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## Revision of the fossil species of *Goneplax* Leach, 1814 (Crustacea, Decapoda, Brachyura, Goneplacidae)

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### Abstract

A revision of the fossil species of *Goneplax* Leach, 1814, has resulted in the assignment of four fossil species to *Goneplax*, but only *G. gulderi* Bachmayer, 1953, and *G. rhomboides* are considered as valid. *Goneplax craverii* Crema, 1895, previously assigned to *Retropluma* Gill, 1894, *G. formosa* Ristori, 1886, and *G. meneghini* Ristori, 1886, are regarded as junior synonyms of *G. rhomboides*, while *G. sacchi* Crema, 1895, is considered a *nomen dubium*. *Albaidaplex* n. gen. is here erected to include both the Italian specimens from the Miocene of Rio Popogna (Livorno, Tuscany, Italy) and the Spanish specimens from the Pliocene of Guadalquivir Basin (Seville, Andalusia, Spain) previously assigned to *G. gulderi*. Finally, *Ommatocarcinus arenicola* Glaessner, 1960, from the Late Oligocene-Middle Miocene of New Zealand, is assigned to the extant *Neogoneplax* Castro, 2007, constituting the first report of this genus in the fossil record.

Keywords: Crustacea, Decapoda, Brachyura, Goneplacidae, Miocene, Pliocene, Italy, Austria, Spain, New Zealand.

### Resumen

La revisión de las especies de *Goneplax* Leach, 1814, ha arrojado la asignación de cuatro especies fósiles de *Goneplax*, pero sólo *G. gulderi* Bachmayer, 1953, y *G. rhomboides* son consideradas como válidas. *Goneplax craverii* Crema, 1895, previamente asignada a *Retropluma* Gill, 1894, *G. formosa* Ristori, 1886, y *G. meneghini* Ristori, 1886, son consideradas como sinónimos junior de *G. rhomboides*, mientras que *G. sacchi* Crema, 1895, es considerada como *nomen dubium*. Se propone *Albaidaplex* n. gen. para incluir tanto los especímenes italianos del Mioceno de Rio Popogna (Livorno, Toscana, Italia) como los especímenes españoles del Plioceno de la Cuenca de Guadalquivir (Sevilla, Andalucía, España), previamente asignados a *G. gulderi*. Finalmente, se asigna *Ommatocarcinus arenicola* Glaessner, 1960, del Oligoceno Tardío-Mioceno Medio de Nueva Zelanda, al género existente *Neogoneplax* Castro, 2007, y constituye el primer registro del género como fósil.

Palabras Clave: Crustacea, Decapoda, Brachyura, Goneplacidae, Mioceno, Plioceno, Italia, Austria, España, Nueva Zelanda.

## 1. Introduction

Castro (2007) reviewed the extant members of the subfamily Goneplacinae MacLeay, 1838, whereas Guinot and Castro (2007) pointed out the status of *Goneplax rhomboides* (Linnaeus, 1758) and Castro *et al.* (2010) gave a detailed table of diagnostic characters of the eleven goneplacoid families. *Goneplax* Leach, 1814, was revised to include the following fossil species previously listed by Karasawa and Kato (2003): *G. arenicola* (Glaessner, 1960), *G. craverii* Crema, 1895, *G. formosa* Ristori, 1886, *G. meneghinii* Ristori, 1886, *G. gulderi* Bachmayer, 1953, *G. saccoi* Crema, 1895, and the fossil and extant *G. rhomboides* (Linnaeus, 1758). *Goneplax craverii* had been previously assigned to *Retropluma* Gill, 1894 (Retroplumidae Gill, 1894) by Beschin *et al.* (1996) (see also De Angeli *et al.*, 2011). New, well-preserved specimens from the Miocene and Pliocene of Italy nevertheless necessitate a revision of the fossil species of *Goneplax*. The main diagnostic characters used in this study have been considered regarding the status of preservation of the specimens, where only the carapace and some other parts of the exoskeleton are observable. On the other hand, the male and female gonopores, male pleopods (G1 and G2) and thoracic sternal sutures, which are important diagnostic structures useful in neontological systematics, are never or very rarely preserved in fossil crabs.

### 1.1. Taphonomy and taxonomic remarks

Several of the reviewed specimens are preserved more or less mineralized as internal moulds only, lacking the original exoskeleton due to the peculiar process during the fossilization which destroys the original cuticle or subsequently washes it. The specimens from some localities such as Albaida del Ajarife (Guadalquivir Basin, Seville, Spain), Monterotondo Marittimo, and Volterra (Tuscany, Italy) are especially preserved as internal moulds, rich in iron redox, as well as the specimen from New Zealand which is also a washed internal mould poorly preserved in a calcareous rock. This kind of preservation mislead some authors who confused the presence of a median frontal notch as an external character on the cuticle (Glaessner, 1960), while it can be interpreted as the imprint of an internal subrostral thickening structure. Therefore lacking the original dorsal ornamentation and the ventral parts, the main diagnostic characters considered to compare fossil and extant species in this study are limited to the general form of the carapace, the shape of the outer orbital tooth, the orbital outline, and the presence or absence of anterolateral teeth or knobs.

## 2. Material

This review includes all the specimens previously

referred to *Goneplax* reported in the paleontological record, as well as additional unreported specimens recently discovered in Italy and Spain.

The material is deposited in the Centro Civico “Ofelia Mangini”, seat of Gruppo GAMPs (Badia a Settimo, Scandicci, Florence, Italy) (CF-TCR); Geological Section of the Museo di Storia Naturale dell’Accademia dei Fisiocritici, Siena (MUSNAF); Gruppo Paleontologico “C. De Giuli”, Biblioteca Comunale Vallesiana (Castelfiorentino, Florence, Italy) (GPDG); Museo Geologico di Castell’Arquato (Piacenza, Italy) (MG); Museo Geológico, Universidad de Sevilla, Spain (MGUS); Museo Regionale di Scienze Naturali di Torino (PU); Museo di Storia Naturale dell’Università degli Studi di Firenze (IGF); Museo di Storia Naturale di Milano (MSNM); Naturhistorisches Museum, Wien (NHMW); New Zealand Geological Survey (GNS).

## 3. Systematic Paleontology

Superfamily Goneplacoidea MacLeay, 1838

Family Goneplacidae MacLeay, 1838

Subfamily Goneplacinae MacLeay, 1838

Key to the fossil genera *Goneplax* Leach, 1814, *Albaidaplex* n. gen., *Neogoneplax* Castro, 2007 (Goneplacinae MacLeay, 1838)

Carapace transversely rectangular to trapezoidal, strongly wider than long; widest at anterolateral tooth; dorsal surface of carapace smooth with raised horizontal ridges, without clear indication of regions; front slightly concave or straight, not marked by slight median notch or projection; front shorter than orbits; orbits wide, greatly expanded distally; supraorbital border conspicuously sinuous; outer orbital angle with conspicuous acute tooth; anterolateral margins diverging frontally or rounded with single acute tooth or knob; male cheliped (P1) elongated in some species: *Goneplax*.

