

Decapod crustaceans from the Paleocene of Central Texas, USA

**Adam Armstrong¹, Torrey Nyborg², Gale A. Bishop³,
Àlex Ossó-Morales⁴, and Francisco J. Vega^{5,*}**

¹ 306 Hilltop Road, Keene, TX 76059, U.S.A.

² Department of Earth and Biological Sciences, Loma Linda University, Loma Linda, California 92350, U.S.A.

³ Department of Geology and Geography, Georgia Southern University, Statesboro, GA 30460, U.S.A.

⁴ Josep Vicenç Foix, 12-H, 1er-1ª 43007 Tarragona, Catalonia, Spain.

⁵ Instituto de Geología, Universidad Nacional Autónoma de México,
Ciudad Universitaria, Coyoacán, México DF 04510, Mexico.

* vegver@unam.mx

ABSTRACT

Fourteen species of decapods crustaceans are described from a single locality near Mexia, Texas, where Paleocene sediments of the Mexia Clay Member of the Wills Point Formation crop out. The species are represented by *Hoploparia* sp., *Linuparus wilcoxensis* Rathbun, 1935, an unnamed paguroid, *Kierionopsis nodosa* Davidson, 1966, *Pithonoton cardwelli* new species, *Caloxanthus* sp., *Macroacaena johnsoni* (Rathbun, 1935), new combination, *Raninoides bournei* (Rathbun, 1928), *R. treldenaesensis* (Collins and Jakobsen, 2003), *Prehepatus* sp., *Tehuacana americana* (Rathbun, 1935), new combination, *Costacopluma texana* new species, *Paraverrucoides alabamensis* (Rathbun, 1935) and *Viapinnixa mexiaensis* new species. Morphological details unknown for previously described species are included. New systematic placements are offered based on recent research. Intraspecific morphological variation is documented for the goneplacoid crab *Tehuacana americana*. *Costacopluma texana* is the second Paleogene species of that genus in southeastern USA, and because of its abundance represents the most completely described species for the genus. This fauna represents one of the most diverse assemblages of Paleocene crustacean decapods.

Key words: Paleocene, Crustacea, Mexia, Texas.

RESUMEN

Se describen catorce especies de crustáceos decápodos colectados en una sola localidad cercana a Mexia, Texas, en donde afloran sedimentos del Miembro Arcilloso Mexia de la Formación Wills Point. Las especies están representadas por *Hoploparia* sp., *Linuparus wilcoxensis* Rathbun, 1935, un paguroideo indeterminado, *Kierionopsis nodosa* Davidson, 1966, *Pithonoton cardwelli* especie nueva, *Caloxanthus* sp., *Macroacaena johnsoni* (Rathbun, 1935), combinación nueva, *Raninoides bournei* (Rathbun, 1928), *R. treldenaesensis* (Collins y Jakobsen, 2003), *Prehepatus* sp., *Tehuacana americana* (Rathbun, 1935) combinación nueva, *Costacopluma texana* especie nueva, *Paraverrucoides alabamensis* (Rathbun, 1935) y *Viapinnixa mexiaensis* especie nueva. Se incluyen detalles morfológicos, no descritos para especies previamente reportadas. Se ofrece una sistemática actualizada, basada en investigaciones recientes.

Se documenta la variación morfológica intraespecífica para el cangrejo goneplacoideo Tehuacana americana. Costacopluma texana es la segunda especie del género en el Paleógeno del sureste de EUA, y debido a la abundancia de ejemplares, es la especie descrita con mayor detalle del género Costacopluma. Esta fauna representa una de las asociaciones más diversas de crustáceos decápodos del Paleoceno.

Palabras clave: Paleoceno, Crustacea, Mexia, Texas.

INTRODUCTION

Decapod crustaceans were collected from a quarry site about two miles west of Mexia, Texas from the Paleocene Mexia Clay Member of the Wills Point Formation (Figure 1). The Wills Point Formation is part of the Paleocene Midway Group of the East Texas Basin (McGowen *et al.*, 1972; Oldani, 1988; Barnes *et al.*, 1992). Deposition of the Midway Group occurred during the Early Paleocene (Danian) associated with a major transgression following the Cretaceous-Tertiary event. The maximum advance of this transgression is represented by the outer neritic deposits of the Mexia Clay Member (Kellough, 1965; Oldani, 1988). The Midway Group is the lowermost stratigraphic Tertiary unit within the East Texas Basin, separated from the underlying Gulfian Cretaceous Navarro Group by a biostratigraphic and depositional hiatus. The Mexia Clay Member is conformably overlain by the Paleocene-Eocene Wilcox Group (Oldani, 1988). In east Texas, the Midway Group consists of two formations (Kincaid and Wills Point formations), each with three members (Oldani, 1988) (Figure 2). The thickness of the Midway Group, within the East Texas Basin, varies between 120 and 550 m; it is more than 300 m at the border of Limestone and Navarro counties, near the town of Tehuacana (Figure 1), and thins to about 120 m at the study quarry (Oldani, 1988). The Wills Point Formation consists of the basal clays of the Mexia Clay Member, overlain by the silty shales of the Kerens Member, which grade into the interbedded sands and shales of the Solomon Creek Member (Oldani, 1988). Like the Midway Group, the thickness of the Wills Point Formation varies between 60 and 300 m (Oldani, 1988). In Navarro County it averages 150 to 200 m (Oldani, 1988). The Mexia Clay Member consists of dark gray, thinly laminated clay shale, bearing pyrite nodules, limonite, siderite and calcareous concretions (Kellough, 1965; Oldani, 1988). The Mexia Clay Member averages 50 meters making up the bottom quarter of the Wills Point Formation (Kellough, 1965).

Abundant decapods, horn corals, scaphopods, pelecypods, gastropods, nautiloids, foraminifera, fish teeth, and some shark teeth occur within the lower part of the Mexia Clay Member (Kellough, 1965), 6-10 meters above the Tehuacana Limestone. At the study quarry, the basal Mexia Clay Member is represented by a series of siltstone/claystone lenses with abundant yellow, brown, and black calcareous nodules that preserve abundant fossils, including the fossil

decapods herein reported. Biostratigraphy is primarily based on foraminifera with good index foraminifera indicative of a Paleocene age (Kellough, 1959; 1965).

Specimens, referred to in this study, are deposited at the Texas Natural Science Center, Austin (previously Paleontological Collection of the Bureau of Economic Geology, University of Texas), under acronym NPL, and Museu de Geologia del Seminari de Barcelona, under acronym MGSB. Classification follows that of Ng *et al.* (2008) and Števíć (2005).

SYSTEMATIC PALEONTOLOGY

Order Decapoda Latreille, 1802
 Infraorder Astacidea Latreille, 1802
 Superfamily Nephropoidea Dana, 1852
 Family Nephropidae Dana, 1852
 Genus *Hoploparia* McCoy, 1849

Type species. *Astacus longimanus* Sowerby, 1826, by subsequent designation of Rathbun, 1926.

Hoploparia sp.
 Figures 3.1, 3.2

Description of study material. Cephalothorax small, elongated, surface covered by small scale-like tubercles, much finer toward ventral and posterior margins; posterior margin curved, rimmed; postcervical groove deep, slightly sinuous; cervical groove one-third the length of postcervical groove.

Material examined. One incomplete cephalothorax and one fragment of a cheliped, hypotypes NPL31148 and NPL31149.

Measurements (in mm). Hypotype NPL31148 cephalothorax length = about 26.0, height = 15.9; hypotype NPL31149 partial palm length = >21.6, height = >22.0.

Discussion. The carapace fragment differs from *Hoploparia johnsoni* Rathbun, 1935 from the middle Eocene of Alabama, in bearing bigger tubercles directed forward. *H. buntingi* (Feldmann and Holland, 1971) from the Paleocene of North Dakota is larger and has a straight postcervical groove. *H. klebsi* Noetling, 1885 from the Paleogene of northern Germany is larger and shows coarser tubercles (see also Förster and Mundlos, 1982). The specimens are too incom-

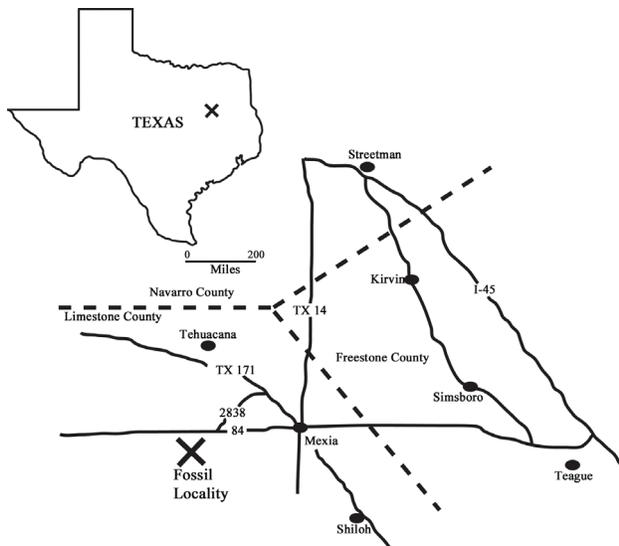


Figure 1. Location map of fossil locality east of Mexia, Limestone County, Texas.

plete to confirm species affinity.

Although most species of *Hoploparia* are documented from Cretaceous deposit, it survived in Paleogene tropical and subtropical areas. According to Schweitzer and Feldmann (2005), the nearly cosmopolitan distribution, particularly in higher latitudes during Cretaceous times, was an important fact to buffer the effects of the K/P event on this genus.

Infraorder Palinura Latreille, 1802
 Superfamily Palinuroidea Latreille, 1802
 Family Palinuridae Latreille, 1802
 Genus *Linuparus* White, 1847

Type species. *Palinurus trigonus* von Siebold, 1824, by original designation.

***Linuparus* sp. cf. *wilcoxensis* Rathbun, 1935**

Figure 3.3

Linuparus wilcoxensis Rathbun, 1935, p. 74, pl. 16, figs. 11-14; Vega *et al.*, 2007, p. 1436, figs. 4.8-4.10.

Description of study material. Small carapace with broadly V-shaped, deep cervical groove; dorsal carapace bounded by blunt parallel ridges; median ridge strong, elevated, with rounded crest; deep aerolations at crests of ridges, remainder dorsal surface covered by evenly-spaced tubercles; gastric area anterior to cervical groove with two subparallel ridges.

Material examined. One incomplete cephalothorax, hypotype NPL31150.

Measurements (in mm). Hypotype NPL31150, cephalothorax length = 14.8, width = 11.5.

Discussion. Carapace fragment most resembles the carapace features as seen in *Linuparus wilcoxensis* from the Lower Eocene of Wilcox, Alabama. Compared with the type specimen figured by Rathbun (1935, fig. 16.13), the specimen from Mexia is smaller and ridges of the gastric area define a lanceolate shape, instead of being subparallel. A more complete specimen reported by Vega *et al.* (2007, fig. 4.9) from the Paleocene of Coahuila, northeastern Mexico, show a lanceolate shape for the ridges of the gastric area. More complete specimens are necessary to define a specific affinity.

Infraorder Anomura MacLeay, 1838
 Superfamily Paguroidea Latreille, 1802

Paguroidea, gen. and sp. indet.

Figures 3.4, 3.5

Description of study material. Right palm small, rectangular, one-third longer than high, narrow at junction with carpus; outer surface convex, covered by coarse punctae; inner surface flat, covered with aerolations that become scarce toward lower margin; fixed finger incomplete, slightly curved inwards, outer surface covered by strong tubercles, inner surface with punctae. Occlusal surface covered by punctae.

Material examined. One right palm, hypotype NPL31151.

Measurements (in mm). Hypotype NPL31151 right palm length = 14.8, height = 11.5.

Discussion. The specimen is too incomplete to offer a more detailed systematic placement. It is different from *Paguristes johnsoni* Rathbun, 1935 from the Eocene of Wilcox County and the Lower Paleocene of Illinois (Cope *et al.*, 2005) in having a straight fixed finger, nearly parallel to the long axis of the manus. This feature is observed in species of *Petrochirus* Stimpson, 1859, but mani in this genus are more massive, with uniformly distributed, coarser granules.

Infraorder Brachyura Latreille, 1802
 Subsection Dromiacea de Haan, 1833
 Superfamily Dromioidea de Haan, 1833
 Family Dromiidae, de Haan, 1833
 Genus *Kierionopsis* Davidson, 1966

Type species. *Kierionopsis nodosa* Davidson, 1966, by original designation.

***Kierionopsis nodosa* Davidson, 1966**

Figures 3.6-3.8

Kierionopsis nodosa Davidson, 1966, p. 212, text-figures 1, 2; Bishop and Whitmore, 1986, p. 298, fig. 1c.

