



# AN ENDEMIC CEPHALOPOD ASSEMBLAGE FROM THE LOWER CAMPANIAN (LATE CRETACEOUS) PARRAS SHALE, WESTERN COAHUILA, MEXICO

CHRISTINA IFRIM,<sup>1</sup> WOLFGANG STINNESBECK,<sup>1</sup> AND JOSÉ FLORES VENTURA<sup>2</sup>

<sup>1</sup>Geowissenschaftliches Institut, Universität Heidelberg, Im Neuenheimer Feld 234, 69120 Heidelberg, Germany, <christina.ifrim@geow.uni-heidelberg.de>; and <sup>2</sup>Santa Engracia 257, Fracc. Santa Elena, Saltillo C.P. 25015, Coahuila, México

**ABSTRACT**—The cephalopods from Union y Progreso represent the first fossil assemblage described from the Parras Shale in Coahuila, Mexico. *Pseudoschloenbachia* (*Pseudoschloenbachia*) aff. *P. (P.) mexicana* (Renz, 1936), *P. (P.) mexicana* (Renz, 1936), *Baculites haresi* Reeside, 1927, and *Menabites* (*Delawarella*) *vanuxemi* (Morton, 1830) have a geographically restricted occurrence. *Didymoceras* juv. sp., *Menuites* juv. sp., *Polyptychoceras* juv. sp., *Pseudoxybeloceras* (*Parasolenoceras*) juv. sp., and *Scaphites* sp. ex gr. *S. hippocrepis* (DeKay, 1828) are represented by juveniles and could not be determined to species level. *Desmophyllites diphylloides* (Forbes, 1846) is the only long-ranging, cosmopolitan species described from this assemblage. Three new species are described: *Eutrephoceras irritilasi* n. sp., *Hypophylloceras* (*Neophylloceras*) *arturoi* n. sp., and *Tetragonites silencioensis* n. sp. The morphotype *Baculites* n. sp. is also inferred to be distinct. The faunal composition of this assemblage indicates a late early Campanian age. This assemblage shows a high degree of endemism. The causes for this endemism are currently unknown and difficult to assess. Nevertheless, the generic composition of the Union y Progreso ammonite assemblage suggests a short-term early Campanian endemic event.

## INTRODUCTION

BIOSTRATIGRAPHIC ZONATION within the Western Interior (WI) is exceedingly high-resolution (Cobban et al., 2006) and based on ammonoids, but correlation with strata and faunal assemblages outside this region is less detailed because of the scarcity of common taxa. Intercontinental correlation by ammonites is based on few species and specimens, although inoceramids provide reliable biostratigraphic indices (compare Jagt et al., 2004; Cobban et al., 2006). During the Campanian (Late Cretaceous), the epeiric Western Interior Seaway (WIS) that connected the Gulf of Mexico to the Arctic Ocean shows a faunal evolution that was strongly endemic (Kauffman, 1973).

To the south, the paleogeographic delimitation of the WIS is placed in Texas where a submarine high was situated. The region to the south of this high has been considered part of the open-shelf of the Gulf of Mexico. In northeastern Mexico, however, WI faunal elements are repeatedly recorded in Upper Cretaceous strata (Ifrim et al., 2004; Stinnesbeck et al., 2005; Ifrim and Stinnesbeck, 2007). This region is thus located in the overlap between faunal provinces and allows for correlation of the WI faunal assemblages with those of the Gulf/Atlantic coastal plains of North America and Europe.

Here, we report on a new ammonite assemblage from the lower Campanian (Upper Cretaceous) Parras Shale at Union y Progreso, which is located approximately 160 km north of Torreon in the northwestern state of Coahuila, Mexico. The sample reported herein consists of 208 specimens referred to ten genera and thirteen ammonoid species, in addition to one nautiloid species. This diverse and well-preserved cephalopod assemblage sheds new insight on the faunal dynamics of the Campanian open shelf in the transition between the WIS and the Gulf of Mexico, but also allows for correlation of biostratigraphic zones between Europe and North America.

## LOCALITY AND FOSSIL PRESERVATION

The fossil site at Union y Progreso was discovered in the 1980s by private fossil collectors and is located approximately 160 km north of Torreon, in the state of Coahuila in northeastern Mexico (Fig. 1). The locality is reached by traveling north from Ejido Gavilan in Torreon to Laguna del Rey and then crossing Los Charcos de Risa. After 116 km on an unnumbered road, there is a dirt road that branches off to the right eastwards to Rancho El Porvenir. The fossil locality is situated 4.5 km down this road on its north side at N 26°45'6.45", W 103°10'5.62" and covers a circular area of about 10 hectares. The village of Union y Progreso is located approximately 1 km to the east of the fossil site (Fig. 2).

The cephalopod specimens were collected directly from surface exposures where they form part of the desert pavement after they weather out of the Parras Shale. This Upper Cretaceous formation was defined by Imlay (1936) to consist of >700 m fine-grained siliciclastics, predominantly shale. The sediment was deposited in a prodeltaic depositional setting (McBride et al., 1974). This unit crops out over broad expanses of southern and western Coahuila; however, there have been few geological studies of this formation, and no fossils have been previously documented.

The cephalopods described from the Parras Shale are preserved as goethitized internal molds with diameters ranging from 9.7–70.2 mm. Pyritization initially produced a thin coat on the shells, which eventually completely infilled chambers of small diameters and left larger chambers hollow. The pyrite was later oxidized to goethite by weathering. In larger individuals, the unfilled chambers were crushed during burial leaving specimens >70 mm unpreserved. The maximum sizes of the present specimens thus reflect a preservational bias. This interpretation is supported by the fact that body chambers are not preserved in Union y Progreso cephalopod specimens. A similar preservational mode has been observed in Maastrichtian

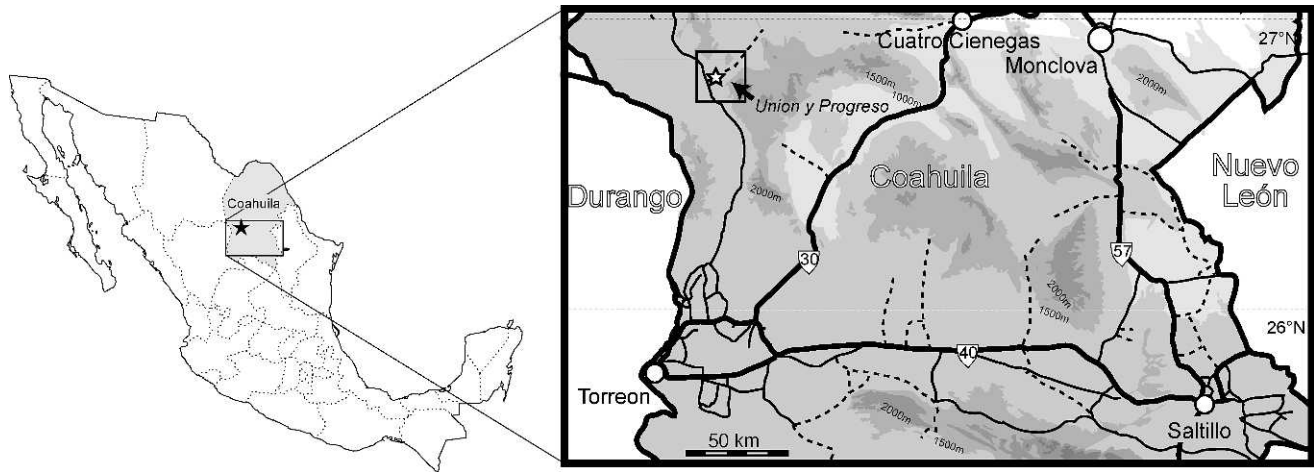


FIGURE 1—Map of Mexico with enlarged view of Coahuila. The square on the enlarged map marks the area shown in Figure 2.

cephalopod fossils from near Cerralvo, Nuevo León (Fig. 1) (Ifrim et al., 2004), from 50 km north of Saltillo, Coahuila (Ifrim et al., 2010b), as well as from a locality 80 km south of Nuevo Laredo, Tamaulipas (Ifrim and Stinnesbeck, in press), although these latter individuals are generally tiny with shell diameters <10 mm and thus much smaller than the Union y Progreso specimens.

#### SYSTEMATIC PALEONTOLOGY

All 208 specimens collected at Union y Progreso are deposited in the *Colección de Paleontología de Coahuila* (CPC) at the Museo del Desierto, Saltillo, Coahuila, Mexico.

Linear dimensions are given in mm, uncertain values due to deformation of specimens and estimated measurements are designated by an asterisk. Values in parentheses refer to percentage of whorl diameters. Abbreviations for shell character measurements include: D, diameter; WB, whorl width; WH, whorl height; U, umbilical diameter; and UL, distance between two measurements, which corresponds to the undeformed length. Abbreviation of sutural elements corresponds to common terminology: E, external lobe; L, lateral lobe; U, auxiliary lobes; I, internal lobe. Rib index of Ancyloceratina

indicates numbers of ribs at a certain WH in a length corresponding to WH.

The abbreviations for different museum repositories mentioned herein include: BMNH, British Museum of Natural History, London, U.K.; CPC, *Colección de Paleontología de Coahuila*, housed at the Museo del Desierto, Saltillo, Coahuila, Mexico; USNM, United States National Museum of Natural History, Washington, D.C.

Systematic nomenclature of ammonoids follows the *Treatise of Invertebrate Paleontology* (Wright, 1996). Synonymies include only the most important citations and those used for determination. Where possible, more complete synonymy lists are indicated.

- Order AMMONOIDEA Zittel, 1884
- Suborder PHYLLOCERATINA Arkell, 1950
- Superfamily PHYLLOCERATOIDEA Zittel, 1884
- Family PHYLLOCERATIDAE Zittel, 1884
- Subfamily PHYLLOCERATINAE Zittel, 1884
- Genus HYPOPHYLLOCERAS Salfeld, 1924
- Subgenus HYPOPHYLLOCERAS (NEOPHYLLOCERAS) Shimizu, 1934
- HYPOPHYLLOCERAS (NEOPHYLLOCERAS) ARTUROI new species
- Figures 3.1, 4.1

*Diagnosis.*—This is the only species of an Upper Cretaceous *Hypophylloceras* (*Neophylloceras*) with an inflated whorl section in combination with straight lirae and distant umbilical folds.

*Description.*—Inflated whorl with rounded whorl section. The umbilicus is small (U/D 0.06) and deep. The umbilical wall is steep and low, bending broadly into the widely rounded flanks. The shells' lateral walls are moderately convergent with greatest whorl width dorsolaterally. The flanks grade into the widely rounded venter. Ornament is composed of ~75 lirae per half whorl, which merge at the mid-flank. They are virtually straight and faintly convex, bending slightly rursiradiately towards the venter. In the half whorl preserved, a single constriction is present. It parallels the lirae and is accompanied by a faint rib at mid-flank. The succeeding five lirae form a bundle. The suture is intensely incised, with a lanceolate E and an elongated L.

Dimensions of CPC-662: D=38.9, WB=14.7 (0.38), WH=23.5 (0.60), WB/WH=0.63, U=2.4 (0.06).

*Etymology.*—This species is named in honor of Arturo Homero González González, the general director of the Museo del Desierto in Saltillo, Coahuila, for his long-lasting support of palaeontology and for his achievements in facilitating greater public awareness and education of paleontology.

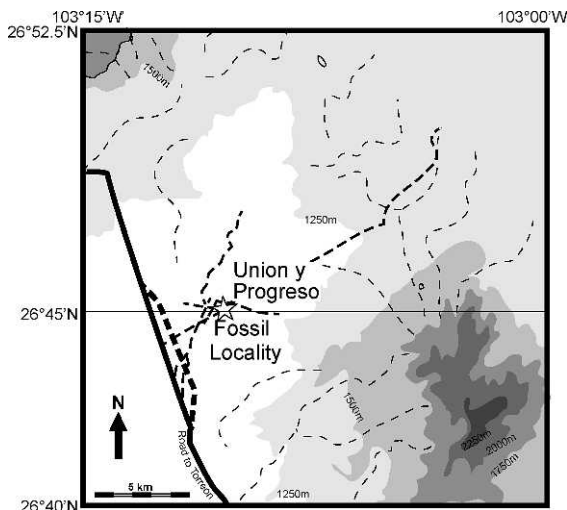


FIGURE 2—Map of fossil locality near Union y Progreso, Coahuila, Mexico.



