A new species of icriocarcinid crab (Crustacea, Portunoidea) from the uppermost Cretaceous of California, USA: palaeobiogeographic implications

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Key words – *Branchiocarcinus*, new species, Maastrichtian, California, Canada.
A new species of icriocarcinid crab, *Branchiocarcinus pacificus*, is described from the uppermost Cretaceous Moreno Formation of California; in addition, an indeterminate species of the same genus is recorded from the Campanian of Hornby Island, Vancouver Island, Canada. The wide distribution of the Icriocarcinidae during the Late Cretaceous is confirmed.

Contents

Introduction

The Icriocarcinidae Števčić, 2005 is an extinct family of portunoid crabs, with a wide geographic distribution during the Late Cretaceous along both coasts of North America and on both sides of the Atlantic (Teodori *et al*., 2013; Phillips *et al*., 2014). According to Teodori *et al*. (2013), the family comprises three genera, namely *Icriocarcinus* Bishop, 1988, *Branchiocarcinus* Vega, Feldmann & Sour-Tovar, 1995 and *Cancrixantho* Van Straelen, 1934. Schweitzer *et al*. (2010) placed *Icriocarcinus* within the Goneplacidae MacLeay, 1838 and *Branchiocarcinus* and *Cancrixantho* within the Carcineretidae Beurlen, 1930. Based upon carapace similarities such as transverse dorsal ridges, anteroteral spines, spinose chelae and mouth parts, and the diagnostic features described by Števčić (2005) for the Icriocarcininae, Phillips *et al*. (2014) assigned *Icriocarcinus* and *Branchiocarcinus* as the only two genera to the Icriocarcinidae, discussing their portunoid affinities and need for inclusion into that family. Teodori *et al*. (2013) reported a single specimen with dorsal carapace features similar to the ones observed in *Cancrixantho* and, based upon the presence of transverse sharp ridges on the dorsal carapace, suggested that the genus should be included in the Icriocarcinidae. Species referred to the Icriocarcinidae are

Icriocarcinus xestos Bishop, 1988 (upper Campanian, northwest Pacific coast of Baja California, Mexico; see Bishop, 1988; Vega *et al*., 2006; Schweitzer *et al*., 2007; Phillips *et al*., 2014), *Branchiocarcinus flectus* (Rathbun, 1926) (lower-upper Maastrichtian, Gulf and Atlantic Coastal plains; see Rathbun, 1926, 1935; Vega *et al*., 1995; Landman *et al*., 2007; Phillips *et al*., 2014) and ?*Cancrixantho* sp. (upper Maastrichtian, southern France; see Teodori *et al*., 2013). *Cancrixantho pyrenaicus* Van Straelen, 1934, from Campanian strata of northern Catalonia, has been considered to be a member of the Carcineretidae by many authors (for example, Via, 1988; Vega *et al*., 1995; Schweitzer *et al*., 2007; Karasawa *et al*., 2008, among others). Van Straelen (1934) related *Cancrixantho* to the Cancridae Latreille, 1802 and Xanthidae MacLeay, 1838; for this reason, he suggested the name *Cancri-xantho* [*sic*]. However, he did not assign it to any family. Subsequently, Via (1951) indicated *Cancrixantho* as a member of the 'Cancrixanthidae Van Straelen'; however, no formal diagnosis of such a family has ever been introduced by Van Straelen. Based upon possessing a distinctive front and posterolateral margin *Cancrixantho* should be considered a member of the Icriocarcinidae. Stratigraphic and geographic distribution of members of this family suggest that the family arose during the late Campanian and had a wide distribution, a pattern which remained until the end of the Cretaceous. *Lithophylax* A. Milne-Edwards & Brocchi, 1879, from the Cenomanian of France, bears similarities in carapace shape and ornamentation with icriocarcinids. However, *Lithophylax trigeri* A. Milne-Edwards & Brocchi, 1879 has reduced P5, among other differences (see Phillips *et al*., 2014) and thus is considered to represent a different family within the Portunoidea (Karasawa *et al*., 2008).

