Bulletin de l'Institut Scientifique, Rabat, Section Sciences de la Vie, 2017, n° 39, 63-70. ***e-ISSN : 2458-7184***

Food and feeding habits of the European eel *Anguilla Anguilla (*Linnaeus, 1758) in Umm Hufayan Lagoon, eastern Libya Mediterranean coast

Alimentation et habitudes alimentaires de l'anguille européenne Anguilla anguilla (Linnaeus, 1758) dans la lagune Umm Hufayan, sur la côte Méditerranée orientale de la Libye

Ahmed H. A. ABDALHAMID, Sayed MOHAMED ALI*, Ramadan, A. S. ALI, Abdalla N. ELAWAD, Esam M. K. BUZAID

*Marine Biology, Department of Zoology, Omar Al-Mukhtar University, Albaida, Libya. *(sayedmaia@yahoo.com).*

Abstract. Stomach contents of 205 *Anguilla anguilla* collected from Umm Hufayan brackish lagoon, eastern Libya Mediterranean Sea, during January to December 2015 were examined by points of assessment to establish food and feeding habits of the eel including annual diet composition, variation of diet composition and feeding intensity during different months and seasons and with eel length. Length of studied eels ranged from 22.5 to 44.4 cm. Major components of the diet was crustaceans, mollusks, polychaetes, echinoderms and sea grass. These items were consumed during all months of the year by eels of all lengths. Crustaceans, mainly small prawns, crabs, copepods, and amphipod made up 33.5 % of the diet, mollusks (bivalves and gastropods) 16.9 %, polychaetes 13.0 %, echinoderms 8.8 %, fishes 8.5 % and sea grass 19.3 %. Monthly variation in diet composition was as follows: In January, February and March the eels consumed crustaceans by values of 44.1 %, 42.3 % and 53.6 % respectively, mollusks by 23.3 % in October, echinoderms by 25.3 % in November, polychaetes by 23.7 % in December and fishes by 23.1 % and 21.2 % in May and July respectively. Sea grass was taken up in January by 22.3 %, February by 23.8 % and March by23.4 %. Echinoderms and fishes were completely absent from the diet during January and February. Changes in feeding habit in relation to eel length were clearly demonstrated in the present study. Crustaceans, mollusks, polychaetes, and echinoderms were consumed by eels of all lengths. However, ingestion of crustaceans, polychaetes, echinoderms, fishes and sea grass increased as the eel length increased, while ingestion of mollusks decreased. The feeding activity of the eels was high during spring (73.8 %) and summer (71.4 %) and low during autumn (38.9 %) and the cold months (winter) (31.7 %).

Keywords: *Anguilla anguilla*, food and feeding, Umm Hufayan, Mediterranean Sea, Libya.

Résumé. Le contenu de l'estomac de 205 individus d'*Anguilla anguilla*, collectés dans la lagune saumâtre d'Umm Hufayan sur la côte Méditerranée orientale de la Libye entre Janvier et Décembre 2015, a été examiné par des points d'évaluation pour établir l'alimentation et les habitudes alimentaires de l'anguille. La composition du régime alimentaire annuel, sa variation ainsi que l'intensité d'alimentation pendant différents mois, saisons et tailles de l'anguille ont également été étudiées. La taille des anguilles échantillonnées variait entre 22,5 et 44,4 cm. Les principaux composants du régime alimentaire étaient les crustacés, les mollusques, les polychètes, les échinodermes et les herbiers marins. Ces aliments ont été consommés pendant tous les mois de l'année par des anguilles de tailles différentes. Les Crustacés, surtout les petites crevettes, les crabes, les copépodes et les amphipodes représentaient 33,5% de l'alimentation des anguilles, les mollusques (bivalves et gastéropodes) 16,9%, les polychètes 13,0%, les échinodermes 8,8%, les poissons 8,5% et les herbiers marins 19,3%. La variation mensuelle de la composition des aliments ingérés montre une consommation de crustacés, en janvier, février et mars, avec 44,1%, 42,3% et 53,6% respectivement; le pourcentage de la végétation marine est de 22,3% (janvier), 23,8% (février) et 23,4%. (Mars); la consommation des poissons, en mai est (23,1%) et en juillet (21,2%), des mollusques (23,3%) en octobre, des échinodermes, (25,3%) en novembre, des polychètes (23,7%) en décembre. Tandis que les échinodermes et les poissons étaient totalement absents dans l'alimentation pendant janvier et février. Les changements dans l'habitude d'alimentation d'anguille par rapport à sa taille ont clairement été démontrés dans cette étude. Crustacés, mollusques, polychètes et échinodermes ont été consommés par des anguilles de toutes les longueurs. Cependant, l'ingestion de crustacés, de polychètes, d'échinodermes, de poissons et d'herbes marines croît lorsque la taille des anguilles augmente, alors que l'ingestion de mollusques a diminué. L'activité alimentaire des anguilles a augmenté au printemps (73,8%) et en été (71,4%) et diminué en automne (38,9%) et en hiver (31,7%).

Mots-clés: *Anguilla anguilla*, alimentation, Umm Hufayan, Mer Méditerranée, Libye.

