Black Sea region of Turkey. It slightly differs with the present study since the previous authors found that *E. encrasicolus* is a zooplanktivorous species. The predominant prey groups of the zooplankton were fish eggs and larvae, and Ctenophorans followed by copepods**.**

In addition, **Sencer *et al.* (2018)** studied the same species in Aegean Sea, Turkey and found that ingested preys belonging to eight groups and crustaceans (mainly Copepoda) were the most significant food item.

Throughout the months of the present study, the crustaceans and polychaetes were found in the examined fish stomach and comprised the major food item. Phytoplankton were completely missed in winter, and fish parts disappeared entirely in spring season. These results agree with those of **Sencer *et al.* (2018)**.

The diet composition regarding the anchovy's size were studied, and the results showed that crustaceans, polychaetes and fish parts were recorded in all length classes. By increasing the fish size, these prey items increased, while phytoplankton reduced. **Honda (1984)** stated that the food extent demands an ability for food acquisition that increases with fish development. **Plounevez and Champalbert (2000)** studied the diet and feeding behavior of *E. encrasicolus* in the Gulf of Lions, the Mediterranean Sea, and their results showed that the numbers and size prey taxa raised up with size according to the ability of larger individuals to consume a wide range of prey sizes than smaller fishes. This phenomenon appeared to be done for the target species in the present study. The attained results match with those of

Borme *et al.* (2009) and **Sencer *et al.* (2018)** who reported that, crustaceans (mainly Copepoda) were the most significant preys in all size groups. While, **Bosiljka and Marijana (2020)** studied the European anchovy inhabiting the eastern Adriatic Sea, the finding of which disagrees with that of the present study, where the contribution of copepods decreased in larger individuals, and were gradually substituted by large crustaceans, decapods, euphausiids, mysids and amphipods.

In the present study, the feeding activities reached the maximum percentage in winter and it recorded the minimum rate in summer; these results were more similar to those of **Bulgakova (1992)** and **Bacha and Amara (2009)**.

E. encrasicolus is a commercially important small pelagic fish distributed worldwide in temperate zones, which accounted for nearly 10.5 million tons of marine fish production in 2009 **(Costalago, 2015)**. According to the **Euro fish International Organization report (2012)**, the Black and the Mediterranean Seas contribute with 5% of the world's anchovy catch, while according to fish statistics year book for **GAFRD (2018)**, anchovy and small sardine contributed by 8.06 % of fish catch from the Mediterranean Sea in 2018. According to the landing sites records, anchovy and small sardine collected from Port Said contributed with 6.78% catch in the year (310 tons from total 4570 tons). In addition to its economic importance, anchovy has a significant role in the south west Mediterranean Sea food web, as a planktivorors fish **(Bacha & Amara, 2009)** for it guarantees the transportation of energy from the lower to higher trophic levels **(Ganias, 2014)**. More investigations on the European Anchovy population (considering it's the most common anchovy species in the Egyptian Mediterranean sector) are recommended to improve the status of fish catch, especially after fluctuations caused by environmental changes that resulted in reducing or rising trends in the anchovy population in the recent years **(IUCN, 2015)**.

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