Carapace transversely rectangular, slightly wider than long; dorsal surface of carapace smooth with slight horizontal ridges, without clear indication of regions; straight front slightly turned downwards; orbits wide, gently expanded distally; supraorbital border gently sinuous; outer orbital angle with short acute tooth; anterolateral margins slightly convex, with single short tooth; male cheliped (P1) short, with stout palm: *Albaidaplex*.

Carapace transversely rectangular, much wider than long; widest at conspicuous outer orbital tooth; dorsal surface of carapace smooth or with slight horizontal ridges, without clear indication of regions; straight front, slightly deflected ventrally; orbits wide, greatly expanded distally; supraorbital border conspicuously convex; outer orbital angle with conspicuous acute tooth; anterolateral margin with one single tooth (acute or obsolete); cheliped (P1) long, slender: *Neogoneplax*.

Genus *Goneplax* Leach, 1814

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

**Diagnosis** (after Castro, 2007): Carapace transversely rectangular to trapezoidal, much wider than long; widest at anterolateral teeth posterior to conspicuous outer orbital teeth; front slightly deflected ventrally, slightly concave or straight, not marked by slight median notch or projection. Notch between front, inner edge of supraorbital border distinct, slight, or absent; orbits wide, greatly expanded distally; supraorbital borders conspicuously sinuous; suborbital borders sinuous, with slight, wide obtuse inner tooth not visible dorsally; anterolateral borders short, straight or slightly convex. Dorsal surface of carapace smooth, with slight horizontal ridges, moderately convex, without clear indication of regions. Outer orbital angle with conspicuous, acute tooth; single acute anterolateral tooth on each side of carapace (short, obtuse, or obsolete in some specimens of *G. rhomboides*). Basal antennal article short, distalmost (third) article reaches front. Eye peduncles long, shorter to as long as front (0.4–1.0 front width); cornea spherical to elongated. No obvious stridulating mechanism other than possible rubbing of proximal portion of cheliped (P1) merus against pterygostomial ridge. Thoracic sternum wide. Median line on thoracic sternite 4 absent; sutures 4/5, 5/6, 7/8 interrupted medially, 6/7 complete. Anterior end of sterno-abdominal cavity anterior to thoracic sternite 4. Cheliped fingers long, slender, straight or slightly curved, shorter than elongated propodus; variable portion of dactylus darker in colour, tip light; carpus with tooth on inner margin (absent in large individuals). Dorsal margins of ambulatory leg (P2–P5) meri with acute distal tooth; dactyli slender, with carina on each side, setose. Male pleon with 6 freely-movable somites plus telson, narrowly triangular, somites 4–6 gradually decreasing in width from somite 3 (widest somite). Telson slightly longer than wide. Somite 3 covers space between P5 coxae, somite 2 much narrower than somite 3 so that somites 1, 2 leave relatively large portion of thoracic sternite 8 visible. G1 long, slender, thin, slightly sinuous, only slightly broadened proximally; pointed, thin tip. G2 slender, slightly longer or slightly shorter than G1, flagellum shorter than proximal part (peduncle), curved; slightly-expanded tip with 1 or 2 spinules. Penis arising from P5 coxa, moderate size; broad, soft proximal expansion. Female pleon with 6 freely-movable somites, wide. Telson much wider than long. Somite 3 covers space between P5 coxae, somite 2 slightly narrower than somite 3 but somites 1, 2 leave relatively large portion of thoracic sternite 8 visible. Vulva of mature females round, extending from oblique 5/6 suture to 6/7 suture or to median portion of thoracic sternite 6, covered by soft membrane, vulvar cover absent.

Key to the fossil species of *Goneplax* Leach, 1814

Carapace transversely subtrapezoidal or quadrate, slightly wider than long, widest at anterolateral tooth; carapace smooth, with two raised horizontal ridges, without clear indication of regions; front slightly concave, not marked by median notch or projection; front as wide as orbits; relatively wide orbits, slightly expanded distally; outer orbital angle with conspicuous acute tooth; anterolateral margins straight frontally; single reduced anterolateral tooth (short or acute); male cheliped (P1) short, with stout palm *Goneplax gulderi*.

Carapace transversely trapezoidal (more marked in male), strongly wider than long, widest at anterolateral tooth; carapace smooth, with two slight horizontal ridges, without clear indication of regions; front slightly concave, not marked by median notch or projection; front shorter than the orbits; wide orbits, greatly expanded distally; outer orbital angle with conspicuous acute tooth; anterolateral margins diverging frontally; single acute anterolateral tooth (short, acute, or obsolete); male cheliped (P1) well developed, with elongated palm *Goneplax rhomboides*.

*Goneplax gulderi* Bachmayer, 1953

## Figure 1.A

*Goneplax gulderi* Bachmayer, 1953: 143, 144, pl. 9, figs. 1–3.

*Goneplax gulderi* – Müller, 1984: 96, pl. 93, figs. 2–3. – Müller, 1993: 23, fig. 11 K. – Mayoral *et al.*, 1998: 508, 509, fig. 2 (5). – Müller, 1998: 38. – Garassino and De Angeli, 2004: 45. – De Angeli and Garassino, 2006: 65. – Castro, 2007: 686. – De Angeli *et al.*, 2009: 187, 188, 189, fig. 18 A, B. – Schweitzer *et al.*, 2010: 135. – Garassino *et al.*, 2012: 46. – Pasini and Garassino, 2013: 321, 322.

*Goneplax* cf. *sacconi* [sic] – Vía, 1948: 146, fig. 6. – Solé and Vía, 1989: 34.

*Goneplax* cf. *gulderi* – Müller, 1979: 6.

**Remark.** Bachmayer (1953) described *G. gulderi* from one complete carapace, decorticated and poorly preserved, and from one isolated dactylus. De Angeli *et al.* (2009) subsequently referred some additional specimens from the Miocene of Tuscany to this species. Their state of preservation allows for the first time to point out the main diagnostic characters of *G. gulderi*.