INTRODUCTION

The family Anguillidae (eels) consists of 15 species worldwide, only a single species, *Anguilla anguilla*, occurs in the Mediterranean (Golani *et al*. 2006). *A. anguilla* spawn in the Sargasso Sea in the Caribbean (Rossi 1976). Their Leptocephelus larvae then drift for 1-3 years with the Gulf Stream to reach Europe and an additional year to reach the Mediterranean shores as glass eels which develop to elver eels (Olivierra 1999) and enter estuaries and coastal brackish lagoons (Dekker 2004). They live for 5-20 years in fresh water as yellow and silver eels before returning to Sargasso Sea to spawn (Schofield and Fuller, 2016). This complicated life cycle and the intensive fishing they encounter made the species very vulnerable. The IUCN status of *A. anguilla* is: critically endangered (Jacoby & Gollock 2014). Since the 1970s, the numbers of eels reaching Europe is thought to have declined by around 90 % (possibly even 98). Recently

farming was responsible for over 90 % of all Anguilla production worldwide (averaging at 280 000 tons per year since 2007, FAO 2013). Artificial breeding, for boosting the natural population and for farming, is very difficult since *A. Anguilla* is generally able to reproduce only after having swum 6,500 km to the Sargasso Sea (Integrated Taxonomic Information System, 2006).

Research on all aspects of *A. anguilla* contributes significantly towards planning conservation and revival measures and farming policies. Despite the importance of this eel as a future potential farm fish in eastern Libya, little known about its biology in the region. The objective of the present study is to establish food and feeding habits of *A. anguilla* in Umm Hufayan brackish lagoon on the eastern coast of Libya Mediterranean Sea (Figs. 1 & 2).

PROCEDURE AND METHODS

Study area

Umm Hufayan is a brackish water Lagoon and wet land located in the Gulf of Bomba at latitude 32° 33' 13.5" N and longitude at 23° 05' 57.2" E, about 80 km east of Darna in the direction of Tobrok. The lagoon covers a surface area of about two Km^2 with a depth range between 0.5 and 3m (Fig. 1). For a more elaborate description of the lagoon, see Abdalhamid *et al*., under publication; Badalamenti *et al*. 2011; Reynolds *et al*. 1995.

Figure 1. Umm Hufayan lagoon, the site of data collection, within the Gulf of Bomba (Google earth map).

Samples collection and examination of stomach contents

Monthly samples of *A. anguilla*, ranging from 3 to 41 individual, were collected randomly from Umm Hufayan lagoon during January to December 2015 (a total of 205 eel), stored in an ice box and taken to the Marine Biology Laboratory of Omar Al-Mukhtar University, Albaida. In the laboratory, the eels were confirmed according to Golani *et al*. 2006, as the European eel *A. anguilla*. Total length (L) in mm and total weight (W) to the nearest 0.1 gm were obtained for each eel. Eels were then dissected and individual alimentary tract removal and preserved in formalin. The degree of fullness of the stomach was assessed by visual estimation and classified as empty, trace, quarter, half full, three quarters and completely full respectively as described by (Pillay 1952). Then each stomach was cut opened longitudinally and its contents scraped off and transferred into a small Petri dish containing a small amount of water. Food items were sorted out and identified down to their groups under a binocular microscope. Diet composition was established by points of assessment following Hynes 1950: Hyslop 1980, and Amisah & Agbo 2008. Here each food item was assigned points in relation to its estimated contribution to stomach volume. Thus points were awarded from 1 to 5 as follows: 1 = traces of the item in the stomach; 2 = ¼ full stomach; 3 = ½ full stomach; 4 = ¾ full stomach; 5 = full stomach. The percentage contribution of each food item to stomach fullness of individual fish was then determined on the basis of the awarded points and monthly mean contribution was then determined.

RESULTS AND DISCUSSIONS

Annual diet composition

The variety of food items consumed by the studied eels was large (Fig. 2). Crustaceans, mainly small prawns, crabs, copepods, and amphipod made up 33.5 % of the diet, mollusks (bivalves and gastropods) 16.9 %, polychaetes 13.0 %, echinoderms 8.8 %, fishes.8.6 % and sea grass 19.3 %.

Monthly variations in diet composition

Crustaceans, mollusks, polychaetes and sea grasses were consumed all year round (Table 1 and Fig. 3). Echinoderms and fishes completely disappeared from the diet during January, February, March and December.

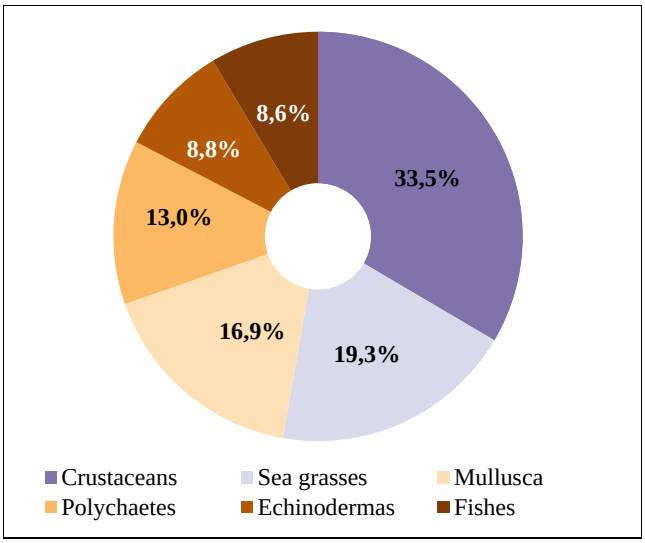

Figure 2. The diet composition of the studied eels (205 *A. anguilla* collected from Umm Hufayan, eastern Libya, during January to December 2015).

Maximum consumption of crustaceans occurred in March (53.6%), of mollusks (23.3%) in October, of echinoderms (25.3%) in November, of polychaetes (23.7%) in December, of fish (23.1%) in May and of sea grass (23.8%) in February.

Seasonal variations in diet composition:

The seasonal variations in diet composition of the studied eels are shown in Table 2 and Fig. 4. In the present study, for simplicity, the cold months of the study period: January, February, March and December 2015, were treated henceforward as winter even though they do not constitute consecutive months. Crustaceans were the main component of the diet during all seasons. Fishes and Echinoderms were absent from the diet during winter.

