

## DECAPOD CRUSTACEANS (BRACHYURA) FROM THE EOCENE TEPETATE FORMATION, BAJA CALIFORNIA SUR, MEXICO

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## ABSTRACT

A large collection of brachyuran specimens from the middle Eocene Tepetate Formation, Baja California Sur, Mexico, has yielded sufficiently well-preserved specimens to provide revised descriptions and diagnoses for genera and species previously known from the area. Revised, more complete descriptions are given for *Eriosachila bajaensis* Schweitzer et al., 2002, and *Lobonotus mexicanus* Rathbun, 1930. A gonopliid specimen is questionably referred to *Carcinoplax*, which has a well-established Pacific record during the Miocene. All of the specimens of *Amydrocarcinus dantei* Schweitzer et al., 2002, thus far collected for which gender can be determined are males, suggesting that there may have been environmental or behavioral segregation of males and females of this species. Analysis of benthic and planktonic foraminiferans suggests that the Tepetate Formation was deposited in subtropical conditions, probably within the photic zone but below the seasonal thermocline, perhaps below 100–120 m. The age of the Tepetate Formation, according to larger foraminiferans, is middle Eocene, and according to planktonic foraminiferans is further constrained as upper middle Eocene (Bartonian). This age corresponds to the P14 foraminiferal zone based upon the Berggren et al. (1995) scheme and the E13 zone based upon the work of Berggren and Pearson (2005).

KEY WORDS: Decapoda, Brachyura, Mexico, Eocene, Bateque Formation, Tepetate Formation, Bartonian

## INTRODUCTION

During the past several years, the decapod fauna of the Eocene Bateque Formation, which crops out in northern Baja California Sur, has been documented in several papers cited below. During that same time, decapods were also described from the Tepetate Formation. The Tepetate Formation, which crops out in southern Baja California Sur, is also Eocene in age and has been correlated with the middle part of the Bateque Formation (Squires and Demetron 1992, 1994). However, previous studies treated only those brachyurans collected from the Tepetate Formation that were available in early field seasons. Subsequent collecting yielded more, and in many cases better, specimens from that unit. Therefore, the purposes of this work are to describe additional brachyurans from the Tepetate Formation, to contrast the decapod faunas from the Bateque and Tepetate formations, and to speculate on the nature of the faunal differences.

## GEOLOGIC SETTING

The specimens described here were collected from local-

ities in the middle Eocene Tepetate Formation, the geology and paleontology of which have been recently summarized elsewhere (Schweitzer et al. 2002; Schweitzer and Karasawa 2004; Schweitzer et al. 2006 [imprint 2005]; Schweitzer et al. 2006). One locality is our Waypoint 39 (WP39) of other publications, near the village of El Cien, Baja California Sur, Mexico, at lat. 24°19'56.8"N, long. 111°01'06.6"W. Other specimens were collected from Waypoint 37 (WP37), in Arroyo Conejo, northwest of La Paz, at lat. 24°10'13.9"N, long. 110°55'06.2"W, the same locality at which some of the specimens described by Schweitzer et al. (2002) were collected (Fig. 1).

Examination of the sediment in which the fossils were preserved indicates that they consist of grey, very fine sandstone, cemented weakly by calcite. Although primarily composed of quartz, less than 1% of the grains were muscovite, biotite, glauconite and a ferromagnesian mineral, possibly hornblende. Although compositionally very similar to that of the fine sandstone of the fossiliferous layers within the Bateque Formation, the grains of the Tepetate Formation are very fine sand, as opposed to

fine sand, and the color of the sediment is reddish brown in the latter unit.

#### MICROPALAEONTOLOGY AND PALEOENVIRONMENT

The sediments of the Tepetate Formation yielded numerous foraminiferans that could be studied in thin section (Fig. 2, 3). The sediments containing the foraminiferans were collected in association with the decapods described herein, from the same rock samples enclosing the decapods. The decapod-bearing level is in the lower part of the section at the Arroyo Conejo (WP37) locality (Schweitzer et al. 2002, fig. 2). The larger, benthic foraminiferans include *Pseudophragmina* (*Proporocyclina*) *flitensis* (Cushman, 1917), *Pseudophragmina* (*Proporocyclina*) *clarki* (Cushman, 1920), *Asterocyclina* *aster* (Woodring, 1930), *Neorotalia vienotti* Greig, 1935, *Amphistegina* sp., *Eorupertia* sp., and miliolids. Planktonic foraminiferans include *Subbotina corpulenta* (Subbotina, 1953), *Subbotina gortanii* (Borsetti, 1959), *Subbotina yeguaensis* (Weinzieri and Applin, 1929), *Acarinina rohri* (Brönnimann and Bermudez, 1953), *Catapsydrax* sp., and *Turborotalia* sp. Other fossils that are recognizable within thin sections include corallinaceans, bryozoans, bivalves, and echinoderms.

The larger foraminiferans typically are represented by broken tests, which suggests some degree of post-mortem transport. Absence of micritization, abrasion, or other signs of degradation indicate probable short distance of transport within the sediment mass. The environment in which the larger foraminiferans lived was within the photic zone in subtropical water. The presence of *Neorotalia* and *Eorupertia* indicates high energy in the living site, probably above normal wave base. The planktonic foraminiferans are also suggestive of low latitude, subtropical water conditions. The association of the muricate *Acarinina* and non-muricate, deeper-dwelling *Subbotina* and *Turborotalia* indicate that the depositional site was deeper, probably within the photic zone but below the seasonal thermocline, perhaps below 100–120 m.

The age of the Tepetate Formation at the collecting sites, determined by the enclosed foraminiferans, is well constrained. The larger foraminiferans indicate a middle Eocene age and the planktonic foraminiferans further constrain the age as upper middle Eocene (Bartonian). This age corresponds to the P14 foraminiferal zone based upon the Berggren et al. (1995) scheme and the E 13 zone based upon the work of Berggren and Pearson (2005).

**Institutional abbreviations.**—MHN-UABCS, Museo de Historia Natural, Universidad Autónoma de Baja California Sur, La Paz, Baja California Sur, México; USNM, United States National Museum of Natural History, Smithsonian Institution, Washington, D.C.

#### SYSTEMATIC PALEONTOLOGY

Order Decapoda Latreille, 1802  
 Infraorder Thalassinidea Latreille, 1831  
 Superfamily Callianassoidea Dana, 1852  
 Family Callianassidae Dana, 1852 *sensu lato*

Callianassidae *sensu lato* species 2 of Schweitzer, González-Barba, Feldmann, and Waugh, 2006 [imprint 2005] (Fig. 4A)

Callianassidae *sensu lato* species 2 Schweitzer, González-Barba, Feldmann, and Waugh, 2006 [imprint 2005], p. 280, fig. 3B.