ERA	PERIOD	EPOCH	AGE	GROUP	FORMATION	MEMBER
CENOZOIC	PALEOGENE	PALEOCENE	LATE	WILCOX	Seguin	Caldwell Knob
			MIDDLE			MIDWAY
				Kerens		
				Mexia Clay		
EARLY	NAVARRO	Kincaid	Tehuacana Limestone			
MESOZOIC			CRETACEOUS	GULFIAN	Pisgah	
					Littig	
					Kemp Clay	

Figure 2. Stratigraphic column showing the Upper Cretaceous and Paleocene stratigraphic units of the East Texas Basin. Stratigraphic position where fossil decapods were collected indicated by dashed line. Adapted from Barnes *et al.*, (1992), McGowen *et al.* (1972) and Oldani (1988).

Description of study material. Carapace about as long as wide: margins well defined, front margin convex, spinose, transversely convex. Rostrum triangular, smooth, bilobed with a shallow medial sinus. Orbits small, round, directed slightly upward and outward. Frontal width 37% of carapace width, orbits narrow. Supraorbital tooth low, blunt, granulate. Suborbital spine extends beyond dorsal shield margin. Row of 4-5 tiny bumps form line behind each orbit. Anterolateral margin with four blunt, granular spines (excluding orbital spine) the anterior and posterior spines longest. Shallow sinus between second and third anterolateral spines extends inward onto the carapace. Sinus behind fourth anterolateral spine forms groove beneath anterolateral margin, terminates beneath first anterolateral spine and behind a granulate subhepatic boss. Posterolateral margin granulate, with prominent, stout, elongate spine at each posterolateral angle. Posterior margin smooth, convex rim overlapping first abdominal segment. Dorsal shield smooth with exception of granulate, tuberculate bosses and granulate posterobranchial region. Regions well delimited by prominent, granulate bosses. Epigastric and mesogastric bosses medial, protoastric bosses slightly anterior to

mesogastric boss; epigastric bosses oval; mesogastric and protoastric bosses larger than epigastric bosses. Cervical groove shallow, arising in gastric pits axially, becoming indistinct laterally. Hepatic region small, smooth, depressed. Urogastric boss forming highest point of carapace, separated from small cardiac boss by shallow groove that possesses a muscle attachment scar across sagittal axis. Branchial region divided transversely by shallow branchiocardiac groove anteriorly and by a slope (and textural) break posteriorly into epibranchial, mesobranchial and metabranchial regions. Branchiocardiac groove marked by muscle attachment scar from epimeral peninsula onto edge of dorsal shield. Epibranchial region with two proximal, granulate bosses; posterior one large with granulate marginal spine (the posterior-most anterolateral spine). Mesobranchial region tuberculate behind branchiocardiac groove with small medial granulate spine on boundary with metabranchial region and large tuberculate marginal spine at the posterior-lateral corner. Metabranchial region coarsely granular, intestinal region indistinct.

Material examined. Three complete carapaces, hypotypes NPL31152 to NPL31154.

Measurements (in mm). Hypotype NPL31152 carapace length = 14.0, width = about 14.5; hypotype NPL311653 carapace length = 13.8, width = 14.5; hypotype NPL31154 carapace length = 13.4, width = 14.3.

Discussion. *Kierionopsis nodosa* was considered to be a member of the Dromiidae de Haan, 1833 (Schweitzer and Feldmann, 2007). Based on morphological similarities with the extant genus *Paradynomene* Sakai, 1963, Guinot (2008) included *Kierionopsis* within the Dynomenidae, and erected the subfamily Paradynomeninae to contain *Kierionopsis nodosa*, along with *Kromtitis* Müller, 1984 and several extant species. However, presence of suborbital spines extending beyond dorsal shield margin is diagnostic to place the genus into the Dromiidae.

Original description of this species is based on specimens collected in strata of the Paleocene Wills Point Formation (Davidson, 1966). Types are deposited at the Paleontological Collection of the Texas Natural Science Center, Austin, Texas.

Section Podotremata Guinot, 1977
 Superfamily Homolodromioidea Alcock, 1899
 Family Goniidromitidae Beurlen, 1932
 Genus *Pithonoton* von Meyer, 1842

Type species. *Pithonoton marginatum* von Meyer, 1842, by original designation.

***Pithonoton cardwelli* new species**

Figures 3.9-3.13

Diagnosis. Carapace small, subovate longitudinally; lateral margins rounded; front relatively narrow; orbits broken,

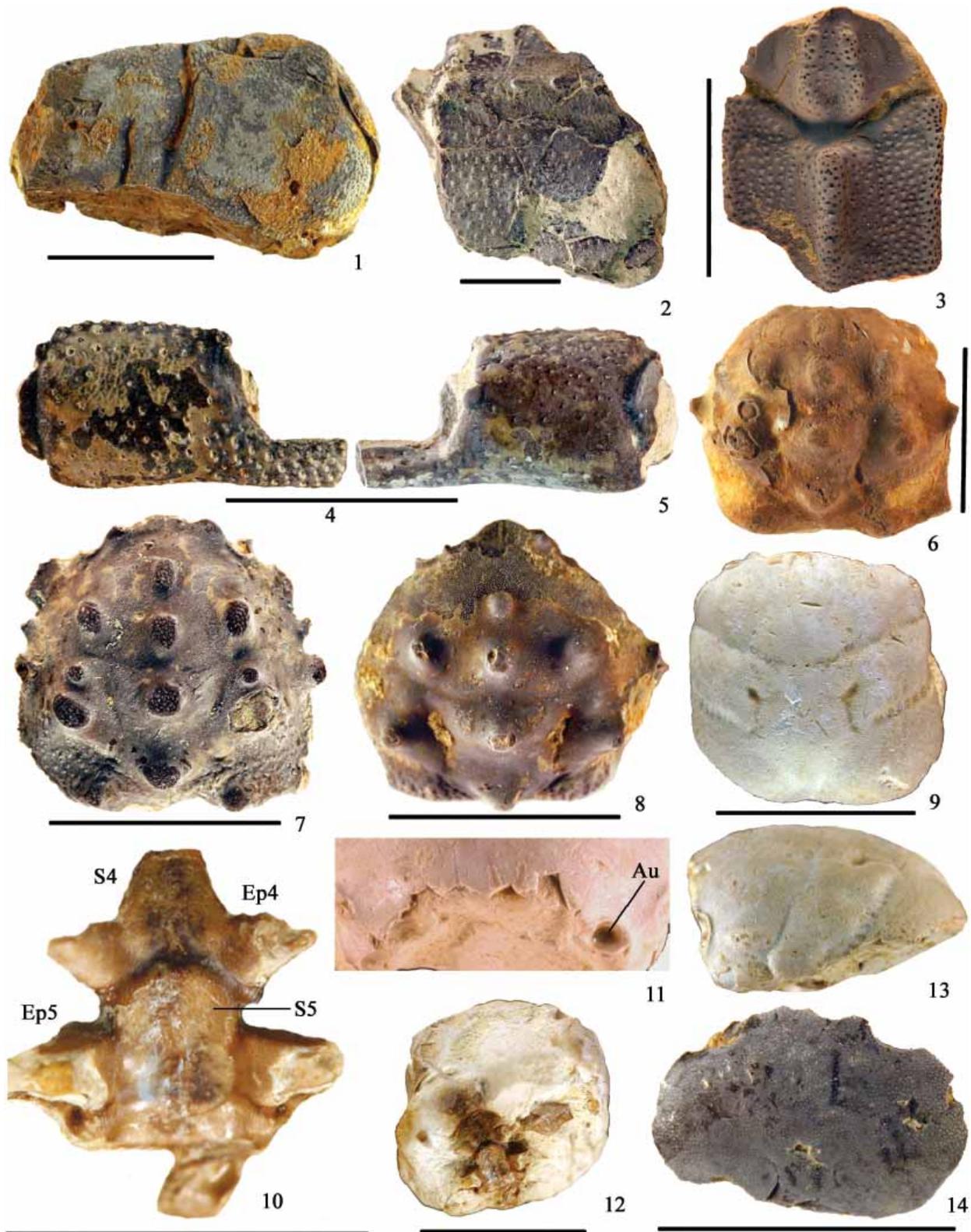


Figure 3. 1, 2: *Hoploparia* sp. 1: Left view of carapace, hypotype NPL31148. 2: Outer view of partial palm, hypotype NPL31149. 3: *Linuparus wilcoxensis* Rathbun, 1935, dorsal carapace, hypotype NPL31150. 4, 5: Paguroidea. 4: Outer view of palm, hypotype NPL31151; 5: Inner view of palm, same specimen. 6-8, *Kierionopsis nodosa* Davidson, 1966. 6: Dorsal view of carapace, hypotype NPL31152; 7: Dorsal view of carapace, hypotype NPL31153; 8: Dorsal view of carapace, hypotype NPL31154. 9-13: *Pithonoton cardwelli* new species. 9: Dorsal view of carapace, holotype NPL31155; 10: Male sternum, same specimen, Ep4, Ep5 = fourth and fifth episternites, S4, S5 = fourth and fifth sternites; 11: Close-up of anterior margin, same specimen, note left augenrest (Au); 12: Ventral view of carapace, same specimen; 13: Left view of carapace, same specimen. 14: *Caloxanthus* sp., dorsal carapace, hypotype NPL31156. Scale bars = 1 cm.

augenrest circular, small; cervical and branchiocardiac grooves well marked, subparallel; male sternum narrow, small, sternite 4 subtrapezoidal, episternites 4 subtriangular, sternite 5 subcircular, episternites 5 subtriangular.

Description. Carapace small, subovate, slightly longer than wide, widest at posterior third of carapace, lateral margins rounded; dorsal carapace surface smooth, covered by uniform, small punctae; anterior margin incomplete, downturned, augenrests round, small, placed at external portion of anterior margin, orbital margin rimmed; anterolateral margin short, curved, with small rounded ridge, delimited by relatively deep cervical groove; lateral margin straight, one-fourth longer than anterolateral margin, delimited by deep branchiocardiac groove; posterolateral margin rounded, one-third longer than lateral carapace; posterior margin concave axially on middle portion; mesogastric process extended to inclined, longitudinal shallow fissures that converge on middle portion of anterior margin; cervical groove well developed, concave forward; urogastric region delimited laterally by deep, axially convex grooves; cardiac region inverted triangular, delimited by shallow grooves.

Male sternum narrow, incomplete. Sternite 4 trapezoidal, height three times its maximum width; episternites 4 subtriangular, projected laterally, with subcircular notch on distal third, tip rounded; sternite 5 semicircular, slightly protruded, widest at midlength; episternites 5 triangular, height one-third its width, tip rounded; remainder of sternum not preserved.

Etymology. Species name honors Dean Cardwell, collector of the sole specimen and enthusiastic paleontologist.

Material examined. One incomplete cephalothorax, holotype NPL31155.

Measurements (in mm). Holotype NPL31155 carapace length = about 11.9, width = 12.2.

Discussion. According to Schweitzer and Feldmann (2007, p. 128), the following species are referred to *Pithonoton* sensu stricto: *P. marginatum* von Meyer, 1842; *P. simplex* (von Meyer, 1837), *P. elongatum* (von Meyer, 1857), *P. rusticum* Patruilius, 1966 and *P. laevimarginatum* Lörenthey and Beurlen, 1929. As *Pithonoton* sensu lato, Schweitzer and Feldmann (2009) included: *P. aequilatum* (von Meyer, 1857); *P. hypocritum* Étallon, 1861; *P. moutieri* (Hée, 1924); and *P. obtusum* (von Meyer, 1857). The new specimen from Texas has strong similarities in shape of carapace, small orbits, shape of cervical and branchiocardiac grooves to *Pithonoton marginatum*. It also resembles species of the genus *Plagiophthalmus* Bell, 1863, but that genus has wider orbits, a more elongate carapace and cervical and branchiocardiac grooves that are wider. The stratigraphic range for the genus *Pithonoton* is restricted to the Middle to Late Jurassic of Europe (Schweitzer and Feldmann, 2007). Most recently, Karasawa and Kato (2007) described *Pithonoton iyonofutanajima* Karasawa and Kato, 2007 from the Upper Jurassic of Japan. Based on stratigraphic occurrences for species of *Pithonoton* sensu stricto (see Schweitzer and Feldmann, 2007, tab. 2), the new species

from Texas represents a significant stratigraphic and paleobiogeographic extension for the genus, placing it for first in America, and as a conservative genus that persisted from mid-Jurassic to the Paleogene. Sternum morphology resembles that of Recent homolodromiids, and the specimen illustrated here help to reinforce previous systematic interpretations at the family level (Schweitzer and Feldmann, 2009).

Superfamily Etyoidea Guinot and Tavares, 2001

Family Etyidae Guinot and Tavares, 2001

Genus *Caloxanthus* A. Milne-Edwards, 1864

Type species. *Caloxanthus formosus* A. Milne-Edwards, 1864, by original designation.

Caloxanthus sp.

Figure 3.14

Description of study material. Carapace small, transversely subovate to subhexagonal, much wider than long; orbits wide, well-developed, delimited on dorsal margin by fine granulated rim; dorsal surface of carapace covered by fine granules; branchiocardiac grooves concave, well defined.

Material examined. One incomplete carapace, hypotype NPL31156.