Variations in diet composition with changes in eellength:

The length range of the 205 studied *A. anguilla*, 22.5cm to 44.4 cm, was subdivided into 11 classes having 1.9 cm intervals (Table 3and Fig. 5). Crustaceans, Mollusks, Polychaetes, and Echinoderms were found in all length classes of *A. anguilla*. Consumption of Crustaceans, Polychaetes, Echinoderms, Fishes and Sea grasses increased as the eel length increased while, that of Mollusks decreased

Table 1. Monthly variations in diet composition of the studied eels

Months	N°. of fish	Food items					
		Crustaceans	Mollusks	Polychaetes	Echinoderms	Fishes	Sea grasses
Jan.	32	44.1	22.4	11.1	**A**	**A**	22.3
Feb.	33	42.3	21.1	12.8	**A**	**A**	**23.8**
Mar.	7	**53.6**	11.3	11.7	**A**	**A**	23.4
Apr.	3	38.3	16.0	**10.1**	13.2	**1.3**	21.1
May	3	**9.5**	21.2	11.3	12.3	**23.1**	22.7
Jun.	4	38.8	11.3	12.8	2.4	12.8	21.9
Jul.	4	22.4	10.7	13.4	11.4	21.2	20.9
Aug.	4	23.9	**9.8**	11.3	17.8	18.4	18.8
Sep.	5	29.4	22.3	12.9	9.8	7.9	17.7
Oct.	41	24.2	**23.3**	12.4	12.9	10.9	16.3
Nov.	32	32.1	**12.2**	12.9	**25.3**	7.2	**10.3**
Dec.	37	43.1	**21.1**	**23.7**	**A**	**A**	12.1
Mean		**33.5**	**16.9**	**13.0**	**8.8**	**8.6**	**19.3**

Remarks: Data expressed as percentage, (**A**): This item was not represented in the monthly diet. Echinoderms and Fishes completely disappeared from the diet during December to March. color for maximum value across columncolor for minimum value.

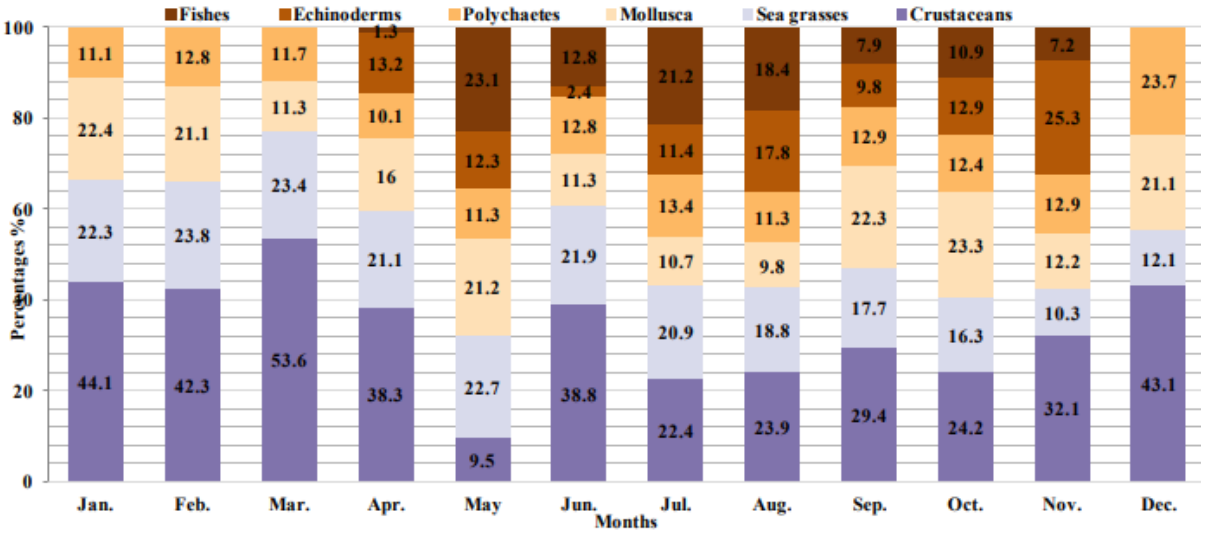

Figure 3. Monthly variations in diet composition of the studied eels.

Table 2. Seasonal variations in diet composition of the studied eels.

Seasons	No.	Food items					
		Crustaceans	Mollusks	Polychaetes	Echinoderms	Fishes	Sea grasses
Winter	**102**	**43.2**	**21.5**	**15.9**	A	A	19.4
Spring	**13**	33.8	16.2	**11**	8.5	8.1	**22.4**
Summer	**12**	**28.4**	**10.6**	12.5	10.5	**17.5**	20.5
Autumn	**78**	28.6	19.3	12.7	**16**	8.7	**14.8**
Mean		**33.5**	**16.9**	**13.0**	**8.8**	**8.6**	**19.3**

Remarks: Data expressed as percentage, (**A**). This item was not represented in the monthly diet **color for maximum value in the column color for minimum value.**

