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FOOD AND FEEDING HABITS OF *LAGOCEPHALUS SCELERATUS* (GMELIN, 1789) IN SOME AREAS OF THE EASTERN COAST OF LIBYA

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ABSTRACT: *The puffer fish Lagocephalus sceleratus (Gmelin, 1789), family Tetraodontidae, is a Lessepsian species which has invaded the Eastern basin of the Mediterranean Sea. The present work is the first study that gives an account of length-weight relationship, condition factors and feeding habits of L. sceleratus in the eastern coast of Libya.L. sceleratus were randomly sampled monthly during January to December 2015 from the artisanal catch of Ain El-Ghazala lagoon (a total of 146 specimens) and Derna coast (22 specimens) on eastern Libya. Ain El- Ghazala fish had total length ranging from 19.5 to 73.4 cm corresponding to total weight of 149.3 to 4000.5 g. Total length of Derna L. sceleratus ranged from 49.5 to 73.4 cm corresponding to total weights of 1657.2 to 4011.8 gm. The length (L) weight (W) relationship W = 0.01881 *L2.8774, n = 146, R2 = 0. 7135 reflects a near isometric growth for Ain El- Ghazala fish (b = 2.8774). Fulton and Clark condition factors (K_F and K_C) of Ain El- Ghazala L. sceleratus were high in spring (1.34 and1.23 consecutively) and summer (1.43 and 1.21) and low in winter (1.21 and 1.13) and autumn (1.25 and 1.16).Mollusks (72.5%), supplemented by crustaceans (17.4%) and fishes (10.2%), composed the diet of Ain El-Ghazala L. sceleratus. Mollusks dominated the diet in all seasons, followed by crustaceans, then fishes. Feeding intensity was high during spring (83.5%) and autumn (72.6%) and low in winter (41.6%) and summer (28.3%). Uptake of mollusks decreased as L. sceleratus size increased, while that of crustaceans and fishes increased. Derna L. sceleratus of all sizes (49.5-73.4 cm) fed only on fishes (100%).*

KEYWORDS: Food and feeding, *Lagocephalus sceleratus*, Length weight relationship, Condition factor, Eastern Libya, Mediterranean Sea. Lessepsian.

INTRODUCTION

Much attention has been given lately to Lessepsian fishes and Lessepsian migration because of their deleterious effects on the Mediterranean ecosystem (Oral, 2010). However, only few studies had investigated the problem along the eastern coast of Libya (e.g. Shakman, 2008 and Abziew and Sayed, 2016).

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The silver stripe blaasop *Lagocephalus sceleratus* (Tetraodontidae) is a Lessepsian rabbit fish which has established itself in the eastern Mediterranean and is spreading at a relatively rapid rate (Bilecenoglu *et al*., 2006; Kassapidis *et al*., 2007; Carpentieri *et al*., 2009; Pancucci-Papadopoulou *et al*., 2011). Today, it is considered one of the worst invasive species in the Mediterranean Sea with a significant impact on the surrounding ecosystem. It is also a nuisance to fisheries (Zenetos *et al*., 2005). In Libya the fish has established itself in great numbers and caused serious problems to the artisanal fisheries because it attacks fish caught in nets and lines and tears gears with its potent tetradonts. Such problems were not known in its homeland (Red Sea) fisheries. *L. sceleratus* is also a serious hazard to consumers since it harbors tetradotoxin (TTX), a toxin that can be fatal to man (Arakawa *et al*., 2010). The present work is the first study that described length-weight relationship, condition factors and food and feeding habits of *L. sceleratus* (Gmelin, 1789) in some areas of the coast of eastern Libya.

MATERIALS AND METHODS

Sites of samples collection

Ain El-Ghazala lagoon

Ain El-Ghazala lagoon (Fig.1 and 2) is a roughly thumb shaped indentation of the Gulf of Bomba that covers an area of some 180 hectare (Reynold *et al*., 1995). The lagoon is shallow with an estimated average depth of 2 m and maximum depth of 4.2 m. It is fed by fresh water springs from various points around its southern coast. The region is known for its high species and ecosystem diversity.

Derna coast

Derna (Fig. 2) is both a city and a harbor. It is located at Latitude 32 16 North and Longitude 22 39 East, 146 km west of Tubrug and 91 km east of Al-Baida city (Reyonold *et al*., 1995; Ben-Ramadan *et al*., 2017). The harbor is 35m deep. It offers modern harbor facilities and good protection along an otherwise very exposed coast. It is provided with many berths and quays set in different sections that serve commercial shipping, fishing crafts and sport fishing boats.

