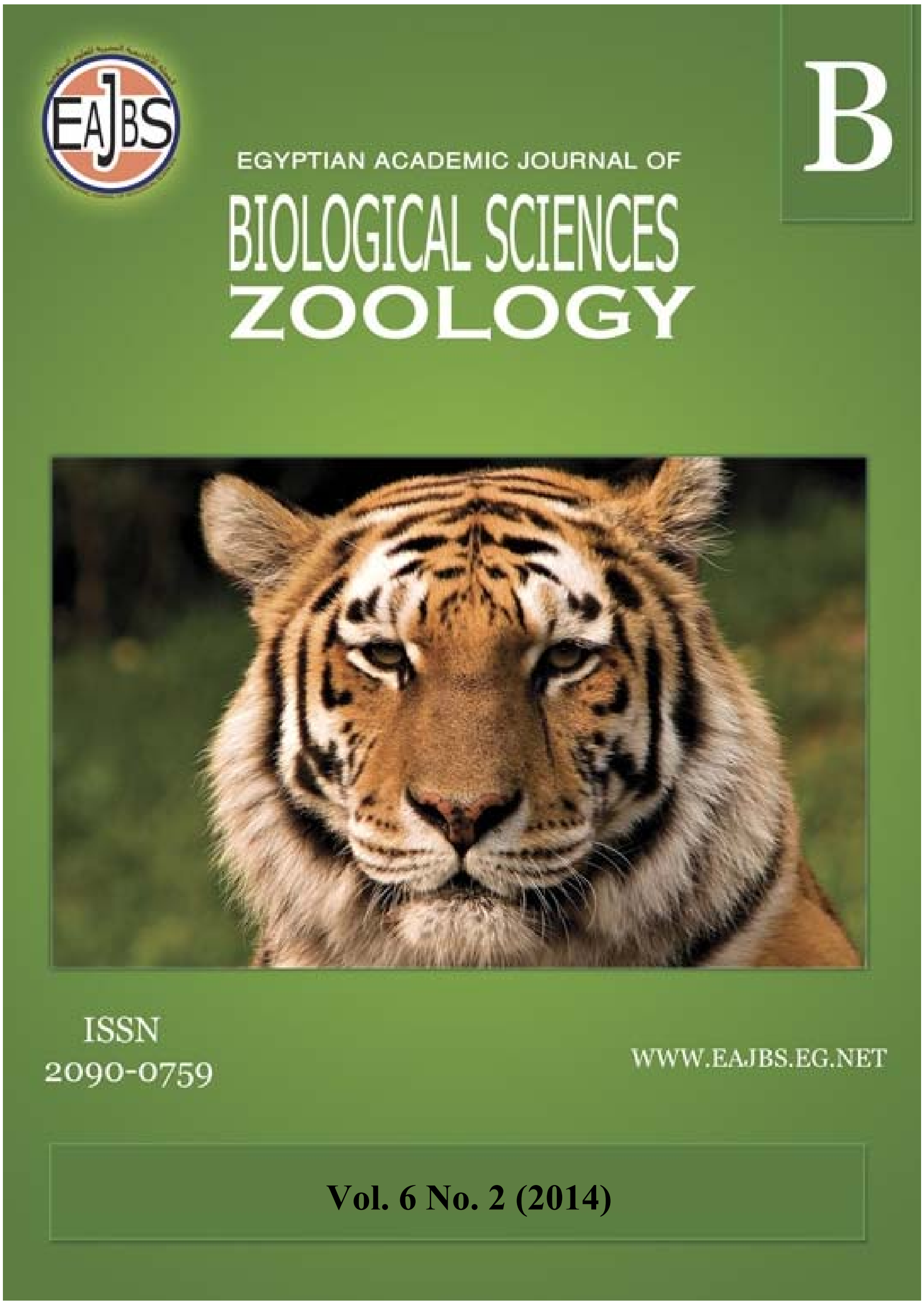


Egyptian Academic Journal of Biological Sciences is the official English language journal of the Egyptian Society of Biological Sciences ,Department of Entomology ,Faculty of Sciences Ain Shams University .

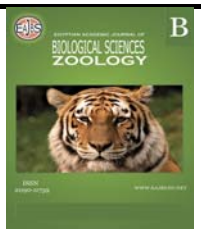
The Journal publishes original research papers and reviews from any zoological discipline or from directly allied fields in ecology, behavioral biology, physiology, biochemistry, development, genetics, systematics, morphology, evolution , and general zoolology

www.eajbs.eg.net

Received : 15/11/2014 Accepted :25/12/2014

Egypt. Acad. J. Biolog. Sci., 6(1): 29- 46 (2014)

Egyptian Academic Journal of Biological Sciences
B. Zoology
ISSN: 2090 – 0759
www.eajbs.eg.net



Ultrastructure of the mouthparts and food habits of the Grapsid crab, *Metopograpsus messor* (Forskal, 1775) from different habitats of the Egyptian Red Sea Coasts.

Maged M.A. Fouda[1], Moustafa M. H. Sarhan[1], Ahmad Hamed Obuid-Allah[2], Abd Allah Tharwat Abd Allah[1] and Mohsen A.Hafez Moustafa[1]

1- Department of Zoology, Faculty of Science, Al-Azhar University, Assiut Branch, Egypt.

2- Department of Zoology, Faculty of Science, Assiut University, Assiut, Egypt.

E.mail: aaaamaged2000@yahoo.com.sg

ABSTRACT

Like all other decapods, the grapsid crab, *Metopograpsus messor* has mouth parts composed of six pairs of modified appendages. The present study revealed the structural significance of this complexity and the feeding habits of this species. Scanning electron microscope was used for examination of the mouth parts of the specimens collected from two different habitats. No differences were found neither in the structure of mouth parts nor in food analyses. The feeding habits showed that *M. messor* is opportunistic omnivore feeding on a wide variety of benthic organisms including algae, epifaunal animals as well as dead fish and other decayed animals in addition to higher plants particularly decomposed sea grass leaves and mangrove.

Keywords: Ultrastructure, Mouthparts, Crustacea, *Metopograpsus messor*.

INTRODUCTION

One of the most interesting features among crustaceans is their very complex mouth apparatus. Little information is available to understand the functional significance of decapods feeding apparatus which consists of at least 20 parts, each with their separate functions. Several mechanisms for gathering and processing certain sorts of foods have produced with producing behavioral responses governing their use, animals select feeding times and sites, choose food items, and may under some circumstances not feed at all even if suitable items are available (Grahame, 1983).

There is much information on the type of food eaten by crabs and the ways in which it captured and brought to mouth (Warner, 1977; Grahame, 1983). Few workers have been concerned with the more subtle aspects of feeding strategies and functional responses (Grahame, 1983). Most crabs are foraging omnivorous, although certain families show tendencies towards a more specialized diet (Warner, 1977). Generally, feeding in brachyuran decapods has been the subject of numerous studies, the majority of which dealt with commercially important or common species or species

Received : 15/11/2014 Accepted :25/12/2014

with specialized feeding habits (Schembri, 1981; El-Sayed; 1992; Fouda, 2000). Early functional studies of the decapod mouth apparatus have resulted in a division into inner mouthparts (mandibles, Md; maxillae 1, Mx1; maxillae 2, Mx2 and maxilliped 1, Mxp1) and outer mouthparts (maxillipeds, Mxp2 and Mxp3) (Nicol, 1932; Kunze and Anderson, 1979; Schembri, 1982a). This division is based on morphology, but is often used in ways that indicate similar functions within the groupings. Many of the studies have concentrated mostly on Mxp3, the largest of the mouthparts, but again many of the functional interpretations are based on morphology alone (Greenwood, 1972; Farmer, 1974; Suthers and Anderson, 1981; Suthers, 1984; Lavalli and Factor, 1992). Grooming of the anterior part of the body using MXP3 is well documented.

