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Upper Cretaceous Crustacea from Mexico and Colombia: similar faunas and environments during Turonian times

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ABSTRACT

Nine taxa represent the crustacean component of the Turonian fauna from the Eagle Ford Group limestones and marls that crop out in several quarries, northwest of Múzquiz, Coahuila, Mexico. Three crustacean taxa are found in common with deposits of similar age and paleoenvironment of the San Rafael Formation of Colombia. Planktic foraminifera, ammonoids, inoceramid bivalves, fishes, marine reptiles, a pterosaur and plant remains were preserved in the Múzquiz quarries, in what has been interpreted as an anoxic, low energy bottom at a water depth of no less than 50 m. The cirriped *Stramentum* preserved on the ammonite *Forresteria* is described. Stomatopod remains of the family Pseudosculdidae are described, their incompleteness and poor preservation prevent their detailed identification. One species of scyllarid lobster is included. An indeterminant species of nephropid lobster is also part of this assemblage. Presence of *Gourretia aquilae* (Rathbun) new combination, confirms correlation with the Eagle Ford Group in Texas. A systematic and morphologic review is provided for *Cenomanocarcinus vanstraeleni* Stenzel, a species widely distributed during Turonian times, and based on morphologic features of the abdomen and its relationship with coxae, it is assigned to the Podotremata. Also, preservation of soft tissue is reported from *C. vanstraeleni* and the scyllarid lobster. The raninid *Cretacorantina* sp. cf. *C. dichrous* (Stenzel) is also reported. In addition, two raninid taxa are described, their poor preservation prevents more detailed identification. The flattened appendages of *C. vanstraeleni* and of the raninid species suggest a burrowing habit and/or active swimming.

Key words: Crustacea, Cretaceous, Turonian, Mexico, Colombia.

RESUMEN

Nueve taxa representan el componente de crustáceos de la fauna del Turoniano en las calizas y margas del Grupo Eagle Ford que aflora en varias canteras al noroeste de Múzquiz, Coahuila, México. Tres taxa de crustáceos se encuentran en común con depósitos de similar edad y paleoambiente de la Formación San Rafael en Colombia. Foraminíferos planctónicos, amonites, bivalvos inocerámidos, peces, reptiles marinos, un pterosauro y restos de plantas fueron preservados en las canteras de Múzquiz, en lo que ha sido interpretado como un fondo anóxico de baja energía, a una profundidad no menor a 50 m. El segundo reporte para esta localidad del cirripedio *Stramentum* sobre una concha de amonite, es ilustrado. Restos de estomatópodos de la Familia Pseudosculdidae son descritos, su pobre preservación previene una identificación detallada. Una especie de langosta scilárida es incluida. Una especie

indeterminada de langosta nefrópida es también parte de esta composición. La presencia de *Gourretia aquilae* (Rathbun) nueva combinación, confirma una correlación con el Grupo Eagle Ford Group en Texas. Se ofrece una revisión sistemática y morfológica para *Cenomanocarcinus vanstraeleni* Stenzel, una especie ampliamente distribuida durante el Turoniano, y con base en características morfológicas del abdomen y su relación con las coxas, es asignada a los Podotremata. La preservación de tejidos blandos es reportada para la langosta scilárida y esta especie. El ranínido *Cretacorantina* sp. cf. *C. dichrous* Stenzel, 1945 es también reportado. Dos taxa más de ranínidos son incluidas, su pobre preservación previene una identificación más detallada. Los apéndices aplanados de ciertas especies sugieren un hábito enterrador y/o nadador activo.

Palabras clave: Crustacea, Cretácico, Turoniano, México, Colombia.

INTRODUCTION

The crustacean assemblage herein reported includes nine species. Clusters of the cirripedian *Stramentum* Logan, 1897 are found in discrete patches, attached to the ammonite shell *Forresteria* (*Forresteria*) sp. Previously, Stinnesbeck et al. (2005) illustrated *Stramentum* specimens attached to one specimen of *Peroniceras tridorsatum* (Schlüter, 1867) from the El Rosario quarry. Three incomplete specimens of pseudosculdid stomatopods, one scyllarid, and an indeterminate nephropid species are also present. Complete and articulated remains of *Gourretia aquilae* (Rathbun, 1935) confirm correlation with the Turonian Eagle Ford Group. The most abundant crustacean is a podotreme crab, *Cenomanocarcinus vanstraeleni* Stenzel, 1945. In the Múzquiz specimens, the third and fourth pairs of pereiopods have flattened articles, and the fifth pair is reduced. Chelae are preserved in most specimens; they are spiny and sharp, suggesting a possible carnivorous diet. Morphological features of the ventral part of the carapace, such as contact of abdominal segments with coxae, indicate that this genus should be considered as a podotrematous group, *sensu* Guinot and Tavares (2001). Raninid remains of *Cretacorantina* sp. cf. *C. dichrous* (Stenzel, 1945) are also found. An indeterminate raninid taxa is found in both the Mexican and Colombian deposits. Also a third raninid taxa is included. One specimen of large stomatopod and a regurgitated raninid appear to be semi-digested, and suggest that crustaceans were part of the diet of large vertebrates, possibly fishes.

Eagle Ford Group, Coahuila, Mexico

A series of small limestone quarries is exposed in the region north of Múzquiz, to the northwest of Coahuila state, Mexico (Figure 1). The quarries consist of limestones and marls of late Turonian to early Coniacian age, which preserve plant remains, planktic foraminifera, ammonoids, inoceramid bivalves, crustaceans, fishes, marine reptiles and a pterosaur (Blanco-Piñón et al., 2004, 2006; Nyborg et al., 2005; Stinnesbeck et al., 2005; Alvarado-Ortega et al., 2006). The El Rosario quarry deposits are considered

part of the Upper Cretaceous Austin Group, which is a widespread limestone unit distributed in northeastern Mexico and southern Texas (Nyborg et al., 2005; Stinnesbeck et

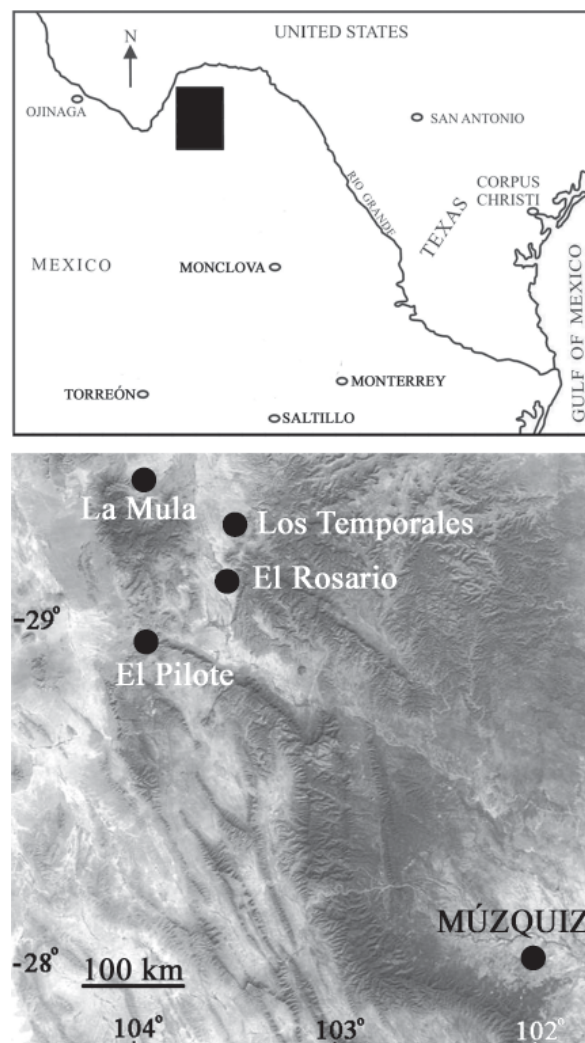


Figure 1. Location map of the El Rosario, La Mula, Rancho El Pilote and Los Temporales quarries, Múzquiz county, Coahuila, northeastern Mexico.

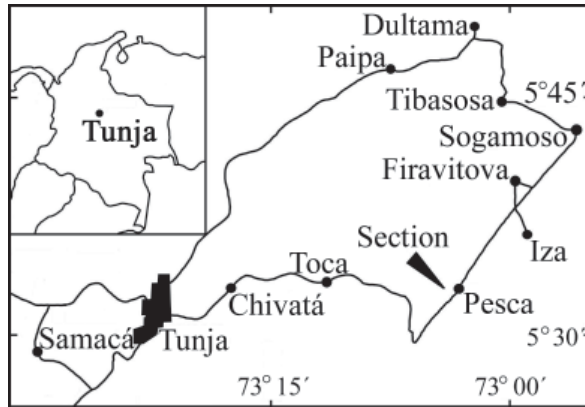


Figure 2. Location map of the stratigraphic section at Pesca, Department of Boyacá, from where Colombian crustaceans were collected.

al., 2005). The La Mula quarry is considered as part of the Eagle Ford Group (Alvarado-Ortega *et al.*, 2006). The Eagle Ford Group crops out in the Sabinas basin area and all of the northwest portion of Coahuila (López-Ramos, 1981). Biostratigraphy is based on planktic foraminifera and ammonites from El Rosario quarry, where an upper Turonian to lower Coniacian sequence has been reported (Stinnesbeck *et al.*, 2005). Based on inoceramid bivalves, Alvarado-Ortega *et al.* (2006) indicated a Turonian age for the sediments at La Mula quarry. Other quarries herein reported include Rancho El Pilote and Los Temporales, equivalent in lithology and age to the La Mula quarry, and to the lower part of El Rosario quarry. Presence of the foraminifera *Helvetoglobotruncana helvetica* (Bolli, 1945) and *Whiteinella baltica* Douglas and Rankin, 1969 [also reported from the age-equivalent Cuautla Formation in southern Mexico (Aguilera-Franco, 2003)], and of the bivalve *Mytiloides (Inoceramus) labiatus* (Schlotheim, 1813) in rocks that include crustacean remains, suggest that this assemblage is lower to middle Turonian age (Harries *et al.*, 1996) (Figure 2). An oxygen-depleted bottom of an open marine shelf, with depths of 50 to 100 m has been interpreted for the Múzquiz deposits (Stinnesbeck *et al.*, 2005). Phosphatized remains of vertebrates, including preservation of soft tissue (Stinnesbeck *et al.*, 2005; Alvarado-Ortega *et al.*, 2006), is also observed in some crustacean specimens from this report. In addition, several ammonite shells preserve one or several fishes in the living chamber, suggesting that fishes were using the empty shell as a shelter, or they were feeding on organic matter left inside the ammonite shell (Nyborg *et al.*, 2005).

San Rafael Formation, Colombia

Villamil and Arango (1998), and Feldmann *et al.* (1999) described Turonian crustaceans from mass mortality surfaces in the San Rafael Formation, exposed near

Samacá (Boyacá). Mass mortality layers from the siliceous unit in the upper part of the San Rafael Formation include specimens of *Cenomanocarcinus vanstraeleni*, previously reported as *Ophthalmoplax spinosus* Feldmann, Villamil, and Kauffman, 1999. Colombian specimens herein illustrated include *C. vanstraeleni* and one unidentified raninid. Both species are also present in the Turonian deposits of Múzquiz, Coahuila.

