Regular paper

Diet of the European eel *Anguilla anguilla* (Linnaeus, 1758) in two transitional waters of Southwestern Mediterranean

by

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Abstract. – On the North African coast, data on the biology and ecology of the European eel *Anguilla anguilla* (L., 1758) are very sparse, despite the economic and ecological status of this species. This study aims to collect basic on the fractions of the populations that colonize two transitional waters in eastern Algeria. We provide here the first information on the composition and variations of the diet of *A. Anguilla* in Mellah lagoon (ML) and Wadi El Kebir (WEK). During one year (December 2008-November 2009), a total of 1120 eels (N_{ML} = 625; 24.3 < TL < 75.8 cm; 23 < TW < 842 g; N_{WEK} = 495; 23.5 < TL < 83 cm; 23 < TW < 1470 g), was sampled. Qualitative and quantitative variations of the diet are looked for in the two sites according to season and development stages. The annual mean values of the coefficient of digestive vacuity were respectively 38.1% and 53.1%. This coefficient varies according to season and development stages. *Anguilla anguilla* is opportunistic and diversifies its diet between molluscs, teleost fish and Macrophyta, with a preference for crustaceans in the two ecosystems (%IRI_{ML} = 89.98%, IRI_{WEK} = 96.15).

Résumé. – Régime alimentaire de l'anguille européenne *Anguilla anguilla* (L., 1758) dans deux masses d'eau de transition de Méditerranée sud-occidentale.

Sur la côte nord-africaine, les données sur la biologie et l'écologie de l'anguille européenne *Anguilla anguilla* (L., 1758) sont éparses, malgré son statut économique et écologique. Cette étude a pour objectif de recueillir des informations de base sur les fractions de populations qui colonisent deux écosystèmes paraliques de l'est algérien. Nous étudions ici la composition et les variations du régime alimentaire d'*A. anguilla* de la lagune Mellah (ML) et de l'oued El Kebir (WEK). Entre décembre 2008 et novembre 2009, 1120 anguilles provenant des deux sites (ML : 625 individus, 24,3 < Lt < 75,8 cm, 23 < Wt < 842 g ; WEK : 495 individus, 23,5 < Lt < 83 cm, 23 < Wt < 1470 g), ont été analysées. Les variations qualitatives et quantitatives du régime alimentaire ont été recherchées dans les deux sites et en fonction des saisons et du stade de développement. Les valeurs respectives du coefficient de vacuité digestive moyen annuel sont de 38,1% et de 53,1%. Ce coefficient fluctue sensiblement en fonction de la saison de capture et du stade de développement des poissons. *Anguilla anguilla* est opportuniste et diversifie son alimentation entre mollusques, téléostéens et macrophytes, mais avec une préférence pour les crustacés dans les deux écosystèmes (%IRI_{ML} = 89,98 ; %IRI_{WEK} = 96,16).

INTRODUCTION

The European eel, *Anguilla anguilla* (Linnaeus, 1758) is an ubiquitous amphihaline migratory fish which reproduces in Sargasso Sea in northwest Atlantic Ocean (Deelder, 1985), then colonizes the majority of European inland waters (Dekker, 2003) and North African lagoons (Farrugio and Elie, 2011) for its somatic growth.

The population of *A. anguilla* has strongly declined throughout its geographical range since the mid 80's (Farrugio and Elie, 2011). It is now listed as Endangered in the IUCN Red List of threatened species of Northern Africa (Azeroual, 2010) and as Critically Endangered in Europe (Freyhof and Kottelat, 2010). It is also listed on Appendix II from the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2007). This decline is mainly due to anthropogenic activities (Bruslé and Quignard, 2013), but also to natural causes, such as viral infections (Van Ginneken *et al.,* 2004, 2005) and the haematophagous nematode parasite *Anguillicoloides crassus* (ICES, 2006; Pelster, 2015). Climate change and changes in existing ocean routes have also been suggested as possible causes for this decline (Knights, 2003; Friedland *et al.,* 2007). As a result, there is an urgent need for research on the ecology and biology of this species at all stages in its typically catadromous life cycle. The collection of such information is essential to propose possible management plans. This data also responds to a supranational request (European Commission Regulation no 1100/2007 and CITES Decisions no 18.197 to 18.202), requiring all states with natural habitats occupied by *A. anguilla* to implement such a management plan, so as to help rebuild stocks. If in Europe, national management plans have been launched since 2007 to survey the evolution of the species, in North Africa this issue is not sufficiently addressed.

