

NEW REPORT OF DECAPOD AND ISOPOD CRUSTACEANS FROM THE LOWER-MIDDLE PLEISTOCENE OF MONTALBANO JONICO, MATERA (BASILICATA, SOUTHERN ITALY)

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Abstract. The study of the Lower-Middle Pleistocene decapod crustacean fauna from Montalbano Jonico succession allowed 12 taxa to be recognized. The studied samples include some fossil species already known from the Pleistocene record of Italy, as *Ebalia nux* A. Milne-Edwards, 1883, *Monodaus bortolotti* Delle Cave, 1988, *Liocarcinus depurator* (Linnaeus, 1758), *Goneplax rhomboides* (Linnaeus, 1758), and *Chlinocephalus demissifrons* Ristori, 1886. These species are reported for the first time from Basilicata, except for *E. nux*, whereas *Carcinoplax jonica* n. sp. and *Neogoneplax bradanica* n. sp. are introduced as new species. Moreover, one poorly preserved specimen is assigned to *Ebalia* sp.; one dubitative specimen to ?*Carcinus* sp.; one specimen to *Bathycalliax* sp. (Axiidea de Saint Laurent, 1979); one to an indeterminate galatheid; and two poorly preserved large-sized specimens are tentatively referred to *Carcinoplax* sp. (Goneplacidae, MacLeay, 1838). Finally, several indeterminate specimens of cirrolanid (Isopoda) are reported, as well.

The studied decapod community from Basilicata allows us to expand our knowledge of Pleistocene fossil crabs and their distribution around the Mediterranean Sea basin in the Lower-Middle Pleistocene.

INTRODUCTION

The fossil record of decapod crustaceans from Basilicata is very scarce; occurrences of Lower-Middle Pleistocene specimens are documented from Montalbano Jonico (Matera, southern Italy). Soldani & Girone (2000: 118), reported *Ebalia nux*

A. Milne-Edwards, 1883 while Ciaranfi et al. (2001: 78, Fig. 11a-d), figured two brachyuran specimens informally reported as *Goneplax rhomboides* (Linnaeus, 1758), one reported as *Ebalia* sp., and one as an indeterminate ‘shrimp’. Finally, D’Alessandro et al. (2003: 170; Figs. 5, 7, 10, 12), simply figured *Ebalia nux*, *Goneplax rhomboides*, *Geryon* sp. and one indeterminate ‘small shrimp’, without providing descriptions and discussions of these specimens (see remarks in the section Systematic palaeontology).

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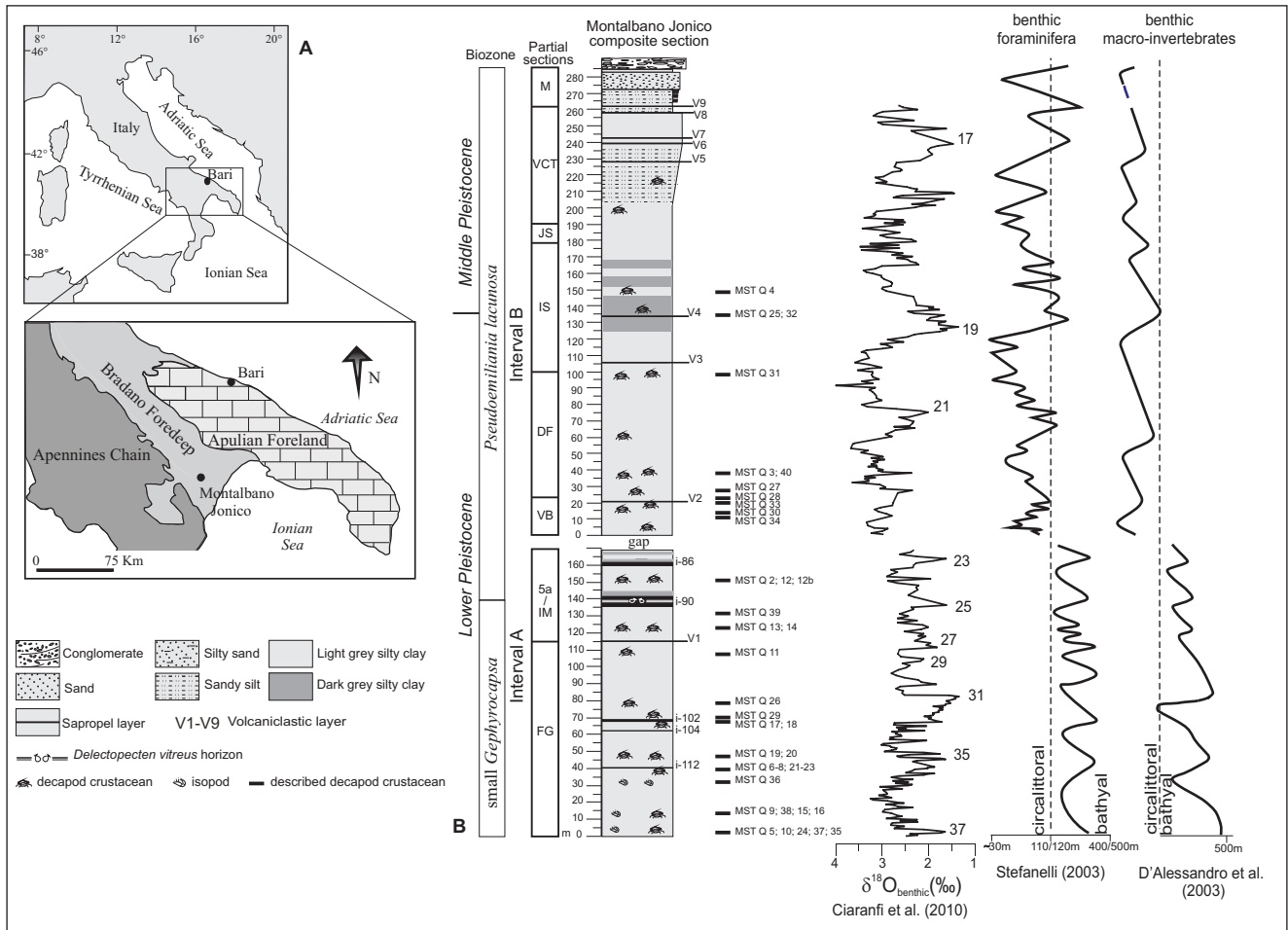


Fig. 1 - A) location of the study area and schematic geological map; B) main lithological features of Montalbano Jonico composite section (Intervals A and B) with stratigraphic position of the studied samples (MST Q2-40) and correlation with paleoenvironmental and oxygen isotope data.

The present paper aims to provide a more detailed study of the rich decapod crustacean fauna collected during the controlled digs carried out at Montalbano Jonico by researchers of the Scienze della Terra e Geoambientali Department of Bari University Aldo Moro (UNIBA). In this area, a clayey marine succession has been reconstructed in a regional protected area named the Special Natural Reserve of the Montalbano Jonico badlands. Montalbano Jonico Section (MJS) consists of the latest phase of marine deposition in the Pliocene-Pleistocene Southern Apennines Foredeep (Ciaranfi et al. 2010). It includes the “Ideale section,” which provides key evidence of global climate evolution across the Lower-Middle Pleistocene transition and, recently nominated as the Standard Auxiliary Boundary Stratotype (SABS) of the Middle Pleistocene Subseries (Subcommission on Quaternary Stratigraphy, July 9, 2023, Marino et al. 2024).

The species described herein allowed us to increase the scarce knowledge on decapod crustacean fauna from Basilicata and to provide its correlation with other Italian Pleistocene assemblages reported to date from the Mediterranean Basin.

GEOLOGICAL SETTING

The Montalbano Jonico section (MJS) crops out about 15 km inland from the Ionian Coast (southern Italy). The area is largely represented by the argille subappennine informal lithostratigraphic unit (Azzaroli et al. 1968) belonging to the post-Messinian Southern Apennines Foredeep (Bradanic Trough, e.g. Casnedi 1988); from a geological point of view the area rests between the Apennines Chain to the west and the Apulia foreland to the east (Fig. 1A). The origin and evolution of the

Bradanic Trough was due to the eastwards roll-back of the subduction hinge of the Apulia Foreland and the evolution of the external Apennines accretionary wedge during the Plio-Pleistocene (e.g., Patacca & Scandone 2007 and references herein). In the late Calabrian, the central sector of the Bradanic Trough emerged while the southern sector, where the Montalbano Jonico area was located, was still subsiding, reaching its maximum deepening in the Early-Middle Pleistocene (e.g. Ciaranfi et al. 2010). Since the Middle Pleistocene, the sedimentary succession of this portion of the Bradanic Trough has been recording a shoaling upwards evolution with an uplift rate of 0.1–0.8 mm/year (Doglioni et al. 1996; Westaway & Bridgland 2007). The sandy and conglomerate deposits of transitional and continental environments of the marine terraced deposits unconformably overlying the argille subappennine in the Taranto Gulf hinterland testify to the gradual emersion of the Bradanic Trough and its interaction with Quaternary glacio-eustatic sea-level changes from the Middle Pleistocene to the present (e.g., Pieri et al. 1996; Pescatore et al. 2009).

The reconstructed MJS, Early to Middle Pleistocene in age (Ciaranfi et al. 2001; 2010), is about 450 m thick and represents the middle-upper portion of the argille subappennine. It consists of a coarsening-upwards sedimentary succession ranging from silty clays to silty sands and includes nine tephra layers (V1-V9) (Fig. 1B) and five dark horizons interpreted as sapropel layers (D'Alessandro et al. 2003; Stefanelli 2004; Maiorano et al. 2008); Fig. 1B. A short stratigraphical gap divides the MJS into two parts: a lower interval A, 168 m thick, and an upper interval B, 280 m thick (Fig. 1B). The whole section has been reconstructed using several partial stratigraphic sections (named Fosso Giuseppe, I.M./5 agosto, Venus bassa, Dito del Diavolo, Ideale, Salvatore-Vecchietto and Molino) including volcanoclastic layers, diagnostic macrobenthic assemblages and calcareous plankton biostratigraphic data (Ciaranfi et al. 2001; D'Alessandro et al. 2003; Stefanelli 2003; Girone et al. 2013; Maiorano et al. 2004, 2008, 2010, 2016; Ciaranfi et al. 2010). The calcareous nannofossil biostratigraphy indicates that the entire succession belongs to the small *Gephyrocapsa* and *Pseudoemiliana lacunosa* zones, based on the biostratigraphic scheme of Rio et al. (1990) (Fig. 1B). Several deepening-shallowing cycles, from outer shelf to upper slope environments, have been

recognized based on micro- and macro-invertebrate benthic assemblages (D'Alessandro et al. 2003; Stefanelli 2003; Ciaranfi & D'Alessandro 2005; Girone 2005). Specifically, benthic paleocommunities from the lower part of the succession (interval A) indicate upper slope environments, with a maximum depth of ca. 500 m (Fig. 1B). In contrast, paleocommunities of upper portion (interval B) point out to outer to inner shelf settings with short-term deepening towards upper slope (Fig. 1B). Stable oxygen isotope analyses performed throughout the section on planktonic and benthic foraminifera combined with calcareous plankton biostratigraphy, radiometric Ar/Ar data of V3, V4 and V5, and sapropel stratigraphy recognized the MIS 37 to MIS 17/16 time interval (Fig. 1B) and allowed the astronomical calibration of MJS, ranging from 1.240 Ma to 0.645 Ma (Ciaranfi et al. 2010; Maiorano et al. 2010, Nomade et al. 2019). A sapropel interval has been identified within MIS 19c and correlated to i-cycle 74 (Maiorano et al. 2016; Nomade et al. 2019). Recently, a large-scale geological map in the Special Natural Reserve of the Montalbano Jonico badlands has been published (Gallicchio et al. 2023) which provides details on the geometry and spatial relationships between the main stratigraphical and structural features of the MJS.