**Description of material.**—Manus of cheliped slightly longer than high, highest about one-third the distance anteriorly from proximal margin, becoming slightly less high distally; proximal margin nearly straight, perpendicular to upper and lower margins; lower margin nearly straight; upper margin weakly convex; distal margin with notch in upper one-third, above position of fixed finger. Fixed finger quite high at proximal end, appearing to have been short.

**Measurements.**—Measurements (in mm) taken on the sole specimen: length of manus = 12.2; height of manus = 11.0.

**Material examined.**—MHN-UABCS/Te8/68-417.

**Occurrence.**—WP39.

**Discussion.**—The specimen bears resemblance to Callianassidae *sensu lato* species 2 of Schweitzer et al. (2006) [imprint 2005] in possessing a notch in the distal margin and a fixed finger that is high proximally. Because several specimens of that taxon were collected from Waypoint 39, the same locality as the currently reported specimen, we refer the new specimen to the same taxon. Unfortunately, the new specimen illustrated here is poorly preserved and does not permit a more specific assignment. However, it does demonstrate that this particular callianassid is relatively common in Tepetate sediments at this locality.

Callianassidae *sensu lato* species 5 Schweitzer, González-Barba, Feldmann, and Waugh, 2006 [imprint 2005] (Fig. 4B)

Callianassidae *sensu lato* species 5 Schweitzer, González-Barba, Feldmann, and Waugh, 2006 [imprint 2005], p. 280, fig. B.

**Description of material.**—Manus longer than high, outer surface convex; upper margin nearly straight; lower margin straight, with row of setal pits parallel to it; distal margin initially perpendicular to upper margin, then at about 110 degree angle to upper margin. Fixed finger long, slender, narrowing distally, angled downwards, lower margin paralleled by row of setal pits.

**Measurements.**—Measurements (in mm): length of manus = >6.3; height of manus = 5.2; length of fixed finger = >4.7.

**Material examined.**—MHN-UABCS/Te/68-418.

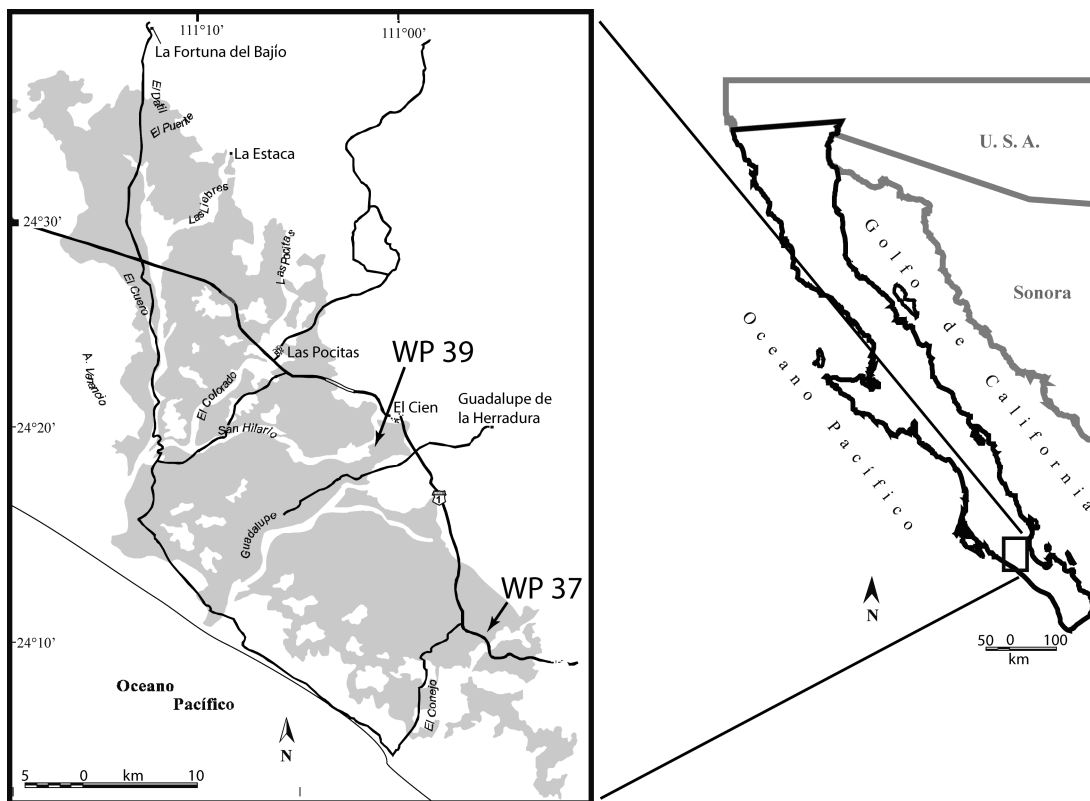


Fig. 1.—Index map of a portion of Baja California Sur, Mexico, denoting the position of Waypoints 37 and 39 from which the fossils described here-in were collected. Shaded area indicates area of outcrop of the Tepetate Formation.

**Occurrence.**—WP39.

**Discussion.**—The new specimen appears to conform to the description of *Callianassidae sensu lato* species 5 of Schweitzer et al. (2006) [imprint 2005] in possessing a long, slender fixed finger and a slender manus. The new specimen possesses a row of setal pits along the lower margin of the manus and the fixed finger, which adds new details to the description of the taxon.

Infraorder Brachyura Latreille, 1802  
 Section Podotremata Guinot, 1977  
 Superfamily Raninoidea de Haan, 1839  
 Family Raninidae de Haan, 1839  
 Subfamily Ranininae de Haan, 1839  
 Genus *Lophoranina* Fabiani, 1910

*Lophoranina bishopi* Squires and Demetron, 1992

*Lophoranina bishopi* Squires and Demetron, 1992, p. 44, fig. 130.  
 Schweitzer, Feldmann, Gonzáles-Barba, and Vega, 2002, p. 7, fig. 8.

**Discussion.**—See Feldmann and Schweitzer (2007).

Section Heterotremata Guinot, 1977  
 Superfamily Calappoidea de Haan, 1833  
 Family Calappidae de Haan, 1833

Genus *Calappilia* A. Milne Edwards,  
*in de Bouillé*, 1873

**Type species.**—*Calappilia verrucosa* A. Milne Edwards, *in de Bouillé*, 1873, by subsequent designation of Glaessner (1929).

**Included species.**—Included species were recently summarized by Feldmann et al. (2005).

*Calappilia hondoensis* Rathbun, 1930  
 (Fig. 4C)

*Calappilia hondoensis* Rathbun, 1930, p. 7, pl. 5, figs. 1, 2. Vega et al., 2001, p. 937, figs. 9–10; Schweitzer et al., 2002, p. 38; Schweitzer et al., 2006, fig. 2.12

**Material examined.**—Three fragmentary specimens, MHN-UABCS/Te14/66-75 through 66-77.

**Occurrence.**—The specimens were collected from WP37. Two specimens which were described previously (Schweitzer et al. 2006) were collected from WP39.