Schembri (1982a) emphasized the need for further studies of the functional morphology of the chelipeds and mouthparts of brachyurans. Intertidal brachyuran species of rocky shores have been especially neglected in this respect, inspite of the fact that feeding in other reptant decapods has been well studied in recent years (eg. Hermit crabs, Greenwood, 1972; Caine, 1975a; Kunze and Anderson, 1979; Schembri, 1982b). The only significant studies of the functional morphology of the feeding appendages of macrophagous brachyuran are these of Caine (1974) for *Ovalipes guadulpensis* and Schembri (1982a) for *Ebalia tuberosa*. Barker and Gibson (1978) described the mouthparts of the large portunid *Scylla serrata*, but offered no functional information. Other functional studies on brachyuran feeding have focused on particulate feeders such as the pinnotherids (Caine, 1975b) and deposit feeding ocypodids (Robertson and Newell, 1982a, b; Robertson and Pfeiffer, 1982). Obuid Allah and Mohammed (2000) focused on the armature of the second maxilliped and their role in feeding in 4 species of crabs, *Grapsus albolineatus*, *Ocypode aegyptica*, *Calappa hepatica* and *Potamonautes niloticus*.

This study aims to investigate the structure and functional significance of mouthparts complexity of the grapsid crab *Metopograpsus messor* and its relation to different food habits from different habitats of some Egyptian coasts of the Red Sea.

MATERIAL AND METHODS

Specimens of the present work were collected seasonally from three sites during 2005 from (Suez Gulf) Ain Sukhna, 62Km south Suez City and Mangrove swamps at 17 km south Safaga and 36 km North El-Quiser Red Sea (Table 1).

Table 1: Shows the positions and general characters of the sites of collection.

No	Sites	Longitudes (E)	Latitudes (N)	General remarks
1	Ain Sukhna, Suez Gulf	32º 21ˋ 42.0ˋˋ	29º 33ˋ 20.6ˋˋ	Sandy, rocky, muddy and coral reefs habitats.
2	17Km south Safaga, Red Sea	34º 00ˋ 55.1ˋˋ	26º 36ˋ 89.9ˋˋ	Fringing mangrove with healthy trees extends about 650 m. with sandy, rocky, muddy and coral reefs habitats.
3	36 Km north El-Qusier, Red Sea	34º 07ˋ 4.6ˋˋ	26º 23ˋ 49.7ˋˋ	Sheltered mangroves with sand bar and healthy trees, extends about 450m length.

Crabs were collected by hand from the intertidal rocky and sandy-rock habitats. A hand net was also used to collect rapidly running large individuals. Burrowing individuals in mangrove swamps were dug out. Collected crabs were preserved in 10% formalin solution and kept in labeled plastic containers.

At laboratory, crabs were sorted, sexed, weighted and dissected. Electronic balance was used to weigh the crab to the nearest 0.1gm (Denver Instrument Company AA-160USA). A binocular microscope (Leica zoom 2000 model 230E USA) was used in dissection. Stomachs were removed, cut longitudinally and all contents of cardiac portions were removed. The stomach contents were placed in divided Petri-dishes, sorted and identified to specific level as possible and examined using Frequency of occurrence according to Williams (1981).

For scanning electron microscope preparations, specimens were washed; mouthparts were separated (from right and left sides) then cleaned manually with a beaver hair brush. Each part was preserved in 70% ethanol then transferred into separate labeled vials. They were dehydrated in a series of ethanol and finally mounted on metal stubs, coated with gold in vacuum evaporator, examined, and photographed by (AMRAY1200, JSM-5400 SEM) at Assiut Electron Microscope Unit, Assiut University.

RESULTS

The grapsid crab *M. messor* has a mouth apparatus composed of six pairs of mouth parts arranged from posterior to anterior as: 3rd maxillipeds, 2nd maxillipeds, 1st maxillipeds, maxillae, maxillule and mandibles. They vary in morphology and structure according to function they perform.

The 3rd maxilliped (Mxp3):

The posterior pair of mouth parts is represented by the 3rd maxillipeds. They form an incomplete cover to the more internal mouth parts. Each maxilliped has 2 parts, exopodite and endopodite (Plate 1-A), each composed of many segments bearing different kinds of hairs in addition to the gill cleaner.

The inner part (endopodite) lies toward the mouth opening, and composed of 5 segments (Plate 1-A), 4 pieces bearing biserrated setae as shown in the terminal piece. The dorsal side of setae is smooth, having a groove on the ventral side (Plate 1-B,C).

The outer part (exopodite) is composed of 2 pieces (Plate 1-D). The proximal piece (Plate 1-D) carries dense plumose setae direct towards the base (Plate 1-E), while its body has 2 kinds of processes (short & long), the short is a teeth like (Plate 1-F), while the long is terminally serrated, its origin shows the ability of moving in all directions (Plate 1-G). It has shaft shows some processes (Plate 1-H).The body of the piece shows some teeth like processes in regular batches (Plate 1-I, arrow). The second piece (the distal) (Plate 1-D) shows some degree of segmentation from one side in the terminal part bearing on each segment a hair like process (Plate 1-J, arrow).The gill cleaner is a flattened portion, with long processes (Plate 1-K). These processes show serration and dense rows of hairs around the shaft (Plate 1-L, arrow, arrowhead).

The 2nd maxilliped (Mxp2):

The second maxilliped is formed of 2 parts in addition to the gill cleaner (Plate 2-A). The inner part or endopodite (the lower part in plate 2A) is composed of 4 pieces with 3 types of hairs concentrated on the terminal piece (Plate 2-B). The first type is plumose setae distributed all over the piece. The other two types concentrated on the terminal end (Plate 2-C), one of them is bristles, tubular in shape (Plate 2-D, arrowhead) and serrated at one side (Plate 2-E, arrows). These bristles move in all directions as seen from their insertion. The second type is long and cylindrical with serration on one side (Plate 2-D, arrows).

The outer part (exopodite) is similar to that found in the 3rd maxilliped with terminal end showing segmentation from the inner side with a hair like structure originating from the site of segmentation (Plate 2-F) with different types of hairs (plumose, serrated and small hairs). The gill cleaner is a long piece like that in 3rd maxilliped (Plate 1-K) with hairs, characterized by biserrated end in the ventral side (Plate 1-L, 2-G, arrow). The shaft of the setae (hairs) bears dense rows of spine like processes near the base (Plate 2-H,I). In the second third of setae (below the terminal serration) there are dense pores that seem to be the site of the dense spine-like processes shown below. In addition there is a row of sharp teeth in the middle of setae (Plate 2-J, arrow).

The 1st maxilliped (Mxp1):

The first maxilliped has 3 pieces (Plate 3-A). The terminal piece is similar to that found in 2nd and 3rd maxillipeds, and characterized by segmentation from one side in addition to originate serrated hairs from the site of segmentation (Plate 3-B). The middle piece consists of two parts, the terminal part shows type of biserrated setae from one side, and seems to be curved from the other surface (Plate 3-C). Another type of setae occurs at the terminal end being as short and long processes like spines seems to be of the same type with difference in structure, but characterized by cylindrical base and pointed end (Plate 3-D). It seems to move in all directions (Plate 3-E, arrow). The examination of the middle piece showed the presence of plumose setae and serrated hairs similar to that found on the gill cleaner.

The 3rd piece or the inner piece is composed of two parts: the terminal part bears different types of hairs (Plate 3-F). The first type is dense plumose setae direct towards the upper side (Plate 3-F,G). The second type seems cylindrical with biserrated terminal end (Plate 3-H). The 3rd type is bristles, tubular in shape showing serration on its surface in the middle (Plate 3-I, J). This type seems having pores in the terminal end. So, it may have secretary function. The body of this piece shows many pores represent sites of processes emersion (Plate 3-K, arrows).

The Maxilla (Mx2):

The maxilla is the fourth pair of mouth parts, consists of 3 pieces arranged as outer, middle and inner ones (Plate 4-A).

The outer piece is flat; with fringed edge has dense hairs of plumose and serrated types. The other type of hairs has cylindrical base, with serrated ends, arranged in a regular row in the middle of the flat area (Plate 4-B,C). The middle piece is comparatively longer, with 3 different types of dense setae (Plate 4-D). On the sides of the segment, it has plumose setae (Plate 4-E). The second type is bristle seems tubular in shape (Plate 4-F) with hair-like processes originating near the terminal end at both sides (Plate 4-G, arrows). The third type is serrated at the ventral terminal third, tubular at its origin (Plate 4-H, arrow).

The inner piece of maxilla is flat, narrow at its base, wide at its end, with different types of hairs (Plate 4-D). It is fringed with serrated and plumose hairs as shown in (Plate 4-H, arrow, arrowhead) like that of the middle piece. On the terminal end, two types of hairs are found, one has serrated terminal end and the other is tubular like (bristles) (Plate 4-I,J, arrow, arrowhead). The body of the piece has small pointed hair-like cylindrical spines (Plate 4-K). The insertions of these types enable them to move in all directions (Plate 4-I, J,K, curved arrow).

