

Feeding of European Pilchard, *Sardina pilchardus* (Walbaum, 1792) in Derna Coast, Eastern Libya

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تغذية سمكة السردين البلشارد الأوروبي *Sardina pilchardus* (Walbaum, 1792) في ساحل درنة، شرق ليبيا

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Abstract

A total of 700 specimens of *Sardina pilchardus* were collected monthly from the catch of trawling net and lampara fishery operating on the Derna coast on the Mediterranean Sea from August to July 2018. The feeding habits including the annual diet composition, monthly variations in the diet composition, and the variations of the diet with length, and the intensity of feeding were studied. *Sardinella pilchardus* feed on a wide variety of prey types: copepods (37.9%), cladocerans (22.0%), polychaete larvae (17.0%), dinoflagellates (14.1%), diatoms (5.2%), and crustaceans eggs (3.9%). Copepods and cladocerans were the major food item all year round (59.9%) and it was found in all length groups. In the present study copepods, cladocerans, polychaeta larvae, and crustacean eggs increased as the size increased while diatoms and dinoflagellates decreased as the fish size increased. The feeding intensity was quite high during the autumn (72.9%), summer (74.7%), and spring (60.7%).

Keywords: Eastern coast, Feeding habits, Mediterranean Sea, *Sardinella pilchardus*, Derna, Libya.

الملخص

تم دراسة 700 عينة أسماك من أسماك السردين بولشارد *Sardina pilchardus* تم تجميعها خلال الفترة من أغسطس 2017 وحتى يوليو 2018م من ساحل درنة شرق ليبيا المطل على البحر المتوسط، وكان للسمكة قائمة غذائية كبيرة تتكون من مجدافيات الأقدام (37.9%)، والكلادوسيرا (22.0%)، والدياتومات (5.2%)، وثنائيات الأسواط (14.1%)، ويرقات الديدان عديدة الأشواك (17.0%)، وبيوض القشريات (3.9%)، وهناك علاقة بين أحجام السمكة والعناصر الغذائية، فقد وجد أن احتياج السمكة من مجدافيات الأقدام والكلادوسيرا وبيوض القشريات ويرقات الديدان عديدة الأشواك يتزايد بزيادة طول السمكة والعكس صحيح تمامًا لثنائيات الأسواط والدياتومات، ولوحظ من الدراسة أن السمكة شديدة الاعتناء في فصول الخريف والربيع والصيف.

الكلمات الدالة: الساحل الشرقي الليبي، تغذية، البحر الأبيض المتوسط، السردين *Sardina pilchardus*، ساحل درنة، ليبيا.

1. Introduction

Currently, most marine fish ecologists consider that the dietary habits of a fish species may depend upon both the availability of prey (Frederiksen *et al.*, 2006) and the anatomy of the fish (Gerking, 1994; and Wainwright *et al.*, 1995). However, the mechanisms that fishes employ for feeding are diverse. In clupeids, two different feeding methods are generally assumed, namely, particulate (selective) and filter (non-selective) feeding (James, 1986). The switch from one feeding mode to the other depends primarily on the concentration of food (Bulgakova, 1996) and can also shift in response to changes in the presence and abundance of particular prey items (Van der Lingen, 1994). The changes in the lowest trophic level of the ecosystem can have drastic consequences for fish recruitment Cushing 1990 (Beaugrand, *et al.*, 2003), particularly in small pelagic fish species, whose prey is exclusively planktonic (Durbin, 1979; Blaxter and Hunter, 1982; and Checkley *et al.*, 2009). The European sardine or pilchard, *Sardina pilchardus*, is a rapidly growing and short-lived small pelagic fish species. It is one of the most important fish resources throughout its range in the northeastern Atlantic, from the North Sea to the Senegalese coast, including the Mediterranean and the Black Seas. Few previous studies have investigated the feeding behavior of sardine in the Mediterranean Sea (Nikolioudakis *et al.*, 2011, 2012; and Borme *et al.*, 2013). Despite the ecological and commercial importance sardine in the Mediterranean (Palomera *et al.*, 2007), information on the trophic ecology of this species in the area remains scarce. Therefore, the main goal of this study was to fill that gap in current knowledge and to contribute to an improved understanding of the functioning of the pelagic ecosystem in Derna coast, eastern Libya, the south Mediterranean. Derna coast has an important fishery for small pelagic fish, particularly anchovy and sardine (Abziew, 2016). However, according to Libya Sardines Prices (FAO, 2018) the sardine in Libya coast has experienced a decrease during the last decade in both tones of catches and biomass, and its population has reached a critical state. This is the first study so far on the feeding habits of *Sardina pilchardus* (family Clupeidae) in Libyan eastern coast. *Sardina pilchardus* position in the trophic structure of the Libyan eastern coast is poorly understood. So the aim of the present study is defining the trophic relationships between *Sardina pilchardus* with other marine organism in this area, in order to understand the dynamic of this regional ecosystem. Beside results from feeding habits of dentex may have direct implications for fisheries management.

