

Biology of Mediterranean and Caribbean Thalassinidea (Decapoda)

Peter C. DWORSCHAK

Dritte Zoologische Abteilung, Naturhistorisches Museum, Burgring 7, A 1014 Wien, Austria
(Peter.Dworschak@nhm-wien.ac.at)

Abstract

Among burrowing organisms, the most complex and extensive burrow systems are found within the Thalassinidea. This group of decapods comprises some 520+ species in currently 11 families and 80+ genera. They live predominantly in very shallow waters, where they often occur in high densities and influence the whole sedimentology and geochemistry of the seabed.

In this contribution I present results of studies on the biology of several Mediterranean (*Upogebia pusilla*, *U. tipica*, *Pestarella tyrrhena*, *P. candida*, *Jaxea nocturna*) and Caribbean (*Axiopsis serratifrons*, *Neocallichirus grandimana*, *Glypturus acanthochirus*, *Corallianassa longiventris*) species.

Of special interest is the occurrence of debris-filled chambers in the burrows of two callianassid species, *Pestarella tyrrhena* and *Corallianassa longiventris*. The possible role of this introduced plant material for the nutrition of the shrimps is discussed.

1. Introduction

The Thalassinidea are a group of mainly burrowing decapod shrimps. They have attracted increased attention in recent ecological studies on marine soft-bottom benthos, especially in terms of their influence on the whole sedimentology and geochemistry of the seabed (Ziebis et al., 1996a, b), their bioturbating activities (Rowden & Jones, 1993; Rowden et al., 1998a, b) and consequent effects on benthic community structure (Posey, 1986; Posey et al., 1991; Wynberg & Branch, 1994; Tamaki, 1994). They are of particular interest because they construct very complex and extensive burrow systems (Griffis & Suchanek, 1991; Nickell & Atkinson, 1995).

This group of decapods comprises some 520+ species in currently 11 families and 80+ genera. (Dworschak, 2000). They occur worldwide from the cold temperate climate to the tropics, but not in the polar regions north of 70°N and south of 55°S. The distribution shows a clear latitudinal gradient with low species numbers in high latitudes and high species numbers in low latitudes (Fig. 1A). For all three species-rich groups (Callianassidae, Upogebiidae and Axioidae) two peaks can be recognised, one between 25° and 10°N and one between 0° and 15°S. All three groups show a drop in species number between 10°N and 5°S.

Most Thalassinidea (95% of the species) occur in shallow water (0-200 m). Among the Callianassidae, 54% inhabit very shallow waters (0-2 m), this percentage is 44% among the Upogebiidae. The depth distribution is quite heterogeneous within the Axioidae, the majority is sublittoral (Fig. 1B).

I will present here some aspects of the biology of some thalassinidean species which I studied in the Adriatic Sea and in the Caribbean.

2. Material and Methods

Studies on the biology of thalassinideans was done in the Mediterranean Sea at several tidal flats in the Northern Adriatic; in the Lagoon of Grado, at Lido di Staranzano (Italy), at Strunjan (Slovenia) and near Rovinj (Croatia), and on sublittoral bottoms near Aurisina (Italy) and Piran (Slovenia) (for details of habitats see Pervesler & Dworschak, 1985; Dworschak, 1987c, 2001, 2002).

Studies in the Caribbean were performed at the Smithsonian Field Research Station on the island Carrie Bow Cay at the Belize Barrier Reef (Central America) (for detail on habitats see Dworschak & Ott, 1993).

Burrow were studies by in situ resin casting using an epoxy resin (for details see Pervesler & Dworschak, 1985). Burrowing shrimp were captured by digging, with a "yabby pump" (Manning, 1975) or by means of "weighted lines" (Vaugelas, 1985a). The density of burrow openings was determined by direct counts or on

photographs of the sediment surface (see Dworschak, 1987c). In the laboratory, the behaviour of the burrowing crustaceans was observed in narrow aquaria filled with natural sediment (see Dworschak, 1987a). The appendages of some species were investigated using standard histological and scanning electron microscopy techniques (see Dworschak, 1998).