The maxillule (Mx1):

The maxillule is composed of 2 pieces. The proximal part (upper part) is flat and the distal part (lower part) is narrower (Plate 5-A). The terminal portion of the upper part bears serrated type of hairs (Plate 5-B,D,arrows), and short cylindrical setae (Plate 5-C,D,arrowheads). The lower part has three types of setae, serrated, plumose (Plate 5-E, arrow, arrowhead) and biserrated leaf-like type (Plate 5-F,arrow).

Mandible (Md):

The mandible is the 6th pair (it is the 1st pair of mouth parts from anterior). It has 2 parts (Plate 6-A) the inner part is nacked without hairs, seems to be fixed; while the outer part is movable has dense hairs (Plate 6-B, arrows). This piece has dense type of plumose hairs towards the base (Plate 6-C), decreases remarkably in density toward the terminal part. It is biserrated at its terminal half can move freely in all directions (Plate 6-D, arrow). At the external surface of the mandibular protopodite, regular patches of fine processes are occurred and arranged in regular form (Plate 6-E, arrows).

The present study showed that there is no difference in morphology of mouth parts between the specimens collected from the two different habitats or between males and females.

Food analysis:

The analysis of stomach contents of *M. messor* collected from the two study sites (Ain Sukhna and Mangrove south Safaga) indicated that this grapsid crab is opportunistic omnivore. It feeds on a wide variety of benthic organisms including algae, epifaunal animals, dead fishes and other decayed animals in addition to higher plants particularly decomposed and fresh seagrass leaves and roots of mangroves. A considerable amount of sediments including sand grains and rock fragments were ingested with associated microbenthos. *M. messor* can exploit the available natural resources in the two different habitats. At Ain Sukhna the specimens found in rocky areas feed on animals like gastropods and amphipods as well as algae, plant cells, while in mangrove areas the food items included more plant tissue like mangrove leaves. The sediment was represented with considerable value in the two habitats. It may be taken accidentally with food items.

DISCUSSION

The present study revealed that the six pairs of mouth parts of the crab *Metopograpsus messor* (Md, Mx 1-2, Mxp 1-3) differ in their morphology. The pronounced differences in size and shape can be correlated with specific function for each part. The large and piriform shape of Mxp2 and Mxp3 can be considered as adaptations for handling large prey items, whereas the smaller and flattened maxillule Mx1, Mx2 and Mxp1 can enable the animal to accurately manipulate even very small food objects. The dorsoventrally flattened form of these small mouth parts enable several independently moving structures to operate close together, a prerequisite to accurate manipulation of small food. The freedom of movement decreases in the mouth parts that are nearer to the mouth and arranged very close together. This explains why maxillule, maxilla and mandible perform rather stereotypical movements in a two dimensional plane. The maxilliped has much more space in which to operate. The Mxp2 and Maxp3 can move in all direction according to their flexible joints, they can manipulate a great variety of food items (Garm and Hoeg, 2001). For most decapod taxa there is a lack of behavioral data, but a few earlier studies described some functional morphology accompanied by movement patterns as in Anomura (Nicol, 1932; Roberts, 1968; Kunze and Anderson, 1979; Schembri, 1982a; Zainal, 1990), Thalassinidea (Stamhuis *et al*., 1998), Palinura (Suthers and Anderson, 1981), Brachyura (Barker and Gibson, 1978; Schembri, 1982b), Astacidea (Barker and Gibson, 1977; Lavalli and Factor, 1995), Caridea (Moore *et al*., 1993) and Penaeidea (Hunt *et al*., 1992).

The 3rd maxilliped (Mxp3):

The 3rd maxilliped composed of 2 parts, each with many segments bearing different kinds of hairs and the gill cleaner. The inner part bears biserrated setae while the outer part has plumose setae, which may have role in filtering food, rejecting large particles and current generation. While its body shows short processes (teeth like) and long processes terminally serrated originating from body of the segment having ability to move in all directions, which enable in crushing food. Its shaft show some processes. The body of the piece shows some teeth like processes in regular patches which may have role in crushing food items. The second piece shows some degree of segmentation from one side (like crista dentata), which gives the piece more ability in moving and help in gathering food items, It also may has role in current generation. Garm and Hoeg (2001) showed in their study on *Munida sarsi* and *M. tenuimana* that the 3rd maxillipeds have role in current generation, prey gathering, sediment gathering, transfer sediment into mouth parts, rejection of large prey and grooming antennae. On the other hand, Skilleter and Anderson (1986) indicated that in *Ozius truncates* the 3rd maxillipeds tear the food and have active role in maceration of food before it reaches the oesophagus. Well-developed crista dentata was reported in the portunids *Carcinus meanas* (Borradaile, 1922), *Ovalipes guadulpenis* (Caine, 1974) and *Sylla serrata* (Williams, 1978). The crista dentata in all of these species are used to grip and tear food as described for *O. truncatus* (Williams, 1978; Borradaile, 1922) and also noted in *Scylla* and *Carcinus;* respectively.

The 2nd maxilliped (Mxp2):

The present study cleared that the 2nd maxilliped is composed of two parts and gill cleaner, inner part has 4 pieces with 3 types of hairs plumose bristles, tubular with serration in one side move in all directions and the last is long cylindrical with serration in one side. The outer part with terminal end has hair-like structures with different types of, plumose, serrated and small hairs. The gill cleaner has hairs with biserrated end, but shaft bears dense rows of spines-like processes and row of sharp teeth in the middle of setae.

Obuid Allah and Mohammad (2000) studied the structure of 2nd maxilliped of 4 species of crabs and noticed that the *Ocypode aegyptica* is provided with 3 types of plumose setae, stout bristles and the 3rd have terminal opening leads to internal canal. *Grapsus albolineatus* provided with plumose setae and spines and stout bristles in addition to acute spines. While in *Calappa hepatica* and *Potamonautes niloticus* the armature on the 2nd maxilliped is well adapted for predatory feeding habits since setae are scarce in number and the majority of them are spines sharing in tearing flesh of the prey. The plumose setae represent good adaptation for capturing vegetation including algae and detritus from water since they make a filter during passage of water between the maxillipeds.

Warner (1977) indicated that grapsid crabs are herbivorous including algivorous crabs and those which eat vascular plants, so the mouthparts are provided with hairs which receive the finely divided food and press it into mouth. Bigalke (1921-22) studied the mode of feeding in *Dotilla fenestrate* and found that the inner surface of the second maxillipeds is bearing different types of hairs, one of them has the free extremity shaped-like the bowl of a spoon with notched border. These spoon tipped setae are also observed in *Uca* (Crane, 1941, 1975; Altevogt, 1955 a,b, 1957, 1976; Miller, 1961and Feest, 1969), in Scopimera (Ono, 1965) and in other filter feeders.

Weissburg (1991) indicated that the ghost Crab *Ocypode* does not seen well adapted to deposit feeding while they do so occasionally. Deposit feeding appears to be facultative response to patches extremely high diatom abundance (Robertson and Pfeifer, 1982). The stout bristles are well suited for holding and tearing food. The stout bristles with terminal opening may act as chemoreceptors. Obuid Allah and Mohammad (2000) showed that the stout bristles on the terminal segment and the spines on merus help the crabs to tear food into pieces and give them the advantage of feeding on flesh. Borradaile (1922) and Williams (1978) noted that in Brachyurans *Carcinus* and *Scylla* respectively, the 2nd maxilliped has a role in tearing food. Skilleter and Anderson (1986) noted that in the grapsid species (*Leptograpsus variegates*), the food reaching the mouthparts is already finely shredded and can be ingested with little further trituration. They also noted that the 2nd maxilliped of the xanthid species. *O. truncatus* has no role in holding or tearing the flesh.

So, one can say that crabs are opportunistic omnivores eating a wide range of live algal and animal tissue, and carrion when available. Hazlett (1968) showed that crabs are able to locate food by chemical means alone indicating the importance of aesthetascs of 1st antennae as the smell detectors involved. The grasping phase of food searching behavior brings into play the chemoreceptors on the ends of the walking legs, when these receptors come into contact with a piece of food, this food is rapidly grasped and passed to the mouth parts (Hazlett, 1971). Garm and Hoeg (2001) mentioned that in *Munida sarsi* and *M. tenuimana* 2nd maxilliped have role in current generation by flagella, transfer sediment to inner mouthparts, rejection of large prey and putting prey between mandibles by the Mxp2 endopodite.