Crustaceans of the San Rafael Formation were collected near Pesca, Department of Boyacá in the Eastern Cordillera of Colombia, approximately 150 km northeast of Bogotá (Figure 3). The type section of the San Rafael Formation is located at Samacá (Etayo-Serna 1968), and includes 84 m of limestone beds and siliceous shales. According to Villamil (1996), the sequence is early to middle Turonian in age, but Feldmann *et al.* (1999) suggested an early Turonian age based on the presence of diagnostic ammonites, bivalves and planktic foraminifera. This sequence overlies the biogenic and siliciclastic deposits of the Churuvita Formation (Cenomanian), and underlies shale deposits of the upper Turonian? – Coniacian Conejo Formation. At Pesca, the stratigraphic section of the San Rafael Formation is 44 m thick (Figure 4), and is comprised of shale, thin limestone layers and siliceous shale. The sili-

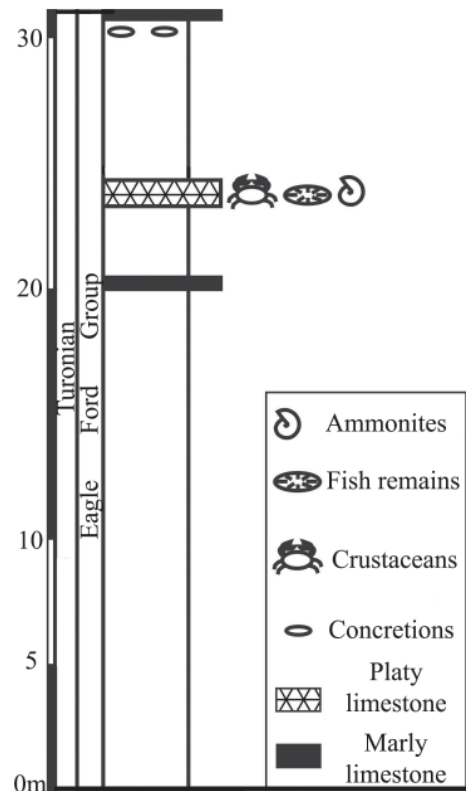


Figure 3. Stratigraphic section of the Eagle Ford Group at the Múzquiz quarries, including level with crustaceans.

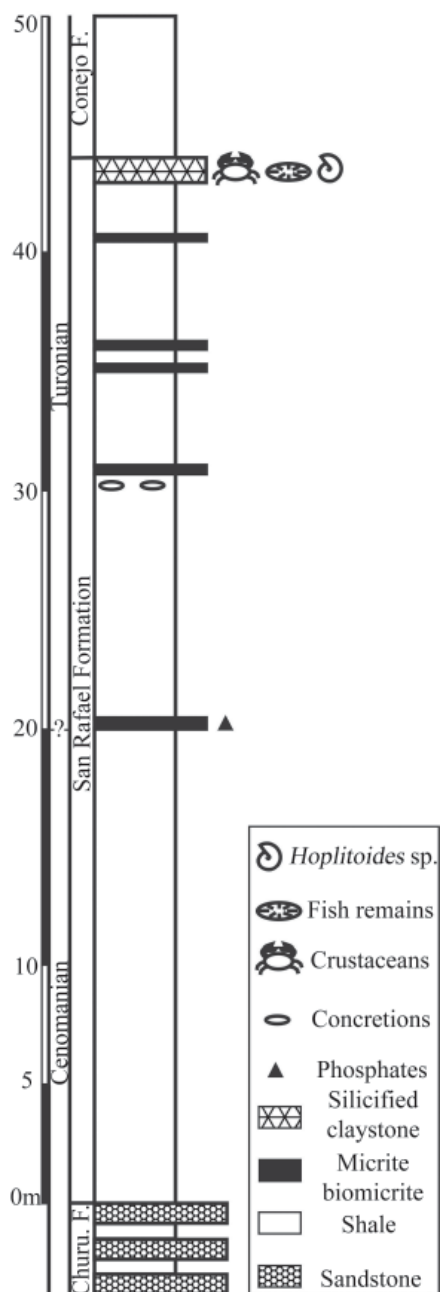


Figure 4. Stratigraphic section of the San Rafael Formation and adjacent units at Pesca, Department of Boyacá, including level with crustaceans, basal Churuvita Formation (Churu. F.), and Conejo Formation (Conejo F.) on top.

ceous shales in the upper part of the unit include *Hoplitoides* sp., crustacean and fish remains, that indicate correlation with the upper part of the type section of the San Rafael Formation (Villamil and Arango, 1998) of early Turonian age (Feldmann *et al.*, 1999).

The studied material is deposited in the collection of the Museo de Múzquiz, Múzquiz, Coahuila, Mexico,

acronym MUZ; Museo del Desierto, Prolongación Pérez Treviño, Centro Metropolitano Parque Las Maravillas, 25015 Saltillo, Coahuila, under acronym CPC; Colección Nacional de Paleontología, Instituto de Geología, UNAM, Ciudad Universitaria, Coyoacán, México DF, 04510, acronym IGM; Colecciones Paleontológicas del Departamento de Geociencias, Universidad Nacional de Colombia, A. A. 14490 Bogotá, Colombia, acronym UN-DG-CR; and in the collection of INGEOMINAS, Museo Geológico José Royo y Gómez, Dg. 53, N. 34-53, Bogotá DC, Colombia, acronym INGEOMINAS.

SYSTEMATIC PALEONTOLOGY

Subphylum Crustacea Brünnich, 1772
 Class Maxillopoda Dahl, 1956
 Subclass Thecostraca Gruvel, 1905
 Infraclass Cirripedia Burmeister, 1834
 Superorder Thoracica Darwin, 1854
 Order Lepodomorpha Pilsbry, 1916
 Family Stramentidae Withers, 1920
 Genus *Stramentum* Logan, 1897

Type species. *Pollicipes hawothi* Williston, 1897, by subsequent designation of Withers, 1920.

***Stramentum* sp.**
 Figure 5.1 – 5.3

Description. Capitulum and peduncle typical for family, comprising 10 plates and 8 columns, respectively. Scutum subtrapezoidal, upper margin narrow; upper latus semitriangular, as high as scutum; tergum subtrapezoidal, about equal to height of upper latus; carina latus triangular, slightly higher but narrower than tergum.

Peduncle joins capitulum obliquely. Peduncle widest at summit. Scutal column plates subtrapezoidal, elongated. Upper lateral column plates of similar shape and size as those of scutal column. Carinal lateral column plates slightly narrower than the scutal and upper lateral column plates.

Material examined. 25 specimens attached to one ammonite shell, hypotypes MUZ-175 to MUZ-199.

Occurrence. Eagle Ford Group, lower-middle Turonian, Coahuila, Mexico, El Pilote.

Measurements. Hypotypes MUZ-175 (largest specimen), length = 9 mm, width = 7 mm; MUZ-186 (smallest specimen), length = 3 mm, width = 2 mm.

Discussion. All *Stramentum* specimens were preserved on one individual of the ammonite *Forresteria* (*Forresteria*) sp. The specimens do not show any preferred orientation, and even small individuals are found attached to older speci-

mens. This suggests that the epibionts were living attached to the shell of *Forresteria* (*Forresteria*) sp. for a period of time, long enough to reproduce and populate the exterior portion of the phragmocone.

Stramentum specimens attached to ammonite shells have been documented by other authors, mainly for Cenomanian and lower Turonian deposits (Collins, 1986; Breton and Boine, 1993, among others). Previously, Stinnesbeck *et al.* (2005) illustrated one specimen of the ammonite *Peroniceras tridorsatum* (Schlüter) from the El Rosario quarry, with several specimens of *Stramentum* sp. attached. Distribution of these cirripedians on ammonite shells from the Múzquiz quarries suggests either that *Stramentum* lived attached while the ammonite was still alive, or that they used the shell as substrate after deposition on the sea bottom, which seems improbable due to the anoxic conditions interpreted for these beds (Stinnesbeck *et al.*, 2005).

Feldmann *et al.* (1999, fig. 2.1) reported the presence of *Stramentum* in the siliceous unit of the San Rafael Formation of Colombia, at the same stratigraphic level where other crustaceans were collected. However, they did not indicate if the cirripedians were associated with or attached to ammonite shells. Previous reports of Cretaceous cirripedians from Colombia include *Loricula colombiana* Royo y Gómez, 1941 from the Turonian of Albán-Cundinamarca, and *L. alvaradoi* Royo y Gómez, 1941 from the Albian of the black schists of the Río Negro in Pacho-Cundinamarca (Royo y Gómez, 1941). Specimens figured of those species resemble *Stramentum*, and were found attached to an indeterminate ammonite shell (Royo y Gómez, 1941, figs. 2–4). Gerhardt (1897) also reported *Archaeolepas strobila* Gerhardt (1897) from the Turonian of Pacho-Cundinamarca. Specimens of *Stramentum* sp. are also reported attached to the shell of the ammonite *Hoplitoides* sp. from the lower Turonian of the type locality of the San Rafael Formation at Villa de Leiva (Villamil and Arango, 1998, p. 138, fig. 71).

Class Malacostraca Latreille, 1802
Subclass Hoplocarida Calman, 1904
Order Stomatopoda Latreille, 1817
Family Pseudosculdidae Dames, 1886

Pseudosculdidae

Figure 5.4–5.8

Description. Medium to large-sized carapace. Thoracic and abdominal somites rectangular; pleurite of eighth thoracic somite subtriangular; abdominal somites 1–3 of similar length, with rounded pleura, sixth abdominal somite the longest; telson semitriangular; right exopod ovate, external margin with a row of setae, internal margin with fine serrations; forked process slightly longer than exopod; endopod subovate, as long and wide as exopod, margin with fine serrations. Antennula long, wider than second thoracopods.

Merus of second thoracopods subrectangular, smooth; carpus subquadrate, half the length of merus; propodus subrectangular, with a row of five circular pits (setae insertions) on lower margin of inner surface; dactylus subtriangular, curved, two thirds the length of propodus, a longitudinal ridge is found near inner surface, three or four pits at proximal portion of thinner, inner surface.

Material examined. Three specimens, hypotypes MUZ-227, MUZ-238, MUZ-245.

Occurrence. Eagle Ford Group, lower-middle Turonian, Coahuila, Mexico, Rancho El Pilote.

Measurements. Hypotypes MUZ-227, length = 122 mm, width of abdominal somite 2 = 44 mm; hypotype MUZ-238, length = 47 mm, width = 18 mm; hypotype MUZ-245, length of right propodus = 24 mm, height = 18 mm.

Discussion. The reported specimens represent the first fossil record of stomatopods for Mexico. A complete and updated list of fossil stomatopods is provided by De Angeli and Beschin (2006).