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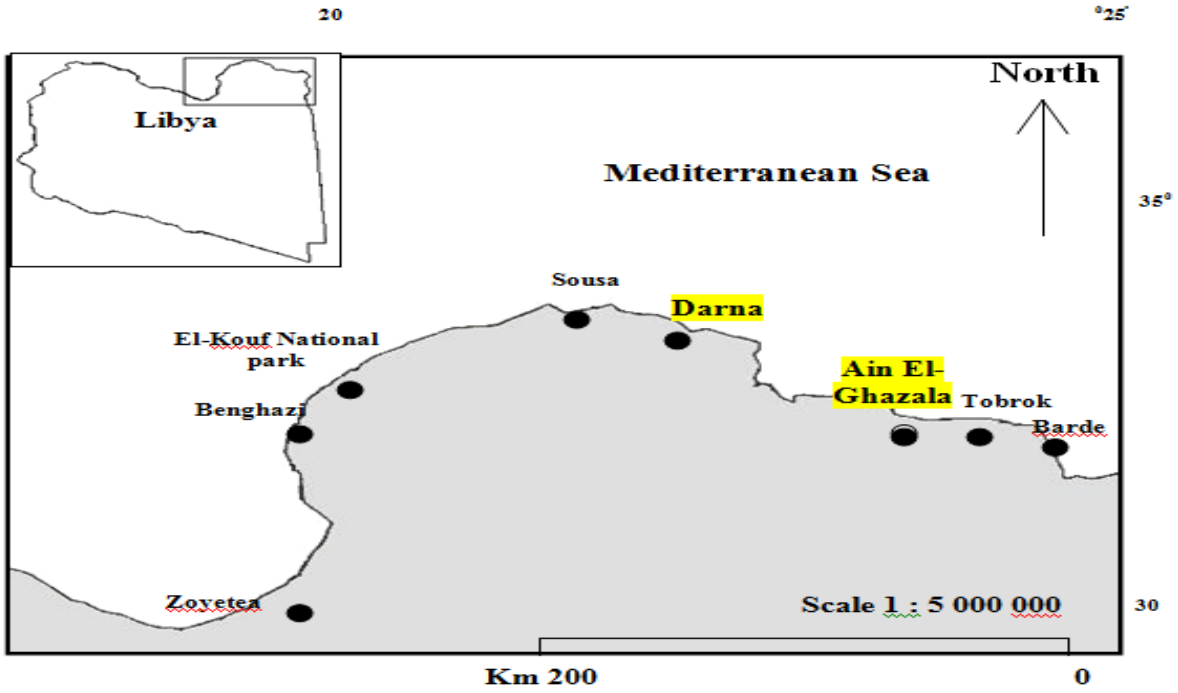

Fig. 1. Ain El-Ghazala and Derna sites

Fig. 2. A close up on Ain El-Ghazala lagoon

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Collection of samples

Monthly samples of *Lagocephalus sceleratus*, totaling 146 specimens, were randomly collected from Ain El-Ghazala artisanal catch during January to December 2015. Other monthly samples totaling 22 specimens were collected from Derna catch during the same period.

The morphological measurement

Total length and total weight were measured for each fish to the nearest 0.1cm and 0.1gm. Then the abdominal cavity of each fish was cut longitudinally and eviscerated, the eviscerated fish weight (We) was measured to the nearest 0.1gm.

Removed stomachs were preserved individually in formalin for later examination of food contents.

The length weight relationship

The length weight relationship of *L. sceleratus* was described by power equation based on Le-Cren (1951); Ricker (1975) and Letourneur *et al*. (1998):

$W = a L^b$ Where W: total weight (gm), L: total length (cm), a and b constants

Condition factors

Fulton (1902), and Clark (1928) condition factors (K_F and K_C) were calculated as:

$K_F = W / L^3 * 100$

$K_C = We / L^3 * 100$ Where We: eviscerated weight (gm)

Food and feeding habit

Degree of fullness of 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).

Each stomach was cut opened longitudinally and its content scraped off and transferred into a small Petri dish containing a small amount of water. Food items were sorted out under a binocular microscope. They were identified down to their groups according to Gobashi (1996) for mollusks and crustaceans, and Golani *et al*. (2006) for Fishes. Food analysis was made

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by the numerical method of Hyslop (1980). Diet composition and feeding intensity were related to months and seasons of the study period and to fish length.

RESULTS AND DISCUSSIONS

Length weight relationship

The Length-weight relationship of *L. scleratus* from Ain El-Gazala lagoon was calculated as:

$W = 0.01881 * L^{2.8774}$, $n = 146$, $R^2 = 0.7135$

The value of the slope "b" reflects isometric growth (b = 2.8774).

Length-weight relationships serve estimation of weight from a given length. Fish length is often more rapidly and accurately measured than fish weight (Aydin, 2011). There are few published works on length-weight relationship of rabbit fishes. In the Gulf of Suez, Egypt, the calculated slope "b" for *L. scleratus* (2.8676) reflects slightly isometric growth (Sabrah *et al*., 2006), and is close to the one obtained in the present study. Bausta *et al*. (2013) stated that b = 2.884 (isometric growth) for *L. scleratus* in Northeastern Mediterranean Turkey. Simon and Mazlan (2008) stated that b = 2.9910 (isometric growth) for the same species in estuaries of South Johore, Malaysia. The "b" value for *L. lunaris* off Visakhapatnam, east coast of India, was 2.7381 (Sirisha and Rao, 2013). A number of factors are known to influence the length weight relationship in fishes including growth phase, sex, size range, habitat and preservation techniques (Aristizabal, 2006). Beckman (1948) mentioned that the coefficients of length- weight relationship differ not only between species but sometimes also between stocks of the same species due to sex season and maturity stage.

Condition factors

Fulton's and Clark's condition factors (K_F and K_C) were calculated monthly for *L. scleratus* samples. K_F and K_C exhibited approximately similar pattern in all months (Fig. 3). January K_F (1.20) and K_C (1.12) increased in the following months to the highest values in June (K_F =1.41 and K_C = 1.17), July (K_F =1.43 and K_C = 1.20) and August (K_F =1.45 and K_C = 1.23) and then decreased in the following months to record the lowest values (K_F = 1.20 and K_C = 1.09) in December. Seasonal condition factors (Fig. 4) recorded the highest values in spring (K_F =1.34 and K_C = 1.23), summer (K_F =1.43 and K_C = 1.21) and autumn (K_F =1.25 and K_C = 1.16) whereas the lowest values were in winter (K_F =1.21 and K_C = 1.13).