The 1st maxilliped (Mxp1):

The present study indicated that the 1st maxilliped is composed of 3 pieces; it is smaller in size than 3rd and 2nd maxillipeds. Only one piece was similar to that found in 2nd and 3rd maxillipeds which may has similar function as in these parts. The middle piece is composed of 2 parts, the terminal one has biserrated setae, while the other type is spine-like, its base shows the ability to move in all directions which increases the importance of its role. The gill cleaner is provided with plumose setae and serrated hairs which serve as filter for coming water and help in cleaning the gills, also it increases the surface area of hairs that help to perform their role. The 3rd piece is composed of two parts; the terminal one bears different types of hairs; the plumose one may have a role in filtration, the cylindrical type with biserrated terminal end may have a role in tearing the food. They also have bristles that are tubular in shape with serration on its surface. These types have pores that may perform secretary function helping in ingestion of food. Garm and Hoeg (2001) showed on study of *Munida sarsi* and *M. tenuimana* that the 1st maxilliped has a role in sediment sorting, particle rejection, putting prey between mandibles, rotating particle by Mxp1 and ingestion by Maxilliped 1 coxa.

Skilleter and Anderson (1986) showed that the coxa and basis of 1st maxillipeds in *O. truncatus* and *L. variegatus* bear well developed endites but the relative sizes of endites differ between species. In *O. truncatus* 2 endites are relatively large and broad. The proximal endite is approximately half the size of the distal endite; both bear long, densely packed simple setae. The proximal and distal endites in *L. variegatus* are equal in size but both are quite small (in relation to rest of the mouth parts) and bears simple setae. The endopod of the 1st maxilliped of *L. variegatus* has a densely setose transverse ridge on the aboral surface, which is not present in *O. truncatus*.

The Maxilla (Mx2) and maxillule (Mx1):

The Maxilla composes of 3 pieces; the first one has dense plumose and serrated hairs that have role in sediment sorting and rotating particles. The second one has 3 types of setae have plumose, bristles and tubular in shapes. The third piece is equipped with serrated and plumose setae only.

The maxillule of the present investigated species consists of 2 small pieces; the terminal portion has serrated type of hairs and cylindrical setae, while the lower portion has 3 types: serrated, plumose and biserrated one that may have respiratory function. Skilleter and Anderson (1986) showed that the difference between *L. variegatus* and *O. truncatus* was only in morphology of the maxilla and maxillule where the two species differ in the relative size of the endites. Both the proximal and the distal endites of these mouthparts in *L. variegatus* are relatively larger and more prominent than on *O. truncatus*.

Garm and Hoeg (2001) summarized the role of maxilla and maxillule in sediment sorting; particle rejection by Maxilla 2 endopod, Maxilla1 endopod, rotating particle by Maxilla 1 basis (Mx1 bas), Maxilla 2 basis (Mx2 bas), biting soft prey and calcified prey Mx1 bas, ingestion Maxilla 1 coxa, Maxilla 2 coxa, and respiration Maxilla 2 Scaphognathite. Almost all collected particles eventually reach the maxillae 2 (Mx2), maxillae 1 (Mx1) basis which are the mouthparts responsible for rejection or retaining food items, Mx1 and Mx2 basis move in circles parallel to the mandibular incisor when sorting sediment. The Mx1 basis are responsible for most of the particle movement and rotation. The animal has serrate and cuspidate setae in contact with the particle at all times. Maxilliped 1 (Mxp1) basis tend to make circular movement that pushes the particle toward the Mx2 basis both during sediment sorting and when sorting rotating a small particle, Mx1, Mx2 and Mxp1 basis normally circular with the same frequency. The Mx2 basis can also move independently of the Mx1 basis, as evidence by the respiratory movements when the animal is not handling any food. Moreover, there is a slight division of functions between Mx1 and Mx2 when handling food items. The robust spines and serrate setae arming the Mx1 basis indicate their main function to be mechanoeffectory, whereas the several types of more delicate setae on the Mx2 basis suggest a mechanosensory function, a chemosensory function or a combination of the two. If this is true, this gives Mx2 basis a key role in sensing the quality of the potential food particles. The palp and labium were also observed to push the food directly into the mouth but this was found unlikely, because their movement must be perpendicular to the mouth opening (Schembri, 1982a).

Schembri (1982a) made some very interesting observations on the function of the basis of Mx1 and Mx2. of *Pagurus rubricatus* and found that it sorts the sediment in a different way from what observed for *Munida*. The Mx2 basis seemed to be the most active, collecting the sediment from the Mxp2 endopods (Mxp1 basis are not involved) and pressing it through cuspidate setae on the medial edge of the Mx1 basis, which then serve as a passive filter.

Mandible (Md):

The mandibles have solid parts which may have a role in crushing prey. The second part is movable and provided with dense plumose hairs, serrated in their terminal end and move in all directions. This modification completes its role in transferring prey to the mouth. The hairs on mandible represent last process of filtration before the mouth opening. Garm and Hoeg (2001) mentioned that the mandibles have role in crushing food and transfer it to mouth. Skilleter and Anderson (1986) showed that the incisor process in *L. variegatus* is distinctly angular compared to a rounded process on *O. truncatus*. There is also a difference in the way the mandibles oppose each other. The two mandibles in *O. truncatus* overlap, where the right mandible lies aboral to the left. In *L. variegatus*, there is no overlapping between the mandibles.

Warner (1977) indicated that grapsid crabs are herbivorous including algivorous crabs and those which eat vascular plants. Obuid Allah and Mohammed (2000) mentioned that the mouth parts of *Grapsus albolineatus* are provided with hairs which receive the finely divided food and pass it into the mouth, where the second maxilliped is provided with long setae. This grapsid species is opportunistic omnivore with a preference for animal food and predatory tendencies Therefore the presence of stout bristles help crab to tear food. This feeding pattern still followed by the majority of species and extreme specialization is relatively rare (Warner, 1977). This opinion was supported by Skilleter and Anderson (1986) on the grapsid species, *L. variegates*, where they noticed that this crab is an opportunistic omnivore, eating a wide range of live algal and animal tissue. Fouda (2000) studied the biology of *M. messor* and *Leptodius exaratus* from Suez Gulf. He found that both species of crabs feed on same food resources. However, *L. exaratus* feeds mainly on polycheates and crustaceans, whereas *M. messor* tends to feed on gastropods and amphipods but algae are the main food items. The food items in the diet of each species of crab are greatly different in proportions with the crab size. The major food items in the diet of both species of crabs exhibit marked seasonal variation in abundance, which are correlated to their either availability in natural habits or breeding season. The activity of feeding stopped during moulting in both species then they continue to feed after moulting.

ACKNOWLEDGEMENT

I thank Prof. Dr. Awaad A. M. El-Sayed for his support and his valuable input on the manuscript.

REFERENCES

Altevogt, R. (1955a). Beobachtungen und Untersuchungen an indischen Winkerkrabben. Zeitschr. Morph.Okol. Tiere, 43:501-522.

Altevogt, R. (1955b). Some studies on two species of Indian fiddler crabs, *Uca marionis nitidus* (Dana) and *Uca annulipes* (Latr.). J. Bombay Nat. Hist. Soc., 52:702-716.

Altevogt, R. (1957). Untersuchungen zur Biologie, Okologie und physiologie indischer Winkerkrabben. Zeitschr. Morph. Okol. Tiere, 46: 1-110.

Altevogt, R. (1976). Feeding apparatus and feeding process in Indian fiddler crabs: A SEM-study. German Scholars in India, 2:1-13 (Nachiketa Publications, Bombay).

Barker, P. L., and R. Gibson. (1977). Observations on the feeding mechanism, structure of the gut, and digestive physiology of the European lobster *Homarus gammarus* (L.) (Decapoda: Nephropidae). J. Exp. Mar. Biol. Ecol., 26: 297–324.

Barker, P. L., and R. Gibson. (1978). Observations on the structure of the mouth parts, structure of the gut and digestive physiology of the mud crab, *Scylla serrata*. J. Exp. Mar. Biol. Ecol., 32: 177–196.

Bigalke, R. (1921-22). On the habits of the crab *Dotilla fenestrate* Hilgendorf with special reference to the mode of feeding. South African J.Nat.Hist., 3: 205-209.