Measurements (in mm). Hypotype NPL31156 carapace length = about 7.2, width = 10.4

Discussion. The specimen is too incomplete to offer a specific identification. However, it represents the first record for the genus in the Paleocene of America. *Caloxanthus americanus* Rathbun, 1935 has a cuticle covered by wide punctae and branchiocardiac grooves that are not well defined; *C. ornatus* (von Fischer-Benzon, 1866) from the Paleocene of Denmark is similar to the specimen from Texas, but the branchiocardiac grooves have a different orientation and the granules on the European species are stronger. Karasawa and Schweitzer (2006, p. 63) suggested including *Caloxanthus* within the Etyidae. In a recent contribution, Karasawa et al. (2008) questioned the podotreme affinity of the Etyidae, which was proposed as a family in the Podotremata by Guinot and Tavares (2001). Since there is no definite data as to placement of this family, we will follow the previous systematic order suggested by Karasawa and Schweitzer (2006).

Section Eubrachyura de Saint-Laurent, 1980

Superfamily Raninoidea de Haan, 1841

Family Raninidae de Haan, 1841

Subfamily Lyreidinae Guinot, 1993

Genus *Macroacaena* Tucker, 1998

Type species. *Lyreidus succedanus* Collins and Rasmussen, 1992, by subsequent designation.

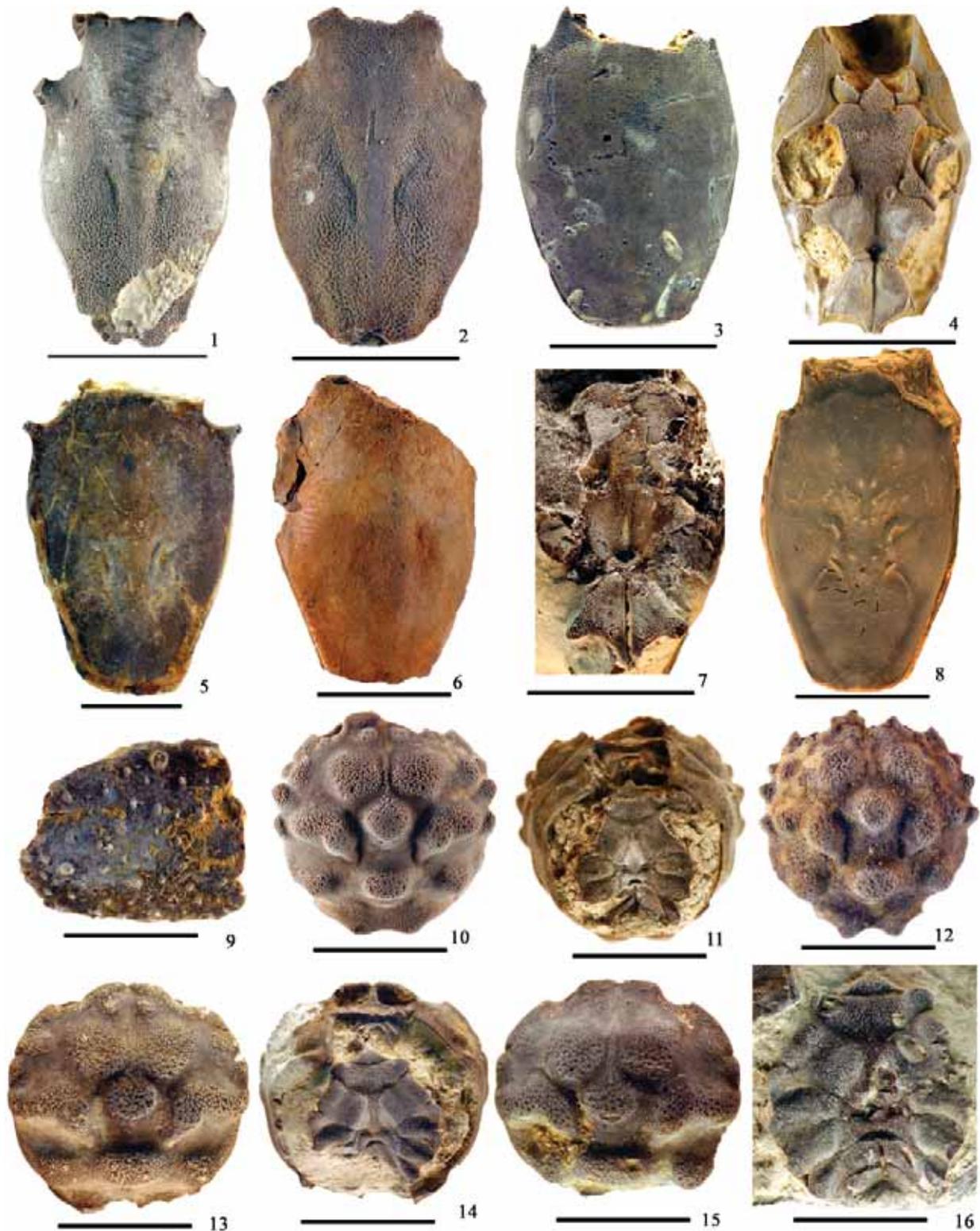


Figure 4. 1, 2, *Macroacaena johnsoni* (Rathbun, 1935), new combination. 1: Dorsal view of carapace, hypotype NPL31157; 2: Dorsal view of carapace, hypotype NPL31158. 3, 4, *Raninoides bournei* (Rathbun, 1928). 3: Dorsal view of carapace, hypotype NPL31159; 4: Sternum, same specimen. 5-8, *Raninoides treldenaesensis* (Collins and Jakobsen, 2003). 5: Dorsal view of carapace, hypotype NPL31160; 6: Dorsal view of carapace, hypotype NPL31161; 7: Sternum, same specimen; 8: Dorsal view of carapace, hypotype NPL31162. 9: *Prehepatus* sp., right palm, hypotype NPL31163. 10-16: *Tehuacana americana* (Rathbun, 1935), new combination. 10: Dorsal view of carapace, hypotype NPL31164; 11: Ventral view of carapace, same specimen; 12: Dorsal view of carapace, hypotype NPL31165; 13: Dorsal view of carapace, hypotype NPL31166; 14: Ventral view of carapace, same specimen; 15: Dorsal view of carapace, hypotype NPL31167; 16: ventral view of carapace, same specimen. Scale bars = 1 cm.

***Macroacaena johnsoni* (Rathbun, 1935), new combination**

Figures 4.1, 4.2

Symethis johnsoni Rathbun, 1935, p. 83, pl. 17, figs. 12, 13, 15 - 17.

Description of study material. Small raninid with elongated carapace, about 1.7 times longer than wide, widest at approximately two-fifths distance from front. Fronto-orbital region about half of maximum width. Rostrum missing. Orbits directed forward. Each orbit has two supra-orbital fissures and an outer orbital spine directed forward. Relatively long, outward-pointing, smooth anterolateral spines. Dorsal carapace cuticle with deep punctae being larger on posterior third of carapace; depressed branchial regions and a central elevated ridge most prominent on posterior half, ending in very faint hepatic furrows.

Material examined. Two small incomplete carapaces, hypotypes NPL31157 and NPL31158.

Measurements (in mm). Hypotype NPL31157 carapace length = about 17.7, width = 11.0 (excluding anterolateral spines); hypotype NPL31158 carapace length = about 14.9, width 9.9 (excluding anterolateral spines).

Discussion. Rathbun (1935, pl. 17) illustrated two different species of raninids for which, most of them (figs. 12, 13, 15-17) are referred to the genus *Macroacaena*, according to the diagnosis provided by Tucker (1998) and Schweitzer et al. (2003). However, the specimen in Rathbun (1935, fig. 14) is different from the others and probably represents a specimen of *Symethis*, however the description provided by Rathbun (1935, p. 83) does not include features of that genus, according to original and subsequent descriptions (Weber, 1795; Rathbun, 1937; Goeke, 1980; Williams, 1984; Correa-Sandoval, 1991; Hendrickx, 1997). Therefore, the specimens illustrated by Rathbun (1935, figures 12, 13, 15-17) are best referred to the genus *Macroacaena* and the specimen illustrated in Rathbun (1935, fig. 14) is indeterminate until the specimen can be examined. *Macroacaena venturairi* Vega, Nyborg, Fraaije and Espinosa, 2007, described from the Paleocene Rancho Nuevo Formation of NE Mexico (Vega et al., 2007) is larger than the specimens from the Paleocene of Texas. It lacks cuticle on the dorsal side of the carapace, however several patches of cuticle observed on sides of carapace show no punctae.

Subfamily Raninoidinae Lörenthey and Beurlen, 1929
Genus *Raninoides* H. Milne Edwards, 1837

Type species. *Ranina laevis* Latreille, 1825 by original designation.

***Raninoides bournei* (Rathbun, 1928)**

Figures 4.3, 4.4

Nostoceles bournei Rathbun, 1928, p. 1, pl. 1; Rathbun, 1935, p. 51, 82, pl. 16, fig. 16, pl. 26, fig. 5.

Laeviranina bournei (Rathbun, 1928), Tucker, 1998, p. 151.

Raninoides bournei (Rathbun, 1928), Schweitzer et al., 2006, p. 28.

Description of study material. Carapace small, longitudinally subovate, one-third longer than wide, widest at mid-carapace length; dorsal and ventral carapaces covered by fine granules; left outer orbital spine strong, triangular; anterolateral margins delimited by short, acute, forward-directed spine; posterolateral margin slightly curved, rimmed, represents half the carapace length; posterior margin nearly straight, rimmed, half the maximum carapace width; anterior portion of carapace depressed to reach anterior margin. Fused sternites 1 – 3 forming a subpentagonal plate; sternite 4 largest, wide, long, with posteriorly curved triangular, anterolateral plates; sternite 5 inverted trapezoidal, slightly wider than sternite 4 on anterior portion, median line deep; spermatheca subpentagonal; sternite 6 subtrapezoidal, median line deep, such that it appears to be formed by two subtriangular plates.

Material examined. One incomplete carapace, hypotype NPL31159.

Measurements (in mm). Hypotype NPL31159 carapace length = about 16.8, width = 10.1 (excluding anterolateral spines).

Discussion. The species has been described from Paleocene strata of Navarro County, Texas, Buzzard Bluff, Arkansas, as well as from several localities in Alabama. It is remarkable the wide range of sizes found within this species, as seen from the small size of some specimens such as the one herein reported, the one illustrated by Rathbun (1928, pl. 1, fig. 4; 1935, pl. 16, fig. 16), in contrast with the other illustrated by Rathbun (1928, pl. 1, figs. 1-3; 1935, pl. 26, fig. 5). This may be the result of differences in age. More intensive collection should be done in order to understand the population biology of this species.

***Raninoides treldenaesensis* (Collins and Jakobsen, 2003)**

Figures 4.5-4.8

Laeviranina treldenaesensis Collins and Jakobsen, 2003, p. 71, fig. 4, pl. 3, fig. 5.

Laeviranina sp. Vega et al. 2001, p. 935, figs. 6.2, 7.

Raninoides treldenaesensis (Collins and Jakobsen, 2003), Vega et al., 2008, p. 55, pl. 2, fig. 3.

Description of study material. Small raninid, carapace elongate oval, narrow at posterior third, lateral margins convergent posteriorly; fronto-orbital region narrow, three-fourths the length of carapace; posterior margin weakly convex, half of maximum width; orbital spines short, orbital fissures deep; rostrum triangular, short; orbital margins sinu-

ous, delimited by inner fissure; outer orbital spines projected beyond level of rostral spine; frontal region depressed below general carapace surface, defined along posterior surface by subtle convex-forward ridge; anterolateral spines short, projected outward 45 degrees with respect to transverse axis; branchiocardiac grooves weakly arcuate, subtle; carapace surface smooth.

Sternite 4 the largest, wide and long, with posteriorly curved triangular, posterolateral plates; sternite 5 inverted trapezoidal, slightly wider than sternite 4 on anterior portion, median line shallow; spermatheca subcircular; sternite 6 subtrapezoidal, median line deep, so it appears to be formed by two subtriangular plates.

Material examined. Two specimens, hypotypes NPL31160 and NPL31161.

Measurements (in mm). Hypotype NPL31160 carapace length = about 27.0, width = 15.4 (excluding anterolateral spines); hypotype NPL31161, carapace length = about 22.3, width = 16.4 (excluding anterolateral spines); hypotype NPL31162 carapace length = 26.3, width = 14.3 (excluding anterolateral spines).

Discussion. Collins and Jakobsen (2003) described *Raninoides treldenaesensis* from the lower Eocene of Denmark. Vega *et al.* (2008) reported the species from lower Eocene deposits from Chiapas, commenting on the differences with other species of the genus. Presence of *R. treldenaesensis* in the Paleocene of Texas represent an extension of the paleobiogeographic and stratigraphic range for the species, confirming the affinity suggested by Vega *et al.* (2008) between Paleocene decapod assemblages from Texas, and those from the Lower Eocene of Chiapas, southern Mexico.