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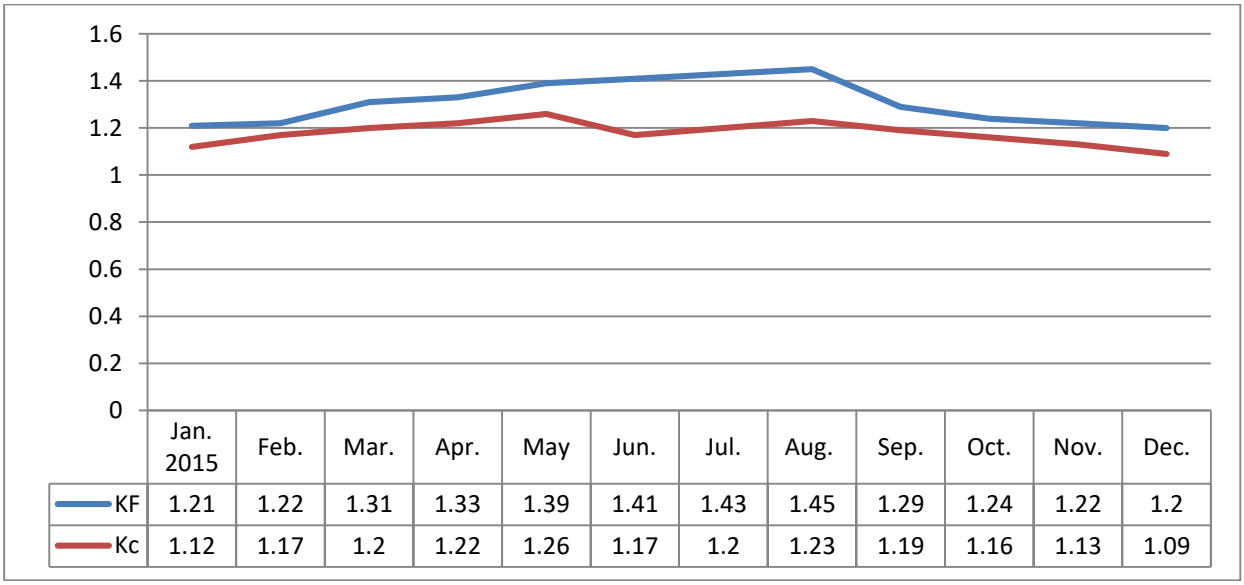
Niklosky (1963) and Roo *et al*. (1999) showed that monthly variations in the condition factors of fish are affected by feeding activities and spawning season which reflects on the body condition. This applies for the present study. The highest condition factor values were recorded in spring and summer. Similar results were obtained by Sabrah *et al.* (2006). They recorded highest K_F and K_c for *L. sceleratus* from the Gulf of Suez, Egypt, during summer when feeding activity was maximal (April). Similar conclusion was reached by Kalogirou (2013) who reported that *L. sceleratus* in Rhodes, eastern Mediterranean Sea had highest condition factor in summer. This was attributed to increased feeding and to the spawning season.



	Jan. 2015	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
KF	1.21	1.22	1.31	1.33	1.39	1.41	1.43	1.45	1.29	1.24	1.22	1.2
Kc	1.12	1.17	1.2	1.22	1.26	1.17	1.2	1.23	1.19	1.16	1.13	1.09

Fig. 3. Monthly variations in condition factor (K_F) and (K_C) of *L. sceleratus* in Ain El-Ghazala lagoon.

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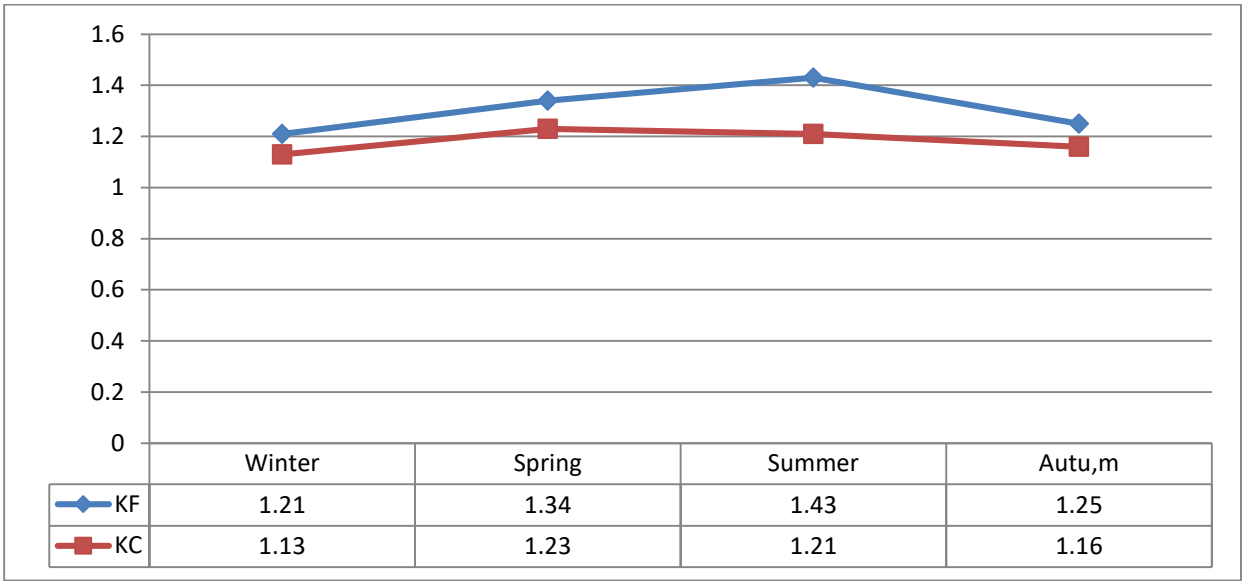

Fig. 4. Seasonal variations in the condition factor of *L. sceleratus in* Ain El-Ghazala Lagoon.

