



The Morphological Characterization of the Abundant Amphipods Associated with *Cystoseira crinita* Duby, 1830: A Case Study from the Northwestern Red Sea Coast, Egypt

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ARTICLE INFO

Article History:

Received: March 29, 2024

Accepted: April 21, 2024

Online: April 29, 2024

Keywords:

Distribution,
Trophic diversity,
Brown algae,
Mouthparts,
Feeding strategies,
Ampithoeramondi,
Cymadusafilosa

ABSTRACT

Cystoseira crinita can be picked up from the intertidal or shallow sub-tidal hard substrates, which are inhabited by a huge number of associated fauna. One of the most prevalent faunal groups which is associated to those brown algae is the amphipod group. The present work was designed to address the distribution, occurrence and adaptation of amphipods species inhabiting brown algae (*Cystoseira crinita* Duby, 1830) in relation to the temporal variation. Samples were collected during the warm and cold seasons of 2020, from four replicates sampling points along the northern west Red Sea. A total of 635 individuals of marine amphipods were recorded associated with *C. crinita*; representing 14 species belonging to 14 genera and 9 families. Faunal distribution is influenced by temporal variation; the recorded species of amphipods were 626 individuals (98.6%) during winter, while during summer, only 9 individuals (1.4%) were detected. Data showed that three amphipod species (*Ampithoe ramondi* Audouin, 1826, *Cymadusa filose* Savigny, 1816, and *Photis lamellifera* Schellenberg, 1928) collectively comprised 78.7 % of the total abundance. The current study highlighted the morphological characterizations of the abundant amphipod species adapting to live in association with *C. crinita*.

INTRODUCTION

Several studies have reported that habitats with high complexity support a large abundance and diversity of species rather than less complexity habitat (Hacker & Steneck, 1990; Norderhaug, 2004; Hauser *et al.*, 2006; Huang *et al.*, 2007). Marine alga species is an important habitat-forming substrate, supporting numerous epiphytes and sessiles as well as mobile associated fauna, which are basically peracarids (Guerra-García *et al.*, 2011a, b).

Structural construction qualities of algal complexity may provide refuge from predators, and interpreted branching algae give more protection from visual predators than simple leaf shaped algae (Jacobi & Langevin, 1996). Brown and red algae produce their secondary metabolites acting as detergents, which can either provide shelter from herbivorous predators or deter mesograzers (Holmlundet *et al.*, 1990). Various concentrations of secondary metabolites make some algae unpalatable (Paul *et al.*, 2001).

Amphipods are small aquatic peracarid invertebrates living on small creatures (Poore *et al.*, 2008), seagrass & macroalgae (Gabr *et al.*, 2020a). They are among the most common species associated with many benthic marine habitats (Lörz, 2001; Gabret *et al.*, 2020b). In

addition, they play an important role in the aquatic food chain, forming live food for both snappers and pinfish in addition to invertebrate predators, such as crabs and shrimp (Sudo & Azeta, 1996). Most of these fauna are herbivorous (Poore, 1994), with other carnivorous and detritivorous. Evidence has shown that gammarideans can prey on conspecific animals and on a variety of dead and live macro-invertebrates (Hunte & Myers, 1984; Dick *et al.*, 1990, 1993; Dick, 1995; Krisp & Maier, 2005). Feeding behavior of amphipods, such as cannibalistic and predatory feeding style with scavenging and herbivorous feeding, proposes that gammarideans are omnivorous (MacNeil *et al.*, 1997).

Numerous methodological approaches are available for analyzing the feeding behavior of peracarids; gut-content analysis, *in situ* observations, stable isotope analysis, lipid analysis, feeding experiments in the laboratory and the descriptions of mouthpart morphology. Nonetheless, limited studies have examined the morphology of mouthparts and their functional morphological structure in amphipods (Poltermann, 2001; Arndt, 2002). Morphology of mouthpart and feeding habits have been studied from the ecological perspective by several researchers on various amphipod families such as Caprellidae (Caine, 1974), Lysianassidae (Dahl, 1979), Acantonothozomatidae (Coleman, 1987), and Gammaridae (Morino *et al.*, 2000).

Therefore, the present study attempted to address and describe in detail some convenient examples of feeding habits based on the mouthparts morphology of the different associated amphipods with the macro brown algal *Cystoseira crinita* (Duby, 1830). Additionally, the current work aimed to evaluate the trophic strategies among the observed associated amphipods.

MATERIALS AND METHODS

The study area, its locality and description

The area under investigation is about 320km along the Egyptian Red Sea coastline, it extends from Quseir (140km south Hurghada City) to the north of Shalateen (40km north Shalateen City), (Table 1). To address *Cystosiera crinata*, four sites were selected, representing the intertidal faunal characterization. The location of the sampling site was determined using the geographical positioning system (GPS).

El Quseir represented the 1st site, which is located at the northern part of the Red Sea (26° 33' 25.92" N & 34° 02' 16.8" E). The sea bottom is composed of sandy to mixed substrate. The area from the shoreline to 30m long consists of large gravels and small rocks, and the maximum depth recorded is 1.5m. From the shoreline, the depth slightly increased to the reef edge after 30m long via the back reef, and the latter is consisted of live or dead patches of isolated branched corals in addition to the scattered patches of macro-algae.

The 2nd site is Abu Dabab on the northern part of the Red Sea (25° 23' 42" N & 34° 42' 18" E). The sea bottom is composed of mixed substrate. The area from the shoreline to 50m long consists of large gravels, small rocks, and small branched coral patches. In this area, the maximum depth is 0.7m.