Second thoracopods preserved on the Mexican specimens reveal their stomatopod position. Exopod in hypotype MUZ-227 is composed of two segments; the shape of the forked process and the elongate, ovate endopod support its placement within the Pseudosculdidae.

Ahyong *et al.* (2007), and Ahyong and Garassino (2007) described and illustrate *Archaeosculda phoenicia* Ahyong, Garassino and Gironi, 2007, from the Cenomanian of Lebanon. This species is similar to the Mexican stomatopod in size and shape, but lack of complete telson and anterior portion prevents a detailed comparison.

Sculda sp. was reported from the Turonian of the San Rafael Formation (Feldmann *et al.*, 1999). *Sculda* has lanceolate uropods, in contrast to the semioval ones on the Mexican specimen. Schram (1968) described *Paleosquilla brevicoxa* from the Cenomanian of Colombia. According to Hof (1998a), this specimen resembles a modern Gonodactylidae. It is much smaller than the Mexican specimen and the shape of uropods is also very different. *Ursquilla yehoachi* (Remy and Avnimelech, 1955) from the Campanian of Israel and Jordan also is large (Hof, 1998b), but the telson seems to be different from the one preserved in the Mexican specimen, in having a semicircular shape.

Specimen MUZ-227 probably represents a regurgitated stomatopod (Figure 5.4), as the anterior portion of the body appears to have been crushed. In addition, the dactyli of second thoracopods are found on one side of the specimen.

Subclass Eumalacostraca Grobben, 1892
Superorder Eucarida Calman, 1904

Order Decapoda Latreille, 1802
 Suborder Pleocyemata Burkenroad, 1963
 Infraorder Astacidea Latreille, 1802
 Family Nephropidae Dana, 1852
 Subfamily Nephropinae Dana, 1852

Nephropinae

Figures 5.9; 6.1, 6.2

Description. Small nephropid; cephalothorax slightly shorter than abdomen, cervical groove deep, inclined towards anteroventral margin, posterior margin broadly rounded; five branchial chambers subovate; eyes relatively large; antennae as long as first pereopods, antennular peduncles with subcylindrical carpopocrite and merocerite, merocerite half the length and height of carpopocrite, antennular flagellum short; third maxilliped short, carpus rectangular, propodus subrectangular, narrow at junction with dactylus, dactylus suboval, half the length of propodus.

Abdomen with lateral grooves that separate tergites from pleura, pleura of abdominal somite 2 subrectangular, pleura of abdominal somites 3 and 4 subtriangular, pleura triangular on somite 6; telson subrectangular, smooth, uropods of similar shape and size, semitriangular, rounded lateral margins, with median longitudinal ridge, without diaeresis.

First pereopods two-thirds the length of the body, merus rectangular, carpus subtriangular, two-thirds the length of merus, wider at junction with propodus, lower surface covered by granules, propodus rectangular, one-third longer than merus, fixed finger acute, triangular; dactylus lanceolate, one-third longer than fixed finger; second pereopod subchelate, one third the length of first pereopod, merus subrectangular, carpus two-thirds the length of merus, propodus half the length of carpus, fixed finger slightly curved downward, movable finger triangular, two-thirds the length of propodus; third pereopod apparently subchelate, two thirds the length of second pereopod, merus semirectangular, carpus subtrapezoidal, shorter at junction with merus, one-sixth the length of merus, propodus semirectangular, three times as long as carpus, fixed finger triangular, dactylus triangular, short, curved downward; fourth and fifth pereopods not well preserved.

Material examined. Three specimens, hypotypes CPC-267, CPC-268, MUZ-233.

Occurrence. Eagle Ford Group, lower-middle Turonian, Coahuila, Mexico, Rancho El Pilote.

Measurements. Hypotypes CPC-267, cephalothorax length = 30 mm, height = 9 mm, abdomen length = 34 mm, height = 10 mm, first pereopods length = 49 mm; CPC-268, cephalothorax length = 24 mm, height = 8 mm, abdomen length = 35 mm, height = 11 mm, first pereopods length = 39 mm; MUZ-233, abdomen length = 38 mm, width = 12 mm.

Discussion. All specimens are molts, as they show disarticulation of cephalothorax and abdomen. The poor preservation of cephalothorax prevents comparison with other fossil nephropids. However, the Mexican material is similar to *Palaeonephrops* Mertin, 1941 in having abdominal segments with transverse grooves.

Infraorder Palinura Latreille, 1802
 Family Scyllaridae Latreille, 1825

Scyllaridae

Figure 6.3 – 6.6

Description. Carapace of medium size; cephalothorax semioval, twice as long as abdomen, widest at posterior third. Anterior margin straight, broad concave orbits, anterolateral spines prominent. Antennal flagella subcylindrical, one-third the cephalothorax length.

Abdomen subtrapezoidal, abdominal segments rectangular, decrease in width posteriorly, pleurae of second abdominal segment subtriangular.

First to third pereopods very similar in shape and length; fourth pereopods similar, non-chelated, ischium subquadrate, merus rectangular, three times as long as ischium, carpus subtrapezoidal, slightly longer than ischium, wider at junction with propodus, propodus semitriangular, narrower at junction with dactylus, nearly as long as carpus, dactylus unciform, half the length of propodus; fifth pereopod the shortest, two-thirds the length of fourth pereopod, articles of same shape and proportions as those of fourth pereopod.

Material examined. One specimen, hypotype CPC-269.

Occurrence. Eagle Ford Group, lower-middle Turonian, Coahuila, Mexico, Rancho El Pilote.

Measurements. Hypotype CPC-269, cephalothorax length = 30 mm, width = 15 mm, abdomen length = 11 mm, width = 9 mm.

Discussion. The specimen represents a medium-sized lobster. No clear carapace ornamentation was preserved. Pereopods do not seem to be chelate. Phosphatized muscles were preserved as patches on several articles of pereopods, but most clearly on the carpus of the right fourth pereopod (Figure 6.6).

Förster (1984) described and illustrated two fossil species of scyllariids. *Palibacus praecursor* (Dames, 1886) from the Cenomanian of Lebanon differs from the Mexican specimen in having a semitrapezoidal cephalothorax, wider than long and antennal flagella that are also wider than long. Similarities are observed between the Mexican specimen and *Parribacus cristatus* Förster, 1984, from the Eocene of Italy, especially in shape and proportion

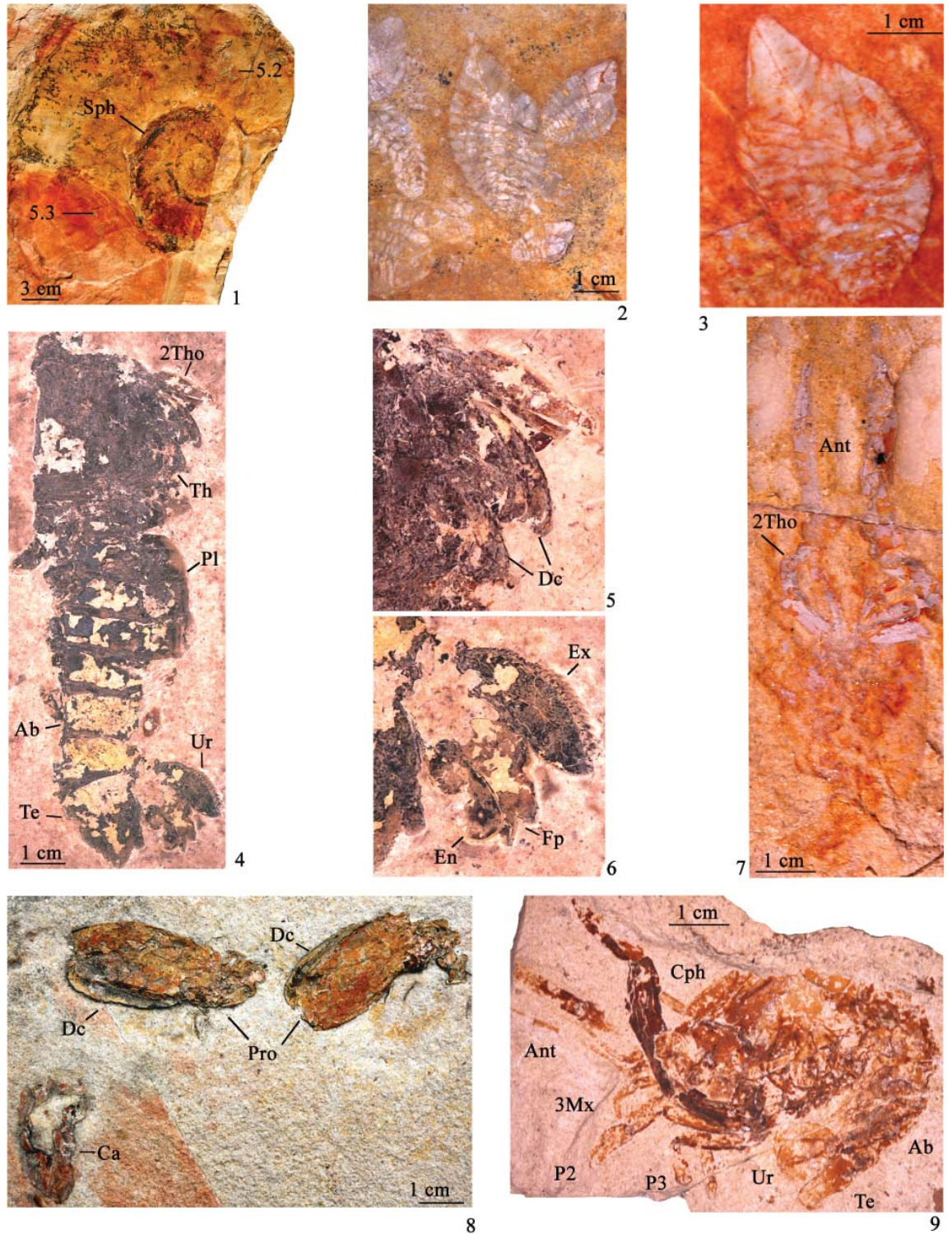


Figure 5. 1-3: *Stramentum* sp. 1: Specimen of *Forresteria* (*Forresteria*) sp. with clusters of *Stramentum*, showing siphuncle (Sph), and location of specimens in figures 5.2 and 5.3. 2: Hypotypes MUZ-175 to MUZ-180, including juvenile forms. 3: Hypotype MUZ-181. 4-8: Pseudosculdidae. 4: Hypotype MUZ-227, showing abdomen (Ab), pleura (Pl), telson (Te), thorax (Th), second thoracopods (2Tho) and uropod (Ur). 5: MUZ-227, close up of dactyli (Dc) of second thoracopods. 6: MUZ-227, close up of right uropods, showing endopod (En), exopod (Ex), and forked process (Fp). 7: Hypotype MUZ-238 in ventral position, showing antennulae (Ant) and second thoracopods (2Tho). 8: Hypotype MUZ-245, carpus (Ca), dactyli (Dc), left and right propodi (Pro) of second thoracopods. 9: Nephropinae, hypotype CPC-267, showing abdomen (Ab), antennulae (Ant), cephalothorax (Cph), third maxillipeds (3Mx), second and third pereiopods (P2, P3), telson (Te) and uropods (Ur).

of antennal flagella. The poor preservation of the Múzquiz specimen only allows placement at the family level at this time.