Food and feeding habits

Annual diet composition

The diet of *L. sceleratus* in Ain El-Ghazala lagoon during January to December 2015 was composed of mollusks supplemented by crustaceans and fishes (Fig 5). Mollusks made up 72.5% by volume of the bulk diet, they were represented by Sepia such as, *Sepia officinalis, S. elegans* and *S. prashadi* with some species of Loligo, and Octopus such as *Octopus vulgaris*. Crustaceans (17.4%) came in the second position of importance. They were composed of prawns and crabs, whereas fishes (10.2%) were mainly represented by *Siganus rivulatus, Siganus luridus, Diplodus vulgaris, Diplodus sargus, Serranus scriba, Litoganthus mormyrus, Epinepheleus guaza, Pagrus pagrus, Dentex dentex, sarpa salpa and sardinella maderensis.*

In Derna coast, *L. sceleratus* fed only on fishes (Fig. 5), such as *Mullus surmuletus, Liza ramada, Liza aurita* and *Diplodus sargus*.

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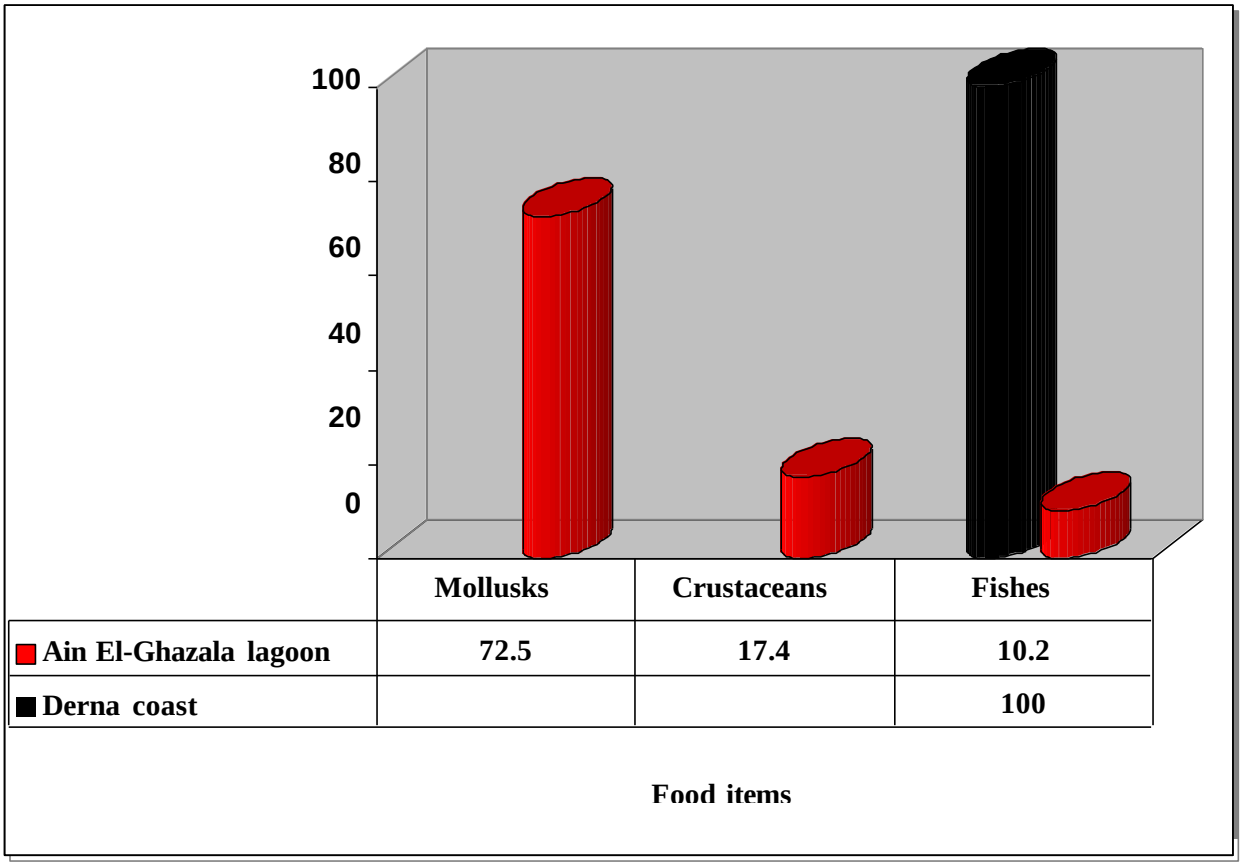

Fig. 5. Diet composition (% by volume) of *L. sceleratus* in Ain El- Ghazala lagoon (red bars) and in Derna coast (black bar).