MATERIAL AND METHODS

The studied crustacean specimens were collected from both intervals (A and B) of MJS. Most specimens were collected during excavation operations, combined with taphonomic observations throughout the MJS (D'Alessandro et al. 2003) and sampling for micro- and macro-paleontological analyses. Scarce, small-sized material was also obtained from bulk samples collected for the study of otolith assemblages (Girone & Varola 2001; Girone 2005). The specimens are usually three-dimensionally preserved or dorso-ventrally compressed, sometimes with minor pyrite mineralization. They are embedded in small-sized irregular blocks of muddy to sandy sediments. Preparation of specimens, where needed, was done with needles and brushes. The examined specimens have been collected at different stratigraphic layers of the partial sections Fosso Giuseppe (FG), IM/5 agosto (IM/5a), Venus bassa (Vb), Dito del Diavolo (DD), Ideale Section (IS) (Fig. 1B). The specimens MST Q2, MST Q12 and MST Q12b have been collected at Cocuzzolo section outcropping in the Montalbano area and not used for the reconstruction of the whole section. Still, it is correlated with a well-defined interval of the IM/5a section.

Photographs were captured using a Canon EOS90D camera with a Canon EF 100mm f/2.8 L Macro IS USM lens, and through a Nikon SMZ 745T microscope, equipped with a Digital Sight DS-F11c camera managed by the NIS-Elements program. For the microscope photos, the focus stacking technique was used using the Affinity Photo program.



Fig. 2 - *Bathycalliax* sp. MST Q2 (level CUC19 – Lower Pleistocene), major cheliped, lateral view.

Anatomical abbreviations: lcxp: carapace length; lindex: index length; lp: palm length; hp: palm height; P1-P5: pereopods 1 to 5; s3-s6: pleonal somites 3 to 6; wcxp: carapace width.

Institutional abbreviation: MST: Museo di Scienze della Terra (Dipartimento di Scienze della Terra e Geoambientali, Università degli Studi di Bari Aldo Moro)

SYSTEMATIC PALAEOLOGY

Infraorder **Axiidea** de Saint Laurent, 1979

Family Callianopsidae Manning & Felder, 1991

Genus *Bathycalliax* Sakai & Türkay, 1999

Type species: *Bathycalliax geomar* Sakai & Türkay, 1999, by original designation.

Included fossil species: *Bathycalliax mediterranea* Garassino, Hyzný & Pasini in Baldanza et al. (2013).

Bathycalliax sp.

Fig. 2

Material: Two disarticulated chelipeds in lateral view: MST Q2, level CuC19; MST Q12b (poorly preserved and crushed), level CuC19.

Measurements: P1 length: 22 mm; lp: 12 mm; hp: 6 mm.

Age: Early Pleistocene (*Pseudoemiliana lacunosa* biozone).

Description. An isolated major P1, preserving articulate merus, carpus, and propodus with both dactylus and index; merus with arcuate upper margin, lower margin scarcely preserved; subtriangular carpus, approximately as long as high, proximal lower margin regularly rounded and smooth, straight upper margin; subrectangular elongate manus, index shorter than dactylus; occlusal margin

of dactylus with a large blunt tooth at its base (as preserved); hook-shaped dactylus, with tip curved downturned.

Discussion. Among Callianopsidae the studied specimens show the main morphological characters of *Bathycalliax* Sakai & Türkay, 1999 in having carpus higher than long, rectangular propodus with index shorter than dactylus, and unarmed dactylus with hooked tip (see Baldanza et al. 2013: 342). Due to the poorly preserved inferior margin of P1 merus, bearing distinctive characters, the studied specimens cannot be compared with *B. mediterranea*, already reported from the Early Pleistocene (late Gelasian-early Calabrian) of Poggio i Sodi (Siena, Tuscany) and the Early Pleistocene of Volterra (Pisa, Tuscany, Baldanza et al. 2013; Pasini et al. 2014).

Despite being poorly represented by body remains, the presence of callianopsid ghost-shrimps in the MJS is also supported by the presence of *Thalassinoides* ichgen. at several levels of both the intervals (A and B), as previously reported by D'Alessandro et al. (2003: 174).

Infraorder **Anomura** MacLeay, 1838

Superfamily Galattheoidea Samouelle, 1819

Family Galatheidae Samouelle, 1819

Genus et species indet.

Fig. 3

Material: One incomplete isolated carapace in dorsal view: MST Q4, level NC 408.

Measurements: lcxp: 4 mm, as preserved; wcxp: 3.5 mm.

Age: Middle Pleistocene (*Pseudoemiliana lacunosa* biozone).

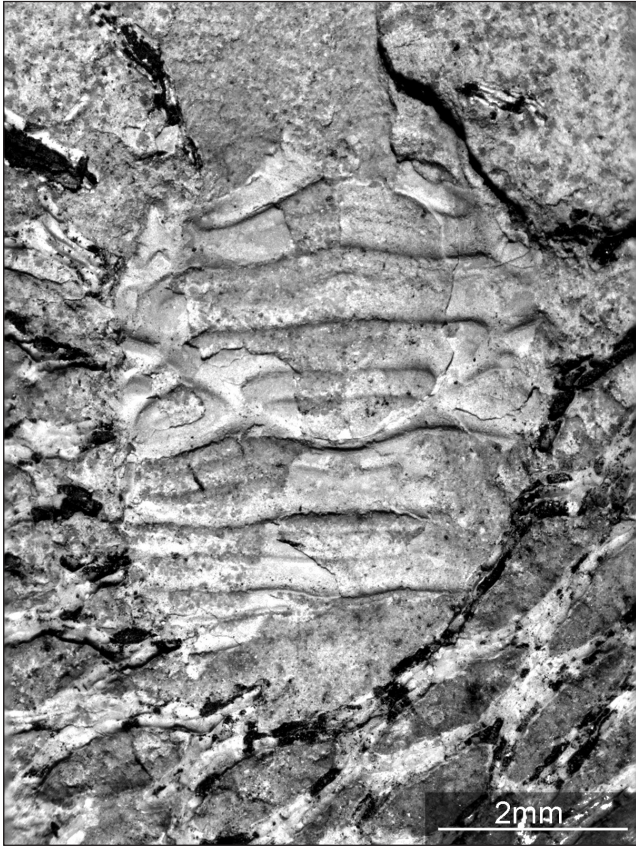


Fig. 3 - Indeterminate Galatheidae. MST Q4 (level NC – Middle Pleistocene), dorsal view.

Description. Carapace subsquare, slightly longer than wide, transversely convex; rostrum and front not preserved; one anterolateral spine forwardly directed; branchial margins slightly convex, convergent posteriorly; posterior margin not preserved; deep cervical groove laterally bifurcated; epigastric region with one main uninterrupted sinuous transverse ridge; proto-, meso-, and meta-gastric regions not well defined, with six main uninterrupted sinuous transverse ridges; subtriangular anterior branchial regions with at least one short uninterrupted ridge; posterior branchial regions with at least six uninterrupted transverse ridges.

Discussion. Fossil representatives of the squat lobsters are limited in the Plio-Pleistocene record of Italy to only two genera, *Galathea* Fabricius, 1793 and *Munida* Leach, 1820.

Galathea affinis was reported from the Miocene of Capo San Marco (Sardinia) (Lörenthey, 1909) and from the late Pliocene of Bianchi (Sicily) (Ristori, 1886). This species is now considered a *nomen dubium* (see Pasini et al. 2020: 112 for complete discussion).

Baldanza et al. (2013: 343) reported *Galathea* sp. from the Early Pleistocene of Poggi i Sodi (Siena, Tuscany). Later Pasini et al. (2020: 112) described *G. tuscia* Pasini, Garassino, De Angeli & Pizzolato, 2020 from the Early Pleistocene of Poggi Gialli (Siena, Tuscany).

Munida grossetana Garassino & Pasini, 2015, reported from Monterotondo Marittimo (Grosseto, Tuscany), is the only species of *Munida* known to date from the Pliocene (Garassino & Pasini 2015).

The studied specimen consists of a isolated, poorly preserved carapace within a bryozoan colony. The lack of rostrum and frontal margin does not allow a confidently generic assignment of the studied specimen to *Galathea* or *Munida*. Therefore, we leave it in open nomenclature within the Galatheidae.

In conclusion, this is the first fossil report of a squat lobster from Basilicata (Italy).

Infraorder **Brachyura** Linnaeus, 1758

Section Podotremata Guinot, 1977

Superfamily Leucosioidea Samouelle, 1819

Family Leucosiidae Samouelle, 1819

Subfamily Ebalinae Stimpson, 1871

Genus *Ebalia* Leach, 1817

Type species: *Ebalia bryerii* Leach, 1817, subsequent designation by Rathbun (1922).

Included fossil species: See Schweitzer et al. (2010) and Garassino et al. (2022).

Ebalia nux A. Milne-Edwards, 1883

Fig. 4

*1883 *Ebalia nux* A. Milne-Edwards, p. 2, pl. 5.

2000 *Ebalia nux* A. Milne-Edwards - Soldani & Girone, p. 115, figs 4 a-d, 5 a-e.

2010 *Ebalia nux* A. Milne-Edwards - Garassino et al., p. 76, figs 1-4.

Material: 17 isolated carapaces in dorsal view, slightly compressed dorso-ventrally: MST Q5, level FG2q; MST Q6, level J31-32 FG; MST Q7, level J30-31; MST Q8, level J30-31; MST Q9, level J12-J13 FG; MST Q10, level FG2q; MST Q11, level -5, -6 (5 agosto); MST Q12, level CUC19; MST Q13, level 5Jb 6J (5 agosto); MST Q14, level 5Jb 6J (5 agosto); MST Q15, level TIA5; MST Q16, level TIA5; MST Q17, level FG J51-51 TIA 23; MST Q18, level FG J51-51 TIA 23; MST Q19, level TIA9; MST Q20, level TIA9; MST Q21 level FG 6q.

One isolated cheliped propodus with dactylus: MST Q22, level FGq6; one isolated cheliped merus: MST Q23, level FGq6.

Measurements: MST Q5 - Q21, lcxp: from 3 mm to 7 mm; wcxp: from 4 mm to 8 mm. MST Q22: 3.5 mm long. MST Q23: 6.3 mm long.

Age: Early Pleistocene (small *Gephyrocapsa* and *Pseudoemiliania lacunosa* biozones).

