

Additions to continental gastropods from the Upper Cretaceous and Paleocene of NE Mexico

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ABSTRACT

Additions are offered to the diverse estuarine, freshwater and terrestrial gastropod fauna of the Upper Cretaceous (Campanian) and Paleocene lithostratigraphic units of the Difunta Group, NE México (Coahuila and Nuevo León). Nineteen species of continental gastropods (five of them new) are reported and illustrated from the upper Campanian Cerro del Pueblo Formation (Las Águilas/Porvenir de Jalpa locality) and the Paleocene Las Encinas Formation (La Leona locality), northern Parras Basin, Difunta Group, Coahuila. The first record of pulmonate gastropods from the Difunta Group is based on several specimens of different species. This is the third contribution dealing with these continental gastropods from the study region and a revised list of reported species is presented. Although we follow the most recent classification of continental gastropods, we also base the identification on paleontological systematics, knowing that some important diagnostic features were not preserved. Thus, we do not intend to propose paleobiogeographic or evolutionary inferences. Our main goal is to present the paleodiversity known from the study area, in hope that these data would be useful for more detailed studies in the near future.

Keywords: Continental Mollusca, Gastropoda, Upper Cretaceous, Paleocene, Coahuila, Mexico.

RESUMEN

Se ofrecen adiciones a la diversa fauna de gastrópodos estuarinos, dulceacuícolas y terrestres de las unidades litoestratigráficas del Cretácico Superior (Campaniano) y Paleoceno del Grupo Difunta, NE de México (Coahuila y Nuevo León). Diecinueve especies de gastrópodos continentales (cinco de ellas nuevas) son reportadas e ilustradas para la Formación Cerro del Pueblo del Campaniano superior (localidad Las Águilas/Porvenir de Jalpa) y la Formación Las Encinas, del Paleoceno (localidad La Leona), porción norte de la Cuenca de Parras, Grupo Difunta, Coahuila. El primer registro de gasterópodos pulmonados para el Grupo Difunta, se basa en varios ejemplares de diferentes especies. Esta es la tercera contribución que trata sobre caracoles continentales de la región y se presenta una lista revisada de especies. Aunque seguimos la más reciente clasificación de gasterópodos continentales, también basamos la identificación en sistemática paleontológica, concientes de que algunas características diagnósticas importantes no fueron preservadas. Por lo tanto, no intentamos proponer inferencias evolutivas o paleobiogeográficas. Nuestro propósito principal es presentar la paleodiversidad conocida para el área de estudio, en espera de que pueda ser de utilidad para estudios más profundos a futuro.

Palabras clave: Mollusca continentales, Gastropoda, Cretácico Superior, Paleoceno, Coahuila, México.

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1. Introduction

The fossil record of the Parras and La Popa basins (Difunta Group) includes a diversity of plants, invertebrates and vertebrates, distributed in diverse facies of a deltaic system that prevailed in north-eastern Mexico from late Campanian to Paleocene (e.g., McBride *et al.*, 1974; Wolleben, 1977; Vega and Perrilliat, 1989; Lawton *et al.*, 2009). McBride *et al.* (1974) subdivided the Difunta Group into two sedimentary basins, the Parras and La Popa basins. Vega and Perrilliat (1992) first report continental gastropods from the Paleogene deposits of the La Popa Basin (Nuevo León). Later, Perrilliat *et al.* (2008) reported eleven species of freshwater gastropods from three localities of the Cerro del Pueblo Formation (Parras Basin, Coahuila). The abundance and diversity of continental gastropods, as found in lithostratigraphic units of the Difunta Group is unique in Mexico.

Although the systematics of continental gastropods are mostly based on soft-body features and molecular data, it is important to know the occurrence of these organisms, whose shell morphology resembles living species distributed around the world. The data could also be helpful for detailed paleogeographic reconstructions of the late Campanian and middle Paleocene sea shore in NE Mexico. This is because the habitats of these gastropods correspond to ponds, marshes, and swamps found near the ancient coast of NE Mexico. Continental molluscs represent the most abundant and diverse fossils of the Difunta Group, being one of the most important for facies interpretation, since nearly all of these gastropods and bivalves are found with little or no transport from their original habitats.

Salt tectonics played an important role in facies distribution and occurrence, mainly at La Popa Basin (Giles and Lawton, 1999, 2002; Lawton *et al.*, 2001, 2009). This halokinetic control was important, especially during Paleocene times, in the formation of small, closed shallow basins. In these zones, organic matter accumulated in

estuarine to freshwater environments, and aquatic continental gastropod populations developed.

On the other hand, late Campanian sequences of the Parras Basin also had significant changes in facies, but with deposition in low-gradient lower coastal plain and shallow marine environments, influenced by high-frequency changes in relative sea level, and coastal storm events (Eberth *et al.*, 2004). This difference may explain the complete absence of terrestrial pulmonate snails in the Paleocene units of La Popa Basin. Figure 1.1 and 1.2 illustrate inferred paleogeography for NE Mexico during Late Cretaceous and Paleocene.

2. Stratigraphy and localities

2.1. LATE CAMPANIAN, CERRO DEL PUEBLO FORMATION

The Cerro del Pueblo Formation is the oldest (late Campanian) lithostratigraphic unit of the Parras Basin (McBride *et al.*, 1974, Eberth *et al.*, 2004) and includes shallow sedimentary environments, represented by delta plains, lagoons, and marshes, located in the ancient northeast coast of Mexico (Figure 1.1). Relatively similar environments were found during the Paleocene in this region (Figure 1.2). A diversity of marine, freshwater, and terrestrial animals has been described from several localities in NE Mexico (Figure 1.3). Perrilliat *et al.* (2008) reported important fossiliferous outcrops of the Cerro del Pueblo Formation. Its lithology and fossiliferous content is similar to the locality here described as Las Águilas/ Porvenir de Jalpa, General Cepeda, Coahuila (25°31'03"N, 101°40'30"W) (Figure 1.4), also from the Cerro del Pueblo Formation. In the latter, light-brown, fine-grained sandstone beds yield hematized gastropods, bivalves, tortoise bones, crocodile teeth, coprolites, wood fragments, and fruits, preserved under anoxic, stagnant freshwater deposits. Estuarine, non-hematized gastropods are also found a few meters above level with hematized remains. The freshwater strata are relatively thin