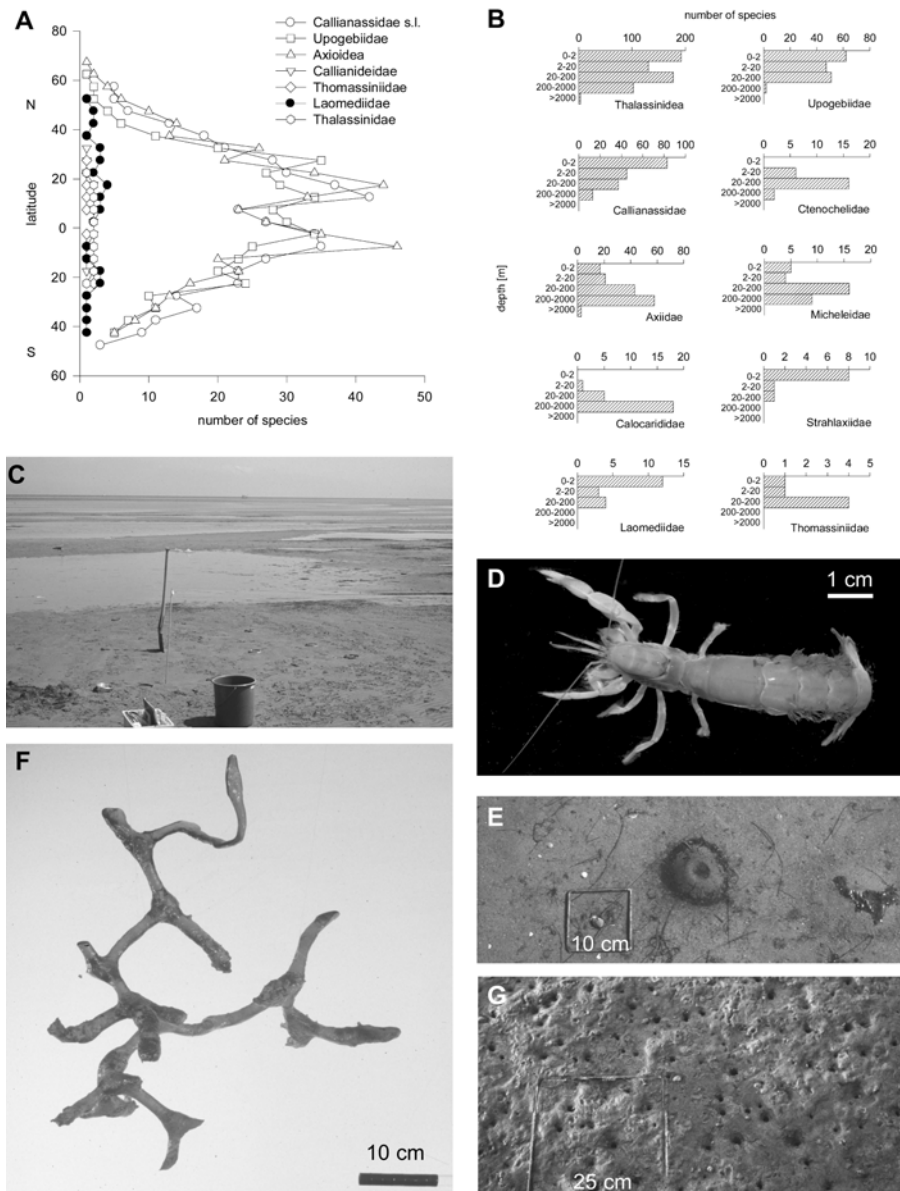


Fig. 1. (A) latitudinal distribution of species numbers in the thalassinidean (super)families. Data for bands of 5° latitude. (B) depth distribution of species numbers in thalassinidean families. (C) Lido di Staranzano (Northern Adriatic, Italy) during low tide. (D) Female *P. candida*. (E) resin cast of *P. candida* burrow, Lido di Staranzano. (F) burrow openings of *Pestarella candida*, Lido di Staranzano. (G) burrow openings of *Upogebia pusilla*, Lagoon of Grado (A, B from Dworschak, 2000; D, E from Dworschak, 2002).