FIGURE 3—Phylloceratina, Lytoceratina, and selected Ammonitina from Union y Progreso; 1, *Hypophylloceras* (*Neophylloceras*) *arturoi* n. sp., holotype, CPC-662; 2, *Tetragonites silencioensis* n. sp., holotype, CPC-793; 3–7, *Desmophyllites diphyloides* (Forbes, 1846): 3, CPC-673; 4, CPC-675; 5, CPC-794; 6, CPC-674; 7, CPC-792; 8, 9, *Menabites* (*Delawarella*) *vanuxemi* (Morton, 1830): 8, CPC-676; 9, CPC-804; 10–13, *Menuites* (*Neopachydiscus*) juv. sp.: 10, CPC-809; 11, CPC-806; 12, CPC-807; 13, CPC-808; all  $\times 1$ .

*Type*.—The holotype is CPC-662 (Fig. 3.1).

*Occurrence*.—*Menabites* (*Delawarella*) *vanuxemi* biozone of the Parras Shale near Union y Progreso, Coahuila, Mexico.

*Remarks*.—The WB/WH ratio of our specimen fits best with the holotype of *Hypophylloceras* (*Neophylloceras*) *inflatum* described from the Maastrichtian of Chile (Stinnesbeck, 1986), however, the ornament of this Maastrichtian species differs in the presence of flexuous lirae that form bundles. *Hypophylloceras*

(*N.*) *ramosum*, widely distributed during the Campanian and Maastrichtian, is usually more discoidal, with a lower WB/WH, even though the WB/WH may be similar (compare Salazar et al., 2010). *Hypophylloceras* (*N.*) *ramosum* also differs in ornament as lirae flex backwards towards the venter and are not substraight as in our specimen. All other species in this subgenus differ by their more discoidal shells and thus have dissimilar whorl sections as well as lower WB/WH ratios.



FIGURE 4—Suture lines of Ammonoidea from Union y Progreso. 1, *Hypophylloceras* (*Neophylloceras*) *arturoi* n. sp. CPC-662; 2–4, *Desmophyllites diphylloides* (Forbes, 1846): 2, CPC-673; 3, CPC-675; 4, CPC-794; 5, 6, *Menabites* (*Delawarella*) *vanuxemi* (Morton, 1830): 5, CPC-676; 6, CPC-804; 7, 8, *Menuites* (*Neopachydiscus*) *juv.* sp., CPC-806; 9–17, *Pseudoschloenbachia* (*P.*) *mexicana* (Renz, 1936): 9, CPC-812; 10, CPC-678; 11, CPC-666; 12, CPC-665; 13, CPC-667; 14, CPC-677; 15, CPC-680; 16, CPC-692; 17, CPC-665; 18–23, *Pseudoschloenbachia* (*P.*) aff. *P. (P.) mexicana* (Renz, 1936): 18, CPC-687; 19, CPC-688; 20, CPC-689; 21, CPC-797; 22, CPC-690; 23, CPC-798; all  $\times 5$ .

Suborder LYTCERATINA Hyatt, 1900  
 Superfamily TETRAGONITOIDEA Hyatt, 1900  
 Family TETRAGONITIDAE Hyatt, 1900  
 Subfamily TETRAGONITINAE Hyatt, 1900  
 Genus TETRAGONITES Kossmat, 1895  
 TETRAGONITES SILENCIOENSIS new species  
 Figure 3.2

*Diagnosis*.—Moderate expansion rate and subquadrate whorl section lacking constrictions.

*Description*.—The grade of involution and the expansion rate of the shell of *Tetragonites silencioensis* are moderate, and the whorl section is subrectangular to subelliptical. Maximum whorl width is below mid-flank. The umbilicus is wide (U/D=0.30) and rather deep. Its subvertical wall passes into an abruptly rounded umbilical shoulder. The flanks are parallel to convex and pass into broadly rounded, convergent ventrolateral shoulders, and from there, to a flattened venter. No ornament is visible and the shell is smooth. The suture line is weakly incised.

Dimensions of CPC-793: D=20.8, WB=9.6 (0.46), WH=8.3 (0.40), WB/WH=1.16, U=6.2 (0.30).

*Etymology*.—This name is derived from the remote part of the Chihuahua desert known as the Zona del Silencio where Union y Progreso is located. In this area, communication is limited and radiotransmission supposedly fails.

*Type*.—The holotype is CPC-793 (Fig. 3.2).

*Occurrence*.—*Menabites (Delawarella) vanuxemi* biozone of the Parras Shale near Union y Progreso, Coahuila, Mexico.

*Remarks*.—*Tetragonites superstes* from the lower-middle Campanian of South Africa and Madagascar (Kennedy and Klinger, 1977) and the lower-upper Maastrichtian of northeastern Mexico (Ifrim et al., 2004; Ifrim et al., 2010b) are similar to this specimen but differ by a lower expansion rate with three additional whorls at similar diameters. This specimen is both less involute and less expanded than *T. epigonus* (Kossmat, 1895), and differs from *T. popetensis* (Yabe, 1903) by the absence of constrictions (Kennedy and Klinger, 1977). *Tetragonites glabus* from the lower Campanian of Japan and Kamchatka has a higher expansion rate and a greater U/D (Maeda et al., 2005). All other species of *Tetragonites* are ornamented by distant ribs or constrictions that are absent in our specimens, or present a different U/D or higher expansion rate. This specimen does not match any known species of *Tetragonites* from the Upper Cretaceous and is therefore regarded as a new species.

Suborder AMMONITINA Hyatt, 1889  
 Superfamily DESMOCERATOIDEA Zittel, 1895  
 Family DESMOCERATIDAE Zittel, 1895  
 Subfamily DESMOCERATINAE Zittel, 1895  
 Genus DESMOPHYLLITES Spath, 1929  
 DESMOPHYLLITES DIPHYLLOIDES (Forbes, 1846)  
 Figures 3.3–3.7, 4.2–4.6

1846 *Ammonites diphylloides* FORBES, p. 105, pl. 8, fig. 8.  
 1898 *Desmoceras desmophylloides* (Forbes); KOSSMAT, p. 108, 173, pl., 19, 25, figs. 8, 9.  
 1898 *Desmoceras phyllimorphum* KOSSMAT, p. 110, 175, pl. 19, 25, fig. 10.  
 1985 *Desmophyllites diphylloides* (Forbes); HENDERSON AND McNAMARA, p. 54, pl. 4, figs. 1–4.  
 1992 *Desmophyllites diphylloides* (Forbes); KENNEDY AND HENDERSON, p. 405, pl. 6, figs. 1–9; pl. 16, figs. 1–3, 7, 8; pl. 17, figs. 4–7; text-fig. 3f (with full synonymy).  
 1995 *Desmophyllites diphylloides* (Forbes); KENNEDY ET AL., p. 397, pl. 4, figs. 1, 2, 6, 7, 14, text-fig. 16.  
 2004 *Desmophyllites diphylloides* (Forbes); IFRIM ET AL., p. 1594, figs. 8c, 8d, 9e, 9f.

TABLE 1—Biometric data for *Desmophyllites diphylloides* (Forbes, 1846).

	D	WB	WH	WB/WH	U	U/D
CPC-673	11.2	5.3 (0.47)	6.8 (0.61)	0.78	0.3	0.03
CPC-795	13.0	6.2 (0.48)	7.1 (0.55)	0.87	0.7	0.05
CPC-794	13.5	6.2 (0.46)	7.3 (0.54)	0.85	0.7	0.05
CPC-674	16.4	7.3 (0.45)	8.3 (0.51)	0.88	0.4	0.02
CPC-792	25.2	11.6 (0.46)	14.2 (0.56)	0.82	1.6	0.06

2005 *Desmophyllites diphylloides* (Forbes); MAEDA ET AL., p. 104, fig. 53.7–53.14.

2010 *Desmophyllites diphylloides* (Forbes); IFRIM ET AL., p. 604, figs. 5j, 5k, 7e–7l.

*Type*.—The lectotype is BMNH C22682, the original of Forbes (1846, pl. 8, fig. 8), by subsequent designation of Matsumoto and Obata (1955, p. 122).

*Description*.—Involute with intermediate expansion rate. The shell is moderately compressed, (WB/WH is ~0.8). The umbilicus is very small (U/D is 0.02–0.06) and shows subvertical walls with narrowly rounded umbilical shoulders. The latter grade into subparallel flanks that bend towards an evenly rounded venter. The greatest whorl breadth is reached below mid-flank. Internal molds are smooth, but this may be caused by abrasion. The suture shows a trifold L which is equal in depth with E. The E/L and L/U saddles are tetraphylloid and asymmetrical. U has at least five minor lobes on the dorsal flank arranged in a slightly reticulate line.

*Material*.—Five internal molds: CPC-673, CPC-674, CPC-792, CPC-794, CPC-795. Measurements are given in Table 1.

*Occurrence*.—Lower Santonian–upper Maastrichtian of southern India (Kennedy and Henderson, 1992), Tunisia (Pervinquier, 1907), western Australia (Henderson and McNamara, 1985), Japan (Matsumoto and Obata, 1955) along the Pacific coast between Alaska and California (Matsumoto, 1959; Jones, 1963), the Gulf Coast Plain (Kennedy and Cobban, 1993), South Africa, and southeast France (Ward and Kennedy, 1993), and Mexico (Ifrim et al., 2004; Ifrim et al., 2010b, and herein).

*Remarks*.—*Desmophyllites diphylloides* (Forbes, 1846) is characterized by a slightly compressed whorl section, parallel flanks, and a tiny umbilicus. This species has been discussed by Kennedy and Henderson (1992), and comparable growth stages were documented extensively from the Maastrichtian of Mexico by Ifrim et al. (2004).

Family MUNIERICERATIDAE Wright, 1952  
 Genus and subgenus PSEUDOSCHLOENBACHIA Spath, 1921  
 PSEUDOSCHLOENBACHIA (PSEUDOSCHLOENBACHIA) MEXICANA  
 (Renz, 1936)  
 Figures 4.9–4.17, 5.1–5.11, 6.1, 7

1936 *Schloenbachia bertrandi* de Grossouvre var. *mexicana* RENZ, p. 6, pl. 1, fig. 2; pl. 3, fig. 1.  
 1963 *Pseudoschloenbachia mexicana* Renz; YOUNG, p. 121, pl. 29, fig. 3, 4; pl. 30, figs. 1–7; pl. 31, figs. 1, 3–9; pl. 32, figs. 1–6; pl. 33, figs. 1–3, 5–7, pl. 44, fig. 1; text-figs. 13e, 28d, 29b, 29d.  
 1963 *Pseudoschloenbachia* sp. juv. cf. *P. mexicana* Renz; YOUNG, pl. 30, fig. 9; pl. 31, fig. 2; pl. 33, fig. 4.  
 1967 *Pseudoschloenbachia mexicana* Renz; WOLLEBEN, p. 1157, pl. 149, figs. 4, 5.  
 1991 *Pseudoschloenbachia (Pseudoschloenbachia) mexicana* Renz; KENNEDY AND COBBAN, p. 172, figs. 6.1, 6.2, 7.5–7.39, 10.17–10.19, 10.22, 10.23, 12.4.

*Types*.—The lectotype, designated as holotype by Young (1963, p. 121), is the original of Renz (1936, pl. 3, fig. 1); the paralectotype is another original of Renz (1936, pl. 1, fig. 2). The



FIGURE 5—*Pseudoschloenbachia (P.) mexicana* (Renz, 1936) from Union y Progreso. 1, CPC-803; 2, CPC-805; 3, CPC-810; 4, CPC-811; 5, CPC-812; 6, CPC-666; 7, CPC-677; 8, CPC-667; 9, CPC-678; 10, CPC-679; all  $\times 1$ .