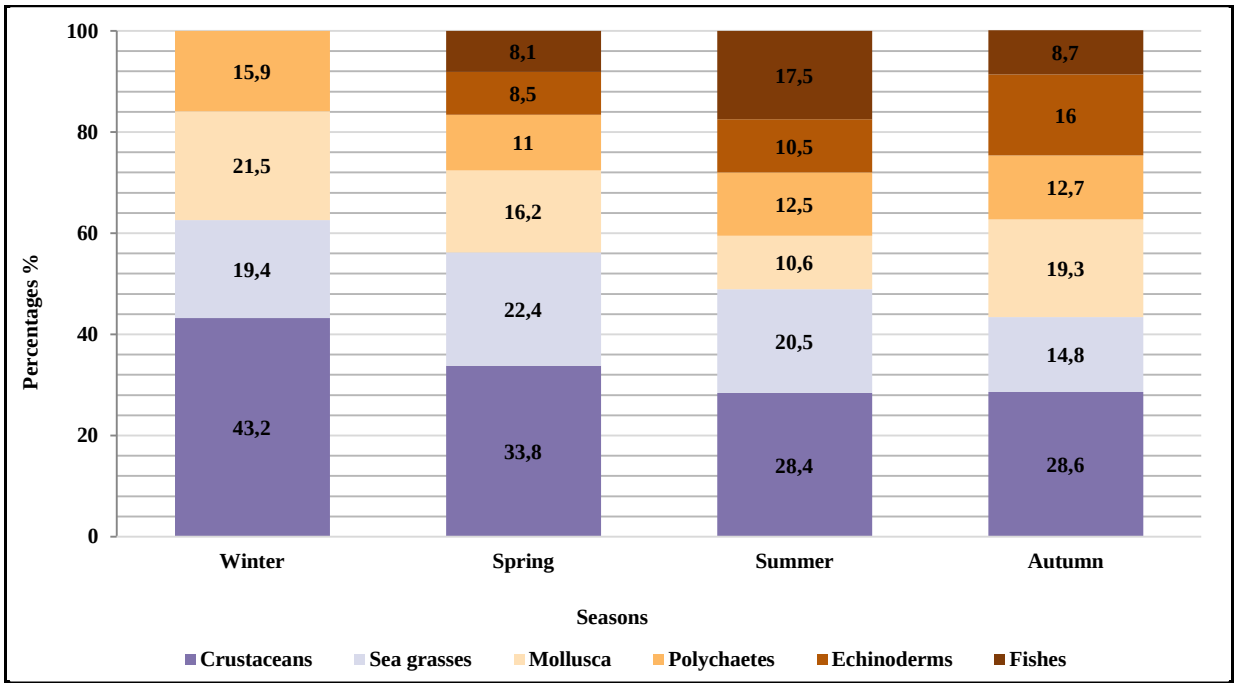

Figure 4. Seasonally variations in diet composition of the studied eels.

Table 3. Diet composition of different length classes of the 205 studied *A. Anguilla*.

length groups (cm)	N°.	Food items					
		Crustaceans	Mollusks	Polychaetes	Echinoderms	Fishes	Sea grasses
22.5-24.4	**25**	**19.3**	**61.1**	**13.5**	**6.1**	**A**	**A**
24.5-26.4	**19**	20.8	53.4	14.3	7.8	1.6	2.1
26.5-28.4	**13**	22.5	46.6	15.6	8.3	3.1	3.9
28.5-30.4	**15**	24.1	39.2	16.9	9.8	4.9	5.1
30.5-32.4	**25**	25.4	35.2	17.1	10.5	5.4	6.4
32.5-34.4	**20**	27.1	28.4	18.3	11.2	6.8	8.2
34.5-36.4	**18**	28.3	20.1	20.8	12.7	8.1	10.0
36.5-38.4	**14**	29.1	12.9	21.7	13.7	11.2	11.4
38.5-40.4	**19**	30.4	9.1	22.1	14.1	12.2	12.1
40.5-42.4	**18**	31.1	4.6	23.4	15.2	13.1	12.6
42.5-44.4	**19**	**32.4**	**1.9**	**24.1**	**16.4**	**13.2**	**13.8**

Remarks: Data expressed as percentage, **color for maximum value in the column color for minimum value** (**A**) : This item was not represented in the monthly diet.