3. Results and Discussion

3.1. Adriatic Sea

Here, in its northern part extensive tidal flats - as for instance that at Lido di Staranzano (Fig. 1C) - are exposed during low water. When walking from the high water line towards the sea we first encounter the burrow openings of a callianassid, *Pestarella* (formerly *Callianassa*) *candida* (Olivi, 1792) (Fig. 1D). Their burrow opening is characterised by a black mound; the second opening is often concealed (Fig. 1E). There are between 1 and 2 such mound per square meter. Their burrow are irregular with horizontal extension of up to 1 m and a

vertical extension of more than 60 cm (Dworschak, 2002)(Fig. 1F).

Further seawards, preferably in troughs, numerous burrow openings of another thalassinid, the upogebiid *Upogebia pusilla* (Petagna, 1792)(TL up to 65 mm) occur (Fig. 1G). Their burrow openings are simple holes (Fig. 2A), flush with the sediment surface in numbers of up to several hundreds per square meter (Dworschak, 1987c). The burrows are Y-shaped, consisting of a U or double-U and a shaft (Fig. 2B). They reach a depth of up to 80 cm (Dworschak, 1983). The burrow diameter is smaller than the rigid carapace of the animal; for changing direction within the burrow, enlargements are needed: the turning chambers. One such chambers occurs on each side of the U, one or more along the shaft. These chambers are also the place where the animals spend about 40% of their time for feeding (Fig.2C). The animals are mainly suspension feeders. Long setae on the P1 and P2 form a basket which intercepts suspended particles entering the burrow via the ventilation current created by intermittent beating of the pleopods. From time to time, the mxp3 wipes through the basket and transfers the particles to the remaining mouthparts. The animal can also be observed to come out of its burrow and browsing the sediment around its burrow opening (Dworschak, 1987a)(Fig. 2D). Due to the ventilation activity, the burrow wall throughout its length has the same tan colour as the oxidised sediment surface, whereas the surrounding reduced sediment appears black (Fig. 2E).