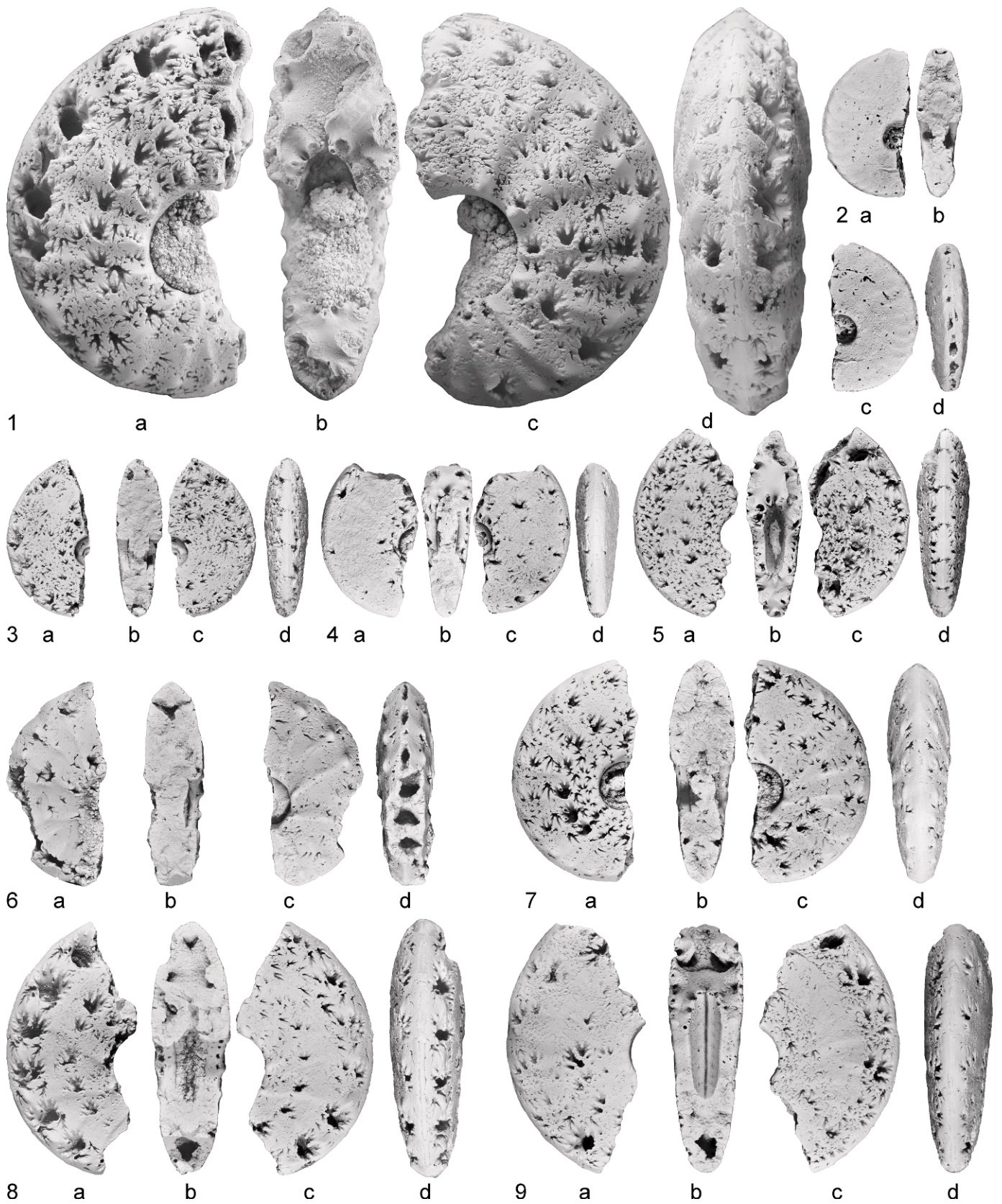


FIGURE 6—*Pseudoschloenbachia* (*P.*) from Union y Progreso. 1, *P. (P.) mexicana* (Renz, 1936), CPC-665; 2–11, *P. (P.)* aff. *P. (P.) mexicana* (Renz, 1936): 2, CPC-802; 3, CPC-801; 4, CPC-800; 5, CPC-799; 6, CPC-814; 7, CPC-797; 8, CPC-795; 9, CPC-798; all  $\times 1$ .

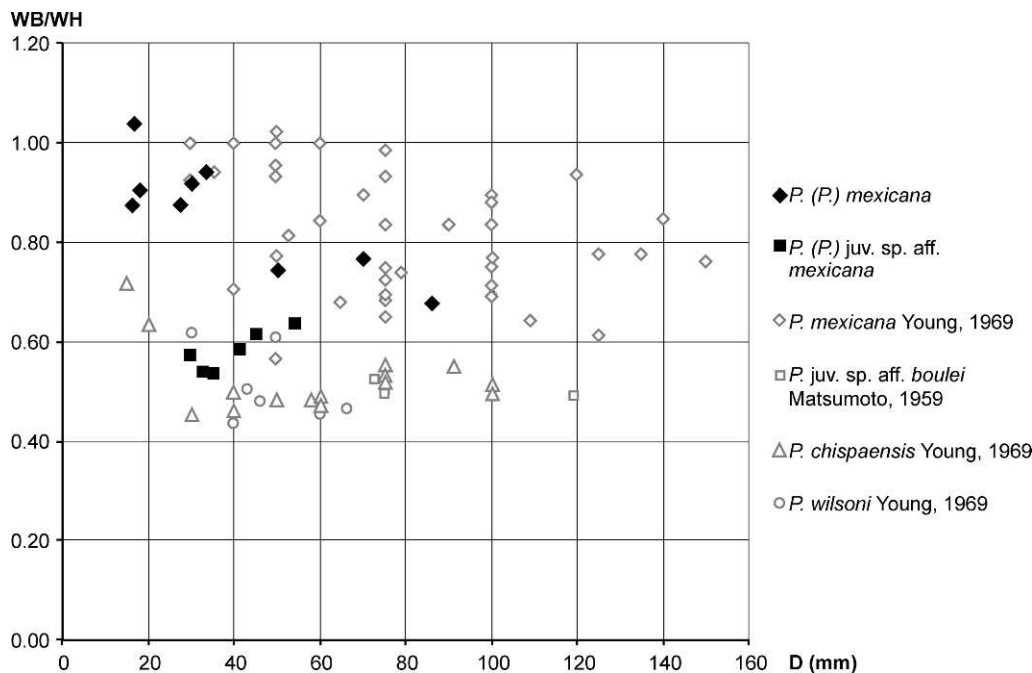


FIGURE 7—Biometry of *Pseudoschloenbachia* (*P.*) from Union y Progreso (solid symbols). Data outside Union y Progreso (empty symbols) are from Matsumoto (1959) and Young (1963).

type specimens are from Arroyo Tecolote and Arroyo del Fresno in northern Coahuila, Mexico.

**Description.**—Oxycone, moderately involute. U is moderately deep, U/D always ~0.25, even though this species shows a wide range of morphologies, from smooth discoidal shells with WB/WH of 0.6 to very stout shells with WB/WH >1.04 and strong ribbing as well as tuberculation. In any case, the umbilical wall is oblique and bends narrowly into sub-parallel flanks. Greatest whorl width is at mid-flank. Ventrolaterally, flanks bend towards the acute venter in a moderately wide arch. Ornament consists of an umbilical row of distant tubercles that give rise to five straight primary ribs per half whorl. Intercalated secondary ribs appear at mid-flank. Both types of ornament (smooth and stout) have equally shaped ventrolateral tubercles along the ventrolateral shoulder that accentuate the narrow edge there. Ventral to this row of tubercles, all ribs show equal strength and are prorsiradiate and straight. In discoidal morphotypes, they fade and disappear towards the venter, even though their crossing angle of 50° equals that of stout morphotypes. Ribs vary in strength with WB/WH, but their number remains constant. The suture line shows an asymmetrically trifold L which exceeds E in depth. Auxiliary lobes are also asymmetrically trifold.

**Material.**—Twenty-six internal molds; biometric data are given in Table 2.

**Occurrence.**—*Pseudoschloenbachia mexicana* Renz is restricted to the upper Santonian to lower Campanian of Texas and Chihuahua (Renz, 1936; Young, 1963; Wolleben, 1967; Kennedy and Cobban, 1991; Becker et al., 1998) and now of Coahuila.

**Remarks.**—The exceedingly wide variation of morphologies of *P. (P.) mexicana* (Renz, 1936) is documented for the first time. The variation in WB/WH correlates with ornament and thus exemplifies Buckman’s law of covariation (defined by Westermann, 1966).

Discoidal shells of *Pseudoschloenbachia mexicana* are separated from other discoidal species of *Pseudoschloenbachia* through biometry, including *P. aff. P. mexicana* from Union y Progreso. In juveniles of this latter taxon, WB/WH (0.4 to 0.7) does not overlap with WB/WH in *P. mexicana* at diameters of

<40 mm. No transitional forms are present in the Union y Progreso assemblage, even though morphologies converge with diameters >40 mm. Due to the differences in juvenile stages, the two morphotypes are treated here as separate species. However, a future discovery of transitional forms may prove the two morphotypes to be conspecific.

PSEUDOSCHLOENBACHIA (PSEUDOSCHLOENBACHIA) aff. MEXICANA (Renz, 1936)

Figures 4.18–4.23, 6.2–6.10, 7

**Description.**—Discoidal involute shell with U/D at ~0.2. The umbilical wall is oblique and bends narrowly into convergent flanks. WB/WH is 0.51–0.64, and greatest whorl width is below mid-flank. At the ventrolateral shoulder, the walls bend narrowly towards the acute venter. Four to six distant umbilical tubercles per half whorl give rise to primary ribs. These are prorsiradiate and flex backwards at mid-flank to be retriradiate towards the ventrolateral shoulder. Secondary ribs rise at mid-flank and are intercalated and parallel to the primaries. Both types of ribs possess tubercles at the ventrolateral shoulder that accentuate the

TABLE 2—Biometric data for *Pseudoschloenbachia* (*P.*) *mexicana* (Renz, 1936). Asterisks mark estimated or uncertain measurements.

	D	WB	WH	WB/WH	U
CPC-675	16.4	6.3 (0.38)	7.2 (0.44)	0.88	4.1 (0.25)
CPC-803	16.5	8.1 (0.49)	7.8 (0.47)	1.04	4.0 (0.24)
CPC-805	18.0	7.5 (0.42)	8.3 (0.46)	0.90	4.1 (0.23)
CPC-810	27.5	11.1 (0.40)	12.7 (0.46)	0.87	6.8 (0.25)
CPC-811	*30.0	12.1 (*0.40)	13.1 (*0.44)	0.92	8.4 (*0.28)
CPC-812	33.5	14.0 (0.42)	14.9 (0.44)	0.94	8.8 (0.26)
CPC-678	—	16.6	18.3	0.91	12.8
CPC-666	—	14.9	22.1	0.67	—
CPC-692	—	17.8	22.6	0.79	—
CPC-677	50.2	17.3 (0.34)	23.2 (0.46)	0.75	11.9 (0.24)
CPC-667	—	16.5	24.6	0.67	—
CPC-680	—	21.7	24.9	0.87	—
CPC-815	—	18.8	31.0	0.61	—
CPC-665	70.2	24.5 (0.35)	32.0 (0.46)	0.77	18.4 (0.26)
CPC-679	—	27.7	26.9	1.03	—



TABLE 3—Biometry for *Pseudoschloenbachia* (*P.*) juv. sp. aff. *P. (P.) mexicana* (Renz, 1936). Asterisks mark estimated or uncertain measurements.

	D	WB	WH	WB/WH	U
CPC-686	—	5.3	9.0	0.59	2.3
CPC-687	—	10.1	17.1	0.59	—
CPC-688	—	10.0	16.0	0.63	6.5
CPC-689	—	10.5	20.2	0.52	—
CPC-690	—	13.4	23.2	0.58	8.2
CPC-691	—	14.7	26.4	0.56	8.6
CPC-796	*54.0	15.5 (0.29)	24.4 (*0.45)	0.64	10.0 (*0.19)
CPC-797	45.0	13.2 (0.29)	21.5 (0.48)	0.61	9.2 (0.20)
CPC-798	—	14.5	27.3	0.53	—
CPC-799	—	10.4	19.8	0.53	6.5
CPC-800	35.0	9.1 (0.26)	17.0 (0.49)	0.54	6.0 (0.17)
CPC-801	32.5	9.0 (0.28)	16.7 (0.51)	0.54	5.5 (0.17)
CPC-802	29.8	8.9 (0.30)	15.5 (0.52)	0.57	5.6 (0.19)
CPC-813	—	14.0	25.5	0.55	—
CPC-814	41.0	11.7 (0.29)	20.0 (0.49)	0.59	9.3 (0.23)

narrow venter. Their number is between ten to sixteen per half whorl. Ventrally from this row of tubercles, all ribs have equal strength; they are prorsiradial as well as straight and disappear on the venter. The suture line shows an asymmetrically trifid L that exceeds E in depth. Umbilical lobes are also asymmetrically trifid.

*Material*.—Twenty-six internal molds; biometric data are given in Table 3.

*Occurrence*.—*Menabites (Delawarella) vanuxemi* biozone of the Parras Shale near Union y Progreso, Coahuila, Mexico.