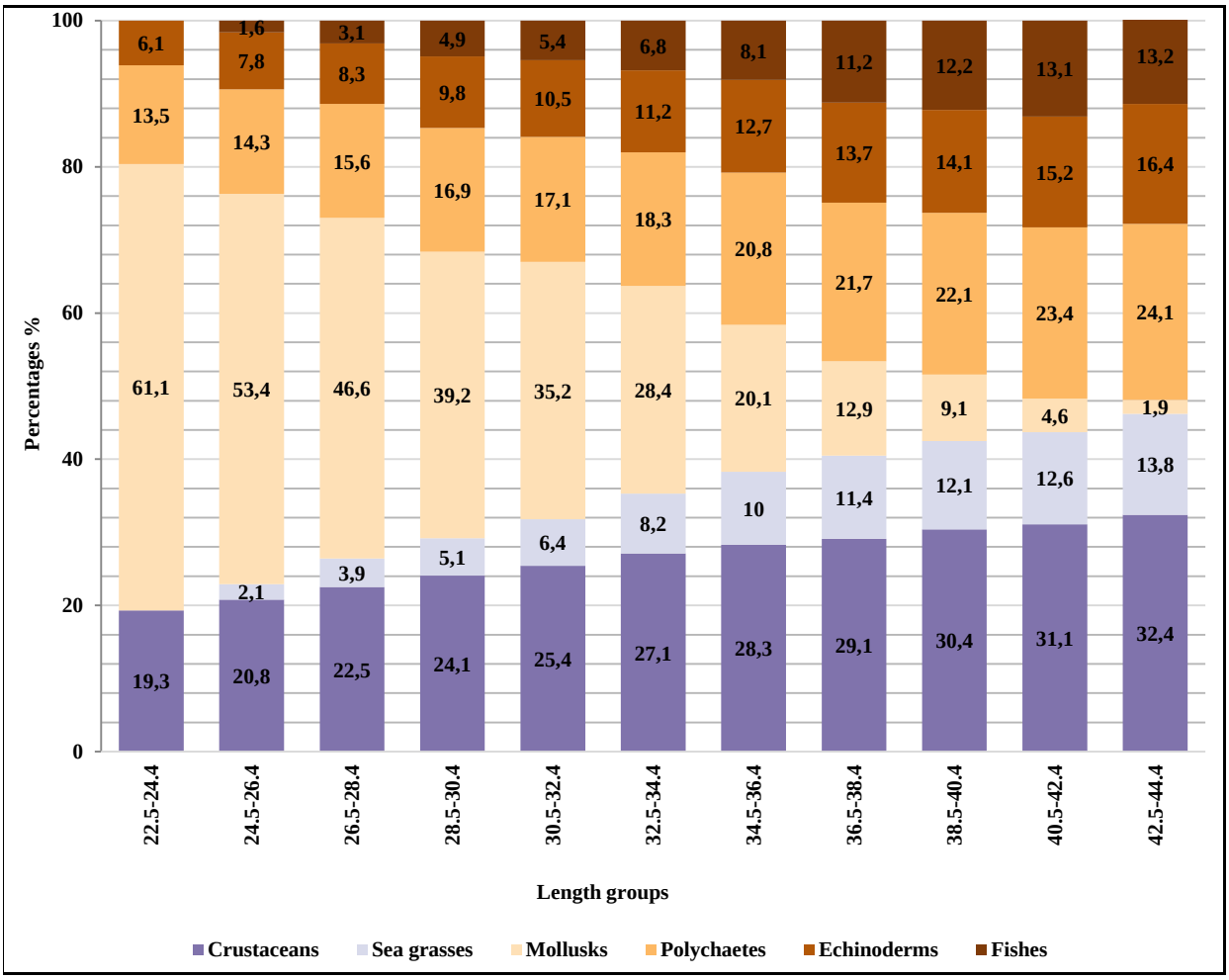

Figure 5. Diet composition of different length classes of the 205 studied *A. Anguilla*.

Feeding intensity

Monthly variations in feeding intensity of the studied eels are shown in Table 4 and Fig. 6. No clear regular trend was observed. Eels (%) with stomach that were empty, with traces of food and quarter full were summed together in the rank a%, they represented 46.0% of the studied eels. Those with stomach half full, almost full and full of food were summed together in the rank b% which included 54.0% of the eels

Seasonal variations in feeding intensity

The feeding intensity (Table 5 and Fig 7) was quite high in spring (73.8%) and summer (71.4%) and low in winter (31.7 %) and autumn (38.9%).

Table 4. Monthly variations in feeding intensity of the studied eels.

Months	N°. of fish	Degree of distension of the stomach							
		Empty	Trace	1/4	a %	1/2	3/4	Full	b %
Jan.	32	6.8	30.1	39.9	**76.8**	13.1	10.1	**A**	**23.2**
Feb.	33	27.2	22.7	26.3	**76.2**	8.9	**A**	14.9	**23.8**
Mar.	7	13.4	**A**	1.3	**14.7**	10.1	48.0	27.2	**85.3**
Apr.	3	24.2	**A**	2.2	**26.4**	15.1	12.4	46.1	**73.6**
May	3	12.4	10.0	15.0	**37.4**	25.0	14.1	23.5	**62.6**
Jun.	4	23.2	A	**A**	**23.2**	15.4	15.4	46.1	**76.9**
Jul.	4	16.0	2.0	2.2	**20.2**	12.0	19.7	48.1	**79.8**
Aug.	4	20.0	13.5	8.9	**42.4**	10.0	25.6	22.0	**57.6**
Sep.	5	26.0	21.1	16.8	**63.9**	16.0	2.0	18.0	**36.0**
Oct.	41	11.3	5.0	45.1	**61.4**	**A**	38.6	**A**	**38.6**
Nov.	32	10.0	4.0	44.0	**58.0**	20.0	22.0	**A**	**42.0**
Dec.	37	24.0	28.0	**A**	**52.0**	24.0	24.0	**A**	**48.0**
Average					**46.0±22.1**				**54.0±29.3**

Remarks : Data expressed as percentage **A** : This item was absent in this month.