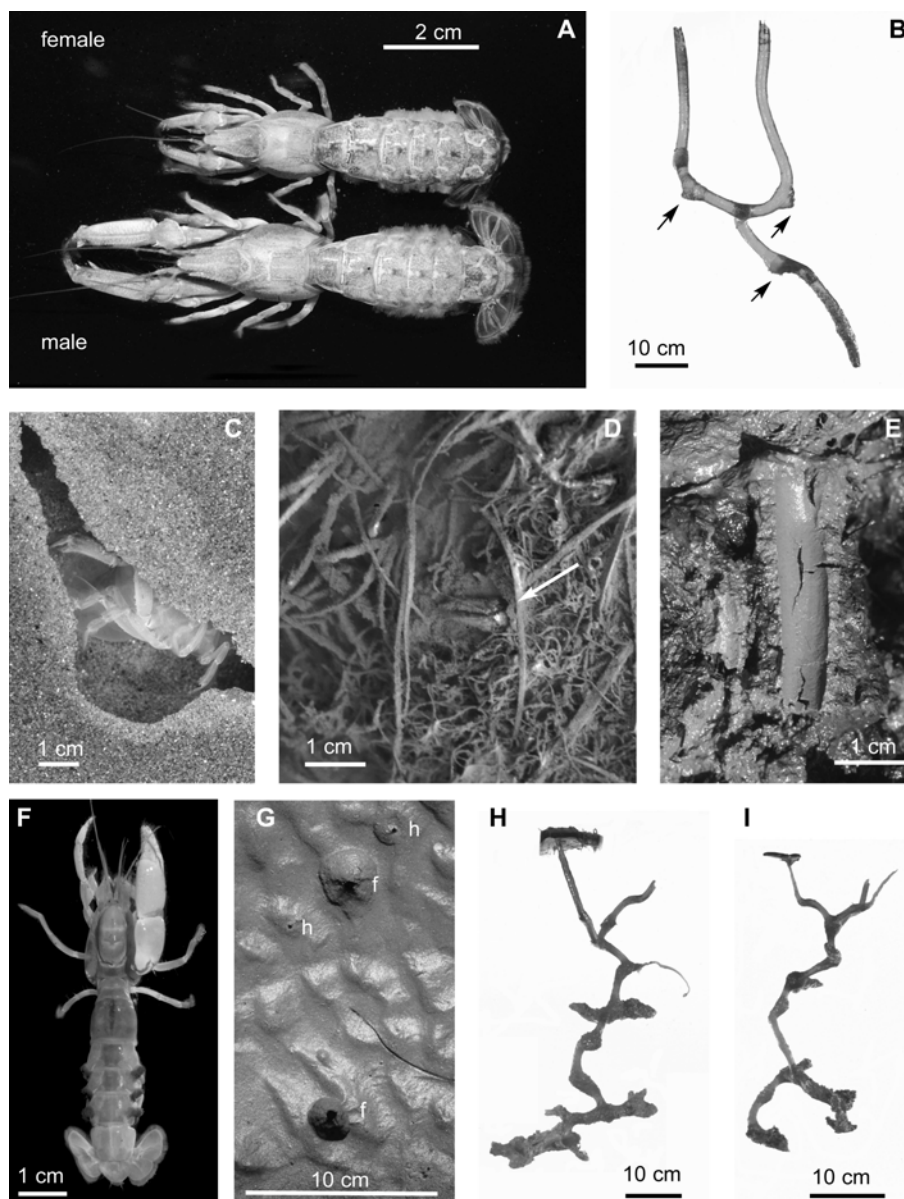


Fig. 2. (A) *Upogebia pusilla* in dorsal view. (B) resin cast of *U. pusilla* burrow, Lagoon of Grado, arrows point to turning chambers. (C) *U. pusilla* in turning chamber, laboratory. (D) *U. pusilla* browsing around burrow opening, Rovinj. (E) burrow wall of *U. pusilla*, Rovinj. (F) burrow opening of *Pestarella tyrrhena*, small holes (h) and funnels (f), Strunjan. (G) male *P. tyrrhena* in dorsal view. (H), (I) resin casts of *P. tyrrhena* burrows, Strunjan (H, I from Dworschak, 2001).

Near the low water line lives another callianassid, *Pestarella* (formerly *Callianassa*) *tyrrhena* (Petagna, 1792)(Fig. 2F). Their burrow openings are either funnels and a small hole nearby, or small mounds (Fig. 2G). Burrow openings occur in a density of up to 60 per square meter. The burrows consist of a single or multiple shallow U with thin shafts leading to the surface and a main central spiral shaft consisting of a series of enlarged chambers linked by other segments (Figs 2H, I). Burrows reach a depth of down to 62 cm. Several chambers filled with seagrass debris branch off (Dworschak, 2001)(Fig. 3A).

Burrow walls of these shrimps are sometimes better oxidized than the sediment surface between burrows (Fig. 3B). Preliminary counts of bacteria show, that there are higher numbers and biomass of bacteria especially in the debris chambers, where large rods can be found which do not occur in the sediment elsewhere (Dworschak, 2001).