*Remarks*.—This compressed morphotype of *Pseudoschloenbachia* is comparable to many other compressed species of this genus. Nevertheless, *P. sinincisa* from South Africa has much stronger ribs and tubercles are absent (Kennedy et al., 2008). *Pseudoschloenbachia umbulazi* from Alaska is ornamented by stronger and much denser ribs than specimens from Union y Progreso (Haggart, 1989). *Pseudoschloenbachia chispaensis* from Texas is characterized by a higher number of ribs per whorl and no tubercles are present at comparable growth stages (Young, 1963). Our specimens appear to be related to *P. wilsoni* that also has bifurcating ribs at ventrolateral tubercles and similar biometric relations, but ribs are much denser than in our specimens (Young, 1963). We tentatively consider the discoidal morphotype of *P. aff. mexicana* to be different from *P. mexicana* based on the absence of transitional forms in early juvenile specimens (Fig. 7), but await further findings to clarify the taxonomic position of this new morphotype.

Superfamily ACANTHOCERATOIDEA de Grossouvre, 1894

Family COLLIGNONICERATIDAE Wright and Wright, 1951

Subfamily TEXANITINAE Collignon, 1948

Genus MENABITES Collignon, 1948

Subgenus DELAWARELLA Collignon, 1948

MENABITES (DELAWARELLA) VANUXEMI (Morton, 1830)

Figures 3.8, 3.9, 4.5, 4.6

1830 *Ammonites vanuxemi* MORTON, p. 244, pl. 3, figs. 2–4.

1962 *Submortonicerias vanuxemi* (Morton); REESIDE, p. 133, pl. 72, figs. 4, 5 (with full synonymy).

1963 *Submortonicerias vanuxemi* (Morton); YOUNG, p. 98, pl. 54, fig. 3; pl. 56, fig. 2; pl. 57, fig. 7; pl. 58, fig. 3; pl. 67, fig. 3; pl. 69, fig. 1, 2, 6; text-figs. 12c, 12e, 26d–26e (with additional synonymy).

1967 *Submortonicerias vanuxemi* (Morton); WOLLEBEN, p. 1156, pl. 17, fig. 1, pl. 148, fig. 3.

1992b *Menabites (Delawarella) vanuxemi* (Morton); COBBAN AND KENNEDY, p. 76, pl. 2, figs. 2–4 (with additional synonymy).

TABLE 4—Biometry for *Menuites* juv. sp.

	D	WB	WH	WB/WH	U
CPC-809	17.2	9.4 (0.55)	7.0 (0.41)	1.34	4.2 (0.24)
CPC-806	20.5	12.2 (0.60)	9.4 (0.46)	1.30	5.5 (0.27)
CPC-807	22.4	13.3 (0.59)	9.8 (0.44)	1.36	6.2 (0.28)
CPC-808	26.5	15.0 (0.57)	10.5 (0.40)	1.43	7.0 (0.26)

*Types*.—The holotype, by monotypy, is No. 19492 in the collection of the Academy of Natural Sciences in Philadelphia (Morton, 1830, pl. 3, figs. 2–4; refigured by Reeside, 1962, pl. 72, figs. 4, 5). It is from the Chesapeake and Delaware Canal in Delaware.

*Description*.—Our specimens are moderately involute juveniles with compressed whorls; WB/WH is approximately 0.7 and U/D is 0.25. U is moderately deep. The umbilical wall is steep and bends narrowly into parallel flanks. These converge towards the venter; greatest whorl width is below mid-flank. The ventrolateral shoulders are narrowly rounded. Eight umbilical bullae per half whorl give rise to pairs of straight, moderately prorsiradial ribs. Additional ribs are intercalated. Shallow tubercles are present on the ventrolateral shoulder. Ribs terminate at small external clavi; there is a smooth zone between these and the siphonal ridge. The suture is moderately incised, with a narrow E, a widely subquadrate bifid E/L, and L as deep as E.

*Material*.—Two fragments of internal molds. Dimensions of CPC-676: WB=11.3, WH=18.1, WB/WH=0.62; CPC-804: D=36.5, WB=13.2 (0.36), WH=17.4 (0.48), WB/WH=0.76, U=9.1 (0.25).

*Occurrence*.—Upper lower Campanian in New Jersey, Delaware, New Mexico and Texas, U.S.A., as well as Chihuahua, and Coahuila, Mexico (Reeside, 1962; Young, 1963; Wolleben, 1967, 1977; Cobban and Kennedy, 1992a, 1992b; Larson et al., 1997, and herein). All records are from the Atlantic, Gulf Coastal Plain and WI of North America and restricted to the upper lower Campanian, which makes this an index species.

*Remarks*.—Compressed whorls, dense, crowded ribs and weak tubercles distinguish this species from all other North American *Delawarella* (Cobban and Kennedy, 1992b).

Family PACHYDISCIDAE Spath, 1922

Genus MENUITES Spath, 1922

MENUITES juv. sp.

Figures 3.10–3.14, 4.8

*Description*.—Inflated shell, moderately involute with depressed whorl section (WB/WH is 1.30–1.43). The umbilicus spans 24 to 28 percent of D. The umbilical wall is overhanging and forms approximately a half circle between the umbilical seam and the flank. Flanks are reduced due to the widely arched venter. Maximum whorl width is at the transition between umbilical wall and flank. Six to seven slightly concave primary ribs per half whorl rise from faint umbilical bullae. They cross the flanks and bend forward towards the venter, which is crossed in a wide arch. Two collared constrictions per half whorl parallel the ribs.

*Material*.—Four internal molds. Biometric data are shown in Table 4.

*Occurrence*.—Our specimens are from the *Menabites (Delawarella) vanuxemi* biozone of the Parras Shale near Union y Progreso, Coahuila, Mexico, and represent the oldest occurrence of the genus *Menuites* in Mexico and the first record of constricted *Menuites* in North America.

*Remarks*.—The presence of up to three collared constrictions per whorl distinguishes our specimens from later *Menuites*; this feature, hitherto undescribed from North America, appears to be restricted to early representatives of the genus. Constricted *Menuites* were formerly included in the subgenus *Neopachydiscus* Yabe and Shimizu 1926, but Wright (1996) assign them to

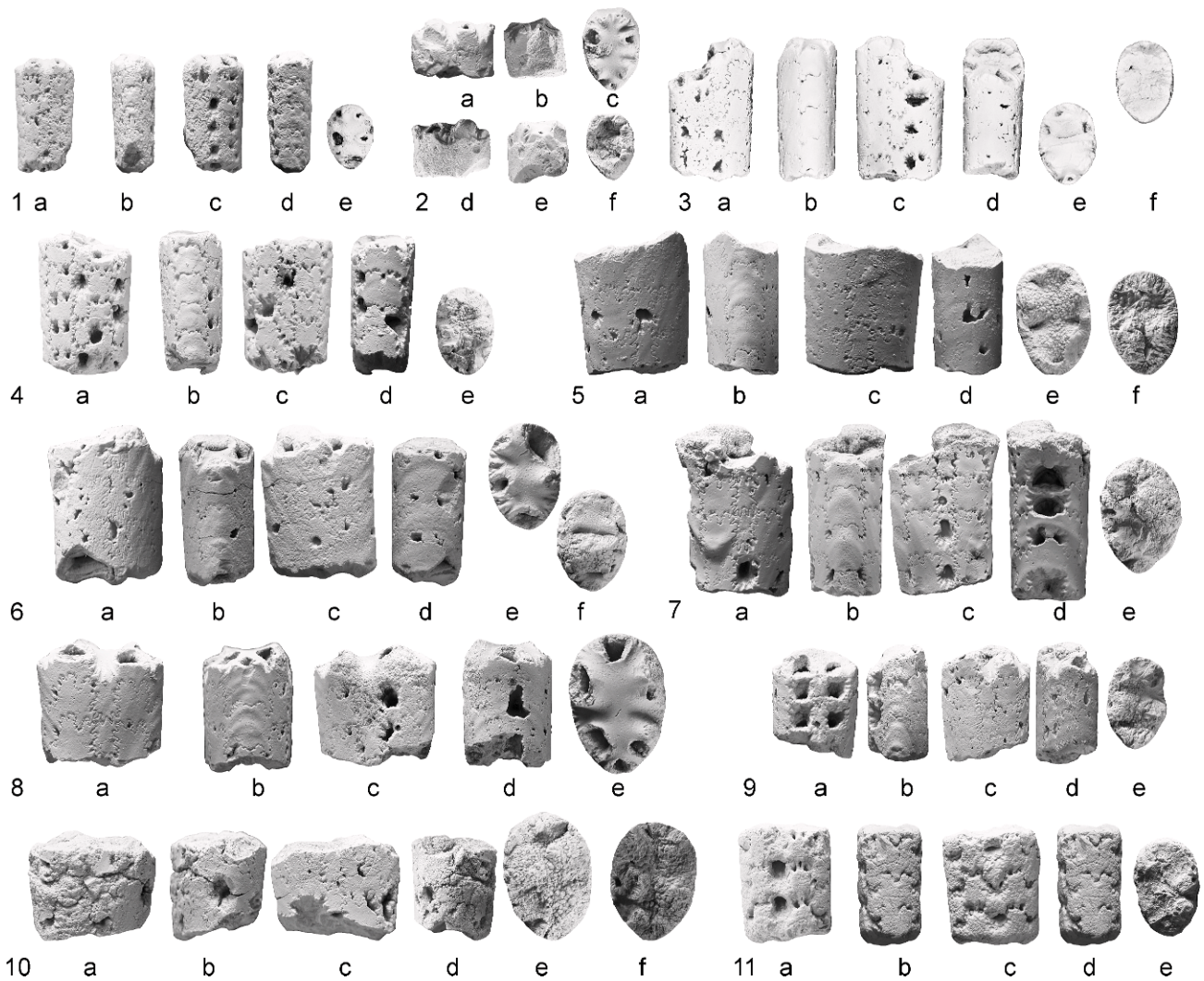


FIGURE 8—*Baculites haresi* Reeside, 1927 from Union y Progreso. 1, CPC-668; 2, CPC-722; 3, CPC-825; 4, CPC-690; 5, CPC-702; 6, CPC-707; 7, CPC-718; 8, CPC-693; 9, CPC-700; 10, CPC-694; 11, CPC-600; all  $\times 1$ .

*Menuites*. Our specimens differ from macroconchs of *M. (N.) boulei* from South Africa and Madagascar by a lower WB/WH and lower number of ribs per whorl, and from *M. (N.) antecursor* of the Austral Province by a larger WB/WH, a smaller U/D and a lower number of ribs per whorl. *M. (N.) hauthali* from the Santonian-Campanian transition in Antarctica is characterized by widely spaced constrictions with associated collared ribs, but no primary or secondary ribs are present at comparable growth stages (Kennedy et al., 2007). A likely fragment of *Menuites* was described as *Anapachydiscus* sp. juv. from the lower Campanian of Texas, but not figured (Cobban and Kennedy, 1992a). WB/WH is 1.17 in this specimen at a diameter of 36 mm. Cobban and Kennedy (1992a, p. 443) further annotate “distant, flat-topped umbilical bullae that were the base of flat-topped spines. These bullae give rise to narrow, distant ribs, single or in pairs, while other ribs arise on the umbilical shoulder, all ribs effacing on the outer flank”. This specimen differs from ours in the absence of constrictions.

The Union y Progreso specimens thus appear to represent a new morphotype. However, Pachydiscidae show great variation during ontogeny, and new taxa should be based on adults, which are yet unknown for our morphotype. We consequently hesitate to establish a new species.

Suborder ANCYLOCERATINA Wiedmann, 1966

Superfamily TURRILITOIDEA Gill, 1871

Family BACULITIDAE Gill, 1871

Genus BACULITES Lamarck, 1799

BACULITES HARESI Reeside, 1927

Figures 8.1–8.13, 9.1–9.6, 10.1–10.7

1927 *Baculites ovatus* var. *haresi*, REESIDE, p. 10. pl. 6 figs. 5–10, pl. 7, figs. 9, 10 (with synonymy).

1992a *Baculites haresi*; COBBAN AND KENNEDY, p. 449, figs. 6.5–6.8, 6.11–6.13, 6.16–6.24, 7.1 (with additional synonymy).

1997 *Baculites haresi*; LARSON ET AL., p. 20.

*Type*.—The lectotype is USNM 73296, the original of Reeside (1927, pl. 6, figs. 5, 6), by subsequent designation of Cobban and Kennedy (1992a, p. 449). It comes from the Elk Basin Sandstone Member of the Telegraph Creek Formation, Wyoming, U.S.A.

*Description*.—Compressed whorl section with rounded dorsum and venter. The shell is smooth or ornamented by faint bullae, falcate ribs in dorsolateral position, accompanied by parallel striae. The suture is simple and composed of rectangular, shallow elements with a moderate grade of incision.