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In the Mediterranean, the biology and ecology of *A. anguilla* is still insufficiently known, especially in transitional waters, *i.e.* estuaries and lagoons, where most of its fishery is concentrated (Kara and Quignard, 2019). The few known data on this type of ecosystems in the Mediterranean were obtained from population fractions in France and Italy. These studies mainly concern the structure and the dynamics of these fractions through the study of age and growth rates (Rossi and Colombo, 1976; Rossi and Villani, 1980; Lecomte-Finiger, 1983, 1985, 1992; Rossi and Cannas, 1984; Ardizzone and Corsi, 1985; GIS ARM, 1986; Mallawa, 1987; Fernandez-Delgado *et al.,* 1989; Lecomte-Finiger and Yahyaoui, 1989; Mallawa and Lecomte-Finiger, 1992; Panfili et Ximénés, 1994; Panfili *et al.,* 1994; De Leo and Gatto, 1995; Melià *et al.,* 2006; Yalçin-Özdilek *et al.,* 2006; Acou *et al.*, 2008; Castaldelli *et al.,* 2014; Capoccioni *et al.,* 2015). The study of trophic diet is more or less addressed in France (Lecomte-Finiger, 1983; Bouchereau *et al.,* 2006, 2009a, b) and North African lagoons (Ezzat and El-Seraffy, 1977; Shaiek *et al.,* 2015; Abdalhamid *et al.,* 2018).

In Algeria, *A. anguilla* has been reported in Mellah lagoon where its fishery has sharply declined since the mid-1980s (Chaoui *et al.,* 2006) and in different transitional and freshwater environments (Kara, 2012). Its current production does not exceed 100 tons per year (MPPH, 2020). The few researches devoted to *A. anguilla* concern its infestation by the nematode parasite *Anguillicola crassus*, mainly in the Mellah lagoon and in the lakes and estuaries of the El-Kala region in the far east of Algeria (Meddour, 1988; Boudjadi *et al.,* 2009; Djebbari *et al.,* 2009, 2015; Loucif *et al.,* 2009; Tahri *et al.,* 2016; Bakaria *et al.,* 2018). Only Djouahra and Arab (2017) provided preliminary information on the biology of this species in lake Tonga (eastern Algeria) and the port of Bouharoun (North central Algeria).

This study is part of a large national research program initiated in 2010 (CNEPRU N° F01120080132; Chaoui, 2009). Its objective is to provide the ecological and biological data necessary to establish a management plan for the European eel in Algeria. We present here the first elements on the composition and variations of the diet of *A. anguilla* colonizing the Mellah lagoon and Wadi El-Kebir, two masses of transitional waters situated in eastern Algeria. These data are important for explaining the characteristics of growth and body condition of the stocks concerned, with a double objective, ecological and halieutic.

MATERIALS AND METHODS

The diet of *A. anguilla* was studied during one year between December 2008 and November 2009. The samples were collected from artisanal fisheries conducted with fyke nets placed in the mouth of the Mellah lagoon (ML) (geo-

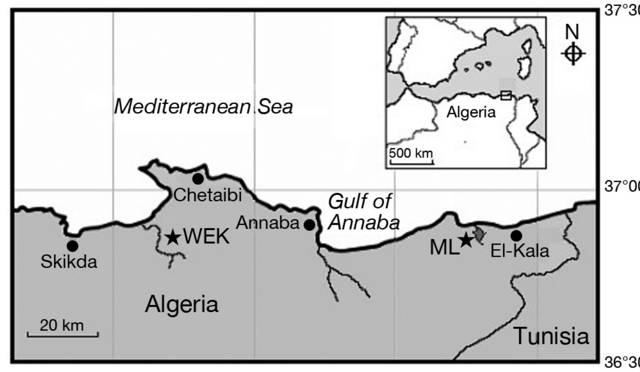

Figure 1. – Geographical location of sampling sites (✶) of *Anguilla anguilla* in Mellah lagoon (ML) and Wadi El Kebir (WEK).