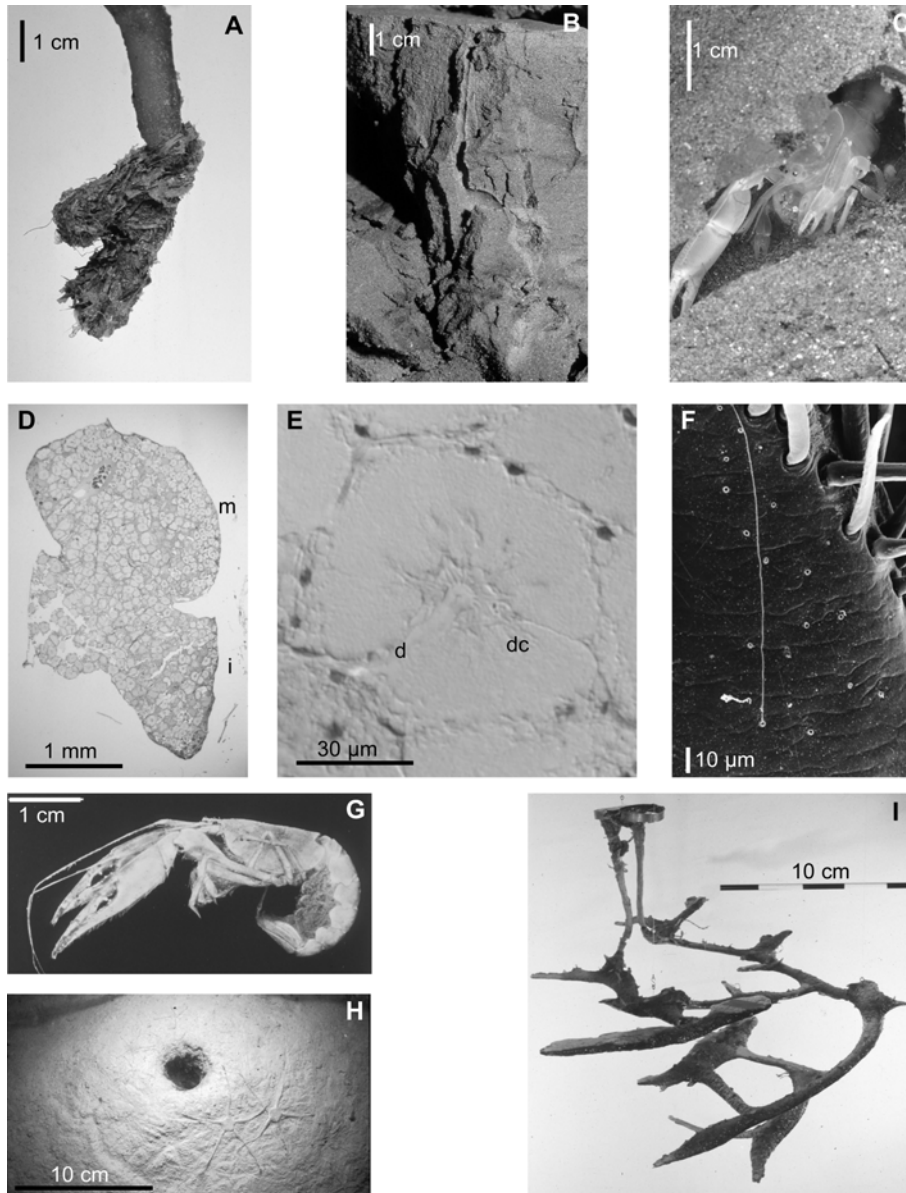


Fig. 3. (A) resin cast of *Pestarella tyrrhena* burrow, detail of debris chamber. (B) upper portion of *P. tyrrhena* burrow in longitudinal section showing oxidised burrow wall. (C) *P. tyrrhena* in the aquarium showing burrow wall lining (arrow). (D) *P. candida*, longitudinal section through central region of schium (i) and merus (m) of maxilliped 3. (E) *P. tyrrhena*, SEM photograph of inner surface of pereiopod 2 showing pores and mucus threads. (F) *P. candida*, pereiopod 3, cross section through central region of carpus showing one rosette gland with drainage canals (dc) and main duct (d). (G) ovigerous female *J. nocturna* in side view. (H) mound with burrow opening of *Jaxea nocturna*, Piran. (I) resin cast of *J. nocturna* burrow, Aurisina (A, B from Dworschak, 2001; D-F from Dworschak, 1998; G, I from Peresler & Dworschak, 1985).

Laboratory observations show that the animal is continuously changing its burrow by opening new tunnels and filling existing ones. The animal feeds obviously on organic matter in the sediment which is ingested directly (Fig. 3C). *Pestarella candida* and *P. tyrrhena* have been observed in aquaria to work sediment into the burrow wall while manipulating it with the mxp3, P 2 and P 3. Histological sections of the appendages involved in manipulating the burrow wall show numerous multicellular glands ("rosette glands")(Figs 3D, E). SEM investigations show numerous pores with mucus threads emanating from these pores (Fig. 3F). These observations suggest that mucus excreted from tegumental glands in mxp 3, P 2, and P 3 is used to stabilise the burrow wall (Dworschak, 1998).