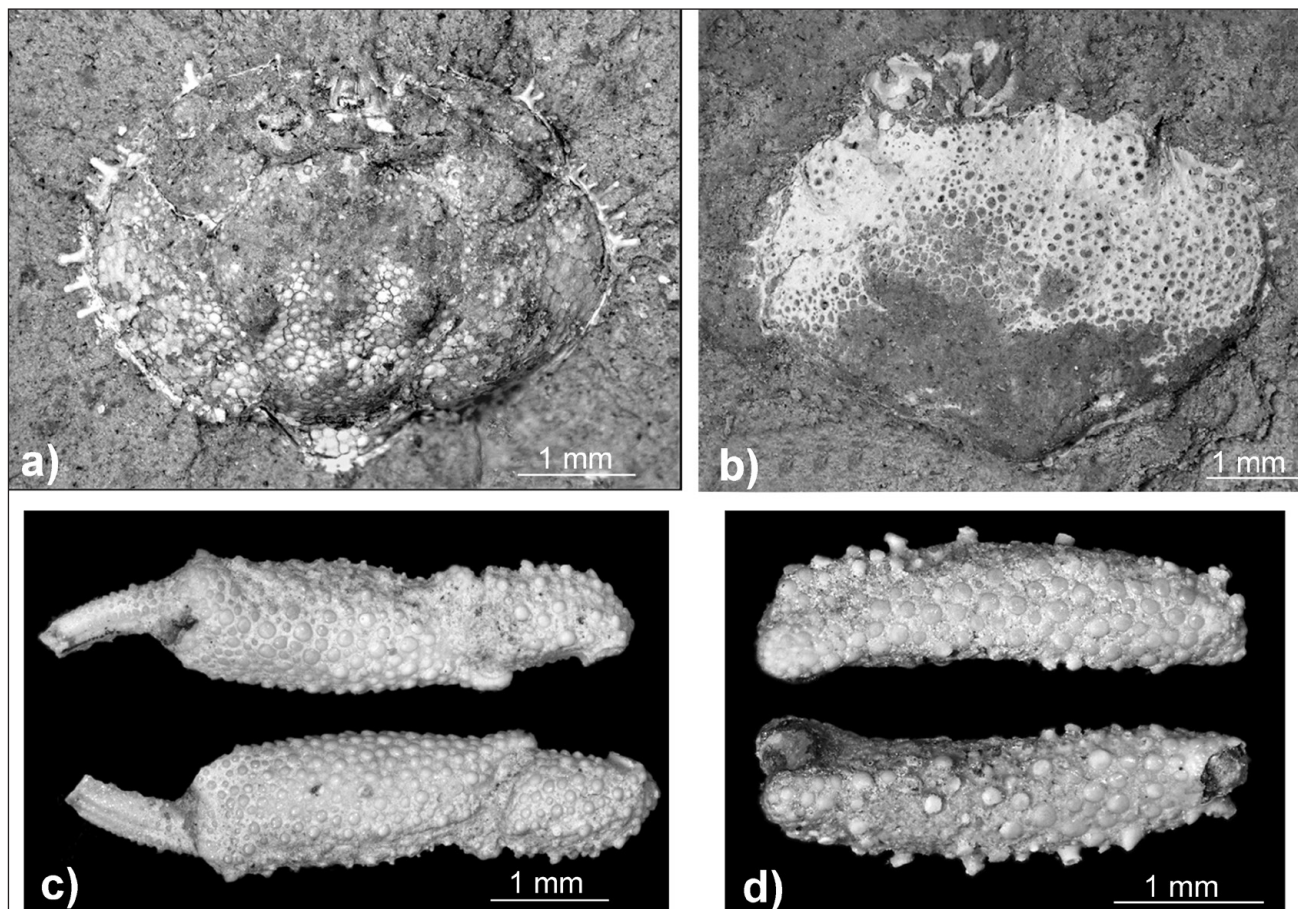


Fig. 4 - *Ebalia nux* A. Milne-Edwards, 1883: a) MST Q6 (level J31-32 FG, Lower Pleistocene), dorsal view; b) MST Q7 (level J30-31, Lower Pleistocene), dorsal view; c) MST Q22 (level FGq6, Lower Pleistocene), cheliped, lateral view; d) MST Q23 (level FGq6, Lower Pleistocene), merus, lateral view.

Description. Carapace subpentagonal, poorly inflated transversally, widest at level of epibranchial angle; frontal margin poorly preserved; anterolateral margins shorter than posterolateral ones; gastric regions with three rounded lobes; distinct hepatic lobe; notch on the anterolateral margin giving a thin posteriorly directed groove; short, concave posterior margin with a rounded lobe on each lateral side or nearly straight; cardiac region strongly inflated forming a bulge; urogastric and cardiac regions marked laterally by deep branchiocardiac grooves; depressed, narrow intestinal region; flat, rounded tubercles densely arranged uniformly on all dorsal surface; mushroom-shaped tubercles along antero- and posterolateral margins; slender elongate P1; granulated propodus twice longer than dactylus; merus shorter than propodus with similar granulations.

Discussion. *Ebalia* Leach, 1817 is still considered a “basket genus,” including many different morphotypes of uncertain affinities. Zariquely Ál-

varez (1968: 322) described the main characters of the carapace, as follows: “carapace usually polygonal, sometime subcircular or suboval, with well delimited regions by grooves or irregularities on the dorsal surface, with frequents granules or nodes. Front prominent, more or less bilobed. Small orbits and eyes”.

Therefore, based on the above-mentioned proxy-characters *sensu* Schweitzer (2003), the studied specimens are herein assigned to *Ebalia*.

Some studied specimens were previously reported and figured by Soldani & Girone (2000) as *E. nux* in a mainly geological work focused on their preservation, diagenetic significance, and taphonomic implications. The authors did not provide, however, a taxonomic description and discussion to justify their systematic assignment, based mainly on the deep water setting of the sediments from which the specimens were collected, a typical (but not exclusive) environment of life for the extant *E. nux* (Soldani & Girone 2000: 115).

Zariquey Álvarez (1968: 329) described the distinctive characters of *E. nux* based on several Atlantic specimens, as follows “subrounded to ovate carapace poorly inflated transversally; dorsal ornamentation with large flat tubercles evenly distributed on the surface of the carapace; pedunculate rounded tubercles along the frontal and anterolateral margins; bilobate frontal margin with each lobe slightly bifid; postfrontal region not or slightly depressed; distinct hepatic lobe; shallow small notch on the anterolateral margin giving a thin posteriorly directed groove ranging the intestinal region; three distinct rounded lobes on the gastric regions”.

Despite the high number of examined specimens, few of them preserve complete carapace and original dorsal epicuticle ornamentation [see the well-preserved specimens figured by Garassino et al. (2010: 76-77, figs 1-4), useful for comparisons]. Anyway, based on the mushroom-shaped granules along the lateral margins and the distinctive elongate, slender P1 propodus twice longer than dactylus unique among the Mediterranean species, we confidently assigned the studied specimens to *Ebalia nux* A. Milne-Edwards, 1883.

Ebalia nux was previously reported only from the Late Pliocene of S. Polo d'Enza (Reggio Emilia, N Italy), supposed to represent an outer shelf environment (Garassino et al. 2010).

This species is the most common decapod species along the interval (A) of MJS, which is represented by individuals at different stages of growth and both sexes.

Ebalia sp.

Fig. 5

Material: One complete carapace in dorsal view, partially compressed: MST Q24, level FGq2.

Measurements: lcxp: 8 mm; wcxp: 5 mm.

Age: Early Pleistocene (small *Gephyrocapsa* biozone).

Description. Carapace subpentagonal, poorly inflated transversally, largest at level of epibranchial angle and strongly narrowing anteriorly; frontal margin bilobed; very small orbits; anterolateral margins shorter than posterolateral ones; straight, smooth anterolateral margins steeply inclined anteriorly; posterolateral margins strongly convex narrowing posteriorly; short posterior margin, as wide as front; indistinct proto- meta-, and mesogastric regions; narrow hepatic region; weakly inflated urogastric

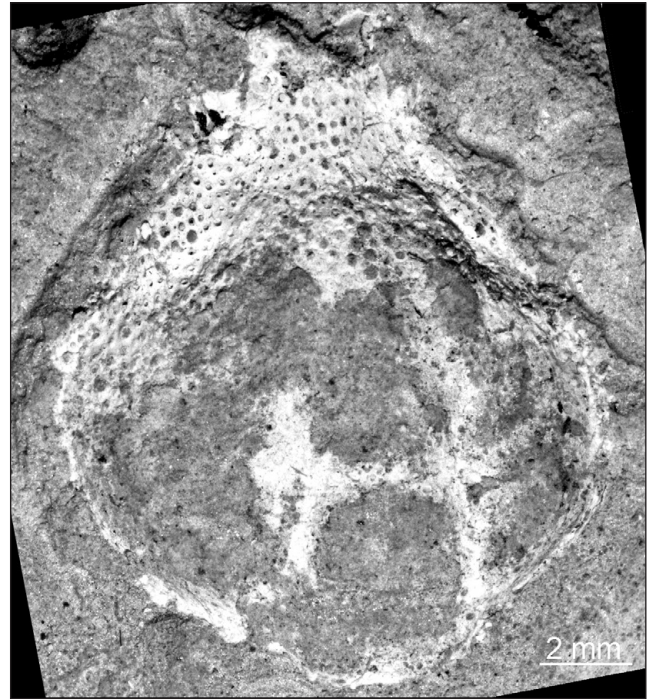


Fig. 5 - *Ebalia* sp. MST Q24 (level FGq2, Lower Pleistocene), dorsal view.

region and subpentagonal cardiac region; depressed, narrow intestinal region; indistinct epi-, meta-, and mesobranchial regions; urogastric and cardiac regions marked laterally by deep branchiocardiac grooves; dorsal surface covered with small tubercles arranged uniformly.

Discussion. This specimen was previously reported and figured as *Ebalia nux* by Soldani & Girone (2000, fig. 4c). Indeed, the more elongate subpentagonal carapace, the distinctly forward-produced bifurcate front, forming a V-shaped frontal margin and the absence of the mushroom-shaped granules along the lateral margins are characters that do not match with those typical of *E. nux*. Therefore, this specimen is considered to belong to a possibly different species within *Ebalia* Leach, 1817.

However, due to the lack of the dorsal carapace cuticle with its original ornamentation, the poorly preserved posterolateral and posterior margins do not allow a closer comparison with the other Mediterranean fossil and extant species of the genus. In conclusion, the studied specimen is kept in open nomenclature within *Ebalia*.

Superfamily Xanthoidea MacLeay, 1838
Family Xanthidae MacLeay, 1838
Subfamily Euxanthinae Alcock, 1898

Genus *Monodaeus* Guinot, 1967

Type species: *Xanto couchii* Couch, 1851, by original designation.

Included fossil species: *Monodaeus bortolottii* Delle Cave, 1988.

Monodaeus bortolottii Delle Cave, 1988

Fig. 6a

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

2019 *Monodaeus bortolottii* Delle Cave - Pasini et al., p. 30, fig. 3A (*cum syn.*).

Material: Two specimens are in dorsal view: MST Q25 (part-counterpart), level IQ3, and MST Q26, level FG T59-T60.

Measurements: lcxp: from 4 mm to 10 mm; wcxp: from 6 mm to 15 mm.

Age: Early Pleistocene (level FG, small *Gephyrocapsa biozona*, level IQ3, *Pseudoemiliana lacunosa* biozone).

Description. Carapace suboctagonal, convex transversely, wider than long; straight frontal margin, with a weak median incision; short, convex anterolateral margins with poorly preserved curved spines forward directed; long, convergent posterolateral margins; 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; well-marked wide branchial regions.

Discussion. Based on the original description provided by Delle Cave (1988), the studied specimens fit the main characters of *M. bortolottii* Delle Cave, 1988 to which they are assigned.

Monodaeus bortolottii was 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 the Early Pleistocene of Poggio i Sodi (Siena, Tuscany). Pasini et al. (2014) reported *M. bortolottii* from the Early Pleistocene of Volterra (Pisa, Tuscany), very close to the type locality originally recorded by Delle Cave (1988). Recently, this species was also reported 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). Finally, Pasini et al. (2019) reported *M. bortolottii* specimen from the Miocene of Brisighella (Ravenna, Emilia-Romagna).

The report of *M. bortolottii* from Basilicata attests to its wide palaeogeographic distribution in Italy and its wide stratigraphic range from the Miocene to the Early Pleistocene.

Superfamily Portunoidea Rafinesque, 1815

Family Carcinidae MacLeay, 1838

Subfamily Carcininae MacLeay, 1838

Genus *Carcinus* Leach, 1814

Type species: *Cancer maenas* Linnaeus, 1758 by monotypy.

Included fossil species: none.

? *Carcinus* sp.

Fig. 6c

Material: One poorly three-dimensionally preserved specimen in dorsal view, with partial left cheliped and pereopods molds: MST Q27 (part-counterpart), level DD(F)5.

Measurements: lcxp: 29 mm; wcxp: c. 35 mm.

Age: Early Pleistocene (*Pseudoemiliana lacunosa* biozone).

Discussion. The studied specimen is slightly compressed dorso-ventrally and shows a subpolygonal carapace with the strongly tuberculate dorsal surface; short frontal margin; incomplete convex anterolateral margins that seem unarmed (as preserved); straight posterolateral margins narrowing to the straight posterior margin wider than the frontal one; regions scarcely distinct; cardiac region marked laterally by deep branchiocardiac grooves. Due to the lack of distinctive characters the specimen is tentatively compared with *Carcinus* Leach, 1814 based on the generic carapace outline.

Carcinus aestuarii Nardo, 1847 is the sole extant species widespread in the Mediterranean Sea, living in marine shallow to sublittoral waters and in estuarine and brackish environments (Falciari & Minervini 1992: 212).

Subfamily Polybiidae Ortmann, 1893

Genus *Liocarcinus* Stimpson, 1871

Type species: *Portunus bolsatus* Fabricius, 1798, by original designation.