2. Materials and Methods

A total of 700 specimens of *Sardina pilchardus* were collected monthly from the catch of trawling net and lampara fishery operating on the Derna coast 32°46'00"N 22°38'00"E as presented in Figure (1) on the Mediterranean Sea from August to July 2018. Feeding habits of *Sardina pilchardus* such as annual, diet composition, seasonal variations of diet, variations of diet with lengths and feeding intensity were estimated in this study. For each fish specimen total length measured to the nearest 0.1 cm. Each fish was dissected and the alimentary tract removed and preserved in formalin. The degree of fullness of the stomach was assessed by

visual estimation and classified as empty, trace, quarter full, half full, three quarters full and completely full respectively as described in Pillay (1952). Food items were identified to their groups. A list of general diet composition was made food analysis was made by points of assessment (Hyslop, 1980; and Hynes, 1985). The results were statistically analysis subjected to the further statistical treatment according to Godfriaux (1969) in order to give more precise information about food and feeding habits of *Sardina pilchardus*.

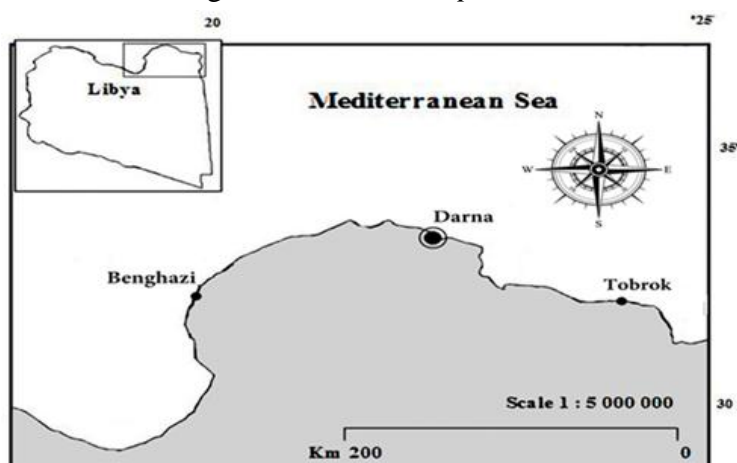


Figure 1. Derna coast on the Mediterranean, eastern Libya.

3. Results

3.1. Annual Diet Composition

The variety of food items was large (Figure 2). However, copepods supplemented by cladocerans formed the major food groups for *Sardina pilchardus*. Copepods made up of 37.9% by volume composition of the bulk of the diet, whereas cladocerans (22.0%) coming in the second position of importance. Polychaete larvae (17.0%), followed by Dinoflagellates (14.1%) were composed of *Ceratium* spp. The other food items were diatoms (*Cyclotella*, *Amphora*, *Cymbella*, *Fragilaria* and *Cocconeis* spp) which constituting 5.2%, with small quantities of crustaceans eggs constituting 3.9%.

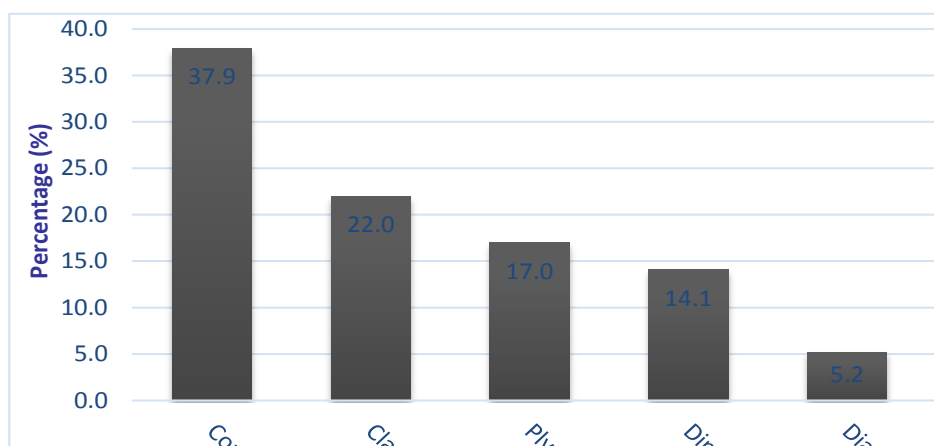


Figure 2. The diet composition of *Sardina pilchardus* from Derna coast eastern Libya during the period from August 2017 till July 2018.

3.2. Monthly Variations in Diet Composition

Food items were occurred in all year round during the study. Copepods and cladocerans constituted the major food items all year round during the study (Table 1).