Superfamily Aethroidea Dana, 1851
Family Aethridae Dana, 1851
Genus *Prehepatus* Rathbun, 1935

Type species. *Prehepatus cretaceous* Rathbun, 1935, by original designation.

***Prehepatus* sp.**
Figure 4.9

Description of study material. Right palm incomplete, triangular, distal margin about one-third higher than junction with carpus; outer surface covered by coarse tubercles, concentrated toward upper and lower margins.

Material examined. One incomplete right palm, hypotype NPL31163.

Measurements (in mm). Hypotype NPL31163 palm length (incomplete height) about 10.7; width = 13.5.

Discussion. From the six known species described for the genus, only *Prehepatus mexicanus* Schweitzer, Feldmann, González-Barba and Čosović, 2006 from the Eocene of Baja California Sur, Mexico, was found in Paleocene deposits,

all the remaining species are reported from Cretaceous strata. The only specimen from the Paleocene of Texas is too incomplete to erect a new species, but represents the first record for the genus in Paleocene deposits.

Superfamily Goneplacoidea MacLeay, 1838
Family Goneplacidae MacLeay, 1838
Family Mathildellinae Karasawa and Kato, 2003
Genus *Tehuacana* Stenzel, 1944 = *Marydromilites*

Type species. *Tehuacana tehuacana* Stenzel, 1944 (= *Dromilites americana* Rathbun, 1935), by original designation.

***Tehuacana americana* (Rathbun, 1935), new combination**

Figures 4.10-4.16; 5.1, 5.2, 5.4-5.7, 5.9, 5.10

Dromilites americana Rathbun, 1935, p. 79, pl. 17, figs. 1-6.

Tehuacana tehuacana Stenzel, 1944, p. 546, pl. 93, figs. 6-9; text-figs. 1-3; Glaessner, 1969, p. 527, fig. 333, 9; Bishop and Whitmore, 1986, p. 298, fig. 1F. Vega *et al.*, 2007, p. 1438, figs. 5.6, 5.7; Vega *et al.*, 2008, pl. 3, fig. 7.

Diagnosis. Carapace small, slightly longer than wide; anterior margin relatively narrow, orbits with two supraorbital notches; anterolateral margins with three anterolateral spines or lobes; dorsal carapace marked by bosses of variable strength; sternum broad, sternites 1 and 2 completely fused, sternite 3 transverse elongated, sternite 4 subtrapezoidal, sternite 5 with press button of abdominal locking mechanism; abdomen subrectangular elongate; chelipeds massive.

Description of study material. Carapace small, slightly longer than wide, highly convex in transversal section. Anterior margin short, one-half maximum carapace width, orbits rounded with two supraorbital notches; anterolateral margins broadly curved, with three anterolateral spines, posterior spine being the largest; posterolateral margins convex, about one-fourth maximum width, forming sub-squared projection at junction with posterior margin, convex on both sides and straight at middle portion. Protogastric regions subsquare, elevated, bordered by deep cervical groove; mesogastric region subpentagonal with narrow, parallel sided anterior process; hepatic regions small, subtriangular; epi- and mesobranchial lobes fused, bilobed, with a posterior triangular extension adjacent to cervical groove; metabranchial areas elevated from margin of carapace, subtriangular; meta- and urogastric regions depressed; cardiac lobe subtrapezoidal; intestinal region flat, inclined towards posterior margin. Third maxillipeds short, semirectangular; coxa subtrapezoidal, granulose, one-seventh the length of ischium and half its width; ischium semirectangular, elon-

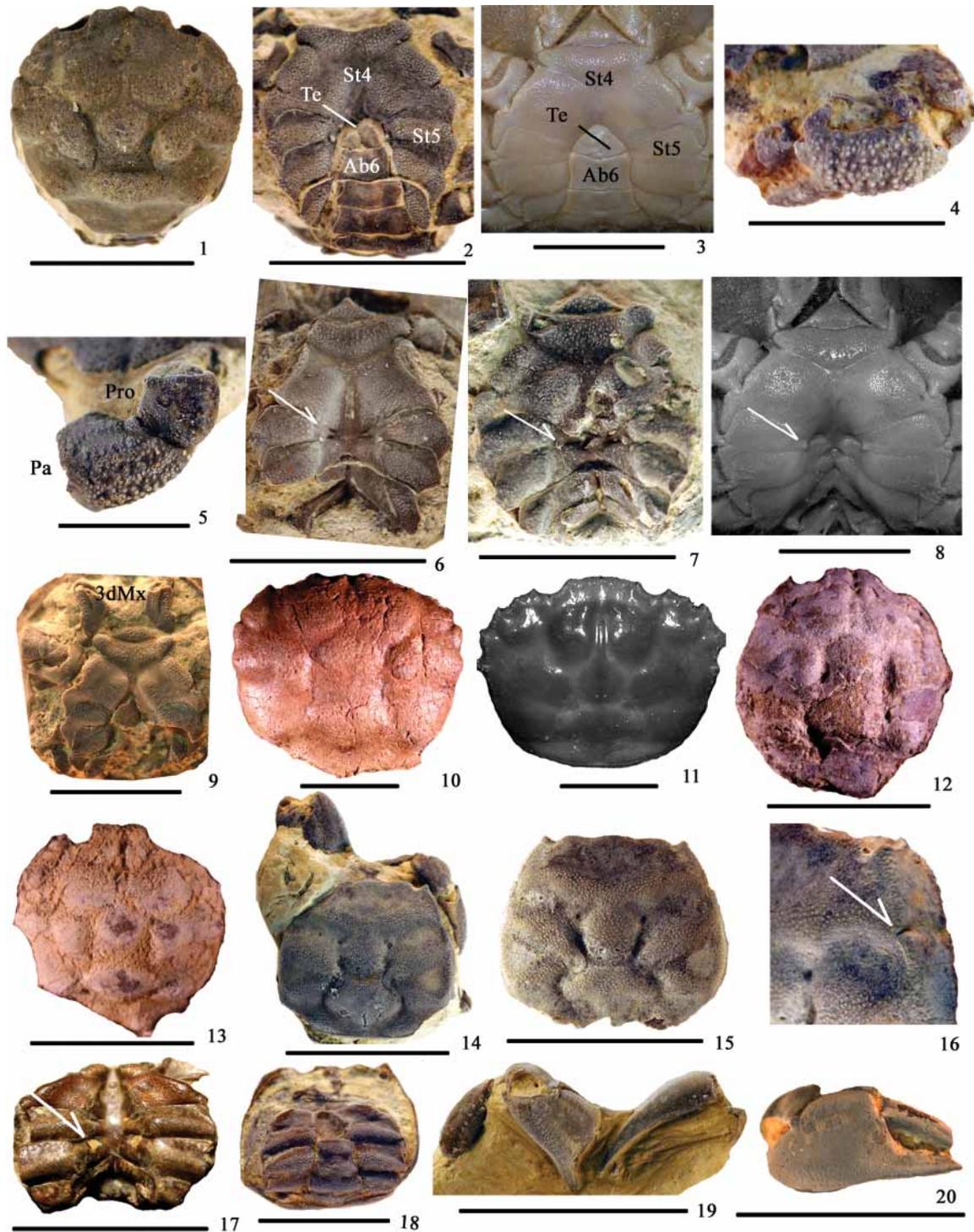


Figure 5. 1, 2, 4-7, 9, 10: *Tehuacana americana* (Rathbun, 1935), new combination. 1: Dorsal view of carapace, hypotype NPL31168; 2: Ventral view of carapace, same specimen, Ab6 = sixth abdominal somite, St4, St5 = fourth and fifth sternites, Te = telson; 4: Left chela, hypotype NPL31170; 5: Left carpus and palm, hypotype NPL31171; 6: Sternum of hypotype NPL31164, arrow points to press button of abdominal locking mechanism; 7: Sternum of hypotype NPL31166, arrow points to press button of abdominal locking mechanism; 9: Ventral view of carapace, hypotype NPL31169, 3dMx = third maxillipeds; 10: Dorsal view of carapace, hypotype IGM 9105, Paleocene Rancho Nuevo Formation, Coahuila, northeastern Mexico. 3, 8, 11: *Intesius pilosus* Guinot and Richer de Forges, 1981. 3, Ventral view, Ab6 = sixth abdominal somite, St4, St5 = fourth and fifth sternites, Te = telson; 8: Ventral view, arrow points to press button of abdominal locking mechanism; 11: Dorsal view of carapace. 12, 13: *Tehuacana schweitzeriae* Vega, Nyborg, Coutiño, Hernández-Monzón, 2008. 12: Dorsal view of carapace, holotype IHNFG-3051, Lower Eocene El Bosque Formation, Chiapas, southern Mexico; 13: Dorsal view of carapace, paratype IHNFG-3053, El Bosque Formation, Lower Eocene, Chiapas, southern Mexico. 14-20: *Costacopluma texana* new species. 14, Dorsal view of carapace and both chelipeds, holotype NPL31172; 15: Dorsal view of carapace, paratype NPL31173; 16: Arrow points to notch on right anterolateral margin, same specimen; 17: Sternum of female, paratype MGSB 75425, arrow points to vulvae on right sixth sternite; 18: Ventral view of carapace, paratype NPL31173; 19: Detail of both chelipeds, holotype NPL31172; 20: Right chela, paratype NPL31176. Scale bars = 1 cm.

gate, narrow at the base, with longitudinal groove at middle portion, surface granulose, except for that of groove.

Sternum broad, sterno-abdominal depression deep; surface covered with small granules; sternites 1 and 2 completely fused without trace of suture in a sharp, small triangle; sternite 3 transversely elongate, clearly demarcated from sternite 2 and 4 by transverse suture, with prominent tubercles on lateral edges; sternite 4 subtrapezoidal, anterolateral margins rimmed, posterolateral projections; suture 3/4 complete, without any prominent depression; posterior margins of sutures 3/4, 4/5 and 5/6 lined with small rounded granules on lateral parts; sternite 4 entire with median part longitudinally depressed but without any distinct groove, posterior part relatively deeper with 2 short, low, rounded, longitudinally curved ridges; sternite 5 complete, narrowing towards median line, with press button of abdominal locking mechanism located at the base of sternite; sutures 4/5 and 5/6 medially interrupted; 7/8 medially interrupted. Abdomen subrectangular elongate, not rounded flap; all somites and telson freely articulating; somite 1 medially narrow, covering entire space between coxae 5; somite 2 medially elongate with concave lateral margins; somites 3-6 subrectangular with lateral margins gently to prominently concave; somite 6 with median transverse ridge; telson semicircular, lateral margins gently convex. Chelipeds massive; left carpus semisquare, outer surface covered by fine granules; left palm globose, twice as long as carpus, outer surface covered by coarse granules, upper margin with a row of tubercles, small spine at junction with carpus, inner surface smooth.

Material examined. Seven complete carapaces, one incomplete chela; hypotypes NPL31164 to NPL31171.

Measurements (in mm). Hypotype NPL31164 carapace length = 14.5, width = 14.6; hypotype NPL31165 carapace length = 13.4, width = 13.1; hypotype NPL31166 carapace length = 15.3, width = 16.2; hypotype NPL31167 carapace length = about 14.0, width = 15.7; hypotype NPL31168 carapace length = 10.0, width = 10.7; hypotype NPL31169 carapace length = 14.6, width = 14.8; hypotype NPL31170 left chela length = 6.4, height = 2.9; hypotype NPL31171 carapace length = 13.1, width = 12.9.

Discussion. Števc̆ić (2005) erected the new genus *Marydromilites*, to include *Dromilites americana* Rathbun, 1935. However, as is discussed below, it is suggested that *Tehuacana* is the senior synonym of *Marydromilites*. *Tehuacana tehuacana* Stenzel, 1944 shows remarkable points of similarity with *Dromilites americana* including: shape of carapace; shape of frontal and epigastric, mesogastric, and protogastric areas, and nodes or bosses developed on these areas; shape and position of nodes forming a transverse arc, convex upwards, across the posterior (cardiac and paired metabranchial); bilobed, thickened postero-lateral margin; presence of two thickened, node-like bosses on posterior margin; five “transverse elevations” of which Rathbun writes in describing *D. americana*, represent a division of the meta- and epibranchial areas, whereas in *Tehuacana*

tehuacana, they are fused but show an indentation. Rathbun (1935, pl. 17, fig. 2) illustrated the sternum of *D. americana*, paratype 371687 from Wilcox County, Alabama, but did not include a description. The sternum closely resembles that of *T. tehuacana*, except for several grooves that appear to be added lines by Rathbun to emphasize morphological details. On close inspection, it appears that Rathbun added a line drawn between sternites 3 and 4, as well as another short longitudinal line at the right edge of sternite 4 (see Rathbun, 1935, pl. 17, fig. 2). In addition, *D. americana* has upper orbital fissures, continued suture delimiting sternites 7 and 8 and a sterno-abdominal cavity reaching posterior of sternite 4, features used by Karasawa and Kato (2003) to erect the family Mathildellinae and include there *Tehuacana* and *Branchioplax* Rathbun, 1916, from the Paleogene around the world, along with the extant genera *Beuroisia* Guinot and Richer de Forges, 1981; *Intesius* Guinot and Richer de Forges, 1981; *Mathildella* Guinot and Richer de Forges, 1981; *Neopilumnoplax* Serène in Guinot, 1969 and *Platypilumnus* Alcock, 1894. The subfamily was elevated to the rank of family by Karasawa and Schweitzer (2006), as part of the Portunoidea. More recent reports place the Mathildellidae into the Goneplacoidea (Ng and Manuel-Santos, 2007; Castro, 2007; Ng *et al.*, 2008). Vega *et al.* (2008) described *Tehuacana schweitzeriae* from the Lower Eocene of southern Mexico, and noticed similarities of that species with *Dromilites americana*, suggesting that this species was in need of review, possibly to be placed into the Mathildellidae. The systematic rearrangement herein proposed confirms that the specimens from the Eocene of Chiapas should remain as *Tehuacana schweitzeriae* (Figures 5.12, 5.13). There is also a strong morphological resemblance between *Tehuacana* with the extant genus *Intesius*, which presents the same distribution of dorsal regions of carapace, and both possess a sternum that is practically identical, including position of press button of abdominal locking mechanism, as seen in *I. pilosus* Guinot and Richer de Forges, 1981, illustrated in Ng and Manuel-Santos, 2007, and in Figures 5.3, 5.8 and 5.11. These similarities suggest a direct relationship between *Tehuacana* and *Intesius*, the former probably being precursor of the last genus.