Included fossil species: See Schweitzer et al. (2010).

Liocarcinus depurator (Linnaeus, 1758)

Fig. 6b

*1758 *Cancer depurator* Linnaeus, p. 627.2017 *Liocarcinus depurator* (Linnaeus) - De Angeli, Garassino & Pasini in Baldanza et al., p. 61, fig. 15D (*cum syn.*).**Material:** One specimen in dorsal view: MST Q28, level Section CZ.**Measurements:** lcxp: 20 mm; wcxp: 30 mm.**Age:** Early Pleistocene (*Pseudoemiliana lacunosa* biozone).

Description. Carapace subhexagonal; trifold frontal margin; convex anterolateral margins, with four triangular spines, forwardly directed; acute outer-orbital spines; posterolateral margins slightly concave and longer than anterolateral margins narrowing posteriorly; slightly inflated granulated protogastric regions; slightly inflated flask-shaped mesogastric region merging with rostral sulcus; flat hepatic regions; narrow urogastric region; slightly inflated diamond-shaped cardiac region; narrow depressed intestinal region; flat, granulated branchial regions; epibranchial regions with a curved oblique ridge; cardiac region with three elevations; dorsal surface with transverse roughness.

Discussion. The characters mentioned above fit those of the extant and fossil *Liocarcinus depurator* (Linnaeus, 1758) to which the studied specimen is assigned. This species was previously reported in the fossil record only from the Early Pleistocene of Poggi Gialli (Tuscany, central Italy) by De Angeli, Garassino & Pasini in Baldanza et al. (2017).

Superfamily Goneplacoidea MacLeay, 1838

Family Goneplacidae MacLeay, 1838

Genus *Carcinoplax* H. Milne Edwards, 1852**Type species:** *Cancer (Curtonotus) longimana* De Haan, 1833, subsequent designation by Glaessner (1929).**Included fossil species:** See Schweitzer et al. (2010); *C. jonica* n. sp. (this study).

Diagnosis by Castro (2007: 623): Carapace transversely rectangular, wider than long, or quadrate, only slightly wider than long; widest at junction of anterolateral, posterolateral borders; front lamellar, straight, very rarely marked by slight median notch or projection; notch between front, inner edge of supraorbital border distinct, very slight, or absent; orbits narrow, not expanded distally; supraorbital borders slightly sinuous; suborbital borders rounded, with short, blunt inner tooth not visible dorsally; anterolateral borders convex; dorsal surface of carapace typically smooth, moderately convex, without clear indication of regions; outer orbital angle with tooth, elongated prominence, or unarmed; 2 (3 in rare cases) anterolateral teeth on each side of carapace.

Carcinoplax jonica Garassino & Pasini n. sp.

Fig. 7

Etymology: From the Jonian Sea in southern Italy, part of the central Mediterranean Sea.**Type material:** Holotype, MST Q29; paratype MST Q30.**Type locality:** Montalbano Jonico (Matera, Basilicata, S. Italy).**Type age:** Early Pleistocene (holotype, small *Gephyrocapsa* biozone; paratype, *Pseudoemiliana lacunosa* biozone).**Material:** One complete specimen in dorsal view: MST Q29, Fosso Giuseppe under V1. One isolated carapace: MST Q30, level VB7.**Measurements:** MST Q29: lcxp: 20 mm; wcxp: 23 mm; MST Q30: lcxp: 13 mm; wcxp: 18 mm

Diagnosis: Carapace subrectangular transversely, slightly wider than long; front straight with a weak axial depression; anterolateral margins with two strong triangular pointed spines forwardly directed, the second one at the epibranchial angle longer; posterolateral margins almost straight, narrowing posteriorly; right P1 slightly stronger than left one.

Description

Carapace: carapace subrectangular transversely, slightly wider than long, widest at the second anterolateral spine; front straight with a weak axial depression; orbits narrow, not expanded distally; supraorbital margins slightly sinuous; elongate acute outer-orbital spines as long as first anterolateral spine; anterolateral margins slightly convex with two acute straight elongate spines forwardly directed, the second one, at level of epibranchial angle, longer; regions well visible due to the lack of the exocuticle; funnel-shaped mesogastric region; slightly raised meso- and metagastric regions forming an undivided single plate; flat urogastric region elongate transversally, separated from metagastric region by shallow cervical groove; large protogastric regions, expanded laterally; slightly raised hepatic regions; diamond-shaped cardiac region delimited by deep branchiocardiac grooves; flat intestinal region; slightly raised branchial regions; partial exocuticle at level of frontal region preserves small tubercle arranged randomly.

Thoracic appendages: P1 slightly unequal with right P1 slightly stronger than left P1; fingers curved, slightly shorter than propodus; occlusal margin of P1 index with acute teeth; short, acute spine on inner (ventral), proximal margin of P1 carpus; P2-P4 incomplete and slender; P5 not preserved.

Discussion. MST Q29 was previously figured by D'Alessandro et al. (2003: 170, fig. 12) and mentioned as "*Geryon* sp.", not providing any description or discussion. Indeed, the extant and fossil

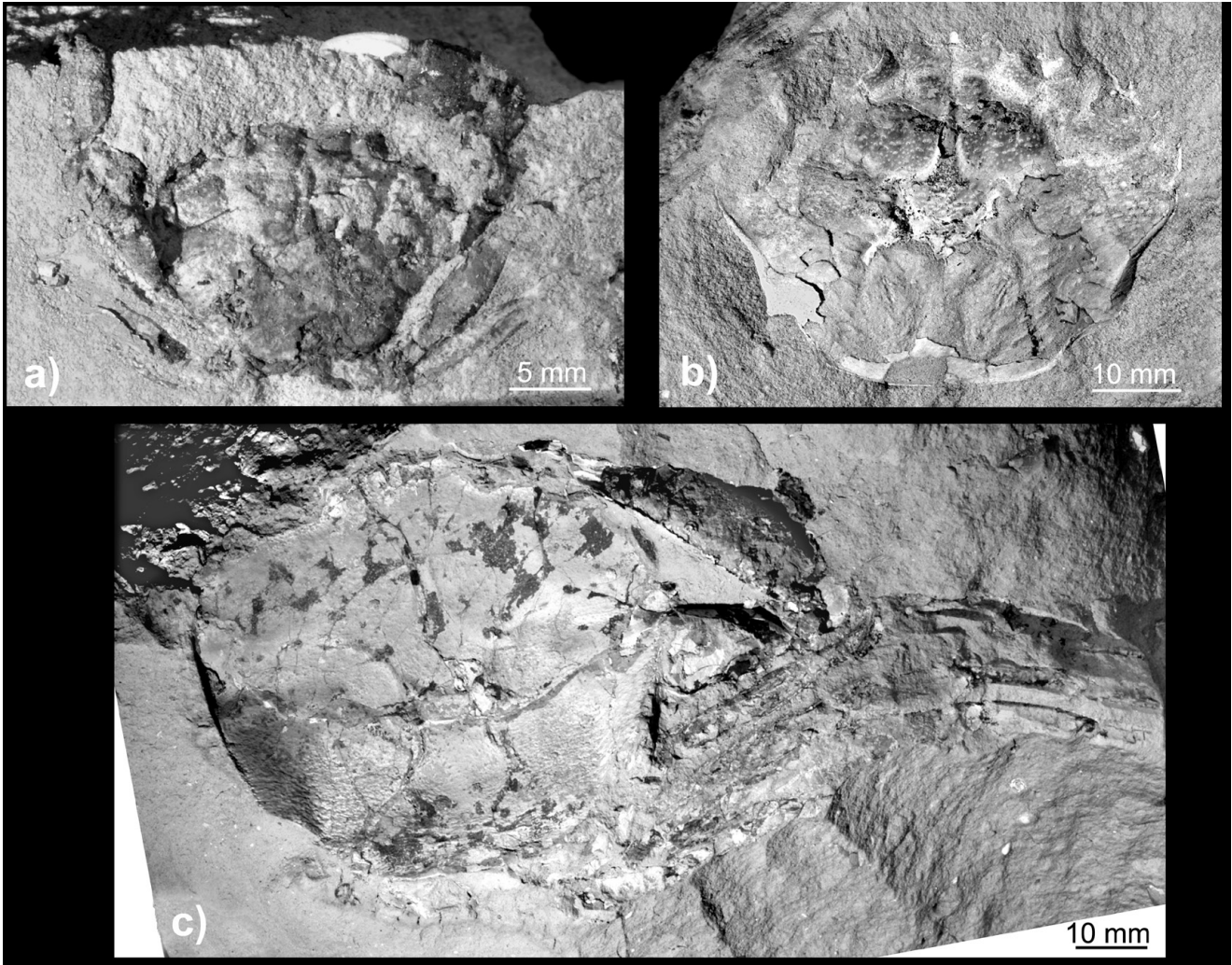


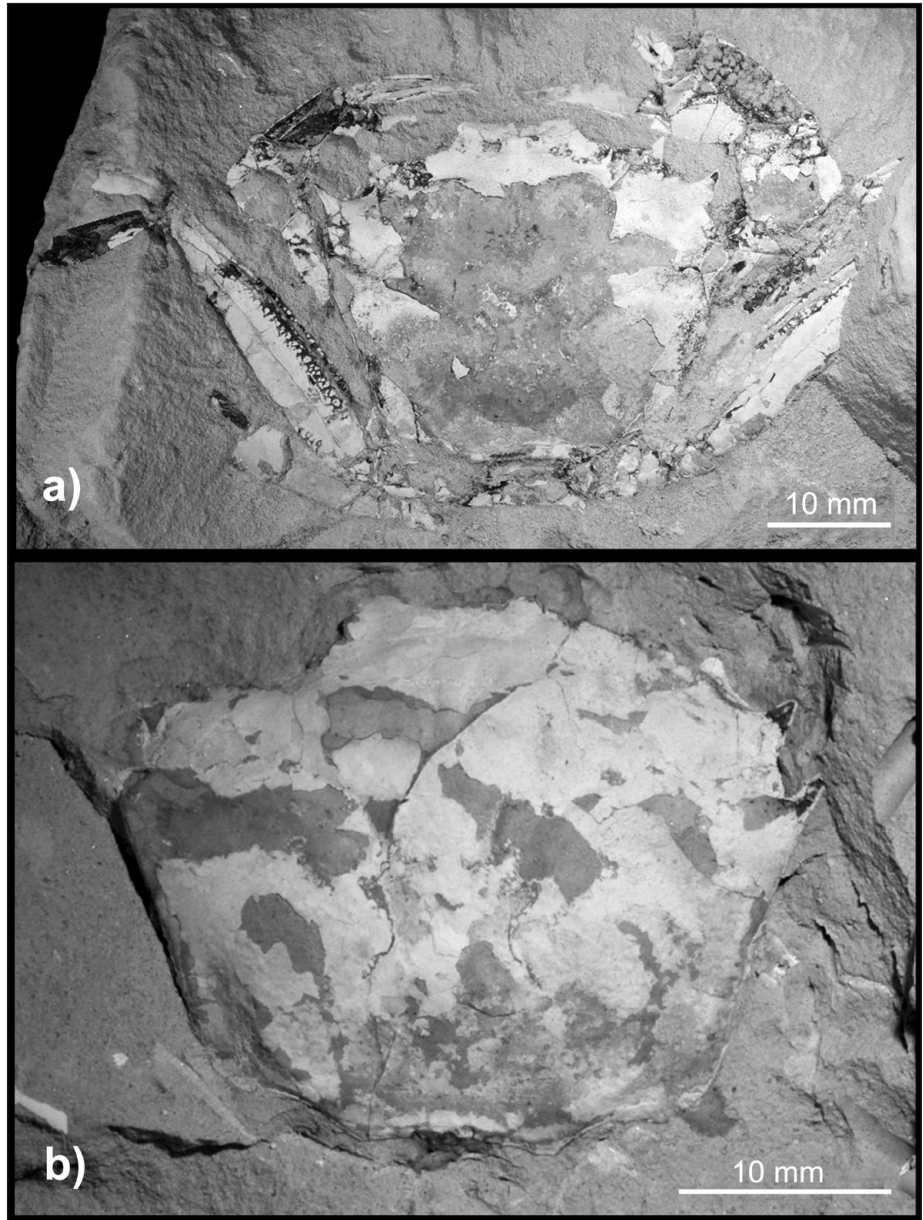
Fig. 6 - a) *Monodaenus bortolottii* Delle Cave, 1988, MST Q26 (level FG T59-T60, Lower Pleistocene), dorsal view; b) *Liocarcinus depurator* (Linnaeus, 1758), MST Q28 (level section CZ, Lower Pleistocene), dorsal view; c) ?*Carcinus* sp., MST Q27 (level DDF5, Lower Pleistocene), dorsal view.