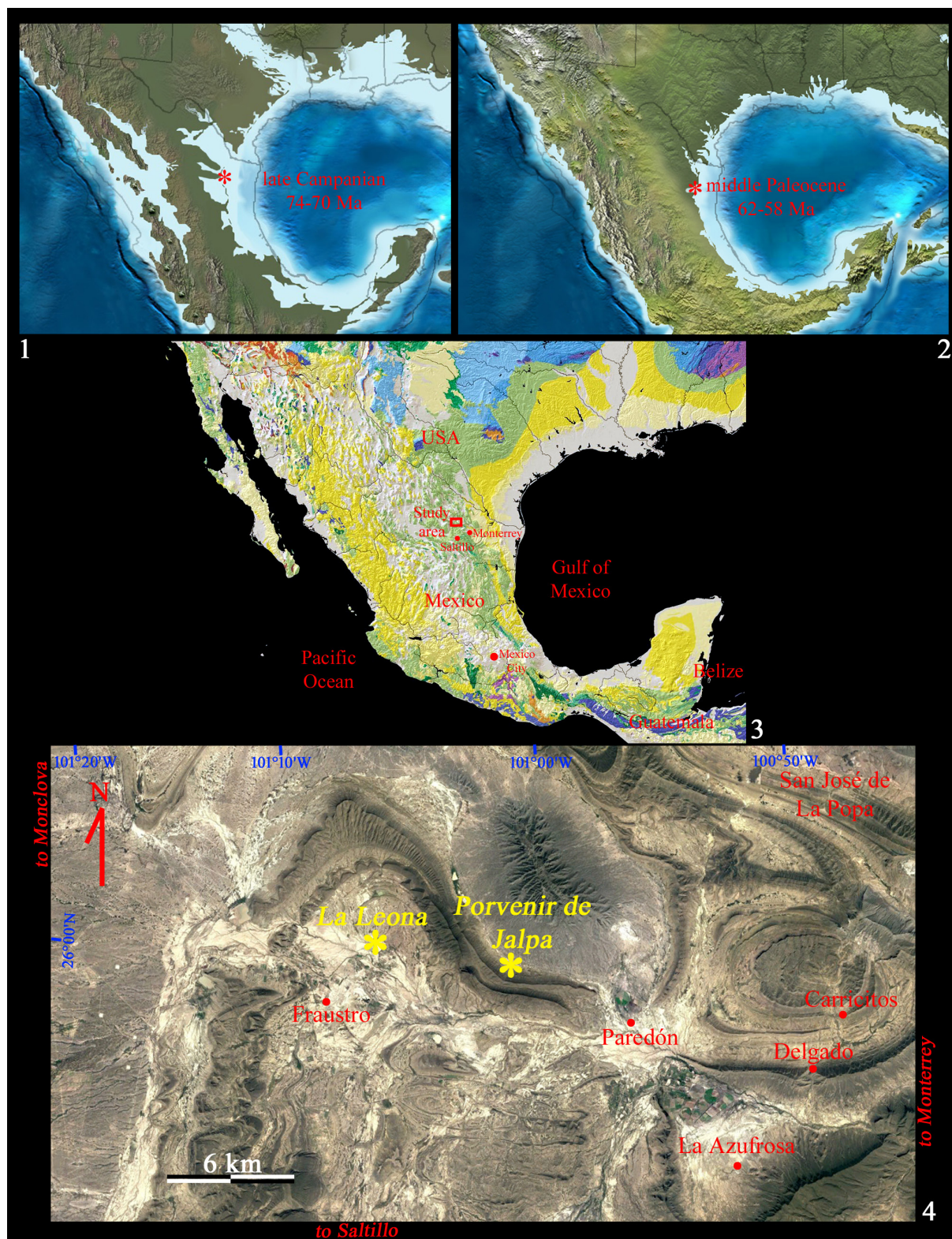


Figure 1 1, Late Cretaceous paleogeographic map, with approximate position of Las Águilas/ Porvenir de Jalpa locality. 2, Paleocene paleogeographic map, with approximate position of La Leona locality. 3, Geologic map with position of study area in NE Mexico. 4, Map of study localities in Coahuila, NE Mexico. Paleogeographic maps courtesy of Ron Blakeley (modified). Figure 1.3 modified from Barton *et al.* (2003). Figure 1.4 from Google Earth.

and interbedded in cyclic sequences with shallow marine sediments that include the ostreoid *Flemingostrea subspatulata* Forbes, 1845 and the ammonite *Sphenodiscus sp.*

Here we report seventeen species of continental gastropods for the upper Campanian Cerro del Pueblo Formation. Five of them are new and three species were previously reported by Perrilliat *et al.*, 2008 for the Cerro del Pueblo Formation, but from different localities (Figure 2). Pulmonate gastropods are here reported for the first time for the Difunta Group. A total of 30 continental gastropods are now known from the Cerro del Pueblo Formation (Figure 3), and a significant number of bivalves are to be reported in future studies.

2.2. PALEOCENE, LAS ENCINAS FORMATION

Four species of freshwater gastropods were reported by Perrilliat *et al.* (2008) from red beds (delta plain) of the Las Encinas Formation (Parras Basin). The Paleocene Adjuntas, Viento and Carroza formations in La Popa Basin also contain

continental gastropods. These specimens were found in delta-plain deposits, with some species in common with those from the Paleocene of Las Encinas Formation (Figure 2). Two species of continental gastropods are here reported from fluvial deposits of the Paleocene Las Encinas Formation at La Leona locality, Ramos Arizpe, Coahuila, (25°58'47"N, 101°06'23"W) (Figure 1.4). A total of 12 Paleocene continental gastropod species are now known from the Paleocene Las Encinas, Adjuntas, and Carroza formations (Figure 3).

Figure 2 illustrates the Upper Cretaceous and Paleocene lithostratigraphic units of the Difunta Group (Parras and La Popa basins), indicating those that yield continental gastropods, for a total of 42 species now known from the Campanian-Paleocene deposits of the Difunta Group (Figure 3). Acronym used: CPC which stands for the Colección de Paleontología, Museo del Desierto, Saltillo, Coahuila.

The order of families is based on Bouchet *et al.* (2017).

Ma	Period	Epoch	Stage	Parras Basin	La Popa Basin
56	PALEOGENE	Paleocene	Thanetian	---	CARROZA *
57				RANCHO NUEVO	VIENTO
58			LAS ENCINAS	Selandian	---
59	Danian	---			
60			CERRO GRANDE	---	
61					
62					
63					
64	CRETACEOUS	Upper	Upper	---	
65			Maas-trichtian		LAS IMÁGENES
66					Lower
67	Campanian	---	CERRO HUERTA	---	
68			CERRO DEL PUEBLO *		
69			PARRAS SHALE		MUERTO
70				PARRAS SHALE	
71					
72					
73					

Figure 2 Distribution of continental gastropods in Campanian and Paleocene lithostratigraphic units of the Difunta Group, Parras and La Popa basins..

3. Systematic paleontology

- Class Gastropoda Cuvier, 1797
- Subclass Caenogastropoda Cox, 1959
- Order Sorbeoconcha Ponder and Lindberg, 1997
- Superfamily Cerithioidea Fleming, 1822
- Family Hemisinidae Fischer and Crosse, 1891
- Genus *Pyrgulifera* Meek, 1877
- Pyrgulifera humerosa* (Meek, 1860)
- Figures 4.1 – 4.3

Description. Elongate shell, with concave shoulder and transversal ribs that finish as tubercles. Fine spiral lines and fine growth lines over the ribs, which give the shell reticulate appearance. Suture well marked. Apex not well preserved and aperture absent.

Material examined. Four specimens, CPC-1034, height = 26.3 mm, width = 17.1 mm, whorls = 6; CPC-1035, height = 21.7 mm, width = 12.6 mm, whorls = 5; CPC-1036, height = 18.7

Difunta Group

GASTROPOD SPECIES	PARRAS BASIN		LA POPA BASIN	
	Campanian	Paleocene	Paleocene	
	Cerro del Pueblo Formation	Las Encinas Formation	Adjuntas Formation	Carroza Formation
Littorinidae				
Genus indeterminate	X			
Naticidae				
<i>Natica</i> sp.			X	
Viviparidae				
<i>Viviparus mcbridei</i>		X		
<i>Viviparus</i> cf. <i>V. leidyi</i>		X		
<i>Viviparus</i> cf. <i>V. raynoldsanus</i>		X		
<i>Viviparus</i> cf. <i>V. australis</i>	X			
Epitoniidae				
<i>Acirsa</i> cf. <i>A. gravaida</i>	X			
Pachychilidae				
" <i>Melanatria</i> " sp.			X	
? <i>Melanatria</i> sp.			X	
<i>Moniquia ypresiana</i>		X	X	
<i>Moniquia</i> cf. <i>M. ypresiana</i>		X		
<i>Pachychilus lawtoni</i>				X
Pleuroceridae				
<i>Goniobasis unilirata</i>	X			
<i>Pleurocera gigantea</i>		X		
Pyrguliferidae				
? <i>Pyrgulifera</i> sp.	X			
<i>Pyrgulifera humerosa</i>	X			
Potamididae				
<i>Tympanotonus</i> (<i>T.</i>) <i>nodosa</i>	X			
Thiaridae				
<i>Hemisinus reticulosus</i>			X	
<i>Hemisinus adjuntaensis</i>			X	
<i>Melanoides</i> (<i>M.</i>) <i>yolandae</i>	X			
<i>Melanoides</i> (<i>M.</i>) <i>wollebeni</i>	X			
<i>Pachymelania wyomingensis</i>	X			
Hydrobiidae				
<i>Birgella burchi</i>	X			
Cylichnoidea				
<i>Cylichna</i> sp.	X			
Physidae				
Genus indeterminate	X			
<i>Haitia taylori</i>	X			
<i>Physa</i> sp.	X			
<i>Physa cepedaensis</i>	X			
<i>Physa</i> cf. <i>P. michaudi</i>	X			
<i>Physa</i> cf. <i>P. usitata</i>	X			
<i>Mesolanistes magnus</i>	X			
<i>Mesolanistes murrayi</i>	X			
Planorbidae				
<i>Bulinus</i> cf. <i>B. atavus</i>	X			
<i>Bulinus</i> sp. 1	X			
<i>Bulinus</i> sp. 2	X			
<i>Bulinus</i> sp. 3	X			
<i>Bulinus</i> sp. 4	X			
<i>Gyraulus zoltani</i>	X			
Holospiridae				
<i>Holospira</i> sp.	X			
<i>Holospira thompsoni</i>	X			
Helicidae				
Genus indeterminate	X			
Zonitidae				
Genus indeterminate	X			

