دراسة تشريحية للجهاز الهضمي والتغذية في الحبار لوليجو فوربيسي من البحر المتوسط

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ملخص البحث:

في هذه الدراسة تم وصف الجهاز الهضمي ، ودراسة محتويات المعدة ، ونوعية الطعام من خلال جمع العينات خلال فصول العام من رحلات الصيد الموسمية التي يستخدمها الصيادين . وبدراسة التركيب التشريحي للجهار الهضمي وجد أنه يتكون من القناة الهضمية التي تبدأ بالكتلة الفمية التي تفتح في المرئ ، والمعدة ، والمستقيم بالإضافة إلى الغدد الملحقة ، وهما الغدتان اللعابيتان الاماميتان ، والخلفيتان ، والغدتان الهضميتان الكبد والبنكرياس.

كما تم دراسة نوعية الطعام ومحتويات المعدة ووزنها ووجد أن الطعام يتغيربتغير فصول السنة وأن الاسماك تشكل النسبة الاكبر من محتويات المعدة للحيوانات الصغيرة.

Anatomical study of digestive system and feeding on the squid *Loligo forbesi* from the Mediterranean Sea

ABSTRACT

In the present study anatomy of digestive systems and feeding for *Loligo forbesi* were described from samples obtained from the commercial trawl vessels off the costs of Alexandria ,East Mediterranean Sea.

The digestive system of *Loligo forbesi* consists of alimentary tract. It begins by buccal mass that opens to the esophagus, stomach, caecum, ceacal sac, intestine and rectum that ends with the anal opening. The accessory glands included salivary and digestive glands.

Regarding to food and feeding the maximum empty stomachs were observed in winter and spring seasons, while autumn exhibited the minimum number of empty stomachs with the food items fish and crustaceans occurring frequently.

INTRODUCTION

Squids are the most diverse group of cephalopods with around 300 species classified into 29 families. Squid species ranged from the largest invertebrate, The squid, *Mesonychoteuthis hamiltoni* (14 m) to much smaller species (5-10 cm) the Caribbean reef squid, *Heteroteuthis servenii* [1].

Squids are divided into two groups, suborder Myopsida and suborder Oegopsida, the major exploited family of Myopisda is Loligonidae, with major genera *Loligo, Sepioteuthis, Alloteuthis* and *Uroteuthis,* while the major exploited family of Oegopsida is Ommastrephidae, with major genera, *Illex, Todaropsis* and *Todarodes* [2]. *L. forbesi* is a subtropical and temperate waters species occurring over the shelf in the temperate part of its distributional range, but found in deeper waters in subtropical areas, the entire depth range extending from about 100 m to 400m [2,3]. *L. forbesi* is found along the continental shelf and on off shore banks at depth of 50-250 m in the British waters [4], 15-150 m in the North Sea and eastern Atlantic Ocean, 150-400 m in the Mediterranean and (100-200 m) in Portugese waters [5]. Additional research in the British waters carried out by [6] suggests that *L. forbesi* is found in deep waters (100-200 m) along the shelf-edge at the beginning of spawning but during peak spawning months, it is recorded from shallower waters (<50 m). The present study aims to investigate anatomical study of digestive system and feeding of *L. forbesi* in the Mediterranean waters.

MATERIAL AND METHODS

1. Macroscopic Anatomy:

The anatomy of digestive systems were carried out on fresh and preserved specimens of *L. forbesi*.

2. Food and Feeding:

Stomachs were removed from all specimens and weighted to the nearest gram. The food content was removed from each stomach and weighted and the food constituents were indentified under a stereoscopic microscope. The food items were identified to the lowest possible taxonomic level. The various degrees of stomach fullness with food were also recorded and divided subjectively into 6 main degrees after [7] as follows: 0-empty, I-traces, II-little, III-half, IV-full, and V-distended.

RESULTS

1. DIGESTIV SYSTEM:

The digestive system of *L.forbesi* consists of alimentary tract and the accessory glands.