Borradaile, L.A. (1922). On the mouthparts of the shore crab. J. Linn. Soc. Lond. Zool., 36:115-142.

Caine, E. A. (1974). Feeding of *Ovalipes guadulpensis* and morphological adaptations to a burrowing existence. Boil. Bull. Mar. boil. lab., Woods Hole, 147:550-559.

Caine, E. A. (1975a). Feeding and masticatory structure of selected Anomura (Crustacea) J. Exp. Mar. Biol. Ecol. 18: 277-301.

Caine, E. A. (1975b). Feeding of *Pinnotheres maculates* Say (Brachyura: Pinnotheridae). Forma Functio. 8: 395-404.

Crane, J. C. (1941). Crabs of the genus *Uca* from the west coast of Central America. Zoological, New York, 26: 145-208.

Crane, J. (1975). Fiddler Crabs of the World: Princeton University Press, Princeton, New Jersey.

El-Sayed, A. A. (1992). Biological studies on some brachyuran crabs (Crustacea) from Suez canal. Ph. D. Thesis Fac. Sci., Al-Azhar University.

Farmer, A. S. (1974). The functional morphology of the mouthparts and pereiopods of *Nephrops norvegicus* (L.) (Decapoda: Nephropidea). J. Nat. Hist. 8: 121–142.

Feest, J. (1969). Morphophysiologische Untersuchungen zur Ontogenese und Fortpflanzungsbiologie von *Uca annulipes* und *Uca triangularis* mit Vergleichsbefunden an *Ilyoplax gangetica*. Forma et functio, 1:159-225.

Fouda, M. M.A. (2000). Biological and ecological studies on some crustacean decapods from the suez Gulf. M.Sc. Thesis, Fac. Sci., Al-Azhar University.

Garm, A. and HØEG, J.T. (2001). Function and Functional Groupings of the Complex Mouth Apparatus of the Squat Lobsters *Munida sarsi* Huus and *M. tenuimana* G.O. Sars (Crustacea: Decapoda). Biol. Bull. 200: 281–297.

Grahame, J. (1983). Adaptive aspects of feeding mechanisms, In: The Biology of Crustacea. Vol. 8.pp.65-107. Academic Press., London, New York.

Greenwood, J. G. (1972). The mouthparts and feeding behaviour of two species of hermit crabs. J. Nat. Hist. 6: 325–337.

Hazlett, B. A. (1968). Size relationships and aggressive behaviour in the Hermit crab *Clibanarius vittatus*. Z. Tierpsychol, 25:608-614.

Hazlett, B. A. (1971). Chemical and chemotactic stimulation of feeding behaviour in the hermit crab *Petrochiru diogenes*. Comp. biochem. Physiol., 39A: 665-670.

Hunt, M. J., H. Winsor, and C. G. Alexander. (1992). Feeding in penaeid prawns: the role of the anterior mouthparts. J. Exp. Mar. Biol. Ecol. 160: 33–46.

Kunze, J., and D. T. Anderson. (1979). Functional morphology of the mouthparts and gastric mill in the hermit crabs *Clibanarius taeniatus*, *Clibanarius virescens*, *Paguristes squamosus* and *Dardanus setifer* (Anomura: Paguridae). Aust. J. Mar. Freshwater Res. 30: 683–721.

Lavalli, K. L., and J. R. Factor. (1992). Functional morphology of the mouthparts of juvenile lobsters, *Homarus americanus* (Decapoda: Nephropidae), and comparison with the larval stages. J. Crustac. Biol. 12: 467–510.

Lavalli, K. L., and J. R. Factor. (1995). The feeding appendages. Pp. 349–393 in Biology of the Lobster *Homarus americanus*, J. R. Factor, ed. Academic Press, San Diego, CA.

Miller, D. C. (1961). The feeding mechanism of fiddler crabs, with ecological considerations of feeding adaptations. Zoological, New York, 46: 89-100.

Moore, P. G., P. S. Rainbow, and R. J. Larson. (1993). The mesopelagic shrimp *Notostomus robustus* Smith (Decapoda: Oplophoridae) observed in situ feeding on the medusan *Atolla wyvillei* Haeckel in the Northwest Atlantic, with notes on gut contents and mouthpart morphology. J. Crustac. Biol. 13: 690–696.

Nicol, E. A. T. (1932). The feeding habits of the Galatheidea. J. Mar. Biol. Assoc. UK, 18: 87–105.

Obuid-Allah, A. H. and Mohammad, A. H. (2000). Scanning electron microscope study on the armature of the second maxillipeds in four species of crabs (Decapoda, Brachyura) and their role in feeding. Egypt. J. Zool. 35: 259-271.

Ono, Y. (1965). On the ecological distribution of ocypoid crabs in the estuary. Mem. Fac. Sci. Kyushu Univ., 4: 1- 60.

Roberts, M. H. (1968). Functional morphology of mouth parts of the hermit crabs, *Pagurus longicarpus* and *Pagurus pollicaris*. *Chesapeake Sci.* **9:** 9–20.

Robertson, J. R. and Newell, S. Y. (1982a). A study of particle ingestion by three fiddler crab species foraging on sandy sediments. J. Exp. Mar. Biol. Ecol., 65: 11-18.

Robertson, J. R. and Newell, S. Y. (1982b). Experimental studies of particle ingestion by the sand fiddler crab *Uca pugilator*. J. Exp. Mar. Biol. Ecol.,59: 1-21.

Robertson, J. R. and Pfeifer, W. J.(1982). Deposit feeding by the ghost crab *Ocypode quadrata* (Fabricius). J. Exp. Mar. Biol. Ecol.,56: 165-177.

Schembri, P. J.(1981): Feeding in *Ebalia tuberosa* (Pennant)(Crustacea: Decapoda: Leucosiidae) J. Expi. Mar. Biol. Ecol. 55:1-10.

Schembri, P. J. (1982a). Functional morphology of the mouth parts and associated structures of *Pagurus rubricatus* (Crustacea: Decapoda: Anomura) with special reference to feeding and grooming. Zoomorphology (Berlin) 101(1): 17–38.

Schembri, P. J. (1982b). The functional morphology of the feeding and grooming appendages of *Ebalia tuberosa* (Crustacea: Decapoda: Leucosiidae). J. Nat. Hist. 16: 467–480.

Skilleter, GA and Anderson, DT (1986) . Functional morphology of the Chelipeds, mouthparts and gastric mill of *Ozius truncatus* (Milne Edwards) (Xanthidae) and *Leptograpsus variegatus* (Fabricius) (Grapsidae: Brachyura). Aust. J. Mar. Freshwater Res. 37: 67–79.

Stamhuis, E. J., B. Dauwe, and J. J. Videler. (1998). How to bite the dust: morphology, motion pattern and function of the feeding appendages of the deposit-feeding thalassinid shrimp *Callianassa subterranea*. Mar. Biol. 132: 43–58.

Suthers, I. M. (1984). Functional morphology of the mouthparts and gastric mill in *Penaeus plebejus* (Decapoda: Penaeidea). Aust. J. Mar. Freshwater Res. 35: 785–792.

Suthers, I. M., and D. T. Anderson. (1981). Functional morphology of mouth parts and gastric mill of *Ibacus peronii* (Palinura: Scyllaridae). Aust. J. Mar. Freshwater Res. 32: 931–944.

Warner, G. F. (1977). The Biology of Crabs. Unwin Brothers limit., London.

Weissburg, M. (1991). Morphological correlates of male claw asymmetry in the fiddler crab *Uca pugnax* (smith) (Decapoda, Brachyura). Crustaceana, 61 (1): 11-20.

Williams, M. J. (1978). Opening of bivalve shells by the mud crab *Scylla serrata* Forskal. Aust. J. Mar. Freshwater.Res., 29: 699-702.

Williams, M. J.(1981). Methods for analysis of natural diet in portunid crabs (Crustacea: Decapoda: Brachyura). J. Exp. Mar. Biol. Ecol. 52: 103-113.

Zainal, K. A. Y. (1990). Aspects of the biology of the squat lobster, *Munida rugosa* (Fabricius, 1775). Ph.D. dissertation, University of Glasgow, 180 pp.

