Decapod assemblage from the late Miocene (early-middle Messinian) of the Romagna Apennines nearby Brisighella, Emilia-Romagna (N Italy)

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Abstract - An assemblage of axiidean and brachyuran decapods is reported from the late Miocene pre-evaporitic (early-middle Messinian) limestone of Cò di Sasso, nearby Brisighella (Ravenna, Emilia-Romagna), located in Romagna Apennines (NE Italy). Except *Monodaeus bortolottii* Delle Cave, 1988 (Xanthidae MacLeay, 1838), which is reported here for the first time in Miocene, all the other specimens have been assigned to species previously known in the Italian Miocene (Messinian *s.l.*), but never reported in this area. The report of *Galathea* cf. *G. weinfurteri* Bachmayer, 1950 (Galatheidae Samouelle, 1819) and *Medorippe ampla* Garassino, De Angeli, Gallo & Pasini, 2004 (Dorippidae MacLeay, 1838) enlarges the stratigraphic range of these Miocene species. This report enlarges our limited knowledge on the composition and distribution of the axiidean, anomuran, and brachyuran decapods during the early-middle Messinian before the evaporitic event in the Mediterranean Basin.

Key words: Axiidea, Brachyura, late Miocene, Brisighella, Emilia-Romagna, Italy.

Riassunto - Associazione a decapodi del Miocene superiore (Messiniano inferiore-medio) dell'Appennino Romagnolo nei pressi di Brisighella, Emilia-Romagna (N Italia).

Viene descritta una associazione di crostacei axiidei e brachiuri provenienti dai calcari pre evaporitici del Miocene superiore (Messiniano inferiore-medio) rinvenuti nell'Appennino faentino presso Cò di Sasso, Brisighella (Ravenna, Emilia-Romagna, N Italia). Con l'eccezione di *Monodaeus bortolottii* Delle Cave, 1988 (Xanthidae MacLeay, 1838) che viene qui segnalata per la prima volta nel Miocene, gli altri esemplari studiati sono stati assegnati a specie già note nel Miocene italiano ma mai segnalate precedentemente in quest'area. La presenza di *Galathaea* cf. *G. weinfurteri* Bachmayer, 1950 (Galatheidae Samoulle, 1819) e *Medorippe ampla* Garassino, De Angeli, Gallo & Pasini, 2004 (Dorippidae MacLeay, 1838) amplia il record stratigrafico di queste specie mioceniche. Questa nuova segnalazione arricchisce le scarse conoscenze sulla composizione e distribuzione dei decapodi axiidei, anomuri e brachiuri durante il Messiniano inferiore-medio prima della crisi evaporitica del bacino Mediterraneo.

Parole chiave: Axiidea, Brachyura, Miocene superiore, Brisighella, Emilia-Romagna, Italia.

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INTRODUCTION AND GEOLOGICAL SETTING

The Romagna Apennine is characterized by an outcropping succession of autochthonous early Miocene to Pleistocene mainly siliciclastic deposits that represents the infill of a foredeep basin (Vai, 1989).

This Apennine margin is characterized, mainly in the western area, by the strong evaporitic outcrop of primary Lower Gypsum (first step of the Messinian Salinity from 5.96 to 5.61 Ma; Roveri *et al.*, 2008), the so-called Vena del Gesso romagnola, upper Messinian in age. Pre-evaporitic deposits crop out usually beneath the gypsum sequence. These deposits are composed by a unit straddling the Tortonian-Messinian boundary made up of finely-interbedded organic and diatomite rich laminites and mudstones, informally named "euxinic shales". Such deposits span a 1,2 million years' time interval (early Tortonian – early Messinian), show a cyclical pattern, and record the palaeoceanographic changes associated with the ensuing Messinian Salinity Crisis (started at 5.96 Ma). The topmost cycles are characterized by the development of thin carbonate layers (Roveri *et al.*, 2006).

