

**Morphological adaptations of digestive tract according to food and feeding habits of the broomtail wrasse, *Cheilinus lunulatus***

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**ABSTRACT**

The present study deals with the morphological adaptations of digestive tract according to food and feeding habits of the broomtail wrasse, *Cheilinus lunulatus*. The highest rate of feeding activity was recorded during spring and the lowest during summer. In the older and younger fish, the rates of feeding activity are nearly similar. The fish is mainly carnivorous benthic feeder. This fish plays an important role as a predator of invertebrates of reef fauna. It consumes a wide range of animal food. Molluscs, echinoderms and small fishes were the main food items consumed by these fish. Molluscs increased and echinoderms decreased in the food with the increasing length of the fish.

The mouth is relatively large, terminal in position, usually with prominent lips. Jaws are extremely protrusible to make the fish able to get food between branches of coral reef. The jaws teeth are conical canine in shape and composed of outer uni-serial pointed teeth. Two enlarged teeth are present in the front of the upper and lower jaws. They are specialized for catching and holding the prey and preventing its escape out of the buccal cavity. The pharyngeal teeth are molar in shape with blunt or round edge and arranged in two rows, usually 7 - 17 in each row of the floor. The teeth in the roof are developed and haphazard distributed. These molariform teeth are adapted for crushing and grinding of hard body preys. 11 gill rakers are present on the bow-shaped gill arch and conical in shape with tapering tips adapted for binding the prey.

Oesophagus is a short muscular distensible tube with few number of large mucosal folds adapted for facilitating conduction of food to the stomach. The J-shaped stomach is of the siphon type with large number of small mucosal folds adapted for food retention to be digested. The intestine is a short uncomplicated tube which recognized by the presence of ileo-rectal valve modified to prevent the passage of food particles into the posterior part before intestinal digestion and absorption is completed. It contains very large number of mucosal folds adapted for facilitating lubrication of feces towards the anus.

**Key words:** food, adaptation, digestive tract, *Cheilinus lunulatus*, feeding habits.

**INTRODUCTION**

Labridae is one of the most interesting and numerically abundant groups of fishes. It is very widely distributed in marine waters; mostly from the coast line to about 160 m depth on sandy bottom, shallow coral and rocky reefs. The broomtail wrasse, *Cheilinus lunulatus* is a large wrasse with a restricted distribution in the Arabian Peninsula. It is found in the Red Sea, Horn of Africa and coasts of Yemen; inhabits coral reefs and adjacent rubble of sand and sea grass habitats. The maximum age of this fish is 19 years with a rapid growth rate (in males 55 cm in TL), it has a primary and initial color phases. It feeds mainly on hard shelled invertebrates especially molluscs. This fish is protogynous and associated in colonies of 4–8

females with a single large male (FAO, 1983; Randall, 1983; Gomon and Randall, 1984 and Lieske & Myers, 1994).

Knowledge on the natural food of animals is important in understanding the feeding habits and nutritional requirements of the species and is also essential in fundamental community analysis for studies of food webs, tropho-dynamics, and resource partitioning and ecological energetic. On the other hand, the food and feeding habits of the fish is important for cultivating a group of fish in a ponds or impoundments, so that their competition for food is minimum (Wu, 1984; Shehata, 1992a&b, 1993a, b, c & d; Rao and Durga Prasad, 2002; Mugisha & Ddumba, 2007; Stephen 2007; Oliveira *et al.*, 2007).

The adaptations of fish alimentary canal to their food are particularly evident in the mouth form, mouth size, shape and structure of the oro-pharynx, dentition, gill rakers, esophagus, stomach and intestine. All these structures are subject to diverse and significant variations and modifications in accordance with the feeding habits of different fishes (Dasgupta, 2000; Khalaf Allah, 2009).

Several studies are available on the adaptations of the alimentary canal of fishes to their food and feeding habits notably by Kamel *et al.* (1995) on the Nile cat fish, *Bagrus docmac*; Shehata (1999) on the grass carp, *Ctenopharyngodon idella*; Shehata *et al.* (1999) on the characinid fish, *Alestes dentex*; Khalaf - Allah (2001 & 2009) on the cichlid fish, *Tilapia zillii*, the mullet fish, *Liza aurata*, the sole fish, *Solea solea*, the spiny checked grunter, *Terapon puta* and the striped sea bream, *Lithognathus mormyrus*; Dasgupta, (2000, 2001, 2002 and 2004) on the four species of genus *Channa*, four species of genus *Labeo* and 50 species of freshwater fishes of West Bengal; Yashpal *et al.* (2006 & 2009) on the carnivorous fish, *Rita rita* and the carp, *Cirrhinus mrigala*; Delashoub *et al.* (2010) on the Bighead Carp, *Hypophthalmichthys nobilis*; Monsefi *et al.* (2010): on the Persian tooth-carp, *Aphanius persicus*; Rodrigues *et al.* (2011) on the corvine, *Plagioscion squamosissimus*, cuiú-cuiú, *Oxydoras niger* and mandimoela, *Pimelodina flavipinnis* and Gamal, *et al.* (2012) on the cat fish, *Clarias gariepinus*.

However, information on the morphological adaptations of digestive tube according to food and feeding habits of the broomtail wrasse, *C. lunulatus* are lacking. Therefore, the present study is conducted to describe the morphological adaptations of jaws teeth, pharyngeal teeth, gill rakers, oesophagus, stomach and intestine of the broomtail wrasse, *Cheilinus lunulatus* according to food and feeding habits.

## MATERIAL AND METHODS

### 1- Specimens collection:

A total of 142 specimens of the broomtail wrasse, *Cheilinus lunulatus* of different sizes (13.9 – 43.2 Cm in St. L.) were collected from different localities of coral reef habitat at Hurghada, Red Sea; during the period from December, 2011 to November, 2012. Long line net was the main fishing method used to collect the fish. Fishes were freshly examined; standard and total lengths were measured to the nearest millimeters and recorded. After dissection, each stomach was cut and preserved in 10% formalin solution for latter examination. In the laboratory, the following studies were carried out.