Branchiocarcinus pacificus n. sp. was collected from the Upper Cretaceous-lower Paleogene (Maastrichtian-Danian) Moreno Formation in the west-central San Joaquin Valley, California (Anderson & Pack, 1915; McGuire, 1988; Schwartz & Moore, 2004) (Fig. 1). The Moreno Formation represents a base-of-slope to shelf-edge sedimentary sequence deposited along the continental margin of central California. It is exposed along a narrow band on the eastern flank of the hills that form the western margin of the San Joaquin Valley (McGuire, 1988; Bartow & Nilson, 1990; Fonseca-Rivera, 1997;

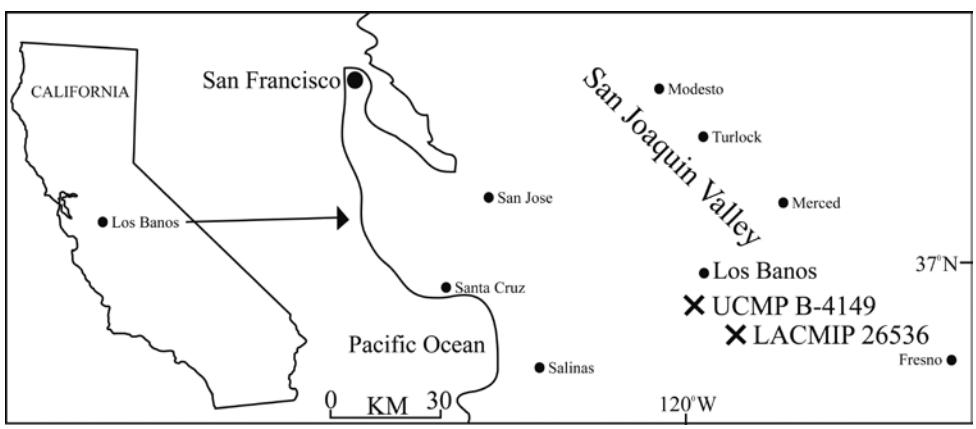

Fig. 1. Schematic map of the San Joaquin Valley, California (USA), with indication of UCMP and LACMIP localities referred to in the text.

Schwartz & Moore, 2004). The formation, composed mostly of shale, mudstone and siltstone with irregularly interbedded sandstone, represents a record of marine sedimentary deposition through the Cretaceous-Paleogene boundary (Saul, 1983; McGuire, 1988). The Moreno Formation is about 800 m thick and is divided into four conformable units, the Dosados, Tierra Loma, Marca and Dos Palos members (Payne, 1951; see McGuire, 1988, fig. 4, for stratigraphic placement and detailed correlation history of the Moreno Formation members). The Moreno Formation is highly fossiliferous, yielding a variety of invertebrates (Payne, 1951, 1962; Matsumoto, 1959a, b, 1960; Saul, 1983; Hilton, 2003; Ford, 2006; Squires & Saul, 2006a, b) and vertebrates (Camp, 1942; Welles, 1943; David, 1946).

Branchiocarcinus pacificus n. sp. was collected from two localities which both correspond to the Tierra Loma Member (see geological map in Payne, 1951, fig. 2) (Fig. 1). The Tierra Loma Member consists of approximately 350 m of dark clay-rich shale and mudstone with interbedded sandstone (McGuire, 1988). Good fossil preservation characterises the calcareous concretions that are scattered randomly throughout the member (McGuire, 1988). The gastropods *Turritella chaneyi* Merriam, 1941 and *T. webbipaynei* Saul, 1983, along with the baculitid ammonite *Trachybaculites columna* (Morton, 1834), which is an intercontinental zonal indicator, plus other molluscs (Popenoe, 1983; Woods & Saul, 1986; Popenoe & Saul, 1987; Popenoe *et al*., 1987; Saul & Popenoe, 1992; Squires & Saul, 2003a, b) indicate an early to early late Maastrichtian age for the Tierra Loma (Squires & Saul, 2003a, fig. 1).