**Emended diagnosis:** Carapace transversely subtrapezoidal or quadrate, 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 tooth; anterolateral margins straight frontally; single reduced anterolateral tooth (short or acute); posterolateral margins tapering posteriorly; straight posterior margin; smooth dorsal surface of carapace, with raised horizontal ridges, without clear indication of regions; male cheliped (P1) short; rounded carpus with anterolateral



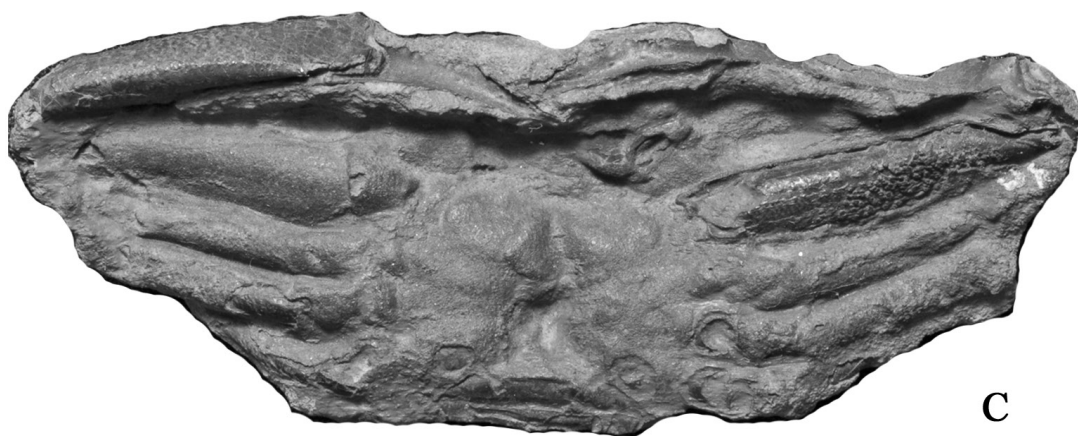
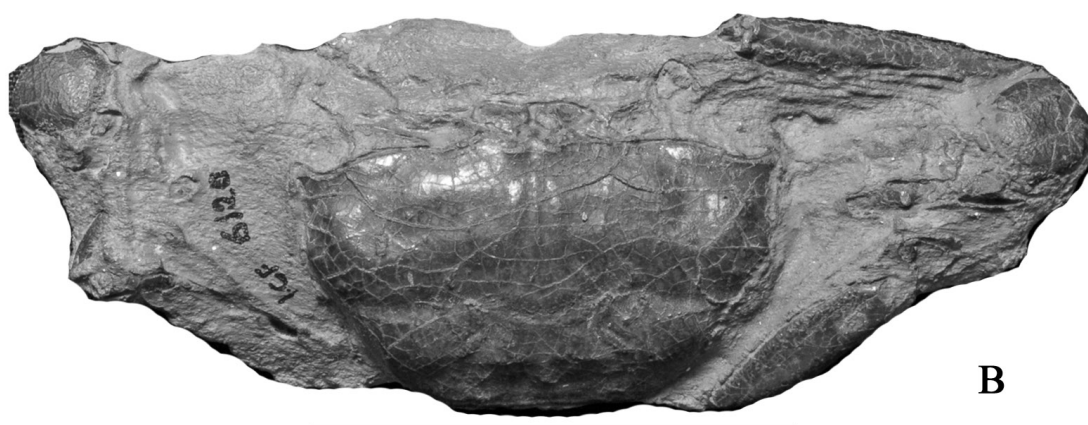
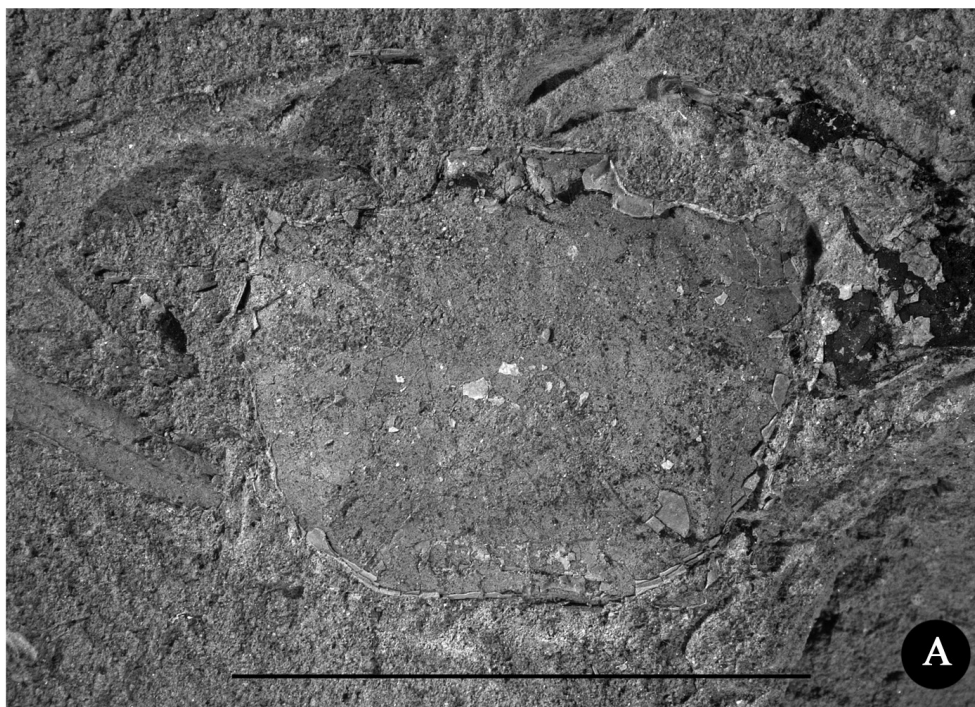


Figure 1. A, *Goneplax gulderi* Bachmayer, 1953, holotype NHMW 1953/0053/0001. Scale bar: 32 mm. B, *Goneplax formosa* Ristori, 1886, holotype IGF 612E. A) dorsal view. Scale bar: 30 mm. C) ventral view. Scale bar: 20 mm.

spine; stout palm; elongated, flat ambulatory legs (P2-P5).

**Holotype:** NHMW 1953/0053/0001.

**Geological age:** Miocene.

**Occurrence:** Austria (Baden); Italy (Tuscany).

**Additional studied material:** complete specimens in dorsal view (MSNM i27082, i27083, i27084, i27085, i27086, i27087; GPDG 0085, 0086, 0087, 0088); isolated dactylus (MHNW 1953/0053/0001b).

**Description:** We confirm the original description by Bachmayer (1953) and the updated data by Müller (1993).

**Discussion:** Bachmayer (1953) was unable to point out the main specific characters of his new species because of the decortication of the dorsal surface of the carapace. *Goneplax gulderi* differs from *G. rhomboides* in the presence of the two well-marked transverse ridges on the wider than long carapace and especially for the anterior margin where each orbit is as wide as the front. In *G. rhomboides* the orbits are indeed wider than the width of the front.

*Goneplax rhomboides* (Linnaeus, 1758)

Figures 1.B, 1.C, 2

*Cancer rhomboides* Linnaeus, 1758: 626.

*Goneplax angulata* Leach, 1814: 430.

*Goneplax impressa* Desmarest, 1817: 504, 505.

