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 bortolotti 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, Miocene superiore, Brisighella, Emilia-Romagna, Italia.

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 calcarri pre evaporitici del Miocene superiore (Messiniano inferiore-medio) rinvenuti nell’Appennino fuentino presso Cò di Sasso, Brisighella (Ravenna, Emilia-Romagna, N Italia). Con l’eccezione di Monodaeus bortolotti 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 Galathea cf. G. weinfurteri Bachmayer, 1950 (Galatheidae Samouelle, 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.

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 mouds 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 (H₂S). 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 duodecimla-mellatum, 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; Lörenthey, 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,
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 *Calliclax* 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

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

**Description.** Carapace subrectangular, slightly voutted 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 voutted transversely; cervical groove deep; anterior and posterior branches 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.

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

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**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 bortolotti* Delle Cave, 1988

Fig. 3A

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

*Monodaeus bortolotti* – 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.

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**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: 15 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: 9 mm; MSF 2326 – lcxp: 15 mm; MSF 2327 – lcxp: 17 mm, wcxp: 24 mm; MSF 2328 – lcxp: 12 mm, wcxp: 14 mm; MSF 2329 – lcxp: 13 mm, wcxp: 7 mm, wcxp: 9 mm; MSF 2331 – lcxp: 6 mm, wcxp: 8 mm).

**Discussion.** The studied specimens have been assigned to *Monodaeus bortolotti* 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 bortolotti* 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 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. bortolotti* 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

**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.

**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. subterranea* and *Calliass* sp.

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

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**Fig. 3**

A) *Monodaeus bortolotti* 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), *Medoriippe ampla* and *Goneplax* cf. *G. guilderi* 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 loose 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.

**Acknowledgements**

We wish to thank the Museo Civico di Scienze Naturali di Faenza for permission to study the specimens and Mathus Hyžný, Department of Geology and Paleontology, Faculty of Natural Sciences, Comenius University, Bratislava, Slovakia for useful suggestions on the Callianassidae specimens, Rodney M. Feldmann, Kent State University, Kent, Ohio, USA and Francisco Vega Instituto de Geología, Universidad Nacional Autónoma de México, Coyoacán, Mexico for careful review and criticism.

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