In the Monte Mauro area (Brisighella, Ravenna), WSW of Cò di Sasso locality, the pre-evaporitic deposits, cropping out under the gypsum sequence, are represented by some metres of more or less marly limestones alternating with strongly altered marls in the upper part. The limestones are locally fossiliferous. Very common are the internal moulds of molluscs, above all gastropods of the family Nassaridae (*Nassarius* cf. *N. semistriatus*), and small bivalves of the family Lucinidae, assigned to *Myrtea* and *Anodontia*, that document particular conditions of the bottom with a high level of hydrogen sulphide (H_2S). A limestone layer, located in the upper part of the section, is highly fossiliferous: in addition to the above-mentioned molluscs, *Aporrhais serresiana*, *Yoldia* sp., *Cuspidaria* sp., *Poromya* sp., *Abra* sp., *Propeamussium duodecimlamellatum*, and decapod crustaceans have been recovered.

This invertebrate assemblage supports a rather deep marine environment (Sami & Taviani, 2019).

MATERIALS AND METHODS

With the exception of six specimens from Ca' Castellina (MSF 2300 to 2305), the studied sample has been collected near Cò di Sasso into the "Parco regionale della Vena del Gesso romagnola", located in Western Romagna Apennines (Ravenna, Emilia-Romagna, N Italy), from pre-evaporitic limestone assigned to the late Miocene (early-middle Messinian).

The specimens are mainly preserved as three-dimensional moulds of the interior, due to the dissolution of the original exoskeleton, or simply as external casts.

The specimens, with the exception of *M. bortolottii*, have been assigned to species already reported from the Italian Miocene.

The Axiidea de Saint Laurent, 1979, includes *Callianassa* cf. *C. subterranea* (Montagu, 1808) (6 specimens) and *Calliax* sp. (1 specimen) (Callianassidae Dana, 1852). The Anomura MacLeay, 1838, includes *Galathea* cf. *G. weinfurteri* Bachmayer, 1950 (Galatheidae Samouelle, 1819) (1 specimen). The Brachyura Linnaeus, 1758, includes *Medorippe ampla* Garassino, De Angeli, Gallo & Pasini, 2004 (Dorippidae MacLeay, 1838) (2 specimens), *Palaeomyra bispinosa* A. Milne Edwards *in* E. Sismonda, 1861 (Leucosiidae Samouelle, 1819) (6 specimens), *Monodaeus bortolottii* Delle Cave, 1988 (Xanthidae MacLeay, 1838) (13 specimens), *Goneplax* cf. *G. gulderi* Bachmayer, 1953 (Goneplacidae MacLeay, 1838) (8 specimens). Moreover, a single small carapace has been assigned to the Brachyura in generic way.

The studied specimens are housed in the Museo Civico di Scienze Naturali di Faenza (MSF).

For the higher-level classification, we follow the recent arrangement proposed by Ng *et al.* (2008), De Grave *et al.* (2009), and Karasawa *et al.* (2014).

Abbreviations

lcxp: carapace length;
lpr: propodus length (including index);
wcxp: carapace width;
wpr: propodus width.

SYSTEMATIC PALAEONTOLOGY

Order Decapoda Latreille, 1802
Infraorder Axiidea de Saint Laurent, 1979
Family Callianassidae Dana, 1852
Subfamily Callianassinae Dana, 1852
Genus *Callianassa* Leach, 1814

Type species: *Cancer* (*Astacus*) *subterraneus* Montagu, 1808, by original designation.

Callianassa cf. *C. subterranea* (Montagu, 1808)
Fig. 1A

Material and measurements: six incomplete propodi in lateral view (MSF 2302 – lpr: 10 mm; wpr: 6 mm; MSF 2303 – lpr: 9 mm; wpr: 4 mm; MSF 2304 – lpr: 10 mm; wpr: 6 mm; MSF 2306 – lpr: 7 mm; wpr: 3 mm; MSF 2312 – lpr: 7 mm; wpr: 3 mm; MSF 2313 – lpr: 11 mm; wpr: 6 mm).