Infraorder Thalassinidea Latreille, 1831
 Superfamily Callianassoidea Dana, 1852
 Family Gourretiidae Sakai, 1999
 Genus *Gourretia* De Saint Laurent, 1973

Type species. *Callianassa denticulata* Lutze, 1937 (= *Callianassa subterranea* var. *minor* Gourret, 1887), by original designation.

***Gourretia aquilae* (Rathbun, 1935), new combination**

Figures 6.7 – 6.12; 7.1

Callianassa aquilae Rathbun, 1935, p. 31, pl. 7, figs. 1-5.

Description. Thalassinoid of medium to small size, cephalothorax semitriangular, smooth, narrow on anterior portion. Branchial chambers suboval.

First pereopods heterochelous; merus subrectangular, with a spine on its lower margin; carpus semicircular, as high as propodus on distal edge; propodus rectangular, elongate, three times as long as carpus, setal pits on upper margin; fixed finger elongate, triangular, with a prominent tooth on occlusal surface, located at one-third the length of the finger; movable finger slightly longer than fixed finger, triangular, occlusal surface smooth. Minor chela half as wide and long as major, elongated, rectangular, with palm tapering distally. Pereiopods 2 chelate, of similar shape and size, merus subrectangular; carpus subtriangular, half the length of merus, wider at junction with propodus; propodus as long as carpus, slightly higher, movable finger triangular; dactylus subrectangular, distal portion triangular, slightly longer than fixed finger; pereiopod 3 non-chelated, carpus semitriangular, wider at junction with propodus; propodus semitriangular, elongated, dactylus triangular, one-fourth the length of propodus; remaining pereopods slender, segments rectangular, elongated.

Abdomen one-third longer than cephalothorax, abdominal somite 2 the largest, twice as long as somite 3, with rounded posterior margin; somite 3 with rounded pleura, slightly wider than pleura of somite 2; somite 4 as long and wide as somite 3, with semisquare pleura; somite 5 slightly longer than somite 4, with subtriangular pleura; somite 6 wider than somite 5. Pleopods elongated, thin; pleopods of somite 5 the longest, about half the length of abdomen. Tail fan one-third the length of abdomen; telson subsquare; uropodal endopod ovate and slightly wider than exopod, exopod ovate.

Material examined. Eleven specimens, hypotypes MUZ-220 to MUZ-225, MUZ-235 to MUZ-237, MUZ-248 and MUZ-249.

Occurrence. Eagle Ford Group, lower-middle Turonian, Coahuila, Mexico, Rancho El Pilote.

Measurements. Hypotypes MUZ-220, length of left cheliped = 46 mm; MUZ-221, length of left cheliped = 48 mm; MUZ-222, length of left manus = 24 mm; MUZ-223, length of left cheliped = 52 mm; MUZ-248, length of left cheliped = 43 mm; MUZ-249, length of left cheliped = 41 mm.

Discussion. Problems in working with fossil thalassinoids were mentioned by Schweitzer and Feldmann (2002), and they recognized the importance to have the merus and carpus preserved, in order to propose a confident generic identification. The specimens from Múzquiz are similar to the ones reported by Rathbun (1935) from the Eagle Ford Group in Texas, especially on the shape of chelipeds, and on shape and position of the fixed finger teeth. Toolson and Kues (1996) placed the species in *Protocallianassa* Beurlen, 1930. However, the Mexican specimens clearly show that the pereopod 2 is chelate and the pereopod 3 is subchelate. These features, along with a single proximal spine on the meri of P1 and small P1 tapering distally, suggest affinities with species of the genus *Gourretia* (de Saint Laurent and Le Loëuff, 1979; López-de la Rosa et al., 1998; Ngoc-Ho, 2003; Sakai, 2004; Sakai and Türkay, 2005). Recent axiids illustrated by Ngoc-Ho (2003) also show similarities with the Mexican specimens in the position of spine near the base on the lower margin of the cheliped carpus. The shape of P2 chelae is also similar. However, difference in size of major and minor P1, slender shape of palms and minor cheliped palm tapering distally are features that support inclusion of this species into the living genus *Gourretia*. Members of the family Micheleidae Sakai, 1992 have also unequal chelipeds and P2 chelate, but propodi of P2 and P3 are wider, and dactyli are more acute; also, remainder pereopods are larger and stronger (Poore, 1994; 1997). Karasawa and Hayakawa (2000) described the micheleid *Paki rurkonsimpu* from the Campanian of Hokkaido, Japan. This species differs from the Mexican material in having two spines on ventral margin of P1 merus, and by the presence of setal pits on pleura of somites 2 – 6. *Etallonia* Opper, 1861 was erroneously synonymized by Förster (1977) with *Protaxius*. According to Garassino and Schweigert (2006), *Protaxius* lacks a spine on the subchela, typical of *Etallonia*. *Etallonia* also differs from the Mexican specimens in having a curved movable finger of chelipeds, propodus of chelipeds more elongated, and difference in size of chelipes not so evident. *Callianassa cenomaniensis* A. Milne Edwards, 1861 from the lower Cenomanian of France has a more elongated carpus and more robust movable and fixed fingers than the ones observed in the Mexican specimens.

Infraorder Brachyura Latreille, 1802
 Section Podotremata Guinot, 1977
 Family Uncertain

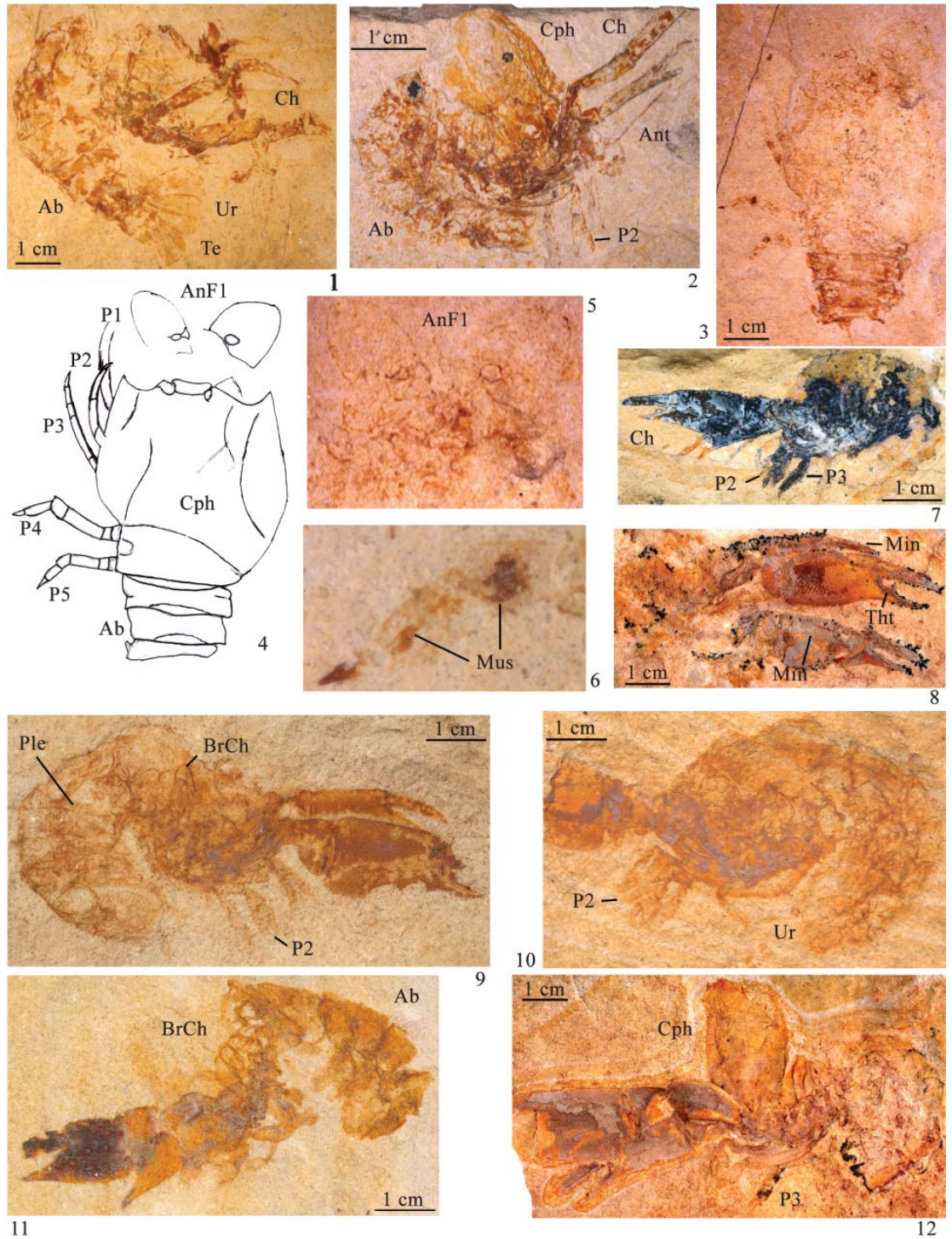


Figure 6. 1, 2: Nephropinae. 1: Hypotype MUZ-233, showing abdomen (Ab), chelae (Ch), telson (Te) and uropods (Ur). 2: Hypotype CPC-268, showing abdomen (Ab), antennula (Ant), cheliped (Ch), cephalothorax (Cph) and second pereiopod with chela (P2). 3-6: Scyllaridae. 3: Hypotype CPC-269. 4: Drawing including abdomen (Ab), antennular flagellum (AnFl), Cph (cephalothorax), first to fifth pereiopods (P1 - P5). 5: Close up of anterior part of carapace, showing antennular flagellum (AnFl). 6: Close up of fourth pereiopod with phosphatized muscle (Mus) in carpus and propodus. 7-12: *Gouretia aquilae* (Rathbun, 1935). 7: Hypotype MUZ-248, showing chela (Ch), second pereiopods (P2) with chelae and third pereiopod (P3). 8: Hypotype MUZ-222, showing two pairs of chelae, note minor chelae (Min) and major chela with tooth on occlusal surface of fixed finger (Tht). 9: Hypotype MUZ-251, showing branchial chambers (BrCh), second pereiopod (P2) with chelae and pleopods (Ple). 10: Hypotype MUZ-221, showing second pereiopods with chelae (P2) and uropods (Ur). 11: Hypotype MUZ-220, showing abdomen (Ab) and branchial chambers (BrCh). 12: Hypotype MUZ-249, showing cephalothorax (Cph) and third pereiopods (P3).

Genus *Cenomanocarcinus* Van Straelen, 1936

Type species. *Cenomanocarcinus inflatus* Van Straelen, 1936, by subsequent designation of Stenzel, 1945.

