



On the pea crabs found in the chiton *Tonicia chilensis* (Frembly, 1827) (Mollusca, Polyplacophora: Chitonidae) identified as “*Orthotheres* sp.” by Melzer & Schwabe (2008), and its reassignment to *Calyptraeotheres* Campos, 1990 (Crustacea: Pinnotheridae)

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Crabs of the family Pinnotheridae have been considered a phylogenetically heterogeneous group and taxonomically problematic (Palacios-Theil 2009, 2016; Tsang *et al.* 2018). The lack of knowledge of sexual dimorphism and morphological variation throughout the life history for many species have complicated its taxonomy and has resulted in errors in its classification (Campos 1989, 1993, 2016). Consequently, if the taxonomy of these symbiotic crabs had been based on juveniles and undeveloped character states, the problems get even more serious (Campos 1989, 1993). Melzer & Schwabe (2008) studied three juvenile crabs living in the chiton *Tonicia chilensis* (Frembly, 1827) (Polyplacophora: Chitonidae) collected in Muelle Dichato, Chile, and they identified them as the putative invasive stage of a species of *Orthotheres* Sakai, 1969. The crabs are of the typical juvenile pinnotherid form with a masculine habitus, including a suborbicular carapace, large eyes and a slender pleon (= abdomen) with the telson well defined (Ocampo *et al.* 2017). Unpublished observations on juveniles and adults of several species of pinnotherid crabs by the author, for example, *Juxtafabia muliniarum* (Rathbun, 1918), *Dissodactylus lockingtoni* Glassell, 1935, *D. xantusi* Glassell, 1936, *Calyptraeotheres granti* (Glassell, 1933), *Austinotheres angelicus* (Lockington, 1877) and *Tumidotheres margarita* (Smith, 1870) have revealed that the third maxilliped exhibit little morphological variation through the post-larval stages of development (from juvenile to adult). This appendage, including the partial or total fusion of the ischium and merus (Fig. 1A–G; Fig 2A, C–G), has been considered a valuable feature for distinguishing genera in the family Pinnotheridae (Bürger 1895; Rathbun 1918; Manning 1993; Ah Yong & Ng 2007; Campos 2009). According to Melzer & Schwabe (2008) the ischium and merus of the third maxilliped are completely fused, the carpus is larger than the propodus and the small dactylus is subterminally inserted on the propodus (Fig 1C), and as such the juveniles studied are possibly members of the genus *Orthotheres* Sakai, 1969. A detailed re-examination of the third maxilliped, chela of pereopod 1 (cheliped) and pleon, however, has shown otherwise. Campos (1989) discussed the taxonomy of *Orthotheres* and treated all the species he recognised as belonging to this genus; characterising its members by its diagnostic third maxilliped palp structure. Ng & Ho (2014) rediagnosed the genus based on the type species, *O. turboe* Sakai, 1969, from Japan, and restricted it for three Indo-West Pacific species; commenting that the American species as well as some Indo-West Pacific taxa will need to be referred to other genera when a full revision is done. This revision is now in progress by the author, PKL Ng and ST Ah Yong. Until the revision is complete, the genus is treated here in the broader sense of Campos (1989) and Geiger & Martin (1999).