Figure 3 List of continental gastropod species reported for the Cerro del Pueblo (Campanian), the Las Encinas (Paleocene), the Adjuntas and Carroza formations, Parras and La Popa basins, Difunta Group, Coahuila and Nuevo León, NE Mexico.

mm, width = 14.4 mm, whorls = 6 remaining; CPC-1037, height = 19.6 mm, width = 14.0 mm, whorls = 4 remaining.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian. Wyoming, Bear River Formation, Eocene; Sulphur Creek, Utah, Upper Kanab.

Discussion. The specimens studied here have the characteristics seen in *Pyrgulifera humerosa* (Meek, 1860) from the Cenomanian Bear River Formation, Wyoming. Yen (1958) reached the conclusion that the genus became extinct in the Maastrichtian.

Pyrgulifera has been found in limestone and calcareous shales, together with fresh water genera. However, there is evidence that it was in associations of alternating fresh to brackish water, nonetheless of low salinity (estuary) (Yen, 1958). *Pyrgulifera* Meek, 1877 is a fossil mollusk inhabiting brackish and freshwater environments, although Bandel and Riedel (1994) suggested that the habitat for the genus was more of brackish water, with certain tolerance of fresh water. Its distribution was greatest during the Late Cretaceous and also during the late Cenomanian (Yen, 1958). Its distribution includes the Sulphur Creek, near Bear River, southwest Wyoming (Yen, 1958). In Europe, it has been found in southern France in lignite beds in the Rhone River basin. Yen (1958) considered *Hantkenia munieri* Repelin, 1902 from the upper Cenomanian Gardonian Formation of southeast France, a true *Pyrgulifera*. Various species of *Pyrgulifera* were described from the coal beds of the Gosau Formation close to Brandenberg, Austria. In addition, in western Hungary other set of species was described from the coal seams of the Ajka Formation (Yen, 1958). Stilwell (1997) recorded *Pyrgulifera kahuitara* Stilwell, 1997 from the Campanian?-Maastrichtian Kahuitara Tuff of Pitt Island,

New Zealand. To Stilwell (1997), *Pyrgulifera* distribution includes Cenomanian to Danian fossiliferous beds of Europe, North America, Asia, India, New Caledonia, and Chatman Islands. However, differing from Yen (1958) who believed that *Pyrgulifera* was a brackish and freshwater inhabitant, Stilwell (1997), at least for *Pyrgulifera kahuitara*, considered it from a marine environment.

Family Pachychilidae Fischer and Crosse, 1892

Genus *Moniquia* Pacaud and Harzhauser, 2012

Moniquia ypresiana (Vega and Perrilliat, 1992) new combination

Figures 4.10, 4.11

Description. Shell medium-sized, turreted; protoconch unknown; teleoconch of four whorls, convex; sculpture of curved axials of moderate strength that extends from suture below almost to suture above; spiral sculpture of threads of subequal strength; aperture not preserved.

Material examined. Two specimens, CPC-2145, height = 62.3 mm, width = 19.2 mm, whorls = 6; CPC-2146, height = 9.2 mm, width = 6.2 mm, whorls = 5.

Occurrence. La Leona, Ramos Arizpe, Coahuila, Las Encinas Formation, Paleocene.

Discussion. Pacaud and Harzhauser (2012) made a review of Cretaceous and Paleogene species of relatively similar genera, including *Melanatria* Bowdich, 1822. Most of the morphological features used by these authors to erect the genus *Moniquia* are found in the numerous specimens of *M. ypresiana*, first reported from the Paleocene Adjuntas Formation of La Popa Basin, Difunta Group, Nuevo León (Vega and Perrilliat, 1992). Although an early Eocene age (Ypresian) age was originally interpreted for the Adjuntas Formation, more recent data suggest a middle Paleocene age for this lithostratigraphic unit (Lawton *et al.*, 2009).