Included species. *Cenomanocarcinus inflatus* Van Straelen, 1936, Cenomanian, France; *C. vanstraeleni* Stenzel, 1945, Cenomanian – Turonian, Texas, North Dakota (USA), Germany, Colombia, Mexico; *C. beardi* Schweitzer, Feldmann, Fam, Hessin, Hetrick, Nyborg, and Ross, 2003, Turonian – Santonian, British Columbia, Canada.

Diagnosis. Carapace subhexagonal, nearly as long as wide; rostrum narrow, triangular; orbits generally small, semicircular, with two notches; anterolateral margin with four to five spines; larger lateral spine divides anterolateral and posterolateral margins; posterolateral margin with one or two, or without spines; posterior margin convex; carapace regions defined by shallow grooves and ridges with tubercles of variable size and number on branchial, and protogastric to intestinal areas; cervical and branchiocardiac grooves distinct; sternum subpentagonal, elongated, with two triangular cavities on upper portion; abdomen semirectangular elongated, composed of six segments plus telson, all except telson with three elongated tubercles; segments in contact with coxae; chelae robust, of about equal size; P2 to P4 long, P5 subdorsal and reduced.

Discussion. The genus had a wide distribution during Cenomanian – Santonian times. *Cenomanocarcinus* has been considered to be closely related to necrocarcinids. Förster (1968) included most of the necrocarcinid genera into the Calappidae De Haan, 1833. Differences between typical calappoids and necrocarcinids have been commented by Jagt *et al.* (2000) and Schweitzer *et al.* (2003). Schweitzer and Feldmann (2000) elevated the Necrocarcininae Förster, 1968 to family status, and provided a diagnosis for the family. Schweitzer *et al.* (2003) also offered a diagnosis for the Necrocarcinidae, and placed it into the Dorippoidea McLeay, 1838, based on similar features of carapace shape and morphology of chelipeds and pereopods. Schweitzer *et al.* (2003) included the following genera into the Necrocarcinidae: *Campylostoma* Bell, 1858; *Cenomanocarcinus* Van Straelen, 1936; *Hasaracancer* Jux, 1971; *Necrocarcinus* Bell, 1863; *Paranecrocarcinus* Van Straelen, 1936; *Pseudonecrocarcinus* Förster, 1968. Larghi (2004) assigned questionably the Necrocarcinidae to the Podotremata, based on characters atypical of calappids, such as reduction of fifth pereopods, and abdomen covering sternum, with abdominal segments in contact with coxae of pereopods. Števcíć (2005) also provided a diagnosis for the Necrocarcinidae, with subdorsal and reduced P5, but placed the family as a possible Heterotremata.

In order to place *Cenomanocarcinus* within the Podotremata, we refer to Guinot and Quenette (2005, p. 330) "When ventral parts exist in fossil records and have been

cleared from the matrix, the dimensional relations between the male abdomen and the thoracic sternum are fundamental, the rule being that a basal podotreme crab is characterized by its sternum completely covered by the male abdomen, which is in contact with the coxae of pereopods". This feature is preserved in specimens of *Cenomanocarcinus vanstraeleni* Stenzel, 1945 from the Turonian of Mexico.

Several features of carapace and legs preserved in *Corazzatocarcinus hadjoulae* (Roger, 1946), suggest that this crab is also a podotreme, as proposed by Larghi (2004). The characteristic "H" shape on the dorsal carapace in *Cenomanocarcinus*, formed by the longitudinal branchial tuberculate ridges and a large tubercle on the cardiac region, defined by Schweitzer *et al.* (2003) is also observed in *Corazzatocarcinus*. However, differences of the long slender P2 and P3, and reduced P4 of *Corazzatocarcinus*, versus the well developed P4 with flattened propodi and dactyli of *Cenomanocarcinus* prevent placement of *Corazzatocarcinus* into the Dynomenidae, and that genus seem to have a more close affinity to the Dromiidae De Haan, 1833, but detailed review of abdomen and of its relationship with coxae on that genus may help define its systematic position.

Cenomanocarcinus vanstraeleni Stenzel, 1945

Figures 7.2 – 7.9; 8.1 – 8.11; 9.1 – 9.5

Cenomanocarcinus vanstraeleni Stenzel, 1945, p. 447-450, text-fig. 15; Förster, 1968, Abb. 4; Finsley, 1989, p. 98, 99, pl. 78, ph. 307, 308; Bishop, Brannen, Hill, Meyer, Pike, Sampson, 1992, fig. 7c.

Necrocarcinus vanstraeleni (Stenzel, 1945) Kues, 1980, p. 862-864, text-fig. 1.

Necrocarcinus (*Cenomanocarcinus*) *vanstraeleni* (Stenzel, 1945)? Toolson and Kues, 1996, p. 114-115, fig. 1.5.

Ophthalmoplax spinosus Feldmann, Villamil and Kauffman, 1999, p. 96, figs. 3.1, 3.2, 4.1, 4.2.

Pinnotheres? sp. Feldmann, Villamil and Kauffman, 1999, p. 98, fig. 5.

Diagnosis. Carapace semicircular to subhexagonal, nearly as long as wide; regions defined with ridges bearing tubercles on branchial, and protogastric to intestinal areas; cervical and branchiocardiac grooves distinct; cuticle covered by small, nearly microscopic granules; rostrum projected, triangular, with two smaller spines at the base; orbits small, semicircular, with two notches; anterolateral margin with four spines; a fifth larger lateral spine is projected posteriorly and divides anterolateral and posterolateral margins; posterolateral margins inclined, smooth; posterior margin convex; chelae of about equal size, with longitudinal rows of tubercles and spines; P2 to P4 long, P5 subdorsal and reduced; sternum subpentagonal, elongated, with two subtriangular cavities on its upper portion; abdomen semirectangular elongated, composed of six segments plus telson, all except telson with three elongated tubercles, segment 6 the largest,

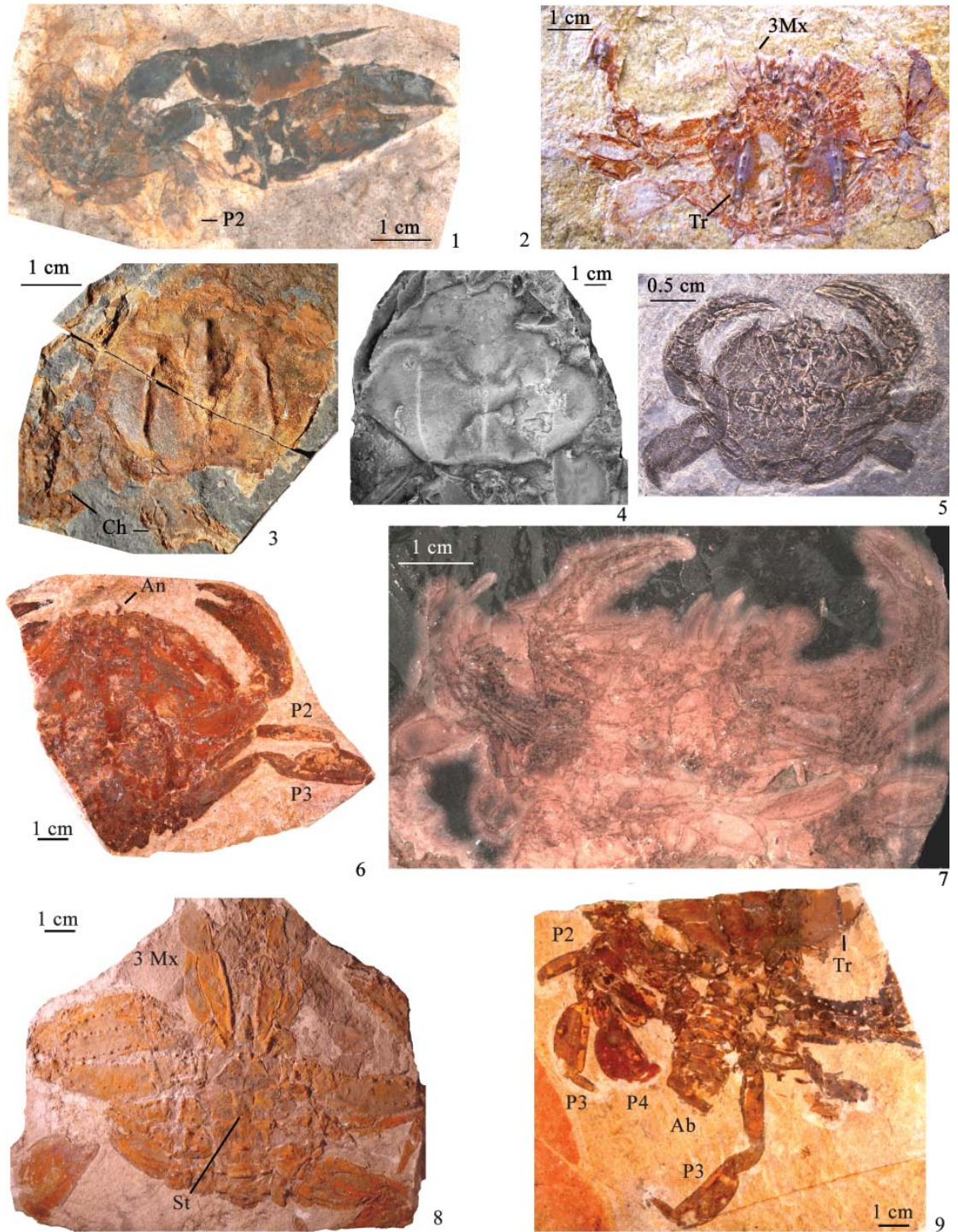


Figure 7. 1: *Gourettia aquilae* (Rathbun, 1935), hypotype MUZ-223, showing chelated second pereiopods (P2). 2-9: *Cenomanocarcinus vanstraeleni* Stenzel, 1945. 2: Hypotype MUZ-246, although it is a dorsal view, third maxillipeds are visible (3Mx), as well as tuberculated ridge (Tr). 3: Hypotype INGEOMINAS-NZ4b-03, dorsal view showing chela (Ch), San Rafael Formation, Colombia. 4: Hypotype CREUTZ M116A+B dorsal view, Ubaté, Department of Cundinamarca, Colombia, Turonian, San Rafael Formation?, black homogeneous mudstone nodule with many decapod remains, deposited at Naturalis Collection, The Netherlands, courtesy of Dr. Flip Hoedemaker, picture courtesy of Barry van Bakel. 5: Hypotype UN-DG-CR004, ventral view of a male, San Rafael Formation, Colombia. 6: Hypotype MUZ-209, ventral view, showing antenna (An), and second and third pereiopods (P2, P3). 7: Hypotype INGEOMINAS-B4V/6 (B), San Rafael Formation, Colombia. 8: Hypotype MUZ-216, ventral view, showing sternum (St) and third maxillipeds (3Mx). 9: Hypotype MUZ-204, dislocated ventral and partial dorsal views, showing abdomen (Ab), second to fourth pereiopods (P2 – P4) and tuberculated row (Tr).

semiquadrate, telson triangular, two continuous longitudinal depressions extend parallel to lateral margins of abdominal segments, being more evident from segment 5 to 1.