The 3rd site is Lahmi, which is located on the southeastern coast of the Egyptian Red Sea province (24° 22' 48" N & 35° 16' 30" E). The sea floor is composed of pure sandy substrate. The area from the shoreline to 600m long consists of large gravels and small rocks, and the maximum depth recorded in this area is 0.7m.

The 4th site is Shalateen, which is located on the southeastern coast of the Egyptian Red Sea province (23° 28' 58.08" N & 35° 29' 32.64" E). The substrate in the intertidal consists of sand characterized with rough grains and calcareous limestone. The back reef area extends from the shoreline to about 150m long till the reef edge. This shallow area is covered by scattered algal patches, a few sponge colonies, and rocks, as well as live and dead coral patched. The reef edge is covered almost with countless species of live corals, which extend deeply to the continental slope.

Table (1): Sampling sites & geographical limits (Lat. & Long.) along the Red Sea coast, Egypt

| Sampling site | Longitude (E) | Latitude (N) |
|---------------|---------------|--------------|
| Quseir | 34° 02' 16" | 26° 33' 25" |
| Abu- dabab | 34° 42' 18" | 25° 23' 42" |
| Lahmi | 35° 16' 30" | 24° 22' 48" |
| Shalateen | 35° 29' 32" | 23° 28' 58" |

Samples collection

Cystoseira crinita Duby, 1830 samples with its associated amphipods were collected during summer and winter seasons 2020. The collection of sampling was done at each site during the low tide in the inter-tidal zone. At each site, *C. crinita* samples with their associated fauna were collected by snorkeling from the shallow area. The samples were collected manually with their associated amphipods by nylon bags (15 x 15cm aperture diameter) with a net mesh size of 500µm). The bags covered all the sample area carefully to prevent escaping out any associated fauna. By using a sharp gift, the target algae were cut off from the hard substrate manually. All the collected samples were immediately fixed onshore with ethanol-seawater of 70% and kept in polypropylene field box *in situ*. While, in laboratory, the samples were reopened, and the nylon bags were washed 3-5 times using tap water to remove all associated amphipods on a 0.5mm sieve for filtration. The associated amphipods on the branched algae were removed using a fine dissecting needle or forceps.

After that, the amphipod specimens were isolated under dissecting microscopes models OPTIKA-SLX-3, (Italy) & EUROMEX-RZT, (Netherlands). Amphipod individuals were sorted, counted and identified to the lowest possible taxon with traditional taxonomic methods and keys (Lincoln, 1979; Barnard & Karaman, 1991; Lowry & Myers, 2013; Zeina & Abu Zaid, 2013; Zeina & Guerra-García, 2016).

Dissection of amphipods

Before measurement and dissection, data were written on the sample card for each collected amphipod species. A fairly exact measurement method was followed, as outlined in Barnard & Drummond (1978). The amphipod was mounted temporarily in glycerin and ethanol mixture or any other preservative on a slide.

Mouth parts dissection

Mouth parts were grouped in a coniform or quadratiform bundle from a lateral view. In some cases, mouth parts need a high power microscope to confirm the position of the dissected part and draw the mounted dissected parts. Mouth parts were removed from the head, again with the amphipod head pointing away from the observer so that motion to the right with the forceps can be used to snap off the mouthparts. The maxillipeds came off together. More anteriorly, a pair of bilobed second maxillae was removed, followed by the first maxillae; caution was performed to avoid damaging the lower lip. Mandibles were removed in the next step. Sclerotic connections to upper and lower lips were disarticulated to avoid their damage. Usually, each mandible has a palp.

RESULTS

1. The faunal composition of amphipods with *Cystoseira crinita*

The present study recorded 14 amphipod species belonging to 9 families as associated species on the brown algae *Cystoseira crinita* Duby, 1830. *Ampithoe ramondi*, Audouin, 1826, *Cymadusa filosa* Savigny, 1816, and *Biancolina* sp. Della Valle, 1893 from family Ampithoidae; *Globosolembos ruffoi* (Myers, 1975) and *Lembos podoceroideus* Walker, 1904 from family Aoridae; *Paradeutella multispinosa* Schellenberg, 1928 from family Caprellidae; *Cyproidea ornata* Haswell, 1879 from family Cyproideidae; *Leucothoe* sp. Leach, 1814 from family Leucothoidae; *Ceradocus* sp. Costa, 1853, and *Elasmopus seticarpus* Myers, 1985 from family Maeridae; *Pereionotus alaniphlias* (Barnard, 1970) from family Phliantidae; *Gammaropsis chelifera* (Chevreux, 1901), and *Photis lamellifera* Schellenberg, 1928 from family Photidae, and *Stenothoe gallensis* Walker, 1904 from family Stenothoidae. Data showed that more than 60% of the associated amphipods belongs to family Ampithoidae, while the rest 8 families consisted less than 40% of the faunal composition (**Fig. 1**).