Branchiocarcinus sp. was collected from a calcareous concretion at Collishaw Point, on the northeastern peninsula of Hornby Island, British Columbia (Canada) (Fig. 2). There, concretions are eroded from wave-cut bench exposures where the upper Campanian Northumberland Formation of the Nanaimo Group crops out (Mustard, 1994; Ludvigsen & Beard, 1994; Katnick & Mustard, 2003). The Northumberland Formation is composed primarily of dark grey silty mudstones with thin-bedded sandstone turbidites (Katnick & Mustard, 2003). Exposures are nearly continuous along the coast of Hornby Island (see Katnick & Mustard, 2003 for detailed geology of the region). These fossiliferous silty mudstones were deposited under deep-water conditions at the edges of a submarine fan complex (Mustard, 1994; Katnick & Mustard, 2003). Concretions from the Northumberland Formation exposures on Hornby Island have yielded a large variety of fossils including birds, pterosaurs, sharks, mosasaurs, crocodiles, turtles, bony fish, clams, gastropods, crustaceans (decapods), belemnites, ammonites, scaphopods, nautiloids, brachiopods, corals, echinoderms, insects and plants (Haggart, 1989; Ludvigsen & Beard, 1994; Morrison *et al*., 2005; Brink *et al*., 2009; Arbour & Currie, 2011; Dyke *et al*., 2011, among others).

Institutional abbreviations – CDM, Courtenay and District Museum Palaeontology Centre, Vancouver Island, British Columbia, Canada; IGM, Colección Nacional de Paleontología, Instituto de Geología, UNAM, Mexico City, Mexico; LACMIP, Department of Invertebrate Paleontology, Natural History Museum of Los Angeles County, California, USA; MMNS, Mississippi Museum of Natural Sciences, Jackson, Mississippi, USA; UCMP, University of California Museum of Paleontology, Berkeley, California, USA.

Systematic palaeontology

Order Decapoda Latreille, 1802
Infraorder Brachyura Linnaeus, 1758
Section Eubrachyura de Saint Laurent, 1980
Subsection Heterotremata Guinot, 1977
Superfamily Portunoidea Rafinesque, 1815
Family Icriocarcinidae Števčić, 2005
Genus *Branchiocarcinus* Vega, Feldmann & Sour-Tovar, 1995

Branchiocarcinus pacificus n. sp.
Pl. 1, figs. 1, 3, 4.

Diagnosis – Carapace of medium size, inverted subtrapezoidal, maximum width at level of anterolateral spines, width/length ratio 1.8; anterolateral margin rounded; strong triangular anterolateral spine, dividing anterolateral from posterolateral margins; posterolateral margin two-thirds of maximum carapace length; posterior margin rimmed; dorsal carapace regions marked by strong transverse ridges; cervical groove deep; pereiopods long and slender.

Description – Carapace of medium size, inverted subtrapezoidal, transversely elongate, maximum width at anterior third, twice as wide as long; anterior margin straight, two-thirds of maximum width; eye stalks long, slender; posterolateral margin posteriorly inclined, two-thirds of maximum carapace length, with a pronounced tubercle at mid-length and a weaker one behind; posterior margin rimmed, nearly straight, slightly concave at center, three-quarters of maximum width; dorsal carapace regions marked mainly by strong transverse ridges; protogastric regions flat, except for relatively strong transverse ridges that crosses at mid-length to reach both sides of protogastric regions; mesogastric process strongly marked, projected towards, yet not reaching frontal margin; meso- and metagastric regions ovate, with a sharp, median transverse ridge; urogastric region transversely subovate, with median ridge; cardiac region with a strong transverse ridge, one-third of maximum carapace width; intestinal region flat; cervical groove deep, extending from limit of antero- and posterolateral margins, running parallel to protogastric regions and convergent towards meso- and metagastric regions and parallel again at level of urogastric region, then extending posterolaterally around intestinal region; epibranchial region with posterolaterally inclined (nearly 45°), short ridge; mesobranchial also with inclined, slightly longer ridge, inclined at approximately 20°; metabranchial marked by transverse ridge; merus of right cheliped with row of spines, dorsal surface of carpus spinose.

Etymology – In reference to the first occurrence of Late Cretaceous *Branchiocarcinus* in the Pacific Realm of North America.

Types – The holotype, LACMIP 14471, is from LACMIP locality 26536 (UCLA locality 6536) (Fig. 1), deposited in the collections of the Department of Invertebrate Paleontology, Natural History Museum of Los Angeles County. This specimen preserves the

dorsal carapace and portions of the right chela and walking legs. The paratypes, UCMP 157380 and 157381, are from UCMP locality B4149 (Fig. 1); they are deposited at the University of California Museum of Paleontology, Berkeley, California, USA. UCMP 157380 preserves only the dorsal carapace, while UCMP 157381 retains the dorsal carapace, a single eye stalk, plus portions of the right chela and walking legs.