Intraspecific variation can explain morphological differences between specimens of *Tehuacana tehuacana* and those of *Dromilites americana*, (P. Ng and P. Castro, pers. comm.), reflected mainly in shape of carapace, being longer in *D. americana*, which also has stronger anterolateral spines, has a more projected front and mesobranchial lobes can be divided in two. No evidence was found to suggest the differences are a result of sexual dimorphism. Press button of abdominal locking mechanism is found in specimens of the two morphotypes in the Paleocene of Texas (Figures 5.6 and 5.7). Interestingly, position of such buttons is very similar to the ones found in the mathildellid extant species *Intesius pilosus* (Figure 5.8). Intraspecific variation has been reported in members of the Goneplacoidea (Guinot and Richer de Forges, 1980; Guinot, 1989; Castro, 2007; Ng

and Castro, 2007; Ng and Manuel-Santos, 2007; Castro and Ng, 2008; Ng and Richer de Forges, 2009). Guinot (1989) documented variation in development and strength of anterolateral spines in members of the same species of the genus *Carcinoplax* H. Milne Edwards, 1852. Following the priority principle, it is here suggested that specimens previously referred to *Dromilites americana* and those of *Tehuacana tehuacana*, should be now considered as *Tehuacana americana* (Rathbun, 1935), new combination.

Superfamily Retroplumoidea Gill, 1894
 Family Retroplumidae Gill, 1894
 Genus *Costacopluma* Collins and Morris, 1975

Type species. *Costacopluma concava* Collins and Morris, 1975, by original designation.

***Costacopluma texana* new species**

Figures 5.14-5.20; 6.1

Diagnosis. Carapace small, subhexagonal, widest at posterior third of carapace; anterolateral margin with notch at level of epibranchial region; strong transverse ridges, with rounded, granulated crests; areas between ridges with fine punctae; sternum wide; abdomen triangular; vulvae subovate on upper, inner portion of sixth sternite; chelipeds massive.

Description. Carapace small, square to subhexagonal, widest at posterior third, three elevated transverse ridges marking carapace regions with finely crenulated crests; regions between ridges smooth; anterior margin sinuous, rimmed with numerous fine tubercles, three-fourths the maximum carapace width; orbits wide, ovate, with a small external orbital spine; rostrum bifid to inverted trapezoidal; a narrow rim marking anterolateral and anterior posterolateral margins, ending at level of metabranchial region, with small tubercles; anterolateral margin slightly curved, half total carapace length, a small notch at level of epibranchial region; posterolateral margin curved, abruptly inclined toward posterior margin at posterior third of carapace; posterior margin straight, two-thirds the maximum carapace width; anterior ridge arched, lateral tip reaching anterolateral margin, becoming wider at level of protogastric lobes; mesogastric lobe rhomboid; median ridge inclined 45 degrees with respect to posterior margin, includes epi- and mesobranchial lobes, wider in middle portion, narrowing at lateral tip, reaching anterolateral margin, narrows also at level of depressed urogastric region, where cervical groove is deeply impressed and curves around cardiac lobe; posterior ridge at level of metabranchial lobes, inclined toward center of carapace, posterolateral edge continuous with lateral rim of small tubercles, widens distally, then narrowing abruptly before inner tip of mesobranchial lobe; cardiac lobe subtrapezoidal, one-third the carapace width, with a fused posterior lobe; intestinal region depressed.

Sternum wide, abdominal cavity deep; sternites 1 and 2 unknown; sternite 3 transversely elongated with two lateral elongated bosses with crests covered by granules, separated from sternite 4 by deep transverse groove; sternite 4 trapezoidal, lateral margins rimmed with numerous tubercles, lateral process triangular, sharp; sternite 5 rectangular, with median ridge with coarse granules on crest, extending to triangular, sharp lateral process; sternite 6 similar to sternite 5, vulvae (female) ovate on anterior internal margin; sternite 7 one-third narrower than sternite 6, with median, granulate crest.

Abdomen triangular, elongated, all abdominal segments with a median granulated transverse crest; segment 4 subtrapezoidal; segment 3 subrectangular, one-third wider and as long as segment 4; segment 2 rectangular, one-third wider and slightly shorter than segment 3. Telson and remainder segments not preserved.

Chelipeds robust, equal; merus rectangular, one-third the carapace length and height being half its own length, lower margin bearing a row of at least 8 strong tubercles, outer surface covered by fine granules, upper margin sharp, smooth; carpus as high as merus, half its length, outer surface with fine granules; palm subtrapezoidal, as long as merus, being wider at distal portion, lower margin wide, with fine granules, upper margin sharp, with fine granules, outer surface smooth; fixed finger triangular, acute, outer margin with a shallow longitudinal groove, occlusal surface with row of teeth; movable finger curved, one-fourth the palm height, outer surface smooth, with a longitudinal shallow groove on upper third, occlusal surface bearing at least four teeth of different size.

Etymology. Species name refers to its occurrence in Paleocene outcrops from Texas.

Material examined. Six complete carapaces, holotype NPL31172, paratypes NPL31173 to NPL31176, and paratype MGSB 75425.

Measurements (in mm). Holotype NPL31172 carapace length = 9.7, width = 10.1; paratype NPL31173 carapace length = about 9.8, width = 11.6; paratype NPL31174 carapace length = about 9.2, width = 10.1; paratype NPL31175 carapace length = about 6.7, width = 7.0; paratype NPL31176 carapace length = 10.9, width = 11.8.

Discussion. Ten species of *Costacopluma* have been previously described ranging from Coniacian to Eocene deposits from America, Greenland, Africa and India, all of which representing what appears to be one of the most diverse and widely distributed extinct brachyuran genera. The Paleocene species described include: *Costacopluma senegalensis* (Rémy, in Gorodiski and Rémy, 1959); *Costacopluma binodosa* Collins and Rasmussen, 1992; *Costacopluma bifida* Collins, Higgs, and Cortitula, 1994; *Costacopluma australis* Feldmann, Casadio Chirino-Gálvez, and Aguirre-Urreta, 1995; *Costacopluma nordestiana* Feldmann and Martins-Neto, 1995 and *Costacopluma salamanca* Feldmann, Rodriguez, Martinez and Aguirre-Urreta, 1997. All these species share the following features: carapace small, sub-

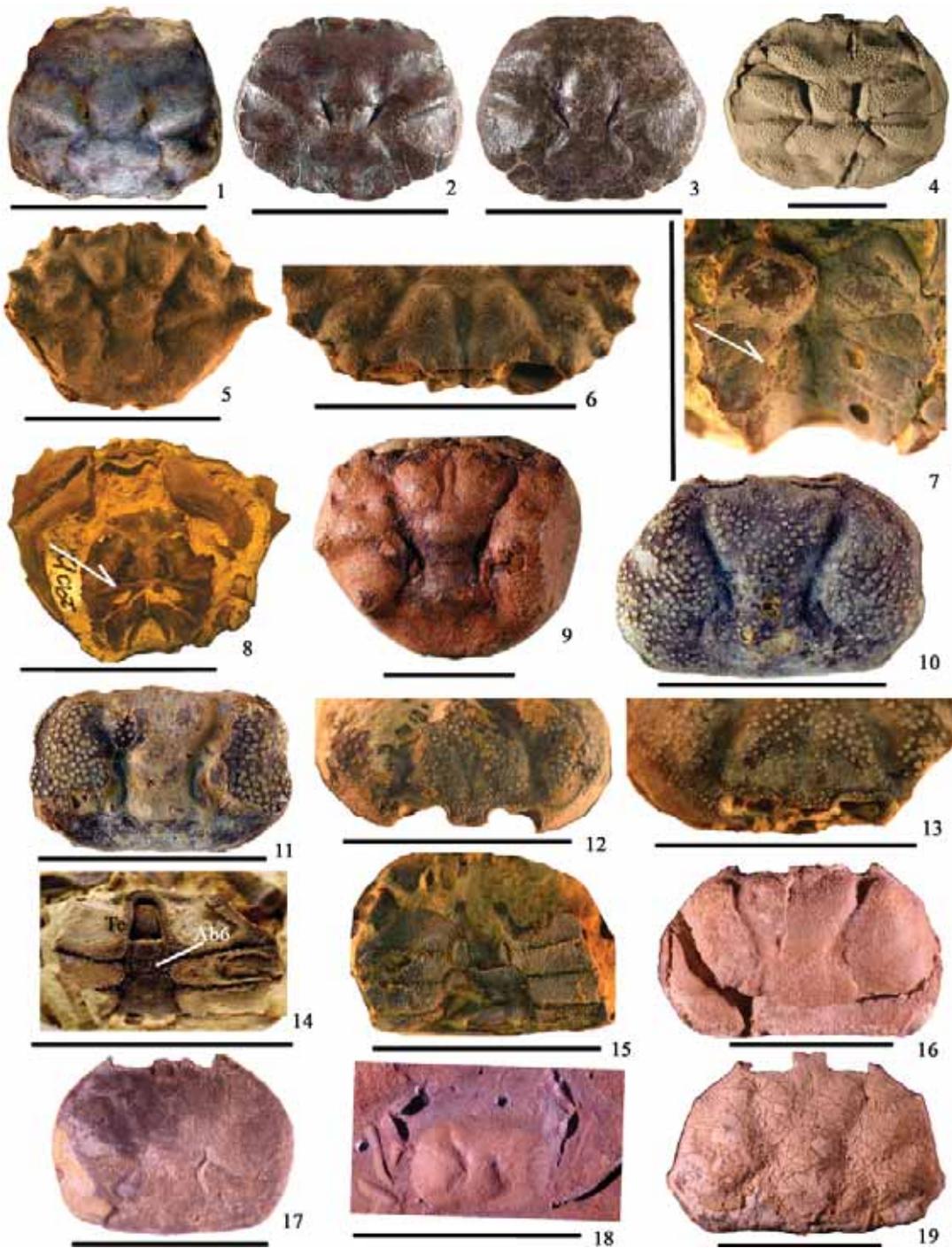


Figure 6. 1: *Costacopluma texana* new species, dorsal view of carapace, paratype NPL31176. 2, 3: *Costacopluma grayi* Feldmann and Portell, 2007. 2: Dorsal view of carapace, holotype UF-113749 (University of Florida), Eocene Tallahata Formation, Alabama; 3: Dorsal view of carapace, paratype UF-113750. 4: *Costacopluma mexicana* Vega and Perrilliat, 1989, dorsal view of carapace, holotype IGM 4128 (Colección Nacional de Paleontología, Instituto de Geología, UNAM), early Maastrichtian Potrerillos Formation, Nuevo León, northeastern Mexico. 5-9: *Paraverrucoides alabamensis* (Rathbun, 1935). 5: Dorsal view of carapace, hypotype NPL31177; 6: Detail of front, same specimen; 7: Detail of female sternum, hypotype NPL31178, arrow points to vulva on right sixth sternite; 8: Sternum of female specimen on private collection, arrow points to vulvae on right sixth sternite; 9: Dorsal view of carapace, hypotype IGM 9104, Paleocene Rancho Nuevo Formation, Coahuila, northeastern Mexico; 10-15: *Viapinnixa mexiaensis* new species. 10: Dorsal view of carapace, holotype NPL31179; 11: Dorsal view of paratype NPL31180; 12: Detail of front, paratype NPL31181; 13: Detail of front, holotype NPL31179; 14: Ventral view of male carapace, paratype NPL31180, Te = telson, Ab6 = sixth abdominal somite; 15: Ventral view of female carapace, paratype NPL31179. 16-18: *Viapinnixa perrillatae* Vega, Nyborg, Fraaije and Espinosa, 2007, Paleocene Rancho Nuevo Formation, Coahuila, northeastern Mexico. 16: Dorsal view of carapace, holotype IGM 9107; 17: Dorsal view of juvenile carapace, paratype IGM 9108; 18: Dorsal view of juvenile carapace, paratype IGM-9109. 19: *Viapinnixa alvarezii* Vega, Cosma, Coutiño, Feldmann, Nyborg, Schweitzer and Waugh, 2001, Lower Eocene El Bosque Formation, Chiapas, southern Mexico, dorsal view of carapace, Hypotype IHNFG 3058 (Museo de Paleontología, Instituto de Historia Natural, Chiapas). Scale bars = 1 cm.

hexagonal; rostrum bifid to inverted subtrapezoidal; three transverse ridges with fine granules on crests and occurrence within Paleocene strata; *C. binodosa* is known from Greenland, the remainder species are from South America. *Costacopluma nordestiana* closely resembles the new species from the Paleocene of Texas, however *C. texana* differs by having: a carapace proportionally wider at the anterior portion, presence of notch on anterolateral margin, rostrum and postorbital spine shorter, transverse ridges more rounded on crests, with tubercles not as strong; and a mesobranchial ridge that is more swollen (see also Araújo-Távora and Cruz-Miranda, 2004).