Within Pinnotheridae seven genera have a similar third maxilliped, with the ischium and merus completely fused, the carpus prominently larger than the propodus, and with a small dactylus that may be terminally or subterminally inserted on the propodus: viz. *Austinotheres* Campos, 2002; *Bonita* Campos, 2009; *Calyptraeotheres* Campos, 1990; *Clypeasterophilus* Campos & Griffith, 1990; *Dissodactylus* Smith, 1870; *Enigmatheres* Campos, 2009 and *Orthotheres* Sakai, 1969 *s. lato* (Figs. 1A–G, 2A, C–G). The American species of *Orthotheres*, symbionts of gastropods, e.g. *Strombus* (see Hernández *et al.* 2017), represent a morphologically homogeneous group that has a third maxilliped with a subconical propodus that has a straight and truncated distal margin into which a small and digitiform dactylus is inserted (Figs. 1 D–G). In contrast, the propodus of Melzer & Schwabe’s juveniles is subtrapezoidal, its distal margin is oblique, and the dorso-distal margin of the propodus clearly extends beyond the insertion point of the dactylus (Figs. 1A–C). With regard to *Dissodactylus* and *Clypeasterophilus*, which are ectosymbionts of echinoids, they differ from the aforementioned juveniles in the general shape of the third maxilliped, including an exopod without a flagellum (Fig. 2A, C), and the dactyli of the walking legs are also bifid, a feature that can be observed as early as the first crab stage (Fig. 2B) (Pohle 1994; present study). As for *Austinotheres* and *Bonita*, both symbionts of bivalve molluscs, and *Enigmatheres*, putative symbionts of gastropod molluscs, they differ from the aforementioned juveniles in the general shape and size of the dactylus of the third maxilliped, which is digitiform and relatively longer, and in having a propodus