Description. Propodus with palm longer than high; upper and lower margins almost straight and divergent; outer surface slightly raised and smooth; elongate index, narrow and curved distally; occlusal margin smooth, without teeth.

Discussion. The general shape of the studied propodi fits the distinctive proxy characters of *Callianassa* Leach, 1814 and mainly with the major propodus of some callianassids close to *C. subterranea* (Montagu, 1808), to which the studied specimens are tentatively compared. This species has been described in the fossil record from the Helvetian (middle Miocene) of Albugnano (Piedmont), the Miocene *s.l.* of Sardinia (Crema, 1895; Lőrenthey, 1909), and the Messinian (late Miocene) of Rio Popogna (Livorno, Tuscany) (De Angeli *et al.*, 2009).

Calliax sp.
Fig. 1B

Material and measurements: one incomplete propodus in lateral view, in part and counterpart (MSF 1157 – 1157bis – lpr: 9 mm; wpr: 5 mm).

Description. One elongate major subrectangular cheliped poorly preserved, having, flattened transversally palm,

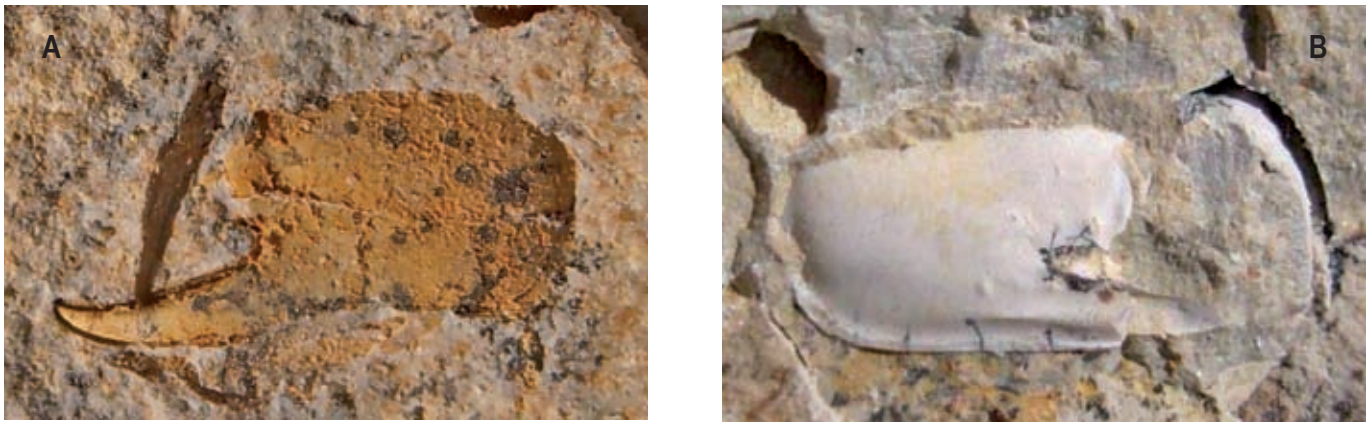

Fig. 1 - A) *Callianassa* cf. *C. subterranea* (Montagu, 1808), MSF 2302 (x 6.5). B) *Calliax* sp., MSF 1157 (x 7.7).

with a faint marginal ridge; triangular, elongate index with a median denticle on the median of the occlusal margin.

Discussion. The general shape of the flattened palm and the nearly straight index bearing median denticle, suggest closer affinities with some species related to *Calliax* de Saint Laurent, 1973, to which the studied specimen has been assigned.

Infraorder Anomura MacLeay, 1838
Superfamily Galatheoidea Samouelle, 1819
Family Galatheidae Samouelle, 1819

Genus *Galathea* Fabricius, 1793

Type species: *Cancer strigosus* Linnaeus, 1761, by subsequent designation by Latreille (1810).

Galathea cf. *G. weinfurteri* Bachmayer, 1950
Fig. 2A

Material and measurements: One incomplete carapace (MSF 2337 – lcxp: 5 mm, wcxp: 5 mm).