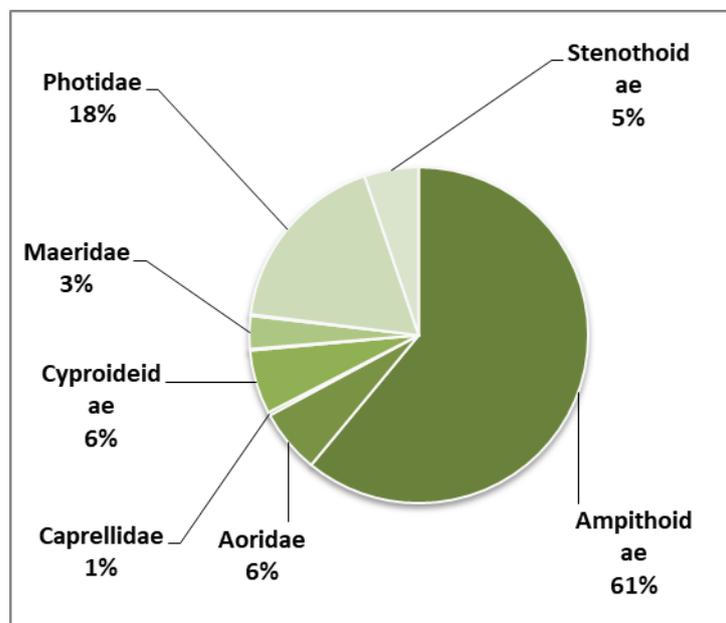


Fig. 1. Faunal structure of associated amphipods with *C. crinita*

2. Spatial vs temporal distribution and diversity of amphipods associated with *Cystoseira crinita*

Data presented in **Table (2)** reveal that there are great variations between sites in the number of individuals of amphipods, where the amphipod densities in Qusier recorded the highest number of individuals (57.9% of total recorded individuals), followed by Shalateen site during cold seasons (40.6% of total recorded individuals), with the absence of amphipod records at Abo dabab and Lahmisites during the same season. Vice versa, during warm season, the presence of amphipods decreased sharply among all collection sites. Therefore, only few species were recorded at Abo dabab and Lahmi (1.5% of total recorded amphipods in both sites), with the absence of amphipods at Qusier and Shalateen.

During two alternative seasons from site to another, 14 species of amphipods were registered during the cold season against only 5 amphipod species during the warm season (35.7% of all recorded amphipods on *Cystoseira crinita*). Only the species *A. ramondi*, *C.*

filosa, *G. ruffoi*, *L. podoceroide*s and *G. chelifera* were reported during the year, regardless of the thermal fluctuation between seasons.

Table (2): Temporal and spatial distribution of amphipod species associated with *C. crinita* among the study sites

| Species | Warm seasons | | | | Cold seasons | | | | Total |
|----------------------------------|--------------|-----------|-------|-----------|--------------|-----------|-------|-----------|-------|
| | Qusier | Abo dabab | Lahmi | Shalateen | Qusier | Abo dabab | Lahmi | Shalateen | |
| <i>Ampithoe ramondi</i> | | 1 | 1 | | 224 | | | 12 | 238 |
| <i>Cymadusa filosa</i> | | | 2 | | 3 | | | 142 | 147 |
| <i>Biancolina</i> sp. | | | | | 2 | | | | 2 |
| <i>Globosolembos ruffoi</i> | | 1 | 2 | | | | | 14 | 17 |
| <i>Lembos podoceroide</i> s | | | 1 | | 8 | | | 13 | 22 |
| <i>Paradeutella multispinosa</i> | | | | | 2 | | | | 2 |
| <i>Cyproidea ornata</i> | | | | | 9 | | | 30 | 39 |
| <i>Leucothoe</i> sp | | | | | | | | 1 | 1 |
| <i>Ceradocus</i> sp | | | | | 11 | | | | 11 |
| <i>Elasmopus seti</i> carpus | | | | | 3 | | | 6 | 9 |
| <i>Pereionotus alaniphlias</i> | | | | | | | | 1 | 1 |
| <i>Gammaropsis chelifera</i> | | | 1 | | | | | 5 | 6 |
| <i>Photis lamellifera</i> | | | | | 73 | | | 34 | 107 |
| <i>Stenothoe gallensis</i> | | | | | 33 | | | | 33 |
| Total number of individuals | | 2 | 7 | | 368 | | | 258 | 635 |
| Total number of species | | 2 | 5 | | 10 | | | 10 | 14 |

Out of 635 individuals recorded during the present study, three amphipod species were the most abundant, collectively comprised 492 individuals (77.5 % of total amphipod). *Ampithoe ramondi* (Family: Ampithoidae) was the most abundant species, with 238 individuals (37.5 % of total amphipod); followed by *Cymadusa filosa* (Family: Ampithoidae) represented by 147 individuals (23.1 % of total amphipod). While, *Photis lamellifera* (Family: Photidae) occupied the third rank in the abundance and comprised 107 individuals, representing 16.9% of total amphipod individuals (**Fig. 2**).

For the spatial distribution of amphipods associated with *C. crinita* species, the results showed that, Qusier and Shalateen sites had 10 amphipod species each, while only two species of amphipods were recorded from Abo dabab. Side by side of the great variation between sites of collection and seasonal alternatives, the availability of *C. crinita* throughout the sampling time facilitated the availability of the associated amphipods over there. Hence, the presence of algal habitat during cold season from Qusier and Shalateen was crowded by amphipods, scoring more than twenty folds of the warm season collections.