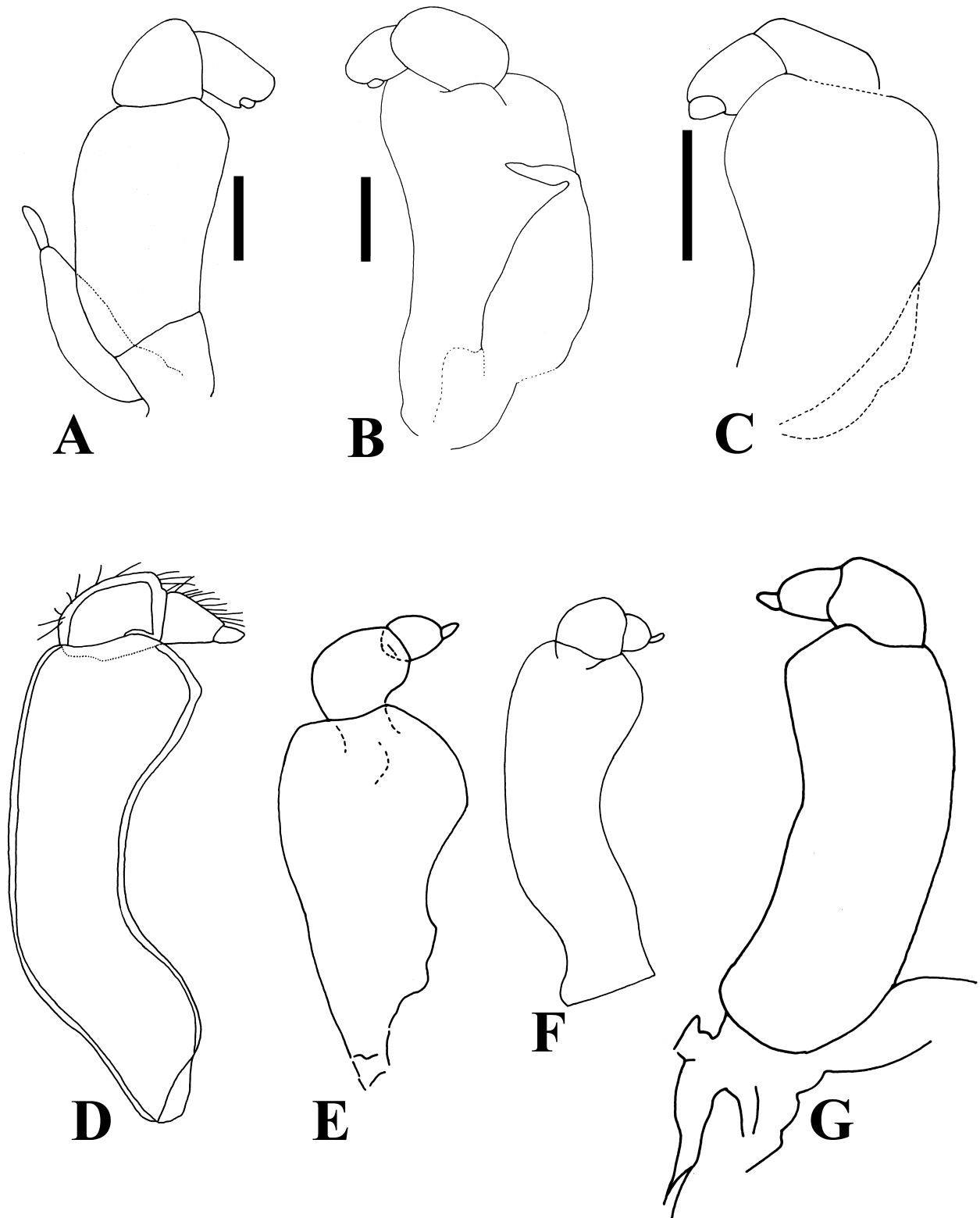


FIGURE 1. Third maxilliped: A, C, D, F, G, outer view; B, E, inner view. A, *Calyptraeothers granti* (Fenucci, 1975), Puerto Quequén, Necochea, Buenos Aires, Argentina; B, *Calyptraeothers politus* (Smith, 1870), Bahía Ancón, Perú; C, *Calyptraeothers* sp., Muelle Dichato, Chile; D, *Orthothes unguifalcula* (Glassell, 1936), female 4.0 x 5.0 mm, Puerto Peñasco, Sonora, México; E, *Orthothes barbatus* (Desbonne, 1867), magnification 40X, Guadeloupe; F, *Orthothes strombi* (Rathbun, 1905), not at scale, female 6.6 x 9.6 mm, Clearwater, Florida, U.S.A.; G, *Orthothes serrei* (Rathbun, 1909), magnification 40X, Puerto Rico. A, B from Campos (1999: figs. 2b, c); C, redrawn from Melzer & Schwabe (2008: fig. 1e); D, from Campos (1989: fig. 3a); E–G, from Rathbun (1918: figs. 44a, 45 and 41 respectively). Scale bars, A= 0.43 mm; B= 0.39 mm; C= 0.10 mm.