Description. Carapace subrectangular, slightly voulted transversely, lacking the rostrum; anterior and lateral margins poorly preserved. Cervical groove distinct, V shaped, diverging frontally. Carapace ornamented with undulate striae, crossing tranversely the dorsal surface, well separated each to others, and alternate by some lateral shorter striae.

Discussion. Though the specimen is poorly preserved lacking of the distinctive specific characters of front and rostrum, some proxy characters of the carapace ornamentation allow us to compare the studied specimen to *Galathea weinfurteri* Bachmayer, 1950, from the Miocene of Paratethys and Mediterranean basin according to Hyžný *et al.* (2014: 244). Indeed, the studied specimen shares with *G. weinfurteri* some characters such as the *carapace subrectangular slightly voulted transversely; cervical groove deep; anterior and posterior branchs equally incisive; carapace ornamented with transverse striae; two postfrontal striae, curved in median part and interrupted by short groove* (Hyžný *et al.,* 2014: 244). This species has also been reported from the early Oligocene (Rupelian) of Valmarana (Vicenza) (De Angeli & Garassino, 2002). Fossil representatives of *Galathea* are commonly associated with reef communities. The extant Atlantic-Mediterranean representatives of the genus inhabits rock bottoms with corals or hydrozoans, or *Posidonia* grasslands ranging from a depth of a few metres to 750 metres.

Infraorder Brachyura Linnaeus, 1758
Section Eubrachyura de Saint Laurent, 1980
Superfamily Dorippoidea MacLeay, 1838
Family Dorippidae MacLeay, 1838

Genus *Medorippe* Manning & Holthuis, 1981

Type species: *Cancer lanatus* Linnaeus, 1767, by monotypy.

Medorippe ampla Garassino, De Angeli, Gallo & Pasini, 2004
Fig. 2B

Medorippe ampla Garassino, De Angeli, Gallo & Pasini, 2004: 260-262, figs. 5, 6a, b.

Medorippe ampla – De Angeli & Garassino 2006: 40. — De Angeli *et al.* 2009: 174, fig. 6. — Schweitzer *et al.* 2010: 79.

Material and measurements: Two carapaces in dorsal view (MSF 2301 – lcxp: 14 mm, wcxp: 15 mm; MSF 2317 – lcxp: 15 mm, wcxp: 16 mm).

Discussion. Though both specimens are preserved as moulds of the interior, some main proxy characters of the carapace of one specimen (MSF 2317) allow us to assign them to *Medorippe* Manning & Holthuis, 1981, in having a subhexagonal convex carapace; divergent anterolateral margins; sinuous posterior margin, slightly convex at the intestinal margin; dorsal regions well marked by grooves; deep cervical groove joining branchial grooves laterally; sinuous branchial grooves joining groove dividing urogastric from cardiac region; and well-developed hepatic regions. Moreover, the carapace is wider than long, the narrow front with two short lobes, the well-developed and elongate extraorbital teeth and the presence of (?granulate) carinae on hepatic, branchial, and supraorbital regions, are all peculiar characters that distinguish *Medorippe ampla* from the extant and fossil type species *M. lanata*, reported from the Pleistocene of Sicily (Gemmellaro, 1914) (Garassino *et al.*, 2004: 262). Based on these distinctive characters the studied specimens are confidently ascribed to *M. ampla* Garassino, De Angeli, Gallo & Pasini, 2004.

Medorippe ampla was previously reported from the late Miocene (Messinian) of Cocconato (Asti, Piedmont) and from the Rio Popogna (Livorno, Tuscany) (Garassino *et al.*, 2004; De Angeli *et al.*, 2009).

Superfamily Leucosioidea Samouelle, 1819
Family Leucosiidae Samouelle, 1819

Genus *Palaeomyra* A. Milne Edwards *in* E. Sismonda, 1861

Type species: *Palaeomyra bispinosa* A. Milne Edwards *in* E. Sismonda, 1861

Palaeomyra bispinosa A. Milne Edwards *in* E. Sismonda, 1861
Fig. 2C

Palaeomyra bispinosa A. Milne Edwards *in* E. Sismonda, 1861: 16, figs. 18-20.