**TABLE 1.** All known taxa of decapod crustaceans known from the Tepetate and Bateque formations to date.

Taxon	Bateque	Tepetate
<b>Infraorder Thalassinidea Latreille, 1831</b>		
Superfamily Callianassoidea Dana, 1852		
Family Callianassidae Dana, 1852		
Subfamily Callichirinae Manning and Felder, 1991		
<i>Neocallichirus</i> cf. <i>N. rhinos</i> Schweitzer and Feldmann, 2002	1	
<i>Neocallichirus</i> sp. in Schweitzer et al., 2006 [imprint 2005]	1	
Callianassidae <i>sensu lato</i> species 1 in Schweitzer et al., 2006 [imprint 2005]	1	
Callianassidae <i>sensu lato</i> species 2 in Schweitzer et al., 2006 [imprint 2005]	1	1
Callianassidae <i>sensu lato</i> species 3 in Schweitzer et al., 2006 [imprint 2005]	1	
Callianassidae <i>sensu lato</i> species 4 in Schweitzer et al., 2006 [imprint 2005]	1	
Callianassidae <i>sensu lato</i> species 5 in Schweitzer et al., 2006 [imprint 2005]	1	1
<b>Infraorder Anomura H. Milne Edwards, 1832</b>		
Superfamily Paguroidea Latreille, 1802		
Family Diogenidae Ortmann, 1892		
<i>Paguristes mexicanus</i> (Vega, Cosma, Coutiño, Feldmann, Nyborg, Schweitzer, and Waugh, 2001)	1	1
Superfamily Paguroidea species 1 in Schweitzer et al., 2006 [imprint 2005]	1	
Superfamily Paguroidea species 2 in Schweitzer et al., 2006 [imprint 2005]	1	
Superfamily Paguroidea species 3 in Schweitzer et al., 2006 [imprint 2005]	1	1
Superfamily Galattheoidea Samouelle, 1819		
Family Galatheidae Samouelle, 1819		
Subfamily Galatheinae Samouelle, 1819		
Galatheinae genus and species indet. in Schweitzer et al., 2006	1	
<b>Infraorder Brachyura Latreille, 1802</b>		
Superfamily Homoloidea de Haan, 1839		
Family Homolidae de Haan, 1839		
<i>Homola bajaensis</i> Schweitzer et al., 2006	1	
Superfamily Raninoidea de Haan, 1839		
Family Raninidae de Haan, 1839		
Subfamily Ranininae de Haan, 1839		
<i>Lophoranina bishopi</i> Squires and Demetron, 1992	1	1
<i>Ranina berglundi</i> Squires and Demetron, 1992	1	
Subfamily Raninoidinae de Haan, 1841		
<i>Raninoides acanthocolus</i> Schweitzer et al., 2006	1	
<i>Raninoides proracanthus</i> Schweitzer et al., 2006	1	
Superfamily Cyclodorippoidea Ortmann, 1892		
Family, genus, and species indet. in Schweitzer et al., 2006	1	
Superfamily Calappoidea H. Milne Edwards, 1837		
Family Calappidae H. Milne Edwards, 1837		
<i>Calappilia hondoensis</i> Rathbun, 1930	1	1

TABLE 1 CONT.

Taxon	Bateque	Tepetate
Family Hepatidae Stimpson, 1871		
<i>Eriosachila bajaensis</i> Schweitzer et al., 2002		1
<i>Prehepatus mexicanus</i> Schweitzer et al., 2006	1	
Superfamily Parthenopoidea MacLeay, 1838		
Family Daldorfiidae Ng and Rodriguez, 1986		
<i>Daldorfia salina</i> Schweitzer et al., 2006	1	
Superfamily Cancroidea Latreille, 1802		
Family Atelecyclidae Ortmann, 1893		
<i>Levicyclus tepetate</i> Schweitzer et al., 2002		1
Family Cancridae Latreille, 1802		
<i>Anatolikos undecimspinosus</i> Schweitzer et al., 2006	1	
Family Cheiragonidae Ortmann, 1893		
<i>Montezumella tubulata</i> Rathbun, 1930		1
Superfamily Xanthoidea MacLeay, 1838		
Family Pilumnidae Samouelle, 1819		
<i>Lobonotus mexicanus</i> Rathbun, 1930	1	1
<i>Paracoralliocarcinus tricarinatus</i> Schweitzer et al., 2006	1	
Family Trapeziidae Miers, 1886		
<i>Archaeotetra inornata</i> Schweitzer, 2005b	1	
Family, genus, and species indet. <i>in</i> Schweitzer et al., 2006	1	
Superfamily Goneplacoidea MacLeay, 1838		
Family Goneplacidae MacLeay, 1838		
<i>Amydrocarcinus dantei</i> Schweitzer et al., 2002		1
<i>Carcinoplax?</i> sp. herein		1
Superfamily Portunoidea Rafinesque, 1815		
Family Portunidae Rafinesque, 1815		
Subfamily Carcininae MacLeay, 1838		
Genus and species indet. <i>in</i> Schweitzer et al., 2006	1	
Portunidae incertae sedis		
<i>Longusorbis eutychius</i> new species this volume		1
Brachyura family, genus, and species indeterminate herein		1

**Discussion.**—The species was recently redescribed and discussed (Schweitzer et al. 2006).

Family Hepatidae Stimpson, 1871

Genus *Eriosachila* Blow and Manning, 1996

**Type species.**—*Eriosachila petiti* Blow and Manning, 1996, by monotypy.

**Other species.**—*Eriosachila bajaensis* Schweitzer et al., 2002; *E. bartholomaeensis* (Rathbun, 1919), as *Zanthopsis*; *E. orri* Schweitzer and Feldmann, 2000; *E. rathbunae* (Maury, 1930), as *Zanthopsis*; *E. rossi* Schweitzer and Feldmann, 2000; *E. terryi* (Rathbun, 1937), as *Zanthopsis*; *Eriosachila* sp. in Vega et al., 2001.

**Diagnosis.**—As in Schweitzer and Feldmann (2000) and Schweitzer et al. (2002).

**Discussion.**—The genus *Eriosachila* recently has received extensive discussion (Schweitzer and Feldmann 2000; Feldmann and Schweitzer 2004); that discussion need not be repeated here. The bases for removal of species from *Zanthopsis* and their placement in *Eriosachila*, as well as the overall revision of *Zanthopsis*, is well-covered ground (Schweitzer and Feldmann 2000; Schweitzer et al. 2002; Schweitzer 2003).

*Eriosachila bajaensis* Schweitzer, Feldmann,  
González-Barba, and Vega, 2002  
(Fig. 4D, 4E)

*Eriosachila bajaensis* Schweitzer, Feldmann, González-Barba, and Vega, 2002, p. 9, figs. 9, 10.