Monthly variations in diet composition:

Mollusks, crustaceans and fishes constituted the food menu of Ain El-Ghazala *L. sceleratus* during all months of the year (Fig. 6).

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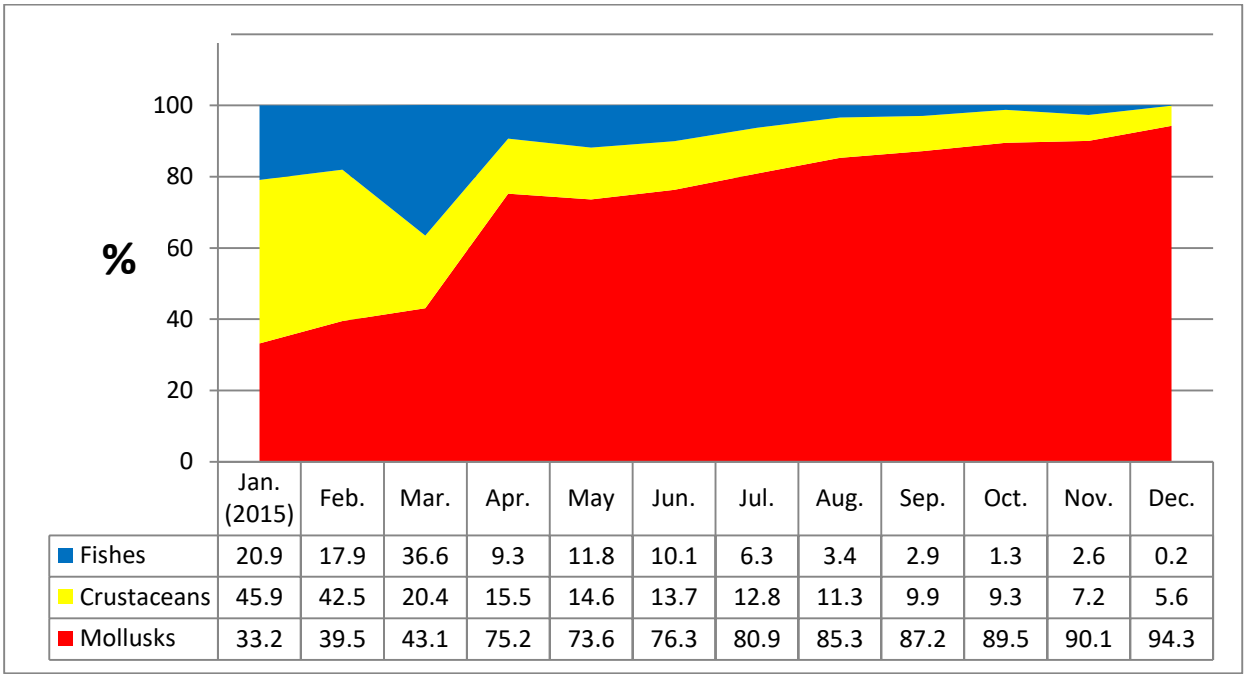

	Jan. (2015)	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Fishes	20.9	17.9	36.6	9.3	11.8	10.1	6.3	3.4	2.9	1.3	2.6	0.2
Crustaceans	45.9	42.5	20.4	15.5	14.6	13.7	12.8	11.3	9.9	9.3	7.2	5.6
Mollusks	33.2	39.5	43.1	75.2	73.6	76.3	80.9	85.3	87.2	89.5	90.1	94.3

Fig. 6. Monthly variations in diet composition (% by volume) of *L. sceleratus* in Ain El-Ghazala lagoon.

In January *L. sceleratus* preyed on mollusks by 33.2%, this rate increased in the following months and recorded the highest value (94.3%) in December. Crustaceans were ingested by 45.9% in January then decreased in the following months and recorded the lowest value (5.6%) in December, the same trend was observed for fish item (20.9 in January and 0.2 in December).

Seasonal variation in diet composition

Variations in diet composition of *L. sceleratus* from Ain El-Ghazala lagoon during the study period is shown in Fig. 7. Mollusks constituted the major food item during all seasons, with an increasing trend from winter to autumn. Crustaceans and fishes followed the opposite trend.

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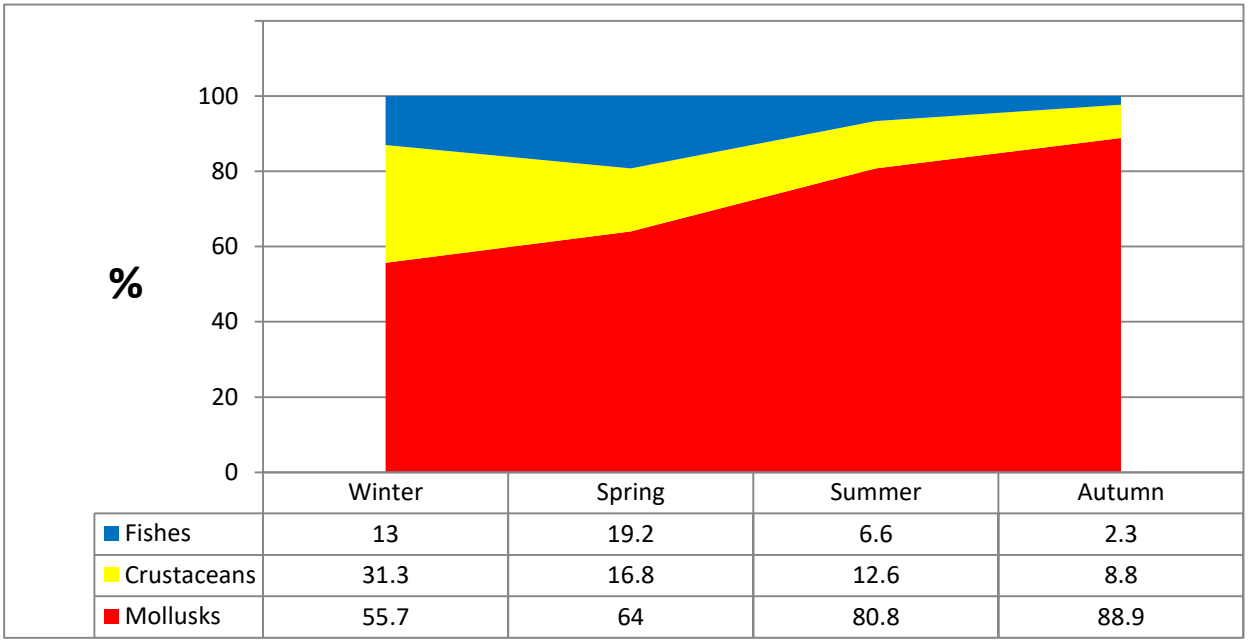