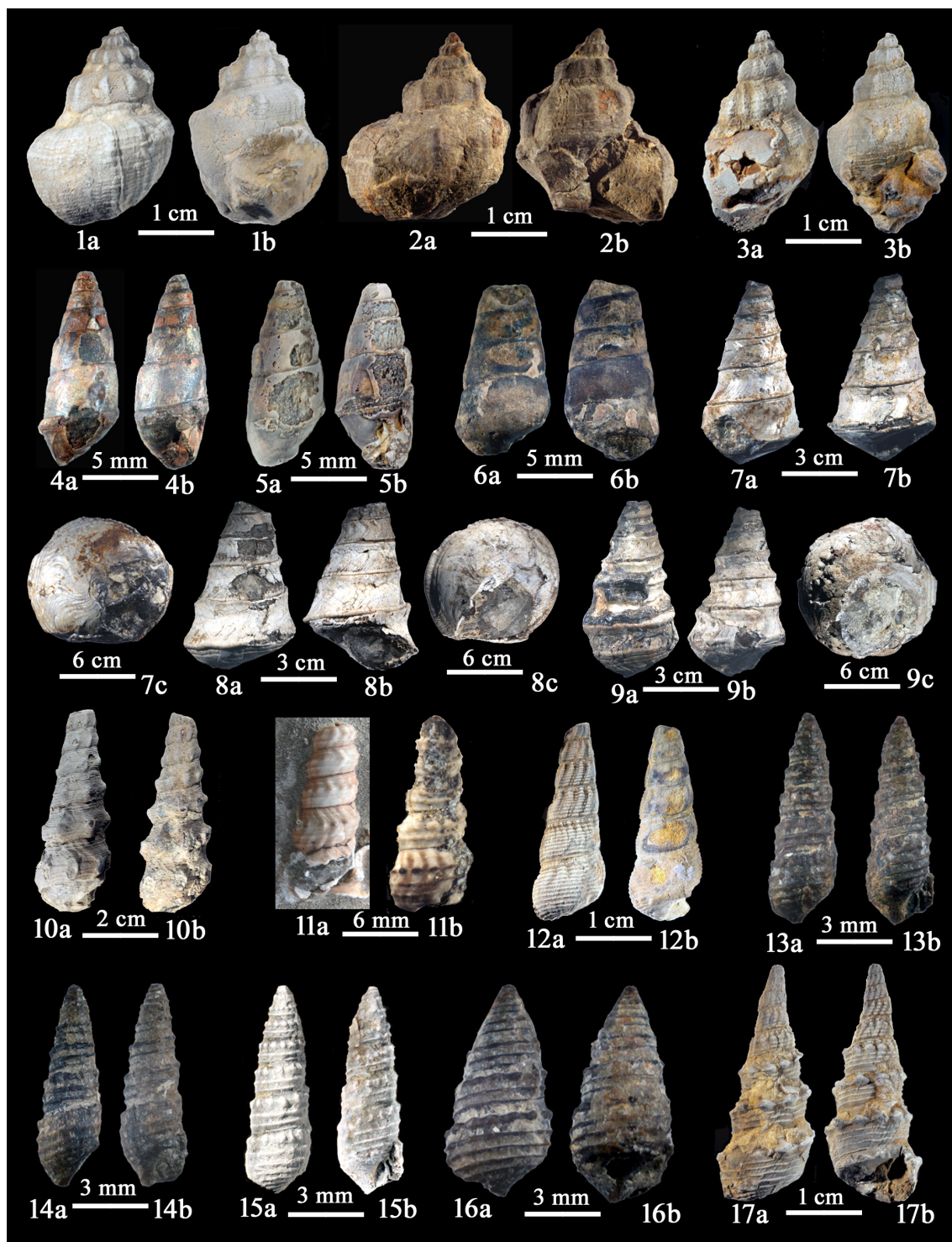


Figure 4 1 - 3, *Pyrgulifera humerosa*; 1a, 1,034, ad.; 1b, ap.; 2a, 1,035, ad.; 2b, ap.; 3a, 1036, ad.; 3b, ap. 4 - 6, *Goniobasis unilirata* Naranjo-García and Aguillón, n. sp.; 4a, ho. 1042, ad.; 4b, ap.; 5a, pa. 1,043, ad.; 5b, ap.; 6a, pa. 1,044, ad.; 6b, ap. 7 - 9, *Pleurocera gigantea* Naranjo-García and Aguillón, n. sp.; 7a, ho. 1047, ad.; 7b, ap.; 7c, po.; 8a, pa. 1048, ad.; 8b, ap.; 8c, po.; 9a, pa. 1,049, ad.; 9b, ap.; 9c, po. 10, 11, *Moniquia ypresiana*; 10a, 2145, ad.; 10b, ap.; 11a, 2146, ad.; 11b, ap. 12, *Acirsa* cf. *A. gravida*; 12a, 2160, ad.; 12b, ap. 13 - 15, *Melanoides* (*Melanoides*) *yolandae*; 13a, 1,038, ad.; 13b, ap.; 14a, 1,039, ad.; 14b, ap.; 15a, 1,040, ad.; 15b, ap. 16, *M. (M.) wollebeni*; 16a, XXXX, ad.; 16b, ap. 17, *Pachymelania wyomingensis*; 17a, 2147, ad.; 17b, ap. 1 - 6, 12 - 17, Coahuila, Cerro del Pueblo Formation, Campanian; 7 - 11, Coahuila, Las Encinas Formation, Paleocene. Ad = adapertural, ap = apertural, ho = holotype, pa = paratype, po = posterior.

Specimens are abundant in green mudstone of delta plain facies in the Adjuntas and Las Encinas formations.

Family Pleuroceridae Fischer, 1885

Genus *Goniobasis* Lea, 1862

Goniobasis unilirata Naranjo-García and Aguillón,
new species

Figures 4.4 – 4.6

Diagnosis. Medium sized elongate conic shell, 5 to 7 whorls; smooth surface, with carinate periphery, aperture elongated, bent columella.

Description. Medium sized shell, elongate conic, whorls flattened, well-marked suture, 5 to 7 whorls. Smooth surface, with carinate periphery over the body whorl, apex unknown, aperture elongated, bent columella to the outside with a lamella over it.

Material examined. Five specimens, holotype CPC-1042, height = 14.9 mm, width = 6.0 mm, whorls = 6; paratype CPC-1043, height = 13.5 mm, width = 5.9 mm, whorls = 5; paratype CPC-1044, height = 10.6 mm, width = 4.8 mm, whorls unmeasurable; paratype CPC-1045, height = 9.9 mm, width = 5.2 mm, whorls = 5 remaining; paratype CPC-1046, height = 9.6 mm, width = 4.8 mm, whorls = 7.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. *Goniobasis unilirata* n. sp. resembles *G. macilenta* White, 1895 of the Bear River Formation of Wyoming and Utah, in the flattened whorls and smooth surface (Grabau and Shimer, 1909). However, *G. macilenta* has no carina over the body whorl, being taller and more slender than *G. unilirata* n. sp. The family Pleuroceridae has an ample distribution. It is found in North and South America, Africa, and Asia. However, the family has had its maximum development in North America (Burch, 1989).

Etymology. The name “unilirata” is given due to the presence of a ridge over the shoulder of the body whorl of the specimens.

Genus *Pleurocera* Rafinesque, 1818

Pleurocera gigantea Naranjo-García and Aguillón,
new species

Figures 4.7 – 4.9

Diagnosis. Shell conic elongated, imperforated, over 10 whorls; whorls with well-marked wave shaped growth lines, with basal cord over the suture; suture strongly indented; base of body whorl with three to six spiral cords; periphery of shell angular at body whorl; parietal callus ample, extending to columellar base.

Description. Shell conic elongated, imperforated, all the specimens lack the apex. The species has over 10 whorls. Sculpture: whorls remaining with well-marked wave shaped growth lines (retracted in the middle: »). Whorls have a basal cord over the suture. Suture strongly indented, whorls round and swollen below the cord of previous whorl. Base of body whorl with three to six spiral cords (three in juvenile specimens and six in mature ones). One cord at the edge of the whorl, the most voluminous (prominent), and the other immediately below (less developed), then 4 spiral incised lines after the cords. At body whorl the periphery of shell is angular. Parietal callus ample, which extends to columellar base; rest of aperture unknown.

Material examined. Twelve specimens, see Table 1.

Occurrence. La Leona, Ramos Arizpe, Coahuila, Las Encinas Formation, Paleocene.

Discussion. *Pleurocera gigantea* n. sp. resembles *P. unciale hastatum* (Anthony, 1854) of the Recent, from North and South Fork of the Holston River, Sullivan County Tennessee (Burch, 1988) in the general outline of the shell; its body whorl is also angular, with two cords at the base close to the

Table 1. Measurements of *Pleurocera gigantea* Naranjo-García and Aguillón new species, from the Paleocene Las Encinas Formation, Parras Basin.

Catalog number	Type	Height mm	Width mm	Whorls number
CPC-1,047	Holotype	74.5	43	7
CPC-1,048	Paratype	80.6	45	7
CPC-1,049	Paratype	74.7	~39.9 (incomplete aperture)	7
CPC-1,050	Paratype	61.8	42.6 (incomplete aperture)	5
CPC-1,051	Paratype	71	50.8	4
CPC-1,052	Paratype	67	38.9	8
CPC-1,053	Paratype	66.3	38.6	8
CPC-1,054	Paratype	80.8	43.2	8
CPC-1,055	Paratype	61.5	43.5	5
CPC-1,056	Paratype	95.2	47.3	5
CPC-1,057	Paratype	84.7	51.9	
CPC-1,058	Paratype	61.5	Sectioned specimen in the middle	4

suture. Also, the new species reached over 100 mm, while *P. unciale hastatum* has a height of 23.5 mm; other differences are that *P. gigantea* n. sp. has a deeper suture and the base of the body whorl has 4 spiral incised lines after the cords. It should be noted that the known Pleuroceridae of the Recent from the United States are small (about 22 mm; Burch, 1989), and in South America can reach 50 mm (Simone, 2006). The specimens examined here are three to five times taller.

The family Pleuroceridae is distributed in North and South America, Africa and Asia; nonetheless, its maximum diversity is seen in North America (Burch, 1989). It is of interest to note that Mesozoic and Paleogene records were very different to the faunas seen in later times (Pliocene), Taylor (1985) alludes to a remarkable situation, pointing out that among other freshwater molluscan families the Pleuroceridae was of a massive size. Such is the case of the *Pleurocera gigantea* described herein. In the Recent, *Goniobasis* and *Pleurocera* have a large number of North American species (Thiele, 1931-1935).