Occurrence – The holotype was collected from the Tierra Loma Member (Moreno Formation) near the town of Los Baños, Merced County, California, from a creek bed about 2 miles south of Ortigalita Creek (SE1/4, NE1/4, section 33, T11S, R10E, USGS Charleston School 7.5′ Quadrangle topographic map, at latitude N 36° 56′ 03″, longitude W 120° 52′ 22″) (Fig. 1). The two paratypes were collected from similar strata within the Tierra Loma Shale Member (NW1/4, SE1/4, section 33, T11S, R10E, USGS Ortigalita Peak NW 7.5′ Quadrangle, at approximately latitude N 36° 55′ 55″, longitude W 120° 52′ 45″) (Fig. 1). All specimens are preserved in calcareous concretions (collected by John M. Alderson in March, 1978).

Measurements – Measurements (in mm) taken on the dorsal carapace of the holotype, LACMIP 14471, are: maximum width 25.7; maximum length, including rostrum, 17.7; fronto-orbital width, measured from tip to tip of outer orbital spines, 20.3; maximum frontal width, 17.6; posterior margin width, 20.7. Paratype UCMP 157380 measures: maximum width 30.2; maximum length, including rostrum, *c.* 20; fronto-orbital width, measured from tip to tip of outer orbital spines, *c.* 25; maximum frontal width 12.9; posterior margin width 21.2. Paratype UCMP 157381 measures: maximum width 30.5; maximum length, including rostrum, *c.* 19; fronto-orbital width, measured from tip to tip of outer orbital spines, *c.* 26; maximum frontal width 12.6; posterior margin width 22.9.

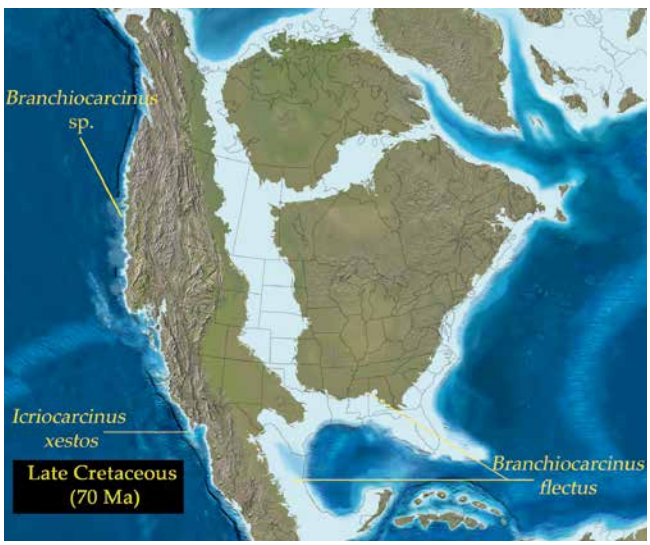

Fig. 2. Late Campanian-early Maastrichtian (70 Ma) palaeogeographic map of North America (image courtesy of R.C. Blakely), with distribution of *Icriocarcinus xestos* Bishop, 1988 (upper Campanian, Rosario Formation, Baja California, Mexico); *Branchiocarcinus flectus* (Rathbun *in* Wade, 1926) (lower Maastrichtian, Coon Creek Formation, Mississippi; lower Maastrichtian Cárdenas Formation, San Luis Potosí, Mexico) and *Branchiocarcinus* sp. (upper Campanian, Northumberland Formation, Nanaimo Group, Hornby Island, British Columbia).

Fig. 3. Late Campanian (75 Ma) palaeogeographic map of Europe (image courtesy of R.C. Blakely), with distribution of *Cancrixantho pyrenaicus* Van Straelen, 1934 (Campanian, near Organyà, Catalonia).