## **2- Food and feeding habits:**

### **A- Feeding activity:**

To study feeding activity, all the examined stomachs were assessed first. The assessment was based on the visual estimation of the distension of the stomachs and the relative amount of food contained in them. The examined stomachs were classified into five groups, according to the following method utilized by Geevarghese (1976):

- 1-Empty: The stomach contained particularly nothing and the wall was evident.
- 2-Poor: The stomach contained little food, but distension of the wall was not evident.
- 3-Medium: The stomach was nearly half full and the wall was slightly distended.
- 4-Good: The stomach was almost full and the distension of wall was quite evident.
- 5-Heavy: The stomach was gorged with food and the wall was fully distended.

Fishes were separated into two length groups, small fishes (13.9 – 24.9 Cm) and large fishes (25 – 43.2 Cm). The percentage of the above five categories of stomachs fullness in each length group, was calculated. The percentage of heavy, good and medium stomachs which was truly reflective of well condition in each season was determined to assess the feeding activity.

### **B- Food composition:**

To study food composition, the point assessment method (Hynes, 1950) was carried out. Each stomach was opened, washed with water and its contents were flushed into a Petri dish and examined under a low power binocular microscope. Food items were taxonomically identified, as far as possible up to genera according to Randall (1983); Soliman (2001) and Rusmore-villaume (2008). The Percentage of each item was estimated and graphically represented for the fish groups.

### **3- Morphology of digestive tube:**

For studying the dentition, after dissection of the head, upper and lower jaws, pharyngeal pads and first gill arch were carefully isolated. They embedded in 3% KOH, with adding a drop of 1% Alizarin red stain for 5 days and transferred into 70% ethyl alcohol, then photographed and described. Esophagus, stomach and intestine were isolated carefully from the body cavity and preserved in 70% ethyl alcohol, then photographed and described.

## **RESULTS**

### **I-Food and feeding habits:**

#### **1-Seasonal variations in the feeding intensity:**

The percentage of heavy, good and medium stomachs of the broomtail wrasse, *Cheilinus lunulatus* which was truly reflecting well condition, in each season, was recorded (Table 1 and Fig. 1) to assess the actively fed and the rest poorly fed.

Results in Table (1) showed that, the annual average value of fish which have empty and poor stomachs constituted 51.27 % of the total fish examined. Such percentage varied considerably from season to season. The highest value of empty and poor stomachs was recorded during summer (56.25%) and the lowest (16.67%) occurred during spring. The annual average value of heavy, good and medium stomachs constituted 48.73% of the total stomachs examined. The highest value of feeding activity was recorded during spring (83.33%) and the lowest (43.75%) occurred during summer.

#### **2- Seasonal variations in the feeding intensity according to size:**

The feeding intensity showed a considerable variation in different sized groups and also of different seasons within the same sized group. The annual average value of



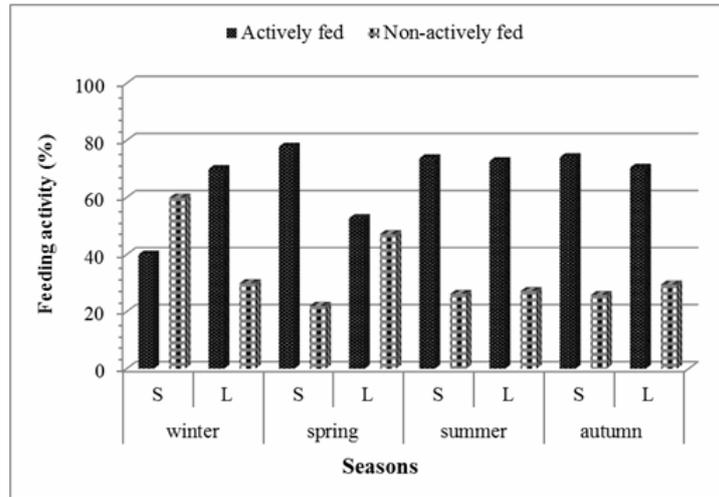


Fig. 2: Seasonal variations of the percentages of feeding intensity of small fishes (S) and large fishes (L) of *Cheilinus lunulatus*, collected from Hurghada, Red Sea, during the year, 2011 - 2012.

### 3- Seasonal variations in the food items:

Data in Table (3) showed that, the fish is mainly carnivorous and consumed a wide range of animal food. Molluscs, echinoderms and small fishes were the main food items consumed by the fish. Foraminifera are sporadically consumed.

Table 3: Point assessment percentages of various categories of food items in the stomachs of *Cheilinus lunulatus*, collected from Hurghada, Red Sea, during the year, 2011 - 2012.

Food items	Seasons				Annual average
	Winter	Spring	Summer	Autumn	
1-Mollusca:	67.98	65.38	85.52	22.45	64.47
<i>Trochus erithreus</i>	39.31	36.13	66.21	0.00	38.35
<i>Pinctada radiata</i>	19.66	0.00	16.55	6.12	10.84
<i>Clanculus pbaraonius</i>	8.19	6.88	2.76	16.33	7.78
<i>Turbo radiatus</i>	0.00	22.37	0.00	0.00	7.22
<i>Chiton affinis</i>	0.82	0.00	0.00	0.00	0.28
2-Echinodermata:	30.30	29.25	12.41	40.82	27.79
<i>Echinometra mathaei</i>	29.48	28.39	12.41	18.37	24.18
<i>Tripistes gratilla</i>	0.00	0.00	0.00	18.37	2.50
<i>Ophiocoma sp.</i>	0.82	0.86	0.00	0.00	0.56
<i>Euclidaris metularia</i>	0.00	0.00	0.00	4.08	0.55
3- Small fishes	0.00	0.00	0.00	36.73	5
<i>Herklotsichthys quadrimaculatus</i>	0.00	0.00	0.00	36.73	5
4- foraminifera	0.49	4.08	0.00	0.00	1.49
5- Un identified	1.23	1.29	2.07	0.00	1.25
Total	100	100	100	100	100