graphical position: 08°20'E-36°53'N, international classification: Reserve of Biosphere of MABUnesco, substrate: fine sand with more or less shell debris and muddy in the central part, communication with the sea: through a 900 m length channel, water temperature: 10 to 30°C, area: 865 ha, salinity: 20 to 30 psu, average depth: 3 m) and Wadi El Kebir (WEK) (geographical position: 07°15'E-36°59'N, water temperature: 14 to 30°C, total length: 1827 km, salinity: 0.3 to 1.0 psu, average depth: 1.5 m) (Fig. 1). These fishing gears of about 3 m in length consist of 4 to 8 hoops with an opening of about 1 m in the diameter. They were placed at midday and removed by the fishermen the next day at the same time. Samples were processed immediately after fishing.

A total of 1120 eels were sampled (N_{ML}: 625, 24.3 < TL < 75.8 cm, 23 < TW < 842 g; N_{WEK}: 495, 23.5 < TL < 83 cm, 23 < TW < 1470 g). Given the presence of preys in different parts of the digestive tract, we examined all of their content. The digestive tracts were kept in absolute alcohol (98°). Each digestive tract was cut longitudinally and its content was emptied into a Petri dish. The various preys ingested were sorted, counted and weighed to the thousandth of a gram. Whenever possible, identification was carried to the finest taxonomic level, taking into account the following:

– The fish were partially digested. They were recognized by presence of the flesh and ossified structures (even or odd fins, scales, bones, ossified spines, fragments of spines). Whatever the number of muscular part, scales or bones we noted the presence of a single prey.

– Crustaceans were identified and counted through their body parts easily recognizable: cephalic (rostrum, periopods) and abdominal appendages (pleopods, uropod, telson) for decapods and brachyuran macrurans. Small crustaceans (amphipods, isopods) are generally fragmented, in which case the count of individuals has been performed by dividing the number of eyes by two.

– The number of bivalve molluscs has been determined by dividing the number of shells by two, while prosobranchia Gastropoda were counted by considering the presence of operculum or apical or basal fragments of the spiral shell. It was counted as a single food. Cephalopods were easily recognized thanks to the presence of tentacular fragments.

– Insect larvae were identified and counted through the cephalic appendages easily recognisable.

– The vegetal, represented by Macrophyta, has been considered as a single prey whatever the abundance of fragments found in the digestive tract.

– The insignificant presence of worms, which were found at oesophagus are parasitic nematodes, which usually colonize the swim bladder of the eel.

Quantitative analysis of the diet was realized by the calculation of the coefficient of digestive vacuity (Cv), which is the percentage of empty digestive tracts compared to the total number of digestive tracts examined. In both sites, changes in the digestive vacuity according to seasons and silvering stages (yellow, intermediate or presilver, silver) were evaluated by the Chi-Square test using Minitab software (Version 16.0). These silvering stages were defined by respecting to two morphological criteria (stage of differentiation of the lateral line and colour contrast) (Acou *et al.,* 2005) and one quantitative criterion (Ocular Index) (Pankhurst, 1982).

The different preys were classified using three simple methods (numeric, gravimetric and frequency of occurrence) and the index of relative importance (IRI) of Pinkas *et al*. (1971), amended by Hacunda (1981). This index has the advantage of integrating in its expression the three main descriptors of the presence of one prey: the numerical percentage (C_{ni}), the weight percentage (C_{pi}) and relative frequency (F_i). His equation is written as follows:

$$IRI = F_i(Cn_i + Cp_i), \text{ with}$$

$F_i(\%)$ = Frequency of prey = (Number of digestive tracts containing prey I or N_i / Number of digestive tracts examined) × 100;

$Cn_i(\%)$ = Numerical percentage of prey = (Number of individuals of prey i or n_i / Total number of prey) × 100;

$Cp_i(\%)$ = Weight percentage of prey = (Total weight of prey i or p_i / Total weight of prey) × 100.