Geryon Krøyer, 1837 is widespread in the Mediterranean Sea with *G. longipes* A. Milne-Edwards, 1882 that shares several features with the studied specimens, such as the general shape of the carapace and the presence of two anterolateral spines (excluding the outer-orbital spines). However, *Geryon* differs in having 2 distinct prominent spines on the middle frontal margin.

According to Castro (2007: 618), the studied specimens are assigned to the Goneplacidae in having a carapace transversely rectangular, narrow, straight front, not marked by a median notch, smooth dorsal surface, single anterolateral spine, a notch between frontal margin, the inner edge of supraorbital border typically slight, orbits moderately wide, and fissure typically absent. According to Schweitzer et al. (2010), Garassino & Pasini (2013),

Pasini et al. (2020), and Garassino et al. (2023), the fossil genera within the Goneplacidae are, as follows: *Albaidaplastax* Garassino, Castro & Pasini, 2023 (Early Pliocene – Early Pleistocene; Italy, Spain); *Aliaplastax* Pasini, Garassino, De Angeli & Pizzolatto, 2020 (Early Pleistocene; Italy); *Amydrocarcinus* Schweitzer, Feldmann, González-Barba & Vega, 2002 (Eocene; Mexico); *Astiplax* Garassino & Pasini, 2013 (Late Pliocene; Italy); *Carcinoplastax* H. Milne Edwards, 1852 (Miocene – Pleistocene; Taiwan, Japan, New Zealand); *Goneplax* Leach, 1814 (Miocene – Early Pleistocene; Italy, Austria); *Kowaicarcinus* Feldmann, Schweitzer, Maxwell & Kelley, 2008 (Pliocene; New Zealand); *Magyarcarcinus* Schweitzer & Karasawa, 2004 (middle Eocene – late Eocene; Italy, Hungary); *Neogoneplax* Castro, 2007 (late Oligocene – Middle Miocene; New Zealand); *Ommato-*

Fig. 7 - *Carcinoplax jonica* n. sp.:
 a) MST Q29 (FG section under V1, Lower Pleistocene), holotype, dorsal view; b) MST Q30 (level VB7, Lower Pleistocene), paratype, dorsal view.



carcinus White, 1852 (Miocene – Pleistocene; Taiwan, Australia, Italy); and *Psopheticus* Wood-Mason, 1892 (Oligocene; Taiwan). We exclude the belonging of the studied specimen to the fossil genera *Aliaplax*, *Astiaplax*, *Goneplax*, *Neogoneplax*, *Ommatocarcinus*, and *Psopheticus* because of the occurrence of narrow orbits not expanded distally (*vs* orbits wide and greatly expanded distally in the six mentioned genera). The lack of the outer-orbital spines and the smooth anterolateral margins in *Amydrocarcinus* and *Magyarcarcinus* rule out the belonging of the studied specimens to these genera. Moreover, the strong outer-orbital spines and the anterolateral margins with two spines exclude the belonging of the studied specimens to *Kowaicarcinus* in having small, blunt outer-orbital spines and anterolateral margins weakly tri-lobated,

as well as the different palaeogeographic distribution. Finally, the studied specimens are not assigned to *Albaidaplax* because they have anterolateral margins with two spines (*vs* anterolateral margin with one spine in *Albaidaplax*).

Castro (2007) included in the Goneplacidae the following extant genera: *Carcinoplax* H. Milne Edwards, 1852; *Entricoplax* Castro, 2007; *Exopheticus* Castro, 2007; *Goneplacoides* Castro, 2007; *Goneplax* Leach, 1814; *Hadroplax* Castro, 2007; *Menoplax* Castro, 2007; *Microgoneplax* Castro, 2007; *Neogoneplax* Castro, 2007; *Neommatocarcinus* Takeda & Miyake, 1969; *Notonyx* A. Milne-Edwards, 1873; *Ommatocarcinus* White, 1852; *Paragoneplax* Castro, 2007; *Psopheticus* Wood-Mason, 1892; *Pynoplax* Castro, 2007; *Singhaplax* Serene & Soh, 1976; and *Thyraplax* Cas-

tro, 2007. The classification and recognition of extant genera are mainly based on the ventral parts, especially sternal sutures 6/7, gonopod 1, sternopleonal cavity, and vulvae. However, adapting and adopting this classification for the fossil species is very difficult because these characters are not usually preserved within the fossil crabs. Therefore, the comparison between the studied specimens and the extant genera is only based on some proxy characters *sensu* Schweitzer (2003), such as the shape of the carapace, the presence or absence of the outer-orbital spines, and the number of anterolateral spines. Such characters suggest comparing and assigning the studied specimens to one extant genus within the Goneplacidae.

Based on the diagnoses for each genus provided by Castro (2007), we can distinguish two main groups: the first, including four genera (*Carcinoplax*, *Menoplax*, *Pycnoplax*, *Thyraplax*), with narrow orbits not expanded distally, and the second, including 13 genera (see list above-mentioned), with wide orbits greatly expanded distally.

The studied specimens having narrow orbits that do not expand distally can be included in the first group.

The studied specimens are not assigned to *Menoplax*, which has the second anterolateral tooth longer and stronger (*vs* anterolateral margins with two equal-size spines in the studied specimens). Moreover, the specimens from MJS differ from *Pycnoplax* having quadrate carapace and short outer-orbital spines (*vs* subrectangular carapace and elongated outer-orbital spines in the studied specimens), and from *Thyraplax*, having a triangular moderately acute outer-orbital prominence and one anterolateral spine (*vs* elongate outer-orbital spines and two anterolateral spines in the studied specimens).

The studied specimens share the elongate outer-orbital spines and the anterolateral margins with two equal size spines with some species of *Carcinoplax*, such as *C. longipes* (Wood-Mason, 1891), *C. jugum* Ng & Castro, 2020, *C. specularis* Rathbun, 1914, and *C. verdensis* Rathbun, 1914 (see Ng & Castro 2020). In conclusion, the studied specimens are characterized by a continuous, smooth, and straight frontal margin, which is considered the main distinctive character of *Carcinoplax* H. Milne Edwards, 1852.

Schweitzer et al. (2010) reported a list of

12 fossil species of *Carcinoplax* from the Eocene to Pliocene of Taiwan, Japan, and New Zealand. This list reflects the geographic distribution of the genus extant species, which are restricted to the Indo-Pacific area. Based on the fossil record of *Carcinoplax* known to date, the new species represents the sole unexpected record of the genus in the Mediterranean Basin.

Carcinoplax sp.

Fig. 8

Material: One incomplete specimen in ventral view (MST Q3, level DD10) and one poorly preserved specimen in dorsal view (MST Q40, level DD10).

Measurements: MST Q3: lp: 41 mm; hp: 12 mm; lindex: 20 mm; MST Q40: wcxp: 55mm; lcxp: 48 mm; lp: 25 mm; hp: 19 mm; lindex: 25 mm.

Age: Early Pleistocene (*Pseudoemiliania lacunosa* biozone).

Description

Carapace: Subrounded carapace, slightly wider than long, widest at level of the epibranchial spine; front slightly protruded beyond orbits; narrow, flat front; shallow, small orbits; supra-orbital margin without fissures; outer-orbital spine absent; anterolateral margins shorter than posterolateral ones; smooth anterolateral margins weakly convex; smooth posterolateral margins strongly convex; straight posterior margin as wide as front not rimmed; strong epibranchial spine outwardly directed; indistinct regions; urogastric and cardiac regions marked laterally by a shallow branchiocardiac groove; dorsal surface covered with small tubercles uniformly arranged.

Thoracic sternum: Sternum relatively wide; s1-s2 fused; s3 subrectangular; s4 subtrapezoidal; s5 subrectangular outwardly directed; s6-s7 subrectangular slightly inclined downward; sternal sutures 4-5, 5-6, and 6-7 not parallel.

Pleon (male): Narrow pleon with s3-s6 preserved; small subtriangular telson; subrectangular s3-s6 narrowing distally; s4 broader than the other ones.

Thoracic appendages: Mxp3 well preserved; subrectangular ischium twice as long as than subrectangular merus; small subrectangular carpus and propodus; elongate, pointed dactylus; elongate subrectangular exopod with flagellum partially preserved; strong P1; hooked subsquare P1 coxa; short P1 ischium; subrectangular P1 merus as long as P1 propodus; subrectangular P1 carpus; ventral and dorsal margins of P1 propodus apparently



Fig. 8 - *Carcinoplax* sp.: a) MST Q3 (level DD10, Lower Pleistocene), ventral view; b) MST Q40 (level DD10, Lower Pleistocene), dorsal view.

smooth; P1 dactylus and index of same length; P1 dactylus slightly hooked distally; straight P1 index; occlusal margins of P1 dactylus and index apparently smooth; P2-P5 very elongate; ventral and dorsal margins of P2-P5 elements smooth; P2-P5 meri as long as propodi and twice as long as P2-P5 carpi; P2-P5 dactyli not preserved.

Discussion. The studied specimens are herein tentatively assigned to the Goneplacidae MacLeay, 1838 and to *Carcinoplax* H. Milne Edwards, 1852, based on some shared morphological generic proxy characters *sensu* Schweitzer (2003), such as their relatively wide body size, the presence and shape of the anterolateral spine (as preserved), the smooth subsquare carapace, the notably elongate pereopods, the strong P1 palm and the pleon general arrangement (see also the discussion of the genus for comparisons).

Genus *Goneplax* Leach, 1814

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

Included fossil species: *Goneplax gulderi* Bachmayer, 1953; *Goneplax rhomboides* (Linnaeus, 1758).

Goneplax rhomboides (Linnaeus, 1758)

Fig. 9

*1758 *Cancer rhomboides* Linnaeus, p. 626.

2013 *Goneplax rhomboides* (Linnaeus) - Garassino et al., p. 359-361, figs 1.B, 1.C, 2 (*cum syn.*).

2014 *Goneplax rhomboides* (Linnaeus) - Pasini et al., p. 253, fig. 8B.

2017 *Goneplax rhomboides* (Linnaeus) - Baldanza et al., p. 62, fig. 16a, b.

2018 *Goneplax rhomboides* (Linnaeus) - Pasini et al., p. 30, 31, fig. 3b.

2020 *Goneplax rhomboides* (Linnaeus) - Pasini et al., p. 54, fig. 3b.

Material: 34 specimens (MST Q41 – Q75, collected at various stratigraphic heights of Interval A and B of the MJS), selected 2 specimens in dorsal view: MST Q31 (part-counterpart), level under V3; MST Q32, level IQ3.