Table 1. Monthly variations in diet composition of 700 *Sardina pilchardus* from Derna coast, eastern Libya during the period from August 2017 till July 2018

Months	Food items						
	No.	Copepods	Cladocerans	Polychaete larvae	Dinoflagellates	Diatoms	Crustaceans eggs
Aug. (2017)	77	39.2	24.3	8.9	16.1	8.9	2.5
Sep.	72	22.5	27.7	18.9	15.7	11.9	3.2
Oct.	64	33.1	20.8	17.6	15.5	9.9	3.1
Nov.	65	35.2	22.5	20.1	19.9	A	3.3
Dec.	57	53.1	33.6	13.2	13.3	3.4	5.2
Jan. (2018)	57	30.3	32.7	A	17.9	2.5	5.5
Feb.	58	27.9	15.7	A	A	11.9	A
Mar.	58	36.3	13.3	19.8	A	A	4.6
Apr.	56	39.2	14.9	19.1	16.2	A	5.5
May	53	35.5	13.3	30.1	12.9	8.1	0.2
Jun.	45	36.1	15.2	30.2	18.5	A	A
Jul.	38	33.3	11.6	11.1	10.9	1.2	9.9
%	700	37.9	22.0	17.0	14.1	5.2	3.9

Table (2) showed seasonally variations in diet composition for 700 specimens *Sardina pilchardus* in Derna coast during the study period, in autumn, winter and summer the fish preferred copepods and Cladocera's. In spring the fish ingested on copepods (41.3%), polychaeta larvae (25.7%) and Cladocera's (15.4%).

Table 2. Seasonally variations in diet composition of 700 *Sardina pilchardus* from Derna coast, eastern Libya during the period from August 2017 to July 2018.

Seasons	No. of fish	Copepods	Cladocera's	Polychaeta larvae	Dinoflagellates	Diatoms	Crustaceans eggs
Autumn	201	30.2	23.6	18.8	17.0	7.2	3.2
Winter	172	41.8	30.8	5.0	11.7	6.7	4.0
Spring	167	41.3	15.4	25.7	10.8	3.0	3.8
Summer	160	39.1	18.4	18.1	16.4	3.6	4.5

Remarks: Data expressed as percentage.

3.3. Feeding habit in relation to fish size

The total length of *Sardina pilchardus* population classified into 7 classes ranged from 10.5 to 24.4 cm with 1.9 cm interval (Table 3). Prey size differed between large size individuals, which had ingested the large size prey, whereas the small sized fish ingested the small size prey. Copepods and Cladocera's were found in all length groups of *Sardina pilchardus*. In the present study Copepods, Cladocera's, polychaeta larvae and crustaceans' eggs increased as the size increased while dinoflagellates and diatoms decreased as the fish size increased.

Copepods were found in all length groups *Sardina pilchardus*, they increased from 19.4% in size class (10.5-12.4 cm) to 38.1% in size class (22.5-24.4 cm). Cladocera's increased from 13.6% in size class (10.5-12.4 cm) to 21.9% in size class (22.5-24.4 cm), polychaeta larvae increased from 13.1% in size class (10.5-12.4 cm) to 17.9% in size class (22.5-24.4 cm), dinoflagellates ingested in size class (10.5-12.4 cm) by 14.1% decreased in the following length groups and recorded the lowest value 3.7% in size class (22.5-24.4 cm). Diatoms decreased from 6.8% in size class (10.5-12.4 cm) to 0.3% in size class (18.5-20.4 cm), then completely absent in the following lengths. Crustaceans eggs ingested in size class (16.5-18.4 cm) by 1.9% increased to 4.2% in size class (22.5-24.4 cm).

Table 3. The diet composition of different size classes of *Sardina pilchardus* from Derna coast, eastern Libya during the period from August 2017 till July 2018.

Size groups	No.	Food items					
		Crustaceans eggs	Diatoms	Dinoflagellates	Plychaete larvae	Cladocerans	Copepods
10.5-12.4	103	13.6	19.4	14.1	13.1	B	6.8
12.5-14.4	110	16.9	20.7	11.8	13.9	B	3.6
14.5-16.4	133	19.6	22.5	10.3	14.6	B	1.1
16.5-18.4	145	20.4	25.1	8.8	16.9	1.9	0.9
18.5-20.4	155	21.4	27.3	8.5	17.1	2.1	0.3
20.5-22.4	37	21.7	29.1	7.9	17.9	2.8	B
22.5-24.4	17	21.9	38.1	3.7	17.9	4.2	B

Remarks: Data expressed as percentage, (B) No food in class occurred

3.4. Feeding intensity

Fishes with stomach half full, almost full and full of food ranked b% constituted 56.3% of all analyzed individual, whereas those with stomach that were empty or with traces of food and quarter full ranked a % represented 43.7% of the total specimens (Table 4). The feeding activities were quite high during autumn (72.9%), summer (74.7%) and spring (60.7%). There is minimal rate of feeding intensity recorded in winter (16.9%).