The classification of different food categories (main prey: %IRI > 50%, accessory prey: 25% < %IRI < 50%, infrequently prey: %IRI < 25%) was established according to the IRI index (Rosecchi and Nouaze, 1987). This index is calculated as follows: %IRI = (IRI/∑IRI) × 100. The coefficient of digestive vacuity (Cv) and %IRI values were compared between the two sites.

RESULTS

Figure 2 shows the evolution of the digestive vacuity of *A. anguilla* from Mellah lagoon and Wadi El Kebir, according to sampling seasons and silvering stage. The seasonal maximum and minimum values of the coefficient of digestive vacuity are higher in Mellah lagoon (72.2% and 31.3%) than in Wadi El Kebir (56.1% and 25.8%), with respective annual averages of 53.1% and 42.9%. Statistical analysis showed the existence of seasonal changes in the digestive vacuity in both sites ($\chi^2_{ML} = 71.014$; $\chi^2_{WEK} = 37.803$; P = 0.000). The digestive vacuity in yellow and intermediary eels are less than 50% while those of silver eels is almost 90% in Mellah lagoon and null in Wadi El-Kebir. In these two sites, digestive vacuity is significantly different between the three silvering stages ($\chi^2_{ML} = 33.309$, P = 0.000; $\chi^2_{WEK} = 7.907$, P = 0.019).

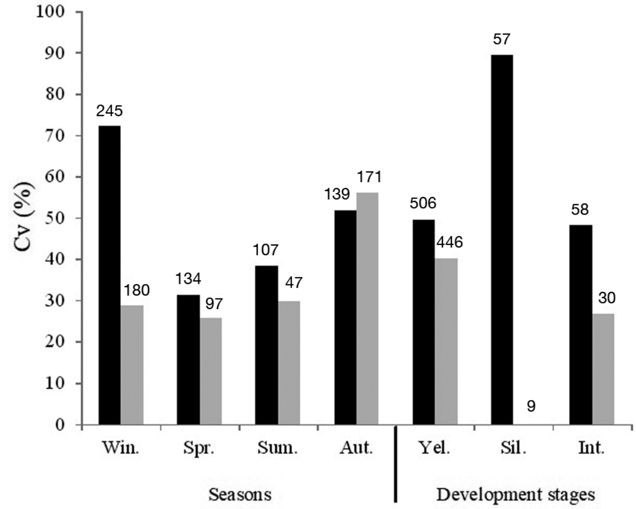

Figure 2. – Evolution of the digestive vacuity coefficient (Cv %) of *Anguilla anguilla* according to season and development stages in Mellah lagoon (in black) and Wadi El Kebir (in gray). The values above the bars mean the number of eels examined.

Tables I and II summarize the composition of the diet of *A. anguilla* and the classification of taxa ingested in Mellah lagoon and Wadi El Kebir, respectively. Qualitative analysis of digestive contents shows poor diet diversity in both sites.

In Mellah lagoon, *A. anguilla* feeds mainly on arthropods, bony fish, molluscs and macrophytes (Tab. I). According to IRI, arthropods are preferred foods (IRI = 89.98%), particularly decapod macrurans (IRI = 58.78%). Bony fish are secondary favourite preys (IRI = 9.59%) while shellfish and macrophytes were ingested accidentally (IRI < 0.5%). Preys identified belong to 11 species attached to the following phylums: Arthropoda (*Palaemon adspersus*, *Penaeus kerathurus*, *Carcinus aestuarii*, *Microdeutopus gryllotalpa*), Chordata (*Aphanius fasciatus*, *Atherina lagunae*, *Gobius niger*), Mollusca (*Abra ovata*, *Cardium glaucum*, *Mytilus galloprovincialis*) and Macrophyta (*Ruppia* sp.). We recognized a total of 462 preys for a total weight of 633 g, which represents approximately 1.6 preys for a weight of 2.16 g per digestive tract.