*Goneplax rhomboides* – Milne-Edwards, A., 1861: 88. – Heller, 1863: 104, pl. 3, figs. 3, 4. – Ristori, 1886: 111–113. Vía, 1948: 146. – Bachmayer, 1953: 145. – Holthuis and Gottlieb, 1958: 99. – Zariquiey Álvarez, 1959: 5. – Holthuis, 1961: 57. – Zariquiey Álvarez, 1968: 414–416, fig. 138 a, b. – Rice and Chapman, 1971: 336, 337, 339, figs 5–7. – Pastore, 1972: 108, 113. – Jenkins, 1975: 33, 57. – Garcia Raso, 1984: 108, 111. – Garcia Socias and Massuti Jaume, 1987: 81, 92. – Falciai and Minervini, 1992: 238, pl. 17, fig. 1. – Müller, 1993: 23. – d’Udekem d’Acoz, 2001: 49. – Karasawa and Kato, 2003: Tab. 1, Tab. 6. – Vukanic, 2003: 150. – Garassino and De Angeli, 2004: 44, 45, figs. 12–15. – Garassino *et al.*, 2004: 274, 275, fig. 14. – Company *et al.*, 2004: 78. – De Angeli and Garassino, 2006: 65. – Suat Ates *et al.*, 2006: 134, 136, 138, 140. – Castro, 2007: 686–690, 692, fig. 27. – Celik *et al.*, 2007: 183. – Fanelli *et al.*, 2007: 22, 23, 25. – Ng *et al.*, 2008: 80. – De Angeli *et al.*, 2009: 188, 189. – Neumann *et al.*, 2010: S27–S30, figs 2, 3. – Schweitzer *et al.*, 2010: 135. – Capezzuto *et al.*, 2010: 204. – Mura and Corda, 2011: 680. – Garassino *et al.*, 2012: 45–47, 53, fig. 20 C, D. – Pasini and Garassino, 2013: 321, 322.

*Goneplax rhomboides* [sic] – Glaessner, 1929: 199. – Vía Boada, 1933: 226.

*Goneplax cf. rhomboides* – Gemmellaro, 1914: 90, pl. 1, fig. 26.

*Goneplax rhomboidea* [sic] – Lörenthey, 1909: 250, 251.

*Goneplax angulata* – Heller, 1863: 103. – Nobre, 1936: 57; pl. 21, fig. 40. – Bouvier, 1940: 278, fig. 176; pl. 9, fig. 2. – Zariquiey Álvarez, 1946: 162, pl. 18, figs. a, b.

*Goneplax* [sic] *impressa* – Desmarest, 1822: 102–104,

pl. 8, figs. 13, 14

*Goneplax impressa* – Garassino *et al.*, 2012: 46.

*Goneplax* [sic] *bispinosa* – Ristori, 1891: 20, 21.

*Goneplax* [sic] *formosa* Ristori, 1886: 111–114, pl. 3, figs. 11–13. **nov. syn.**

*Goneplax formosa* – Glaessner, 1929: 198. – Castro, 2007: 686. – De Angeli *et al.*, 2009: 188. – Schweitzer *et al.*, 2010: 135. – Garassino *et al.*, 2012: 46.

*Goneplax* [sic] *meneghinii* Ristori, 1886: 114–116, pl. 3, figs. 8–10. **nov. syn.**

*Goneplax* [sic] *meneghinii* – Ristori, 1891: 21. – Ristori, 1892: 89. – Ristori, 1896: 506.

*Goneplax meneghinii* – Lörenthey, 1909: 250, 251. – Glaessner, 1929: 199. – Castro, 2007: 686. – De Angeli *et al.*, 2009: 188. – Schweitzer *et al.*, 2010: 135. – Garassino *et al.*, 2012: 46.

*Goneplax* [sic] *meneghini*? [sic] – Tettoni, 1924: 161.

**Holotype:** Most probably not extant (Castro, 2007: 688).

**Geological age:** Miocene – Pleistocene.

**Occurrence:** Italy (Piedmont, Emilia Romagna, Tuscany, Lazio, Sicily).

**Additional studied material:** *G. rhomboides* – complete specimens (GPDG 0137, 0138; IGF 100007; MG 0596, 0597, 0598, 0599, 0600, 0602, 0612, 0614, 0621; MSNM i27766; PU 41185, 41186); incomplete specimens (MSNM i27762, i27764, i27765); complete specimen in ventral view (CF-TCR 2) erroneously assigned by De Angeli *et al.* (2009) to *G. gulderi*; chelae (MG 0601, 0632, 0633); type material of *G. formosa* – holotype (IGF 612E); type material of *G. meneghinii* – syntypes (IGF 609E, 610E, 611E).

**Remark:** The incomplete specimen assigned to *G. bispinosa* by Ristori (1891) (Zuccari coll., Museo di Geologia e Paleontologia, Rome, Italy); the isolated dactylus assigned to *G. cf. rhomboides* by Gemmellaro (1914) (Museo Geologico, Palermo, Sicily, Italy); and the specimen assigned to *G. impressa* by Desmarest (1817, 1822) (paleontological collection of Muséum national d’Histoire naturelle, Paris) are lost. Milne-Edwards, A. (1861) reported many carapaces from Monte Pellegrino (Palermo) without repositories.

Ristori (1896) assigned one specimen from the Pliocene of Pancoli (Limite, Valdarno) to *Goneplax meneghinii*, without repository; Tettoni (1924) assigned dubiously some specimens from the Pliocene of S. Venanzio (Modena) to *Goneplax meneghini* (Museo Geologico, Università di Modena, without catalogue numbers); the rich collection of decapods from S. Venanzio probably includes Tettoni’s specimens; however it was impossible to recognise Tettoni’s original specimens because of the lack of catalogue numbers and figured specimens (P. Serventi, pers. comm., 2012).

**Discussion:** *Goneplax rhomboides* (Linnaeus, 1758) is so far known only in the fossil record of Italy from the Miocene to Pleistocene of Piedmont, Emilia Romagna, Tuscany, Lazio, and Sicily, as reported by many authors (Desmarest, 1817, 1822; Milne-Edwards, A., 1861; Gemmellaro, 1914; Garassino and De Angeli, 2004;