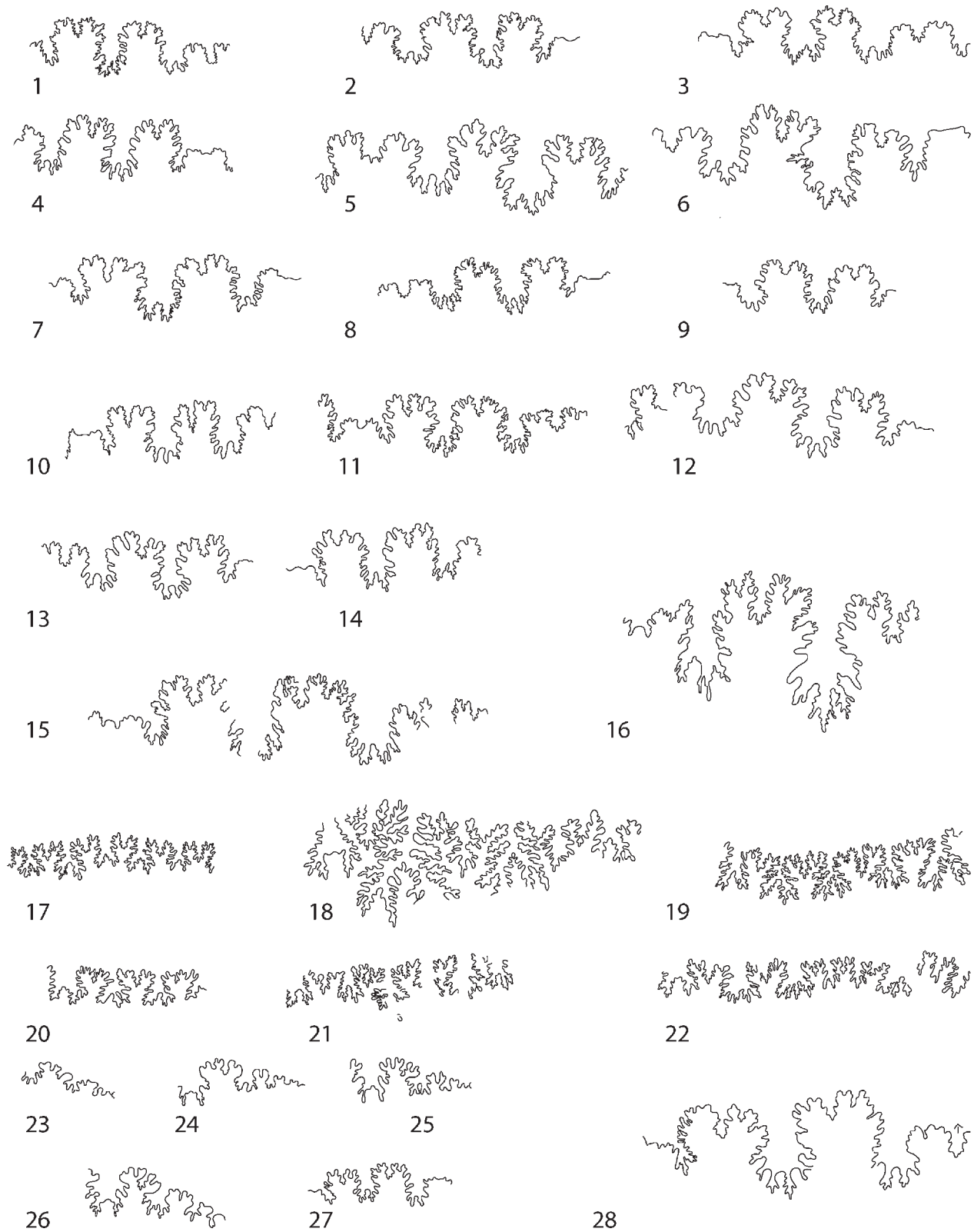


FIGURE 9—Suture lines of Ancyloceratina from Union y Progreso. 1–7, *Baculites haresi* Reeside, 1927: 1, CPC-670; 2, CPC-710; 3, CPC-716; 4, CPC-718; 5, CPC-751; 6, CPC-707; 7–16, *B. n. sp.*: 7, CPC-712; 8, CPC-715; 9, CPC-710; 10, CPC-700; 11, CPC-825; 12, CPC-693; 13, CPC-702; 14, CPC-709; 15, CPC-829; 16, CPC-830; 17, 18, Nostoceratidae gen et sp. indet.: 17, CPC-833; 18, CPC-837; 19, *Polyptychoceras* juv. sp., CPC-832; 20–22, *Pseudoxybeloceras* (*Parasolenceras*) juv. sp.: 20, CPC-835; 21, CPC-714; 22, CPC-840; 23–28, *Scaphites* juv. sp. ex gr. *S. hippocrepis* (DeKay, 1828): 23, CPC-664; 24, CPC-684; 25, CPC-681; 26, CPC-683; 27, CPC-695; 28, CPC-704; all  $\times 1$ .

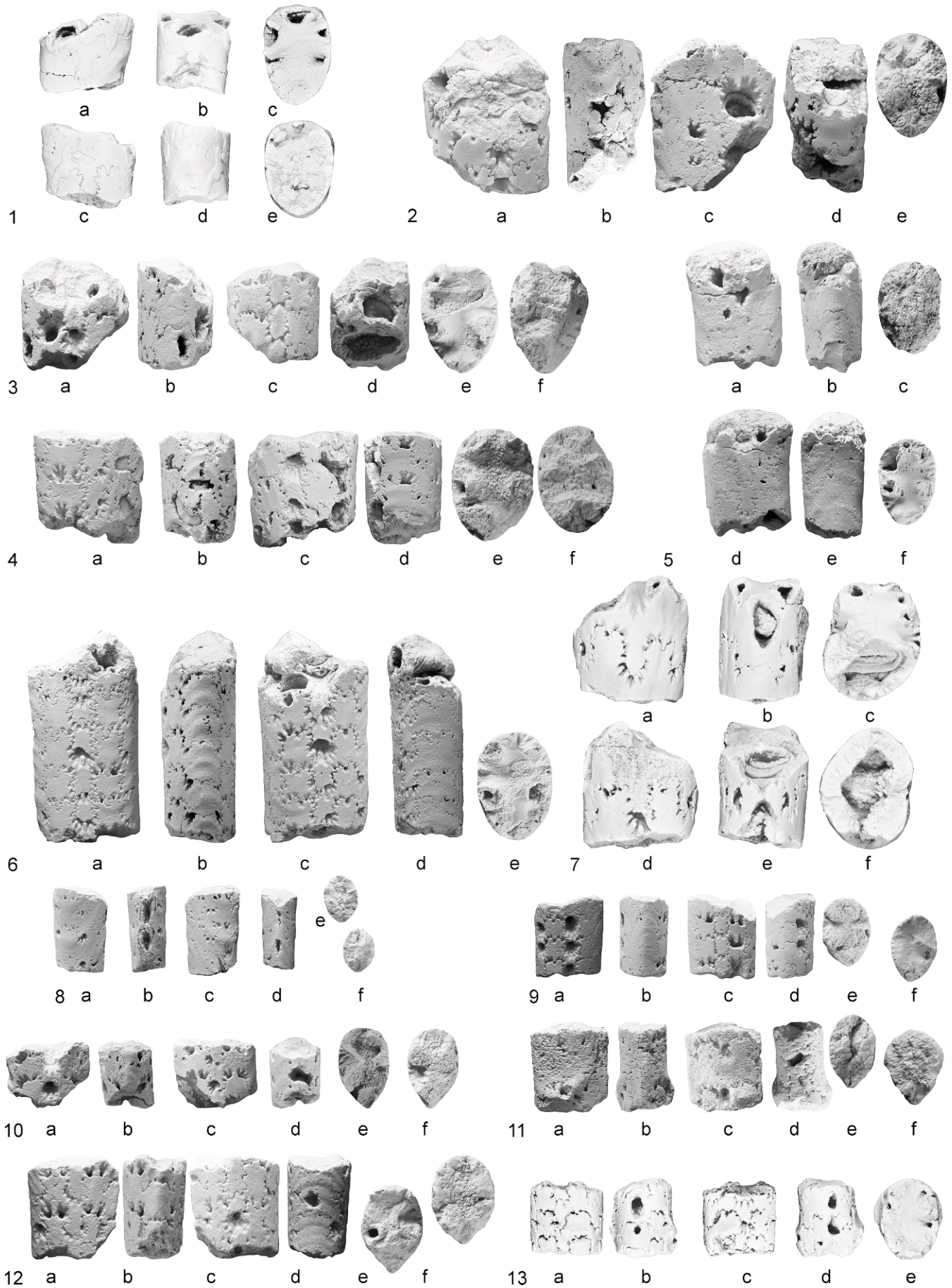


TABLE 5—Biometry for *Baculites haresi* Reeside, 1927.

	WB	WH	WB/WH	UL
CPC-695	5.8	8.2	0.71	10
	6.7	9.5	0.71	
CPC-668	5.8	8.5	0.68	13
	6.5	9.4	0.69	
CPC-669	7.0	10.8	0.65	14
	7.7	11.9	0.65	
CPC-722	8.5	11.7	0.73	
CPC-670	8.4	12.1	0.69	15
	9.1	13.2	0.69	
CPC-699	8.0	12.1	0.66	
CPC-825	8.3	12.1	0.69	11
	9.0	12.8	0.70	
CPC-715	8.8	12.5	0.70	11
	9.3	13.3	0.70	
CPC-716	9.4	12.9	0.73	15
	9.6	14.5	0.66	
CPC-718	9.0	13.0	0.69	12
	9.8	13.4	0.73	
CPC-826	10.0	13.7	0.73	5
	11.8	13.8	0.86	
CPC-717	9.4	14.0	0.67	15
	10.0	14.5	0.69	
CPC-710	9.1	14.1	0.65	13
	10.2	14.9	0.68	
CPC-698	10.1	15.8	0.64	
CPC-694	11.6	16.8	0.69	
CPC-707	12.3	17.2	0.72	15
	12.9	18.9	0.68	
CPC-712	10.9	17.3	0.63	
CPC-828	13.0	17.8	0.73	
CPC-705	13.4	18.2	0.74	
CPC-704	14.6	21.7	0.67	

*Material*.—Forty-one fragmented internal molds; measurements are given in Table 5.

*Occurrence*.—*Baculites haresi* is widely distributed in lower Campanian strata from Wyoming to Texas (Larson et al., 1997). Isolated records exist from the lower Campanian of New Jersey (Klinger and Kennedy, 2001) and Greenland (Birkelund, 1965). This is the first record of this species south of the WI.

*Remarks*.—Our specimens correspond closely to the lectotype of Reeside (1927, pl. 6, figs. 5, 6) in whorl section, ornament and moderately incised suture line with broad elements. Superficially, *B. haresi* Reeside, 1927 resembles *B. scotti* Cobban, 1958 and *B. eliasi* Cobban, 1958, but the latter two species differ in the shape of their sutural elements, which are much more constricted than the widely rectangular lobes and saddles of *B. haresi*. *Baculites haresi* differs from *Baculites* n. sp. that co-occurs at Union y Progreso, in its oval whorl section with both rounded venter and dorsum, and a suture line with wide rectangular elements. Instead, *B. n. sp.* is characterized by an ovoid whorl section with flattened dorsum and narrowly rounded venter, and a suture line with high elements.

#### BACULITES new species

Figures 9.7–9.16, 10.8–10.14, 11.1–11.8

*Description*.—Ovoid whorl section, with WB/WH 0.62–0.78. The dorsum is widely rounded and grades into rounded, convergent flanks. The venter is narrowly rounded and in some specimens even acute. Other specimens show faint ventrolateral grooves indicating an early stage of the development of a keel. Striae cross the venter in a wide arch, flex forward dorsolaterally and project strongly forward towards the venter, which then cross in a narrow arch. In longer fragments, crescentic concave ribs are present on the flanks. They parallel the striae and disappear

towards the venter and the dorsum. Rib index is <1. Both shallow ribs and striae disappear towards the venter or split into shallow delicate secondary ribs or striae. These flex back on the ventral area and cross the venter in a narrow convexity. The suture is composed of high elements, including a broad external lobe, narrow high E/L and L/U, narrow bifid L with rounded base, broad U and small I.

*Material*.—Fifty-one internal-molds fragments. Measurements are given in Table 6.

*Occurrence*.—*Menabites (Delawarella) vanuxemi* biozone of the Parras Shale near Union y Progreso, Coahuila, Mexico.