Etymology. It is named because of the unusual big size for a *Pleurocera* species.

Family Thiariidae Gill, 1871

Genus *Melanooides* Oliver, 1804

Melanooides (Melanooides) yolandae Perrilliat, Vega, Espinosa and Naranjo-García, 2008
Figures 4.13 – 4.15

Description. Shell small, slender, turreted; protoconch unknown; teleoconch of eight whorls; whorls profile straight; suture impressed; the first three whorls with two beaded spirals, subsequent whorls with three beaded spirals, the anterior whorl less prominent; last whorl with eight spirals, only the upper three remain beaded, the others becoming nearly smooth; axial sculpture not preserved; aperture ovate.

Material examined. Three specimens, CPC-1038, height = 10.3 mm, width = 2.2 mm, whorls = 6; CPC-1039, height = 9.8 mm, width = 2.3 mm, whorls = 5; CPC-1040, height = 10.7 mm, width = 2.4 mm, whorls = 6.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. More than 200 specimens of this species were reported by Perrilliat *et al.* (2008) from outcrops of the upper Campanian Cerro del Pueblo Formation near Rincón Colorado, 7 km NE of General Cepeda, Coahuila, being one of the most abundant continental species of the Difunta Group.

Melanooides (Melanooides) wollebeni Perrilliat, Vega, Espinosa and Naranjo-García, 2008
Figures 4.16

Description. Shell small, narrowly conic or turritiform; whorls flattened on the periphery, with two spiral cords that become three over the body whorl. The upper cord wider, the middle less developed

and the third cord underdeveloped. Chain of spiral papillae over shoulder. Body whorl with 6 to 7 spiral ribs. Aperture with thick callus over columella. Apex and aperture not well preserved.

Material examined. Four specimens, CPC-1038, height = 9.9 mm, width = 3.2 mm, whorls = 7; CPC-1039, height = 10.3 mm, width = 3.9 mm, whorls = 4; CPC-1040, height = 10.3 mm, width = 3.2 mm, 8 whorls; CPC-1041, height = 5.4 mm, width = 2.5 mm, whorls = 6.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. The specimens differ from *Melanoides (Melanoides) yolandae* Perrilliat, Vega, Espinosa and Naranjo-García, 2008, being wider, with weaker tubercles on last whorl spirals. *M. (M.) yolandae* has two chains of nodules over the entire shell, and the observed specimens of *M. (M.) wollebeni* have only one chain of nodules over the shoulder. The Family Thiaridae is known from Africa, Asia and the Americas. Their closer relatives are the Planaxidae (Morrison, 1954). Thiarids use partenogenetic reproduction and inhabit fresh water (Burch, 1989). The family Thiaridae represents the tropical assemblage of the fauna (Taylor, 1985). *Melanoides* is also found in Quaternary deposits in northeast Africa and Asia (Williamson, 1981; Leng, *et al.*, 1999). In the Recent, is distributed in southeast Asia, India and South Africa (with 30 species) (De Kock and Wolmarans 2009). Morrison (1954) stated that all species of the genus are ovoviviparous and partenogenetic. They live in lentic or lotic waters and might be intermediate host of human or animal parasites (Pointier, 1999). In addition, the species *Melanoides tuberculata* (Müller, 1774) had become an invasive species in new habitats where it is introduced (Gutiérrez-Amador *et al.*, 1995). Nowadays, it is widely spread around the world (Abbott, 1973; Pointier *et al.*, 1993; Contreras-Arquieta and Contreras-Balderas, 2000; Guimarães

et al., 2001; Facon *et al.*, 2003). *M. tuberculata* has a rapid growth and it has numerous offspring. It withstands desiccation and lives in diverse habitats and has a life span of 2 years (Dudgeon, 1989).

Genus *Pachymelania* Smith, 1893

Pachymelania woyomingensis (Meek, 1873)

Figures 4.17, 5.1 – 5.12

Description. Shell medium-sized, moderately convex; teleoconch of seven whorls; suture linear; sculpture in last whorls with a prominent, strong spiral rib, outward projecting with tubercles; upper whorls with crenulated longitudinal ribs, crossed by five spiral lines.

Material examined. Eight specimens, see Table 2.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. This is by far the most abundant continental gastropod from the upper Campanian

Table 2. Measurements of *Pachymelania woyomingensis* (Meek, 1873), from the upper Campanian Cerro del Pueblo Formation, Parras Basin.

Catalog number	Height mm	Width mm	Whorls number
CPC-2147	41.5	8.7	8
CPC-2148	38.6	6.9	7
CPC-2149	37.7	8.2	9
CPC-2150	28.1	6.6	8
CPC-2151	27.2	8.8	7
CPC-2152	30.1	7.9	7
CPC-2153	32.3	8.9	7
CPC-2154	22.8	10.2	5
CPC-2155	30.1	6.2	7
CPC-2156	35.4	5.8	8
CPC-2157	20.8	9.5	5
CPC-2158	33.3	8.1	7
CPC-2159	25.5	7.8	7