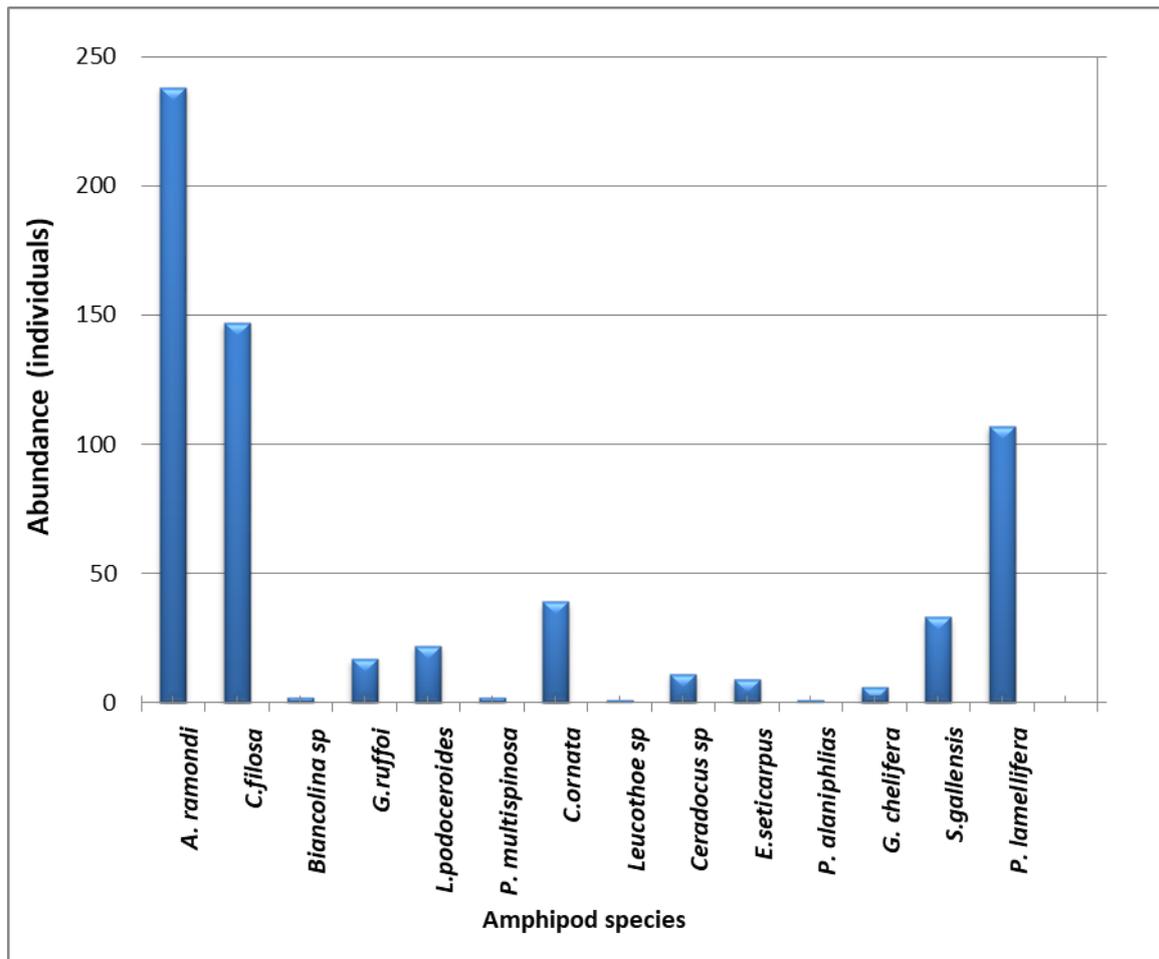


Fig. 2. Abundance of associated amphipods with *C. crinita*

3. Morphological characterization of different associated amphipod species with *C. crinita*

3.1. *Ampithoe ramondi* Audouin, 1826

This species is one of the most abundant amphipods associated with *C. crinita* in the present study. Its body structure plays a good functional adaptation with its life style of living. Head appendages morphology act as an assimilation part with its feeding habits and capturing there food items. Usually, antenna 1 is longer than antenna 2, movable, flexible, work as a sensory or olfactory organ for selecting the acceptable and edible food items. Moreover, the other mouthparts consist of labrums (Upper and Lower), mandibles, maxilla (1 and 2) and maxillipeds. Labrum (Upper and Lower), partially covered with ciliated setules, play a role in bite slipping and movement through mouthparts cavity prior to the esophagus entrance. Mandibles are medium size in there length and consists of incisor, laciniamobilis, a row of setae and the molar process (Fig. 3A). The incisor part is five toothed, followed by 5-6 toothed laciniamobilis and a row of a gnathobasic seta. Then, the mandibular molar part is well developed, rounded for grinding, chewing and crushing different food items. The inner plate of the lower lip is shorter than the notched outer plate. Maxilla 1 has bi-articulate developed palp. Maxilla 2 outer plate is broader than the inner. The maxilliped is strongly setose. Gnathopod 1 is smaller than gnathopod 2, and the palm is entire and straight. The dactylus is subequal to the palm (Figs. 4B, D). Pereiopods from 5-7 are simple. Propodus of pereiopods from 6-7 are sub-rectangular; distal articles are slender.

3.2. *Cymadusa filosa* Savigny, 1816

This species is also one of the most abundant species that is associated with *C. crinita* in the current work. Usually, Antenna 1 and antenna 2 have a subequal work as sensory or olfactory organs for food selection. Besides, the other mouthparts consist of labrum, mandibles, maxilla and maxillipeds. The lower lip outer lobe is longer than the inner lobe. The mandible has similar structure of *A. ramondi*, but the molar part is larger and triturative, with a well-developed palp (**Fig. 3B**). The maxilla 2; outer lobe is broader than the inner. Maxilliped is strongly setose notched (**Fig. 3C**). Gnathopod 1 is smaller but longer than gnathopod 2; the carpus is longer than the merus; it is longer than the propodus; the propodus is ovoid; the palm is entire and the posterodistal tooth is absent; the mid-palmar tooth is absent, and the dactylus is longer than the palm (**Fig. 4A**). Gnathopod 2; the carpus is longer than the merus; it is shorter than the propodus; the palm is entire, and the posterodistal tooth is present, and the dactylus is shorter than the palm (**Fig. 4E**). Pereiopods from 5-7 are simple and similar to *A. ramondi*.