Both *Pestarella tyrrhena* and *Upogebia pusilla* occur also in the shallow subtidal, the latter up to a depth of at least 6-7 m. Here, their burrows are much shallower than those from the intertidal, they have usually only one turning chamber on one side, the "shaft" has none.

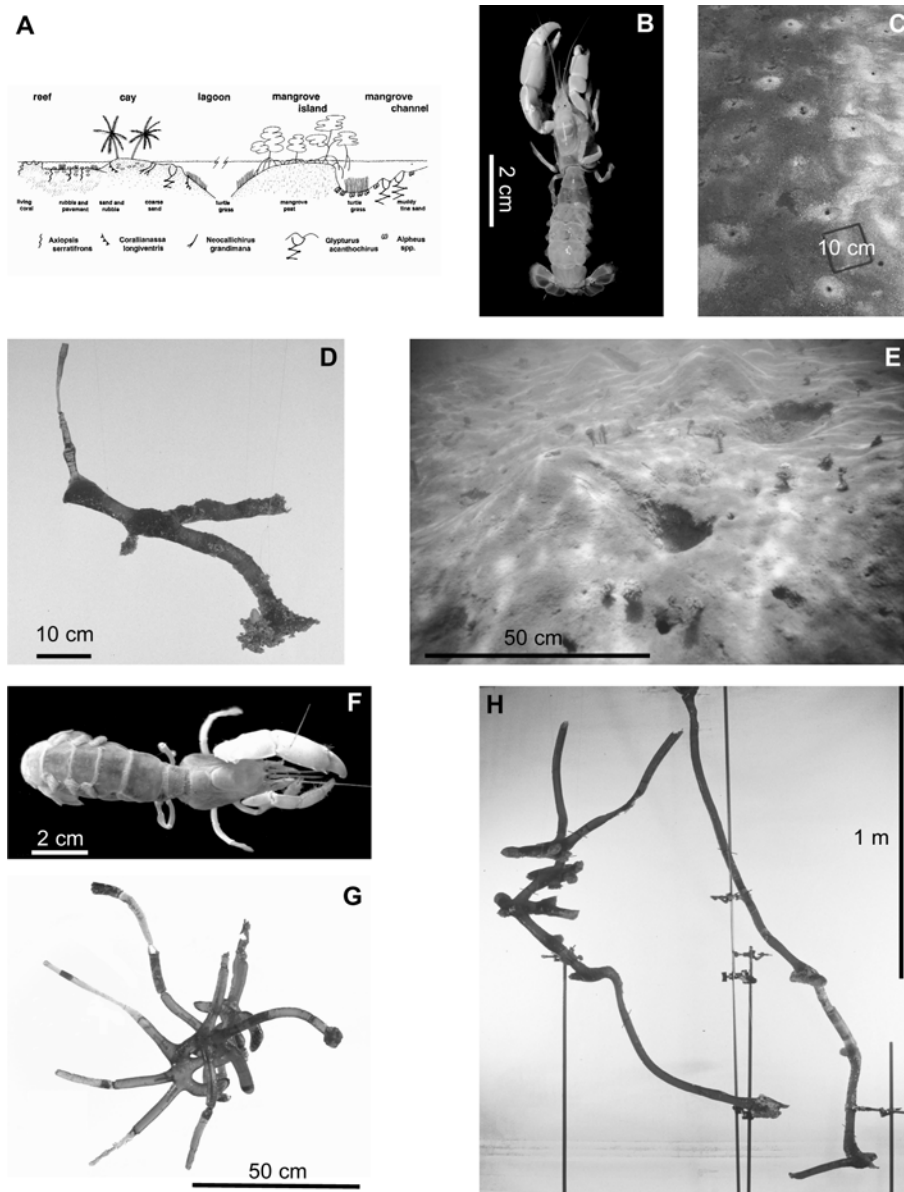


Fig. 4. (A) schematic burrow distribution in mangrove-channel and back-reef environments at Belize. (B) male *N. grandimana* in dorsal view. (C) burrow openings of *Neocallichirus grandimana*, South Water Cay. (D) resin cast of *N. grandimana* burrow in side view, South Water Cay. (E) mounds and funnels produced by *Glypturus acanthochirus*, Twin Cays. (F) male *G. acanthochirus* in dorsal view. (G) resin cast of *G. acanthochirus* burrow viewed from above, Twin Cays. (H) another resin cast of a *G. acanthochirus* burrow in side view, Twin Cays (A, D, E, G and H from Dworschak & Ott, 1993).