The alimentary tract:

It begins by buccal mass that opens to the oesophagus, stomach, caecum, ceacal sac, intestin and rectum that ends with the anal opening. The accessory glands included salivary and digestive glands (Fig.1 a,b).

The buccal mass (Fig.1 b,c):

The buccal mass is a muscular bulb that provided with beak and radula. The mouth lies in the center of the arms, surrounded by a fleshy papillated, movable outer and inner circular lips, enclosed within the lobes a pair of powerful horny jaws with the ventral jaw overlapping the dorsal one. The posterior and lateral walls of the two jaws are embedded in the muscle of the buccal mass. The roof of the mouth is formed entirely by the concave surface of the dorsal jaw.

The oesophagus (Figs.1 b,c):

It is a long tubular muscular organ. It runs along the posterior end of the buccal mass. Its anterior part lies quite freely in the peri oesophagea sinus. At the posterior end of the skull, the oesophagus runs along the middle line, between the two lobes of the digestive gland to open into the stomach.

The stomach (Fig.1a,b):

It is a muscular sac, laying on the right side of the animal, with the oesophagus opening on its anterior end by a sphincter valve. The entire stomach is lined by museles. The lining is comparatively thin except in the region of a very powerful grinding musele which encircles the stomach transversely.

The vestibule (Fig.3):

This is the chamber with which the stomach, the caecum and the intestine communicate, each through a special sphincter. Three valves control between them the direction in which the contentes of the stomach and caecum move (Fig.4,a). If the sphinoter of the stomach and intestine are relased, the hard shally residues can be expelled from the stomach to the intestine directly without entering the caecum. Semi digested food can flow from the stomach to the caecum when the stomach and caecum sphincters are relaxed, while relaxation of the caecum and intestine sphincter allow the contents of the caecum to travel into intestine.

The caecum (Figs.1a,b):

It is the largest organ of digestive system and the ceacal sac. The caecum surface is greatly increased by the preasence of leaflet-like glandular fold, which vary in size. The caecum cosists of two parts: an anterior, spiral portion about one and half turns and a long sac, blown out, as it were from the posterior side of spiral. The spiral portion has its axis obliquely dorso-ventral, and last half turn is seprated from the rest by the wedge sheped pancreas whose thin

end runs in the columella of the spiral and opensat its apex; the caeco-intestinal opening is at the other end of the spiral. These two opening are connected by a groove the hepato-pencreatic groove which runs round the columella of the spiral and it is bounded on one side by a well-marked ridge the columellar rodge and on the other by a fold the hepato-pencreatic duct into the intestine. The caecal valve regulate passing the food (Figs.4a,b).The posterior part of the caecam is oval like sac. The caecal sac is thin musele sac used for food storage.

The intestine (Figs.1a,b):

It is a comparatively short tube. It extends from the caeco-intestinal opening to the rectum (Fig.4,a). It has two distinct ridges, running closely along the dorsal wall internal, enclosing a groove between them.

The rectum (Fig.1,a):

It is a small tube that ends interiorly by anus. The latter is characterized by the presence of anal valves that arise at the sides of the anus in the vicinity of the ink sac opening. The ink duc, just before it enter the rectum.

2. Accessory glands:

Anterior salivary glands (Fig.2,b):

It is comperaratively large paried structure, contained within the palatine lobes of the baccul mass. It extends throughout the whole length of each lobe, but posterior it is limited to the dorsal part. The gland opens on both sides of the radula by two ducts.