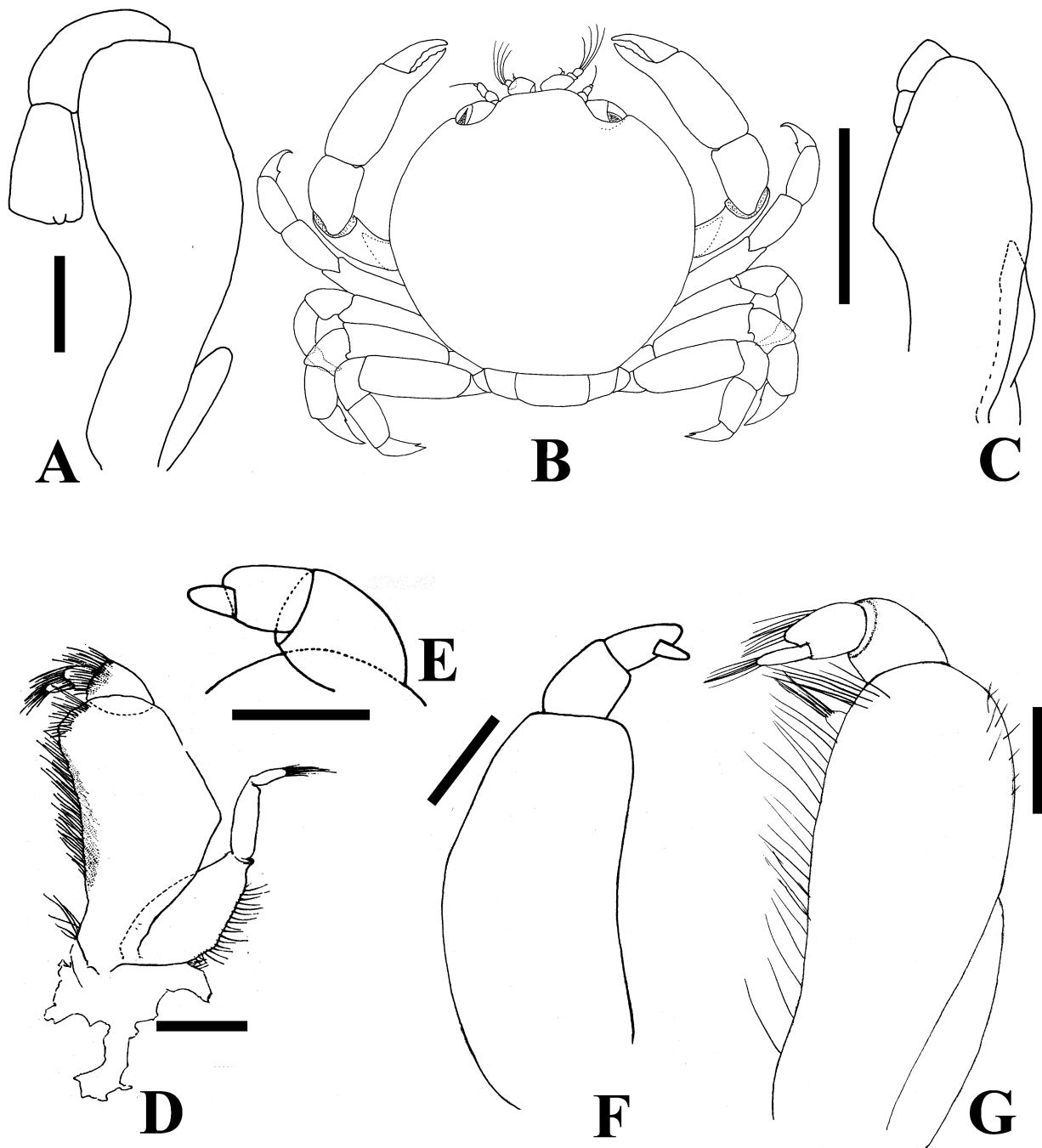


FIGURE 2. A, C–G, third maxilliped, outer view; B, juvenile, dorsal view, carapace width 1.5 mm. A, B, *Dissodactylus lockingtoni* Smith, 1870, Puerto Peñasco, Sonora, México and Campo El Pescador, San Felipe, Baja California, México, respectively; C, *Clypeasterophilus rugatus* (Bouvier, 1917), Jamaica; D, E, *Austinotheres angelicus* (Lockington, 1877), Los Angeles Bay and Campo El Pescador, San Felipe, Baja California, México; F, *Enigmatheres canfieldi* (Rathbun, 1918), Monterey, California, U.S.A.; G, *Bonita mexicana* Campos, 2009, Bahía Tortugas, Baja California Sur, México. A, C from Griffith (1987: fig. 8a, j); D, from Glassell (1935: plate 14, fig. 4); F, from Rathbun (1918: fig. 57); G, from Campos (2009: fig 3e). Scale bars, A, C= 0.5 mm; D–E= 1.0 mm; F= 0.57 mm; G=0.23 mm.

with an oblique distal margin and a dorso-distal margin clearly extending beyond the insertion point of the dactylus (Fig. 2D–G). The American *Calyptraeothers* has six species grouped in two morphological sub-groups, all symbionts of limpets (Calyptraeoidea, Calyptraeidae). The larger group includes four subtropical-tropical species which share a bi-segmented palp of the third maxilliped, with the dactylus absent, and, as far as is known, are symbionts of slipper shells of the genus *Crucibulum* and *Crepidula*: viz. *Calyptraeothers granti* (Glassell, 1933) (Gulf of California and west coast of Baja California Sur at Magdalena Bay, Pacific coast of Mexico), *C. pepeluisi* Campos & Hernández-Ávila 2010 (off the Lázaro Cárdenas port, Michoacán, Pacific coast of Mexico), *C. camposi* Ayón-Parente & Hendrickx, 2014 (Sinaloa,