Table 4. Seasonally variations in the intensity of feeding of 700 *Sardina pilchardus* from Derna coast, eastern Libya during the period from August 2017 till July 2018.

Seasons	No. of fish	The degree of distension of the stomach							
		Empty	Trace	1/4	%	1/2	3/4	Full	%
Autumn	201	11.2	9.3	6.6	27.1	11.1	27.9	33.9	72.9
Winter	172	24.1	19.6	39.4	83.1	5.0	7.3	4.6	16.9
Spring	167	18.0	10.7	10.7	39.3	18.0	24.0	18.7	60.7
Summer	160	16.4	4.0	5.0	25.4	17.5	16.5	40.7	74.7
Total	700	17.4	10.9	15.4	43.7	12.9	18.9	24.5	56.3

Remarks: Data expressed as percentage

4. Discussion

The study of the food and feeding habits of fish species remains a subject of continuous research, because it constitutes the basis for development of a successful fisheries management on fish capture and culture (Oronsaye and Nakpodia, 2005). Analysis of stomach contents could provide useful information on positioning of the fishes in the food web of their environment and estimation of trophic levels (Pauly and Christensen, 2000; and Post *et al.*, 2000). In addition, the quality and quantity of food are among the most important exogenous factors directly affecting growth and indirectly, maturation and mortality of fish, thus being ultimately related to fitness (Wootton, 1990). *S. pichardus* being a commercially important fish needs special attention and the study of its food and feeding is important. This study provides more insights the feeding habits of *S. pichardus* at Derna coast, eastern Libya which was observed from samples obtained during the four seasons of 2017-2018. The relatively low percentage of occurrence of empty stomach was due to the availability of food material for this species as appeared from the density of plankton in the water samples. Presence of occasional empty stomach may be due to regurgitation or digestion of food items in fish stomachs as the fish struggled for escape from the nets. The feeding intensity was high during the autumn, summer and spring which have been reported as spawning season for *S. pichardus* in the Mediterranean (Wassef and Eisawy, 1985). This may be explained by the fact that during spawning, the fish had fully occupied abdominal cavity with the ripe gonads and empty stomach. The synchronization of the period of poor feeding activity with spawning season has been reported for other fish species (Shalloof and Khalifa, 2009). Diet composition of *S. pichardus* revealed that they usually feed at the surface as indicated by their planktonic stomach contents. The present result reveals that *S. pichardus* has a preference for copepods that were most numerous in the diet during all seasons. This could be attributed to its ability to select its prey based on its large size, regardless of the abundance of smaller alternatives. Furthermore, the highest consumption of copepods coincided with spawning season of *S. pichardus* in winter and spring and this may be because copepods swim longer and more consistently than diatoms making them easier to capture, providing maximum energy gain per unit of handling time and increase the ability of fish to use most of their energy reserves for spawning (Nunn *et al.*, 2007). Studies of the diet of European sardine on the southern coast of England (Lebour, 1921) and in Turkish waters (Demirhindi, 1961) have reported contrasting results. Lebour (1921) stated that sardine shift after metamorphosis to a diet with a higher proportion of phytoplankton, whereas Demirhindi (1961) claimed that the diet consisted almost entirely of zoo-plankton at all ages. This discrepancy appears to have been resolved by the present study and by other recent studies. In the current study *S. pichardus* were found to consume a wide range of food items ranging from copepods, supplemented by cladocerans, polychaete, larvae dinoflagellates, diatoms and crustaceans' eggs formed the major food group for the target species this is full agreement with Costalago and Palomera (2014). Generally, the food extent demands and ability for food acquisition increase with fish development (Honda, 1984). Madkour (2011) studied the feeding habits of the *S. aurita* in Egyptian

Mediterranean water she concluded that the numbers and size prey taxa increased with size of the common two banded sea bream due to the ability of larger fishes to consume a wide range of prey sizes than smaller fishes, this phenomenon appeared to be done for the target species in present work. In the present study copepods, cladocerans, polychaeta larvae and crustacean's eggs increased as the size increased while diatoms and dinoflagellates decreased as the fish size increased which is in agreement with Bat *et al.* (2005).

5. Conclusions

In the present study is defining the trophic relationships between *S. pichardus* with other phytoplankton and zooplankton in this area, in order to understand the dynamic of this regional ecosystem. Beside results from feeding habits of *S. pichardus* may have direct implications for fisheries management. *S. pilchardus* feed on a wide variety of prey types: copepods, cladocerans, polychaeta larvae, crustaceans' eggs, diatoms and dinoflagellates.

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