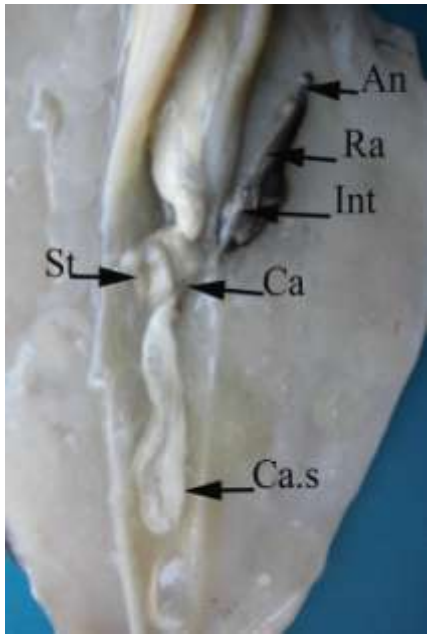
Posterior salivary gland (Figs.1,b. 2,b):

The posterior salivary glands are larger than the anterior ones. It is a paired structure, lying partly embedded in the anterior end of the digestive gland on every lope the liver, its duct opens at the tip of the odontophore between the anterior salivary glands.

Hepatopancreas (Fig.1):

The division of digestive gland into liver and pancreas enables the production of large variety of digestive and this could explain the large size of *L. forbesi* compared to its short life span.

The digestive glands are localized at the dorsal side on the midline of visceral mass. It is a white large organ extending from the posterior end of the buccul mass to the anterior end of the stomach. It is divided into a wide large anterior portion (liver) and a small posterior pancreas. The liver consists of pair digestive glands fused in the midline, it's a triangular organ with the base located ventrally near the collar.The pancreas has a U-shape, it lies anterior to the stomach. The duct of pancreas unites with that of the liver before passing into the caecum.



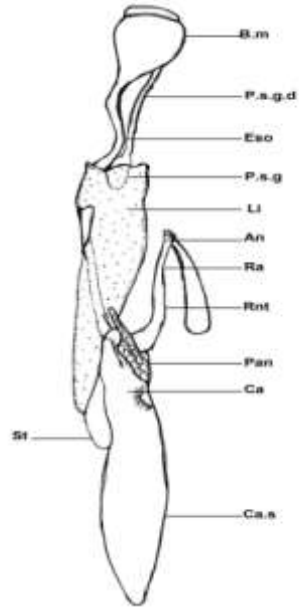


Fig.1,a : Photograph showing the digestive system of *L.forbesi*

Fig.1,b:Diagram the digestive system of *L.forbesi*

An: anus, Ra: rectum, Int: intestine, St: stomach, Pan: pancreas, Li: liver, Eso: esophagus, P.s.g: posterior salivary gland, Ca: caecum, Ca.s: ceacal sac

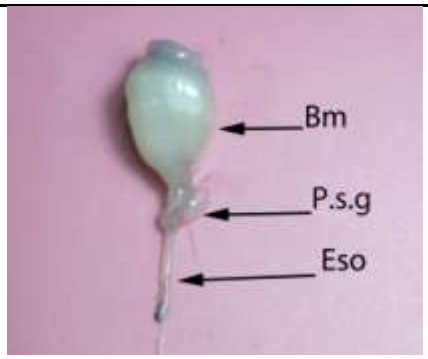


Fig.1,c: Photograph showing the buccal mass(Bm), posterior salivary gland(P.s.g) and esophaguso (Eso) of *L.forbesi*