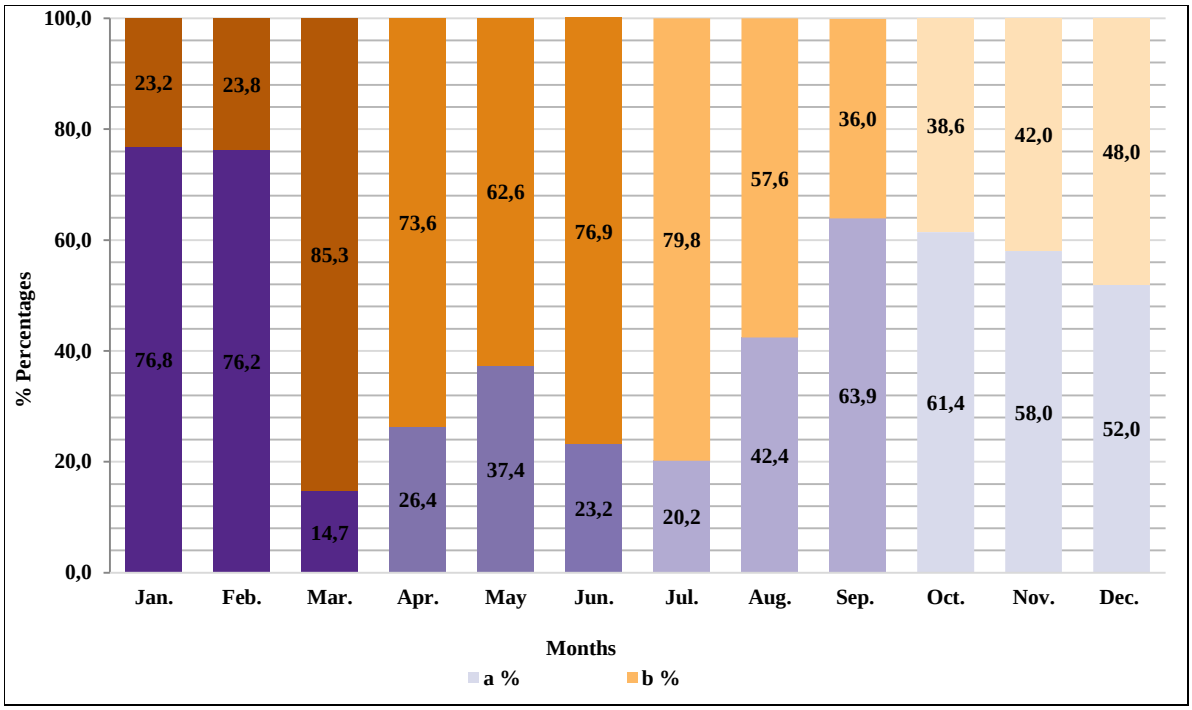

Figure 6. Monthly variations in feeding intensity of the studied eels. [a%: (empty + trace + ¼ stomachs), b% : (½ + ¾ + full stomachs)]

Table 5. Seasonal variations in feeding intensity of the studied eels.

Seasons	No. of fish	Degree of distension of the stomach							
		Empty	Trace	1/4	a%	1/2	3/4	Full	b%
Winter	**102**	19.3	26.9	22.1	**68.3**	15.3	11.4	5.0	**31.7**
Spring	**13**	16.7	3.3	6.2	**26.2**	16.7	24.8	32.3	**73.8**
Summer	**12**	19.7	5.2	3.7	**28.6**	12.5	20.2	38.7	**71.4**
Autumn	**78**	15.8	10.0	35.3	**61.1**	12.0	20.9	6.0	**38.9**

Remarks: Data expressed as percentage **color for maximum value color for minimum value**

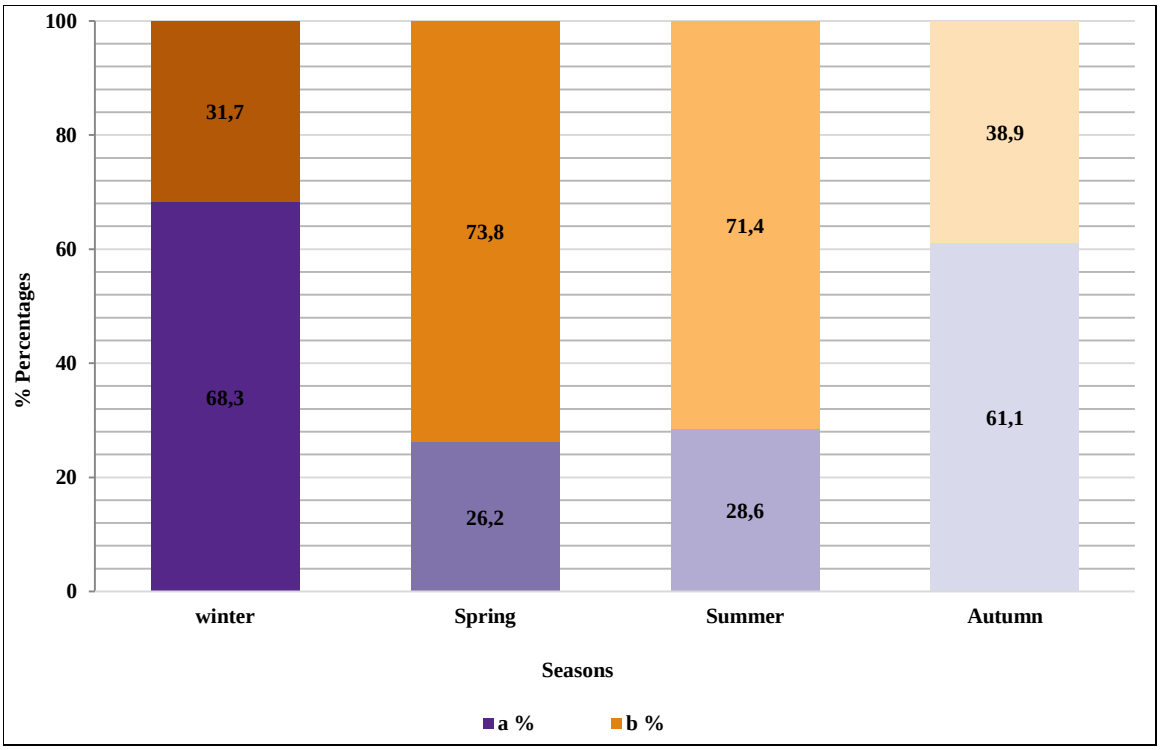

Figure 7. Seasonal variations in feeding intensity of the studied eels. [a%: (empty + trace + ¼ stomachs), b% : (½ + ¾ + full stomachs)]