3.3. *Photis lamellifera* Schellenberg, 1928

Most photid species are distinguished by a lateral cephalic lobe and coxal margin. All of these family members have well developed mandible consisting of incisor dentate, robust row of seta, and triturative molar process, with an accessory lateral plate and long plumose seta (**Fig. 3F**), well developed maxilliped (**Fig. 3E**). Maxilla 1 plates with robust setae, and Maxilla 2 with a row of facial setae. Gnathopods 1 & 2 subchelate, robust and well developed, in addition to the dactylus fitting palm with an inner serrate margin (**Fig.4C**).

3.4. *Cyproidea ornata* Haswell, 1879

Incisor dentate, laciniamobilis multi-dentate, mandible molar vestigial; maxilla 1 with uni-articulate palp; maxilla 2 inner plate shorter than the outer one; maxilliped outer plate not reaching the distal margin of palp article 1; asymmetrically upper lip; lower lip outer lobe: apical margin with small and deep cleft; Gnathopod 1 is sub-chelate and palm with very sharp margin and dactylus inner margin half serrate. Gnathopod 2 is carpo-chelate and carpus lobe extending along the entire of propodus and palm with bidentate serration as well as its inner margin is smooth.

3.5. *Globosolembos ruffoi* (Myers, 1975)

Antenna 1 is equal to body length, and antenna 2 equals two-third antenna 1 in length. Mandible robust similar in both right and left sides. Incisor composed of five-toothed process in addition to four toothed laciniamobilis. Strong molar part cuboidal shape and extended to the laciniamobilis, with a row of serrated seta varied in setal number. Gnathopod 1 dactyle over lapping palm. Gnathopod 2 is consisted of a propodus longer than the carpus, and dactylus fitting the palm.

3.6. *Lembos podocerooides* Walker, 1904

Antenna 1 flagellum is longer than body and antenna 2 equals half antenna 1 in length. Mandible robust similar in both right and left sides. Incisor composed of five-toothed process in addition to four toothed laciniamobilis. Strong molar part cuboidal shape, extending to the laciniamobilis, with a row of serrated seta varied in setal number. Gnathopod 1 dactyle over lapping palm. Gnathopod 2 is consisted of propodus longer than carpus, and dactylus fitting palm.

4. Feeding tools

Mouthparts not only the structure parts that play a role in amphipod feeding strategy but also gnathopods and antennae. The observation of associated amphipods with *Cystoseira crinita* revealed that more than 98% of amphipods have the same mouthparts components; labrum, mandibles, maxilla and maxillipeds. In most cases of the natural position of mouthparts, the components are mostly incognito beyond the two pairs of gnathopods and maxillipeds. All mouthparts are anteriorly held in a way that the posterior surfaces of the appendages are exposed. Labrum sometimes is a dome-like structure reduced or enlarged according to the protrusible cone structure of the animal mouthparts. The mouthparts cone sizes are varied according to the species size range and its feeding life style and feeding behavior.