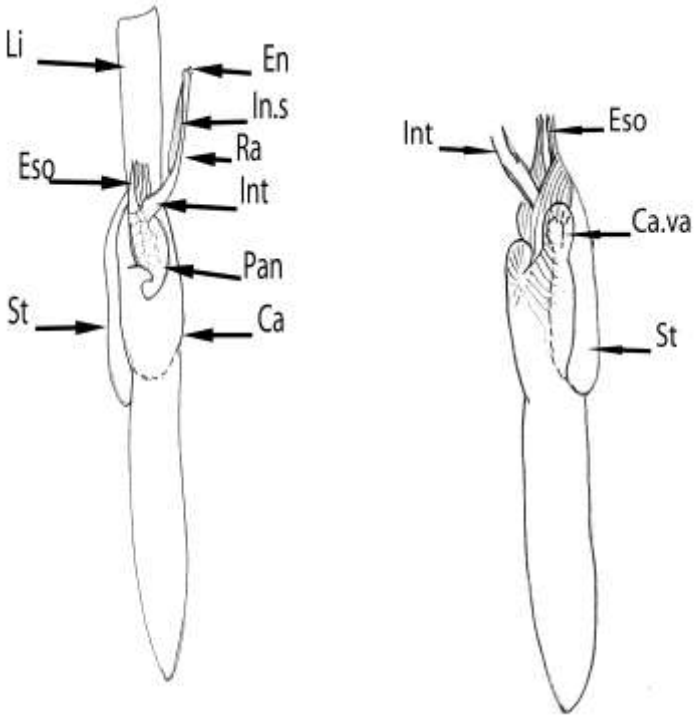


Fig.1,d. ventrl view **Fig.1,e.lateral view**

Fig.1: Diagram showing of the digestive system of *L.forbesi*

Li: liver, Eso: esophagus, St: stomach, En: enus, In.s: ink sac, Ra: rectum, Int: intestin, Ca: caecum, Ca.va: caecal valve

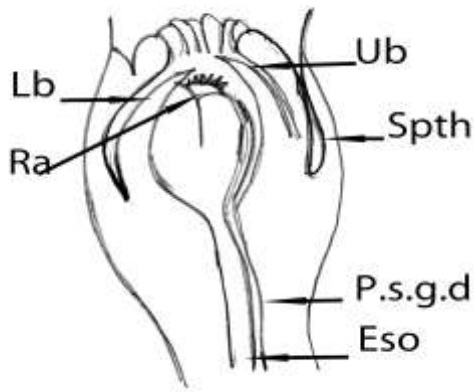


Fig.2a: Diagram showing of L.S through buccal mass of *L.forbesi*

Lb: lower beak, Ub: upper beak, Ra: radula, Spth: spermatotheca, P.s.g.d: posterior salivary gland, Eso: esophagus

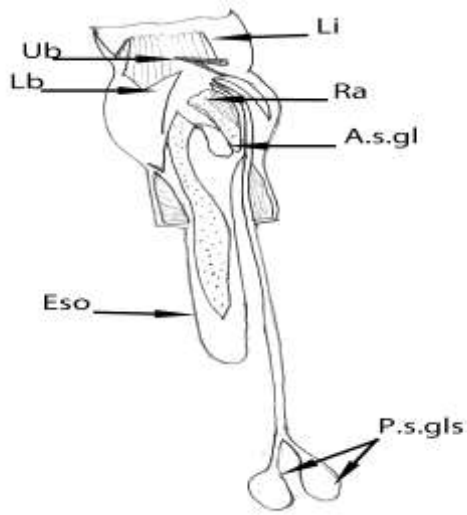


Fig.2b: Diagram showing anterior and posterior salivary gland of *L.forbesi*.

Ub: upper beak, Lb: lower beak, Li: liver, Ra: radula, A.s.gl: anterior salivary gland ,P.sgls: posterior salivary glands

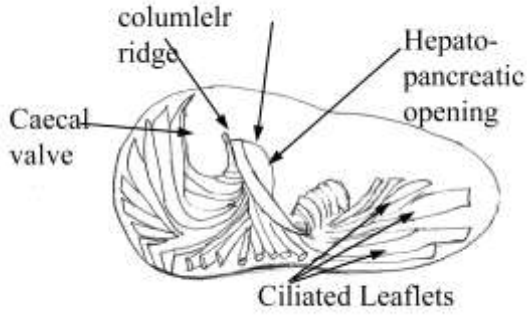


Fig.3: Diagram showing longitudinal section (T.S) in the anterior end of caecum of *L. forbesi.*