CONCLUSION

Because of their complicated life cycle, European eels have completely different diets during different life stages. The adult eel diet is composed almost entirely of bottom-living organisms. According to Deelder 1985, eel's food includes virtually the whole aquatic fauna occurring in the eel's area. In the present study *A. anguilla* were found to consume a wide range of food items ranging from crustaceans supplemented by mollusks to polychaetes, echinoderms, fishes. It is not clear whether sea grass which constituted 19.3 % of the diet was actually taken up as food or accidentally during ingestion of the other items. In particular, gastropods and crustaceans are frequently found between sea grass or attached to it. This is in full agreement with Godfrey 1957; Rasmussen and Therkildsen 1979; and Thomas 1962. Bouchereau *et al*, 2009, found that in Ingril Lagoon, Mediterranean France, *A. anguilla* feeds on benthic organisms, primarily amphipods, crustaceans, polychaetes, insect larvae and small fish. Eels were found to be opportunistic feeding on the available food without using a particular feeding strategy. Twelve prey categories in stomachs of *A. anguilla* from the Lippenbroek river, Belgium (Van Liefferinge 2012), were found, whereas only three categories were retrieved from eels in the River Schelde. In the Lippenbroek, eels fed on terrestrial organisms (lumbricids, caterpillars and other insects), but also on fish and fish eggs and to a lesser extent on other aquatic prey (Lumbricullidae, chironomids and Hirudinea). In contrast, eels from the main river fed mainly on tubificids, fish, and some gammarids. Consequently, eels in the Schelde estuary are opportunistic feeders, but with a preference for large benthic prey. In the present study dependence ofeels on piscivoryis not marked. Although crustaceans, mollusks, polychaetes and sea grasses were consumed all year round, echinoderms and fishes completely disappeared from the diet during January, February, March and December (the months that constitute the winter season). Feeding intensity of the eels decreased during the cold months. It may be that eels were conserving precious energy during these months by not perusing fish as food because the process requires a lot of effort. However, cold can reduce activity alone without any energy sparing strategy. The diet of *A. anguilla* in the River Shannon, Ireland, was found to be dominated by larval Ephemeroptera and Trichoptera, reflecting the typical composition of the macroinvertebrate species assemblage of the riffle habitat sampled. Little evidence of piscivory was observed (Cullen & McCarthy, 2007). However, in two British rivers (Sinha & Jones 1975), this species feeds mainly on fish (33 and 70 % by volume respectively) and oligochaetes (12 and 18 %).

Generally, the food extent demand and ability for food acquisition increase with fish development (Honda, 1984).Mallawa & Finiger 1992, in French Mediterranean Sea, and Alp *et al*,. 2008, in Turkey, showed that *A. anguilla* is carnivorous and crustaceans are its major food item, and concluded that the numbers and length prey taxa increased with length of the *A. anguilla* due to the ability of larger fishes to consume a wide range of prey lengths than smaller fishes, this is true for the present study. In the present study, dependence on crustaceans, mollusks, polychaetes, echinoderms, fishes "and sea grass" increased as the fish length increased, while dependence on mollusks decreased, as the fish length increased. This is in agreement with Mann and Blackburn, 1991, and Dekker *et al*. 1998. Moriarty, 1974, found that *A. anguilla* in the Munster Blackwater River, Ireland, of less than 40 cm fed largely on invertebrates whereas eels of 50 cm and over fed mainly on fish. *A. anguilla* in English chalk stream preyed more on benthic invertebrates. Piscivory was most marked in eels >400 mm (Mann and Blackburn 1991).

In the present study the feeding intensity of the eels was quite high in spring and summer and low in winter and autumn. Variations in feeding intensity may be reflected in the condition of the body (Vassilopoulau 1989). In the present study the highest condition factor values (Fulton K_F and Clarck Kc) of *A. Anguilla* in Umm Hufayan, eastern Libya,were recorded in spring and summer (Abdalhamid 2016) which coincided with medium to high degree of stomach fullness during these seasons. This supported similar observation reported by Tesch 2003.*A. anguilla* in the River Shannon, Ireland feed to some degree all year round, however, foraging activity was highest in the months of May to September, inclusive (Cullen and McCarthy 2007). Diel and seasonal shifts in the feeding activity and intensity of a riverine stock of *A. anguilla* were assessed in northwestern Spain by Costa-Dias and Lobón-Cerviá 2008. No consistent diel cycles were detected in either season but increased feeding activity was evidenced during the warmer months relative to weaker but still significant activity in winter.

REFERENCES

Abdalhamid, A H. 2016. *Ecological and biological studies on Anguilla anguilla (Linnaeus, 1758) in Ain Umm Hufayan - eastern Libyan coast,* Department of Zoology – Marine Biology Branch, Faculty of Science, Omar AL-Mukhtar University, master's thesis, 66 p.

Alp A., Yeg¢en V., Yag¢ci M. A., Uysal R., Biçen E. and Yag¢ci A. 2008. Diet composition and prey selection of the pike, *Esoxlucius*, in C¸ ivril Lake, Turkey. *Journal of applied Ichthyology* 24, 670-677.

Amisah, S. and Agbo, N.W., 2008.An investigation into the food and feeding ecology of a potential aquaculture candidate, *Sarotherodongalilaeusmultifasciatus*in a meteoritic crater lake in Ghana. J. Appl. Sci. Environ. Manage, 12, 3 15 – 18

Badalamenti F., Ben Amer I., Dupuy De La Grandrive R. *et al*., 2011. Scientific field survey report for the development of Marine Protected Areas in Libya.32 p.

Bouchereau, J. Catarina Marques, Patricia Pereira, Oliver Guelorget, Sven-Michel Lourie and Yvan Vergne, 2009. Feeding behavior of *Anguilla anguilla* and trophic resources in the Ingril Lagoon (Mediterranean, France). *Cahiers de Biologie Marine*, 50, 319-332.

Costa-Dias S. and J. Lobón-Cerviá, 2008. Diel feeding activity and intensity in the European eel *Anguilla anguilla* (L.) during an annual cycle in a Cantabrian stream. *knowledge management aquatic ecosystems,* 390-391, 01.

Cullen, P. and T. K. McCarthy, 2007. Eels *Anguilla anguilla* (L.) of the Lower River Shannon, with Particular Reference to Seasonality in their Activity and Environment: Proceedings of the Royal Irish Academy, 107b, 2, 87 - 94.