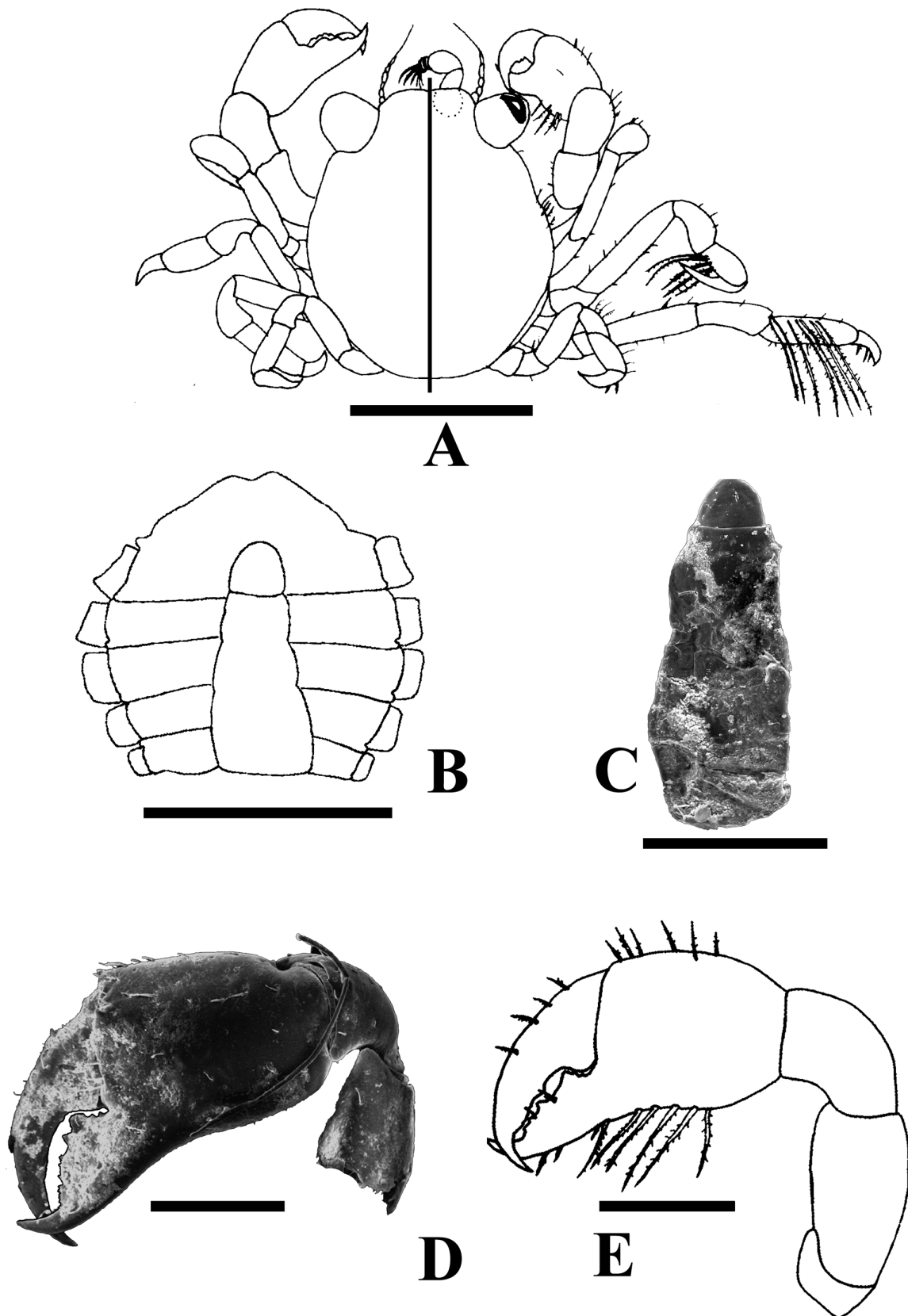


FIGURE 3. Juvenile crab: A, B, E, *Calyptraeotheres garthi* (Fenucci, 1975), Gulf San Matias, North Patagonia, Argentina; C, D, *Calyptraeotheres* sp., Muelle Dichato, Chile. A, dorsal view; B, sternal somites and pleon; C, pleon; D, E, chelipeds. A, B, E, from Ocampo *et al.* (2017: figs. 1a, a', 2a); C, D, from Melzer & Schwabe (2008 figs. 1d, f). Scale bars: A, B = 0.5 mm; C = 0.4 mm; D, E = 0.25 mm.