**Emendation to diagnosis.**—Orbit incomplete; anterolateral margins crispate, with numerous small anterolateral spines.

**Emendation to description.**—Carapace slightly wider than long, L/W = 0.90, widest about 40%-50% the distance posteriorly on carapace; regions broadly inflated; moderately vaulted transversely, strongly vaulted longitudinally.

Front axially notched, straight segments extending weakly posteriorly on either side of notch; frontal width about one-third maximum carapace width; surface of front axially sulcate, inflated along distal edges and inner-orbital angle. Orbits circular, directed forward, at least one closed fissure centrally, suborbital margin incomplete; fronto-orbital width about half maximum carapace width. Anterolateral margin tightly convex, crispate, with several small spines, margin thickened into rim. Posterolateral margin with two protuberances; larger one placed anteriorly at about midlength of margin; second smaller, placed about half the distance between larger protuberance on posterolateral corner. Posterior margin about one-quarter to one-third maximum carapace width, weakly convex centrally, broadly rimmed.

Protogastric region strongly inflated, especially posteriorly; mesogastric region with long anterior process, widening and inflated posteriorly; urogastric region long, depressed; cardiac region elongated, inflated, less inflated posteriorly; intestinal region not differentiated, flattened. Hepatic regions set well below level of protogastric regions, with spherical swelling near anterolateral margin. Branchial regions not differentiated, with large swelling anteriorly, smaller swelling just

posterior to large swelling, remainder of region flattened. Ventral aspects and appendages unknown.

**Measurements.**—Measurements (in mm) on specimens of *Eriosachila bajaensis*. MHN-UABCS/Te8/68-408: W (maximum carapace width) = 18.0; L (maximum carapace length) = >13.0; FW (frontal width) = 5.6; FOW (fronto-orbital width) = 8.5. MHN-UABCS/Te8/68-412: W = 16.2; L = 14.9; FW = 5.2; FOW = 9.8; PW (posterior width) = 4.0; LMW (length to position of maximum carapace width) = 6.1. MHN-UABCS/Te8/68-411: W = 18.0; L = 15.9; PW = 5.4; LMW = 8.0.

**Material examined.**—Five specimens, MHN-UABCS/Te8/68-408 through 68-412.

**Occurrence.**—All four specimens were collected from WP39.

**Discussion.**—The specimens described here are more complete than the type material upon which *Eriosachila bajaensis* was based; thus, emendations to the diagnosis and description are provided. Some notable differences in the new material as compared to the type material are that the anterolateral margins are better preserved, so that small anterolateral spines can be observed. The anterolateral margin of the species was originally described as entire and sinuous. The suborbital margin can be observed in the new material, permitting the observation that the orbit is incomplete.

Superfamily Xanthoidea MacLeay, 1838  
Family Tumidocarcinidae Schweitzer, 2005a

Genus *Lobonotus* A. Milne Edwards, 1864

*Lobonotus* A. Milne Edwards, 1863, pl. 10, fig. 4, 1864, p. 39. Rathbun, 1930, p. 2, pl. 1; Stenzel, 1935, p. 382–385, fig. 1, pl. 14, figs. 1–4; Glaessner, 1969, p. R518, figs. 326, 12a, 12b; Schweitzer et al., 2002, p. 19, fig. 21; Karasawa and Schweitzer, 2004, p. 150; Schweitzer et al., 2004, p. 105.

*Archaeopilumnus* Rathbun, 1919, p. 177, pl. 7, figs. 10–13.

*Titanocarcinus* A. Milne Edwards, 1864 (part). Blow and Manning, 1996, p. 24, pl. 5, fig. 5.

*Glyphithyreus* Reuss, 1859 (part). Feldmann et al., 1998, p. 13, figs. 17, 18.

*Eohalimede* Blow and Manning, 1996 (part). Blow and Manning, 1997, p. 177, fig. 2; Blow and Manning, 1998, p. 409.

*Plagiolophus* Bell, 1858 (part). Rathbun, 1935, p. 94, pl. 21, fig. 23.

**Type species.**—*Lobonotus sculptus* A. Milne Edwards, 1864, by original designation (= *Archaeopilumnus caelatus* Rathbun, 1919) (Miocene).

**Other species.**—*Lobonotus bakeri* (Rathbun, 1935), as *Plagiolophus* (Eocene); *L. brazoensis* Stenzel, 1935 (Eocene); *L. mexicanus* Rathbun, 1930 (Eocene); *L. natchitochensis* Stenzel, 1935 (Eocene); *L. purdyi* (Blow and Manning, 1996), as *Titanocarcinus* (Eocene); *L. sandersi* (Blow and Manning, 1998), as *Eohalimede* (Eocene); *L. sturgeoni* (Feldmann et al., 1998), as *Glyphithyreus* (Eocene).

**Emendation to diagnosis.**—Sternites 1 and 2 fused with no evidence of sutures; suture between sternites 2 and 3 complete, open; suture between sternites 3 and 4 a deep groove, sternite 3 divided into halves by longitudinal broad, shallow groove; sternite 4 with grooves