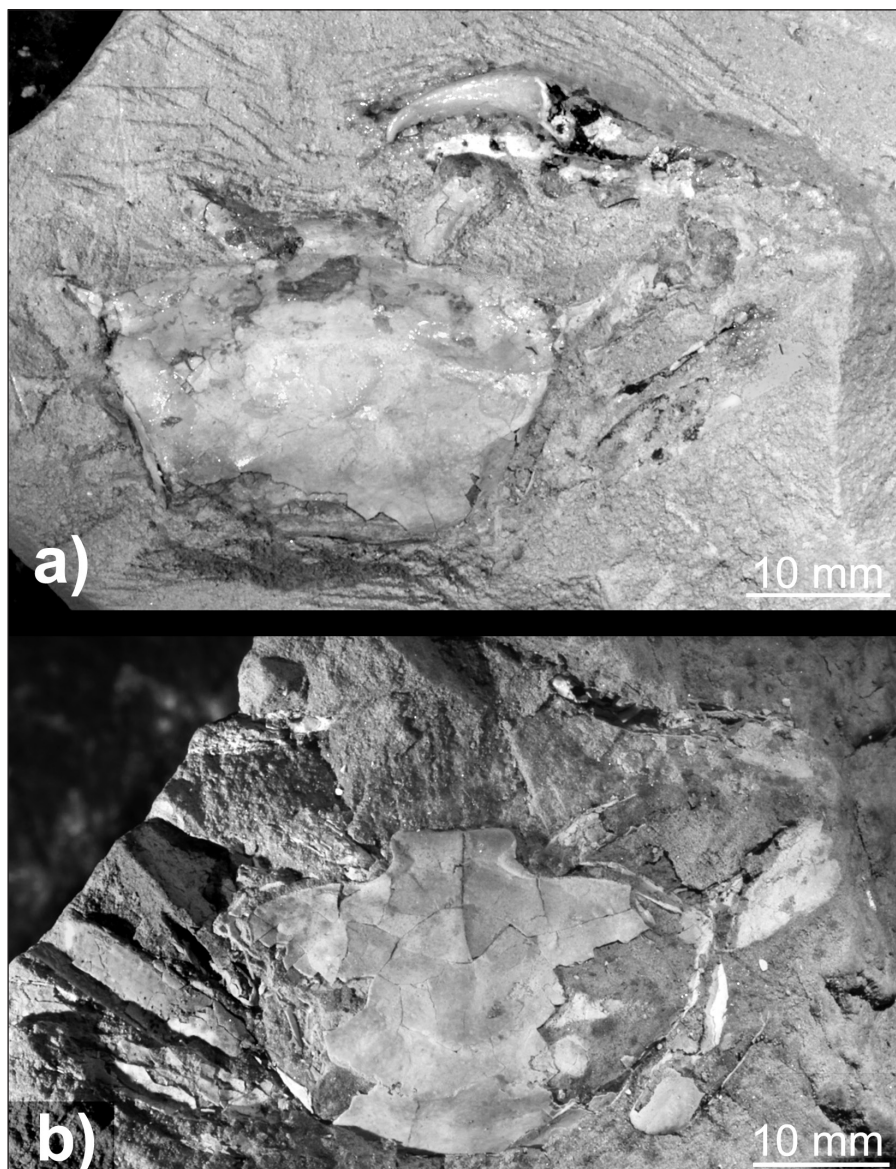


Fig 9 - *Goneplax rhomboides* (Linnaeus, 1758): a) MST Q31 (level under V3, Lower Pleistocene), dorsal view; b) MST Q32 (level IQ3, Middle Pleistocene), dorsal view.

Measurements: exp: from 7 mm to 14 mm; wexp: from 11 mm to 26 mm.

Age: Early and Middle Pleistocene (small *Gephyrocapsa* and *Pseudoemiliania lacunosa* biozones).

Description

Carapace: Carapace transversely subtrapezoidal, slightly wider than long, widest at anterolateral tooth; front straight, not marked by median notch or projection; front as wide as orbits; relatively wide orbits, slightly expanded distally; outer-orbital angle with triangular, conspicuous acute spine; anterolateral margins straight frontally; single reduced anterolateral spines; posterolateral margins tapering posteriorly; straight posterior margin; smooth dorsal surface of carapace, with raised horizontal ridges, without clear indication of regions.

Cephalic appendages: a1 and a2 not preserved; eyestalk long, slightly longer than front.

Thoracic appendages: right P1 preserved; elongate propodus with curved dactylus; right slender P2? or P3 partially preserved.

Discussion. The studied specimens show the typical morphological characters of the extant and fossil *Goneplax rhomboides* (Linnaeus, 1758), to which they are assigned. Ciaranfi et al. (2001: 78, fig. 11b) previously showed one of the studied specimens assigned informally to *G. rhomboides*. We concur with this systematic assignment.

According to Pasini et al. (2020), this eurybathic species was widespread from the Miocene to the Pleistocene in several Italian regions, such as Piedmont, Emilia-Romagna, Tuscany, Lazio, and Sicily. This is the first record from Basilicata, enlarging the geo-

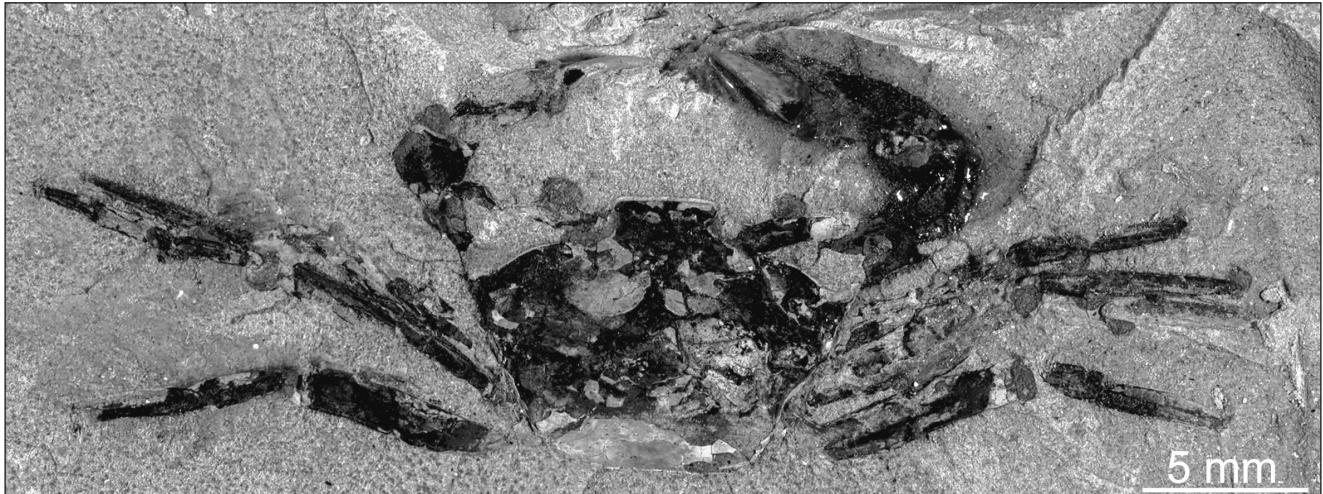


Fig. 10 - *Neogoneplax bradanica* n. sp. MST Q33 (level Vb2q, Lower Pleistocene), holotype, dorsal view.

graphic distribution of this Mediterranean species, which has a wide geographic range but also a long stratigraphic distribution from the upper Miocene to Recent.

Genus *Neogoneplax* Castro, 2007

Type species: *Neogoneplax renoculis* (Rathbun, 1914), subsequent designation by Castro (2007).

Included fossil species: *Neogoneplax arenicola* (Glaessner, 1960) and *N. bradanica* n. sp. (this study).

Diagnosis by Castro (2007: 699): Carapace transversely rectangular, much wider than long; widest at conspicuous outer orbital teeth; front slightly deflected ventrally, sinuous, marked by two slight emarginations, small to minute median projection between emarginations; slight notch between front, inner edge of supraorbital border; orbits wide, greatly expanded distally; supraorbital borders conspicuously convex; anterolateral borders short, straight; dorsal surface of the carapace smooth or with slight horizontal ridges, moderately convex, without precise indication of regions; outer orbital angle with conspicuous, acute tooth; acute anterolateral tooth on each side of the carapace or much reduced; eye peduncles long, shorter than or longer than front.

Neogoneplax bradanica Garassino & Pasini n. sp.

Fig. 10

Etymology: The trivial name alludes to the Bradanic foredeep (Avanfossa Bradanica) sedimentary basin in Basilicata (southern Italy), from which the studied specimen was collected.

Type material: Holotype MST Q33, by monotypy.

Type locality: Montalbano Jonico (Matera, Basilicata, S Italy).

Type age: Early Pleistocene (*Pseudoemiliania lacunosa* biozone).

Material: One complete specimen with chelipeds and walking legs in dorsal view: MST Q33, level Vb2q.

Measurements: lcxp: 8 mm; wcxp: 15 mm.

Diagnosis: Carapace rectangular transversely, wider than long; T-shaped wide flat front with basal constriction; wide orbits, greatly expanded distally; sinuous supraorbital margins without fissure/s; wide posterior margin twice longer than front.

Description

Carapace: Carapace transversely rectangular, wider than long, slightly convex, without precise indication of regions; antero- and posterolateral margins slightly oblique from outer-orbital spine to posterior margin; T-shaped wide flat front with basal constriction; wide orbits, greatly expanded distally; sinuous supraorbital margins without fissures; elongate, acute outer-orbital spines slightly curved distally; outer-orbital spines forwardly directed; oblique spineless antero- and posterolateral margins; wide posterior margin twice longer than front; smooth dorsal surface.

Cephalic appendages: a1 and a2 not preserved; long eyestalk, longer than front (1.5 front width).

Thoracic appendages: P1 slightly unequal with right P1 slightly stronger than left P1; fingers curved, somewhat shorter than propodus; short, acute spine on inner (ventral), the proximal margin of P1 carpus; P2 incomplete distally; P3, P4 elongate equal in length; P5 slightly shorter than P3, P4.

Discussion. This specimen was previously figured by Ciaranfi et al. (2001: 78, fig.11a) and by D'Alessandro et al. (2003: 170, Fig. 10) as "*Goneplax rhomboides* (Linnaeus)" but based on the characters discussed below, it is assigned to *Neogoneplax bradanica* n. sp.

According to Castro (2007: 618), the studied specimen is assigned to the Goneplacidae in having a carapace transversely rectangular, narrow, straight front, not marked by median notch, smooth dorsal surface, single anterolateral spine, reduced notch between frontal margin, inner edge of supraorbital border typically slight, orbits modera-

tely or largely wide, and fissure generally absent.

In a comparison of the studied specimen with the Goneplacidae fossil genera mentioned above, the MJS specimen differs from *Amydrocarcinus*, *Carcinoplax*, *Kowaicarcinus*, and *Magyarcarcinus* in having orbits wide and greatly expanded distally (*vs* orbits narrow, not expanded distally in the four mentioned genera). MST Q33 also differs from *Albaidaplax*, *Goneplax*, and *Psopheticus* in having spineless anterolateral margins (*vs* anterolateral margins with one spine in the three mentioned genera). Moreover, it cannot belong to *Aliaplax* in having carapace trapezoidal, strongly elongate transversely, twice wider than long, with one transverse uninterrupted ridge on the posterior third (*vs* carapace rectangular slightly wider than long, without transverse ridge in the studied specimen). The short, rounded front in *Astiaplax* rules out the belonging of the studied specimen to this genus (*vs* wide, T-shaped flat front in the studied specimen). Finally, the carapace transversely rectangular, much wider than long and the outer-orbital spines strongly downwardly directed in *Ommatocarcinus* excludes the belonging of the studied specimen to this genus (*vs* carapace rectangular slightly wider than long and outer-orbital spines forwardly directed in the studied specimen).

As the discussion about *Carcinoplax* points out, the comparison between the studied specimen and the extant genera is based on some proxy characters *sensu* Schweitzer (2003). The studied specimen differs from *Entricoplax*, *Goneplacoides*, and *Exopheticus* in having one or two anterolateral spines (*vs* no anterolateral spine/s in the studied specimen) and from *Singhaplax* and *Microgoneplax* in having adult of small size (wcxp rarely more than 4.5 mm) (*vs* wcxp = 15 mm in the studied specimen).

The specimen from MJS differs from *Neommatocarcinus* in having a carapace transversely rectangular, much wider than long, outer-orbital spines downwardly directed, and eyestalk longer than the front (*vs* carapace transversely rectangular, slightly wider than long, outer-orbital spines forwardly directed, and eyestalk slightly longer than the front in the studied specimen).

Finally, it also differs from *Notonyx* in having a carapace quadrate, slightly wider than long without outer-orbital spines (*vs* carapace rectangular, with outer-orbital spines in the studied specimen).