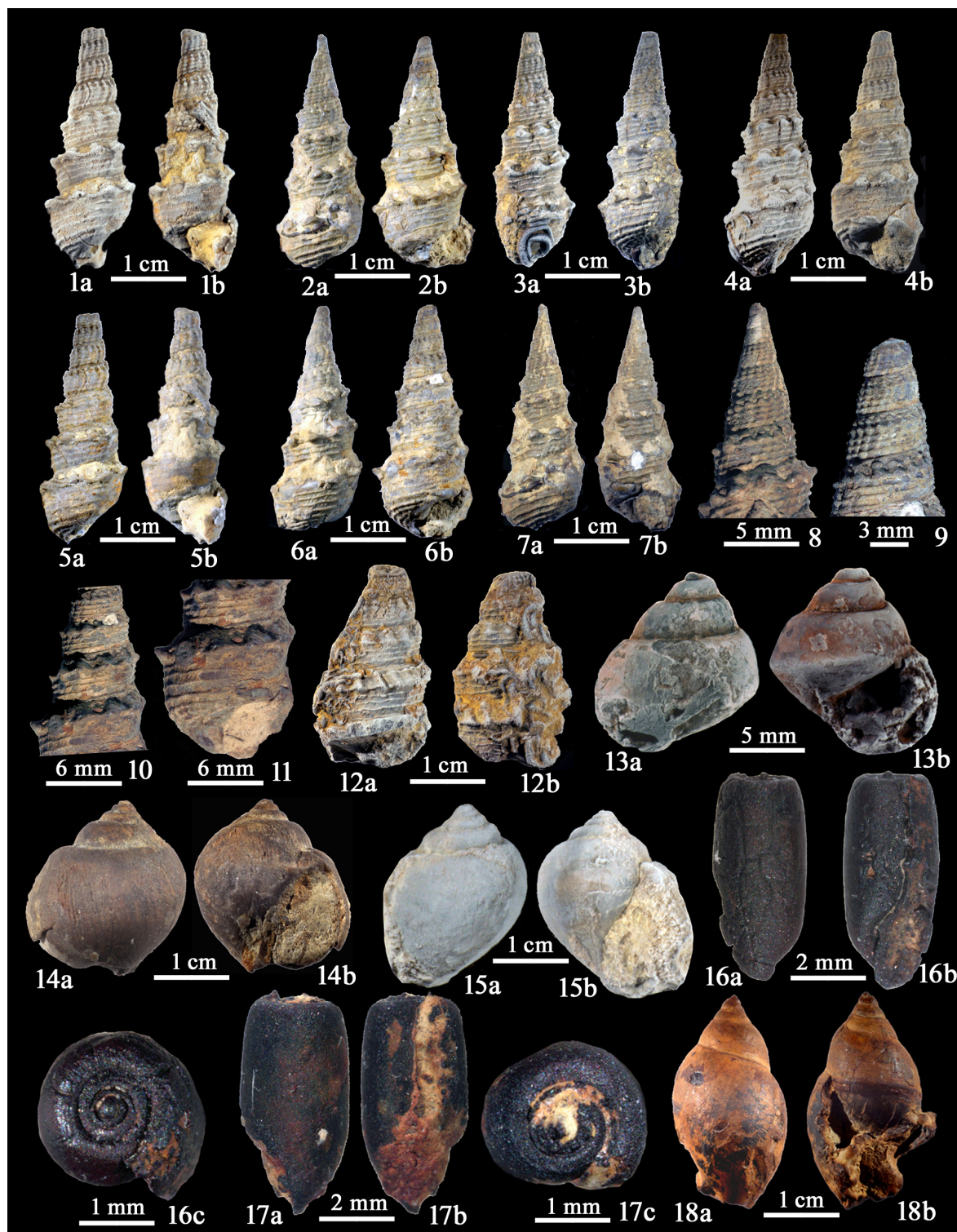


Figure 5 1 – 12, *Pachymelania wyomingensis*; 1a, 2148, ad.; 1b, ap.; 2a, 2149, ad.; 2b, ap.; 3a, 2150, ad.; 3b, ap.; 4a, 2151, ad.; 4b, ap.; 5a, 2152, ad.; 5b, ap.; 6a, 2153, ad.; 6b, ap.; 7a, 2154, ad.; 7b, ap.; 8, 2155, spi.; 9, 2156, spi.; 10, 2157, spi.; 11, 2158, ap.; 12a, 2159, ad.; 12b, ap. 13, Littorinidae; 13a, 2161, ad.; 13b, ap. 14, 15, *Birgella burchi* Naranjo-García and Aguillón, n. sp.; 14a, ho. 1032, ad.; 14b, ap.; 15a, pa. 1033, ad.; 15b, ap. 16, 17, *Cylichna* sp.; 16a, 2162, ad.; 16b, ap.; 16c, an.; 17a, 2163, ad.; 17b, ap.; 17c, an. 18, *Physa* sp.; 18a, 1059, ad.; 18b, ap. Coahuila, Cerro del Pueblo Formation, Campanian. Ad = adapertural, an = anterior, ap = apertural, ho = holotype, pa = paratype, spi = spire.

Cerro del Pueblo Formation. Some specimens have attached serpulid worms and ostreoids, suggesting an estuarine habitat. This species was also reported from the Maastrichtian Laramie Formation of Colorado (Hartman, 1998) and Wyoming (Taylor, 1975).

Superfamily Epitonioida Berry, 1910

Family Epitoniidae Berry, 1910

Genus *Acirsa* Mørch, 1857

Acirsa cf. *A. gravida* Sohl, 1964

Figure 4.12

Description. Shell medium-sized, moderately convex; teleoconch of five whorls; suture linear; sculpture in last whorls with a prominent, strong spiral rib, outward projecting with tubercles; upper whorls with crenulated longitudinal ribs, crossed by five spiral lines.

Material examined. One specimen, CPC-2160, height = 23.2 mm, width = 8.4 mm, whorls = 5.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. This species was reported from the Maastrichtian Coffee Sand of Mississippi (Sohl, 1964).

Superfamily Littorinoidea Children, 1834

Family Littorinidae Children, 1834

Genus indeterminate

Figure 5.13

Description. Small trochiform shell, protoconch not preserved, spire with three whorls; narrow umbilicus; aperture wide, subovate.

Material examined. One specimen, CPC-2161, height = 15.1 mm, width = 18.6 mm, whorls = 3.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. The single specimen is poorly preserved and a more detailed identification is not possible.

Superfamily Rissooidea Gray, 1847

Family Hydrobiidae Stimpson, 1865

Genus *Birgella* Baker, 1926

Birgella burchi Naranjo-García and Aguillón, new species

Figures 5.14, 5.15

Diagnosis. Shell small, globose; growth lines marked; small umbilicus with lip of columella bent over; aperture roundly-lunate.

Description. Shell globose, small, round whorls, slightly indented suture. Growth lines marked, more so, near to suture. Apex unknown, lip of columella bent over the small umbilicus. Aperture roundly lunate. Height of aperture about two-thirds the height of shell.

Material examined. Two specimens, holotype CPC-1032, height = 8.5 mm, width = 8.5 mm, whorls = 6; paratype CPC-1033, height = 7.4 mm, width = 7.4 mm whorls = 5.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. *Birgella burchi* n. sp. is closer to *B. subglobosa* (Say, 1825), a Recent species from the Great Lakes, United States. The species differ in the size, with *B. burchi* n. sp. being taller. In *B. subglobosa* the aperture is round and less than two-thirds the height of shell. It possesses fewer whorls (4), the suture is more deeply marked and the whorl of the spire has a shoulder. *B. subglobosa* has also an umbilicus with a straight lip of the columella. In *B. burchi* n. sp., the spire is shorter and the aperture taller. The width and height of the shell are equal, while *B. subglobosa* is taller than wide. The Family Hydrobiidae is widely distributed and common around the world in temperate, subtropical, and tropical regions. The vast majority of species inhabit fresh-water bodies, although few inhabit brackish water (Burch, 1989). Recent molecular-based studies (Wilke *et al.*, 2013) strongly support the monophyly of the family Hydrobiidae, which is part of the big and taxonomically problematic superfamily Rissooidea. For the moment, Wilke *et al.* (2013)

remarked that more in-depth studies are needed to identify its sister group relationships. The Hydrobiidae is distributed in western Palearctic, eastern Nearctic, northern Neotropic and in South Africa (Wilke *et al.*, 2013).

Etymology. The species is named after Dr. John B. Burch, who had greatly contributed to the knowledge of freshwater mollusks of North America.

Order Cephalaspidea Fischer, 1883
 Superfamily Cylichnoidea Adams and Adams,
 1854
 Family Cylichnidae Adams and Adams, 1854
 Genus *Cylichna* Lovén, 1847
Cylichna sp.
 Figures 5.16, 5.17

Description. Shell small, slender, rounded at inferior extremity, subtruncated above. Shell smooth. Aperture long. Columella twisted and bears weak fold.

Material examined. Two specimens, CPC-2162, height = 6.5 mm, width = 2.9 mm; hypotype CPC-2163, height = 7.2 mm, width = 2.9 mm.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. Perrilliat *et al.* (2000) reported *Cylichna secalina* Shumard, 1861 from the late Maastrichtian Mexcala Formation of Guerrero, Southern Mexico. The species was originally reported from the Upper Cretaceous Nacatoch Sand of Texas and the Ripley Formation of Mississippi. The poor preservation of the specimens here reported prevents a specific determination.

Order Basommatophora Schmidt, 1855
 Superfamily Planorboidea Rafinesque, 1815
 Family Physidae Fitzinger, 1833
 Figures 6.16, 6.17

Description. Shell small, elongate; protoconch unknown; teleoconch of five whorls, flat; suture channelled; surface smooth; aperture not preserved.

Material examined. Two specimens, CPC-2164, height = 8.1 mm, width = 2.6 mm, whorls = 4; CPC-2165, height = 10.1 mm, width = 5.4 mm, whorls = 4.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. The specimens resemble *Bulinus* sp. 4, reported by Perrilliat *et al.* (2008, p. 264, fig. 5.16, 5.17) from the upper Campanian Cerro del Pueblo Formation at General Cepeda, Coahuila.

Genus *Physa* Draparnaud, 1801
Physa sp.
 Figure 5.18

Description. Shell sinistral, oval, of medium size, with marked growth lines over the body whorl (just in one specimen), whorls slightly swollen, suture slightly indented, shiny shell surface, apex and aperture of shell not present.