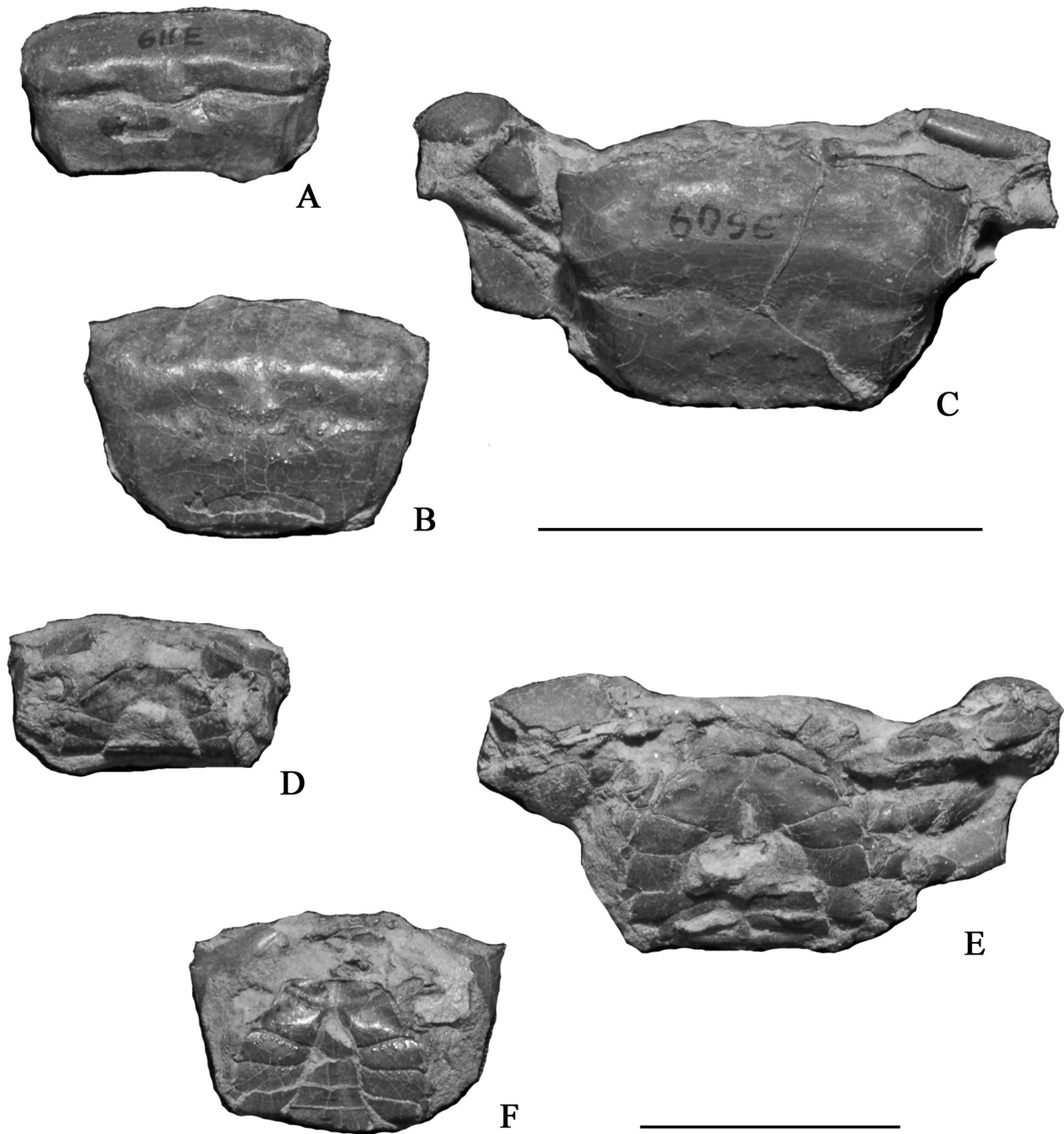


Figure 2. *Goneplax meneghinii* Ristori, 1886, dorsal and ventral views of syntypes IGF 609E (A, D, female), 610E (B, F, male), 611E (C, E, female). Scale bars: 30 mm

Garassino *et al.*, 2004; Garassino *et al.*, 2012; Pasini and Garassino, 2013). This species is widespread in the eastern Atlantic, western Africa, and Mediterranean Sea, burrowing in sublittoral shallow muddy and sandy bottoms from a few to about 100 m deep (Falciai and Minervini, 1992; Zariquiey Álvarez, 1968).

Ristori (1886: pl. 3; figs. 11, 12, 13) described *G. formosa* Ristori, 1886, from the Pliocene of Rapolano (Siena, Tuscany) by a single three-dimensionally preserved male

carapace, with incomplete legs and right propodus. Ristori (1886: 111, 112) pointed out that the specimen was closer to *G. rhomboides*, but differed in having a marked trapezoidal carapace with orbito-frontal margin wider than the posterior margin; well-distinct regions, some small granulations on the cardiac lobe and orbital cavity (?different from *G. rhomboides*). Some measurements of the carapace were reported and compared with a carapace of an extant specimen of *G. rhomboides* to show the differences between



the two species (Ristori, 1886: 111).

Müller (1993) subsequently marked that "...As it was pointed earlier, the carapace of the Mediterranean extant species *G. rhomboides* is extremely variable. Its range of variability most probably covers the two Pliocene Italian forms (*G. formosa* Ristori, 1886, and *G. meneghini* Ristori, 1886...)". Following Müller (1993), and based on the original description and comparison with the holotype of *G. formosa*, we consider as non-diagnostic the characters described by Ristori, due to the variability in the carapace shape and ornamentation in *G. rhomboides*. Therefore, *G. formosa* is here considered as junior synonym of *G. rhomboides*.

Ristori (1886: 112; pl. 3, figs. 8, 9, 9a, 10) described the main characters of *G. meneghini* Ristori, 1886, from the Pliocene of Rapolano (Siena, Tuscany) using three carapaces (two females and one male), three-dimensionally preserved. Ristori (1886) pointed out that "...this species is more similar to the extant form (= *G. rhomboides*), than the previous one (= *G. formosa*) ...". Especially the females show some different characters: subquadrate carapace; wider front; more developed posterior margin; small sparse tubercles ranged along the cardiac lobes and the frontal margins. Other possible differences are described on the general distribution of the lobes and form of the ocular orbits. Also for this species still stand the remarks of Müller (1993), (see above in this discussion). We point out that the shape of the carapace observed by Ristori (1886) fits into variability of the extant females of *G. rhomboides*, where the form is generally less trapezoidal and more subquadrate due the shorter fronto-orbital margin and the wider posterior, as seen in the Adriatic Sea specimens. For these reasons, and following Müller (1993), we consider the characters described by Ristori (1886), as non-specific, including *G. meneghini* as a junior synonym of *G. rhomboides*.

#### *Goneplax sacci* Crema, 1895

##### Figure 3

*Goneplax* [sic] *sacchi* Crema, 1895: 674, 675, fig. 15.

*Goneplax sacci* – Lörenthey, 1909: 250, 251. – Müller, 1993: 23. – De Angeli and Garassino, 2006: 65. – De Angeli *et al.*, 2009: 189. – Garassino *et al.*, 2012: 48, 47, fig. 20E.

*Goneplax* cf. *sacchi* – Lörenthey, 1907: 94, pl. 3, figs. 4a–c, 6, 7; pl. 4, fig. 6. – Lörenthey, 1909: 249, pl. 1, figs. 4 a–c, 6–7, pl. 2, fig. 6. – Glaessner, 1928: 193, 194, fig. 7. – Bachmayer, 1953: 145. – Jenkins, 1975: 57.

*Goneplax saccoi* [sic] – Glaessner, 1929: 199, 200. – Karasawa and Kato, 2003: Tab. 6. – Castro, 2007: 686. – Schweitzer *et al.*, 2010: 135.

**Holotype:** PU (Rovasenda coll.) lost (D. Ormezzano, pers. comm., 2012).

**Geological age:** Early Pliocene (Zanclean).

**Occurrence:** Italy (Piedmont, Tuscany, Sardinia); Austria?

**Remark:** the specimens assigned to *Goneplax* cfr. *sacchi*

by Lörenthey (1907, 1909) from Capo S. Marco (Cagliari, Sardinia – Lovisato coll.) and by Glaessner (1928) from Tegel (Austria – Graz coll.) appear to be lost.