SE Gulf of California, Pacific coast of Mexico) and *C. hernandezi* Hernández-Ávila & Campos, 2006 (Cubagua Island, Caribbean Sea, Venezuela). The second subgroup, relevant for the present comparisons, includes the austral species, *C. garthi* (Fenucci, 1975) (Brazil, Rio Grande do Sul; Argentina, Mar del Plata, Necochea, Golfo San Matías), and *C. politus* (Smith, 1870) (Bahía Ancon, Perú to Castro, Isla Chiloé, Chile), both of which have the palp of the third maxilliped composed of three segments (Fig. 1A–B) and prefer to inhabit the slipper shells of the genus *Crepidula* (see Campos 1999, Ocampo *et al.* 2012). Ocampo *et al.* (2013) argued that on the basis of molecular data *C. garthi* (palp of the third maxilliped with 3 segments) and *C. hernandezi* (palp of the third maxilliped with 2 segments) are synonyms. Nevertheless, the morphology and variation of the third maxilliped structure, particularly the presence and absence of dactylus respectively, argue against this hypothesis, unless the dactylus is intraspecifically variable in *C. garthi*, something that has not yet been reported by any worker (see Campos 1999; Ocampo *et al.* 2013, 2017). Therefore, I recommend keeping both species as valid until further molecular and morphological studies are conducted to resolve this uncertainty.

A morphological comparison of the third maxilliped of *Calyptraeotheres* with that of the juveniles studied by Melzer & Schwabe (2008) shows a very close match. It is noteworthy that these juveniles were collected within the geographic range of *C. politus* (see Campos 1999, 2016). In both cases the ischium-merus widens distally, with the distoexternal angle obtuse and the distointernal angle produced and obliquely truncated; the carpus is robust, larger than the propodus, and the dactylus is tiny and inserted obliquely at the distal lower margin of the propodus, while the dorsal margin extends beyond the insertion point of the dactylus (Figs. 1A–C). As the juvenile stage of development of *C. politus* remains unknown, it is not possible to categorically establish whether or not the aforementioned juveniles belong to this species. In addition, the pleon of these juveniles is very similar to that described by Ocampo *et al.* (2017) for the juvenile of *C. garthi*, a species morphologically close to *C. politus*. In particular, both have the pleonal somites not well delimited (fused) (Fig. 3B–C), and there is a close resemblance in the overall shape and teeth of the fingers of the chelae (Fig. 3D–E). The form of the juvenile pleon and chelae are believed to be generic traits and are probably present even in juvenile *C. politus* and other species of *Calyptraeotheres*. Regarding hosts, the slipper shells, like chitons, live attached on the rock surface leaving a space (pallial groove) between the foot, mantle and shell when undisturbed (see Melzer & Schwabe 2008: fig. 1). The author believes that the chiton, *Tonicia chilensis* (Frembly, 1827), was possibly a temporary refuge, perhaps an intermediate host, since it cannot provide a suitable space, as calyptraeids do, for the adult crabs of 7–8 mm of carapace width. The juvenile crabs would eventually move to a definitive host (e.g. a species of *Crepidula*) during their subsequent development, as reported for other symbiotic species (e.g. porcellanid crabs, Baeza & Stots 2001). Enrico Schwabe has informed me (in litt. 14/5/2009) that additional collections of *T. chilensis* in different times did not produce any juvenile or other stage of development of this pinnotherid crab which support the notion this chiton is only a temporary host.

In review, the morphology of the juveniles recorded by Melzer & Schwabe (2008) supports the present hypothesis that they are not a species of *Orthoheres* but instead belonging to *Calyptraeotheres*, possibly *C. politus*.

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