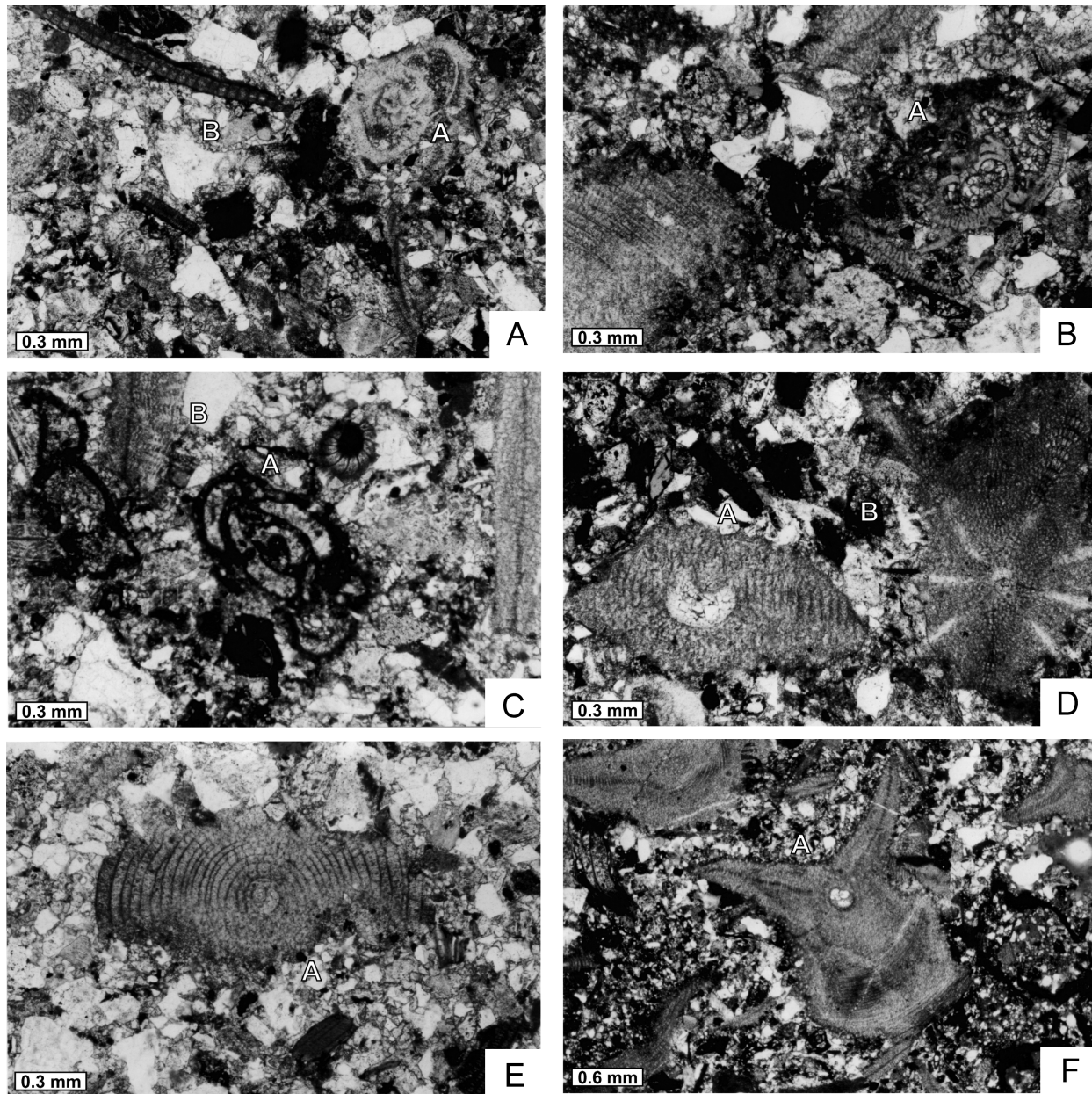


Fig. 2.—Biota, identified in thin section, from the Tepetate Formation. **A**, thin section containing a large foraminiferan, probably *Victoriella* sp. (A), and coralline debris (B). **B**, thin section containing the large foraminiferan, *Victoriella* sp. (A). **C**, thin section containing unidentified miliolid foraminifera (A). **D**, thin section containing *Pseudophragmina* (*Proporocyclus*) *clarki* (Cushman, 1920) (A), and *Asterocyclus* *habanensis* (Cole and Bermudez, 1947) (B). **E**, thin section containing *Pseudophragmina* (*Proporocyclus*) *flitensis* (Cushman, 1917). **F**, thin section containing *Asterocyclus* *aster* (Woodring, 1930).

parallel to margins that appear to delineate fused episternal projections of sternite 3 with sternite 4, sternite 4 with broad shallow groove extending anteriorly from sterno-abdominal cavity, groove continuous with groove on third sternite; male abdomen appearing to fill entire space between coxae of fifth pereopod; sternite 8 not visible in dorsal view.

**Discussion.**—The family-level placement of *Lobonotus* was discussed by Schweitzer et al. 2007, in press. Only two specimens of members of the genus are known with preserved sterna, both *L. mexicanus*. The male specimen of *L. mexicanus* illustrated by Rathbun (1930, pl. 1) has a well-preserved sternum, and from the illustration it appears that the abdomen may not cover the entire space between the coxae of the fifth pereopods (Schweitzer et al. 2004). However, examination of that specimen (USNM 371096) indicates that the eighth sternite was most likely covered by the abdomen. Another specimen, described here, retains a portion of the male sternum and abdomen; however, the somites and sternites in question are not preserved. Thus, this specimen does not help to confirm that the eighth sternite was in fact covered.

*Lobonotus mexicanus* Rathbun, 1930  
(Fig. 4F, 4G)

*Lobonotus mexicanus* Rathbun, 1930, p. 2, pl. 1. Glaessner, 1969, p. R520, fig. 326.12a, 12b; Schweitzer, Feldmann, Gonzáles-Barba, and Vega, 2002, p. 20, figs. 21, 22; Schweitzer, Feldmann, and Gingerich, 2004, p. 105; Schweitzer, Artal, van Bakel, Jagt, and Karasawa 2007, in press.

**Emendation to description.**—Suture between sternite 2 and 3 complete, open; suture between sternites 3 and 4 a deep groove, sternite 3 divided into halves by longitudinal broad, shallow groove; sternite 4 with grooves parallel to margins that appear to delineate fused episternal projections of sternite 3 with sternite 4, sternite 4 with broad shallow groove extending anteriorly from sterno-abdominal cavity, groove continuous with groove on third sternite; sternites 5, 6 and 7 visible; sternite 8 not preserved. Male abdomen narrow, with concave lateral margins; somites 1, 2, and 3 not preserved; somites 4 and 5 distinct, not fused; somite 6 long, about as long as telson; male abdomen reaching about midlength of sternite 4.

Chelipeds weakly heterochelous. Right chela larger, stouter, highest distally, appearing to have had rows of tubercles on outer surface; fixed finger short, with blunt tubercles on occlusal surface. Left chelae smaller, more slender, highest distally, with at least seven rows of tubercles on outer surface; fixed finger very short. Carpi of chelipeds equant, outer surfaces granular; merus of major cheliped equant, outer surface coarsely granular, with long spine on lower distal margin.

**Material examined.**—Three specimens, MHN-UABCS/Te8/68-414 through 68-416.

**Occurrence.**—Three specimens from WP39.

**Discussion.**—The well-preserved specimen with ventral aspects permits a more detailed description of the male sternum, abdomen, and chelipeds than has been previously possible.

Superfamily Goneplacoidea MacLeay, 1838  
Family Goneplacidae MacLeay, 1838

Genus *Amydrocarcinus* Schweitzer, Feldmann,  
Gonzáles-Barba, and Vega, 2002

*Amydrocarcinus* Schweitzer, Feldmann, Gonzáles-Barba, and Vega, 2002, p. 17, fig. 19. Schweitzer and Karasawa, 2004, p. 73, figs. 1.1, 1.2.

**Type and sole species.**—*Amydrocarcinus dantei* Schweitzer, Feldmann, Gonzáles-Barba, and Vega, 2002, by monotypy.

**Diagnosis.**—As for species.

*Amydrocarcinus dantei* Schweitzer, Feldmann,  
Gonzáles-Barba, and Vega, 2002  
(Fig. 4H, 4I)

**Diagnosis.**—As in Schweitzer et al. (2002) and Schweitzer and Karasawa (2004).

**Material examined.**—MHN-UABCS/Te14/66-79 through 66-87.

**Occurrence.**—WP37.

**Discussion.**—The new specimens do not add substantially to the already well-described and illustrated material. However, it is interesting to note that every known specimen with a preserved abdomen is a male. Whereas the sample size is relatively small (six), this suggests that there may have been some sort of gender segregation in this taxon as has been previously noted for *Branchioplex washingtoniana* Rathbun, 1916, known from Eocene rocks of Washington, USA (Conkle and Schweitzer 2005).