Hadroplax and *Paragoneplax* share with the studied specimen the shape of carapace which is

transversely rectangular, wider than long, without anterolateral spine/s, and the outer-orbital spines are forwardly directed. Still, they are characterized by eyestalk shorter than front, while the studied specimen is characterized by eyestalk longer than front.

Based on the diagnosis of *Neogoneplax*, some characters, such as the dorsal surface of the carapace smooth, moderately convex, without precise indication of regions; the outer-orbital spines forwardly directed; the spineless anterolateral margins; and the eyestalk long, longer than the front, are shared with the studied specimen, which is tentatively assigned to this genus. Indeed, among the species of *Neogoneplax* listed by Castro (2007), *N. costata* Castro 2007 is the most closely related species to the studied specimen, though the carapace is longer, the front wider, and the orbits more inclined in the latter. Based on these observations we justify the description of *Neogoneplax bradanica* n. sp. to accommodate the studied specimen. However, we cannot exclude that it could represent a new undescribed genus having morphological affinities with the Indo-Pacific genera. The question could be solved only by additional well-preserved specimens, including the ventral parts.

Based on Garassino et al. (2013), the extant *Neogoneplax* Castro, 2007 is represented in the fossil record with the sole species *N. arenicola* (Glaessner, 1960) from the late Oligocene – middle Miocene of New Zealand and *N. bradanica* n. sp. represents the first record for the genus out of the Indo-Pacific area.

Family Euryplacidae Stimpson, 1871

Genus *Chlinocephalus* Ristori, 1886

Type species: *Chlinocephalus demissifrons* Ristori, 1886, by monotypy.

Included fossil species: *Chlinocephalus demissifrons* Ristori, 1886.

Chlinocephalus demissifrons Ristori, 1886

Fig. 11

*1886 *Chlinocephalus demissifrons* Ristori, p. 101-103, pl. 2, figs 5, 6.
2020 *Chlinocephalus demissifrons* Ristori - Pasini et al., p. 54, fig. 3C-D
(*cum syn.*)
1936 *Geryon latifrons* Van Straelen, p. 477, 478, pl. 23, fig. 4.

Material: One complete carapace in dorsal view with translate pleon with thoracic appendages: MST Q34 (part-counterpart), level Vb1q.

Measurements: lcxp: 19 mm; wcxp: 22 mm.

Age: Early Pleistocene (*Pseudoemiliana lacunosa* biozone).

Discussion. The studied specimen reflects the main morphological characters of *Chlinocephalus demissifrons*, as follows: suboval, convex, smooth carapace, slightly wider than long; well-developed fronto-orbital region; wide, straight front; shallow, wide orbits with short eyestalk; one short outer-orbital spine; one sharp pointed spine on anterolateral margins; epibranchial spine; convex posterolateral margin; wide, straight posterior margin; dorsal region no distinct, with two transverse ridges, marking a dorsal depression on the carapace among them; suboval, wide cardiac region; well-developed P1 with elongate merus; subcylindrical carpus with a strong spine on inner distal margin; robust chelae with elongate, curved dactylus.

Chlinocephalus demissifrons has already been reported from the Pliocene of Savona, Liguria (Ristori 1886) and Biella, Piedmont (N Italy, Garassino et al. 2004), the Early Pleistocene of Umbria (central Italy, Baldanza et al. 2018), and recently from the Miocene of Emilia-Romagna (N Italy, Pasini et al. 2020) and Spain and Algeria (N Africa, Charbonnier et al. 2024).

Order **Isopoda** Latreille, 1816
Suborder **Cymothoida** Wägele, 1989
Family **Cirolanidae** Dana, 1852

Genus and species indet.

Fig. 12

Material: 16 specimens preserved as molts (MST Q76 – Q92, collected at various stratigraphic heights from Interval A), selected 5 in dorsal and ventral view: MST Q35, level FGD 3; MST Q36 (part and counterpart), level T23-T27 FG; MST Q37, level FGq2 bis; MST Q38, level T12-T13 FG; MST Q39, level T12-T13 5 agosto.

Measurements: Total body length including telson: from 7 mm to 24 mm (evaluation); body wide: *c.* from 1.7 mm to 6 mm.

Age: Early Pleistocene (small *Gephyrocapsa* biozone).

Description. Elongate, semicylindrical body, smooth with sparse small pits dorsally; lateral margins subparallel; convex cephalon poorly preserved with rounded front, smaller than pereonite 1; separate lateral eyes; pereonites 1-7 longer than pleonites 1-5; coxal plates more prominent and acute on pereonites 6 and 7; pleonites 1-4 similar in shape; pleonite 1 partially concealed dorsally under pereonite 7, pleonite 5 overlapped laterally by pleonite 4; pleonite 4 with longer acute pointed coxa; pleotelson slightly wider than long, tapering to the narrow rounded po-

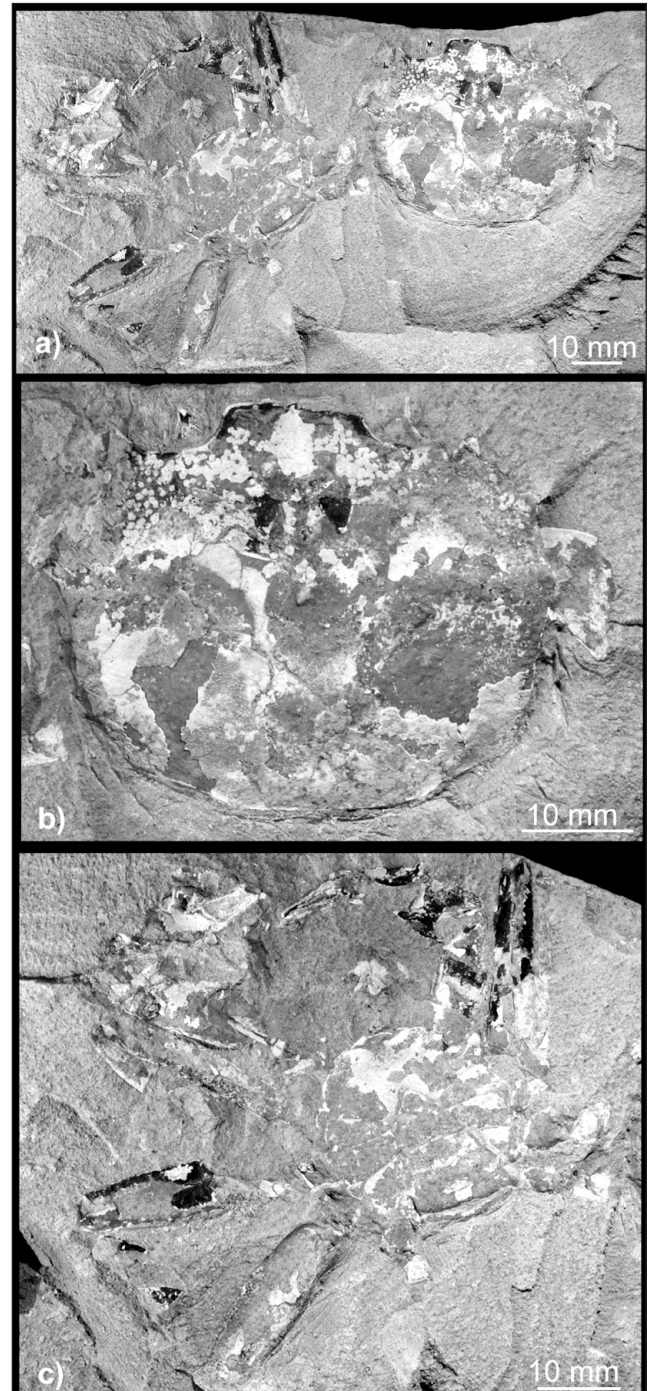


Fig. 11 - *Chlinocephalus demissifrons* Ristori, 1886: a) MST Q34 (level Vb1q, Lower Pleistocene), carapace, dorsal view; P1-P5, thoracic sternum, and pleon, ventral view. b) MST Q34, close-up of carapace, dorsal view. c) MST Q34, close-up of carapace in ventral view.

sterior margin; pleotelson rounded, narrowing distally; uropodal rami not extending beyond the posterior margin; exopod shorter than endopod.

Discussion. MST Q35 was previously figured by Ciaranfi et al. (2001: 78, fig. 11d) and mentioned as “shrimp” and later by D’Alessandro et al. (2003: 70, fig. 5) as “small shrimp”.

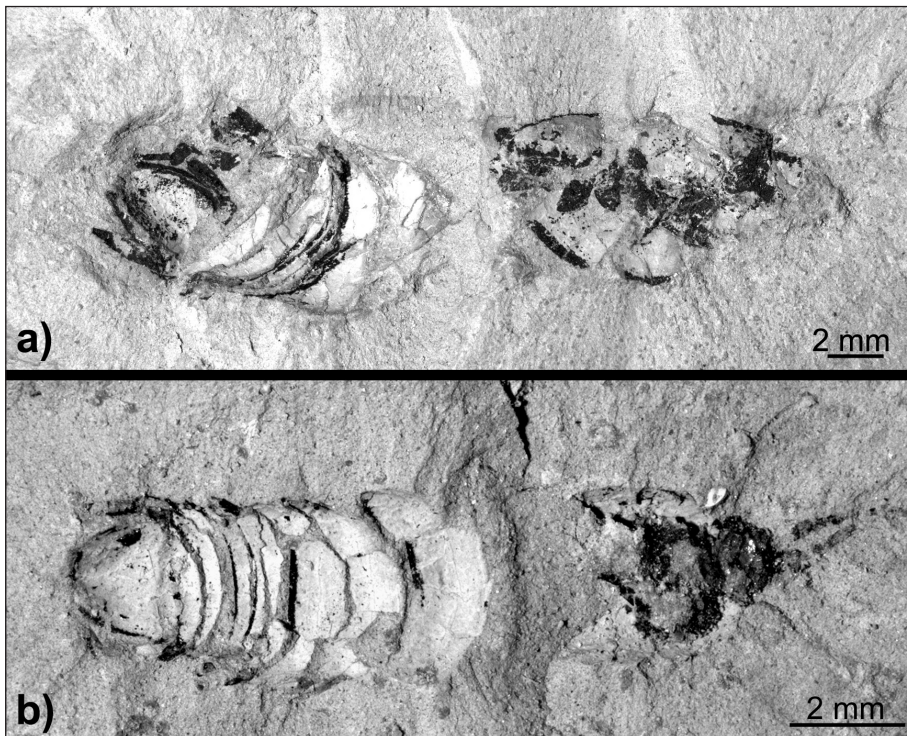


Fig. 12 - Indeterminate isopod cirolanid: a) MST Q39 (level T12-T13 5 agosto, Lower Pleistocene), dorsal view; b) MST Q35 (level FGD3, Lower Pleistocene), dorsal view.