Results also showed that, there are quantitative differences of the food items during different seasons. As already stated, molluscs and echinoderms are invariably consumed through the year around. The highest value of mollusca (85.52%) was recorded during summer and the lowest (22.45%) occurred during autumn. (22.45%) while, the highest value of echinoderms (40.82 %) was recorded during autumn and the lowest (12.41%) occurred during summer. Thus, there is an inverse relation in the quantity of molluscs and echinoderms food consumed by the fish. The consumption peak of molluscs food (85.52%) takes place during summer, however, the consumption peak of echinoderms and small fishes food (40.82% and 36.73% respectively) takes place during autumn (Table 3 and Figs. 3&4).

Mollusca (64.47%) were by far the most dominant and preferred food item consumed by the fish. The highest value of molluscs food was recorded during summer (85.52%) and the lowest (22.45%) occurred during autumn. During winter and spring, molluscs food were moderate and nearly similar, being 67.98% in the former and 65.38% in the latter. *Trochus erithreus* (38.35%), *Pinctada radiata* (10.84%), *Clanculus pbaraonius* (7.78%) and *Turbo radiatus* (7.22%) were the main molluscs food consumed by this fish (Table 3 and Figs. 3&4).

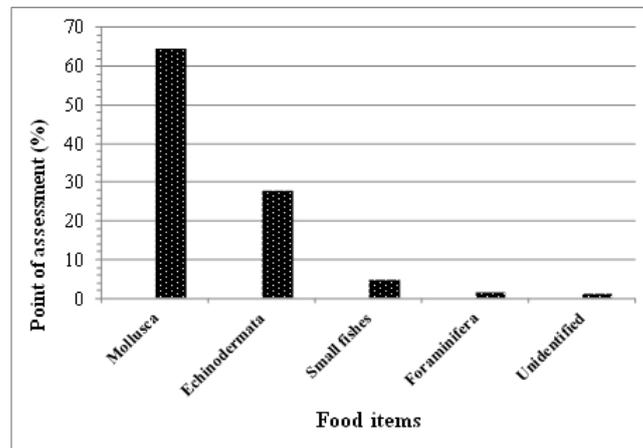


Fig. 3: Point assessment percentages of various categories of food items in the stomachs of *Cheilinus lunulatus*, collected from Hurghada, Red Sea, during the year, 2011 - 2012.

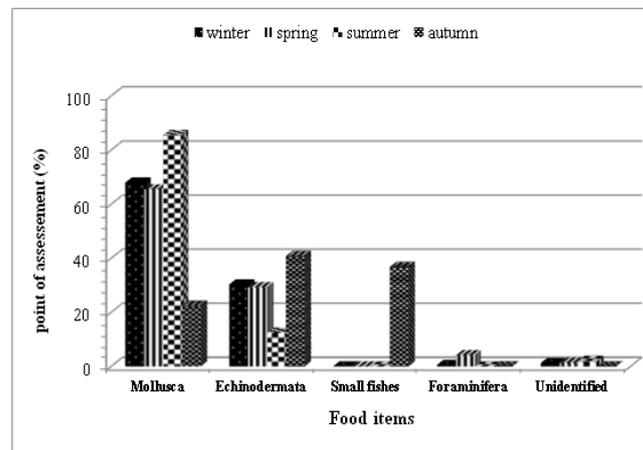


Fig. 4: Seasonal variations in the percentages of various categories of food items in the stomachs of *Cheilinus lunulatus*, collected from Hurghada, Red Sea, during the year, 2011 - 2012.

The maximum value of *Trochus erithreus* (66.21%) were recorded during summer and the lowest occurred during winter and spring; being 39.31% and 36.13% respectively. It was entirely absent in autumn. The highest value of *Pinctada radiata* (19.66%) was recorded during winter and the lowest occurred during autumn (6.12%). It was entirely absent in spring. The highest value of *Clanculus pbaraonius* (16.33%) was recorded during autumn. It decreased gradually during winter (8.19%) and spring (6.88%) and reached to the lowest value during summer (2.76%). *Turbo radiatus* (22.37%) was recorded only during spring. *Chiton affinis* (0.82%) was of periodic importance and occurred only during winter.

Next to molluscs in relative importance are echinoderms. They shared by 27.79% of the total food. The highest value of echinoderms food (40.82%) was recorded during autumn. It decreased gradually during winter (30.30%) and spring (29.25%) and reached to the lowest value during summer (12.41%). The main

echinoderm species is *Echinometra mathaei*, which shared by a large amount of food (24.18%) during the year. The highest values of *Echinometra mathaei* was recorded during winter and spring, being 29.48% and 28.39% respectively. *Tripenstes gratilla* (18.37%) and *Eucidaris metularia* (4.08%) were recorded only during autumn. *Ophiocoma* sp. was of periodic importance and occurred during winter (0.82%) and spring (0.86%). Small fishes constituted about 5% of the total food items. It was recorded only during autumn (36.73%). Foraminifera and unidentified food are of periodically consumed. The highest value of foraminifera was recorded during spring (4.08%) and the lowest (0.49%) occurred during winter. It was entirely absent in summer and autumn (Table 3 and Figs. 3&4).