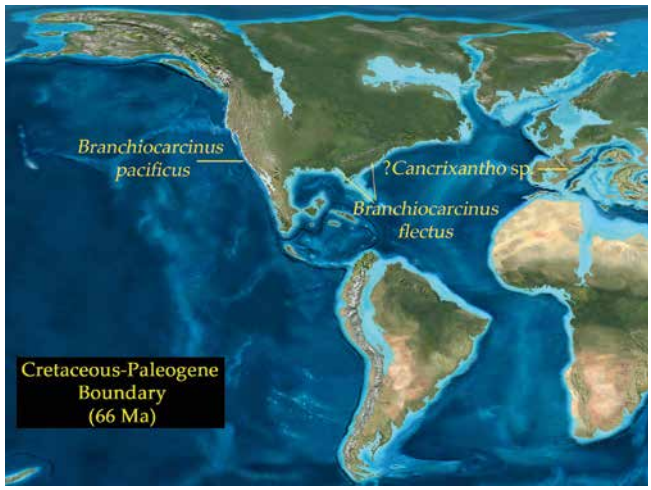

Fig. 4. Latest Cretaceous global palaeogeographic map (image courtesy of R.C. Blakely), with distribution of *Branchiocarcinus pacificus* n. sp. (Maastrichtian, Tierra Loma Member, Moreno Formation, Merced County, California), *Branchiocarcinus flectus* (Rathbun *in* Wade, 1926) (uppermost Maastrichtian, Owl Creek Formation, Mississippi; uppermost Maastrichtian Tinton Formation, New Jersey) and ?*Cancrixantho* sp. (Larcan algal limestones Formation, southern France).

Discussion – The new species differs from *Branchiocarcinus flectus* (Pl. 1, fig. 2) in having stronger tubercles on the posterolateral margin, a divided mesogastric transverse ridge, a slightly wider mesogastric process, stronger tubercles at the level of the mesogastric region, a slightly wider cardiac region with the transverse ridge not as sharp, a more sinuous mesobranchial ridge that does not reach the posterolateral margin, and a narrower metabranchial transverse ridge.

Remarks – The palaeogeographic distribution of the Icriocarcinidae during the late Campanian/early Maastrichtian was extensive, including *Icriocarcinus xestos* (Fig. 1; Pl. 1, figs. 6, 7) along the Pacific coast of North America, *Branchiocarcinus flectus* in the Gulf Coast Plain (Fig. 2) and *Cancrixantho pyrenaicus* in southwest Europe (Fig. 3) (compare

Rathbun, 1926, 1935; Van Straelen, 1934; Via, 1988; Vega *et al*., 1995; Phillips *et al*., 2014). A small crab from the upper Campanian Northumberland Formation on Hornby Island, British Columbia, Canada (Pl. 1, fig. 5; specimen CDM 2013.64.1) represents a possible juvenile of *Branchiocarcinus*, but more specimens are needed to verify its systematic placement. By late Maastrichtian times, the distribution of icriocarcinids remained the same, with the exception that *Icriocarcinus* was no longer present and ?*Cancrixantho* sp. was found in the south of France (Teodori *et al*., 2013). More complete specimens of *Cancrixantho* are needed to confirm if it constitutes a distinct genus, as many similarities exist in carapace shape between *Cancrixantho* and *Branchiocarcinus*. If both are indeed identical, then a single genus was distributed along the east and west Atlantic Coast, as well as along the Pacific coast of North America (Fig. 4); thus, the nomenclature and composition of the Icriocarcinidae should be revised.

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Plate 1

Late Cretaceous icriocarcinid crabs from North America. Scale bars equal 10 mm.

Branchiocarcinus pacificus n. sp.

Fig. 1. Holotype (LACMIP 14471); LACMIP locality 26536 (= UCLA locality 6536), upper Maastrichtian, Tierra Loma Member, Moreno Formation, Merced County, California.
Figs. 3, 4. Paratypes (UCMP 157380 and UCMP 157381, respectively); UCMP locality B4149, upper Maastrichtian, Tierra Loma Member, Moreno Formation, Merced County, California.