Description. In order to acknowledge the complete and precise descriptions of Stenzel (1945) and Feldmann *et al.* (1999, as *Ophthalmoplax spinosus*), only morphological details are included that were not preserved in the type material.

Carapace medium to large, subhexagonal; posterior part of longitudinal branchial ridges with at least five tubercles; protogastric to intestinal longitudinal ridge with smaller tubercles; anterior margin narrow, orbits subcircular, rostrum triangular, with two smaller spines at the base; antennal flagellum twice as long as rostrum; anterolateral margin with four spines, decreasing in size toward orbital spine; prominent, elongate and acute lateral spine divides antero and posterolateral margins; posterolateral margin inclined, with two small spines on anterior third; posterior margin smooth, convex. Third maxillipeds long, pedunculate, about half of carapace length, coxa subtrapezoidal, with a median longitudinal tuberculate ridge; endognath basis subtriangular inverted, smooth, wider at junction with ischium, ischium subrectangular elongate, twice as long as basis, wider at midlength, with a longitudinal ridge on internal margin, merus ovate, half the length of ischium, with a distal notch; exognath ischium smooth, subrectangular, concave, as long as endognath but half its width, merus ovate.

On ventral side, subparallel to anterolateral margin, a sinuous tuberculate ridge extends from mid-carapace length to anterior margin, another smaller, smooth ridge lies parallel to the first one. Sternum subpentagonal, elongated, with two triangular cavities on its upper portion. Female abdomen elongate, subrectangular, slightly wider toward telson, composed by six segments, all rectangular, except for abdominal segment 6, which is nearly square; three aligned transverse ridges on each abdominal segment, except for the sixth segment, in which the middle ridge is positioned more anteriorly. Sides of abdominal segments in contact with coxae of pereopods. Male? abdomen narrower, subrectangular, widest at telson, segments 5 and 6 semicircular, segments 4 and 3 rectangular. Possible sexual dimorphism, female larger.

Chelipeds of similar size and shape. Carpus of cheliped subquadrate, spinose; carpus of P2 subrectangular, smooth, about one-fourth the length of merus; propodus subrectangular, elongate, smooth, nearly as long as merus, dactylus styliform, smooth, two-thirds as long as propodus; merus of P3 subrectangular, elongate, one-third longer and higher than merus of P2, with four tubercles at the base, carpus semitriangular, smooth, one-third the length of merus, much narrower at junction with merus, propodus subovate, smooth, two-thirds the length of merus, narrows to half its width at junction with carpus, a longitudinal pair of muscles extend on the lower third from junction of carpus to junction of

dactylus, dactylus styliform, smooth, two-thirds as long as propodus; merus of P4 rectangular, smooth, two-thirds the length of P3 merus, carpus subtriangular, wider at junction with propodus, propodus subovate, smooth, about the length but twice the height of merus, wider at junction with dactylus; dactylus ovate, smooth, half the length of propodus; P5 reduced and subdorsal, ischium subtriangular, smooth, wider at junction with merus, merus subrectangular, wider at junction with ischium, one-third the length and one-fourth as high as merus of P4, carpus rectangular, smooth, two-thirds the length of merus, propodus subtriangular, smooth, wider at junction with dactylus, dactylus styliform, smooth, nearly as long as propodus.

Material examined. 24 specimens, hypotypes MUZ-200 to MUZ-204, MUZ-206 to MUZ-211, MUZ-212, MUZ-214 to MUZ-216, MUZ-218, MUZ-219, MUZ-226, MUZ-246; IGM-7655; UN-DG-CR001A, UN-DG-CR004; INGEOMINAS-B4V/6; INGEOMINAS-NZ4b-03.

Occurrence. Eagle Ford Group, lower-middle Turonian, Coahuila, Mexico, Rancho El Pilote, MUZ-200 to MUZ-204, MUZ-206, MUZ-207, MUZ-209, MUZ-211, MUZ-212, MUZ-214 to MUZ-216, MUZ-218, MUZ-219; LosTemporales, MUZ-246; El Rosario IGM-7655; San Rafael Formation, lower Turonian, Colombia, Pesca, Department of Boyacá, UN-DG-CR001A, UN-DG-CR004; Ubaté, Department of Cundinamarca, INGEOMINAS-B4V/6, INGEOMINAS-NZ4b-03.

Measurements. Hypotypes MUZ-209, carapace length = 76 mm, width = 58 mm; MUZ-208, carapace length = 43 mm, width = 45 mm; MUZ-210, carapace length = 44 mm, width = 46 mm; MUZ-204, P3 length = 66 mm; MUZ-216B, right cheliped length = 31 mm; MUZ-226, male?, carapace length = 22 mm, width = 26 mm; MUZ-215, male?, carapace length = 28 mm; MUZ-212, male?, carapace length = 36 mm; MUZ-246, female, carapace length = 32 mm, width = 34 mm; UN-DG-CR001A, carapace length = 15 mm, width = 9 mm; IGM-7655, carapace length = 75 mm, width = 98 mm; UN-DG-CR004, carapace length = 13 mm, width = 17 mm; INGEOMINAS-B4V/6, carapace length = 38 mm, width = 42 mm; INGEOMINAS-NZ4b-03, carapace length = 3.2 cm, width = 4.4 cm.

Discussion. Guinot and Breton (2006) stated that *Cenomanocarcinus vanstraeleni* and *C. siouxensis* were typically podotreme, and that the two species, as well as other necrocarcinids, might be referred to a new genus to be included in the Podotremata. Taxonomic affinities of *Cenomanocarcinus* have been commented by several authors (Schweitzer and Feldmann, 2000; Guinot and Tavares, 2001; Fraaije, 2002; Schweitzer *et al.*, 2003; Larghi, 2004). A list of *Cenomanocarcinus* spp. is given by Schweitzer *et al.* (2003). The peculiar ornament on the dorsal carapace consisting of tuberculate transverse and longitudinal ridges

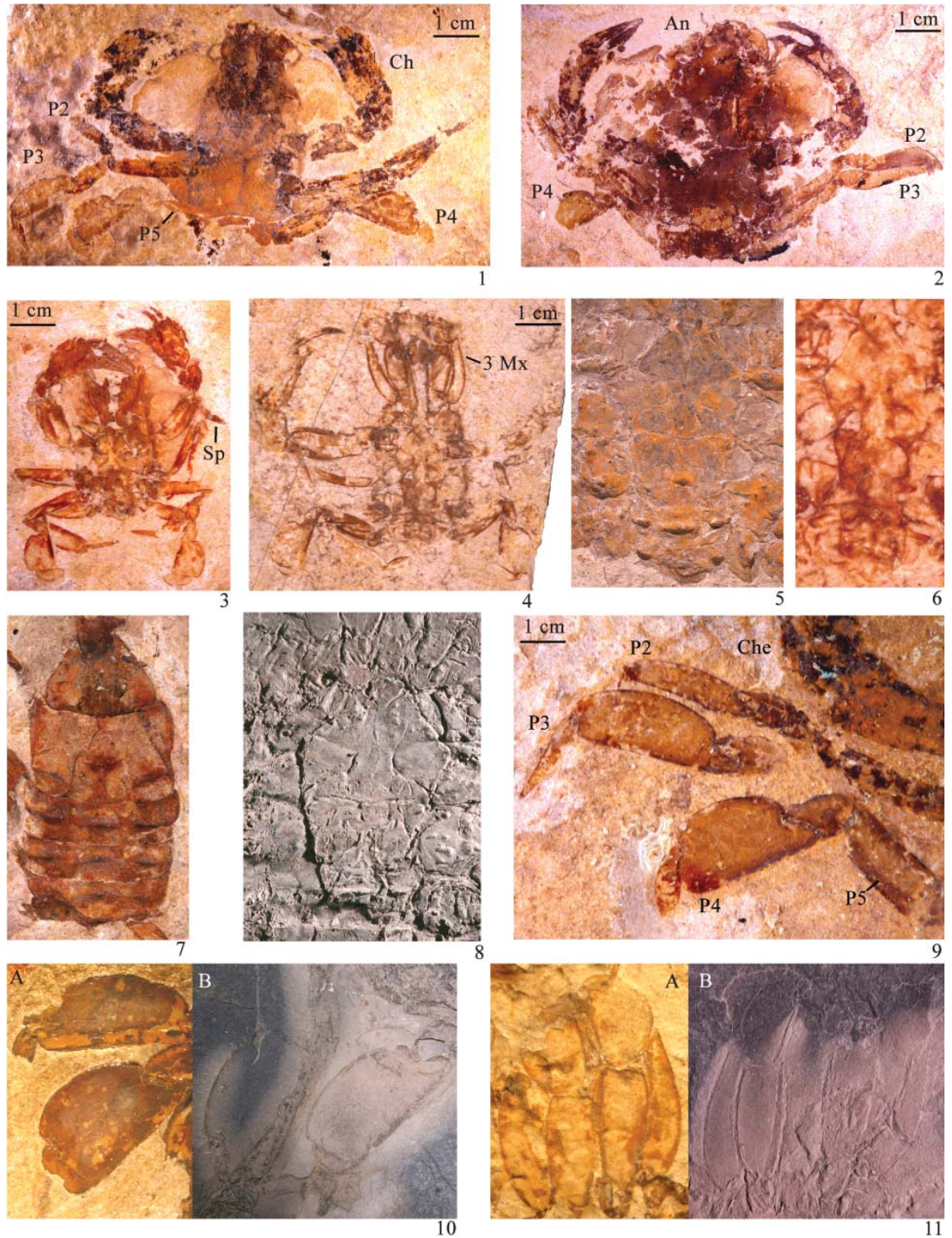


Figure 8. 1: Holotype MUZ-208, ventral view, showing chelae (Ch) and second to fifth (reduced) pereiopods (P2 - P5). 2: Hypotype MUZ-210, dorsal view of carapace, showing second to fourth pereiopods (P2 - P4) and left antenna (An). 3: Hypotype MUZ-226, ventral view of a male? specimen, with lateral spine (Sp) visible. 4: Hypotype MUZ-215, ventral view of a male?, showing third maxillipeds (3Mx). 5: Hypotype MUZ-216, close up of female sternum. 6: Hypotype MUZ-226, close up of male? sternum. 7: Hypotype MUZ-201, close up of female abdomen. 8: Female sternum of hypotype INGEOMINAS-B4V/6 (B). 9: Hypotype MUZ-211, close up of right cheliped (Che), and second to reduced fifth pereiopods (P2 - P5). 10: Comparison of third and fourth pereiopods of hypotypes MUZ-204 (A) from the Eagle Ford Formation, Coahuila, and INGEOMINAS-B4V/6 (B) from San Rafael Formation, Colombia. 11: Comparison of third maxillipeds of hypotypes MUZ-211 (A) from the Eagle Ford Formation, Coahuila, and INGEOMINAS-B4V/6 (B) from San Rafael Formation, Colombia.