Material examined. Ten specimens, see Table 3.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. *Physa* sp. resembles some forms of *P. acuta* Draparnaud, 1805, in particular that from Connecticut, Litchfield County, Salisbury, north

Table 3. Measurements of *Physa* sp., from the upper Campanian Cerro del Pueblo Formation, Parras Basin.

Catalogue number	Type	Height mm	Width mm	Whorls number
CPC-1,059	Hypotype	19.2	10.5 compressed specimen	5
CPC-1,060	Hypotype	15.8	7.5 compressed specimen and cast	3 ½
CPC-1,061	Hypotype	15.5	8.0 cast	4 ½
CPC-1,062	Hypotype	15	9.1 cast	3 ½
CPC-1,063	Hypotype	14.9	8.5	5 ½
CPC-1,064	Hypotype	14.7	8.7 cast	2 ½
CPC-1,065	Hypotype	13.5	6.1 compressed specimen	5 ½
CPC-1,066	Hypotype	10.1	4.9 compressed specimen and collapsed over itself	5
CPC-1,067	Hypotype	9	4.9 collapsed over itself	5
CPC-1,068	Hypotype	8.9	4.8	4

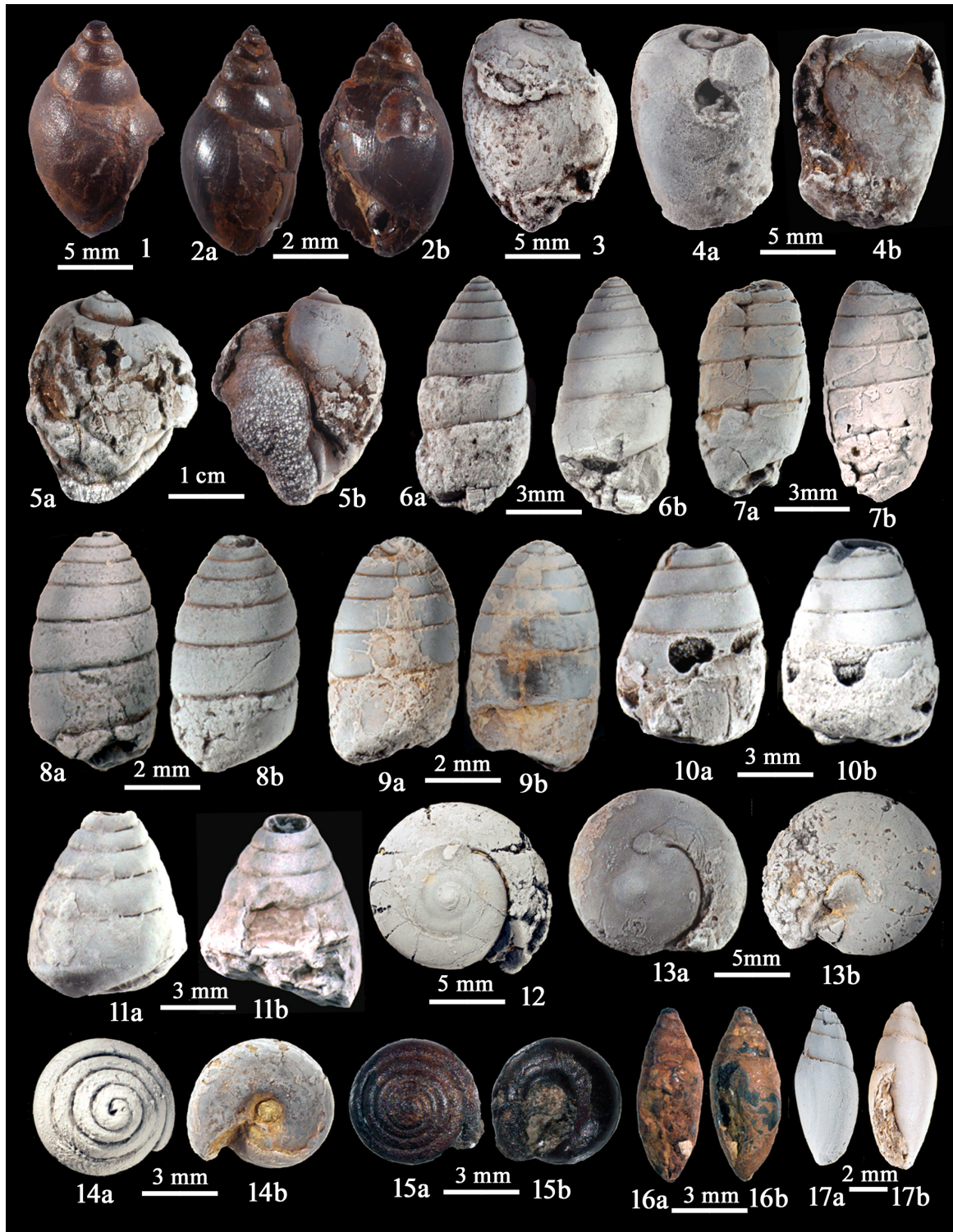


Figure 6 1, 2, *Haitia taylori* Naranjo-García and Aguillón, n. sp.; 1, pa. 1070, ad.; 2a, ho. 1069, ad.; 2b, ap. 3 - 5, *Mesolanistes* sp.; 3, 2166, ad.; 4a, 2167, ad.; 4b, ap.; 5a, 2168, ad.; 5b, ap. 6 - 9, *Holospira thompsoni* Naranjo-García and Aguillón, n. sp.; 6a, ho. 1,071, ad.; 6b, ap.; 8a, pa. 1,072, ad.; 8b, ap.; 9a, pa. 1,073, ad.; 9b, ap. 10, 11, *Holospira* sp.; 10a, 1,074, ad.; 10b, ap.; 11a, 1,075, ad.; 11b, ap. 12, 13, *Helicidae*; 12, 2169, an.; 13a, 2170, an.; 13b, po. 14, 15, *Zonitidae*; 14a, 2171, an.; 14b, po.; 15a, 2172, an.; 15b, po. 16, 17, *Physidae*; 16a, 2164, ad.; 16b, ap.; 17a, 2165, ad.; 17b, ap. Coahuila, Cerro del Pueblo Formation, Campanian. Ad = adapertural, an = anterior, ap = apertural, ho = holotype, pa = paratype, po = posterior.

shore of Lake Wononscopomuc (Taylor, 2003). However, our specimens of *Physa* sp. reach higher sizes and *P. acuta* from Lake Wononscopomuc is 13.5 to 12.2 mm in height. In *Physa* sp. the aperture of the shell inserts in the body whorl at about half the height of the shell, while in *P. acuta* from Lake Wononscopomuc the aperture inserts in the first third of the body whorl.

Genus *Mesolanistes* Yen, 1945

Mesolanistes sp.

Figures 6.3 – 6.5

Description. Shell small to medium-sized, ovate; commonly with moderately elevated spire of three whorls but depressed in some specimens; suture incised; last whorl enlarging rapidly; aperture ovate; sculpture of fine axial ribs.

Material examined. Three specimens, CPC-2166, height = 28.1 mm, width = 26.6 mm, whorls = 3; CPC-2167, height = 30.2 mm, width = 25.6 mm, whorls = 3; CPC-2168, height = 42.5 mm, width = 33.6 mm, whorls = 3.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. Perrilliat *et al.* (2008) described two species of *Mesolanistes* from the upper Campanian Cerro del Pueblo Formation, in outcrops found near Rincón Colorado, Coahuila. The specimens here reported cannot be assigned to any of those species, due to the poor preservation of the hematised remains.

Genus *Haitia* Clench and Aguayo, 1932

Haitia taylori Naranjo-García and Aguillón, new species

Figures 6.1, 6.2

Diagnosis. Shell broadly conic, small, sinistral; growth lines marked; height of aperture half the height of shell.

Description. Small, sinistral shell; broadly conic; whorls somewhat round; suture slightly indented, growth lines marked. Apex not preserved. Height of aperture about half the height of shell, aperture not preserved.