Despite having a close geographic and stratigraphic position to *Costacopluma grayi* Feldmann and Portell, 2007 from the Eocene of Alabama, *C. texana* has clearly defined differences. *Costacopluma grayi* possesses an ovate carapace, wider near midlength; narrow crests of transverse ridges; areas between ridges broader; and anterior margin proportionally wider (see illustration of holotype UF113749 and paratype UF113750, Figures 6.2 and 6.3, respectively). It is interesting to note *C. grayi* shares many features with *C. senegalensis* (Rémy, 1959) from the Paleocene of Senegal, as pointed out by Feldmann and Portell (2007), but also in carapace shape with *C. concava* Collins and Morris, 1975; *C. mexicana* Vega and Perrilliat, 1989 (Figure 6.4) and *C. bishopi*, Vega and Feldmann, 1992 (see also Fraaije et al. 2006), being ovate and wider at midlength. It appears possible to divide all species of *Costacopluma* into two main groups: the ovate carapace group, represented by Cretaceous American-African species and the Eocene *C. grayi*, and the subhexagonal carapace species, represented by Paleocene species from Greenland, North and South America.

McLay (2006) suggested that *C. mexicana*, *C. bishopi*, *C. binodosa* and *C. australis* should be removed from the Retroplumidae and included into the Palicidae Bouvier, 1898, based on lack of diagnostic features for that family established by Sain-Laurent (1989), such as carapace wider than long and presence of transverse sternal carinae, among others. *C. bishopi* and *C. mexicana* have an ovate, wider than long carapace and in particular, *C. mexicana* has strong transverse sternal carinae (Vega and Perrilliat, 1989, p. 85, figs. 2h and 2j). Detailed review of the Palicidae by Castro (2000) indicate that palicids have a rough dorsal carapace surface, very small chelae, anterolateral spines and spiny front. None of the species suggested by McLay (2006) to be removed from the Retroplumidae include these features. It is true that morphological knowledge for every species of *Costacopluma* is far from being complete, but they all share common features that suggest they are closely related and probably are part of the same family. A more detailed study is needed to define the phyletic relationships between species of *Costacopluma*. The worldwide regression in the Late Cretaceous as a cause for extinction of *Costacopluma* in America (Brösing, 2008) should be reconsidered, as it seems the genus was still an important element of the Paleogene shelf faunas.

Superfamily Carpilioidea Ortmann, 1893
Family Palaeoxanthopsidae Schweitzer, 2003
Genus *Paraverrucoides* Schweitzer, 2003

Type species. *Xanthilites alabamensis* Rathbun, 1935, by original designation.

***Paraverrucoides alabamensis* (Rathbun, 1935)**

Figures 6.5-6.9

Xanthilites alabamensis Rathbun, 1935, p. 91, pl. 20, figs. 3-16; Toulmin, 1977, p. 177, pl. 9, fig. 3.

Paraverrucoides alabamensis (Rathbun, 1935). Schweitzer, 2003, p. 1123, figs. 6.1, 6.3, 6.6; Vega et al., 2007, p. 1438, figs. 5.3-5.5, 6.1.

Description of study material. Carapace subhexagonal, maximum width at midlength; anterior margin broad, two-thirds maximum width; orbits circular, broad, orbital notch triangular, front bifid, wide, projected beyond front, with four small spines; anterolateral margin inclined, with three spines, anterolateral one being the most developed; posterolateral margin smooth, nearly two-thirds maximum length; posterior margin straight, about one-half maximum width, with small elevations on lateral sides. Dorsal surface covered by fine granules; carapace regions well defined; branchiocardiac groove deep, inclined posteriorly from orbital spine to base of cardiac region; protogastric lobes swollen; mesogastric region semioval, long anterior process projected to base of rostrum; hepatic lobes a prominent boss; epibranchial lobes distinct, semioval; meso- and metabranchial areas flat, with prominent boss at midlength of posterolateral margin; metagastric and urogastric regions depressed; cardiac region subhexagonal, inflated with two small tubercles transversely aligned; intestinal region indistinct.

Sternum broad, sterno-abdominal depression shallow; surface smooth; sternites 1, 2 form a small triangle (based on paratypes 371707 and 371708 illustrated by Rathbun, 1935, pl. 20, figs. 14 and 15); sternite 3 transversely elongate, with lateral projections extending beyond margin of sternum and a median groove, clearly separated from sternite 4 by a deep inclined transverse groove; sternite 4 subtrapezoidal with posterolateral projections, median part longitudinally depressed without any distinct groove; sternite 5 narrowing towards median line; sutures 4/5 and 5/6 medially interrupted; vulvae on sternite 6 tear-shaped, relatively large; sternite 7 subrectangular; sternite 8 not preserved.

Material examined. Two carapaces, hypotypes NPL31177 and NPL31178.

Measurements (in mm). Hypotype NPL31177 carapace length = 16.5, width = 24.0; hypotype NPL31178 carapace length = 13.7, width = 19.0.

Discussion. Vega et al. (2007) reported *Paraverrucoides alabamensis* from the Paleocene Rancho Nuevo Formation of northeastern Mexico, based on specimens without a trace of cuticle and only preserving dorsal structures (Figure 6.9).

The new material from Texas help complete morphological description and expands the paleobiogeographic range for this species.

Superfamily Pinnotheroidea de Haan, 1833

Family Pinnotheridae de Haan, 1833

Subfamily Pinnothereliinae Alcock, 1900

Tribe Pinnixini Števčić, 2005

Genus *Viapinnixa* Schweitzer and Feldmann, 2001

Type species. *Pinnixa (Paleopinnixa) nodosa* Collins and Rasmussen, 1992, by original designation and monotypy.

***Viapinnixa mexiaensis* new species**

Figures 6.10-6.15

Diagnosis. Carapace small, transversely subovate, widest at level of metabrachial regions; outer orbital spines weak; supraorbital margin rimmed, with fine tubercles; cervical groove deeply impressed; cuticle with strong, uniform tubercles; sternites covered by fine granules; sternite 4 subtrapezoidal, with area surrounding telson rimmed with fine granules; male abdomen slender, elongated; in female abdomen lateral margin divergent posteriorly becoming much wider to abdominal somite 5.

Description. Carapace small, transversely ovate, 1.5 times wide as long, widest at posterior third. Front narrow (16% of carapace width), strongly downturned, sulcate. Orbits wide (50% of carapace), transversely quadrate, somewhat constricted by upper and lower margins near middle. Orbits rimmed by granulate ridge arising on rostrum, merging with pterygostomial wall laterally and produced into a small suborbital spine. Eyestalks fill entire orbits. Frontal margin convex, somewhat indented by orbital regions. Anterolateral margins evenly rounded, raised into granulate ridge. Lateral margins straight for short distance, divergent posteriorly. Posterolateral margins emarginated, concave inward. Posterior margin slightly convex, nearly straight except distally at junction with posterolateral emarginations. Carapace ornamented by more or less well defined, smooth grooves. Two well-defined, longitudinal grooves originate near outer angle of orbits, extending in a sinuous path concave inward medially, nearly to posterior margin delimiting a sagittal and two lateral fields. In the concave middle part, a subtle groove extends forward and inward separating the mesogastric and protogastric regions, also giving rise to rostral sulcus. Epigastric regions marked by a densening of granulation on either side of anterior process of mesogastric region, or a part of slight longitudinal ridges on steinkerns. Cervical groove arising in a pair of gastric pits on either side of sagittal axis, curves forward into longitudinal groove; obsolete on lateral fields. Cardiac and intestinal regions continuous with one another, poorly separated by shallow grooves from lateral fields. Lateral fields evenly continuous, granulate except for anterolateral ridge

and a pit near anterior third. Transverse pair of tubercles or tuberculate ridges on cardiac region; and a single medial tubercle on intestinal region, a pair of epigastric swellings aforementioned longitudinal epigastric ridges flanked by a pair of tubercles just proximal to longitudinal grooves, defined transverse grooves on posterior lateral fields, and lacks “double-groove” (formed by the aforementioned groove becoming subparallel to the branchiocardiac) along anterior of cardiac region. Sternum subrectangular, covered with fine granules; sternite 4 subtrapezoidal, representing one third total sternum length; sternites 5 to 7 rectangular, much wider than long. Male abdomen relatively narrow; telson trapezoidal elongate, smooth; abdominal somite 6 subquadrate, smooth; somite 5 rectangular, elongate, with a few fine granules on lateral edges; somite 4 rectangular, elongate, one-third wider than somite 5, with a few, scattered fine granules. Female abdomen twice as wide as male abdomen; telson subtrapezoidal, elongate; abdominal somite 6 subrectangular, uniformly covered with even granules; somite 5 one-third wider than somite 6, granules concentrated on lateral edges; somite 4 slightly wider than somite 5; somite 3 similar to somite 4; remainder somites unknown.

Etymology. The species name is dedicated to the Mexia locality, one of the most important Paleocene outcrops for fossil Crustacea.

Material examined. Three specimens, holotype NPL31179, paratypes NPL31180 and NPL31181.

Measurements (in mm). Holotype NPL31179 carapace length = 8.2, width = 12.4; paratype NPL31180 carapace length = 8.6, width = 13.4; paratype NPL31181 carapace length = 8.5, width = 13.5.

Discussion. The new species differs from *Viapinnixa nodosa* (Collins and Rasmussen, 1992) from the Paleocene of Greenland by the absence of the pair of tubercles in the cardiac region. The cervical groove is much stronger than that of the Texan species. *Viapinnixa perrilliatae* Vega, Nyborg, Fraaije and Espinosa, 2007 (Figures 6.16-6.18) from the Paleocene of northeastern Mexico has stronger outer orbital spines, is wider near midlength of carapace and has a cuticle with much finer tubercles. *Viapinnixa alvarezii* Vega, Cosma, Coutiño, Feldmann, Nyborg, Schweitzer and Waugh, 2001 from the lower Eocene of Chiapas (Figure 6.19) has a more subtrapezoidal carapace shape, stronger outer orbital spines, and the junction between lateral and posterolateral margins is marked by a strong angle. Vega *et al.* (2008) suggested that the genus *Viapinnixa* may have originated in Greenland during the Paleocene, and then migrated southward to its latest known occurrence in the lower Eocene of Chiapas. Presence of the genus in the Paleocene of Texas appears to confirm this hypothesis.

FINAL COMMENTS

As possible reasons for the small size of a Cretaceous

crustacean fauna from Mexico, Fraaije *et al.* (2006, p. 129) included: limited food supply, size-correlated predators and/or strong fluvial input/admixture inducing brackish waters. Specimens from the Paleocene crustacean assemblage from Mexia are indeed small when compared with specimens of the same species and approximately the same age reported from other localities. Thus, the possibility of local environmental conditions affecting the size of the specimens cannot be discarded. The stratigraphic position of the Mexia locality, along with the crustaceans reported for the Cannonball Formation, represent the earliest record of Paleocene decapod crustaceans in North America. Vega *et al.* (2007) suggested a middle Paleocene age for the Rancho Nuevo crustacean assemblage of northeastern Mexico, represented by specimens of comparatively larger size. However, the high diversity observed from a single locality suggests that environmental stress may not have been the cause for the small size of the crustaceans here reported. Some genera such as *Costacopluma* remain small even in Eocene times, compared with the Cretaceous species representative of this genus. The species can be five times larger than the Cretaceous representatives.