EXPLANATION OF PLATES

Plate (1): Scanning electron micrograph of the third maxilliped of *M. messor* showing :

a) External features of the 3rd maxilliped (Endopodite, Endo; Exopodite, Exo) (ventral view).
b) Enlarged setae shown on the endopodite of 3^{rd} maxilliped showing the dorsal side of the setae and the serration in lateral view 1000X.
c) Enlarged setae on the endopodite showing serration, and the groove in ventral side 1000X.
d) External features showing the exopodite of the 3^{rd} maxilliped (base, proximal piece, Px; terminal part, distal piece, Ds) 15X.
e) Enlarged setae on the base of exopodite of the 3^{rd} maxilliped 200X.
f) Enlarged teeth on the base of exopodite of the 3^{rd} maxilliped 350X.
g) Enlarged setae on the base of exopodite of the 3^{rd} maxilliped 200X.
h) Enlarged setae on the base of exopodite of the 3^{rd} maxilliped showing some processes on the shaft 350X.
i) Enlarged portion of the base of exopodite showing patches of small teeth like processes (arrows) 350X.
j) External features of the terminal part of the exopodite of 3^{rd} maxilliped showing segmentation from one side, segments with hair-like processes (arrow) 100X.
k) External features on the gill cleaner (Gc) 15X.
l) Enlarged portion of processes on the gill cleaner showing 2 types of setae one with serration (arrow), the other shows rows of dense hairs around the shaft (arrowhead) 1500X.

Plate (2): Scanning electron micrograph of the second maxilliped of *M. messor* showing :

a) External features of the 2^{nd} maxilliped (ventral view) 15X.
b) Enlarged part of the endopodite in A 150X.
c) Enlarged part of the terminal piece of endopodite of 2^{nd} maxilliped 75X.
d) Enlarged bristles from plate (2-c) and long processes with serration in ventral side (arrows), tubular shape (arrowhead) 500X.
e) Enlarged bristles ventral view showing two rows of serration (arrows) 500X.
f) Enlarged features of the terminal piece of exopodite of 2^{nd} maxilliped 50X.
g) Enlarged setae on gill cleaner showing biserration in ventral side (arrow) 1000X.
h) Enlarged part of spine like processes on gill cleaner 1500X.
i) Enlarged part of the processes in (h) 5000X.
j) Enlarged part of the processes on gill cleaner showing sharp teeth (arrow) 3500X.

Plate (3): Scanning electron micrograph of the first maxilliped of *M. messor* showing :

a) External features of the 1^{st} maxilliped (Outer, O; Middle, M; Inner, I; ventral view) 15X.
b) External features of the terminal part of the outer piece 50X.
c) Type of biserrated setae on the middle piece of 1^{st} maxilliped 750X.
d) Type of processes like spines on the middle piece of 1^{st} maxilliped 350X.
e) Enlarged spine like process showing its base (arrow) 3500X.

f) External features of the inner piece of the 1^{st} maxilliped (ventral view) 35X.
g) Enlarged plumose setae on the inner piece of 1^{st} maxilliped 500X.
h) Enlarged setae (cylindrical with biserrated terminal) on the inner piece of 1^{st} maxilliped 750X.
i) Enlarged bristles on the inner piece of 1^{st} maxilliped 350X.
j) Enlarged bristles on the inner piece of 1^{st} maxilliped 1000X.
k) External features on the surface (arrow) of the inner piece of 1st maxilliped 1000X.

Plate (4): Scanning electron micrograph of the maxilla of *M. messor* showing:

a) External features of the maxilla; the 3 pieces are outer, middle and inner (ventral view) 50X.
b) External features of the outer piece 100X.
c) Enlarged hairs in middle of the outer piece in photo (B) 750X.
d) External features of the middle and inner pieces 75X.
e) Enlarged plumose setae on the middle piece 350X.
f) Enlarged bristles setae on the middle piece 750X.
g) Enlarged bristles showing processes near terminal end (arrow) 1500X.
h) Enlarged setae on the middle piece, serrated (arrow) and plumose (arrowhead) 350X.
i) Enlarged hairs on the terminal end of the inner piece showing serrated (arrow), tubular (arrowhead) and site of insertion (curved arrow) 350X.
j) Enlarged hairs on the terminal end of the inner piece as in (i) 500X.
k) Enlarged hair like (spines) on the body of the inner piece showing site of insertion (curved arrow) 1500X.

Plate (5): Scanning electron micrograph of the maxillule of *M. messor* showing:

a) External features of the maxillule (ventral view) 50X.
b) Enlarged serrated hairs (arrow) on the proximal part of the maxillule 1000X.
c) Enlarged type on the terminal of proximal part (arrowhead) 200X.
d) External features of the 2 types of hairs on the proximal part, serrated (arrow) and cylindrical (arrowhead) 150X.
e) Enlarged hairs (serrated, arrow; plumose, arrowhead) on the distal part 350X.
f) Enlarged type of processes biserrated leaf-like on the distal part (arrow) 1500X.

Plate (6): Scanning electron micrograph of the mandible of *M. messor* showing:

a) External features of the mandible (Inner part,I; Outer part, O; ventral view) 35X.
b) External features of the movable part (outer) of the mandible with dense hairs (arrows, dorsal view) 35X.
c) Enlarged part of the movable part showing dense plumose hairs 200X.
d) Enlarged hairs on the movable part showing serrated terminal setae (arrow) 500X.
e) Enlarged surface of the fixed (inner) part showing regular processes (arrows) 2000X.