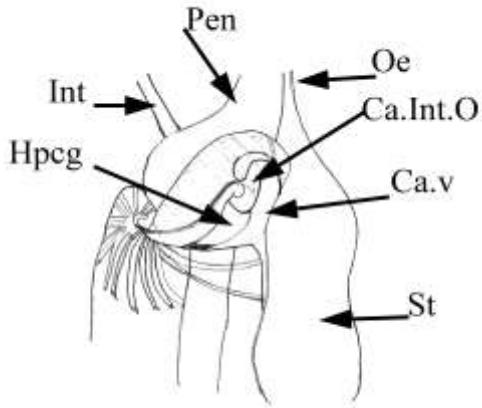


Fig.4 ,a : Diagram showing hepato-pancreatic opening of *L. forbesi*.

Int: intestine, Pen: pancreas, Oe: oesophagus,, Ca.v: caecal valve, St:stomach

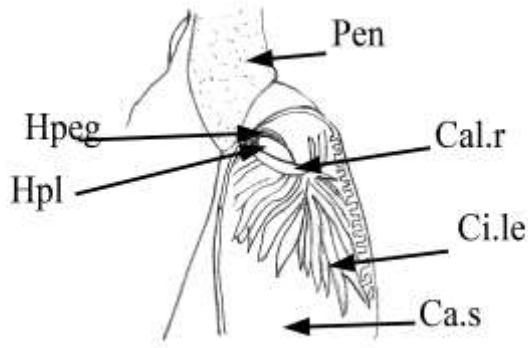


Fig.4,b: Diagram showing the caecal valve, the ciliated leaflets of *L.forbesi*.

Pen: pancreas, Calr: columellar ridge, Ci.le: ciliated leaflets , Ca.s: caecal sac**.**

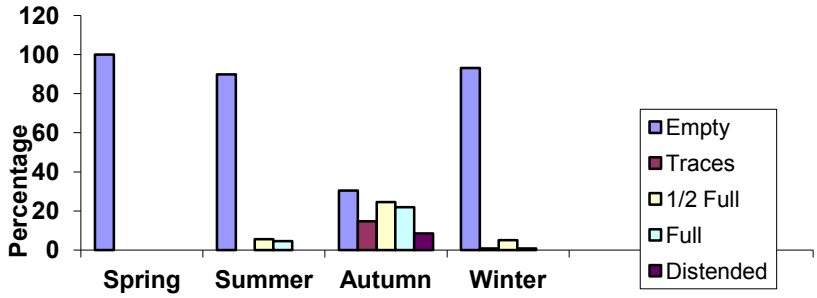


Fig. 5 Sesonal distribution of the stomachs fullness degree for *L. forbesi*

DISCUSSION

The digestive system in *L. forbesi* is well developed and resembles that of vertebrate animals [8, 9, 10]. In general, the basic plan of organization of the digestive system of *L. forbesi* has been to conform to the picture of pstructure described in other members of the loliginidae, with the exception of certain features as alength and dimension of certain parts [11]. Generlly the morphology of the

digestive system of *L.forbesi* is greatly similar to that of other lologinids as described by [9,12,13,14].

[15] showed that the presence of radula and powerful beaks are an important adaptive character for the predatory life of loliginidae squids. [16] showed that the separation of the mid-gut into stomach and caecum in *Sepia savignyi* makes it possible to differentiate the digestive mechanism into two independent and simultaneous phases, a preliminary phase in the stomach, and a final are in the caecum under the action of their appropriate enzymes. The duration of digestion in squids is very variable. He also stated that the digestion process in *Sepia savignyi* takes about 12 hours and represents 2-3 times as that of the loliginidae.