	Winter	Spring	Summer	Autumn
Fishes	13	19.2	6.6	2.3
Crustaceans	31.3	16.8	12.6	8.8
Mollusks	55.7	64	80.8	88.9

Fig. 7. Seasonal variations in diet composition (% by volume) of *L. sceleratus* in Ain El-Ghazala Lagoon.

Feeding habit in relation to fish size

Total length spectrum of Ain El-Ghazala *L. sceleratus* population was ranked into 9 classes ranging from 19.5 to 73.4 cm with 5.9 cm intervals (Fig. 8). Large size *L. sceleratus*, ingested large size prey, whereas small size fish ingested the small size prey. Mollusks and crustaceans were represented in the diet of *L. sceleratus* of all length classes. Dependence on mollusks decreased as fish size increased while dependence on crustaceans and fishes increased. Larger fish with their large mouths are better adapted to consume large prey such as crustaceans and fishes.

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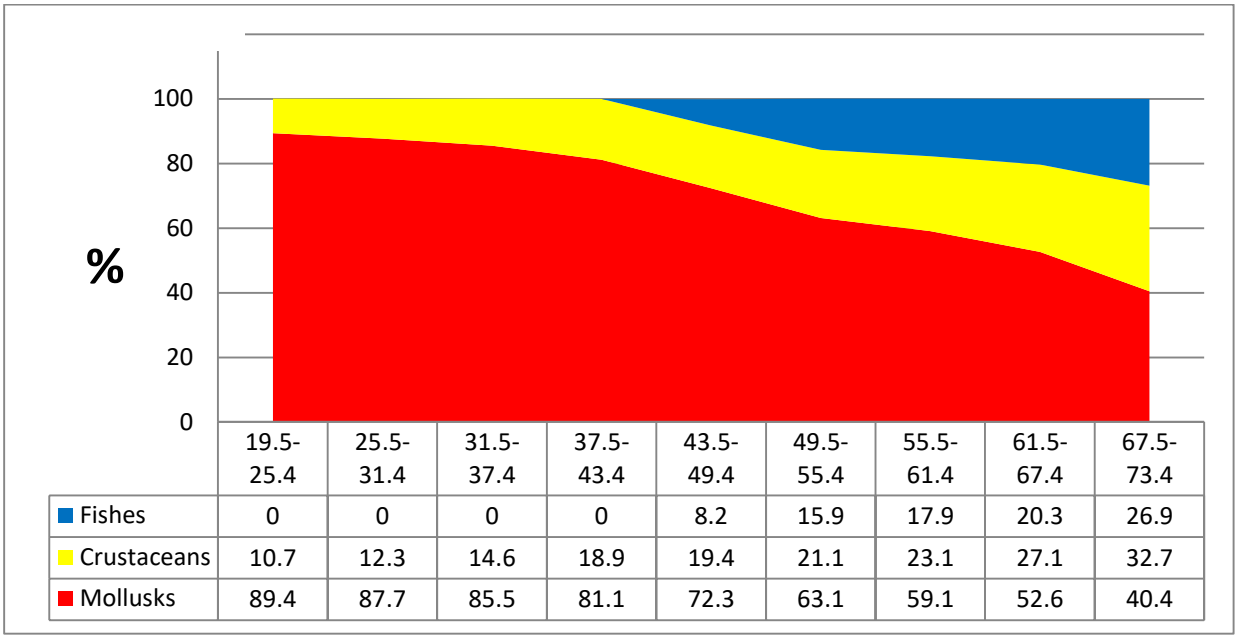

	19.5-25.4	25.5-31.4	31.5-37.4	37.5-43.4	43.5-49.4	49.5-55.4	55.5-61.4	61.5-67.4	67.5-73.4
Fishes	0	0	0	0	8.2	15.9	17.9	20.3	26.9
Crustaceans	10.7	12.3	14.6	18.9	19.4	21.1	23.1	27.1	32.7
Mollusks	89.4	87.7	85.5	81.1	72.3	63.1	59.1	52.6	40.4

Fig. 8. Diet composition (% by volume) of Ain El-Ghazala *L. scleratus* of different size classes

For Derna *L. scleratus* population, total lengths were ranked into 4 classes ranging from 49.5 cm to 73.4 cm with 5.9 cm intervals (Table 1). Fish items constituted the only food of (100% by volume) of *L. scleratus* of all size classes (49.5-73.4 cm).