In Wadi El Kebir, molluscs and nematods und. are only accidental preys in the eels feeding (Tab. II). Deca-

Table I. – Diet composition of *Anguilla anguilla* in Mellah lagoon and classification of ingested preys according to the % IRI importance. N_i: number of gut containing prey; n_i: number of individuals of a prey; F_i: frequency of occurrence of prey; P_i: prey weight; C_n: numeric percentage of a prey; C_p: weight percentage of a prey; % IRI: Index of relative importance.

Items	C_n(%)	C_p(%)	F_i(%)	IRI	IRI (%)
ARTHROPODA	**71.86**	**70.34**	**67.73**	**9631.55**	**89.98**
Amphipoda	1.30	0.12	0.71	1.00	
Microdeutopus gryllotalpa	1.30	0.12	0.71	1.00	
Decapoda macrura	60.17	59.71	52.48	6291.51	
Palaemon adspersus	37.66	29.40	19.86	1331.75	
Penaeus kerathurus	4.76	16.40	7.09	150.10	
Und.	17.75	13.90	25.53	808.13	
Decapoda brachyura	10.39	10.52	14.54	304.03	
Carcinus aestuarii	4.33	5.79	4.96	50.22	
Und.	6.06	4.73	9.57	103.36	
CHORDATA	**18.40**	**26.82**	**22.34**	**1010.23**	**9.44**
Osteichthyes	18.40	26.82	22.34	1010.23	
Atherina lagunae	4.76	7.88	4.96	62.78	
Gobius niger	1.95	4.18	1.42	8.69	
Aphanius fasciatus	1.95	3.60	0.35	1.97	
Und.	9.74	11.16	15.60	326.15	
MOLLUSCA	**6.28**	**2.66**	**4.96**	**44.35**	**0.41**
Gastropoda	0.22	0.02	0.35	0.08	
Bivalvia	0.87	0.31	1.42	1.67	
Mytilus galloprovincialis	0.43	0.12	0.71	0.39	
Cardium glaucum	0.22	0.16	0.35	0.13	
Abra ovata	0.22	0.03	0.35	0.09	
Und.	5.19	2.33	3.19	24.01	
MACROPHYTA	**3.46**	**0.18**	**4.96**	**18.09**	**0.17**
Ruppia sp.	3.46	0.18	4.96	18.09	

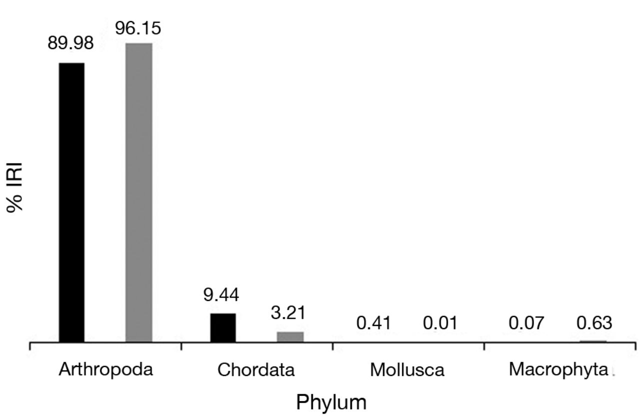

Figure 3. – Comparison of the IRI of major items ingested by *Anguilla anguilla* from Mellah lagoon (in black) and Wadi El Kebir (in gray).

pods crustaceans are the basis of their diet (IRI = 91.37%) with a preference for small shrimp *Atyaephyra desmarestii* (IRI = 67.02%). Bony fish, especially small Mugilidae, are ingested in second position (IRI = 3.21%). The Atherinidae and Gobiidae fish are consumed in negligible quantities. The majority Osteichthyes could not be identified due to their advanced state of digestion. Qualitatively, 9 items are part of its basic food, including 3 crustaceans (*P. adspersus*, *C. aestuarii*, *Sphaeroma* sp.), 1 insect (*Libellula quadrimaculata*), 4 Osteichthyes (*Mugil cephalus*, *Chelon saliens*, *C. ramada*, *C. labrosus*) and a snail (*Hydrobia* sp.). Each sampled eel ingested approximately of 2.2 preys for a total weight of 4.4 g per digestive tract.