The feeding pattern of cephalopods has been studied by several authors. [17] observed that *Sepietta oweniana* feed mainly at night. [18] on *Sepia officinalis* found that feeding pattern increases with dusk and the first hours of darkness.[19] observed the feeding spectrum of squid is rather wide and includes various fish species: cephalopoda, crustaceans (copepoda, euphausiids, mysids, decapoda), chaetognaths and young squid, and found that in *L.peali* the fish occupy the first plas by occurrence and volume, the squids are on the second place, and the significance in mixed feeding is half as much that of fishes. Euphausiids occupy the third plas and shrimps the fourth place by significance. [20] showed that *L.gahi* has atype and food intake similar to that of other Lologinids from Falkland Islands waters. [3] has reviewed certain aspects of food and feeding behavior in several cephalopods, and stated that most species change their diet as seems to happen with *S.officinalis* and *S.elegans* in Riade Viigo. [21] found that crustaceans were more frequent than either fish or squid, but fish was eaten by a wide size range of squids and more frequently, and suggest that *L. pealei* is highly opportunistic predator, whose diet promanly reflects the

local abundance of potemand the prey species.The present investigation clarified that a large number of *L. forbesi* stomachs analyzed were empty. This can probably be attributed to the habit of squid to neglect feeding or eat little during the final weeks or days before spawning season which coincides with the findings of [13,22] for *L. opalescens.*

According to [23]on the gaint squid *Dosidic gigas* in the Gulf Califorinia and Mexico, the largest percentage of empty stomachs observed could possibly indicate very high digestion rate. It is apparent from this study that fish were the most important prey for *L. forbesi* in Alexandria waters followed by crustaceans which is similar to the finding of [6,24,25,26,27] in Scottish waters, [28] in Irish waters and [29] in Alexandria waters for *Loligo vulgaris*. The comparatively high percentage of stomachs with fish content for *L. forbesi* also confirm previous studies by [30,31] who stated that ordinarily young or adult small ocean squids eat fish and crustaceans.[27] stated that, in *L. forbesi*, it is apparent that most juveniles fed on small crustaceans or smaller fish, and switched to eat mainly fish and cephalopods as they grew. [32] found that the large squid *Illex illecebrosus* feeds mostly on fish. [33] pointed out to the preference of the squid *Loligo opalescens* for crustacean diet besides scarce representation of fish eye lenses, mandibles and otoliths within the stomach. [34] mentioned that crustaceans were the most frequent food item in *Loligo pealie* followed by squid and fish (only bones and scales). [35] Stated that Loliginidae can catch fast swimming mackerel fish, and the giant squid *Ommastrophes gigas* attack tunny fish and eat everything except the head. [36] showed that *Loligo vulgaris* fed mainly on fishes, crustaceans and its own species. In general small squids tend to feed on crustaceans, while the large squids on fish and cephalopods, therefore, selection of prey seems to be a function of size and not adulthood or

maturity. This could be attributed to the probable faster swimming ability, aggressiveness, and strength of the larger squids.

[26, 28] noted that cannibalism in *L. forbesi* occurs more frequently in larger squids rather than in smaller ones. In the present study cannibalism was not observed. This can be emphasized on the basis of [37, 38] who found that, cannibalism in squid may occur because of food shortage. The higher incidence of cannibalism in squids may possibly be attributed to feeding on dying squid as well as to the shortage of other food during the post- spawning period where a high mortality percentage occurs in many cephalopod species [39]. According to [27], seasonal variation is one of the important sources of variation in diet composition and size selectivity of the *L. forbesi* in the Scottish waters, while seasonal changes in prey availability may be important in determining squid diet. Moreover, in the present study fishes and crustaceans occurred more often in autumn.

According to [40], the development of the prey capture, ingestion and digestion systems (tentacles, beaks, digestive tract) during cephalopod lifespan seems likely to be a crucial process influencing the prey selection, defining the morphological constraints on foraging, feeding and digestion.

Predators such as *L. forbesi* may represent a useful biological indicator of changes in the size- and species- composition of fish communities [27].

CONCLUION

The results revealed better understanding for biology of this species which could serve as a guide in future studies.

Carrying more studies on mathentical modls to study the impact of multivariables (ecological and biological) on *L. forbesi.*

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