*Remarks*.—The ornamentation and suture patterns of our specimens correspond to juveniles of *Baculites mclearni* Landes, 1940 described by Cobban (1962a) and Cobban and Kennedy (1993a), but differs from it clearly by its ovoid whorl shape and keeled venter. *Baculites obtusus* Meek, 1876 and *B. asperiformis* Meek, 1876 are also quite similar but have a higher rib index as well as a rounded venter. *Baculites taylorensis* Adkins, 1929 has been recorded together with *Menabites (Delawarella) vanuxemi* in the Demopolis Formation of Alabama and Mississippi, but it displays nodes rather than crests, and they are stronger than in our specimens. In addition, its venter is more rounded. Our specimens differ markedly from associated *B. haresi* Reeside, 1927 in having a narrowly rounded keel, an ovoid cross section with flattened dorsum, distant crescentic ribs in laterodorsal position that parallel the striae, and a suture line with deeper elements and a higher grade of incision.

The presence of a narrowly rounded to acute venter is unusual in a lower Campanian *Baculites*. Forms with convergent flanks and narrowly rounded venter occur in middle to upper Campanian Western Interior biozones and include *B. asperiformis*, *B. compressus* Say, 1821, *B. cuneatus* Cobban, 1962b, *B. reducus* Cobban, 1977, but these species differ in many other details of their cross section, suture, and ornament (compare Larson et al., 1997). Our specimens are thus unique in their combination of characters. Due to the poor preservation, we hesitate to establish a new species and await further material until the entire set of characters can be verified in more completely preserved specimens.

#### Family NOSTOCERATIDAE Hyatt, 1894

##### Genus and species indeterminate

Figures 9.17, 9.18, 12.16, 12.18, 12.19

*Material*.—Three fragments of internal molds, CPC-833, CPC-836 and 837.

*Description*.—Short fragments of open helically coiled spirals with rounded whorl sections. The fragments are ornamented by dense ribs (rib index is 4–5) that are straight on the venter and outer flank. On the inner flank, ribs flex forward in a wide bow to become widely convex on the dorsum. The suture line is deeply incised. E is shallow and moderately asymmetric. On the inner flank, sutural elements are equal in height and depth (Fig. 9.17). On the outer flank, L exceeds E in depth. E is bifid, whereas E/L is asymmetrical and tetracyphaloid. L/U is bifid and widely triangular in shape with a narrow base (Fig. 9.18).

*Material*.—Three fragments of internal molds, CPC-833, CPC-836 and 837. Measurements of CPC-833: WB=5.0, WH=5.3, WB/WH=0.94; CPC-837, WB=12.3, WH=12.3, WB/WH=1.00.

*Remarks*.—The high degree of incision of the suture line, the shape of ribs, absence of tubercles or bullae, coiling as well as the whorl section correspond to juveniles of Campanian *Didymoceras* from the WI of North America. Early growth stages of *Didymoceras* have been documented for *Didymoceras* cf.

FIGURE 10—*Baculites* from Union y Progreso. 1–7, *Baculites haresi* Reeside, 1927: 1, CPC-828; 2, CPC-704; 3, CPC-705; 4, CPC-707; 5, CPC-710; 6, CPC-721; 7, CPC-830; 8–13, *Baculites* sp. indet.: 8, CPC-695; 9, CPC-715; 10, CPC-712; 11, CPC-711; 12, CPC-713; 13, CPC-826; all ×1.

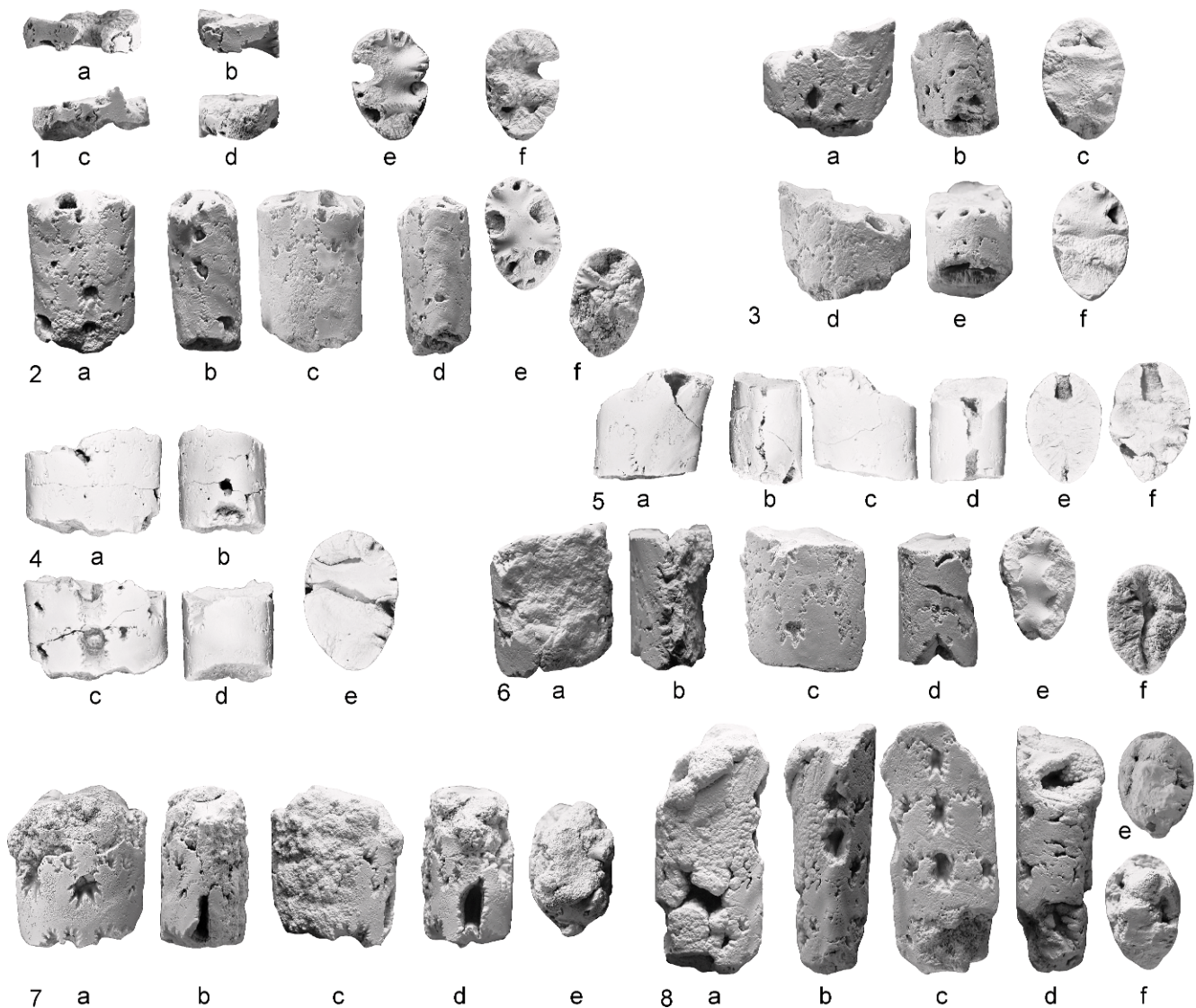


FIGURE 11—*Baculites* sp. indet. from Union y Progreso. 1, CPC-720; 2, CPC-706; 3, CPC-708; 4, CPC-829; 5, CPC-827; 6, CPC-696; 7, CPC-701; 8, CPC-709; all  $\times 1$ .

*aurarium* by Larson (2012), however, most species that belong to this genus are based on ornament and coiling of ontogenetic growth stages with adult ornamentation. Suture lines of *Didymoceras* have been rarely documented. Upper Campanian *D. cheyennense* has a suture line (Kennedy and Cobban, 1994, fig. 8.5) similar to specimen CPC-837, particularly in the limited extension of L.

*Eubostrychoceras* is a rare Upper Cretaceous genus in North America, its youngest record is from the middle Campanian Anacacho Limestone in Texas (Kennedy and Cobban, 2001). In its earliest whorls, the style of coiling differs from the helicooidal coiling of later juvenile whorls. The juvenile whorls of some *Eubostrychoceras* are always in contact and, therefore, must have a concave groove to accommodate the previous whorl (compare Matsumoto, 1967), but they are loosely coiled in others (Matsumoto, 1977). In straighter parts of early juvenile *E. japonicum* from the Turonian of Japan, ribbing is comparable to that of our specimens at similar WH (Matsumoto, 1977, pl. 49, fig. 3a–3c). Our specimens are too short to exclude the possibility of distant constrictions which are diagnostic for *Eubostrychoceras*. The suture line of CPC-837 is also very similar to that of *E.*

*elongatum* from Canada, particularly with its elongated L, although in the Canadian species ribbing is coarser than in our specimens (compare Ward, 1976).

Both Campanian genera may have similar early juvenile stages and similar suture lines. On basis of the characteristics preserved in the Union y Progreso specimens it is impossible to decide whether our two specimens belong to either *Didymoceras* or *Eubostrychoceras*.

Family DIPLOMOCERATIDAE Spath, 1926  
 Subfamily POLYPTYCHOCERATINAE Matsumoto, 1938  
 Genus POLYPTYCHOCERAS Yabe, 1927  
 POLYPTYCHOCERAS juv. sp.  
 Figures 9.19, 12.21, 12.25

*Description.*—Fragments of straight shafts with a round whorl section and stout ribbing. Rib index is 2–3. The ribs are straight and prorsiradiate on the flanks, straight on the dorsum and on the venter. The suture line is moderately incised with subtriangular, bifid elements of almost equal size and shape, except I which is trifid.

*Material.*—CPC-832 and CPC-834, two internal-mold

TABLE 6—Biometry for *Baculites* n. sp.

	WB	WH	WB/WH	UL
CPC-672	8.5	12.1	0.70	15
	9.0	13.5	0.67	
CPC-711	7.9	12.7	0.62	
CPC-720	8.8	12.8	0.69	12
	9.1	13.2	0.69	
CPC-706	8.7	13.1	0.66	16
	9.1	14.2	0.64	
CPC-702	9.2	13.2	0.70	15
	9.9	14.8	0.67	
CPC-700	8.9	13.3	0.67	
CPC-709	9.0	13.4	0.67	16
	10.6	14.2	0.75	
CPC-713	9.6	14.0	0.69	14
	10.5	14.7	0.71	
CPC-671	9.3	14.6	0.64	
CPC-703	9.9	15.3	0.65	
CPC-697	10.3	15.5	0.66	
CPC-696	11.5	16.2	0.71	
CPC-719	11.2	16.2	0.69	
CPC-827	12.0	16.5	0.73	
CPC-693	12.3	17.2	0.72	1
	12.8	18.5	0.69	
CPC-708	11.4	17.3	0.66	
CPC-701	11.5	17.8	0.65	1
	11.7	18.8	0.62	
CPC-721	12.0	17.8	0.67	21
	12.8	18.7	0.68	
CPC-824	14.5	19.5	0.74	
CPC-830	16.6	21.4	0.78	
CPC-829	14.8	21.8	0.68	

fragments. Measurements of CPC-832, WB=6.8, WH=7.0, WB/WH=0.97; CPC-834, WB=10.8, WH=11.3, WB/WH=0.96.

**Occurrence.**—*Polyptychoceras* is known from the Coniacian–Campanian of California, Japan, Antarctica, boreal Europe (Wright, 1996), and now Mexico.

**Remarks.**—This morphotype is distinguished from other Union y Progreso heteromorphs based on its low rib index, its coarse ribs, and suture line. Coiling in the Union y Progreso specimens appears to be helicoidal instead of planispiral, as indicated by the asymmetry of ribs and suture line. This is typical for *Polyptychoceras* juveniles. Species in this genus are mainly distinguished by ornamentation, which changes throughout ontogeny (e.g., Kennedy and Summesberger, 1984). The fragmentary nature of the Union y Progreso specimens does not permit examination of ontogenetic changes; we do not assign these specimens to a particular species.

Genus PSEUDOXYBELOCERAS Wright and Matsumoto, 1954

Subgenus PARASOLENOCERAS Collignon, 1969

PSEUDOXYBELOCERAS (PARASOLENOCERAS) juv. sp.

Figures 9.20–9.22, 12.17, 12.20, 12.22–12.24, 12.26

**Description.**—Straight, moderately curved shafts of planispirally open-coiled shells with rounded whorl sections (WB/WH=0.91–0.95), ornamented by coarse ribs. These are straight dorsally and ventrally, but moderately prorsiradiate on the flanks. Faint traces of a pair of ventral tubercles are also present (e.g., Fig. 12.17b). The suture line is preserved in all specimens and composed of subtriangular bifid elements of almost equal height.

**Material.**—CPC-714, CPC-835 and CPC-838 to CPC-840, CPC-846, six fragments of internal molds. Biometric data are provided in Table 7.

**Occurrence.**—Coniacian–Maastrichtian, globally distributed in lower-middle latitudes (Wright, 1996), including *Menabites* (*Delawarella*) *vanuxemi* biozone of the Parras Shale near Union y Progreso, Coahuila, Mexico.