Interesting stratigraphic occurrences, such as the first Tertiary record of *Pithonoton* is indicative of the need for more studies of Paleocene decapods crustaceans around the world, in order to understand the extinction, recovery and survival of crustaceans after the K/P event. Schweitzer and Feldmann (2005) discussed the extinction dynamics in decapod crustaceans, concluding that biogeographic distribution of genera had an important role in survival of certain genera, such as *Hoploparia* and *Costacopluma*, but that ecologic strategies were also important, as was the case with homolodromiid crabs, considered as generalists. The Chicxulub impact has severe effects, especially in northeast Mexico and southeast USA, and the Mexia assemblage may represent a sample of the recovery and replacement of the decapod crustacean communities.

ACKNOWLEDGMENTS

Our sincere gratitude to Ann Molineaux (Texas Natural Science Center), for her support and kindness. Roger Portell, Florida Museum of Natural History, generously provided images of types illustrated in this contribution. Dean Cardwell donated unique specimens for this contribution. Thanks to Dan Woehr who also donated an important specimen. Peter Ng, Department of Biological Sciences, National University of Singapore, provided images and opinions for this contribution. Peter Castro, Biological Sciences Department, California State Polytechnic University, California, Daniel Guinot, Museum national d'Histoire naturelle, Paris, Patsy A. McLaughlin, Shannon Point Marine Center, Western Washington University, USA and Dwi Listyo Rahayu, Indonesian Institute of Sciences, Indonesia, shared important references. Steve Hetrick kindly prepped several

of the specimens used in this study. Our deep gratitude to R. Feldmann, H. Karasawa and C.M. González for their detailed reviews and suggestions to improve the original manuscript.

REFERENCES

- Alcock, A., 1894, Natural history notes from the Indian Marine Survey Steamer "Investigator". Series II. No. 1. On the result of deep-sea dredging during the season of 1890-1891: *Annals and Magazine of Natural History*, Series 6(13), 400-411.
- Alcock, A., 1899, Materials for a carcinological fauna of India, 5: The Brachyura Primigenia or Dromiacea: *Journal of the Asiatic Society of Bengal*, 68, part 2(3), 123-169.
- Alcock, A., 1900, Materials for a carcinological fauna of India. Number 6, The Brachyura Catometopa or Grapsoidea: *Journal of the Asiatic Society of Bengal*, 69, part 2(3), 1-104.
- Araújo-Távora, V. de, Cruz-Miranda, M.C. de, 2004, Sistemática e tafonomia de uma fauna de crustáceos decápodes da Formação Maria Farinha (Paleoceno), Estado de Pernambuco, Brasil: *Revista Brasileira de Paleontologia*, 7(1), 45-52.
- Barnes, V.E., Hartmann, B.M., Scranton, D.F., 1992, Geologic Map of Texas, scale 1:500,000: Austin, University of Texas, Bureau of Economic Geology.
- Bell, T., 1863, A Monograph of the fossil malacostracous Crustacea of Great Britain, Pt. II, Crustacea of the Gault and Greensand: London, Palaeontographical Society Monograph, 40 p.
- Beurlen, K., 1932, Brachyurenreste aus dem Lias von Bornholm mit Beiträgen zur Phylogenie und Systematik der Brachyuren Dekapoden: *Paläontologische Zeitschrift*, 14, 52-66.
- Bishop, G.A., Whitmore, J.L., 1986, The Paleogene crabs of North America, in Harris, W.B., Zullo, U.A., Otte, L.J. (eds.), Eocene Carbonate Facies of the North Carolina Coastal Plain: Society of Economic Paleontologists and Mineralogists, Third Annual Midyear Meeting, Fieldtrip guidebook 8, 297-306.
- Bouvier, E.L., 1898, Observations on the crabs of the family Dorippidae: *Annals and Magazine of Natural History*, 7(1), 103-105.
- Brösing, A., 2008, A Reconstruction of an evolutionary scenario for the Brachyura (Decapoda) in the context of the Cretaceous-Tertiary boundary: *Crustaceana*, 81(3), 271-287.
- Castro, P., 2000, Crustacea Decapoda: A revision of the Indo-West Pacific species of palicid crabs (Brachyura: Palicidae), in Crosnier, A. (ed.), *Résultats des Campagnes MUSORSTOM 21: Mémoire du Muséum national Histoire naturelle*, 184, 437-610.
- Castro, P., 2007, A reappraisal of the family Goneplacidae Maceay, 1838 (Crustacea, Decapoda, Brachyura) and revision of the subfamily Goneplacinae, with the description of ten new genera and eighteen new species: *Zoosystema*, 29(4), 609-773.
- Castro, P., Ng, P., 2008, *Rhadinoplax*, a new genus of Progeryonidae Števíč, 2005, for *Carcinoplax microphthalmus* Guinot & Richer de Forges, 1981, and a redescription of *Paragalene longicrura* (Nardo, 1868) (Crustacea: Decapoda: Brachyura: Goneplacoidea): *Zootaxa*, 1777, 53-68.
- Collins, J.S.H., Jakobsen, S.L., 2003, New crabs (Crustacea, Decapoda) from the Eocene (Ypresian/Lutetian) Lillebælt Clay Formation of Jutland, Denmark: *Bulletin of the Mizunami Fossil Museum*, 30, 63-96.
- Collins, J.S.H., Morris, S.F., 1975, A new crab, *Costacopluma concava*, from the Upper Cretaceous of Niger: *Palaeontology*, 18, 823-829.
- Collins, J.S.H., Rasmussen, W., 1992, Upper Cretaceous-Lower Tertiary decapod crustaceans from West Greenland: *Grønlands Geologiske Undersøgelse, Bulletin*, 162, 1-46.
- Collins, J.S.H., Higgs, R., Cortitula, B., 1994, A new crab, *Costacopluma bifida* (Crustacea, Decapoda) from the Paleocene of Venezuela: *Bulletin of the Mizunami Fossil Museum*, 21, 29-34.
- Cope, K.H., Utgaard, J.E., Masters, J.M., Feldmann, R.M., 2005, The

- fauna of the Clayton Formation (Paleocene, Danian) of southern Illinois: a case of K/P survivorship and Danian recovery. *Bulletin of the Mizunami Fossil Museum*, 32, 97-108.
- Correa-Sandoval, F., 1991, Catálogo y bibliografía de los cangrejos (Brachyura) del golfo de California: Baja California, México, Comunicaciones Académicas CICESE. Serie de Acuicultura, 117 p.
- Dana, J.D., 1851, *Conspectus crustaceorum quae in orbis terrarum circumnavigatione, Carolo Wilkes e classe reipublicae foederatae ducit, lexit et descripsit.* (Preprint from): *Proceedings of the Academy of Natural Sciences*, Philadelphia, 5, 267-272.
- Dana, J.D., 1852, Crustacea. United States Exploring Expedition During the Years 1838, 1839, 1840, 1841, 1842 Under the Command of Charles Wilkes, U.S.N., 13. C: Philadelphia, Sherman, 1620 p.
- Davidson, E., 1966, A new Paleocene crab from Texas: *Journal of Paleontology*, 40(1), 211-213.
- de Haan, W., 1833-1850, Crustacea, Pp. i-xviii, i-xxxii, 2, in von Siebold, P. F. (ed.), *Fauna Japonica Sive Description Animalium*: Leiden, Lugduni-Batavorum, 141 pp.
- Étallon, A., 1861, Notes sur les Crustacés Jurassiques du bassin du Jura: *Mémoires de la Société de l'Agriculture, des Sciences et Lettres de la Haute Saône*, 9, 129-171.
- Feldmann, R.M., Holland, F.D., 1971, A new species of lobster from the Cannonball Formation (Paleocene) of North Dakota: *Journal of Paleontology*, 45(5), 838-843.
- Feldmann, R.M., Martins-Neto, R.G., 1995, *Costacopluma nordestiana* n. sp. (Decapoda: Retroplumidae) from the Maria Farinha Formation (Paleocene) of Brazil: *Journal of Paleontology*, 69(3), 610-611.
- Feldmann, R.M., Portell, R.W., 2007, First report of *Costacopluma* Collins and Morris, 1975 (Decapoda: Brachyura: Retroplumidae) from the Eocene of Alabama, U.S.A.: *Journal of Crustacean Biology*, 27(1), 90-96.
- Feldmann, R.M., Casadio, S., Chirino-Gálvez, L., Aguirre-Urreta, M., 1995, Fossil decapod crustaceans from the Jaguel and Roca formations (Maastrichtian-Danian) of the Neuquén basin, Argentina: *Journal of Paleontology*, 69(5), 1-22.
- Feldmann, R.M., Rodriguez, M.F., Martinez, G.A., Aguirre-Urreta, M., 1997, *Costacopluma salamanca* new species (Decapoda, Retroplumidae) from the Salamanca Formation (Danian) of Patagonia, Argentina: *Journal of Paleontology*, 71(1), 125-130.
- Fraaije, R.H.B., Vega, F.J., Van Bakel, B.W.M., Garibay-Romero, L.M., 2006, Late Cretaceous dwarf decapods from Guerrero, Southern Mexico and their migration patterns: *Contributions to Zoology*, 75, 121-132.
- Förster, R., Mundlos, R., 1982, Krebse aus dem Alttertiär von Helmstedt und Handorf (Niedersachsen): *Paläontographica Abhandlungen*, 179, 148-184.
- Gill, T., 1894, A new bassalian type of crabs: *American Naturalist*, 28, 1043-1045.
- Glaessner, M.F., 1969, Decapoda, in Moore, R.C. (ed.), *Treatise on Invertebrate Paleontology, Part R, Arthropoda 4, 2*: Boulder, Colorado and Lawrence, Kansas, The Geological Society of America Inc., and The University of Kansas Press, 339-533.
- Goeke, D.G., 1980, Symethinae, new subfamily, and *Symethis garthi*, new species, and the transfer of *Raninoides ecuadorensis* to *Nostoceles* (Raninidae: Brachyura: Gymnopleura): *Proceedings of the Biological Society of Washington*, 93, 971-981.
- Gorodiski, A., Rémy, J.-M., 1959, Sur les Décapodes éocènes du Sénégal occidental: *Bulletin de la Société géologique de France*, 7(1), 315-319.
- Guinot, D., 1969, Les Goneplacidae (suite): *Recherches préliminaires sur les groupements naturels chez les Crustacés Décapodes Brachyours*, VII: *Bulletin du Muséum national d'Histoire naturelle*, Paris, 2(41), 688-724.
- Guinot, D., 1977, Propositions pour une nouvelle classification des Crustacés Décapodes Brachyours: *Comptes Rendus hebdomadaires des séances de l'Académie des Sciences (Paris)*, série D(285), 1049-1052.
- Guinot, D., 1989, Le genre *Carcinoplax* H. Milne Edwards, 1852 (Crustacea: Brachyura: Goneplacidae), in Forest, J. (ed.), *Resultats des Campagnes Musorstom, Volume 5: Mémoire du Museum nationale d'Histoire naturelle*, (A)144, 265-345.
- Guinot, D., 1993, Données nouvelles sur les Raninoidea de Haan, 1841 (Crustacea Decapoda Brachyura Podotremata): *Comptes Rendus hebdomadaires des séances de l'Académie des Sciences (Paris)*, Sciences de la vie, 316, 1324-1331.
- Guinot, D., 2008, A re-evaluation of the Dymomenidae Ortmann, 1892 (Crustacea, Decapoda, Brachyura, Podotremata), with the recognition of four subfamilies: *Zootaxa*, 1850, 1-26.
- Guinot, D., Richer de Forges, B., 1980, Crabes de profondeur, nouveaux ou rares, de l'Indo-Pacifique (Crustacea, Decapoda, Brachyura) (Première partie): *Bulletin du Muséum national d'Histoire naturelle*, Paris, 2(A4), 1113-1153.
- Guinot, D., Richer de Forges, B., 1981, Crabes de profondeur, nouveaux ou rares, de l'Indo-Pacifique (Crustacea, Decapoda, Brachyura) (Deuxième partie): *Bulletin du Muséum national d'Histoire naturelle*, Paris, 4(A1), 227-260.
- Guinot, D., Tavares, M., 2001, Une nouvelle famille de crabes du Crustacés et la notion de Podotremata Guinot, 1977 (Crustacea, Decapoda, Brachyura): *Zoosystema*, 23(3), 507-546.
- Hée, A., 1924, Catalogue critique des Crustacés jurassiques du Calvados et de l'Orne: *Bulletin de la Société Linnéenne de Normandie*, 7(6), 126-157.
- Hendrickx, M.E., 1997, Los Cangrejos Braquiuros (Crustacea: Brachyura: Dromiidae hasta Leucosiidae) del Pacífico Mexicano: Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO)/Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, 178 pp.
- Karasawa, H., Kato, H., 2003, The family Goneplacidae MacLeay, 1838 (Crustacea: Decapoda: Brachyura): systematics, phylogeny, and fossil records: *Paleontological Research*, 7(2), 129-151.
- Karasawa, H., Kato, H., 2007, New prosopid crabs (Crustacea, Decapoda, Brachyura) from the Upper Jurassic Torinosu Group, Shikoku, Japan: *Memorie della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, 35(2), 62-65.
- Karasawa, H., Schweitzer, C.E., 2006, A new classification of the Xanthoidea sensu lato (Crustacea: Decapoda: Brachyura) based on phylogenetic analysis and traditional systematic and evaluation of all fossil Xanthoidea sensu lato: *Contributions to Zoology*, 75(1-2), 23-73.
- Karasawa, H., Ohara, M., Kato, H., 2008, New records for Crustacea from the Arida Formation (Lower Cretaceous, Barremian) of Japan: *Boletín de la Sociedad Geológica Mexicana*, 60(1), 101-110.
- Kellough, G.R., 1959, Biostratigraphic and paleoecologic study of Midway Foraminifera along Tehuacana Creek, Limestone County, Texas: *Transactions of the Gulf Coast Association of Geological Societies*, 9, 147-160.
- Kellough, G.R., 1965, Paleoecology of the foraminifera of the Wills Point Formation (Midway group) in northeast Texas: *Transactions of the Gulf Coast Association of Geological Societies*, 15, 73-153.
- Latreille, P.A., 1802, *Histoire naturelle, general et particulière des crustacés et des insectes*, Tome 3: Paris, F. Dufart, 468 pp.
- Latreille, P.A., 1825, *Histoire naturelle, générale et particulière, des crustacés et des insectes*, Tome 6: Paris, F. Dufart, 391 pp.
- Lörenthey, E., Beurlen, K., 1929, Die fossilen decapoden der Länder der Ungarischen Krone: *Geologica Hungarica, Series Palaeontologica, Fasciculus*, 3, 1-420.
- MacLeay, W.S., 1838, On the Brachyurous Decapod Crustacea brought from the Cape by Dr. Smith, in MacLeay, W. S., Smith, A., *Illustrations of the Annulosa of South Africa; being a portion of the objects of Natural History chiefly collected during an expedition into the interior of South Africa, under the direction of Dr. Andrew Smith, in the years 1834, 1835 and 1836; fitted out by "The Cape of Good Hope Association for Exploring Central Africa"*: London, 53-71.
- McCoy, F., 1849, On the classification of some British fossil Crustacea with notices of new forms in the University Collection at Cambridge: *Annals and Magazine of Natural History*, 2(4), 161-179.
- McGowen, J.H., Proctor, Jr., C.V., Haenggi, W.T., Reaser, D.F., Barnes, V.E., 1972, *Geologic Atlas of Texas*, Dallas Sheet: Austin, Texas,