Cirolanid fossils are usually known only from posterior parts of their exuviae as a result of their biphasic molting. According to Hyžný et al. (2013), “In the absence of antennae, mouthparts or pereopods, one cannot confidently differentiate the isopod families Cirolanidae, Aegidae, Corallanidae and Tridentellidae from each other.” Among isopods the Cirolanidae is one of the most diverse marine isopod families, with five fossil genera attributed to the family (*Brunnaega*, *Cirolana*, *Palaega*, *Pseudopalaega*, *Bathynomus*, see Hyžný et al. 2013 for complete discussion). The studied specimens consist of biphasic molts preserving only some generic proxy characters (*sensu* Schweitzer 2003), such as the semi-cylindrical elongate body and convex cephalon smaller than pereonite 1. The pleotelson, rounded posteriorly, lacks a median rim, smooth margins, and biramous uropod, allowing us to compare them to the representatives of the Cirolanidae Dana, 1852. The only fossil cirolanid reported from the Mediterranean Lower Pleistocene is the *Cirolana forticrura* De Angeli, Garasino & Pasini *in* Baldanza et al., 2017 from the shallow water deltaic environment of Poggi Gialli (Siena, central Italy, Baldanza et al. 2017), from which the studied specimens differ for the general shape and ornamentation of the pleonites and pleotelson (as preserved). However, the lack of cephalic characters does not allow a closer comparison with the extant Mediterranean species of the family. Therefore, we

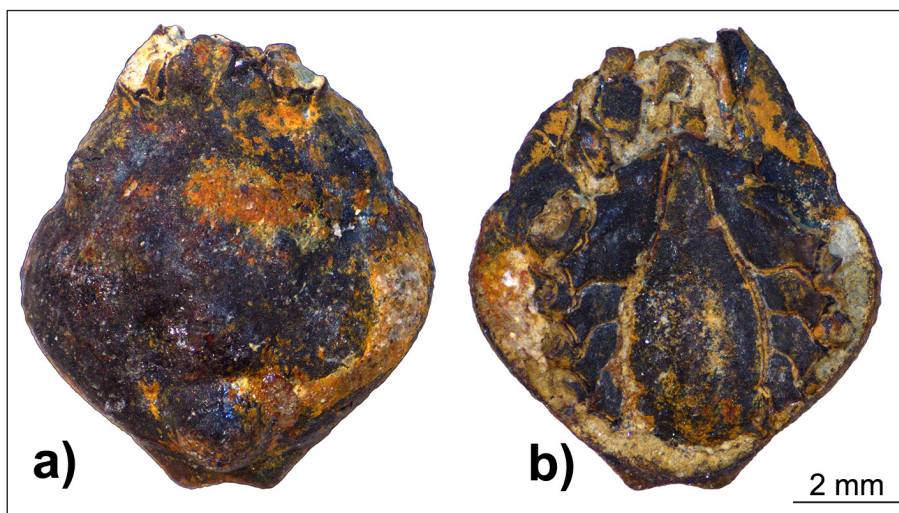
report the studied specimens in open nomenclature within Cirolanidae. The close preserved on each other *in situ* anterior and posterior biphasic molt parts demonstrate that the molting (Fig. 12a, b) was nearly simultaneous “instead of hours or even days known in extant taxa so far” (Hyžný et al. 2013: 626), also supporting the hypothesis of rapid burial or lower water energy, at the bottom of the sedimentary basin.

All the studied specimens were collected from the lowermost stratigraphic interval of the Fosso Giuseppe section and the 5 agosto section (Interval A, Lower Pleistocene) referable to the upper bathyal setting (D’Alessandro et al. 2003).

DISCUSSION AND CONCLUDING REMARKS

The decapod crustacean assemblage from MJS allows us to enlarge the knowledge of several crustacean species already known from the Pleistocene of Italy as *Ebalia nux* A. Milne-Edwards, 1883 (Leucosidae Samouelle, 1819); *Monodaeus bortolottii* Delle Cave, 1988 (Xanthidae MacLeay, 1838); *Liocarcinus depurator* (Linnaeus, 1758) (Portunidae Rafinesque, 1815), *Goneplax rhomboides* (Linnaeus, 1758) (Goneplacidae MacLeay, 1838); and *Chlinocephalus demissifrons* Ristori, 1886 (Euryplacidae Stimpson, 1871). Two new species, *Carcinoplax jonica* n. sp., and *Neogoneplax bradanica* n. sp. (Goneplacidae MacLeay, 1838) also occur.

Fig. 13 - *Ebalia ?nux* A. Milne-Edwards, 1883 (level FGq6, Lower Pleistocene): a) dorsal; b) ventral view. Example of pyrite steinkern.



Taphonomy

In the present study, specimens are generally preserved three-dimensionally, though they are frequently crushed by sediment compaction. Preservation varies from almost complete and articulated specimens (Figs. 7a; 9; 10) to strongly disarticulated remains (Figs. 2; 3; 4c-d). Diagenetic dissolution is generally present and particularly strong in small specimens, but it is less extensive in larger specimens and strongly calcified parts (chelipeds).

As observed by Soldani & Girone (2000), who first reported on the decapods from the MJS, specimens can be clustered in two groups which are representative of distinct taphonomic processes. The first group includes disarticulated carapaces, generally with well-preserved morphological details despite diffuse decalcification, without neformed minerals (Figs. 3; 4a-b; 6b). The second group includes articulated specimens, with well-preserved morphological details, sometimes partly decalcified, often with pyrite internal linings or fillings (Figs. 2; 6a; 10a). These distinct taphonomic processes are related to environmental factors since homogeneous taxonomic assemblages can be preserved differently. While the taphonomic traits of the first group can be referred to as normal sedimentation rate, low enough to leave exoskeletons exposed at the sediment/water interfaces until their complete decay and disarticulation, the second one is indicative of catastrophic burial of living animals. In these cases, pyrite is formed within exoskeletons by bacterial reduction of sulfates from decaying organic matter (Berner 1984; Schoonen 2004). Pyritization is particularly extensive in small-sized specimens, forming pyrite steinkerns (Fig.13), while

in larger specimens it forms inner linings (Figs. 7a; 10). Frequent changes in sedimentation rate, from moderate to high and even catastrophic events, are known all through the MJS and documented by taphonomic and paleoecological characters (D'Alessandro et al. 2003). Of course, disarticulated remains and complete specimens can be found at the same level. In this case, the former are older, exposed remains buried by the sedimentary event together with living specimens. In no case, except for cirrolanid specimens, was it possible to understand if skeletons were the result of molting or dead animal remains (except for pyritized specimens, assumed to have been killed by burial).

The preservation conditions recorded within the studied material are consistent with the previous knowledge of marine arthropod taphonomy. Based on experimental studies (Mutel et al. 2008; Klomp maker et al. 2017), decapods have a variable potential for preservation, increasing with the degree of calcification. Fossilization of decapod crustaceans and other marine arthropods is favored by the presence of a mineral component in their chitinous cuticle. The mineral fraction generally consists of low-Mg calcite (Fay & Smith 2021), both crystalline and amorphous (Luquet 2012). The calcification degree varies, from about 50% to almost 100% among crabs (Fay & Smith 2021), with maximum values recorded in claws (Boßelmann et al. 2007). Cuticle strength, depending on thickness and amount of calcification, is strongly variable and related to lifestyle, as benthic decapods provide more robust exoskeletons (Amato et al. 2008). In particular, brachyurans are among the most frequent arthropods in the fossil record,

	Taxa	palaeoenvironmental setting
Subfamily EBALIINAE	<i>Ebalia nux</i> A. Milne-Edwards, 1883	upper slope
Subfamily EUXANTHINAE	<i>Monodaeus bortolottii</i> Delle Cave, 1988	upper slope and slope transitional to shelf
Subfamily CARCININAE	? <i>Carcinus</i> sp.	middle-inner shelf
Subfamily POLYBIIDAE	<i>Liocarcinus depurator</i> (Linnaeus, 1758)	outer shelf
Family GONEPLACIDAE	<i>Carcinoplax jonica</i> Garassino & Pasini n. sp.	upper slope and inner-middle shelf
	<i>Carcinoplax</i> sp.	middle-inner shelf
	<i>Goneplax rhomboides</i> (Linnaeus, 1758)	upper slope and shelf
	<i>Neogoneplax bradanica</i> Garassino & Pasini n. sp.	outer shelf
Family EURYPLACIDAE	<i>Chlinocephalus demissifrons</i> Ristori, 1886	outer shelf

Tab. 1 - Summary of the palaeoenvironmental preferences of the studied taxa recorded at MJS.

thanks to their generally high degree of calcification. Carapace and chelipeds are among the most durable parts of crab exoskeletons. Still, the former strongly degrade in a few years in underexposed conditions, while claws, mandibles, and terminal anterolateral spines tend to be preserved longer. However, it can become extensively fragmented (Mutel et al. 2008). According to the experimental finding, disarticulated claws are common in screen-washed samples from MJS. Therefore, experimental observations confirm that rapid burial and mineralization during diagenesis are necessary for the fossil preservation of complete or mostly articulated crab remains.

Paleoecology and paleobiogeography

The well-constrained stratigraphical and palaeoenvironmental data available for the MJS, based on micro and macroinvertebrate assemblages, allow us to improve our knowledge about the stratigraphic distribution and paleoecology of the crustacean decapods during the Early and Middle Pleistocene in the Mediterranean (Table 1).

Ebalia nux (MST Q5-23) has been found at various heights along the interval A of MJS. It is more frequent in levels that were deposited during deepening phases related to interglacial phases (Fig. 1). Here, it is found in associations with typical bathyal macro-invertebrate taxa or with molluscan fauna indicative of upper slope facies (D'Alessandro et al. 2003), in agreement with the modern bathyal distribution of the taxon. *E. nux* is, among the extant species of *Ebalia*, a deep-water species, living between 80 and 2500 m on muddy bottoms (Zariquiey Álvarez 1968; Falciai & Miner-

vini 1992). It is widespread in the eastern Atlantic, from Great Britain to Cape Verde Islands, and in the Mediterranean Sea. *Goneplax rhomboides* (MST Q31-32), in agreement with its modern bathymetric distribution, is the most frequent decapod along the entire MJS (Fig. 1), where it is found in association with bathyal or shelf molluscan assemblages at various stratigraphic heights. Nowadays, *G. rhomboides* is widespread in the Mediterranean Sea and Atlantic Ocean from the North Sea to southern Africa and the Indian Ocean coast of South Africa (see Guinot & Castro 2007) on muddy or slightly sandy bottoms from intertidal to 700 m in depth (Falciai & Minervini 1992: 238).

The distribution of the extant *Liocarcinus depurator* (MST Q28) seems to point to Pleistocene ecological preferences similar to the modern ones. It is widespread in the Atlantic Ocean and Mediterranean Sea on muddy bottoms between a few meters and 300 m (Zariquiey Álvarez 1968; Falciai & Minervini 1992). At MJS *L. depurator* occurs a few meters above the volcanoclastic layer V2 in association with a *Venus multilamella*-dominated palaeocommunity (D'Alessandro et al. 2003) indicative of outer shelf setting correlated to an interstadial phase of glacial MIS 22, confirming its preference to temperate water conditions (Christiansen 1982; Pérès & Picard 1965). Similar ecological requirements can be inferred for the fossil taxa *Chlinocephalus demissifrons* (MST Q34) and *Neogoneplax bradanica* n. sp. (MST Q33), both of them occur below V2 (Fig. 1). Based on Castro (2007) the bathymetric distribution of the extant *Neogoneplax* species ranges between 50-550 m, in accordance with the palaeobathymetric data from MJS.

A very distinct stratigraphic occurrence is displayed by the fossil species *Monodaenus bortolottii* (MST Q25; 26), which was found in the FG section (interval A) and Ideale section (interval B) in association with macro-invertebrate assemblages typical of bathyal (FG section) and shelf transitional-to-slope setting (Ideale section), deposited respectively during MIS 31 and MIS 19, considered two long and warm interglacial phases, at a global scale. Such an occurrence seems to be indicative of a warm or warm-temperate affinity, in accordance with its Pliocene records. A warm-temperate affinity and a wide bathymetric range can be inferred for the Pleistocene species *Carcinoplax jonica* n. sp. (MST Q29, Q30). It occurs in upper slope (FG section) and shelf (VB section) paleoenvironmental settings correlated to two warming phases (Fig. 1). The co-generic *Carcinoplax* sp. (MST Q3 and Q40) also shows warm-temperate sea water preference but in a shallower setting since both specimens were found in association with middle-inner shelf molluscan palaeocommunity. The occurrence in the Mediterranean basin of *Carcinoplax* and *Neogoneplax*, both with clear Indo-Pacific affinities points out the issue concerning the presence of some “exotic” fossil taxa within the Mediterranean basin, as highlighted by Baldanza et al. (2017). Indeed, the paleogeographic reconstructions show that the Indian Ocean gateway to the Mediterranean closed in the Langhian-Serravallian (Early-Middle Miocene) (Bialik et al. 2019). Since then, faunistic exchange between the Indian Ocean and the Mediterranean became impossible. The occurrence of taxa of Indo-Pacific affinity in the Mediterranean during the Pliocene and Pleistocene is well-known (“Tethyan relics”), throwing back to the time when the Mediterranean region was in connection with the Indo-Pacific (Taviani 2002; Sabelli & Taviani 2014 with references).

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