**Remarks.**—This taxon is similar to our specimens of *Polyptychoceras*, but the suture line in *Pseudoxylloceras* (*Parasolenoceras*) is less incised and somewhat more irregular with

finer and more oblique ribs. In addition, ventral tuberculation is absent in *Polyptychoceras* and relates our specimens to *Pseudoxylloceras* (*Parasolenoceras*). In our fragmentary specimens, no helicoidal coiling is observed which contrasts to other open-coiled taxa of this genus. Maastrichtian *Pseudoxylloceras* (*Parasolenoceras*) *pulcher* differs from our specimens by denser ribbing (Cobban and Kennedy, 1993b). They are separated from the specimens assigned to the Nostoceratidae by their suture line which lacks the extended L.

SCAPHITES sp. ex gr. *S. HIPPOCREPIS* (DeKay, 1828)

Figures 9.23–9.28, 12.1–12.15

**Description.**—Globular shape with inflated whorl section. WB/WH is <1.76 in juveniles but decreases to 1.03 in shells with D>16 mm. Maximum width is reached at mid-flank. In early growth stages, expansion rate is high, but decreases at larger diameters, as indicated by similar WB of the early and later whorl. The whorl section then grades into a subtriangular shape. U is small, with U/D decreasing from 0.2 in early juveniles to 0.1 at larger D. The umbilicus is deep. Umbilical walls are rounded and grade into rounded flanks, which are short due to a widely rounded venter. Eight tubercles are present per half whorl and give rise to bullae that each grade into pairs of moderately prorsiradiate convex ribs. These are occasionally intercalated by secondaries, resulting in approximately 17 primaries and secondaries per half whorl. The suture is simple, with shallow, subrectangular, asymmetrically bifid elements. Only E/L and L are asymmetrically trifid.

**Material.**—Thirty-five specimens, internal molds of septate shells. Measurements are provided in Table 8.

**Occurrence.**—In North America, this species is exclusively known from the middle lower Campanian of the Western Interior, Gulf Coast, and Atlantic Coast Plan (Cobban, 1969; Cobban and Kennedy, 1992a). Its last form *S. hippocrepis* III co-occurs with *Menabites* (*Delawarella*) *vanuxemi* in Texas (Cobban and Kennedy, 1992a, 1992b). A lower middle Campanian record of *S. hippocrepis* also exists from Spain (Küchler, 2000a). Our record from the *Menabites* (*Delawarella*) *vanuxemi* biozone of the Parras Shale near Union y Progreso, Coahuila, Mexico, seems to be coeval to the records in Texas, so they are among the last records of this group in North America.

**Remarks.**—Specimens from Union y Progreso are juveniles with a globular whorl section; the absence of tubercles and bullae relate them to the genus *Scaphites*. Other scaphitids, such as *Trachyscaphites* or *Hoploscaphites*, are more compressed and present tubercles or bullae at comparable growth stages. Most lower Campanian *Scaphites* are also compressed in juvenile growth stages. The globular juvenile stage relates our specimens to the group of *Scaphites hippocrepis* (DeKay, 1828).

Order NAUTILIDA Agassiz, 1848

Suborder NAUTILINA de Blainville, 1825

Superfamily NAUTOLOIDEA de Blainville, 1825

Family NAUTILIDAE de Blainville, 1825

Genus EUTREPHOCERAS Hyatt, 1894

EUTREPHOCERAS IRRITILASI new species

Figure 12.27–12.29

**Diagnosis.**—The shallow, lateral groove is unique to this species.

**Description.**—Smooth internal molds, nautiliconically depressed, with a high expansion rate. WB/WH is 1.3, U is small (0.05). The siphuncle is at mid-whorl. Umbilical shoulders are rounded, grading into short flanks forming a wide arch. A short concave zone, or shallow groove, is present laterally. The suture is simple with a very shallow L developed on the flank.

**Etymology.**—This species is named after the extinct Indian

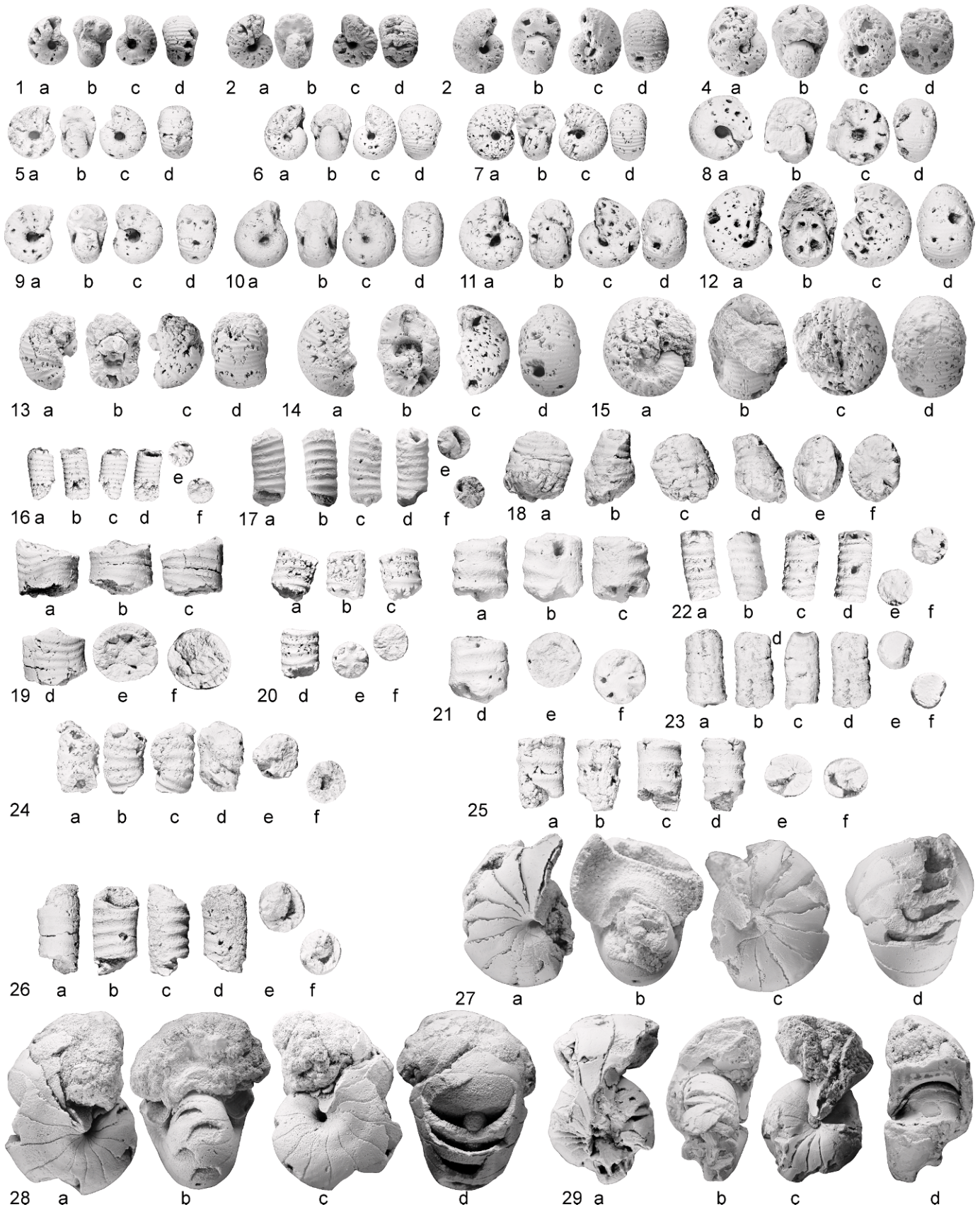


FIGURE 12—Anclycoceratina and *Eutrephoceras* from Union y Progreso. 1–15, *Scaphites* juv. sp. ex gr. *S. hippocrepis* (DeKay, 1828): 1, CPC-663; 2, CPC-664; 3, CPC-681; 4, CPC-682; 5, CPC-816; 6, CPC-818; 7, CPC-819; 8, CPC-821; 9, CPC-817; 10, CPC-820; 11, CPC-822; 12, CPC-823; 13, CPC-684; 14, CPC-685; 15, CPC-683; 16, 18–19, Nostoceratidae gen et sp. indet.: 16, CPC-833; 18, CPC-836; 19, CPC-837; 17, 20, 22–24, 26, *Pseudoxybeloceras* (*Parasolenoceras*) juv. sp.: 17, CPC-714; 20, CPC-839; 22, CPC-838; 23, CPC-846; 24, CPC-835; 26, CPC-840; 21, 25, *Polyptychoceras* juv. sp.: 21, CPC-834; 25, CPC-832; 27–29, *Eutrephoceras irritilasi* n. sp.: 27, CPC-659; 28, holotype CPC-660; 29, CPC-661; all  $\times 1$ .



TABLE 7—Biometry for *Pseudoxybeloceras* (*Parasolenoceras*) juv. sp.

	WB	WH	WB/WH
CPC-714	6.0	6.7	0.90
CPC-839	6.2	6.8	0.91
CPC-835	6.4	6.8	0.94
CPC-838	7.7	8.5	0.91
CPC-840	8.3	8.6	0.97
	8.8	9.5	0.93

tribe of the Irritilas, which inhabited southwestern Coahuila until the Spanish conquest.

*Types*.—The holotype is CPC-660 (Fig. 12.28), paratypes are CPC-659, CPC-661, and CPC-841.

Biometric data are listed in Table 9.

*Occurrence*.—*Menabites* (*Delawarella*) *vanuxemi* biozone of the Parras Shale near Union y Progreso, Coahuila, Mexico.

*Remarks*.—These specimens closely resemble depressed taxa such as *E. planoventer* Stephenson, 1941 and *E. dekayi* Morton, 1834, but in contrast, *E. planoventer* has a flattened venter and *E. dekayi* a well-rounded whorl section. In addition, the ventrolateral shallow groove of *E. irritilasi* is unique among Upper Cretaceous *Eutrephoceras* species.

#### BIOSTRATIGRAPHY

Much progress has been made in biostratigraphic correlation of the Campanian between North America and Europe during the last decades. A summary of biostratigraphic correlation between North America and Europe has been given by Küchler (2000b) and is included in Figure 13.

Within the Union y Progreso assemblage, *Menabites* (*Delawarella*) *vanuxemi* (Morton, 1830) represents the upper lower Campanian along the Gulf/Atlantic Coastal plain(s) where it co-occurs with *Menabites* (*Delawarella*) *delawarensis* (Young, 1963; Cobban and Kennedy, 1992b). This latter species is an index fossil for the upper lower Campanian in North America (Kennedy et al., 1992). The subgenus *Menabites* (*Delawarella*) is a zonal index for the upper lower Campanian in the Gulf/Atlantic Coastal plains (Cobban, 2008) and Europe (Kennedy, 1986; Küchler, 2000b). In addition to these taxa, juvenile *Scaphites* sp. occur at Union y Progreso that are similar to the upper lower Campanian *Scaphites hippocrepis* (DeKay, 1828). The subspecies *S. hippocrepis* III is a zonal index, even though the lineage of *S. hippocrepis* reaches into the overlying lower Campanian *Baculites smooth* sp. zone (discussion in Cobban and Kennedy, 1992a, p. 441). In Spain, the chronosubspecies *Scaphites hippocrepis* IV also extends into units above the lower Campanian substage (Küchler, 2000a).

TABLE 8—Biometry for *Scaphites* ex gr. *S. hippocrepis* (DeKay, 1828).

	D	WB	WH	WB/WH	U
CPC-663	9.7	7.2 (0.74)	4.1 (0.42)	1.76	1.9 (0.20)
CPC-816	10.8	7.3 (0.68)	5.8 (0.54)	1.26	1.9 (0.18)
CPC-664	11.2	8.0 (0.71)	5.4 (0.48)	1.48	1.7 (0.15)
CPC-819	11.5	7.9 (0.69)	6.1 (0.53)	1.30	1.9 (0.17)
CPC-817	11.5	8.0 (0.70)	5.6 (0.49)	1.43	2.4 (0.21)
CPC-818	11.8	9.0 (0.76)	6.1 (0.52)	1.48	1.5 (0.13)
CPC-681	13.3	9.4 (0.71)	7.1 (0.53)	1.32	1.4 (0.11)
CPC-820	13.8	9.1 (0.66)	7.8 (0.57)	1.17	1.8 (0.13)
CPC-821	14.0	9.6 (0.69)	6.8 (0.49)	1.41	2.6 (0.19)
CPC-822	14.9	10.1 (0.68)	8.8 (0.59)	1.15	2.0 (0.13)
CPC-682	15.2	12.0 (0.79)	8.2 (0.54)	1.46	1.7 (0.11)
CPC-684	15.6	11.3 (0.72)	8.8 (0.56)	1.28	1.9 (0.12)
CPC-823	17.8	12.4 (0.70)	12.0 (0.67)	1.03	1.3 (0.07)
CPC-683	18.8	13.9 (0.74)	12.1 (0.64)	1.15	1.3 (0.07)
CPC-685	18.9	12.8 (0.68)	11.4 (0.60)	1.12	2.0 (0.11)

TABLE 9—Biometry for *Eutrephoceras irritilasi* n. sp. Asterisks mark estimated or uncertain measurements.