Genus *Carcinoplax*? H. Milne Edwards, 1852

**Type species.**—*Cancer (Crutonotus) longimanus* (de Haan, 1833), by subsequent designation of Glaessner (1929).

**Fossil species.**—*Carcinoplax antiqua* Ristori, 1889 (early-middle Miocene); *C. granulimanus* Karasawa and Inoue, 1992 (middle Miocene); *C. imperfecta* Karasawa and Inoue, 1992 (middle Miocene); *C. longimanus* (late Pliocene, also extant); *C. mongosungi* Hu and Tao, 1985 (unknown); *C. prisca* Imaizumi, 1961 (early Miocene [Collins et al., 2003], late Miocene–early Pliocene); *C. proavita* (Glaessner, 1960) (early Miocene); *C. senecta* Imaizumi, 1961 (Miocene); *C. purpurea* Rathbun, 1914 (latest Pliocene, also extant); *C. sp. aff. C. purpurea* Rathbun, 1914 (late Pliocene); *C. shukumi* Hu and Tao, 1985 (Miocene); *C. temikoensis* Feldmann and Maxwell, 1990 (late Eocene); *C. thongi* Hu and Tao, 1985 (Miocene); *C. tsengi* Hu and Tao, 1985 (Miocene); *Carcinoplax* sp. Feldmann and Keyes, 1992 (late Pliocene–early Pleistocene); *Carcinoplax* sp., Karasawa, 1997 (early Pliocene); *Carcinoplax* sp., Kato, 1996 (middle Miocene). Occurrence information in part after Karasawa (1993) and Karasawa and Kato (2003).

**Discussion.**—*Carcinoplax* embraces an extremely variable dorsal carapace morphology. Species range from possessing long anterolateral spines to blunt protuber-



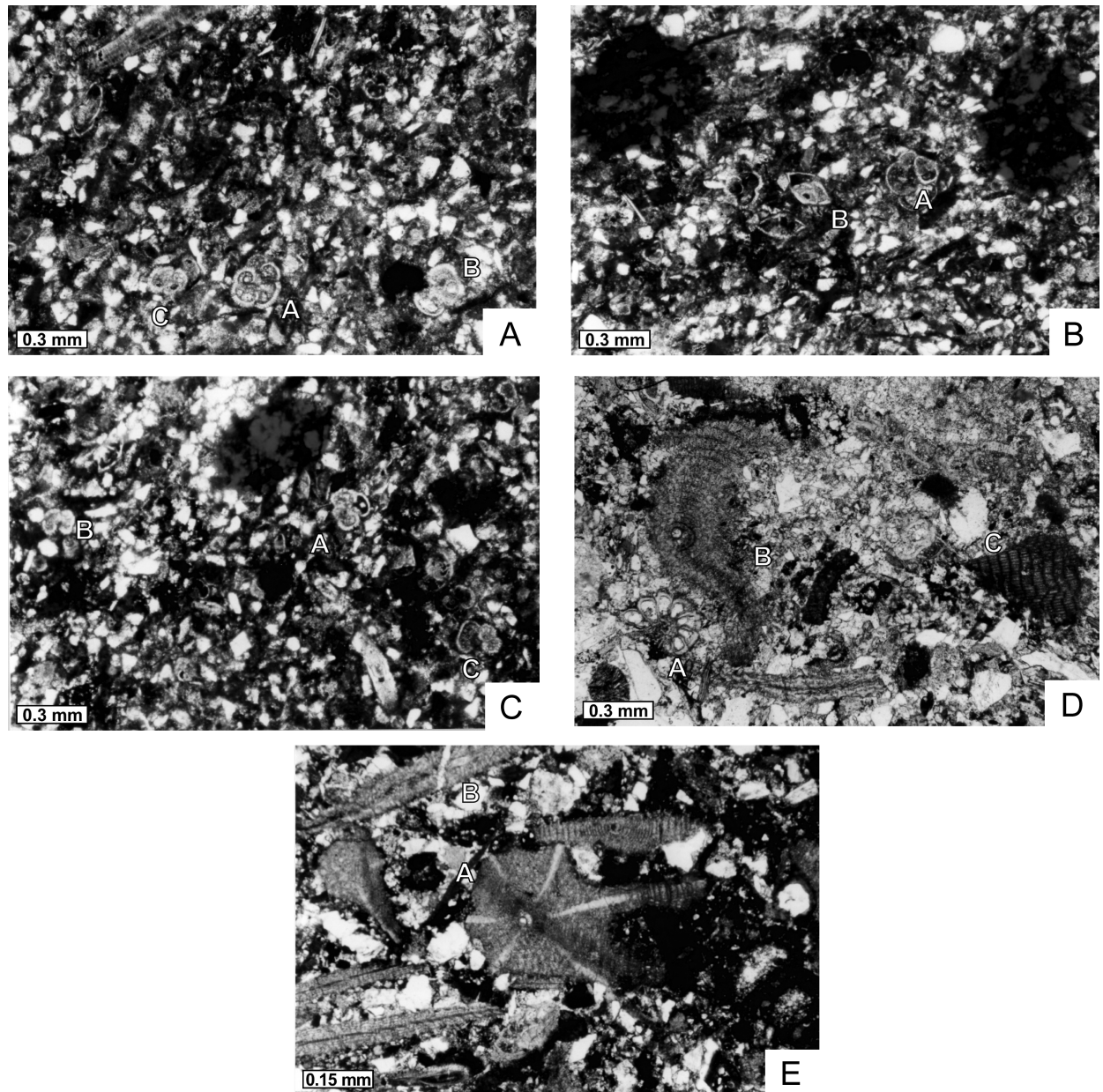


Fig. 3.—Biota, identified in thin section, from the Tepetate Formation. **A**, thin section containing the planktonic foraminifera *Catapsydrax* sp. (A), *Subbotina yeguaensis* (Weinzieri and Applin, 1929) (B), and *Acarinina rohri* (Brönnimann and Bermudez, 1953) (C). **B**, thin section containing *Subbotina gortanii* (Borsetti, 1959) (A), and *Turborotalia* sp. (B). **C**, thin section containing *Subbotina corpulentai* (Subbotina, 1953) (A), *Acarinina* sp. (B), and *Subbotina yeguaensis* (Weinzieri and Applin, 1929) (C). **D**, thin section containing the benthic foraminifera *Neorotalia* sp. (A), *Pseudophragmina (Proporocyclina) flitensis* (Cushman, 1917) (B), and coralline debris (C). **E**, thin section containing *Asterocyclina aster* (Woodring, 1930) (A), and *Pseudophragmina* sp. (B).

ances on the anterolateral margin to no anterolateral spines at all; from having orbits placed on the margins of the anterior edge of the carapace (fronto-orbital width to maximum carapace width ratio of about 100%) to orbits positioned well-within the anterior edge of the carapace (fronto-orbital width to maximum carapace width ratio of 60%); and from hexagonal to square to round dorsal carapace shapes (see illustrations in Guinot 1989). Thus, the specimen described below, which is known only from a rather poorly preserved dorsal carapace, easily falls within the range of morphology ascribed to *Carcinoplax*. *Carcinoplax* as currently defined is an Indo-Pacific genus, with fossil occurrences in the same general region. Thus, we questionably refer the specimen to *Carcinoplax*, based upon its broad orbits placed at the margins of the anterior edge of the carapace; equant carapace; apparent lack of anterolateral spines; and Pacific occurrence, until better material can be recovered. It differs from other species of *Carcinoplax* in possessing a notch between the front and the orbits. If the specimen were to be confirmed as a member of *Carcinoplax*, the record of that genus would be extended into the Eocene; currently the oldest known occurrences are early Miocene (Karasawa 1993).