Figure 3 compares the IRI of the 4 main prey categories eaten by *A. anguilla* from the two study sites. Arthropoda are always main preys (IRI_{ML} = 89.98%; IRI_{WEK} = 96.15%). Chordata (Osteichthyes fish), Mollusca and Macrophyta are rarely consumed in both sites (IRI < 10%).

DISCUSSION

The average monthly values of the digestive vacuity coefficient are higher in the eel population of Mellah lagoon (53.1%) than in that of Wadi El Kebir (42.9%). These values were higher than what has been recorded elsewhere in Mediterranean lagoons: 33% in Ichkeul, Tunisia (Shaiek *et al.,* 2015), 41.5% in Mauguio (Bouchereau *et al.,* 2009a) and 31.4% in Prevost (Bouchereau *et al.,* 2006) in France. In the Umm Hufayan lagoon (eastern Libya), eels with empty or slightly full stomachs are estimated at 46.0% (± 22.1%) and with a higher feeding intensity in spring (73.8%) and summer (71.4%) than in winter (31.7%) and autumn (38.9%, Abdalhamid *et al.,* 2017). Eels of Mellah lagoon and Wadi El Kebir feed continuously with a slowdown in autumn and winter in Mellah and in autumn in El Kebir. Seasonal changes in trophic activity of *A. anguilla* have already been observed in different localities in the Mediterranean (Ezzat and El-Seraffy, 1977; Lecomte-Finiger, 1983; Bouchereau *et al.,* 2006, 2009a, b; Abdalhamid *et al.,* 2017) and Atlantic basins (De Nie, 1987; Barak and Mason, 1992; Costa *et al.,* 1992; Cullen and McCarthy, 2007; Costa-Dias and Lobón-Cerviá, 2008). The periods of strong trophic activity is believed to be favoured by the rise in water temperature (Ezzat and El-Seraffy 1977; Hussein, 1981; Barak and Mason, 1992; Tesch, 2003; Yalçin-Özdilek and Solak, 2007). In Mellah, the annual water temperature varies between 10 and 30°C with values below 15°C from December to March (Chaoui *et al.,* 2006). In Wadi

Table II. – Diet composition of *Anguilla anguilla* in Wadi El Kebir and classification of ingested preys according to the % IRI importance. N_i: number of gut containing prey; n_i: number of individuals of a prey; F_i: frequency of occurrence of prey; P_i: prey weight; C_n: numeric percentage of a prey; C_p: weight percentage of a prey; % IRI: index of relative importance.

Items	Cn(%)	Cp(%)	Fi(%)	IRI	IRI(%)
ARTHROPODA	**86.09**	**71.11**	**76.50**	**12026.34**	**96.15**
Decapoda	81.01	71.10	75.14	11429.19	
Atyaephyra desmarestii	72.32	63.44	61.75	8383.11	
Carcinus aestuarii	5.94	7.43	11.20	149.76	
Amphipoda und.	0.29	0.00	0.27	0.08	
Isopoda	2.47	0.21	1.85	4.97	
Sphaeroma sp.	2.32	0.21	1.64	4.14	
Isopoda und.	0.14	0.00	0.27	0.04	
Insecta	5.07	0.02	1.37	6.95	
Libellula quadrimaculata	3.62	0.01	0.82	2.98	
Chironomid larvae	1.45	0.01	0.55	0.80	
CHORDATA	**7.39**	**26.01**	**12.02**	**401.9**	**3.21**
Osteichthyes	7.39	26.01	12.02	401.49	
Mugilidae	3.33	20.29	4.64	109.73	
Mugil cephalus	1.59	11.44	2.19	28.49	
Chelon saliens	1.01	4.72	1.37	7.84	
C. ramada	0.29	1.82	0.55	1.15	
C. labrosus	0.43	2.31	0.55	1.50	
Gobiidae und.	0.15	0.07	0.26	0.06	
Atherinidae und.	0.43	0.78	0.82	0.99	
Osteichthyes und.	3.48	4.87	6.28	52.46	
MACROPHYTA	**5.65**	**2.36**	**9.84**	**78.85**	**0.63**
Macrophyta und.	5.65	2.36	9.84	76.58	
MOLLUSCA	**0.72**	**0.51**	**1.37**	**1.69**	**0.01**
Gastropoda	0.43	0.00	0.82	0.36	
Hypsogastropoda	0.58	0.00	1.09	0.62	
Hydrobia sp.	0.29	0.00	0.55	0.16	
Gastropoda und.	0.29	0.00	0.55	0.16	
Cephalopoda und.	0.14	0.51	0.27	0.18	
NEMATODA	**0.14**	**0.01**	**0.27**	**0.04**	**0.00**
Nematoda und.	0.14	0.01	0.27	0.04	