Material examined. Two specimens, holotype CPC-1069, height = 7.62 mm, width = 4.15 mm, whorls = 6 1/2; paratype CPC-1070, height = 6.96 mm, width = 3.55 mm, whorls = 6.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. *Haitia taylori* n. sp. resembles *H. pomilia* (Conrad, 1834) of Alabama, Randons Creek, near Clairborne, Monroe County of the Recent (Taylor, 2003). These species are alike in the general shape of the shell. The height of the aperture reaches over half the length of the shell but both species differ in size; *H. pomilia* is over two times the size of *H. taylori*, which is less globose than *H. pomilia*. The Physidae are found from the northern temperate to the Arctic, as well as throughout the Americas. These freshwater mollusks live in small to large water bodies (ditches, ponds, lakes, brooks and rivers). The genus *Physa* is distributed from Eurasia, in the temperate and Arctic zone, and in North America (Taylor, 2003). Today some species of *Physa* became invasive in places where they have been introduced, for example *Physa acuta* Draparnaud, 1805 is found in Europe, Africa, some places in Asia, Australia, and South Africa (Pointier and Marquet, 1990; Appleton, 2003; Guo *et al.*, 2009; Zukowski and Walker 2009; Van Leeuwen *et al.*, 2013). In addition, the genus *Haitia* is part of the fauna of the temperate and tropical areas of North America, the Antilles, Colombia, and the western side of South America, from Peru to middle Chile (Taylor, 2003). Physids can be found in all types of freshwater habitats (Burch, 1989).

Etymology. Named after the late Dr. Dwight W. Taylor, who dedicated much of his life to the study of the family Physidae.

Order Stylommatophora Schmidt, 1855
 Superfamily Urocoptoidea Uit de Weerd, 2008

Family Holospiridae Pilsbry, 1946

Holospira von Martens in Albers, 1860

Holospira thompsoni Naranjo-García and Aguillón,
 new species

Figures 6.6 – 6.9

Diagnosis. Shell subcylindrical, small, 7 to 8 whorls; suture nearly linear, surface smooth.

Description. Shell small, subcylindrical, obtuse apex, 7 to 8 whorls, compactly coiled firsts three whorls, the other four or five more loosely coiled; suture nearly linear. Surface smooth. Aperture unknown.

Material examined. Three specimens, holotype CPC-1071, height = 12.3 mm, width = 6.4 mm, whorls = 7; (two compressed specimens) paratype CPC-1072, height = 14.4 mm, whorls = 8 remaining; paratype CPC-1073, height = 13.1 mm, whorls = 7.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. *Holospira thompsoni* n. sp. differs from *Holospira* sp. from Temalac, Guerrero, Lower Maastrichian, Mexcala Formation (Perrilliat *et al.*, 2000) in the general shape of the shell which in *Holospira* sp. is subcylindrical with the obtuse apex, and has compactly coiled whorls, while in *H. thompsoni* n. sp. whorls grow slower and are ample. They also differ in size, being 9.5 to 12.1 mm in *Holospira* sp. while in *H. thompsoni* its height is 12.3 to 14.4 mm. Holospiridae are terrestrial pulmonate gastropods that inhabit submesic and xeric environments, from southern United States (south Texas, New Mexico and Arizona) to the north of Oaxaca (mid Mexico). They require limestone or dolomite terrains and their distribution is in narrow areas (Thompson and Mihalcik, 2005).

Etymology. *Holospira thompsoni* n. sp. is named after the late Fred G. Thompson of the University of Florida, because of his enormous contributions to the knowledge of the Central American non-marine mollusks of the area.

Holospira sp.

Figures 6.10, 6.11

Description. Shell of medium size, ovate-conic, apex absent, 5 whorls remaining, it has very narrow whorls near the apex, increasing relatively faster in width toward the aperture. Whorls flattened, suture slightly indented. Surface smooth, aperture not preserved.

Material examined. Two specimens, CPC-1074, height = 8.1 mm, width = 6.7 mm, whorls = 5; CPC-1075, height = 8.5 mm, width = 6.1 mm, whorls = 5.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. *Holospira* sp. differs from other Recent species in the shape of the first whorls, including *H. mesolia* from Sanderson, Terrell County, Texas, United States (Pilsbry, 1946) and *H. pasonis* Dall, 1895 of Mule canyon, El Paso County, Texas, United States (Pilsbry, 1946). However, it is not possible to assign this *Holospira* to any other known species or subgenera of the genus *Holospira*, which differ in the inside of the columella and in the presence or absence of lamellae (Thompson, 2011). Additionally, specimens are incomplete or they could be of juvenile age, and measure 8.1 and 8.5 mm and have 5 whorls. *H. mesolia* has a height that goes from 20 to 23.5 mm and has 12³/₄ to 14 whorls, *H. pasonis* has a height of 22.3 to 24.7 mm and has 11 to 11 1/2 whorls.

For Recent specimens of the genus *Holospira* the geographical distribution ranges from Texas, Arizona, New Mexico (Pilsbry, 1946) to most of Mexico (except The Peninsula of Baja California, Chiapas, Tabasco, Campeche and Yucatán) The genus *Holospira* gets to Oaxaca at about 29 degrees of latitude (Bequaert and Miller, 1973). Fossil specimens of the family Holospiridae date back to the New Mexico Paleocene (Cockerell, 1914), Lower Maastrichtian (Mexcala Formation), Temalac, Guerrero, Mexico (Perrilliat *et al.*, 2000), and the Tertiary deposits of Wyoming (Henderson, 1935). In the Recent the Family Holospiridae is

distributed from the states of Arizona, New Mexico, and Texas to central Mexico, these terrestrial snails today live and are abundant in dry climates where there are limestone and dolomite beds (Thompson and Mihalcik, 2005). The genus *Holospira* is known to inhabit the Recent from western Arizona, New Mexico and Texas in the United States to northern Oaxaca, Mexico (Thompson, 2011). *Holospira* spp. are usually found in limestone outcrops, where colonies have several individuals (Bequaert and Miller, 1973).

Superfamily Helicoidea Rafinesque, 1815

Family Helicidae Rafinesque 1815

Figures 6.12, 6.13

Description. Small, discoidal and compressed shell; umbilicus narrow; aperture not preserved.

Material examined. Two specimens, CPC-2169, height = 4.8 mm, width = 16.2 mm, whorls = 5; CPC-2170, height = 4.5 mm, width = 14.4 mm, whorls = 5.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. The hematized specimens represent the first record of helicid snails for the upper Campanian Cerro del Pueblo Formation.

Superfamily Zonitoidea Mørch, 1864

Family Zonitidae Mørch, 1864

Figures 6.14, 6.15

Description. Shell small, smooth, trochoid; umbilicus narrow.

Material examined. Two specimens, CPC-2171, height = 4.1 mm, width = 5.4 mm, whorls = 5; CPC-2172, height = 3.9 mm, width = 5.1 mm, whorls = 5.

Occurrence. Las Águilas/Porvenir de Jalpa, General Cepeda, Coahuila, Cerro del Pueblo Formation, upper Campanian.

Discussion. The specimens are very small and their preservation prevents offering a more precise identification.

4. Conclusions

The great diversity and abundance of continental mollusks found in the upper Campanian Cerro del Pueblo Formation is related to the paralic environments whose outcrops are found in a broad area. Their distribution includes several localities found west of Saltillo to north of the Parras Basin, near the border with the La Popa Basin. The lithology of these areas was controlled by mainly salt tectonics that formed small sub-basins, where brackish and freshwater environments prevailed during Paleocene times. Although the preservation of the shell of many species of continental gastropods from the Difunta Group can be acceptable, the main problem relies on that modern systematics of continental gastropods is based mainly on soft-body morphology and more recently, molecular biology. This report is presented in the hope that it can be useful as foundation for future work on paleoecology and evolution of the continental mollusk communities during the Late Cretaceous and Paleogene.

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