The possibility of the specimen being a juvenile of *Amydrocarcinus dantei* was considered. However, examination of growth trends in *Carcinoplax* spp. (Guinot 1989) indicates that patterns of change during growth in the relative position of the orbits and proportion of the fronto-orbital width exclude the new specimen as a juvenile of *A. dantei*. In species of *Carcinoplax*, the fronto-orbital width itself and the ratio of the fronto-orbital width to maximum carapace increase with age (Guinot 1989). Those features in the new specimen are large, and in the much larger, presumably adult *A. dantei* they are much smaller, showing the opposite trend. Thus, it seems more likely that the new specimen is a member of a distinctive taxon.

?*Carcinoplax* sp.  
(Fig. 4J)

**Description of material.**—Carapace nearly square, slightly wider than long, maximum length about 96% maximum width, regions moderately defined as swollen areas, weakly vaulted transversely and longitudinally. Front projected well beyond orbits, appearing to have been straight, about 38% maximum carapace width. Orbits deep, sinuous, with blunt projection near inner-orbital angle, outer-orbital angle produced into triangular, forward-directed spine; fronto-orbital width about 100% maximum carapace width. Anterolateral and posterolateral margins confluent, too poorly preserved to indicate if there were spines or other ornamentation. Posterior margin broad, rimmed, 60% maximum carapace width.

Protogastric regions long, very weakly inflated; mesogastric region with very long anterior process, widening posteriorly, somewhat inflated posteriorly. Urogastric region depressed, with concave lateral margins, about as long as wide; cardiac region pentagonal, apex directed posteriorly, with two tubercles positioned aside one another anteriorly, posterior half depressed well below level of anterior half; intestinal region very

short, poorly differentiated. Hepatic region flattened. Epibranchial region arcuate, beginning at anterolateral angle, arcing anteriorly and terminating along urogastric region. Mesobranchial region flattened; metabranchial region depressed well below level of mesobranchial region, so that posterior portion of mesobranchial region and anterior half of cardiac region together form a transverse ridge behind which the carapace is steeply depressed.

**Measurements.**—Measurements (in mm): maximum carapace width = 5.2; maximum carapace length = 5.0; fronto-orbital width = 5.2; frontal width = 2.0; posterior width = 3.1.

**Material examined.**—MHN-UABCS/Te14/66-78.

**Occurrence.**—WP37.

**Discussion.**—The specimen is poorly preserved, and the anterolateral margins appear to have exfoliated some of the outer cuticle layers. Thus, it is difficult to determine whether or not the anterolateral margins may have been ornamented with spines. However, it is clear that the front is quite projected in advance of the orbits and that the orbits possess a blunt projection on the inner-orbital angle; these features may be diagnostic when better preserved material is collected.

Brachyura family, genus, and species indeterminate  
(Fig. 4K)

**Description of material.**—Carapace appearing to have been wider than long, surface granular; posterolateral margins longer than anterolateral margins, converging markedly posteriorly; posterior margin about 35 % maximum carapace width. Carapace width two prominent transverse ridges; one ridge across epibranchial and mesogastric regions; second ridge across metabranchial and cardiac regions.

Remainder of carapace and appendages unknown.

**Measurements.**—Measurements (in mm) on the sole specimen: carapace width = 16.6; carapace length > 12.0; posterior width = 6.4.

**Material examined.**—MHN-UABCS/Te/8/68-419.

**Occurrence.**—WP39.

**Discussion.**—The transverse ridges on this specimen are very prominent; however, no other diagnostic features of the carapace are preserved. The front, orbits, anterolateral margins, and other important details are all missing; thus, it is impossible to classify this specimen. Taxa with prominent carapace ridges such as are possessed in this specimen include members of the Retroplumidae Gill, 1894; however, the narrow posterior margin and posteriorly converging posterolateral margins are not seen in retroplumids. Schweitzer et al. (2006) described a new species of *Paracorallicarcinus* Tessier et al., 1999, which is typified by transverse carapace ridges; however, that species is rectangular, much wider than long, and lacks the posteriorly converging posterolateral margins seen in the new specimen. The taxon most similar to the new specimen is *Carinocarcinoides* Karasawa and Fudouji, 2000, species of which possess transverse ridges on the dorsal carapace, a carapace that is not