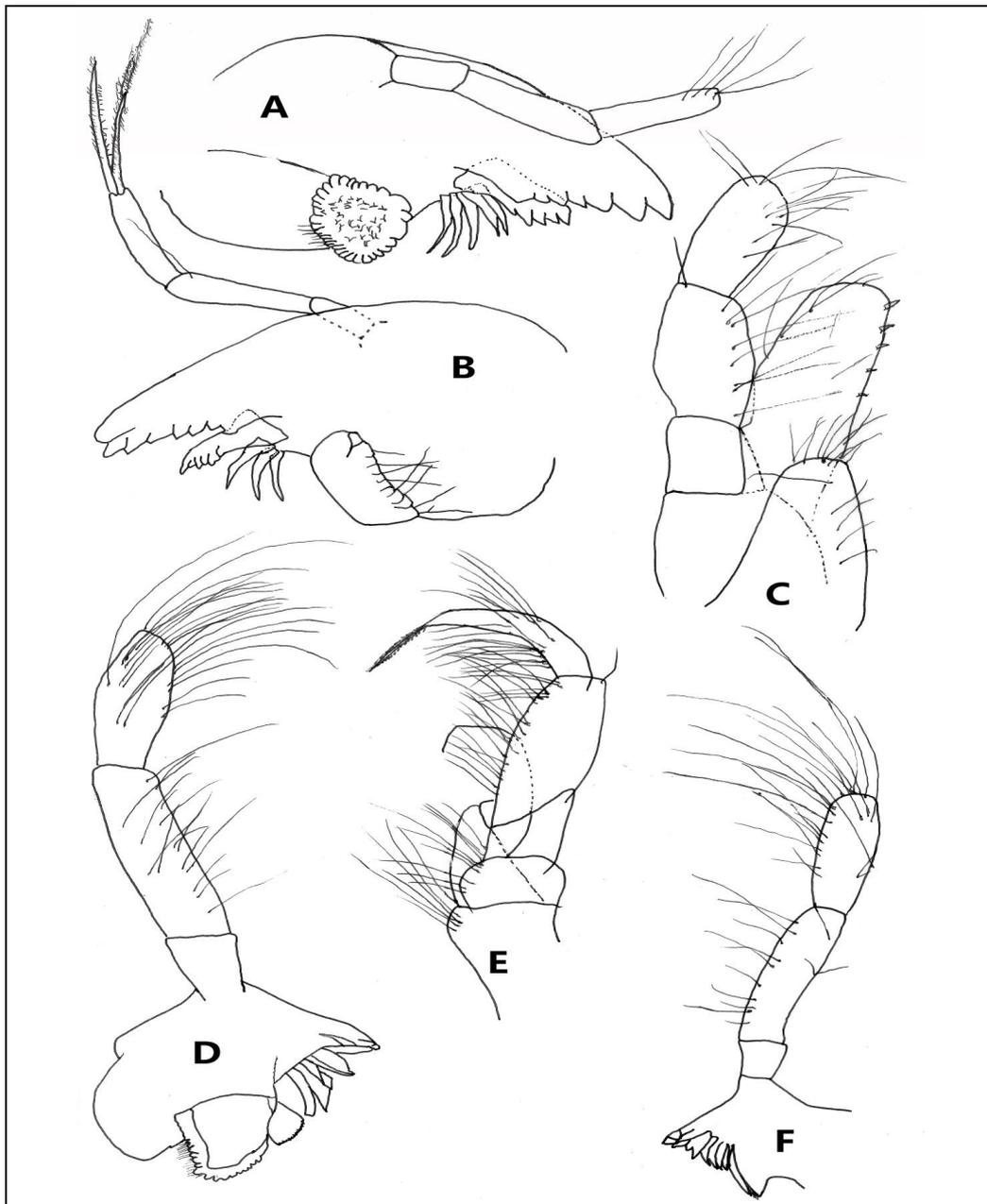


Fig. 3. Ampithiodae: **A:** Mandible of *Ampithoe* spp.; **B:** Mandible of *Cymadusa* spp.; **C:** Maxilliped of *Cymadusa* spp.; **D:** Mandible of *Biancolina* spp.; **E:** Maxilliped of *Photis* spp.; **F:** Mandible of *Photis* spp.

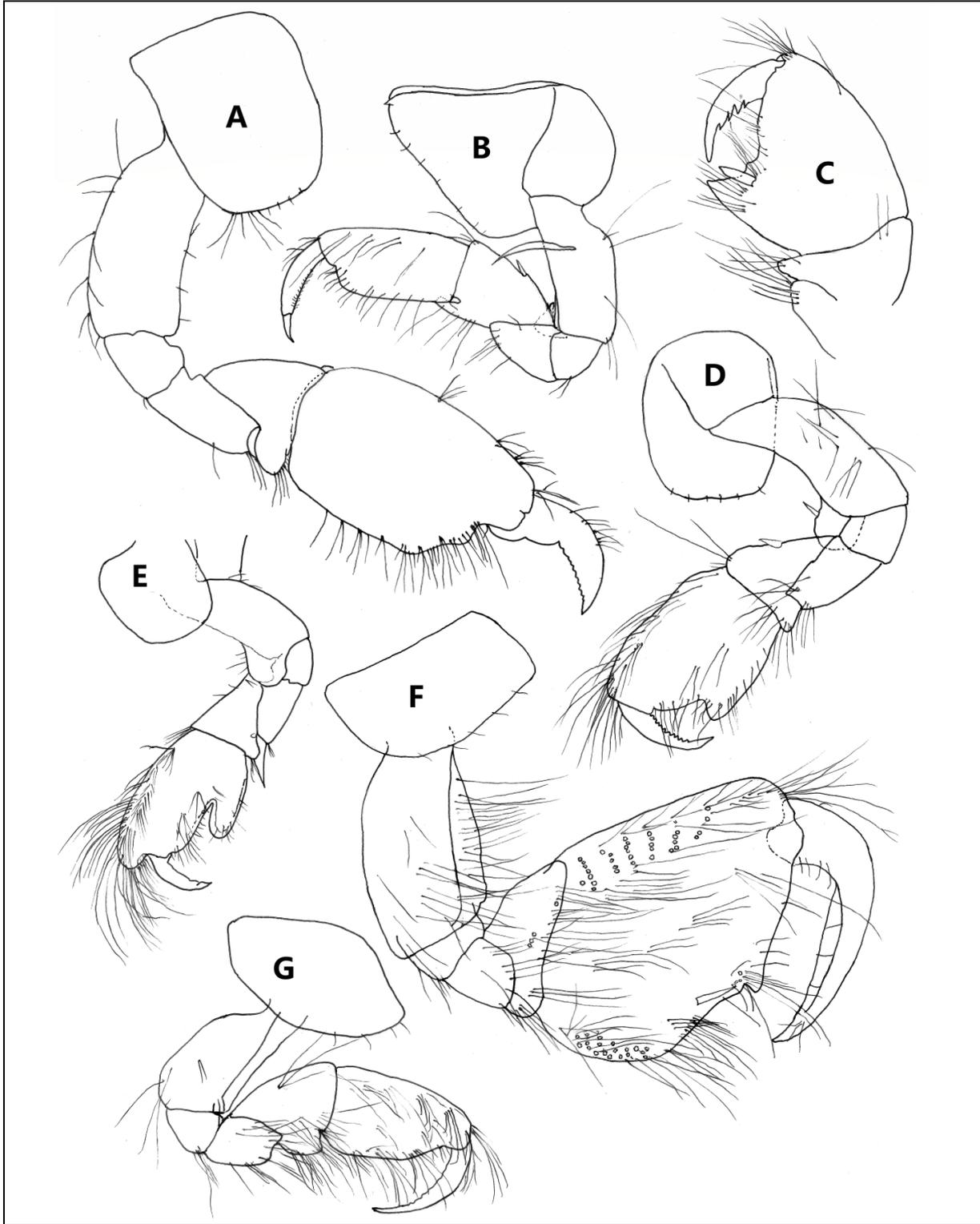


Fig. 4. Ampithiodae and Photidae; A: Gnathopod 1 of *cymadusa* spp.; **B:** Gnathopod 1 of *Ampithoe* spp.; **C:** Gnathopod 2 of *Photis* spp.; **D:** Gnathopod 2 of *Ampithoe* spp.; **E:** Gnathopod 2 of *cymadusa* spp.; **F:** Gnathopod 2 of *Gammaropsis incideris* spp.; **G:** Gnathopod 1 of *Gammaropsis incideris*