In deeper (below 9 m) muddy bottoms lives another species of *Upogebia*, which still often is confused with *U. pusilla*: *Upogebia tipica*. Resin casts show that their burrows differs from that of its congener in that it has a

very narrow U, with parallel parts, a very short shaft branching off one side and several protuberances above the turning chambers (Dworschak, 1987b).

In these muddy bottoms occurs another thalassinid, the laomediid *Jaxea nocturna* (Fig. 3G) whose burrows are characterized at the surface by a large mound and a funnel nearby (Fig. 3H). The burrow consists of two inclined or crossing J's, which - after joining - lead downwards in form of a spiral with several wide chambers (Pervesler & Dworschak, 1985)(Fig. 3I).

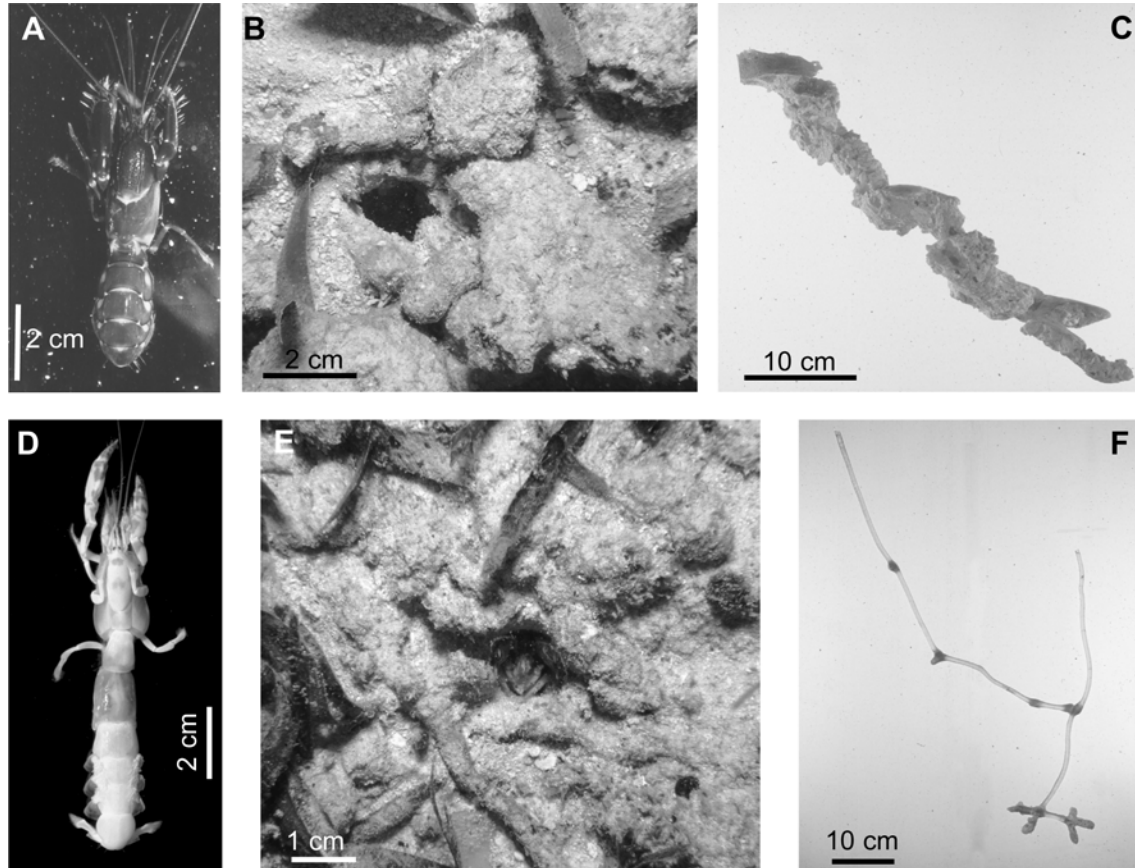


Fig. 5. (A) *Axiopsis serratifrons* in dorsal view. (B) burrow opening of *Axiopsis serratifrons*, Carrie Bow Cay. (C) resin cast of *A. serratifrons* burrow in side view, Carrie Bow Cay. (D) *Corallianassa longiventris* in dorsal view. (E) burrow opening of *Corallianassa longiventris* with specimen near opening. (F) resin cast of *C. longiventris* burrow in side view, Carrie Bow Cay (B, C, F from Dworschak & Ott, 1993).