#### 4-seasonal variations in the food items according to size:

The diet of this fish showed considerable variations in different sized groups and also in different seasons within the same sized group. The older fish was found to eat more of molluscs food than the younger one; being 62.88% in the former and 55.4% in the latter. Younger fish was found to eat more of echinoderms than the older one; being 43.46% and 30.62% respectively. In the small fish, the maximum amount of molluscs food was recorded during spring (70.48%) and the minimum occurred during autumn (21.63%). In the large fish, however, the highest value of molluscs food was recorded during summer (92.4%) and the lowest occurred during autumn (34.5%). During winter, summer and autumn, the older fish was found to eat more of molluscs diet than the younger one; being 74.8%, 92.4% and 34.5% in the former and 60.98%, 68.5% and 21.63% in the latter. During spring, however, the smaller fish was found to eat more of molluscs diet than the larger one, being 70.48% and 49.8% respectively (Table 4 and Fig. 5).

Table 4: Percentage occurrence of various categories of food items in different size groups in the Stomachs of *Cheilinus lunulatus*, collected from Hurghada, Red Sea, during the year, 2011 - 2012.

Food items	Seasons								Annual average	
	Winter		Spring		Summer		Autumn			
	16.5-24.9 Cm	25-35.2 Cm	17.9-24.9 Cm	25-32.2 Cm	15.9-24.9 Cm	25-43.2 Cm	13.9-24.9 Cm	25-32.2 Cm	13.9-24.9 Cm	25 - 43.2 Cm
1-Mollusca:	60.98	74.8	70.48	49.8	68.5	92.4	21.63	34.5	55.4	62.88
<i>Trochus erithreus</i>	41.35	63.4	44.13	48	56.12	66.18	0.00	0.00	35.4	44.4
<i>Pinctada radiata</i>	15.32	8.6	0.00	0.00	6.55	20.5	6.5	6.52	7.09	8.9
<i>Clanculus pbaraonius</i>	4.31	1.98	6.35	1.8	5.83	5.72	15.13	27.98	7.91	9.37
<i>Turbo radiatus</i>	0.00	0.00	20	0.00	0.00	0.00	0.00	0.00	5	0.00
<i>Chiton affinis</i>	0.00	0.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
2-Echinodermata:	38.53	23.97	25.44	48.2	31.5	5.53	78.37	44.77	43.46	30.62
<i>Echinometra mathaei</i>	38.53	23.15	25.44	47.34	31.5	5.53	60	28.19	38.87	26.05
<i>Tripenstes gratilla</i>	0.00	0.00	0.00	0.00	0.00	0.00	18.37	12.5	4.5	3.13
<i>Ophiocoma</i> sp.	0.00	0.82	0.00	0.86	0.00	0.00	0.00	0.00	0.00	0.42
<i>Eucidaris metularia</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.08	0.00	1.02
3- Small fishes:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.73	0.00	5.18
<i>Herklotsichthys quadrimaculatus</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.73	0.00	5.18
4- foraminifera:	0.49	0.00	4.08	0.00	0.00	0.00	0.00	0.00	1.14	0.00
5- un identified:	1.23	1.23	0.00	2	0.00	2.07	0.00	0.00	0.00	1.32
Total	100	100	100	100	100	100	100	100	100	100

During winter, summer and autumn, the small sized fish was found to eat more of echinoderms food than the large sized one; being 38.53%, 31.5% and 78.37% in the former and 23.97%, 5.53% and 44.77% in the latter. During spring, however, the larger fish was found to eat more of echinoderms food than the smaller one, being 48.2% and 25.44% respectively. Small fishes was recorded only during autumn (20.73%) in the stomachs of older fish, while, foraminifera was recorded only during

winter (0.49%) and spring (4.08%) in the stomachs of younger one. Unidentified food was recorded only in the stomachs of larger fish by negligible amounts (Table 4 and Fig. 5).

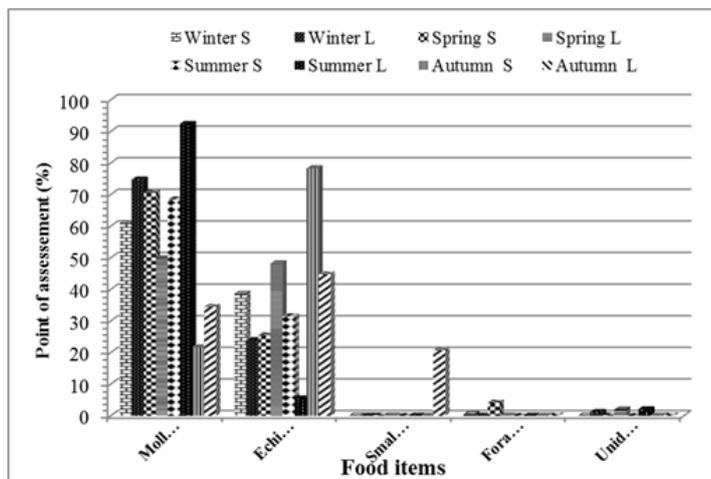


Fig. 5: Seasonal variations in the percentages of various categories of food items in different size groups in the Stomachs of *Cheilinus lunulatus*, collected from Hurghada, Red Sea, during the year, 2011 - 2012.

## II- Morphology of the digestive tube:

### 1-The Jaws teeth:

The mouth of the broomtail wrasse, *C. lunulatus* is relatively large, terminal in position and is bounded by the upper and lower jaws, usually with prominent lips. Jaws are extremely protrusible. Each jaw beset with outer uniserial canine teeth. The teeth are conical in shape and Pointed. Two enlarged teeth are present in the front of the upper and lower jaws. It was separated by some shorter teeth in the upper jaw (plate 1, A).