- Bureau of Economic Geology and The University of Texas at Austin.
- McLay, C.L., 2006, Retroplumidae (Crustacea, Decapoda) from the Indo-Malayan archipelago (Indonesia, Philippine) and the Melanesian arc islands (Solomon Islands, Fiji and New Caledonia), and paleogeographical comments, *in* Richer de Forges, B., Justine, J. L. (eds.), *Tropical Deep-Sea Benthos*, 24: Mémoires du Muséum national d'Histoire naturelle, 193, 375-391.
- Milne-Edwards, A., 1862-1865, Monographie des Crustacés fossils de la famille Cancériens: Annales des Sciences Naturelles, Zoologie, 4(18) [1862], 31-85; 20 [1863], 273-324; (5)1 [1864], 31-88; 3 [1865], 297-351.
- Milne-Edwards, H., 1834-1840, Histoire naturelle des Crustacés comprenant l'anatomie, la physiologie et la classification des ces animaux: Roret's Suite à Buffon, 1 [1834], 1-468; 2 [1837], 1-532; 3 [1840], 1-638.
- Milne-Edwards, H., 1852, Observations sur les affinités zoologiques et la classification naturelle des Crustacés: Annales des Sciences Naturelles (Zoologie), 3(18), 109-166.
- Müller, P., 1984, Decapod Crustacea from the Badenian: Geologica Hungarica, Series Palaeontographica, 42, 1-317.
- Ng, P.K.L., Castro, P., 2007, On a new genus and species of euryplacid crab (Crustacea: Decapoda: Brachyura: Goneplacoidea) from the Philippines: Zootaxa, 1549, 43-53.
- Ng, P.K.L., Manuel-Santos, M.R., 2007, Establishment of the Vultocinidae, a new family for an unusual new genus and new species of Indo-West Pacific crab (Crustacea: Decapoda: Brachyura: Goneplacoidea), with comments on the taxonomy of the Goneplacidae: Zootaxa, 1558, 39-68.
- Ng, P.K.L., Richer de Forges, B., 2009, *Vultocinus anfractus* Ng & Manuel-Santos, 2007 (Decapoda, Brachyura, Vultocinidae): a new record for New Caledonia, with notes on female characters: Crustaceana, 82(5), 627-634.
- Ng, P.K.L., Guinot, D., Davie, P.J.F., 2008, Systema Brachyurum Part 1. An annotated checklist of extant brachyuran crabs of the world: The Raffles Bulletin of Zoology, 17, 1-286.
- Noetling, F., 1885, Die Fauna des Samländischen Tertiärs: Abhandlungen der Geologie Spezialkarte Preussen, 6(3-2), 112-172.
- Oldani, M.J., 1988, Regional stratigraphy of the Paleocene Midway Group, East Texas Basin: Waco, Texas, Baylor University, Master's thesis, 212 p.
- Ortmann, A.E., 1893, Die Dekapoden-Krebse des Strassburger Museums, VII Teil. Abteilung: Brachyura (Brachyura genuine Boas). II. Unterabtheilung: Cancroidea, 1. Gruppe: Cyclometopa: Zoologische Jahrbucher, Abteilung für Systematik, Geographie und Biologie der Tiere, 7, 411-495.
- Patrullius, D., 1966, Les Décapodes du Tithonique inférieur de Woïniki (Carpatés Polonaises Occidentales): Annales de la Société Géologique de Pologne, 36, 495-517.
- Rathbun, M.J., 1916, Description of a new genus and species of fossil crab from Port Townsend, Washington: American Journal of Science, 41, 344-346.
- Rathbun, M.J., 1926, The fossil stalk-eyed Crustacea of the Pacific Slope of North America: United States National Museum, Bulletin, 138, 1-155.
- Rathbun, M.J., 1928, Two new crabs from the Eocene of Texas: Proceedings of the United States National Museum, 73, 1-6.
- Rathbun, M.J., 1935, Fossil Crustacea of the Atlantic and Gulf Coastal Plain: Geological Society of America, Special Paper, 2, 1-160.
- Rathbun, M.J., 1937, The Oxystomatous and allied crabs of America: Natural History Museum, Bulletin, 166, 1-278.
- Saint-Laurent, M. de., 1980, Sur la classification et la phylogénie des Crustacés Décapodes Brachyours. II. Heterotremata et Thoracotremata Guinot, 1977: Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences, Paris, 290, D, 1317-1320.
- Saint-Laurent, M. de, 1989, La nouvelle superfamille des Retroplumidae Gill, 1894 (Decapoda, Brachyura): systématique, affinités et évolution, *in* Forest, J. (ed.), Résultats des Campagnes MUSORSTOM 5: Mémoires du Muséum national d'Histoire naturelle, A(144), 103-179.
- Sakai, T., 1963, Notes from the carcinological fauna of Japan: Researches Crustacea, 2, 12-17.
- Schweitzer, C.E., 2003, Utility of proxy characters for classification of fossils: an example from the fossil Xanthoidea (Crustacea: Decapoda: Brachyura): Journal of Paleontology, 77(6), 911-932.
- Schweitzer, C.E., Feldmann, R.M., 2001, Differentiation of the fossil Hexapodidae Miers, 1886 (Decapoda: Brachyura) from similar forms: Journal of Paleontology, 75(2), 330-345.
- Schweitzer, C.E., Feldmann, R.M., 2005, Decapod crustaceans, the K/P event, and Paleocene recovery, *in* S. Koenemann S., and Jenner R.A. (eds.), Crustacea and Arthropod Relationships: New York, Taylor and Francis, 17-53.
- Schweitzer, C.E., Feldmann, R.M., 2007, A new classification for some Jurassic Brachyura (Crustacea: Decapoda: Brachyura: Homolodromioidea): Families Goniidromitidae Beurlen, 1932 and Tanidromitidae new family: Senckenbergiana Lethaea, 87, 119-156.
- Schweitzer, C.E., Feldmann, R.M., 2009, Revision of the Proposinae *sensu* Glaessner, 1969 (Crustacea: Decapoda: Brachyura) including four new families, four new genera, and five new species: Annalen des Naturhistorischen Museums in Wien, A(110), 55-121.
- Schweitzer, C.E., Feldmann, R.M., González-Barba, G., Čosović, V., 2006, New Decapoda (Anomura, Brachyura) from the Eocene Bateque and Tepetate Formations, Baja California Sur, México: Bulletin of the Mizunami Fossil Museum, 33, 21-45.
- Schweitzer, C.E., Feldmann, R.M., Fam, J., Hessin, W.A., Hetrick, S.W., Nyborg, T.G., Ross, R.L.M., 2003, Cretaceous and Eocene decapods crustaceans from Southern Vancouver Island, British Columbia, Canada: Ottawa, Ontario, NRC Research Press, 66 p.
- Sowerby, J., 1826, Description of a new species of *Astacus*, found in a fossil state at Lyme Regis: Zoological Journal, 2, 493-494.
- Stenzel, H.B., 1944, A new Paleocene catometope crab from Texas, *Tehuacana tehuacana*: Journal of Paleontology, 18, 546-549.
- Števičić, Z., 2005, The reclassification of brachyuran crabs (Crustacea: Decapoda: Brachyura): Natura Croatica, 14(1), 1-159.
- Stimpson, W., 1859, Notes on North American Crustacea, 1: Annals of the Lyceum of Natural History of New York, 7(2), 49-93.
- Toulmin, L.D. 1977, Stratigraphic distribution of Paleocene and Eocene fossils in the Eastern Gulf Coast Region: United States of America, Geological Survey of Alabama, 602 p.
- Tucker, A.B., 1998, Systematics of the Ranimidae (Crustacea: Decapoda: Brachyura), with accounts of three new genera and two new species: Proceedings of the Biological Society of Washington, 111, 320-371.
- Vega, F.J., Feldmann, R.M., 1992, Occurrence of *Costacopluma* (Decapoda: Brachyura: Retroplumidae) in the Maastrichtian of southern Mexico and its paleobiogeographic implications: Annals of Carnegie Museum, 61(2), 133-152.
- Vega, F.J., Perrilliat, M.C., 1989, Una especie nueva del género *Costacopluma* (Crustacea: Decapoda: Retroplumidae) del Maastrichtiano del estado de Nuevo León: Universidad Nacional Autónoma de México, Revista del Instituto de Geología, 8, 84-87.
- Vega, F.J., Cosma, T., Coutiño, M.A., Feldmann, R.M., Nyborg, T.G., Schweitzer, C.E., Waugh, D.A., 2001, New Middle Eocene decapods (Crustacea) from Chiapas, México: Journal of Paleontology, 75(5), 929-946.
- Vega, F.J., Nyborg, T.G., Fraaije, R.H.B., Espinosa, B., 2007, Paleocene decapod Crustacea from the Rancho Nuevo Formation (Parras Basin – Difunta Group), Northeastern Mexico: Journal of Paleontology, 81(6), 1432-1451.
- Vega, F.J., Nyborg, T., Coutiño, M.A., Hernández-Monzón, O., 2008, Review and additions to the Eocene decapod Crustacea from Chiapas, Mexico: Bulletin of the Mizunami Fossil Museum, 34, 51-71.
- von Fischer-Benzon, R., 1866, Über das relative Alter des Faxoe-Kalkes und über die in demselben vorkommenden Anomuren und Brachyuren: Kiel, Schweis'sche Buchhandlung, 30 pp.
- von Meyer, H., 1837, Briefliche Mitteilungen: Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie, 1-314.

- von Meyer, H., 1842, Über die in dem dichten Jurakalk von Aalen in Württemberg vorkommenden Spezies des Crustaceengenus *Prosoxon*: Beiträge zur Petrefaktenkunde, 5, 70-75.
- von Meyer, H., 1857, Briefliche Mitteilungen: Jahrbuch für Mineralogie, Geologie, und Paläontologie, 1-556.
- von Siebold, P.H., 1824, De historiae naturalis in Japonia statu, nec non de augmento emolumentisque in decursu perscrutationum exspectandis dissertatio, cui accendunt Spicilegia Faunae Japonicae: Batavia, 16 p.
- Weber, F., 1795, Nomenclator entomologicus secundum Entomologiam Systematicum ill. Fabrici, adjectis speciebus recens detectis et varietatibus: Chilonii and Hamburgi, C. E. Bohn, 171 p.
- White, A., 1847, Short descriptions of some new species of Crustacea in the collection of the British Museum: Annals and Magazine of Natural History, 20(132), 205-207.
- Williams, A.B., 1984, Shrimps, lobsters and crabs of the Atlantic coast of the Eastern United States, Maine and Florida: Smithsonian Institution, 550 p.

Manuscript received: June 26, 2009

Corrected manuscript received: August 24, 2009

Manuscript accepted: September 2, 2009