Branchiocarcinus flectus (Rathbun *in* Wade, 1926)

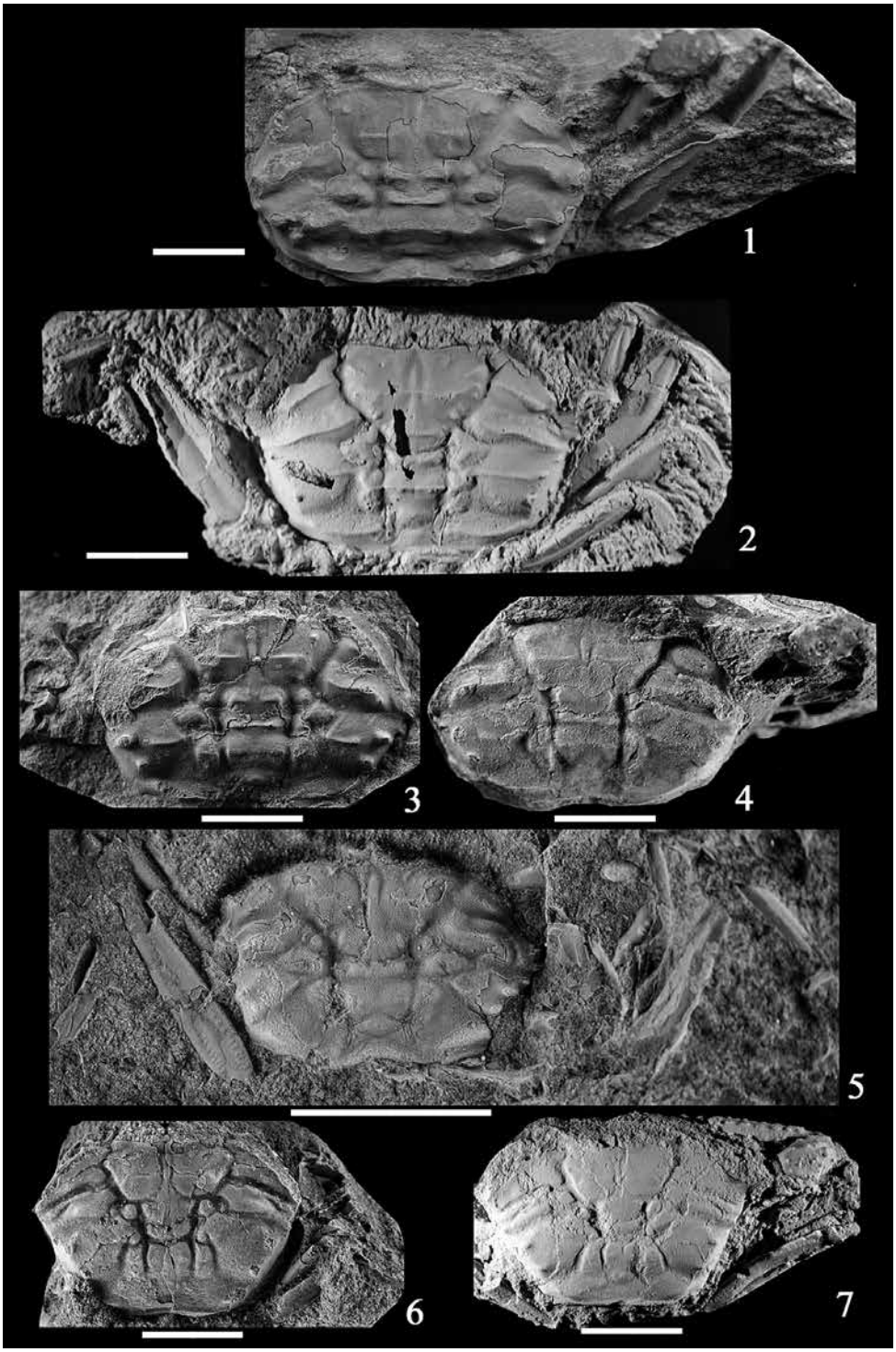
Fig. 2. MMNSIP-4388, uppermost Maastrichtian, Owl Creek Formation, Owl Creek type locality, Tippah County, Mississippi.

Branchiocarcinus sp.

Fig. 5. CDM 2013.64.1, upper Campanian Northumberland Formation, Nanaimo Group, Hornby Island, British Columbia.

Icriocarcinus xestos Bishop, 1988

Figs. 6, 7. UCMP unregistered and IGM-7722, respectively; upper Campanian, Rosario Formation, Punta Santo Tomás, Baja California, Mexico.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