**Discussion:** Crema (1895) assigned one poorly preserved specimen from the Early Pliocene of Monte Capriolo (Bra, Turin, Piedmont, Italy) to *Goneplax sacci* Crema, 1895. The loss of the holotype questions the validity of this species. The perfunctory description and the poorly preserved specimen, as reported and figured by Crema (1895: fig. 15), do not permit to determine the peculiar diagnostic characters of the genus ("...subtrapezoidal to quadrate smooth carapace..., regions more marked than in *G. rhomboides*..., front wide less of 1/3 of the total wideness with frontal margin straight and rounded lateral corners..., orbits less developed than in *G. rhomboides*..., anterolateral margins diverging posteriorly ..., postorbital and lateral spines broken..."). Moreover, as pointed out by Crema (1895: 675) the regions of the carapace are well distinct with well-marked transversal ridges, characters closer to both *G. gulderi* and *retroplumids* in which the regions of the carapace are always indistinct, having very weak transversal ridges. Although the holotype is lost, we could suppose that *G. sacci* belongs to *Retropluma*, as *Goneplax craverii* Crema, 1895 (= *Retropluma craverii* not *Goneplax craverii* as reported by Schweitzer *et al.*, 2010) having distinct carapace regions and well-marked transversal ridges. Based on these observations, we consider *G. sacci* a *nomen dubium*.

In contrast to what was recently stated by some authors (De Angeli and Garassino, 2006; De Angeli *et al.*, 2009; Schweitzer *et al.*, 2010; Garassino *et al.*, 2012), *G. gulderi* Bachmayer, 1953, must not be considered a synonym of *G. sacci*. These authors have erroneously followed Müller (1993: 23) who did not consider *G. sacci* a synonym of *G. gulderi*: "...The ill preserved type of *G. sacci* have [sic] a fronto-orbital margin similar to that of *G. gulderi*, but

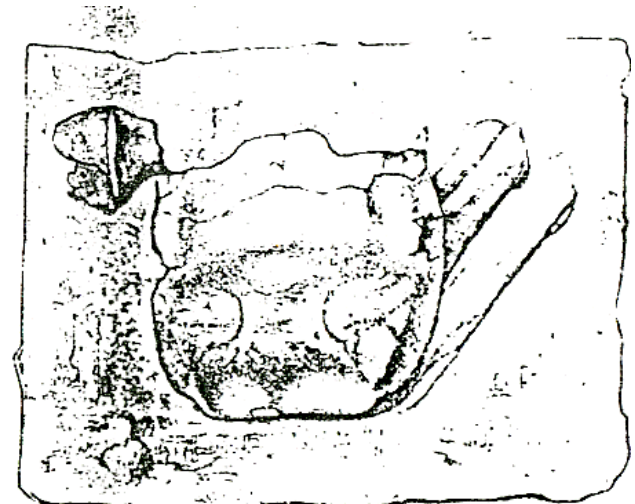


Figure 3. *Goneplax sacci* Crema, 1895, line drawing reported by Crema (1895: fig. 15).



their identity might be decided only with well preserved topotypes in hand...". This observation supports the validity of *G. gulderi* as valid species.

Genus *Albaidaplex* n. gen.

**Diagnosis:** Carapace transversely rectangular, much wider than long; dorsal surface of carapace smooth with slight horizontal ridges, without clear indication of regions; straight front slightly turned downwards; wide orbits, gently expanded distally; supraorbital border gently sinuous; outer orbital angle with short acute tooth; anterolateral margins slightly convex, with single short tooth; male cheliped (P1) short, stout.

**Etymology:** from Albaida del Aljarafe, village nearby the quarry where the specimens were discovered.

**Type species:** *Albaidaplex ispalensis* n. sp. (gender feminine).

**Description:** as for the type species.

**Discussion:** The family Goneplacidae, as reported by Castro (2007: 616), has the following diagnostic characters: carapace transversely rectangular, subquadrate, or trapezoidal; front narrow to wide, typically lamellar, straight; dorsal surface smooth; varying number of anterolateral spines posterior to outer orbital angle (sometimes none but typically one or two); orbits moderately to conspicuously wide, long; fissure in supraorbital margin absent; dorsal surface of carapace typically smooth or with slight horizontal ridges, moderately convex, without clear indication of regions. Most of these characters are present in *Albaidaplex* n. gen., here assigned to Goneplacidae. Moreover, we justify the erection of the new fossil genus based on some additional morphological observations. The rectangular carapace and the anterolateral margins with single short tooth of *Albaidaplex* n. gen. excludes its belonging to *Notonyx* Milne-Edwards, A., 1873, or *Pycnoplax* Castro, 2007, both having quadrate carapace and anterolateral toothless margins or with two acute teeth respectively. The new genus does not belong to *Carcinoplax*. Milne Edwards, H., 1852, *Eutricoplax* Castro, 2007, or *Menoplax* Castro, 2007, which have rectangular carapace and anterolateral margins with two acute teeth. *Albaidaplex* n. gen. cannot be assigned to *Hadroplax* Castro, 2007, *Paragoneplax* Castro, 2007, *Singhaplax* Serène and Soh, 1976, *Microgoneplax* Castro, 2007, or *Neommatocarcinus* Takeda and Miyake, 1969, genera that present rectangular carapace and anterolateral margins toothless. *Albaidaplex* n. gen. does not belong to *Ommatocarcinus* White, 1852, which has rectangular carapace and straight front with a median notch. Finally, the new genus does not belong to *Psopheticus* Wood-Mason, 1892, *Exopheticus* Castro, 2007, or *Pedroplax* Ng and Komai, 2011, as these have subquadrate and subcircular carapaces and anterolateral margins with single short tooth, respectively.

Some morphological characters of *Albaidaplex* n. gen., such as the carapace transversely rectangular, much wider

than long; orbits wide, gently expanded distally; supraorbital border gently sinuous; outer orbital angle with short acute tooth; and anterolateral margins slightly convex, with single short tooth, are also present in *Thyraplax* Castro, 2007, *Goneplax* Leach, 1814, *Goneplacoides* Castro, 2007, and *Neogoneplax* Castro, 2007. However, the new genus does not present certain characters that these genera do: *Thyraplax* present narrow orbits, not expanded distally; *Goneplax* has wide orbits, greatly expanded distally; and *Neogoneplax* present supraorbital borders conspicuously convex, while *Albaidaplex* n. gen. has wide orbits, gently expanded distally and supraorbital border gently sinuous. *Goneplacoides*, with the only extant species *G. marivenae* (Komatsu and Takeda, 2003), is the only extant genus sharing the above-mentioned morphological characters of the new fossil genus. However, it differs in the wide orbits expanded distally and strongly inclined distally (almost straight in *Albaidaplex* n. gen.), the much reduced anterolateral margins (longer in *Albaidaplex* n. gen.), and the straight posterolateral margins strongly converging to the posterior margin (gently rounded in *Albaidaplex* n. gen.).