Palaeomyra bispinosa – Glaessner 1969: R498. — Garassino *et al.* 2004: 267, 268, figs. 9, 10a, b. — De Angeli & Garassino 2006: 46. — Schweitzer *et al.* 2010: 91.

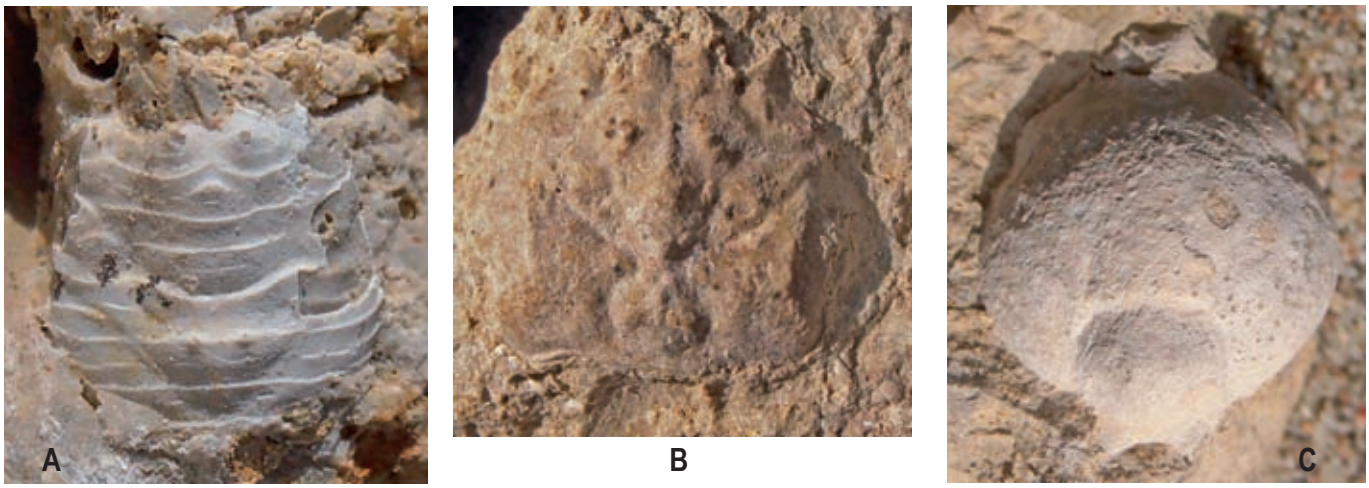

Fig. 2 - A) *Galathea* cf. *G. weinfurteri* Bachmayer, 1950, MSF 2337 (x 3.1). B) *Medorippe ampla* Garassino, De Angeli, Gallo & Pasini, 2004, MSF 2317 (x 8). C) *Palaeomyra bispinosa* A. Milne Edwards *in* E. Sismonda, 1861, MSF 2314 (x 3).

Material and measurements: Six complete carapaces in dorsal view (MSF 1171 – lcxp: 9 mm, wcxp: 9 mm; MSF 2314 – lcxp: 15 mm, wcxp: 13 mm; MSF 2321 – lcxp: 6 mm, wcxp: 5 mm; MSF 2322 – lcxp: 8 mm, wcxp: 6 mm; MSF 2323 – lcxp: 14 mm, wcxp: 13 mm; MSF 2324 – lcxp: 10 mm, wcxp: 8 mm).

Discussion. The studied specimens are confidently assigned to *Palaeomyra bispinosa* A. Milne Edwards *in* E. Sismonda, 1861 in having a globose subrounded carapace covered by irregular small tubercles; bilobate front; small rounded orbits; deep gastro branchial groove; suboval rounded cardiac region; and posterolateral corners with an elongate spine.

The species was described by A. Milne Edwards *in* E. Sismonda (1861) from the Miocene sandstone of the hills around Torino (Piedmont, NW Italy), and later reported from the Oligocene of Morbello, Alessandria, and the Miocene of Cocconato (Asti, Piedmont) by Garassino *et al*. (2004).