Table 1. Diet composition (% by volume) of different size classes of 22 *L. scleratus* in Derna coast.

Size groups (cm)	**No.**	**Food items**		
		Mollusks	**Crustaceans**	**Fishes**
49.5-55.4	**4**	**0**	**0**	**100**
55.5-61.4	**9**	**0**	**0**	**100**
61.5-67.4	**3**	**0**	**0**	**100**
67.5-73.4	**6**	**0**	**0**	**100**

Monthly and seasonal feeding intensity

Ain El-Ghazala *L. sceleratus* with stomach half full, almost full and full of food were summed together in the rank b% which designates high feeding intensity (Table 2 and Fig. 9). b% constituted 56.5% examined fish. The feeding intensity was high during March to May and during September to November. *L. sceleratus* with stomachs that were empty, with traces of food and quarter full were grouped in the rank a% which designates low feeding intensity. a% included 43.5% of the examined fish. The feeding intensity was low during June to August and during December and January.

Table 2. Monthly variations (% by volume) in intensity of feeding of *L. sceleratus* in Ain El-Ghazala Lagoon.

Months	No. of fish	The degree of distension of the stomach							
		Empty	Trace	1/4	a %	1/2	3/4	Full	b %
Jan. (2015)	6	11.3	4.8	47.1	63.2	19.3	17.6	0	36.9
Feb.	9	24.0	28.0	0	52.0	24.0	24.0	0	48.0
Mar.	11	16.0	2.0	0	18.0	12.0	20.0	50.1	82.1
Apr.	10	11.4	0	0	11.4	13.1	48.3	27.2	88.6
May	5	20.2	0	0	20.2	15.4	15.4	49.1	79.9
Jun.	7	6.0	30.1	39.9	76.0	13.9	10.1	0	24.0
Jul.	16	26.2	22.7	26.3	75.2	8.9	0	15.9	24.8
Aug.	18	26.0	21.1	16.8	63.9	16.0	2.0	18.0	36.0
Sep.	30	20.0	10.0	0	30.0	18.0	26.0	26.0	70.0
Oct.	15	10.0	10.0	15.0	35.0	25.0	14.1	25.9	65.0
Nov.	9	17.2	0	0	17.2	15.4	21.4	46.1	82.9
Dec.	10	10.0	5.0	45.1	60.1	0	40.0	0	40.0
Average				43.5±24.1				56.5±23.9	

Green cells indicate highest values; red cells indicate lowest values

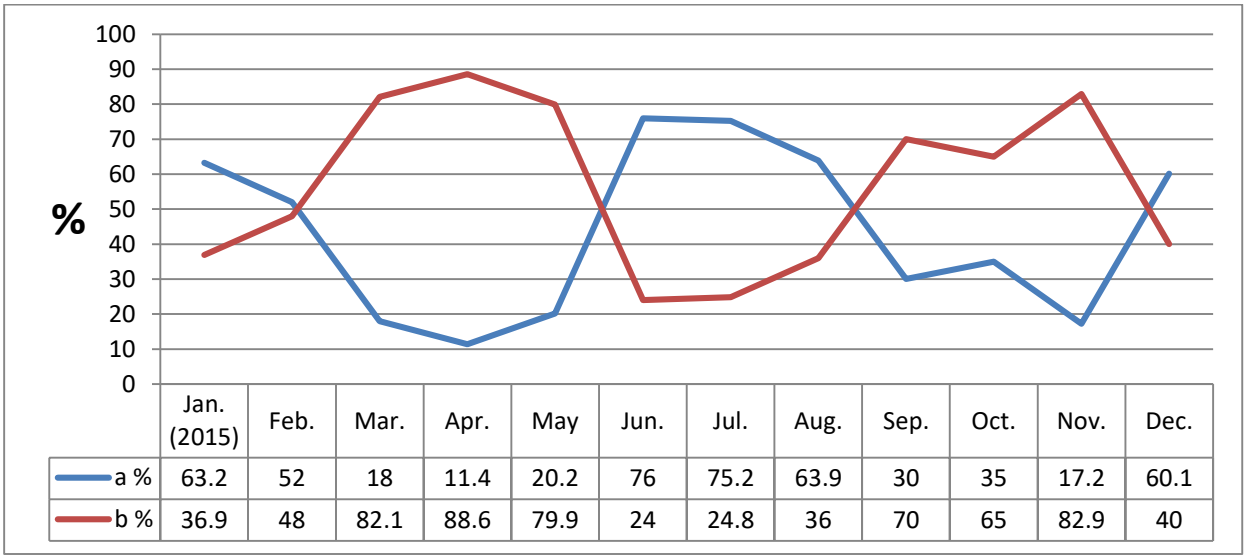

Fig. 9. Monthly variations (% by volume) in the intensity of feeding of *L. sceleratus* in Ain El-Ghazala Lagoon. a%: low feeding intensity, b%: high feeding intensity.

The feeding intensity of Ain El-Ghazala *L. sceleratus* (Table 3 and Fig. 10) was high during spring (83.5%) and autumn (72.6%) and low in winter (41.6%) and summer (28.3%). Summer is the breeding season of this fish. During summer most of the abdominal cavity is occupied by gonads and so there is no enough space for the stomach when it is full with food

Table 3. Seasonal variations (%) in the intensity of feeding of *Lagocephalus sceleratus* in Ain El-Ghazala Lagoon.