	D	WB	WH	WB/WH	U
CPC-659	26.3	23.0 (0.87)	*17.0 (0.65)	*1.35	1.1 (0.04)
CPC-841	*30.2	22.9 (*0.76)	18.5 (*0.61)	1.24	1.0 (*0.03)
CPC-660	30.5	26.1 (0.86)	20.2 (0.66)	1.29	1.6 (0.05)
CPC-661	30.6	—	*18.9 (0.62)	—	1.5 (0.05)

*M. (D.) delawarella* co-occurs with *S. hippocrepis* in France (Kennedy, 1986), Texas (Cobban and Kennedy, 1992a, 1992b), and New Jersey (Reese, 1962), where these zones are included into the upper lower Campanian. The *M. (D.) delawarensis* zone is correlated to the *S. hippocrepis* I to III WI zones (Cobban, 2008). Cobban and Kennedy (1992a, p. 441) discuss that *B. haresi*, also present at Union y Progreso, ranges into to *S. hippocrepis* III WI zone.

*Pseudoschloenbachia mexicana* (Renz, 1936) is known to range from the upper Santonian to lower Campanian of Alabama and Texas to Chihuahua and Coahuila. Its occurrence at Union y Progreso is among its youngest records. *Pseudoschloenbachia* aff. *mexicana* represents a new morphotype that cannot be exactly separated from the mother species. Its presence at Union y Progreso may point to a remnant population, prior to the final extinction of the genus.

#### PALEOBIOGEOGRAPHIC INTERPRETATION

Results from the palaeobiogeographic analysis are shown in Figure 14. Shares are calculated as percent of individuals. Juveniles of *Menuites* (*Neopachydiscus*) sp., Nostoceratidae gen. et sp. indet., *Parasolenoceras* juv. sp., *Polyptychoceras* juv. sp., and *Scaphites* sp., which form 25 percent of the assemblage, are excluded from the palaeobiogeographic analysis due to the lack of data on species level.

*Desmophyllites diphyllodes* (Forbes, 1846) is the only cosmopolitan species present at Union y Progreso, but with five individuals it comprises only 2 percent of individuals in the assemblage. Records of *Menabites* (*Delawarella*) *vanuxemi* (Morton, 1830) exist from the Gulf and Atlantic Coastal plains and the WI. *Baculites haresi* Reese, 1927 is known from the Gulf and Atlantic Coastal plains, however, this species is most common in the WI. Individuals of these two species comprise 21 percent of the faunal assemblage. All other species have been previously recorded from only Texas and Chihuahua, or are now known to occur in Coahuila. These include: *Eutrephoceras irritilasi* n. sp., *Hypophylloceras* (*Neophylloceras*) *arturoi* n. sp., *Pseudoschloenbachia* (*P.*) *mexicana* (Renz, 1936), *P. (P.)* aff. *mexicana*, *Tetragonites silencioensis* n. sp., and possibly *Baculites* n. sp. Individuals of these endemic taxa make up 52 percent of the individuals in the Union y Progreso assemblage. This high degree of endemism is further emphasized when species richness is considered; of the 14 taxa identified here, nine species can be further interpreted. One species is cosmopolitan, two are North American (WI, Gulf of Mexico-Atlantic, or both), and six are endemic. The Union y Progreso ammonites thus indicate an unexpectedly high degree of endemism, which suggests limited exchange with other ammonoid faunas or faunal provinces during the late early Campanian. This limitation even existed with respect to the Western Interior Seaway; exchange between the WIS and the Mexican Gulf Coast northeastern Mexico was repeatedly established during the Late Cretaceous (Ifrim et al., 2004; Ifrim et al., 2005; Stinnesbeck et al., 2005; Ifrim and Stinnesbeck, 2007, 2008; Ifrim et al., 2010a; Ifrim and Stinnesbeck, 2010).

	Western Interior Cobban <i>et al.</i> , 2006	Gulf of Mexico and Atlantic coast Young, 1963, and Kenedy <i>et al.</i> 1997	Northern Spain Navarra Küchler 2000	Northern Aquitaine Kennedy 1986	Northern Germany Lower Saxony from Küchler 2000	Northern Germany Schmidt and Ernst 1975, Ernst <i>et al.</i> 1979, Schultz <i>et al.</i> 1984, Schultz 1985
<b>MIDDLE CAMPANIAN</b>	<i>Baculites scotti</i> <i>Baculites reduncus</i> <i>Baculites gregoryensis</i> <i>Baculites perplexus (late)</i> <i>Baculites sp. (smooth)</i> <i>Baculites asperformis</i> <i>Baculites mcelarni</i> <i>Baculites obtusus</i>	<i>Hoplitoplacenticeras marroti</i>  <i>Baculites taylorensis</i>	<i>Trachyscaphites spiniger</i> <i>Pseudoxybeloceras phaleratum</i> <i>Pseudoxybeloceras sp.</i> <i>Trachyscaphites spiniger</i> <i>Pachydiscus haldemisi</i>  <i>Hoplitoplacenticeras marroti</i> <i>Scaphites (S.) hippocrepis</i> IV <i>Glyptoxoceras retrorsum</i> <i>Baculites</i> spp.	<i>Hoplitoplacenticeras marroti</i> <i>Scaphites (S.) haugi</i> <i>Scaphites (S.) gibbus</i> ( <i>Placenticeras bidorsatum</i> )	<i>Pseudoxybeloceras phaleratum</i> <i>Trachyscaphites spiniger</i>  <i>Trachyscaphites spiniger</i> <i>Patagiosites stobaei</i> <i>Scaphites gibbus</i> <i>Pachydiscus haldemisi</i> <i>Hoplitoplacenticeras</i> spp. <i>Scaphites gibbus</i> <i>Glyptoxoceras retrorsum</i>	<i>Galerites roemeri</i> ( <i>Galerites vulgaris</i> )  <i>conica / senior</i> ( <i>conica / mucronata</i> )
<b>LOWER CAMPANIAN</b>	<i>Baculites sp. (weak flank ribs)</i> <i>Baculites sp. (smooth)</i>	<i>Delawarella delawarensis</i>	<i>Menabites</i> spp. <i>Scaphites (S.) hippocrepis</i> III <i>Eupachydiscus levyi</i>	<i>Menabites (D.) delawarensis</i> <i>M. (australiella) cf. besairei</i> ( <i>S. (S.) hippocrepis</i> ) <i>Scaphites (S.) hippocrepis</i> III <i>Placenticeras bidorsatum</i>	<i>Scaphites gibbus</i> <i>Glyptoxoceras retrorsum</i>	<i>gracilis / senior</i> <i>conica / papillosa</i> <i>papillosa</i> <i>senonensis</i> <i>pilula / senonensis</i> <i>Offaster pilula</i> <i>lingula / quadrata</i> <i>granulataquadrata</i>
	<i>Scaphites (S.) hippocrepis</i> II  <i>Scaphites (S.) hippocrepis</i> I  <i>Scaphites (S.) leei</i> III	<i>Submortoniceras tequesquitense</i>	<i>Scaphites (S.) hippocrepis</i> III <i>Glyptoxoceras</i> spp.  Unnamed Interval	<i>Placenticeras bidorsatum</i> <i>Pachydiscus duelmensis</i> <i>P. (P.) launayi</i> <i>Eupachydiscus isculensis</i>	<i>Scaphites hippocrepis</i>          <i>Placenticeras bidorsatum</i>	<i>Scaphites gibbus</i> <i>Scaphites hippocrepis</i>          <i>bidorsatum</i>

FIGURE 13—Biostratigraphic correlation between North America and Europe. The bar marks the level to which the Union y Progreso assemblage is correlated. European zonations are from Küchler (2000b), North American zonations from and Cobban *et al.* (2006).

but is very restricted among ammonoids during the late early Campanian.

The border region of southern Texas and northern Chihuahua was interpreted as an endemic center for the Upper Cretaceous (Kauffman, 1973), but without further specification. The high degree of endemism developed in the Union y Progreso cephalopod assemblage, including 52 percent of individuals and 43 percent of the species, suggests that this endemic center extended into Coahuila during the early Campanian. The region may thus have been partially isolated from the WI and the Atlantic in that time. The only cosmopolitan taxon found at Union y Progreso is *Desmophyllites diphyloides*, which is rare at the locality. However, the taxon is morphologically stable with a long range from the Santonian to the late Maastrichtian; it may have survived in the region without further evolution despite the biogeographic cutoff from other ammonoid populations.

Endemism in early Campanian ammonoids of the WIS has been noted before. In this region, the disappearance of the *S. hippocrepis* lineage is associated with a reduction in ammonoid diversity, with *Placenticeras*, *Baculites*, and *Hoploscaphites* (formerly *Jeletzkyites*) as the only abundant faunal preserved (Cobban, 1993). This observed specialization supports the biogeographic cutoff interpreted for the western Gulf of Mexico here. The high degree of endemism of the Union y Progreso

assemblage thus matches the overall evolutionary pattern observed in the WI. This endemism is, however, surprising because of the location of the Union y Progreso area on the open shelf, and species from this locality are assigned to genera with much wider biogeographic distributions. More specifically, *Hypophylloceras* (*Neophylloceras*) has a global distribution, with more abundant records in intermediate and high latitudes. *Baculites*, *Didymoceras*, *Menuites*, *Desmophyllites*, and *Tetragonites* are also cosmopolitan genera. *Pseudoschloenbachia* and *Scaphites* are abundant in low and intermediate latitudes, whereas *Menabites* (*Delawarella*), *Polyptychoceras*, *Pseudoxybeloceras* (*Parasolenoceras*) are similarly distributed but are usually rare. None of the genera are restricted to a certain faunal province or continent. This points to a short term cut-off from the interchange with other ammonoid populations, and thus a short-term late early Campanian endemic event.

CONCLUSIONS

The cephalopod described here represents the first fossil assemblage described from the Parras Shale in Coahuila, Mexico. This assemblage consists of 14 taxa. The correlation between European and WI ammonite zonations is based on the presence of *Menabites* (*Delawarella*) *vanuxemi* (Morton, 1830), which is restricted to the upper lower Campanian. *Baculites haresi* shows a longer range and wider occurrence, but is also restricted to the North American continent. Three new species were identified: *Hypophylloceras* (*Neophylloceras*) *arturoi* n. sp., *Tetragonites silencioensis* n. sp. and *Eutrephoceras irritilasi* n. sp. In addition, *Baculites* n. sp., and *Pseudoschloenbachia* (*P.*) aff. *mexicana* also appear to represent new species. *Pseudoschloenbachia* (*P.*) *mexicana* is abundant at Union y Progreso and endemic to a small region comprising Texas, northern Chihuahua, and now western Coahuila. Thus, it seems that this region was isolated from other faunal provinces, including the WIS and the Atlantic during the late early Campanian. The conservative cosmopolitan species *Des-*

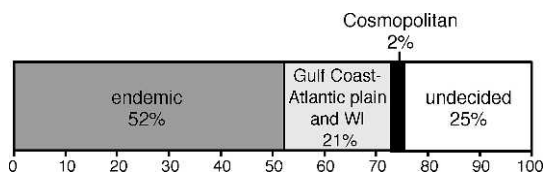


FIGURE 14—Paleobiogeographical composition (percent of individuals, n=208) of the Union y Progreso assemblage reveals a high degree of endemism.

*mophyllites diphylloides* is rare at Union y Progreso and may have persisted in the region without visible evolution.

The western Gulf of Mexico is regarded an open-shelf setting with no geographical barriers known to restrain faunal exchange. The high degree of endemism observed in the upper lower Campanian ammonite fauna is thus surprising. The causes for this endemism remain unknown, however, it is noticeable in a wider context and, therefore, regarded here as a regional bioevent among ammonoids. It appears, that northeastern Mexico or eastern Coahuila, was partially isolated from other regions, even though this region was located in the overlap of several faunal provinces. This early Campanian endemic event appears to have been short-term, as indicated by the abundance of genera in the assemblage with broad geographic distributions.

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