Superfamily Xanthoidea MacLeay, 1838
Family Xanthidae MacLeay, 1838
Subfamily Euxanthinae Alcock, 1898
Genus *Monodaeus* Guinot, 1967

Type species: *Xanto couchii* Couch, 1815, by original designation.

Monodaeus bortolottii Delle Cave, 1988
Fig. 3A

Monodaeus bortolottii Delle Cave, 1988: 123-126, Pl. 1, figs. 1, 2, Pl. 2, figs. 1-5.

Monodaeus bortolottii – De Angeli & Garassino 2006: 74. — De Angeli *et al.* 2009: 185, 195, fig. 16. — Schweitzer *et al.* 2010: 126. — Garassino *et al.* 2012: 52. — Baldanza *et al.* 2013: 347, 348, fig. 13. — Pasini & Garassino 2013a: 325, 326, fig. 5. — Pasini & Garassino 2013b: 344, 345, fig. 2. — Pasini *et al.* 2014: 254, 255, fig. 9B. — Baldanza *et al.* 2017: 60, 61, fig. 15C. — Pasini *et al.* 2018: 31, fig. 3A.

Material and measurements: 13 carapaces in dorsal view (MSF 2300 – lcxp: 18 mm, wcxp: 26 mm); MSF 2307 – lcxp: 16 mm, wcxp: 22 mm; MSF 1154 – lcxp: 20 mm, wcxp: 28 mm; MSF 2309 – lcxp: 13 mm, wcxp: 18 mm; MSF 2315 – lcxp: 10 mm, wcxp: 14 mm; MSF 2318 – lcxp: 6 mm, wcxp: 9 mm; MSF 2325 – lcxp: 10 mm, wcxp: 13 mm; MSF 2326 – lcxp: 9 mm, wcxp: 12 mm; MSF 2327 – lcxp: 17 mm, wcxp: 24 mm; MSF 2328 – lcxp: 12 mm, wcxp: 14 mm; MSF 2329 – lcxp: 13 mm, wcxp: 15 mm; MSF 2330 – lcxp: 7 mm, wcxp: 9 mm; MSF 2331 – lcxp: 6 mm, wcxp: 8 mm).

Discussion. The studied specimens have been assigned to *Monodaeus bortolottii* Delle Cave, 1988 in having a slightly convex suboctagonal carapace, wider than long; straight front margin, with a weak median incision; short convex anterolateral margin; long convergent posterolateral margin; posterior margin straight medially; dorsal region well marked by grooves, with wide raised epigastric lobes; well-marked suboval protogastric regions; subpentagonal mesogastric regions with narrow, elongate anterior process between protogastric regions; cardiac region well marked by branchiocardiac grooves; small poorly marked hepatic regions; and wide, well-marked, branchial regions.

Monodaeus bortolottii has been previously reported from the Pliocene of Volterra (Delle Cave, 1988) and Grosseto (De Angeli *et al.*, 2009). Later Pasini & Garassino (2013a, b) and Garassino, Hyžný & Pasini *in* Baldanza *et al.* (2013) reported this species from the Pliocene (Piacenzian) of Castellarano and Monticelli di Quattro Castella (Reggio Emilia, Emilia-Romagna), from the early Pliocene of Cassine (Alessandria, Piedmont), and from the early Pleistocene of the Poggio i Sodi (Siena, Tuscany). Later Pasini *et al.* (2014) reported *M. bortolottii* from the early Pleistocene of Volterra (Pisa, Tuscany), close to the type locality originally reported by Delle Cave (1988). Recently this species has been reported also from the early Pleistocene of Poggi Gialli (Sinalunga, Tuscany) by De Angeli, Garassino & Pasini *in* Baldanza *et al.* (2017), and from the Pliocene of Faenza (Ravenna, Emilia-Romagna) (Pasini *et al.,* 2018). This is the first

record of this species in the Miocene, notably enlarging its stratigraphic range.