El Kebir, the temperature is between 12.5 (February) and 28°C (July) (Rouag-Laouira, 2012). According to Deelder (1970), the feeding peak is observed at 25-26°C, with an optimum between 15 and 26° C. Beyond 28°C, temperature would have a reverse action on food intake causing adverse effects on growth with a cessation of all development activity (Lecomte-Finiger, 1983). Another abiotic factor such as salinity could also influence dietary differences between eel populations colonizing brackish and freshwater habitats. Indeed, the analysis of fatty acid and stable isotopes to investigate the trophic ecology of different stages of *A. anguilla* shown higher dietary plasticity in brackish water populations compared to those in freshwater (Parzanini *et al.,* 2021). In freshwater, this species exhibits a high lipid content and omega-6 polyunsaturated but a low stable isotope ratio, suggesting a major dietary difference between eels populations colonizing these two types of habitats.

In the two sampled ecosystems, development stage significantly influenced food intake. Silver eels were found in "anorexic" crisis in Mellah lagoon. As fishing is intensified in the mouth of this lagoon during the downstream period, the samples taken were probably composed of a majority of fasting individuals that were beginning their migration towards the ocean. In Wadi El Kebir, the small number of individuals sampled (9) does not allow any interpretation. The slowing down followed stopping of food intake (anorexic state) is a characteristic of silver eels that have mobilized enough energy reserves and are preparing for transatlantic migration to their spawning grounds without feeding (Boëtius and Boëtius, 1980; Olivereau and Olivereau, 1997; Farrugio and Elie, 2011).

In the two areas, diet of *A. anguilla* is composed of macrozoobenthic preys, mainly Arthropoda, which confers to it the status of carnivorous predator, with a preference for decapod crustaceans. Crustaceans constitute one of the main faunistic components of the two ecosystems, especially in Mellah lagoon where they represent 26.26% of the macrozoobenthic settlement after the polychaetes (57.21%) (Draredja *et al.,* 2012). In Ichkeul Lake (North Tunisia), only 50% of ingested preys by *A. anguilla* consist of macrobenthos (bivalves: 30%, crustaceans: 10%, teleost fish: 10%) (Shaiek *et al.,* 2015). This clear predominance of macrozoobenthic preys (crustaceans: 33.5%, bivalves and gastropods: 6.9%, polychaetes: 13%, echinoderms: 8.8%, fish: 8.5%) is also observed in the diet of the eel population of Umm Hufayan brackish lagoon, eastern Libya (Abdalhamid *et al.,* 2017). By studying the changing isotopic food webs in three neighbouring Mediterranean brackish costal lakes located on the Tyrrhenian coast of central Italy (Caprolace, Fogliano and Sabaudia), Sporta Caputi *et al.* (2020) showed that *A. anguilla* has a generalist diet including 20 different categories of food source. Some of these were common to the three lake populations (*e.g.* Actinopterygii, Bivalvia, Gastropoda, Decapoda and Polychaeta) but with varying consumed proportions.