		The degree of distension of the stomach							
Seasons	**No. of fish**	**Empty**	**Trace**	**1/4**	**a%**	**1/2**	**3/4**	**Full**	**b%**
Winter	**25**	**15.1**	**12.6**	**30.7**	**58.4**	**14.4**	**27.2**	**B**	**41.6**
Spring	**26**	**15.9**	**0.7**	**B**	**16.5**	**13.5**	**27.9**	**42.1**	**83.5**
Summer	**41**	**19.4**	**24.6**	**27.7**	**71.7**	**12.9**	**4.0**	**11.3**	**28.3**
Autumn	**54**	**15.7**	**6.7**	**5.0**	**27.4**	**19.5**	**20.5**	**32.7**	**72.6**

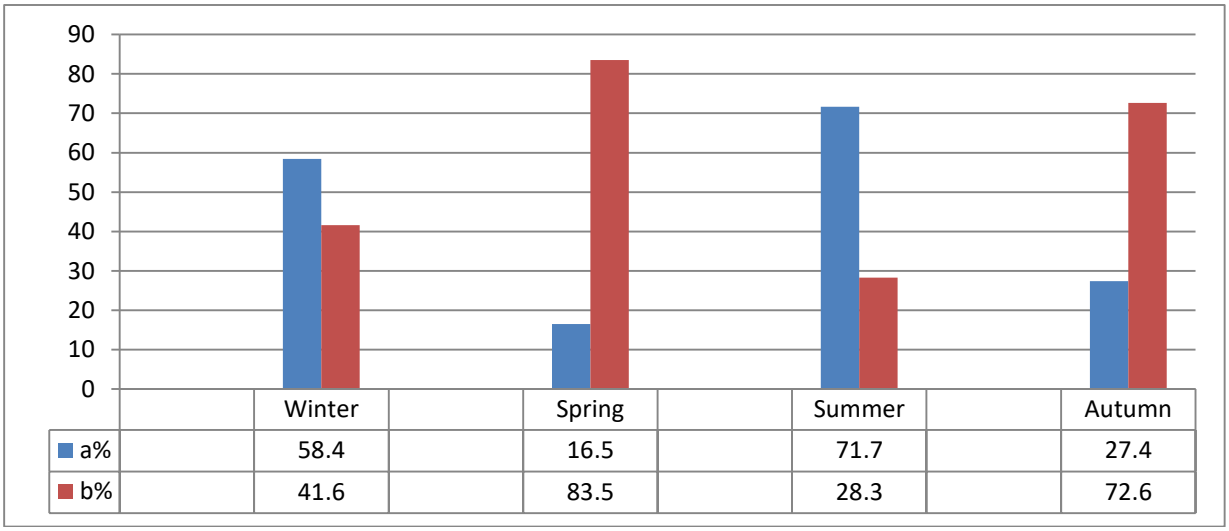

Fig. 10. Seasonal variations (% by volume) in the intensity of feeding of *L. sceleratus* in Ain El-Ghazala Lagoon. a%: low feeding intensity, b%: high feeding intensity.

In the current study *L. sceleratus* in Ain El-Ghazala lagoon were found to consume mollusks supplemented by crustaceans and fish, with ontogenic shift in favor of the latter. This is in agreement with Sabrah *et al*. (2006), and Aydin (2011) studies on *L. sceleratus* which revealed an ontogenetic diet shifts to mollusks and prey fish as fish grew in size. The food and feeding habits of rabbit fish have been studied by few authors (Sabrah *et al*., 2006; EastMed, 2010; Aydin, 2011 and Kalogirou, 2011). Young fish live in sandy bottoms and feed on invertebrates which are common in the sandy habitat. Older fish live in *Possidonia oceanica* meadows and feed on mollusks and small fishes which are common in this habitat (Kalogirou, 2011). This is possibly the case for *L. sceleratus* in Ain El-Ghazala lagoon which is characterized by high species and ecosystem diversity and well preserved multitude of natural habitats. The lagoon is rich with sandy substrates and Possidonia meadows. Derna *L. sceleratus*, on the other hand, were found to feed only on fish. This may be due to the small sample collected (22 individuals), all of which had large sizes, starting from 49.5 cm total length. Also it may be that Derna coastal waters is appreciably polluted with the output of a large desalination plant, dump of human remains, waste water and other activities characteristic of populous coastal cities to the extent that the habitat is not conducive for flourishing of Possidonia meadows, mollusks and crustaceans.

Analysis of *L. sceleratus* diet in Turkey's Mediterranean Sea showed that the fish is carnivorous and crustaceans are its major food items (Aydin, 2011), the numbers and size prey taxa increased with size of the *L. sceleratus* due to the ability of larger fish to consume a wider range of prey sizes than smaller fishes, this phenomenon appeared to be true for *L. sceleratus* of the present

work where dependence on crustaceans and mollusks decreased as the fish grew in size, while dependence on fishes increased. This is in agreement with Sabrah *et al*. (2006) in Gulf of Suez, Egypt. Monthly variations in condition factors of fish may be due feeding activities which reflect on the body condition (Vassilopoulau, 1989), this phenomenon appears to be correct for the species in the present work. The highest condition factors values $K_F$and K_C were recorded in summer and spring; which coincided with the degree of stomach fullness and the breeding season. This supports the observations described by Kalogirou (2011).

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