### 2- The Pharyngeal teeth:

The fifth branchial arch is reduced to a single strong bone on each side; the length of each pharyngeal bone is about four and a half times the width. The posterior limb is slightly shorter than the anterior limb, while, the pitted surface is narrow. The teeth are affixed to the medium-ventral aspect of each pharyngeal bone. Each tooth is molar in shape with a blunt or rounded edge, close-set, haphazard distributed in small fishes and arranged in two rows, usually 7 - 17 teeth in each row in large one. The number of teeth was increased with the increasing length of the fish. The medial teeth in the internal row are larger in size, stronger and graduated to small size towards the lateral one and external row. The tips of teeth are rounded in large teeth and tapering in small one, but never hooked. Small teeth may be found embedded in the mucous membrane of the pharynx in the vicinity of the pharyngeal bones. The pharyngeal pad in the dorsal wall of the pharynx lies below the occipital region of the skull opposite to the pharyngeal pad in the ventral wall of the pharynx. The teeth are developed and haphazard distributed. The teeth in the dorsal pad, faced together with the position of the teeth in the ventral one, which are thus enabled to crush the shells (plate 1, B & C).

### 3- Gill rakers:

The first gill arch has bow-shape and formed of one piece, so, it seems stouter and carries two rows of rakers, one on each side. 11 rakers on the anterior row differ from that on the posterior row. They are varying in size and conical in shape with tapering tips. Gill rakers on the posterior row are slightly less numerous. They are

noticeably shorter and thicker than that on the anterior row. Their tips are less tapering and so they seem as smooth inclined conical (plate 1, D & E).

#### **4- Esophagus:**

The esophagus of the broomtail wrasse, *C. lunulatus* is a short muscular distensible tube. It extends backwards from the pharynx, few millimeters from the pharyngeal teeth pads and immediately passes through the transverse septum, ventral to the swim-bladder to open in the anterior portion of the stomach. There is no sharp line of demarcation between the two organs, except for changes in the degree of mucosal folding. The esophagus is provided with few numbers of large mucosal folds (plate 2, A & B).

#### **5- Stomach:**

The stomach is of the siphon type, grossly divisible into the proximal cardiac, the mesial fundic and the distal pyloric regions. The three portions all together formed the J-shaped stomach. The cardiac stomach continuous with esophagus, forming a cone shape. The base of the cone is connected on the greater curvature to form the fundic stomach and on a lesser curvature to give the pyloric one. The boundaries between the two organs can hardly be distinguished. The fundic stomach is pouched-shape with a relatively wide lumen. The stomach is provided with large numbers of small mucosal folds (plate 2, A & C).

#### **6- Intestine:**

The intestine is a short uncomplicated tube. It runs from the pylorus forward as a thicker ascending segment (the duodenum), then bent on itself and passes backwards without further convolution to the vent forming a thinner descending segment (the ileum) and a thicker terminal one (the rectum). The intestinal wall is much thinner, flabby with variations in the diameter of segments. The ileo-rectal valve marked the beginning of the terminal segment (the rectum). The intestine is provided with very large numbers of nearly zigzag shaped mucosal folds in the duodenum and ileum, and wavy mucosal folds in the rectum (plate 2, A, D, E & F).

## **DISCUSSION**

In the present work, the morphological adaptations of jaws and pharyngeal teeth, gill rakers, esophagus, stomach and intestine of the broomtail wrasse, *Cheilinus lunulatus* are subject to diverse and significant variations and modifications in accordance with the food and feeding habits. Food is one of the important factors promoting growth and enriching the biochemical composition of fishes. The seasonal and diurnal abundance of different food organisms may influence the movements and migrations of fishes. Hence it is essential to have an understanding of the relationship between the fishes and food organisms for prediction and exploitation of fish populations. The importance of the knowledge of food and feeding habits of fish in understanding its biology has been well established. It helps in finding the distribution of a fish population which is highly essential for successful management of fisheries (Rao and Durga Prasad, 2002).

In the present study, feeding intensity of the examined fish indicated that, the fish changed their feeding activity with the changes of seasons. The highest value of feeding activity was recorded during spring and the lowest occurred during summer. The lowest rate of feeding activity during summer might be due to the effect of breeding season. Similar observations were recorded by many authors including Shehata (1992a & b, 1993a, b, c & d and 1994); Shehata and Zaki (1994); Allam

(1995); Khalaf-Allah (2001); Kiran & Puttaiah (2004) Argyris (2005) and Oliveira *et al.* (2007).

Within the reef community as a whole, fish appear to occupy a prominent position and dominate the carnivore trophic levels. This proportion was broadly similar to those for coral reef communities where carnivorous species also predominate in number of species (Russel, 1983; Wu, 1984; Shehata, 1993b and Shehata & Zaki, 1994). In rocky reefs, carnivorous fishes form two groups: open water feeders and benthic feeders. The benthic feeders are the dominate group of carnivores. In the present study, the broomtail wrasse, *C. lunulatus* can be classified as a carnivorous benthic feeder. This fish play an important role as predator of the invertebrate reef fauna. Food organisms that most heavily used-in order of descending importance-are molluscs, echinoderms, small fishes and foraminifera. The highest value of molluscs food was recorded during summer and the lowest occurred during autumn. Composition of food and average size of the preys increased with the increasing length of the fish. Similar heavy predation, mainly on benthic invertebrates, were recorded by Smith *et al.* (1991); Rao and Durga Prasad (2002); Manojkumar (2003); Argyris (2005); Figueiredo *et al.* (2005); Gianna *et al.* (2006); Sukree *et al.* (2006); Yashpal *et al.* (2006) and Gamal, *et al.* (2012).

In the light of these observations, the broomtail wrasse, *C. lunulatus* is a bottom-dweller, carnivorous and often of voracious habits. It feeds by sight and appeared to be diurnal feeders. They can be distinguishing between the desirable food items and the undesirable ones. The eyes and taste buds appear to play an important role in selection and orientation towards the food. Stomach contents reflect the relative density of food items in different seasons and the ability of the fish to make use of the available food according to their need. Similar observations were observed by many authors notably Shehata (1992a & b, 1993a, b, c & d and 1994); De Bruin *et al.* (1995); Khalaf-Allah (2001&2009); Argyris (2005) and Oliveira *et al.* (2007).