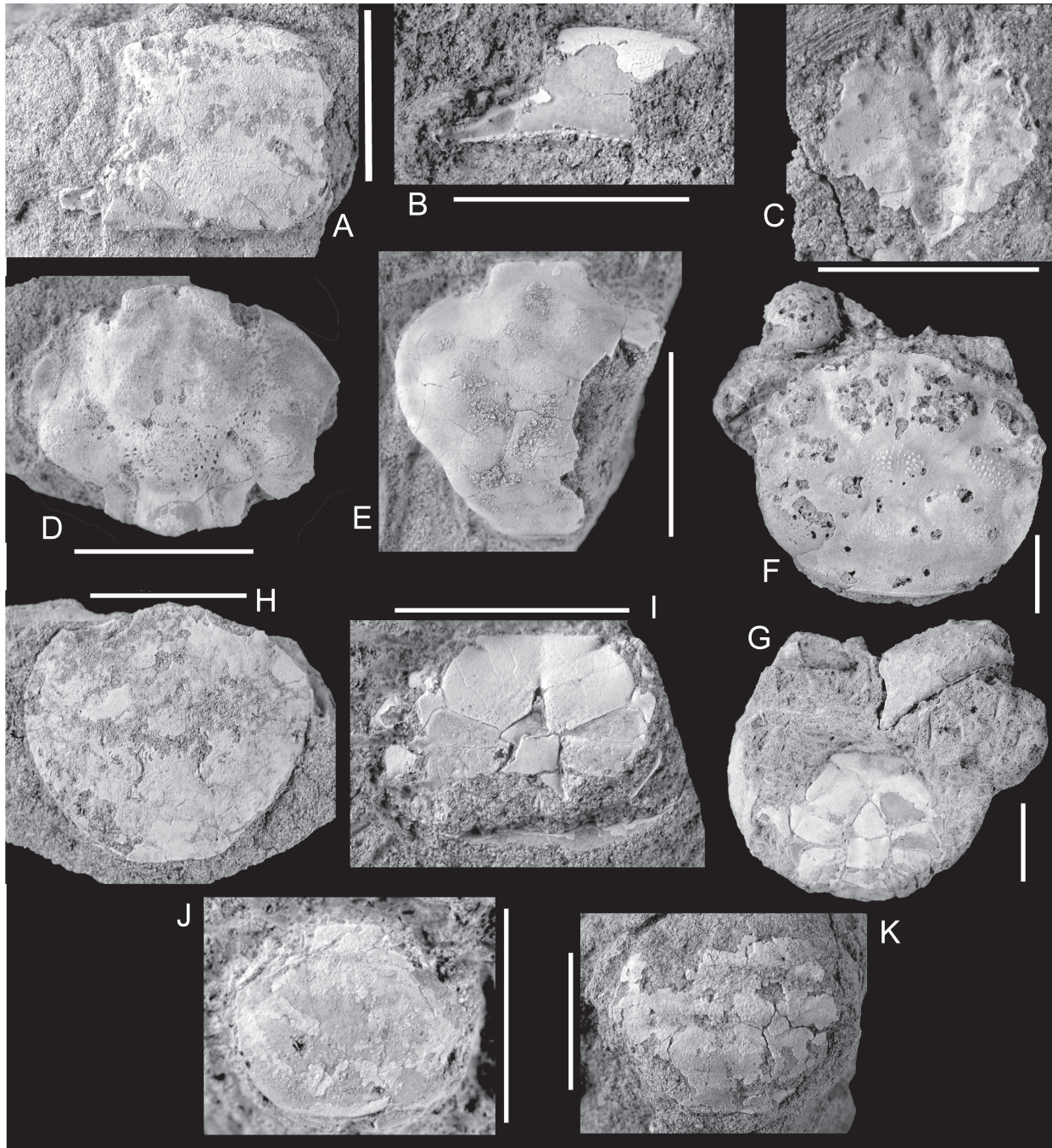


Fig. 4.—Decapod Crustacea collected from the Tepetate Formation. **A**, Callianassidae *sensu lato* species 2 of Schweitzer et al., 2006 [imprint 2005], MHN-UABCS/Te 8/68-417, outer surface of left manus. **B**, Callianassidae *sensu lato* species 5 of Schweitzer et al., 2006 [imprint 2005], MHN-UABCS/Te 8/68-418, outer surface of left manus. **C**, *Calappilia hondoensis* Rathbun, 1930, MHN-UABCS/Te 14/66-75, interior surface of cuticle of axial regions and broken branchial regions. **D**, **E**, *Eriosachila bajaensis* Schweitzer, Feldmann, González-Barba, and Vega, 2002, MHN-UABCS/Te 8/68408 (**D**) and MHN-UABCS/Te 8/68/412 (**E**), showing broken portions of dorsal carapace. **F**, **G**, *Lobonotus mexicanus* Rathbun, 1930, MHN-UABCS/Te 8/68-416, dorsal (**F**) and ventral (**G**) views of carapace and left cheliped. **H**, **I**, *Amydrocarcinus dantei* Schweitzer, Feldmann, González-Barba, and Vega, 2002, MHN-UABCS/Te 14/66-82, dorsal carapace (**H**) and MHN-UABCS/Te 14/66-80, part of sternum and abdomen of a male specimen (**I**). **J**, *Carcinoplax?* sp., MHN-UABCS/Te 14/66-78, poorly preserved dorsal carapace. Scale bar equals 0.5 cm. **K**, Brachyura family, genus, and species indeterminate, MHN-UABCS/Te 8/68-419, dorsal carapace. Scale bars = 1 cm, except where noted.

much wider than long, and posteriorly narrowing posterolateral margins. Much better-preserved specimens will be needed, however, to test whether or not *Carinocarcinoides* is indeed present in North America. Currently, species are known only from Oligocene of Japan (Karasawa and Fudouji 2000).

#### PALEOECOLOGY

The decapod fauna from the Tepetate Formation is much less robust than that of the Bateque Formation (Table 1). Of the nine species known from the Tepetate Formation, seven are shared with the Bateque Formation fauna, including *Paguristes mexicanus*, *Lophoranina bishopi*, *Calappilia hondoensis*, *Lobonotus mexicanus* and three unnamed species of hermit crabs and callianassid shrimp. The species known only from the Tepetate fauna include *Eriosachila bajaensis*, *Levicyclus tepetate* Schweitzer et al., 2002, *Montezumella tubulata* Rathbun, 1930, *Amydrocarcinus dantei*, *?Carcinoplax* sp., and *Longusorbis eutychi* new species this volume.

In attempting to discern a pattern of distribution that would explain the differences in faunal diversity and faunal composition between the two formations, only two observations seem relevant. Seven of the taxa uniquely occurring in the Bateque Formation are species of mudshrimp and hermit crabs; only two species of hermit crab and two taxa of callianassids occur in both formations. The large number of these taxa in the Bateque Formation may indicate deposition of the sediment in an environment that was particularly conducive to their lifestyle. Alternatively, it is certainly possible that, because these taxa are almost entirely represented by isolated claws, a certain amount of taxonomic “splitting” may have occurred. This latter possibility is considered unlikely because the authors have studied mudshrimp and hermit crabs in several other rock units and, although it is not possible to assign specimens to genera with confidence in all cases, patterns of morphology that clearly distinguish species can be discerned. Every attempt has been made to recognize what seem to be legitimately different species-level taxa.

No other taxonomic pattern clearly distinguishes the faunas in the two formations. Among the Brachyura, four species of burrowing forms within the Raninidae are known from the Bateque Formation, whereas only one of those, *Lophoranina bishopi*, occurs in both formations. The remainder of the crabs are epifaunal, benthic creatures, many of which are xanthoid crabs that are common in warm water settings. Thus, no obvious ecological patterns are evident.

The one striking difference in the faunas is related to size of the individuals that were collected. Most of the species reported from the Bateque Formation were represented by very tiny specimens that were discovered serendipitously in which surface collecting had yielded

little. The rocks in that area were infused with salt from evaporation of seawater, the fossils were extremely fragile, and specimens undoubtedly disintegrated upon exposure at the surface. The numerous specimens that were collected from that locality, WP 32, were discovered by digging below the surface to expose fossils that had not been subjected to surface weathering. The shallow quarrying revealed a large number of specimens that could then be wrapped in tissue and preserved for study. Very little additional preparation was possible because of the delicate nature of the material. Because of this fortuitous discovery, the faunal list of the Bateque Formation was greatly expanded. Thus far, no such discovery has been made in the Tepetate Formation.

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