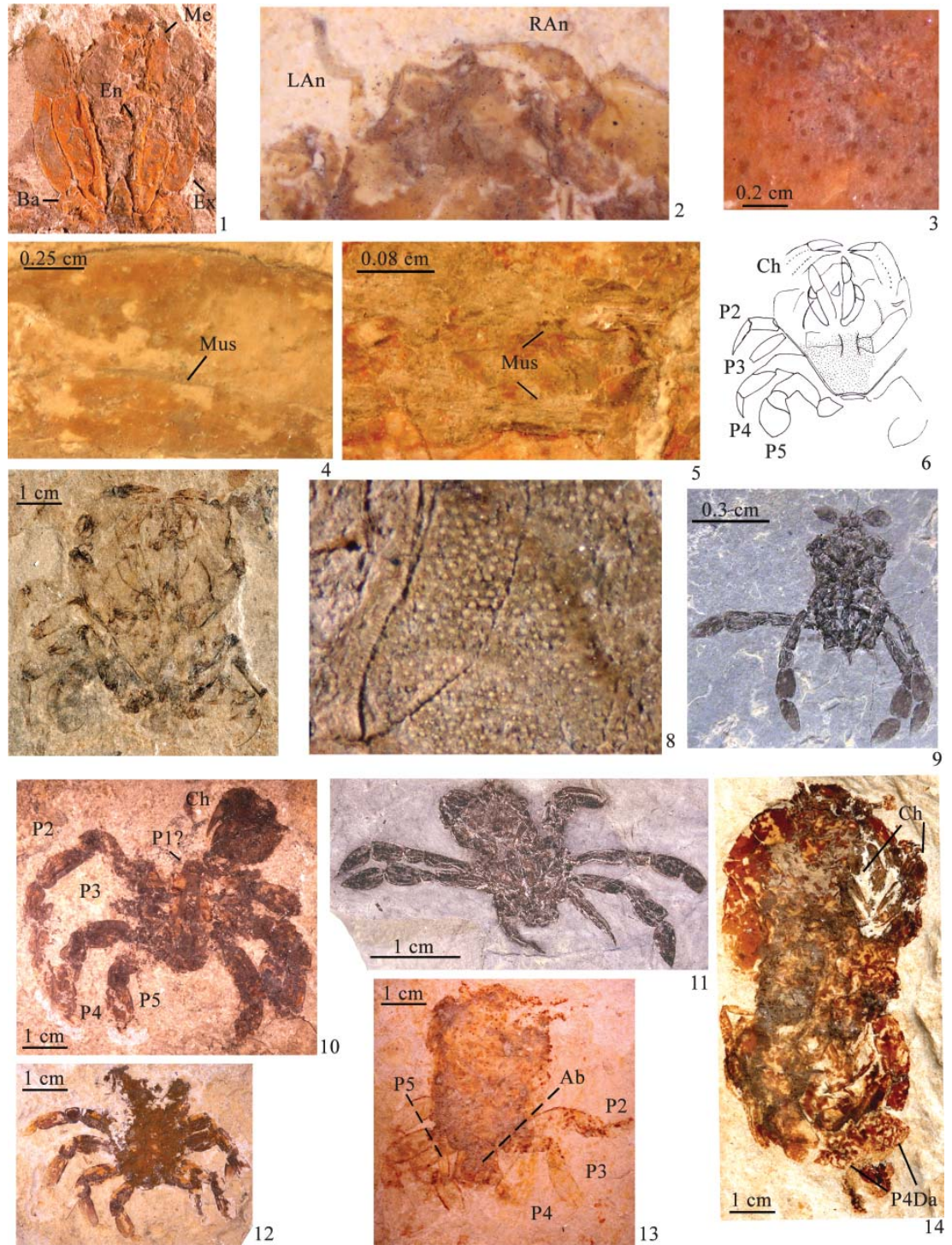


Figure 9. 1-5: *Cenomanocarcinus vanstraeleni* Stenzel, 19451. 1: Hypotype MUZ-216, close up of third maxillipeds, showing basis (Ba), endognath (En), exognath (Ex), and merus (Me). 2: Hypotype MUZ-210, close up of rostrum, showing left (LAn) and right (RAn) antennae. 3: Hypotype MUZ-210, detail of small tubercles on dorsal carapace cuticle. 4, 5: Hypotype MUZ-209, detail of left P3 propodus, showing phosphatized muscles (Mus). 6-8: *Cretacoranina* sp. cf. *C. dichrous* (Stenzel, 1945). 6: Drawing of hypotype MUZ-247, showing chelipeds (Ch) and pereopods two to five (P2 – P5). 7: Hypotype MUZ-247. 8: Hypotype MUZ-247, detail of dorsal cuticle with impression of right ischium of third maxillipeds. 9-12: Raninidae 1. 9: Hypotype INGEOMINAS-NZ1-02, San Rafael Formation, Pesca, Colombia. 10: Hypotype MUZ-232, ventral view showing chelipeds (Ch), right second to fifth pereopods (P2 – P5), and plastron (Pl?). 11: Hypotype UN-DG-CR003, San Rafael Formation, Colombia, ventral view. 12: Hypotype MUZ-231, ventral view. 13, 14: Raninidae 2. 13: Hypotype MUZ-228, showing abdomen (Ab) and second to fifth (reduced) pereopods (P2 – P5). 14: Hypotype CPC-270, remains into a possible coprolite or regurgitation, showing chelipeds (Ch) and ovate dactyli of fourth pereopods (P4Da).

has led some authors to synonymize *Cenomanocarcinus* with *Necrocarcinus* Bell, 1863 (Wright and Collins, 1972; Kues, 1980; Feldmann *et al.*, 1993). Förster (1968) suggested that there are small differences that can separate the genera *Cenomanocarcinus*, *Necrocarcinus* and *Orithopsis* Carter, 1872. Fraaije (2002) offered a review of the systematic placement of *Cenomanocarcinus*, which he recognized as a valid genus, and according to Stenzel (1945) includes the following species: *C. inflatus*, *C. vanstraeleni* and *C. oklahomensis* (Rathbun, 1935). This last species was assigned to *Necrocarcinus* by Kues (1980) and by Schweitzer *et al.* (2003), who also described *C. beardi* Schweitzer, Feldmann, Fam, Hessin, Hetrick, Nyborg and Ross, 2003 from the Turonian – Santonian of British Columbia. Differences between *C. vanstraeleni* and the other two species are based on number of tubercles present on the branchial and cardio-intestinal ridges (see Stenzel, 1945, p. 449). *Cenomanocarcinus inflatus* from the upper Cenomanian of France also has a more ovoid carapace outline, and according to Stenzel (1945, p. 150) “*Cenomanocarcinus vanstraeleni* Stenzel is the most spinous and most tuberculate of the three species”. *Cenomanocarcinus siouxensis* (Feldmann, Awutoua and Welshenbaugh, 1976) was also assigned to *Necrocarcinus* by Schweitzer *et al.* (2003). This species differs from *Cenomanocarcinus vanstraeleni* in being smaller, with a different disposition of dorsal carapace ridges, much larger orbits, third maxillipeds proportionally smaller, and a fused abdomen of different shape lacking typical transverse ridges of *Cenomanocarcinus* spp. *Cenomanocarcinus beardi* from the Turonian-Santonian of Vancouver Island has a more ovate carapace shape, it has fewer and stronger tubercles on the longitudinal and transverse branchial ridges, although the lateral spine is also very large.

Larghi (2004) suggested that the specimen of *Cenomanocarcinus* cf. *C. vanstraeleni* reported from the upper Cenomanian of Israel by Remy and Avnimelech (1955), should be assigned to *Corazzatocarcinus* Larghi, 2004. This new genus is similar to *Cenomanocarcinus* in the presence of strong and continuous tuberculate ridges, tubercles of uniform size, smooth carapace areas between ridges, as well as the number of abdominal segments and their ornament of transverse ridges and tubercles (Larghi, 2004). However, there are substantial differences in the pereopods of these two genera. Although fifth pereopods of *C. vanstraeleni* are reduced as in *Corazzatocarcinus hadjoulae* (Roger, 1946), fourth pereopods are the most conspicuous, followed by third pereopods, with flattened propodus in both appendages, a semiovoid dactylus on fourth, and styliform on third pereopods. *Corazzatocarcinus hadjoulae* has reduced fourth and fifth pereopods, and second and third seem to be longer and thinner than in *C. vanstraeleni*.

Feldmann *et al.* (1999) described the carcineretid *Ophthalmoplax spinosus* Feldmann, Villamil and Kauffman, 1999, and *Pinnotheres?* sp. from siliceous shales of the lower Turonian of Colombia, based on a collection of 23 specimens, and interpreted a mass mortality event

caused by anoxia. Neumann and Jagt (2003) illustrated a ?carcineretid specimen from the lower Turonian black shales of Misburg, Germany. In the Colombian and German specimens, the morphology of chelipeds and fourth pereopods is very similar to that of *C. vanstraeleni* specimens from Mexico. For this reason, we consider it important to compare the morphology of some specimens of *O. spinosus* directly with that of *C. vanstraeleni*. Figures 8.10 and 8.11 compare morphology of propodi and dactyli of fourth pereopods, as well as third maxillipeds in specimens from Mexico and Colombia. Based on morphological similarities, stratigraphic position, and occurrences of these crustaceans associated with anoxia events, we propose that *O. spinosus* is the synonym of *C. vanstraeleni*, and that this species had a wide distribution during early Turonian times, as previously suggested by Kues (1980). Some carcineretid crabs have flattened propodi and dactyli on fifth pereopods, and *Ophthalmolax* can have acute spines on fingers of chelipeds. However, these features seem to be a clear example of convergence between unrelated species, and they may reflect a carnivorous and/or scavenging habit.

Kues (1980, p. 864) mentioned that *C. vanstraeleni*... “lived subtidally, probably several kilometers from the shoreline.” Stinnesbeck *et al.* (2005) suggested that deposition of Múzquiz quarries sediments was in an open marine shelf, several hundreds of kilometers south of the North American coastline. Paleoenvironmental interpretation for the deposits of the San Rafael Formation where *C. vanstraeleni* occurs, is of poorly oxygenated, relatively deep water, 40 to 60 km of the eastern shoreline of the Colombian epicontinental sea (Feldmann *et al.*, 1999). Specimens from New Mexico and Colombia were interpreted to have suffered little or no transport at all, and Feldmann *et al.* (1999) suggested high population numbers for a pelagic to vagrant benthonic crustacean, linked to nutrient-rich waters, and that subsequent anoxia were responsible for mass-mortality events of these crustaceans and other organisms. Most specimens from the Múzquiz quarries are found articulated, and their size ranges suggests a well-represented population. Additionally, only two specimens were preserved in dorsal position, in relation to the stratigraphic plane. A few specimens are disarticulated, suggesting a minimum amount of transport. Although differentiation between molts and corpses is difficult in the kind of preservation of the crustacean remains from Múzquiz, we consider that most of them represent corpses, as soft tissues (muscles) are observed in the propodi of P3 of several specimens (Figure 9.4, 9.5). This same feature is observed in propodi of P3 of the specimen in figure 3.2 of Feldmann *et al.* (1999). According to Stenzel (1945), *C. vanstraeleni* is also well represented by copious material from Turonian deposits of Texas.