The adaptations of the digestive tube of the fish to their food are particularly evident in the form of mouth, size and shape of the bucco-pharyngeal cavity, dentitions, gill-rakers, oesophagus, stomachs, intestine and the relative length of gut (Dasgupta, 2000; Khalaf-Allah, 2001 and Al-Abdulhadi, 2005). On the other hand, the mucosal folding in the different regions of the alimentary tract is specialized according to conduction, retention and absorption of the ingested food (Moitra & Sinha, 1972 and Shehata, 1997a&b).

In the present study, the mucosal folds are large and few in number in the oesophagus adapted for facilitating conduction of food to the stomach. Mucosal folds are small and large in number in the stomach adapted for food retention to be digestion. Mucosal folds are nearly zigzag shaped and very large numbers in the duodenum and ileum and wavy mucosal folds in the rectum for facilitating lubrication of feces towards the anus. Sinha & Moitra (1976) mentioned that, the longitudinal mucosal folds in *Cirrhinus reba* an adapted for facilitating conduction of food in the oesophagus and lubrication of feces towards the anus in the rectum. While, the zigzag mucosal folds adapted for retention of food in the intestinal bulb.

The modes of feeding and food type are associated with the body form and digestive apparatus. A tremendous diversity exists in the form and size of fish teeth. The character of the dentition is a clue to the fish's feeding habits and the kind of food it consumes. In the present study, the mouth of the broomtail wrasse, *C. lunulatus* is relatively large, terminal in position, usually with prominent lips. Jaws are extremely protrusible to make the fish able to get food between branches of coral reef. Each jaw beset with outer uniserial canine teeth. The teeth are conical in shape and Pointed.

Two enlarged teeth are present in the front of the upper and lower jaws. They are specialized for catching and holding of the prey and preventing its escape out of the buccal cavity. Gill rakers are conical in shape and pointed to binding the prey. These modifications are in conformity with those of the carnivorous fishes described by Shehata (1997a), Shehata *et al.* (1999); Dasgupta (2000 and 2001) and Monsefi *et al.* (2010).

The present work revealed that, the pharyngeal teeth are molar in shape with a blunt or rounded edge, close-set and arranged in two rows, usually 7 - 17 teeth in each row in the floor. In the roof, the teeth are developed and haphazard distributed. Small teeth may be found embedded in the mucous membrane of the pharynx in the vicinity of the pharyngeal bones. These accessory growing teeth destined to replace old teeth if these are lost. The teeth in the dorsal pad, faced together with the position of the teeth in the ventral one, which are thus enabled to crush the shells, completes an exceedingly efficient crushing apparatus. Poyato-Ariza, (2005); Yashpal *et al.* (2006) and Gamal, *et al.* (2012) reported that, the molariform teeth may be associated with the crushing and grinding of hard body preys (e.g., mollusks, crustaceans). Bond (1979) suggested that, the fish, *Anarrhichthys ocellatus*, molariform teeth are used to crush the shells, which feed on shelled animals. Molar-like or plated teeth were also reported in adult, *Sparus aurata*, which feed mainly on mollusks, polychaetes and crustaceans (Cataldi *et al.*, 1987). Molariform teeth may also be used to compress food into a manageable lump, prevent its escape and ensure its progress toward the throat (Whitehead, 1977).

In the present study, the oesophagus of the fish species examined is a short muscular distensible tube. The stomach is of the siphon type. It can be divisible into three portions: the proximal cardiac, the mesial fundic and the terminal distal pyloric regions. The three portions together form J shaped. In this respect, the stomachs of these fishes resembles the stomachs of many carnivorous fishes including *Morone labrax* (Shehata, 1997a); *Clarias gariepinus* & *Bagrus bajad* (Hussein, 2004) and *Mylio cuvieri* (Al-Abdulhadi, 2005).

In the present study, the intestine is relatively short. The posterior intestine is recognized by the presence of ileo-rectal valve as well as by increase in diameter. The ileo-rectal valve, which is more or less constant feature of teleost intestines, marked the beginning of the terminal segment (the rectum). Its structure presumably prevents the passage of food particles into the posterior part before intestinal digestion and absorption is completed. Similar observations were detected in many carnivorous fishes (Shehata, 1997b & 1999; Khalaf-Allah, 2001&2009; Albattal, 2002; Dasgupta, 2002 & 2004; Al-Abdulhadi, 2005; El Bakary, 2007 and Khojasteh, 2012).

The present work shed more light on the morphological adaptations of digestive tract of the broomtail wrasse, *Cheilinus lunulatus* and concluded that, the morphology of jaws teeth, pharyngeal teeth, gill rakers, oesophagus, stomach and intestine are subject to diverse and significant variations and much modifications in accordance with the food and feeding habits.

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**Explanation of plates**

- Plate 1(A): Photograph of canine teeth in upper and lower jaws of *Cheilinus lunulatus*, (Alizarin red stain).
- (B): Photograph of pharyngeal teeth in the roof of the pharynx of *Cheilinus lunulatus*, (Alizarin red stain).
- (C): Photograph of pharyngeal teeth in the floor of the pharynx of *Cheilinus lunulatus*, (Alizarin red stain).
- (D): Photograph of the anterior row of gill rakers of *Cheilinus lunulatus*, (Alizarin red stain).
- (E): Photograph of the posterior row of gill rakers of *Cheilinus lunulatus*, (Alizarin red stain).
- Plate 2(A): Photograph of lateral view of isolated digestive tube of *Cheilinus lunulatus*, showing oesophagus (E), stomach (S), duodenum (D), ileum (I), rectum (R) and ileo-rectal valve (v).
- (B): Photograph of mucosal folds in the oesophagus of *Cheilinus lunulatus*.
- (C): Photograph of mucosal folds in the duodenum of *Cheilinus lunulatus*.
- (D): Photograph of mucosal folds in the ileum of *Cheilinus lunulatus*.
- (E): Photograph of mucosal folds in the stomach of *Cheilinus lunulatus*.
- (F): Photograph of mucosal folds in the rectum of *Cheilinus lunulatus*.