On the other hand, mandibular part occupies from one third to half of the total mouth parts cone peripheral size. Most of our amphipod mouth parts have similarities between right and left mandibles, which involved distal process (incisor = pars incisiva) and proximal process (molar = pars molaris). Between both incisor and molar parts, a mobile lacinia inserts and one row of setae sequentially until the molar process (**Fig. 3**). The variation of incisors structure, shape and size, as well as the molar process variations in their shape and size could be a valuable point of interest that could share the feeding tools adaptation. The setal row varied in shape from stiletto-like (straight or curved) to feathered-like seta. The molar part is well developed rounded medium size as in *A. ramondi* and larger and triturative as in *C. filosa*, *P. lamellifera* and somewhat strong as well as cuboidal in shape as in *L. podoceroides* and *G. ruffoi*, but it could be vestigial as in *C. ornata*.

Incisors in all associated amphipods observed during the present study are represented as multi-dentate (toothed); this dentation varied in tooth number, orientation and sharpness based on their specific variation but still have the same functional structure. Dentate incisor or toothed incisor acts as a bite maker of large food items, which is bigger than the mouth cavity and esophagus opening by snapping and nipping.

Antennae support the mouthparts but are though specifically important in the detection and capture process. Just briefly mentioned on antennae is noticed here but our concentration on the mouthparts and gnathopods. The antennae, the gnathopods and the coxae-shield (in many amphipods) generate a ventral water current used for feeding and respiration.

The first and second gnathopods are much larger than the head appendages, which consist of a coxa and 6-segmented endopod that are very differently shaped. The distal two or three segments form a chela-form. This form is alternate from simple to complex component. The component structure varied from sub-chelate, chelate and carpo-chelate. The robust palm portions lie ventrally to the mouthparts, parallel with the body axis, at a resting position.

5. Feeding strategy

Most recorded species are active motile amphipods with prehensile pereopods, which help each species walk, cling or hang. Moreover, this group of species can jump by using its pleopods for short distance and hang its body by gnathopods and pereopodal dactyls. Each species has its own way to climb the associated macro algae (*Cystoseira crinita*) not to eat the algal tissue mainly, but most of these amphipods are deposit feeders or suspended feeders, where the amphipods filtering particulate organic material from water column or algal body surface, such as the remaining of soft tissues whether plant or animal source, diatoms & carcass. This kind of feeding coincides with stomach content analysis of similar species collected, which are characterized by short stomach.

DISCUSSION

The classification of amphipods (**Barnard & Karaman, 1991; Bousfield & Shih, 1994**) is today mainly based on the morphology of the mouthparts, gnathopods, coxae-shield and urosome (**Watling, 1993**). In reality, very little is known about the functional morphology of these features although some studies have been presented that aim at understanding the functional morphology of the various appendages (**Pirlot, 1936; Coleman 1989a; Watling, 1993**). In addition, our knowledge about most of amphipod biology is almost weak.

For few groups such as some intertidal species, we are able to describe their general biology in some detail, but for most taxa living deeper, information is still scarce about it so far. In general, it is extremely difficult to find descriptions regarding direct observations of feeding behavior in amphipods. Few researchers addressed this point of view (**Enequist, 1949; Watling, 1993**). In the last years, the situation has improved somewhat, and a very

recent paper (**Daubyet al., 2001**) provides the unprecedented combination of direct observations of feeding behavior in aquaria, with an examination of gut contents of field-collected material.

The study of mouthparts form and components provided a detailed understanding of how mouthparts operate in feeding behaviors among the Red Sea *C. crinita* related amphipod taxocoenosis. Peracarids in marine invertebrate communities have adapted macro-herbivory, utilizing various food sources ranging from unicellular plankton to vertebrate corpses (**Mayer et al., 2008**).

The trophic diversity of the Red Sea species is lower compared to the Antarctic marine fauna; however, it may be similar to the temperate regions like the Mediterranean Sea. The grazing behavior of animals is influenced by the fragmentation of communities and the availability of hosting habitats. Algal habitat with unique plant and animal communities and diverse eating patterns, but knowledge regarding the feeding habits of the amphipod fauna living in these habitats is currently incomplete and dispersed.

The high diversity of amphipod species may be linked to the abundant oxygen levels in the Antarctic waters. **Levin & Gage (1998)** demonstrated strong relationships between oxygen levels and the diversity of macrobenthos in different bathyal regions. Oxygen availability has been suggested as the cause of the enlarged size range and gigantism seen in amphipods in the Southern Ocean (**Chapelle & Peck, 1999**). Lake Baikal has chilly and oxygen-rich waters, similar to those of other lakes. It is home to a highly diverse population of amphipods, as noted by Bazikalova in 1945. Conversely, the decline and dwarfism were seen in tropical and subtropical amphipods in the Red Sea distribution area, known for its faunal size reduction (**Barnard, 1965; Zeina & Guerra-Garcia, 2016**).