Qualitatively and quantitatively, the eel from the Mellah lagoon target decapod crustaceans, including shrimp (*P. adspersus*, *P. kerathurus*) and crabs (*C. aestuarii*). The predominance of these three species can be explained by their continued availability in this lagoon (Draredja and Derbal, 1997; Draredja *et al.,* 2012), especially in its northern part subject to marine influence (Derbal, pers. obs.). In Wadi El Kebir, we also find crustaceans decapods with a preference for *A. desmarestii* and *C. aestuarii*. Elsewhere, this abundance of crustaceans is also reported in the Severn estuary (Great Britain) with a predominance of small shrimp Carides (*Crangon, Neomysis, Praunus*) and gammarid amphipods (Moore and Moore, 1976). In Tagus estuary nature reserve (Portugal), eels prefer primarily Brachyura and amphipods (Costa *et al.,* 1992). In Mauguio and Prévost lagoons (France), the proportion of amphipods *Gammarus gr. locusta* varies between 24 and 48%. In Mauguio lagoon, these preys come at the second position after fish of which the numerical importance reaches 62.5% in spring (Bouchereau *et al.,* 2009a) against 1.96% for the same period in Prévost lagoon (Bouchereau *et al.,* 2006). These zoobenthophagous behaviour (Deelder, 1985) of eels was already demonstrated in different lagoons: Ichkeul (Shaiek *et al.,* 2015), Prévost, Ingril and Mauguio (Guelorget and Perthuisot, 1982; Bouchereau *et al.,* 2009a), Caprolace, Fogliano and Sabaudia (Sporta Caputi *et al.,* 2020).

Small fish (mainly mullet and silverside fish) are rarely targeted by eels in both sites, whatever the development stage or sampling season. Generally, youngest freshwater eels in the Pacific, Atlantic and Mediterranean regions have tendency target small invertebrates, such as small crustaceans (isopods: Asellidae, amphipods: Gammaridae), gastropod molluscs and mainly larvae of insects, such as Chironomidae, Megaloptera, Trichoptera, Odonata and Lepidoptera, conversely to biggest eels which are rather piscivorous (Golani *et al.,* 1988; Jellyman, 1989; Barak and Mason, 1992; Yalçin-Özdilek and Solak, 2007; Van Liefferinge *et al.,* 2012). In two freshwater lakes of different environmental state and corresponding differences in food availability (Lake Grosser Vätersee, Germany and Lake Vallum, Denmark), Döerner *et al.* (2006) found that large eels piscivorous behaviour was generally controlled to a large extent by the low availability of insect larvae. On the other hand, the analysis of stable isotopes carried out by these authors demonstrated the importance of the benthic dependence of large eels in the carbon signature, which indicates that this predator could act as integrator between benthic and pelagic food webs when availability of insect larvae was low.

Except crustaceans, which are the main preys, ingestion of others invertebrates such as molluscs (Bivalvia, Gastropoda), annelids and insects (chironomid larvae and *Libellula quadrimaculata*) is rare in the two study sites. The proportions of insects consumed by eels, which can reach up to 90% in freshwaters (Denoncourt and Jay R. Stauffer, 1993), may be linked to the hydrobiological and geomorphological characteristics of the hydrosystems that temporarily host the eels during their anadromous migration (river, lagoon, estuary, wadi, lake, pond), but also to opportunistic behaviour of the eel which feeds according to availability of prey within environment. This feeding opportunism is observed not only in lagoon populations (Bouchereau *et al.,* 2006, 2009a, b; Sporta Caputi *et al.,* 2020), but also in other freshwater eel populations, such as *A. australis* and *A. dieffenbachii* (Jellyman, 1989), *A. rostrata* (Denoncourt and Jay R. Stauffer, 1993) and *A. japonica* (Kaifu *et al.,* 2013). In Wadi El Kebir, the presence of a single nematode morphologically similar to *Anguillicola crassus* just at the entrance of the oesophagus is considered accidental since this ectoparasite generally colonizes the swimbladder of adult eel (De Charleroy *et al.,* 1990).

The feeding heterogeneity, qualitative and quantitative, as well observed in Mellah lagoon and Wadi El Kebir, is due to the ability of adaptation of eels to colonize various aquatic biotopes (marine, brackish, freshwater). On the other hand, the hydrological characteristics of these different continental hydrosystems, in particular salinity, can indirectly affect dietary plasticity of the eels as well as their condition (Parzanini *et al.,* 2021).

In a perspective of sustainable exploitation of *A. Anguilla* and its best management, the collection of other information on movements, growth performances and fitness of the population fractions that colonize the various coastal aquatic ecosystems of Algeria is fundamental.

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