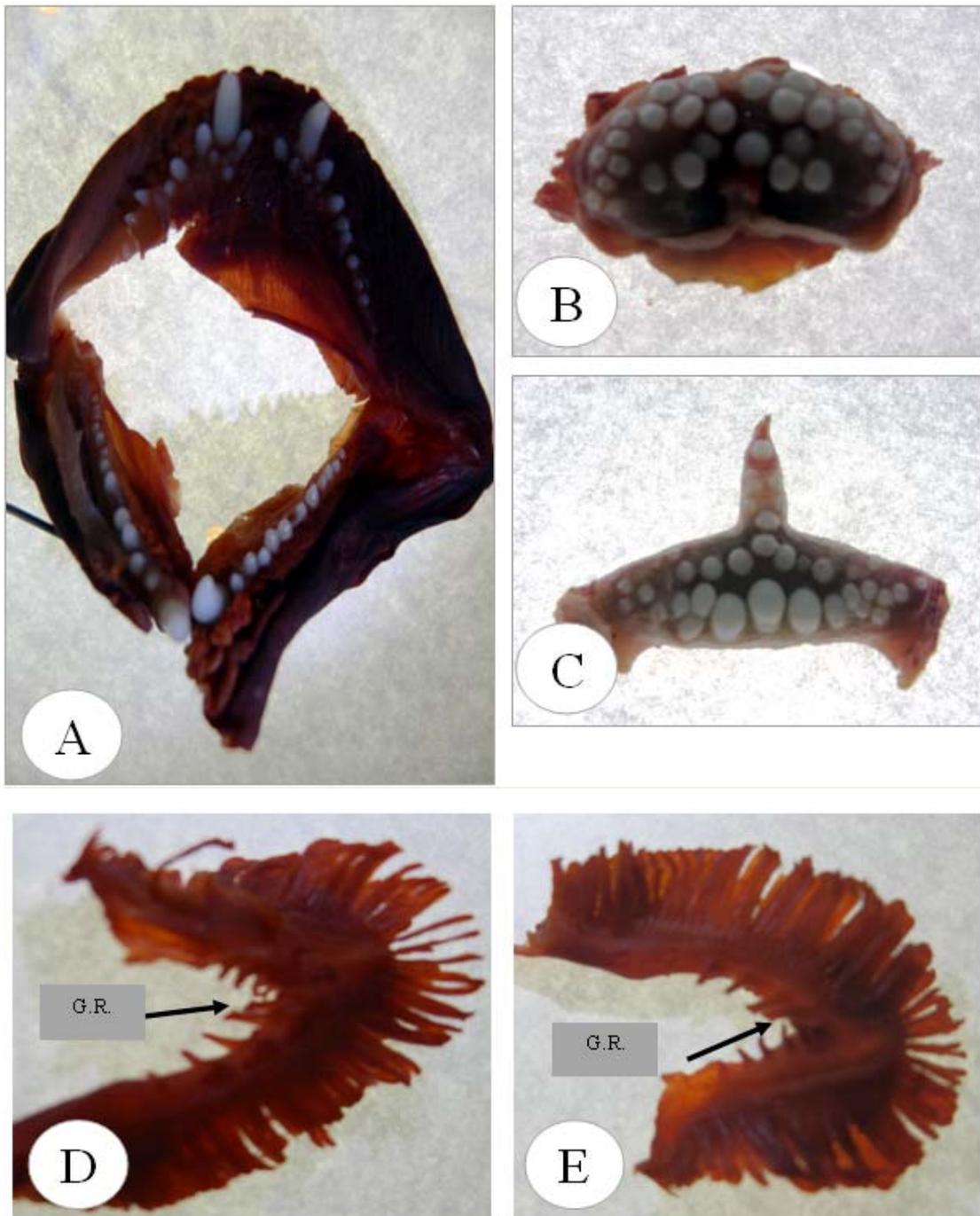


Plate 1

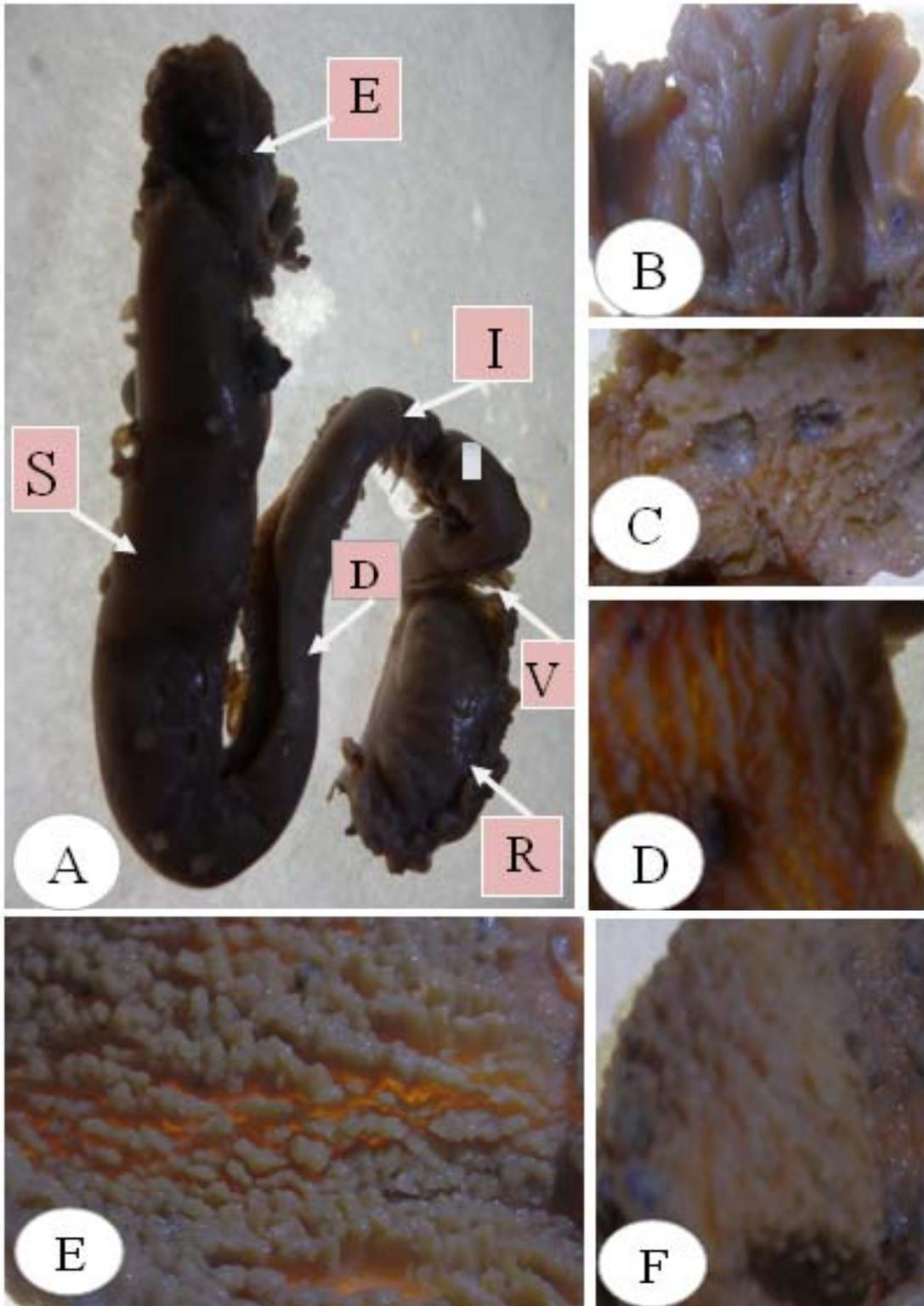


Plate 2

## ARABIC SUMMARY

## موانمة مورفولوجية القناة الهضمية تبعاً للغذاء والعادات الغذائية في سمكة الملاص

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تتناول الدراسة الحالية موانمة مورفولوجية القناة الهضمية تبعاً لنوع الغذاء والعادات الغذائية في سمكة الملاص القاطنه للشعاب المرجانية بمنطقة الغردقة بالبحر الأحمر. استخدمت دلائل عديدة في الوصف المعدي والمحتوى الغذائي بقصد التعرف على أصناف الغذاء، وعادات (سلوك) التغذية والدور الوظيفي لهذه النوعية من الأسماك في السلاسل الغذائية.

تبين من وصف حالة امتلاء المعدة أن هذه النوعية من الأسماك نهائية التغذية ومتوسطة النشاط الغذائي. سجل النشاط الغذائي أعلى معدل له خلال موسم الربيع وأقل معدل له خلال موسم الصيف. لا يزداد النشاط الغذائي لهذه النوعية من الأسماك بزيادة أطوالها. دل فحص المحتوى المعدي على أن أسماك الملاص من الأسماك المفترسة للافقاريات القاعية التي تقطن الشعاب المرجانية مثل الرخويات، الجلدشوكيات والأسماك الصغيرة. تختلف نسب هذه المكونات باختلاف المواسم. تزداد نسبة الرخويات وتقل نسبة الجلدشوكيات بزيادة أطوال الأسماك.