Eight different feeding strategies were classified to describe the feeding behavior of amphipod species (**Daubyet al., 2001**), where their results revealed the characterization of different potential feeding types and differentiated it as; 1-predators, 2-opportunistic predators/scavengers, 3-necrophages, 4-micropredatory grazers, 5-micro-herbivores, 6-suspension-feeders, 7-deposit-feeders and 8-macro-herbivores (Browsers). Usually, all the trophic types could not be found at the same habitat in spite of the mouthparts of peracarids consisting of the same components but functionally diverse. Because of that almost the associated amphipods with *C. crinita* have slight difference between their mouthparts architecture and most of them belonging to suspension-feeders or deposit-feeders.

On the other hand, commensal or partly feed on host tissue were not determined in the current study since some of these species may have lived as ectoparasite such as *Stenothoe gallensis*, which could be commensalism with other associated invertebrate not included in our observations during this study. **De Broyeret al. (1999)** discovered commensalism between ascidians and several lysianassid, stegocephalid, and stenothoid species, without any clear host-specific interactions. They also observed associations between some stenothoid species and hydrozoans and gorgonians (Primnoella).

Numerous Red Sea amphipods have a diverse diet and exploit various food sources depending on the season. Spring–summer bloom circumstances provide a big production of fresh organic matter, which is used very swiftly by water-column and bottom primary consumers. In contrast, winter circumstances are marked by a relative lack of fresh food resources. Opportunistic eating behavior is expected in generalist eaters, with a gradual transition from hunting to scavenging based on the availability of different types of food.

The study demonstrated a correlation between the feeding methods, food preferences, and mouthpart structure in various specialized feeding amphipods. Specialists who eat on

animal prey have mandible modifications for cutting tissue. The incisors of the acanthonotozomatidae gammaridean *Echiniphimedia hodgsoni* Walker, 1906, are widened and consistently toothed, which aids in feeding on sponges. The right laciniamobilis is widened and aligned parallel to the right incisor, serving as an additional cutting edge (like some recorded species surrounding the *Cystoceira crinite*). The left incisor moves into the space between the right incisor and right laciniamobilis during biting. The mouthparts of these specialists have typically fewer and smaller setae or are transformed into robust spiniform setae (Coleman, 1989b).

The mandible of the stilipedid gammaridean *Bathypanoploea schellenbergi* (Holman & Watling, 1983) has adapted to deal with the tough body wall of its holothuran prey. The left laciniamobilis and the incisors are widened here. Similar alterations are detailed for the stegocephalidae gammaridean *Parandania boeckii* was described by Stebbing (1888), as mentioned by Moore & Rainbow (1989). Some scavenging lysianassids, such as *Lysianassa* sp., and the acanthonotozomatidae *Maxilliphimedia longipes* Walker, 1906, exhibit notable similarities to these adaptations (Dahl, 1979; Sainte-Marie, 1984). In summary, incisors and the laciniamobilis of amphipods that feed on animal tissue are widened to form strong cutting edges; molars are not designed for grinding, and setae are decreased in quantity and size.

The detritus-feeding iphimeriid gammaridean *Anchiphimedia dorsalis* Barnard (1930) describes the presence of long and closely spaced setae on the medial and apical borders of the maxillipeds, maxillulae, and maxillae. These setae aid in brushing food particles from sand grains or other surfaces and help prevent them from being carried away by water. The molars are underdeveloped (Coleman, 1991). The teeth of the Oedocerotidae gammaridean, which burrows in sand and feeds on detritus; *Perioculodes* sp. and *Synchelidium* sp. displays a file-like surface composed of closely packed fine and rigid setae. The palps and endites of maxillulae and maxillipeds are decorated with long, unbranched setae. Interlocking simple setae provide a thick sieve along the midline between the maxillae (Dennell, 1933). The molars of *Hyperialgalba* Montagu, 1812 (Hyperidea: Hyperidae) are used for grinding food and have a consistent pattern of closely packed strong cusps.

The amphipod is a food parasite that infests huge scyphozoan medusae, feeding on plankton caught by its host, first described by (Dittrich, 1992). *Paracallio peaustralis* Haswell, 1880, an amphipod from the Gammaridea family Paracalliopiidae, has adaptations for scraping algae from the surface of the substratum while feeding on periphyton. The basipodalendites of the maxillulae have robust tooth-like spines on their top edge. The coxalendites have a line of feathery setae along their outer and middle margins to prevent dislodged food from being carried away. The molar surfaces are designed for grinding, consisting of closely packed columnar teeth (McGrouther, 1983). *Hyalerupicola*, a species of Gammaridea in the family Hyalidae, is specialized in consuming macrophytes. The coxalendites of its maxillulae are tiny and have only two pappose setae. The basipodalendites end with strong apical spine teeth. The mandibular palp is missing, and the left incisor is positioned in front of the right incisor. The left laciniamobilis is serrated and the molars have grinding surfaces resembling rasps (McGrouther, 1983). Agrawal (1965) detailed the mouthparts of *Gammarus pulex*, a gammarid that feeds on decaying leaf material and fresh *Nitella* (Charales) according to Willoughby (1983). The molars are designed for grinding, with rough, file-like surfaces. The distal endites of the maxillulae have a row of six sturdy knob-like setae, which extend distally into tiny tooth-like projections.

ACKNOWLEDGEMENT

This work is financially funded by Science, Technology & Innovation Funding Authority (STIFA) for Young Researchers call 8 (YR-30198). One of the authors (AZ) also is grateful to M. Maaty, K. Darweesh and A. Nofal for their help during sampling process.

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