3.2. Caribbean

Here, four species of thalassinideans occur in different habitats (Fig. 4A).

In the intertidal of Carrie Bow Cay and in higher numbers at the neighbour island South Water Cay lives *Neocallichirus grandimana* (Gibbes, 1850)(Fig. 4B), a large species with total length of up to 82 mm. The burrow openings are simple holes to small funnels in densities of up to 36 per square meter (Fig. 4C). The burrows are quite simple, consisting of a vertical thin shaft leading to wider horizontal galleries (Fig. 4D). The burrows reach a depth of 36 cm. The burrow wall is lined with fine-grained brown sediment. In the laboratory, the animal was a rapid burrower and completed a simple burrow within one day (Dworschak & Ott, 1993).

In mangrove channels of the nearby island Twin Cays lives another callianassid, *Glypturus acanthochirus* Stimpson, 1866. Its burrow are characterised on the sediment surface by large mounds and nearby funnels (Fig. 4E); often avalanches of sediment can be seen sliding from the mounds into the funnels. The large - total length up to 132 mm - animals (Fig. 4F) are difficult to catch, this can be best done with weighted lines. The burrows consist of a spiral with several radiating tunnels branching of the upper level, one of them leading to a funnel, the other to a mound (Figs 4G, H). The others are blocked and are either filled funnels or "irrigation tunnels". Deeper side branches are filled with coarse shell material (Dworschak & Ott, 1993). The animals feed on the material which enters the funnel, coarse particle are sorted out and stored away in blind tunnels. This sorting action makes it possible to catch the animal with a weighted line in which it gets entangled (de Vaugelas, 1985a).

These animals have a turnover rate of sediment of up to 0.5 kg (dw) per square meter and day at a density of 0.5 mounds per square meter as determined in the Red Sea congener *G. laurae* (de Vaugelas, 1985b).

The third species of thalassinidean can be found in shallow water characterised by rubble and sand at the edges of seagrass meadows. It is the axiid *Axiopsis serratifrons* (A. Milne-Edwards, 1873), a circumtropical species (total length up to 60 mm) (Fig. 5A). Its burrow opening is irregular, always surrounded by pieces of coral rubble (Fig. 5B). The black to brown shrimps which live in pairs can often be seen near the opening and can be baited with seagrass which they try to pull into their burrow. The cast shows a simple inclined slightly spiral burrow with chambers in different sediment depths (Fig. 5C). The burrow wall is unlined (Dworschak & Ott, 1993).

In the same habitat lives the fourth species, again a callianassid, *Corallianassa longiventris* (A. Milne-Edwards, 1870) (Fig. 5D). Its burrow openings are regular circular holes, which are often blocked. When open, the brightly coloured animals (total length up to 130 mm) can be seen near the opening (Fig. 5E) and can be baited with seagrass or meat which it tries to pull into its burrow. It could be observed catching seagrass blades floating by. The burrow is a deep U with short side branches and branched tunnels in depths of over 1 m (Fig. 5F). These deeper chambers are filled with seagrass blades and coarse sediment (Suchanek, 1985; Dworschak & Ott, 1993).

In the laboratory, *C. longiventris* also show this behaviour. If offered they pull seagrass into their burrows, cut them into pieces and store them in blind tunnels. We assume, that these plant debris and its microbial community play an important role in the nutrition of the shrimps. Several observations and analyses are currently underway to test the microbial gardening hypothesis: the debris chambers function as a fermenter - in which the animals as gardeners, foster the growth of a symbiotic microorganism community and thus exploit their broad enzymatic capabilities.

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