Cenomanocarcinus vanstraeleni appears to have been an abundant, widely distributed, predating/scavenging crab (Stenzel, 1945) on Turonian sea bottoms of no less than

50 m depth. Its abundance and completeness of carapace morphology allow to reconstruct phylogenetic relationships, as already stated by Stenzel (1945).

Subsection Archaeobrachyura Guinot, 1977
 Superfamily Raninoidea De Haan, 1839
 Family Raninidae De Haan, 1839
 Subfamily Palaeocorystinae Lörenthey *in*
 Lörenthey and Beurlen, 1929

Genus *Cretacorantina* Martin, 1941

Type species. *Raninella schloenbachi* Schlüter, 1879 by original designation.

***Cretacorantina* sp. cf. *C. dichrous* (Stenzel, 1945)**

Figure 9.6 – 9.8

Description. Raninid of medium size, carapace rectangular, elongated; carapace covered by evenly distributed, fine small granules; anterolateral margins with two sharp spines; anterior margin straight, represents the widest part of carapace; lateral margins nearly straight, slightly rounded; posterior margin convex, two-thirds of maximum carapace width. Carapace covered by evenly spaced tubercles; cervical and branchiocardiac grooves deep.

Abdomen subtrapezoidal, segments rectangular, with sinuous sutures, segment 3 the widest. Third maxillipeds long, pedunculate, about half the length of carapace; endognath ischium subrectangular elongate, wider at junction with merus; merus ovate, elongated, two-thirds the length of ischium, with a distal notch; exognath concave, elongated, slightly longer than endognath ischium, merus semicircular, one-fourth the length of ischium.

Chelipeds of similar size and shape; ischium rectangular, slightly wider at both ends; merus rectangular, as long but slightly wider than ischium; carpus short, subtrapezoidal, two-thirds the length of merus; propodus rectangular, three times as long as carpus; fingers semitriangular, slightly concave, half the length of propodus. P2 long, merus rectangular, elongated; carpus subtrapezoidal elongated, half the length of merus, wider and sinuous at junction with propodus; propodus subrectangular, two-thirds the length of merus; dactylus unciform, as long as propodus. Only merus of P3 preserved, being rectangular. P4 long, merus rectangular elongated; carpus subtrapezoidal, wider at junction with propodus, which is subrectangular; dactylus unciform, as long as propodus. P5 relatively short, ischium suboval, concave and wider at junction with merus; merus subrectangular, elongated, about three times as long as ischium; carpus subtrapezoidal, two-thirds the length of merus, concave and wider at junction with propodus, which is semiquadrate, with rounded margins, half the length of carpus; dactylus broad, oval to semicircular, flattened, tip narrow.

Material examined. Two specimens, hypotype MUZ-234, and MUZ-247.

Occurrence. Eagle Ford Group, lower-middle Turonian, Coahuila, Mexico, Rancho El Pilote, MUZ-234, and MUZ-247.

Measurements. Hypotype MUZ-234, carapace length = 37 mm, width = 19 mm; MUZ-247, carapace length = 42 mm, width = 31 mm.

Discussion. Although the Múzquiz specimens show certain similarities with *Cretacorantina dichrous*, the preservation of carapace is not adequate enough to confirm specific placement. Chelipeds and pereopods 2 to 5 are preserved, but these features are not described with detail for the conferred species. The cuticular structure of *C. dichrous* has been described as ornamented with densely crowded granules which have flat, polished tops and which are separated by cracks or occasional pits (Stenzel, 1945; Haj and Feldmann, 2002). The cuticle ornamentation preserved in specimen MUZ-247, consists of fine granules, similar to the ones observed in the cuticle of *Cretacorantina dichrous* illustrated by Haj and Feldmann (2002, fig. 10.4).

Cretacorantina dichrous is part of the crustacean assemblage reported from the Cenomanian Britton Shale of the Eagle Ford Group (Bishop *et al.*, 1992), found along with *Cenomanocarcinus vanstraeleni*, which is also common in the Múzquiz deposits. Some similarities may be observed with the genera *Eucorystes* Bell, 1863 and *Cristafrons* Feldmann, Tshudy and Thomson, 1993, and specimens with better preservation will help define if this relatively abundant raninid belongs to *Cretacorantina dichrous*.

Raninidae 1

Figure 9.9 – 9.12

Description. Raninid of medium size, carapace elongate, suboval; plastron subrectangular elongate, with convex corners, sternites rectangular.

Left cheliped massive, carpus subtrapezoidal, elongated; manus as long as carpus, with two longitudinal rows of tubercles on external surface, fixed finger subrectangular, teeth on occlusal surface and upward directed spine on distal portion, movable finger smaller, triangular, with smooth occlusal surface. P2, P3, and P4 of similar size and shape, segments of uniform width; P5 about one-third proportionally smaller, but segments of similar shape as the ones of the other pereopods, median longitudinal carina on all segments: merus rectangular, the longest of all segments; carpus subtriangular, narrow on junction with merus, half the length of merus; propodus rectangular, twice the length of carpus; dactylus lanceolate, two-thirds the length of propodus, narrow on junction with propodus.

Material examined. Seven specimens, hypotypes

MUZ-229 to MUZ-232; UN-DG-CR003, CPC-271, INGEOMINAS-NZ1-02.

Occurrence. Eagle Ford Group, lower-middle Turonian, Coahuila, Mexico; Rancho El Pilote, MUZ-229; La Mula, MUZ-230, MUZ-231; Los Temporales, MUZ-232, CPC-271; San Rafael Formation, lower Turonian, Colombia, Pesca, Department of Boyacá, UN-DG-CR003, INGEOMINAS-NZ1-02.

Measurements. Hypotypes MUZ-232, carapace length = 34 mm; MUZ-231, carapace length = 32 mm; UN-DG-CR003, carapace length = 28 mm; INGEOMINAS-NZ1-02, carapace length = 5 mm.

Discussion. All specimens are preserved in ventral position. Morphology of pereopods is very similar between the Mexican and the Colombian specimens. No detailed identification is possible at this time, without a specimen preserving the dorsal carapace. Specimens from Mexico and Colombia show similar shape of sternum and pereopods. All pereopods have: a median carina; an elongate, rectangular merus; short carpi; a subquadrate, rectangular propodus; and lanceolate dactylus.

Beikirch and Feldmann (1980) illustrate and described *Notopoides(?) pflugervillensis* Beikirch and Feldmann, 1980, from the Campanian Austin Group of Texas. The morphology of the carapace and pereopods of this species resemble the specimens here described, but the specimens from Texas are much smaller and the abdomen is long and slender.

Raninidae 2

Figure 9.13, 9.14

Description. Raninid of medium size, carapace elongate, suboval; plastron subrectangular elongate, with convex corners; carapace marked by deep grooves and covered by evenly spaced, strong tubercles.

Abdominal segments rectangular, slightly wider than concave posterior margin.

Chelipeds of similar size and shape; propodus triangular, dactyli sharp, triangular elongated. P2 long, merus rectangular, with setal pits on lower margin; carpus sub-rhombic, half the length of merus, setal pits on lower margin; propodus semirectangular, elongate, slightly narrow at junction with carpus, twice the length of carpus; dactylus semicircular, distal edge with setae, one-third the length of propodus. P3 long, merus rectangular, with setal pits on lower margin; carpus triangular, wider at junction with propodus, one-third the length of merus; propodus semioval, narrows at both ends, twice the length of carpus, with setal pits on lower margin; dactylus unciform, concave, two-thirds the length of propodus. In P4, the longest pereopod; ischium triangular, short; merus rectangular, five times as long as ischium, narrow on junction with

carpus, setal pits on lower margin; carpus triangular, wider at junction with propodus, one-third the length of merus; propodus subtrapezoidal, elongate, much wider at junction with dactylus, twice the length of carpus; dactylus ovate to lanceolate, smooth, half the length of propodus. P5 reduced, subdorsal, propodus small, rectangular, carpus rectangular, inner margin with setae, dactylus unciform.

Material examined. Two specimens, hypotypes MUZ-228 and CPC-270.

Occurrence. Eagle Ford Group, lower-middle Turonian, Coahuila, Mexico, Los Temporales, MUZ-228, CPC-270.

Measurements. Hypotypes MUZ-228, carapace length = 44 mm, width = 28 mm; CPC-270, length = 58 mm, width = 32 mm.

Discussion. This raninid is clearly different from the other raninids described herein by possessing a stronger carapace sculpture of tubercles and deeply impressed grooves. The P3 and P4 appear to have broad, subtrapezoidal, flattened propodi, as well as oval dactyli. The P5 are reduced and appear to be subdorsal. The poor preservation prevents a more detailed identification.

Specimen CPC-270 (Figure 9.14) probably represents a coprolite or the regurgitated carapace of this type of raninid, as dactyli of chelipeds, portions of granulated dorsal carapace, and oval dactyli of P4 are still recognizable. Study of stomach contents on some of the fossil fishes from the Múzquiz quarries may reveal if this crab was part of their diet.

CONCLUSIONS

The crustaceans from the Múzquiz quarries represent one of the most diverse assemblages reported from the Cretaceous of Mexico. Most specimens are preserved in ventral position, but with appendages articulated. This may indicate little or no transport of corpses. Anoxic conditions suggested previously for the Múzquiz deposits (Stinnesbeck *et al.*, 2005) may have caused mass mortality events, as reported for deposits of similar age in Colombia (Feldmann *et al.*, 1999). It is also important to note the flattened shape of appendages seen in *Cenomanocarcinus vastraeleni*, and in the two species of raninids here reported. This would indicate that most specimens covered themselves with the fine mud, either for protection or as a strategy to catch fishes and other invertebrates. Bishop *et al.* (1992) suggested that both *C. vastraeleni* and *Cretacorantina dichrous* were semi-infaunal decapods. However, dactyli of P3 in these two species are unciform, and there is also the possibility that these crustaceans lived associated with floating algae, as remains of this type of algae are found in the Múzquiz sediments (W. Stinnesbeck, pers. obs.)

The correlation between Colombian and Mexican crustaceans (*Stramentum* sp., *Cenomanocarcinus vanstraeleni* and Raninid 1) is significant as an indication of a wide distribution for certain species, such as *C. vanstraeleni*, whose distribution during Turonian times included New Mexico, Texas, Coahuila, Colombia, and probably Germany. Worldwide distribution of marine paleobiotas has been discussed by other authors (Gallo *et al.*, 2007). The Múzquiz brachyuran crustaceans represent "primitive" podotreme groups, in a time prior to the diversification of the more "advanced" eubrachiuran groups. In a recent contribution, Breton and Collins (2007) documented 14 taxa from the Cenomanian stratotype in France.

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