أوضحت نتائج دراسته أن الفم كبير نسبياً وذو موضع طرفي. الفم قابل للامتداد مما يجعل الأسماك قادرة على الحصول على الغذاء من بين تفرعات الشعاب المرجانية. الأسنان الفكيه من النوع النابي وتأخذ شكل مخروطي مدبب وتتنظم في صف واحد على الفكين العلوي والسفلي. يوجد زوج من الأسنان النابية الطويلة على قمتي الفك العلوي والسفلي متوائمه مع مسك وقبض الفرائس وكذلك تمنع هروب الفرائس من التجويف الفمي. الأسنان البلعومية تأخذ شكل الضروس ذو حافة دائرية عريضه. تترتب الأسنان على أرضية البلعوم في صفين، يتراوح عدد الأسنان بين 7 - 17 في كل صف. الأسنان على سقف البلعوم متطورة وتأخذ ترتيب عشوائي. هذه الأسنان متكيفه مع سحق وطحن أصداف الفرائس. القوس الخيشومي الأول يحمل 11 سن خيشومي ذو شكل مخروطي مدبب موانمة مع إلزام الفرائس بدخول المرئ.

بينت نتائج الدراسة أن المرئ عبارة عن أنبويه مرنة عضليه قصيرة وبه ثنيات مخاطيه طويله وقليلة العدد وذلك لكي يتم تسهيل توصيل الغذاء الى المعدة. المعدة من النوع الأنبوبي وتأخذ شكل حرف J وبها ثنيات مخاطيه كثيرة العدد متوائمه مع إستبقاء الغذاء في المعدة لكي يتم هضمه. الأمعاء عبارة عن أنبوية قصيرة وتحتوى على صمام يفصل بين اللفانفي والمستقيم وذلك لمنع أجزاء الغذاء من الوصول الى المستقيم قبل اكتمال هضمها في الأمعاء ثم امتصاصها. الأمعاء بها ثنيات مخاطيه كثيرة العدد تتوائم مع تسهيل وصول الفضلات الى فتحة الشرج.