According to Karasawa and Kato (2003) and Schweitzer et al. (2010) the Goneplacidae includes eight fossil genera: *Amydrocarcinus* Schweitzer, Feldmann, González-Barba and Vega, 2002; *Carcinoplax* Milne Edwards, H., 1852; *Goneplax* Leach, 1814; *Icriocarcinus* Bishop, 1988; *Kowaicarcinus* Feldmann, Schweitzer, Maxwell and Kelley, 2008; *Magyarcarcinus* Schweitzer and Karasawa, 2004; *Ommatocarcinus* White, 1852; and *Psopheticus* Wood-Mason, 1892. *Carcinoplax*, *Goneplax*, *Psopheticus*, and *Ommatocarcinus* are extant genera from which *Albaidaplex* n. gen. is excluded (see discussion above). *Amydrocarcinus* was described from the Eocene Tepetate Fm. (Mexico) (Schweitzer et al., 2002; Schweitzer and Karasawa, 2004), *Icriocarcinus* from the Late Cretaceous (late Campanian or early Maastrichtian) of San Diego County (California, USA) (Bishop, 1988), *Kowaicarcinus* from the Pliocene of New Zealand (Feldmann et al., 2008), and *Magyarcarcinus* from the Late Eocene of Hungary (Schweitzer and Karasawa, 2004). We exclude *Albaidaplex* n. gen. from these genera not only for geological and paleogeographic implications, but also for the ovoid carapace, small and squared orbits of *Amydrocarcinus*; the pentagonal carapace, anterolateral margins with three acute spines, and the dorsal surface of the carapace strongly ridged of *Icriocarcinus*; the hexagonal carapace, small and ovoid orbits, and tri-lobed anterolateral margin of *Kowaicarcinus*; and the circular carapace, small and ovoid orbits of *Magyarcarcinus*.

*Albaidaplex ispalensis* n. sp.

Figure 4

*Goneplax gulderi* – Mayoral et al., 1998: 508, 509, fig. 2 (5).

*Goneplax* cf. *saccai* [sic] – Via, 1948: 146, fig. 6. – Solé and Via, 1989: 34.

**Diagnosis:** Carapace transversely rectangular, slightly wider than long; smooth dorsal surface of carapace, with slight horizontal ridges, moderately convex, without clear indication of regions; straight front slightly turned downwards; front as wide as the orbits; inner edge of supraorbital margin distinct; wide orbits, gently expanded distally; supraorbital border gently sinuous; outer orbital angle with short acute tooth; anterolateral margins slightly convex, with single short tooth; posterolateral margins gently rounded, slightly converging posteriorly; long, straight posterior margin, slightly convex medially; male cheliped (P1) equal, short, with stout palm.

**Etymology:** from Ispal, name of an ancient village nearby Sevilla, city located close to the quarry where the specimens were discovered.

**Holotype:** MGUS AA5.

**Paratypes:** MGUS AA2, AA3, AA4, AA6, AA45.

**Type locality:** Albaida del Aljarafe (Guadalquivir Basin, Seville, Andalusia, Spain).

**Geological age:** Early Pliocene - Early Pleistocene.

**Additional studied material:** MGUS AA7-AA27, AA29-AA40, AA42-AA44, AA46, AA47, AA49, AA50; GPDG 0194.

**Additional material:** MSNM i27830, i27831, i27832 (Monterotondo Marittimo, Grosseto, Tuscany): Pliocene *sensu lato*; MSNM i27833 (Volterra, Pisa, Tuscany): Early Pliocene (Zanclean); MUSNAF 7074 (Poggio i Sodi, Castelnuovo Berardenga-Scalo, Siena, Tuscany): Early Pleistocene.

**Remark:** Garassino *et al.* (2012) ascribed one specimen (GPDG 0194) from the Early Pliocene (Zanclean) of La Serra quarry (San Miniato, Pisa, Tuscany) to *Goneplax sacci*. However, its rectangular carapace, slightly wider than long and the wide orbits, gently expanded distally excludes its belonging both to *Goneplax*, which has rectangular carapace strongly wider than long and wide orbits, conspicuously expanded distally, and to *G. sacci*, here considered as species *nomen dubium*. The rectangular carapace, slightly wider than long and the wide orbits, slightly expanded distally allow to assign this specimen to *A. ispalensis* n. sp.

**Description:** Carapace transversely rectangular, slightly wider than long; straight front slightly turned downwards; front as wide as the orbits; inner edge of supraorbital margin distinct; wide orbits slightly expanded distally with one short tooth on outer orbital angle; supraorbital margins gently sinuous, without fissures; sinuous, spineless suborbital margins; anterolateral margins slightly convex, with one short tooth; long, gently rounded posterolateral margins, slightly converging posteriorly; long, straight posterior margin; deep gastric pits; smooth dorsal surface of carapace; slight horizontal ridges, moderately convex, without clear indication of regions; stout, heavy chelipeds (P1), with moderately long merus; subtriangular, spineless carpus; stout, globular palm; dactylus and index slender, as long as the propodus, with toothless occlusal margin; smooth

surface of chelipeds; ambulatory legs (P2-P5) conspicuously long, slender, smooth.

**Discussion:** Mayoral *et al.* (1998) assigned a rich sample of goneplacids from the Early Pliocene of Guadalquivir Basin (Sevilla, Spain) to *Goneplax gulderi*. This species was also reported by some authors in different areas of Spain: Vía (1948) reported one specimen from the Miocene of Montjuich (Barcelona) (Villalta coll.) today lost (Gallemi, pers. comm., 2012); although the specimen was assigned to *Goneplax* cf. *saccoi* [sic] by Vía (1948) and Solé and Vía (1989), Müller (1993) ascribed it to *G. gulderi*; Müller (1993) assigned two specimens from the Early Pliocene of St. Feliu de Llobregat (Barcelona, ARES coll.) and Sant Vicenç dels Horts (Barcelona, Viader coll.) to *Goneplax gulderi*, without repositories. Based on these observations, the only available Spanish sample is that from the Guadalquivir Basin. The review of this rich collection has pointed out that these specimens cannot belong to *Goneplax*, which has rectangular carapace, slightly wider than long, and wide orbits, gently expanded distally, characters not diagnostic of *Albaidaplax* (Castro, 2007). So the Spanish specimens are assigned to *A. ispalensis* n. sp. (see discussion of the genus).