Deelder, C. L. 1985.Synopsis of Biological Data on the Eel, *Anguilla anguilla* (FAO Fisheries Synopsis). FAO. 73 p.

Dekker, W. 2004. What caused the decline of Lake Ijsselmeer eel stock since 1960? *ICES Journal of Marine Science* 61, 394-404.

Dekker, W., B. van Os and J. van Willigen, 1998. Minimal and maximal size of eel.L'Anguille Europeenne. 10E Reunion du groupe de travail "Anguille" EIFAC/ICES. Bulletin Francais de Peche et Pecherie, Conseil superieur de la peche, Paris (France). 31 p.

FAO, 2013.Capture and Aquaculture Production (1950 - 2011) and Fisheries Commodities Production and Trade (1976-2009) data. http://www.fao.org/fishery/statistics/en. (Accessed: August 2013).

Godfrey, H., 1957. Feeding of eels in four New Brunswick salmon streams. Proc. Rep. Atlant. biol. Stn. 67, 19–22.

Golani, D. ;Ozturk, B. and Basusta, N. 2006.The Fishes of the Eastern Mediterranean.Turkish Marine Research Foundation, Istanbul, Turkey.259 p.

Honda, H. 1984. Food acquisition patterns in some demersal telosts, Tohoku. *Journal of Agriculture Research*, 35, 1, 33-54.

Hynes, H. B. N. 1950.The food of freshwater sticklebacks (Gasterosteusaculeatus and Pygosteuspungitius) with a review of methods used in studies of food of fishes. *Journal of Animal Ecology*, 19: 36-58.

Hyslop, E. J. 1980 .stomach content analysis . A review of methods and their application .*Journal of fish Biology*, 17: 411 – 429.

IAC (International Agribusiness Corporation), 1981.'Feasibility study on pen and cage culture.'(Coastal and Inland Aquaculture Development Project of the Socialist People's Libyan Arab Jamahiriya.) International Agribusiness Corporation. Manila, Philippines. 53 p.

Integrated Taxonomic Information System, 2006."*Anguilla anguilla*". (http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=161128). Retrieved 11 March2006.

Jacoby, D. &Gollock, M. 2014.*Anguilla anguilla*. The IUCN Red List of Threatened Species 2014: e.T60344A45833138. Downloaded on 03 October 2016.

Mallawa A. and Lecomte-Finiger, R., 1992. Comparative study of two populations of Anguilla anguilla (Linnaeus, 1758) eels from French Mediterranean lagoons (Bages-Sigean and Canet-Saint-Nazaire): age and population structure, *Sciences Marine*, 56, 1, 1-6.

Mann, R. and Blackburn, J. 1991. The biology of the eel *Anguilla anguilla* (L.) in an English chalk stream and interactions with juvenile trout Salmo trutta L. and salmon Salmo salar L. Hydrobiologia, 218, 1, 65-76.

Moriarty, C., 1974. Studies of the Eel *Anguilla anguilla* in Ireland No. 4. In the Munster Blackwater River, Department of Agriculture and Fisheries.[Fisheries Division], Ireland. 15 p.

Oliveira, K. 1999.Life History and Strategies of American eel, *Anguillarostrata*. Canadian Journal of Fisheries and Aquatic Sciences 56, 795-802.

Pillay, T. V. R. 1952 .A critique of the methods of study of food of fishes. *Journal of the Zoological Society of India*, 4, 181 – 199.

Rasmussen, G. &Therkildsen, B. 1979. Food, growth, and production of *Anguilla anguilla* L., in a small Danish stream Rapport. PV *Réunion du conseil international des explorations de la mer*, 174, 32-40.

Reynolds, J. E., Haddoud, D. A., Vallet, F., 1995. Prospects for aquaculture development in Libya, Libfish Field documents No 9. Tripoli / Rome, FAO. 122 p.

Rossi, R., Colombo, G. 1976.Some investigation on growth of sliver eels of north Adriatic lagoons. Bollettino di *Pesca Piscicoltura e Idrobiologia*, 31, 1-2, 283-289.

Schofield, P. J. and Pam Fuller, 2016. *Anguilla anguilla*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. https://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=308 Revision Date: 3/5/2011

Sinha, V. R. & J. W. Jones 1975.The European freshwater Eel.Liverpool Univ. Press. . 146 p. Smith, D. G. 1990.Anguillidae. In Quéro, J. C.; J. C. Hureau, C. Karrer, A. Post and L. Saldanha (eds). Check-list of the fishes of the eastern tropical Atlantic.151-152. JNICT-Portugal, SEI and UNESCO. 151-152.

Tesch, F. W. (Thorpe, J.E., ed.). 2003. T*he eel*, 5th ed. Blackwell Science, Oxford, England. 408 p.

Thomas, J. D. 1962. The growth and food of the brown trout (*Salmo trutta* L.) and its feeding relationships with the salmon parr (*Salmo trutta* L.) and the eel *Anguilla anguilla*(L.) in the river Teify, west Wales. *Journal of Animal Ecology*, 31, 175–205.

Van Liefferinge, C. A. Dillen, C. Ide, A. Herrel C. Belpaire, A. Mouton, E. de Deckere and P. Meire, 2012. The role of a freshwater tidal area with controlled reduced tide as feeding habitat for European eel (*Anguilla anguilla*, L.). *Journal of Appllied Ichthyology*, 28,, 572–581.

Vassilopoulou V., 1989.Some biological parameters on the red porgy (*Pagrus pagrus)* in the Kastellorizo area, FAO Fisheries, 412, 108-115.

Manuscrit reçu le 16/02/2018
Version révisée acceptée le 04/12/2018
Version finale reçue le 18/02/2019
Mise en ligne le 19/02/2019