Plate 1

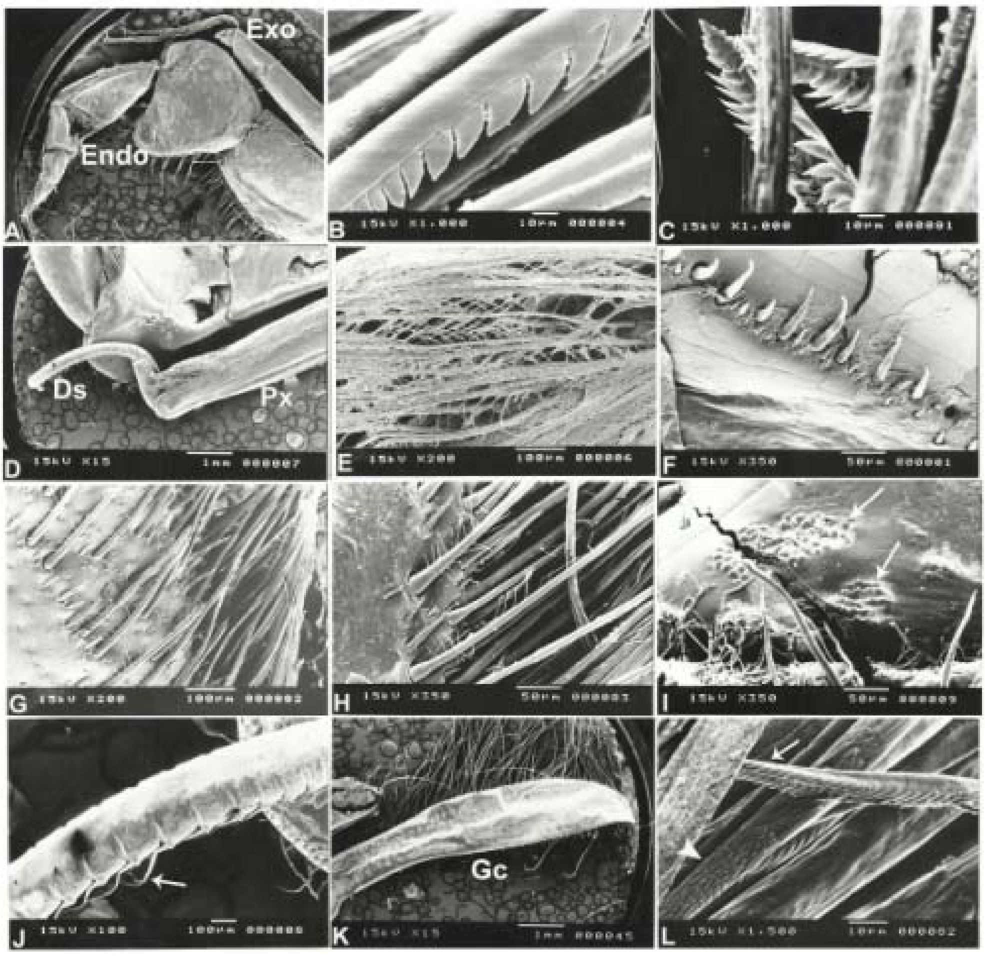


Plate 2

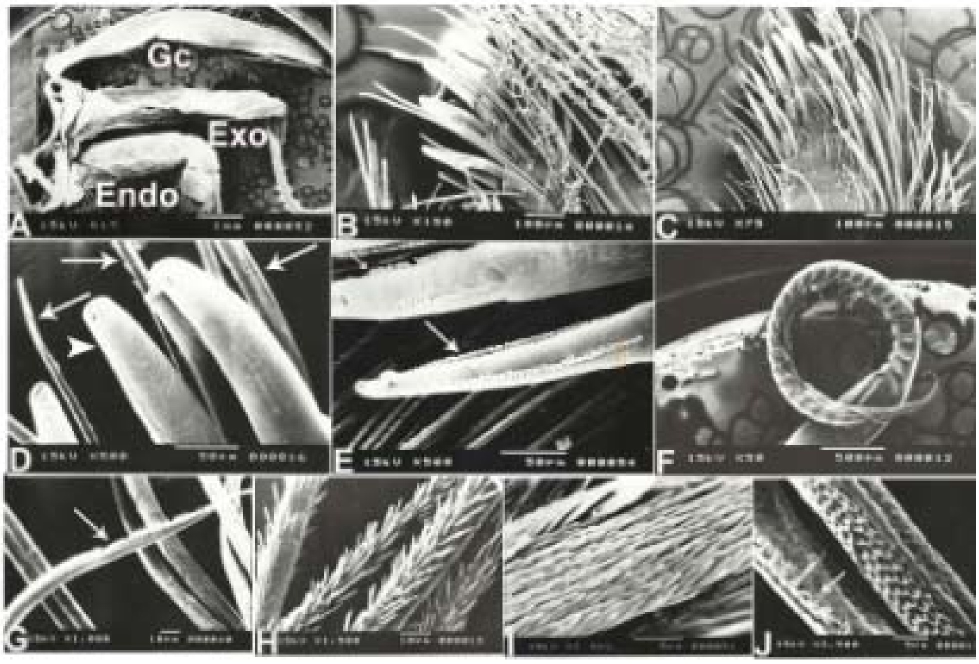


Plate 3

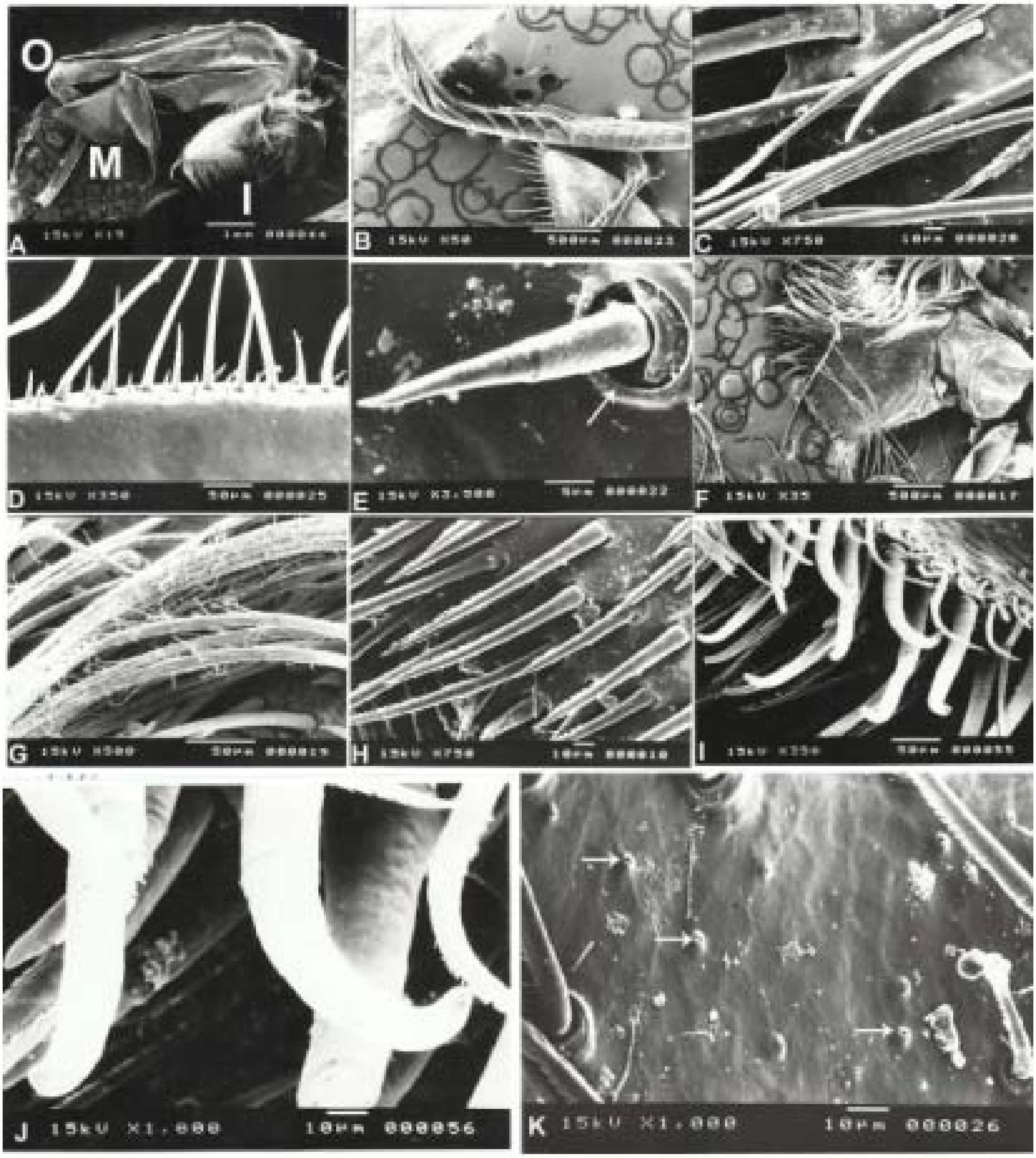

O
M
I
A
B
C
D
E
F
G
H
I
J 15kV X1,000 10µm 000056
K 15kV X1,000 10µm 000026

Plate 4

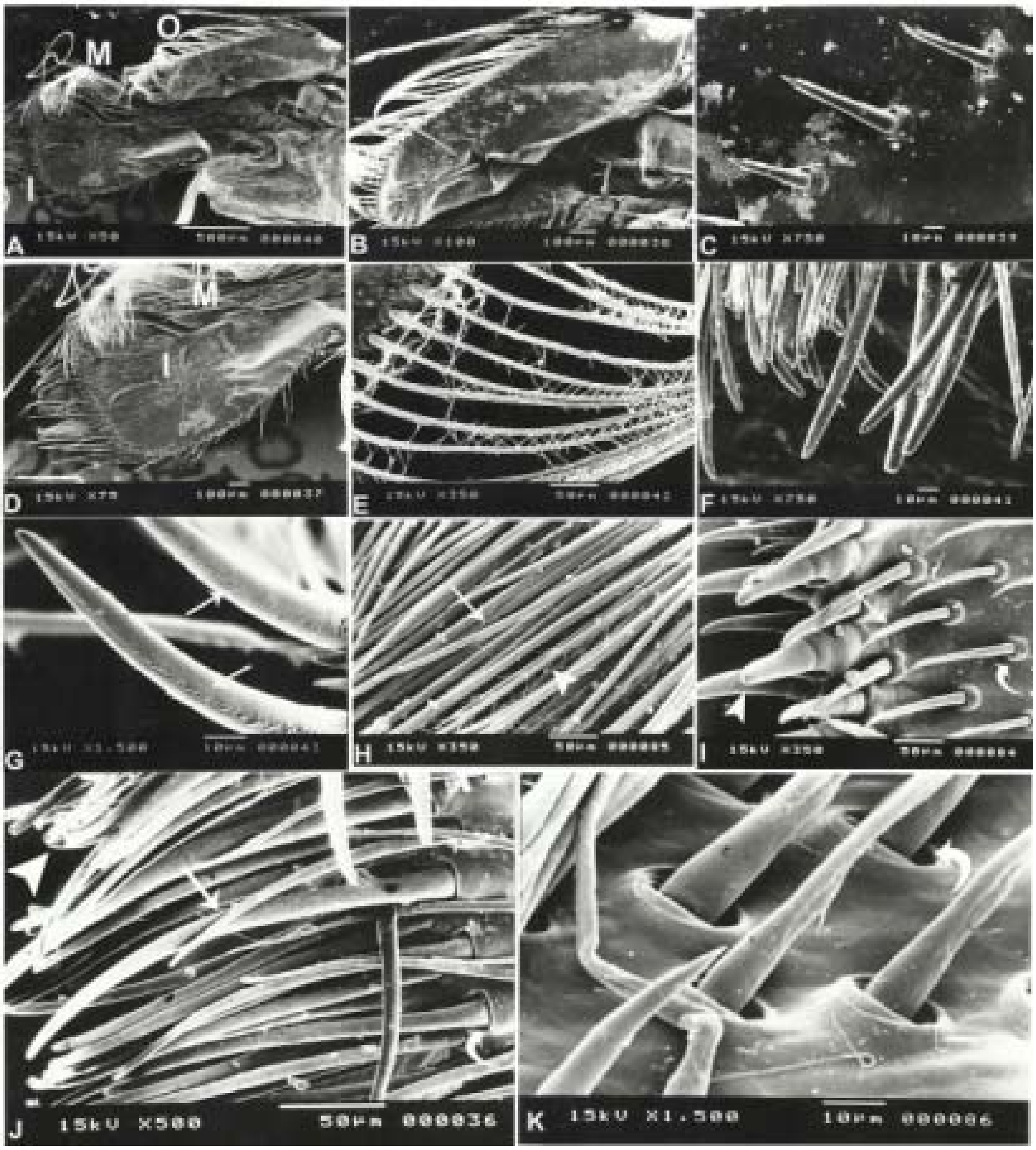

O
M
I
A
B
C
D
M
I
E
F
G
H
I
J 15kV X500 50µm 000036
K 15kV X1,500 10µm 000086

Plate 5

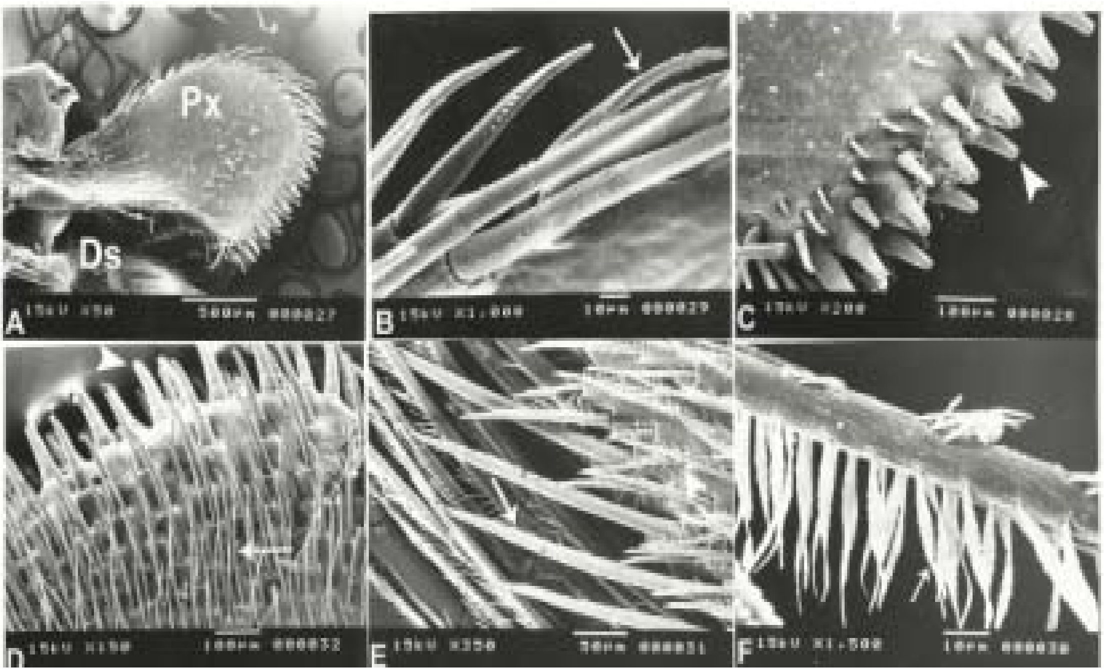
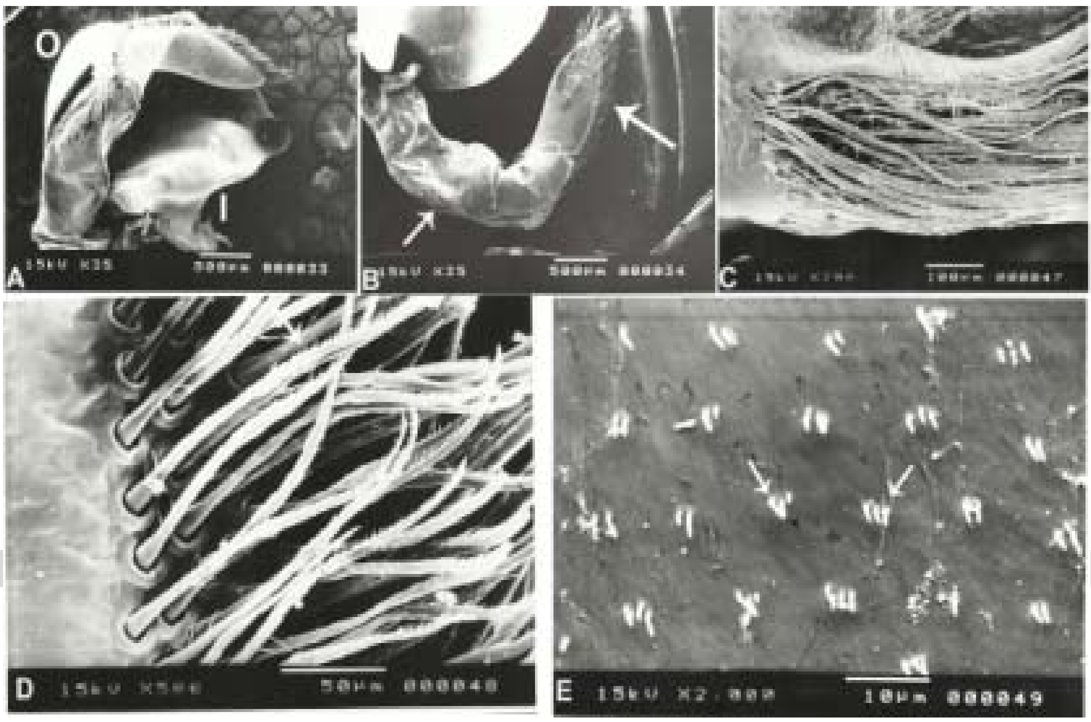


Plate 6



ARABIC SUMMARY

التركيب الدقيق لاجزاء الفم وطبيعه الغذاء فى سرطان ميتوبوجرابسس ميسور من بيئات مختلفة بساحل البحر الأحمر المصرى.

ماجد محمد على فودة[1]- مصطفى محمد حميدة سرحان[1] - أحمد حامد عبيد الله[2]- عبدالله ثروت عبدالله[1] ومحسن عبد الحافظ مصطفى[1]

١- قسم - علم الحيوان، كلية العلوم، جامعة الأزهر، فرع أسيوط، مصر.

٢- قسم - علم الحيوان، كلية العلوم، جامعة أسيوط، أسيوط، مصر.

مثل عشريات الأرجل الاخرى من الحيوانات القشرية، يتمتع السرطان ميتوبوجرابسس ميسور بفم يتألف من ستة أزواج من الزوائد المحورة. فقد اظهرت هذه الدراسة الأهمية التركيبية المعقدة لاجزاء الفم لهذا النوع وذلك من خلال عمل دراسة مقارنة لتركيب أجزاء الفم لعينات جمعت من بيئتين مختلفتين باستخدام المجهر الإلكتروني الماسح وبالرغم من الاختلاف فى البيئة إلا انة لم تظهر الدراسة فروقا جوهرية سواء في تركيب أجزاء الفم أو في تحليل الغذاء. كما أوضحت نتائج تحليل الغذاء للسرطان ميتوبوجرابسس ميسور أن هذا الكائن إنتهازى التغذية، يتغذى على أجزاء نباتية وحيوانية شملت مجموعات متنوعة من الكائنات القاعية بما في ذلك الطحالب و الأسماك والحيوانات الميتة الأخرى بالإضافة إلى بقايا النباتات المتحللة ولا سيما الأوراق والأعشاب البحرية وأشجار المنجروف