Genus *Neogoneplax* Castro, 2007

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

**Diagnosis** (after Castro, 2007): 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; suborbital borders convex, with one or two slight, obtuse inner teeth not visible dorsally; anterolateral borders short, straight. Dorsal surface of the carapace smooth or with slight horizontal ridges, moderately convex, without clear indication of regions. Outer orbital angle with conspicuous, acute tooth; acute anterolateral tooth on each side of the carapace (much reduced in *N. costata* Castro, 2007). Basal antennal article short, distalmost (third) article nearly reaches front. Eye peduncles long, shorter than or longer than front (0.8-1.1 front width); cornea strongly reniform, dorso-ventrally flattened, nearly divided into anterior and posterior portions. Anterior border of endostome well demarcated from buccal cavern, ridges faint but clearly defined. Third maxillipeds nearly completely close the buccal cavern. No obvious stridulating mechanism other than possible rubbing of proximal portion of cheliped (P1) merus against pterygostomial ridge. Wide thoracic sternum. Median sulcus on thoracic sternite 4 absent; sutures 4/5, 5/6, 7/8 interrupted medially, 6/7 complete. Anterior end of sterno-abdominal cavity anterior to thoracic sternite 4. Cheliped fingers long, slender, shovel-like, curved, pollex



A



B

Figure 4. *Albaidaplex ispalensis* n. sp. A) holotype AA5. B) paratype AA2. Scale bar: 10 mm.



higher than dactylus in large individuals, shorter than elongated propodus; dactylus light in colour, without dark portion; carpus with conspicuous tooth on inner margin. Dorsal margins of ambulatory leg (P2-P5) meri unarmed, or with acute distal tooth or with several teeth; dactyli slender, with carina on each side, non-setose. Male pleon with 6 freely-movable somites plus telson, wide, somites 4-6 gradually decreasing in width from somite 3 (widest somite). Telson wide, clearly longer than wide. Somite 3 covers space between P5 coxae, somite 2 narrower than somite 3; somites 1, 2 leave small to large portion of thoracic sternite 8 visible. G1 varies from long, slender, slightly sinuous, slightly broadened proximally to stout, short, with obtuse tip. G2 slender, slightly shorter to slightly longer than G1, flagellum slightly longer than proximal part (peduncle), tip curved or straight, pointed. Penis arising from P5 coxa, moderate size; broad, soft proximal expansion. Female pleon with 6 freely-movable somites, wide. Telson much wider than long. Somite 3 covers space between P5 coxae, somite 2 slightly narrower than somite 3; somites 1, 2 leave small portion of thoracic sternite 8 visible. Vulva of mature females small, oval, extending from 5/6 suture to median portion of thoracic sternite 6, vulvar cover present.

*Neogoneplax arenicola* (Glaessner, 1960)

Figure 5

*Ommatocarcinus arenicola* Glaessner, 1960: 28-30, fig. 12b, pl. 7, fig. 3.

*Ommatocarcinus arenicola* – Takeda and Miyake, 1969: 175. – Jenkins, 1975: 34, 35, 48, 57, fig. 4b. – Feldmann, 1992: 11, 21.

*Goneplax arenicola* – Karasawa and Kato, 2003: Tab. 6. – Feldmann *et al.*, 2006: 422. – Castro, 2007: 686. – Schweitzer *et al.*, 2010: 135.

**Emended diagnosis:** Carapace transversely trapezoidal, slightly wider than long, widest at anterolateral obsolete tooth; carapace smooth, with two slight horizontal ridges, without clear indication of regions; straight front slightly turned downwards; front shorter than the orbits; wide orbits, greatly expanded distally; outer orbital angle with conspicuous acute tooth; anterolateral margins slightly diverging frontally; single obsolete anterolateral tooth; male cheliped (P1) well developed, with elongated palm (after Glaessner, 1960).

**Holotype:** GNS AR 155 (A. McKay coll.).

**Geological age:** Late Oligocene - Middle Miocene.

**Occurrence:** South Island of New Zealand (Mt. Brown, Waipara River).

**Description:** Glaessner (1960) gave a detailed description of the species here confirmed. The only remark is that the front median notch reported by the author, is not a diagnostic character, but only the imprint of an internal subrostral thickening structure, as already revealed in other reviewed specimens from Spain and Italy lacking the original exoskeleton.

**Discussion:** Glaessner (1960: 29) described *Ommatocarcinus arenicola* from the Late Oligocene - Middle Miocene of New Zealand, pointing out that "... The new species is closer in the shape of its carapace to the less specialised genus *Goneplax* Leach, but the front is more like that of *Ommatocarcinus*, to which the species is assigned as an early primitive form...". Later Takeda and Miyake (1969: 175) proposed a new goneplacid genus, pointing out "...



Figure 5. *Neogoneplax arenicola* (Glaessner, 1960), holotype GNS AR 155. Scale bar: 32 mm.



Though the specimen may be possibly assigned to an early primitive form of the genus *Ommatocarcinus*, it is impossible to be retained in the genus, and represents a distinct genus due to bearing the quite different contour of the carapace that is less specialized somewhat like that of the genus *Goneplax* Leach, 1814. The new generic name, *Glaessneria*, is therefore proposed for a fossil species *Ommatocarcinus arenicola* Glaessner, 1960 ...". Although Glaessner (1960) and Jenkins (1975) reported that *Ommatocarcinus arenicola* has a straight front, marked by slight median notch, we point out that this cannot be considered as a diagnostic character, but only an artificial impression due to the taphonomy process, as remarked for other fossil specimens reviewed from Spain and Italy. Karasawa and Kato (2003) did not agree with the assignment of *O. arenicola* to a proposed new genus by Takeda and Miyake (1969), pointing out that "The carapace in this species bears two anterolateral teeth with an anterolaterally directed outerorbital tooth, has a relatively wide front without a median projection, and lacks a distinct transverse ridge dorsally; therefore the species is here moved to *Goneplax*". However, the review of the type specimen of *O. arenicola* has pointed out that this species cannot be assigned to *Goneplax*, as proposed by Karasawa and Kato (2003), because of certain characters, not diagnostic for this genus, such as the carapace transversely trapezoidal, slightly wider than long; wide orbits, greatly expanded distally; supraorbital border conspicuously convex; outer orbital angle with conspicuous acute tooth; anterolateral margins slightly diverging frontally; and single obsolete anterolateral tooth (Castro, 2007). Moreover, *arenicola* cannot be assigned to *Ommatocarcinus* for the lack of the front median notch, even though it shares the carapace transversely rectangular, wider than long and one anterolateral tooth with two extant genera, *Thyraplax* and *Goneplacoides*. However, the wide orbits, conspicuously expanded distally and the supraorbital border conspicuously convex of *arenicola* exclude its assignment both to *Thyraplax* (orbits narrow, not expanded distally) and to *Goneplacoides* (supraorbital border conspicuously sinuous). Finally, *arenicola* shares its main morphological characters, such as the carapace transversely rectangular, wider than long; wide orbits, conspicuously expanded distally; and the supraorbital border conspicuously convex with the extant *Neogoneplax* to which is assigned. Indeed, *arenicola* shares these characters mainly with the extant *N. costata* (Castro, 2007: fig. 30) from Philippine Islands, which presents carapace transversely rectangular, wider than long, supraorbital border conspicuously convex, and reduced anterolateral tooth, appearing as slight prominence.

## Conclusion

This revision attests that *Goneplax*, with *G. rhomboides* and *G. gulderi*, is restricted to the Mediterranean area,

from the Miocene to Recent. *Albaidaplax* appears to be restricted to the Mediterranean area during the Pliocene-Pleistocene. The assignment of *arenicola* to *Neogoneplax* attests the restricted geographic distribution of this genus in the Eastern Pacific Ocean.

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