Superfamily Goneplacoidea MacLeay, 1838
Family Goneplacidae MacLeay, 1838
Subfamily Goneplacinae MacLeay, 1838

Genus *Goneplax* Leach, 1814

Type species: *Ocypoda bispinosa* Lamarck, 1801 [= *Goneplax rhomboides* (Linnaeus, 1758)], by original designation.

Goneplax cf. *G. gulderi* Bachmayer, 1953
Fig. 3B

Material and measurements: Eight carapaces in dorsal view (MSF 2305 – lcxp: 8 mm, wcxp: 11 mm; MSF 2308 – lcxp: 8 mm, wcxp: 13 mm; MSF 2310 – lcxp: 11 mm, wcxp: 15 mm; MSF 2319 – lcxp: 4 mm, wcxp: 5 mm; MSF 2320 – lcxp: 8 mm, wcxp: 10 mm; MSF 2332 – lcxp: 4 mm, wcxp: 6 mm; MSF 2333 – lcxp: 12 mm, wcxp: 16 mm; MSF 2334 – lcxp: 10 mm, wcxp: 17 mm).

Discussion. The studied specimens fit the characters of *Goneplax* Leach, 1814 in having the typical dorsal carapace proxy characters *sensu* Schweitzer (2003) as pointed out by Garassino *et al.* (2013: 357). Moreover, according to Garassino *et al.* (2013: 357), the subtrapezoidal carapace with the frontal margin nearly as wide as the orbits and the dorsal surface of carapace, with raised transverse ridges suggest comparison with *G. gulderi* Bachmayer, 1953.

Indeed, the general carapace shape and ornamentation of the studied specimens is very similar to the specimen reported from the late Miocene of Rio Popogna (Livorno, Tuscany) (De Angeli *et al.*, 2009: 187, Fig. 18A). This species has been previously recorded in Italy from the Miocene and Pliocene of Piedmont, Tuscany, and Sardinia (for updated list, see Garassino *et al.*, 2013).

Family, genus and species indet.
Fig. 3C

Material and measurements: One small carapace in dorsal view (MSF 2316 – lcxp: 3 mm, wcxp: 3 mm).

Discussion. The studied specimen shows some general dorsal proxy characters that do not seem to fit into any brachyuran described to date, such as the great development of the undifferentiated branchial regions and single posterior smooth transversal ridge. However, the tiny size of the carapace (most probably an immature individual) and the poorly preserved frontal and anterolateral margins do not allow close comparisons. Therefore, the specimen is simply assigned to the Brachyura in a generic way.

CONCLUSIONS

The studied assemblage is the first useful record of the scarcely reported decapod communities living in the Mediterranean just before the late Miocene evaporitic event that, following the interrupted connection with the Atlantic Ocean, dramatically affected the sea basin with significant ecological repercussions.

The burrowing ghost shrimps are represented by incomplete, poorly preserved propodi, attributable to *Callianassa* cf. *C. sutberranea* and *Calliax* sp.

The stratigraphic range of *Monodaeus bortolottii* is enlarged to the Miocene, representing the oldest record for the genus from Italy.

Fig. 3 - A) *Monodaeus bortolottii* Delle Cave, 1988, MSF 2300 (x 2.6). B) *Goneplax* cf. *G. gulderi* Bachmayer, 1953, MSF 2332 (x 10). C) Family, genus and species indet., MSF 2316 (x 16.6).

The distribution range of *Galathea* cf. *G. weinfurteri*, *Palaeomyra bispinosa* (in general scarcely reported), *Medorippe ampla* and *Goneplax* cf. *G. gulderi* Bachmayer, 1953 is enlarged to the eastern coasts of the paleo Adriatic Gulf and at the same time, these species are reported for the first time from the Emilia-Romagna.

The poor preservation of the specimens, limited to loosen propodi and single disarticulated carapaces, indicates that the studied assemblage was most probably not representative of the real original bio-community, but seems to be originated by burial events and post-mortem transportation of the specimens in a reworked environment.

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