New Echinoid (Spatangoida: Toxasterinidae) from the Campanian of Coahuila, Northeastern Mexico

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ABSTRACT

Three specimens corresponding to a new echinoid species from the Upper Cretaceous (Lower Campanian) from Austin Formation in the northeastern of Mexico are reported here. The morphology of the specimens (test with a cordiform aboral region) as well as the sedimentary environment reported at the Austin Formation, suggests that this species represents an infaunal and detritivorous dweller living in a shallow water environment within the continental shelf. This is consistent with the more actual knowledge for other species of *Diplodetus*

Keywords: Echinoids, *Diplodetus*, Upper Cretaceous, Campanian, Austin Formation, NE Mexico.

RESUMEN

Se reportan tres especímenes de Diplodetus brisenoi, una nueva especie de equinoideo del Campaniano Inferior (Cretácico Superior) de la Formación Austin, en Jiménez, Coahuila, noreste de México. Tanto su morfología (testa con ámbito cordiforme) como el ambiente de depósito reportado para la Formación Austin sugieren que esta especie representa un elemento de la infauna con hábitos detritívoros en ambientes de plataforma, lo cual es consistente con lo reportado para otras especiesdel género Diplodetus.

Palabras clave: Equinoideos, Diplodetus, Cretácico Superior, Campaniano, Formación Austin, NE de México.

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1. Introduction

The echinoid *Diplodetus* was described by Schlüter (1900) and currently contains eight formal species, represented by *D. brevistella* (Schlüter, 1899), *D. parvistella* (Schlüter, 1899), *D. americanus* (Stephenson, 1941), *D. bucardium* (Goldfuss, 1829), *D. dupon-ti* (Lambert, 1911), *D. nutrix* (Lambert, in Boule, 1899), *D. gauthieri* (Cotteau, 1908); *D. coloniae* (Cotteau, 1877). This genus is also known in Upper Cretaceous rocks from Belgium (Jagt, 2000), Germany (Newman *et al.*, 2000), Netherlands (Jagt, 2000), Spain (Rehfeld and Ernest, 1998) and it is less common from the Paleocene of Madagascar, Ukraine and Western Europe (Cotteau, 1877). In Mexico, the only known record for this genus was reported by Silva-Martínez *et al.* (2014) in outcrops of the Austin Formation (Lower Campanian: Upper Cretaceous), at the localities of Arroyo El Freno and Arroyo El Tecolote, in the municipality of Jiménez, Coahuila.

The present work provides a more detailed description of the specimens reported by Silva-Martínez (2014) in order to raise *Diplodetus brisenoi* as a new echinoid fossil species from Lower Campanian of Coahuila, Northeast of Mexico, and to give a short comment concerning its paleoecological significance within the Austin Formation at the study area.

In the collecting area (Figure 1), the Austin Formation consists in a section of at least 8 m of clayish limestone and calcareous marl, the last ones with a decimetric thickness (Figure 2 and Figure 3). The limestone shows a thickness that varies from 10 cm to 80 cm, it exhibits a yellowish gray color in weathered samples or gray to light brown and occasionally dark brown in fresh samples. The limestone is characterized by the presence of a fine parallel lamination in a millimetric scale as well as the presence of pyrite nodules of more than 4 cm in diameter. The thickness of marl varies from 10 to 69 cm and exhibits a light gray coloration with yellowish tonalities in fresh samples, and gray bluish to green color in weathered samples. Some layers have reddish iron oxide bands whose thickness varies between of 3 – 4 cm.

The marly sediments of the Austin Formation at Jiménez, Coahuila, hold up diverse fossil groups of fauna represented by several species of ammonoids, various genera of bivalves and echinoids, as well as one specimen of elasmobranchii and one specimen of a teleostean fish. Ammonoids are depicted by *Bevahites internodosus*, *Jimenites cantusi*, *Delawarella delawarensis* and *Scaphites hippocrepis*. Bivalves include ostreids of the genera *Exogyra*, *Lopha* and *Gryphaea*; as well as the inoceramids *Cladoceramus undulatopliocatus* and *Inoceramus balticus*. Echinoids are represented by *Cidaris texanus*, *C. splendens*, *Salenia mexicana*, *Holectypus* sp., *Heteraster texanus*, *Diplodetus* sp., *Diplopodia hilli*, *Orthopsis casanovai*, *Micraster uddeni*, *Mecaster batnensis* (Silva-Martínez *et al.*, 2014). Fishes are represented by an Elasmobranchii of the genus *Ptychodus* (Hybodontoidei) and a Teleostean preliminary assigned to *Goulmimichthys* sp. (Figure 5).

In a previous work carried out by Vega *et al.* (2013) at Austin Formation, in the vicinity of the study area, he reported the presence of the ostreids *Phrysaea* (*Gryphaea*) *aucella* and *Exogyra laeviscula*, the ammonoid *Parapuzosia boisei* and two species of the genus *Menabites* as well as the crustacean (Decapoda) species *Enoploclytia tepeyacensis*.

According to Silva-Martínez *et al.* (2014) the presence of the ammonite *Delawarella delawarensis* (Morton, 1841) along the studied section supports the assignment of a Lower Campanian age for this unit.

2. Methodology

The specimens described in this work and assigned as *Diplodetus brisenoi* nov. sp. were collected from the section using traditional methods using a rock hammer and chisel. Subsequently they were labeled and transported to the Laboratorio de Paleobiología, of the Facultad de Ciencias Biológicas, at Universidad Autónoma de Nuevo León for

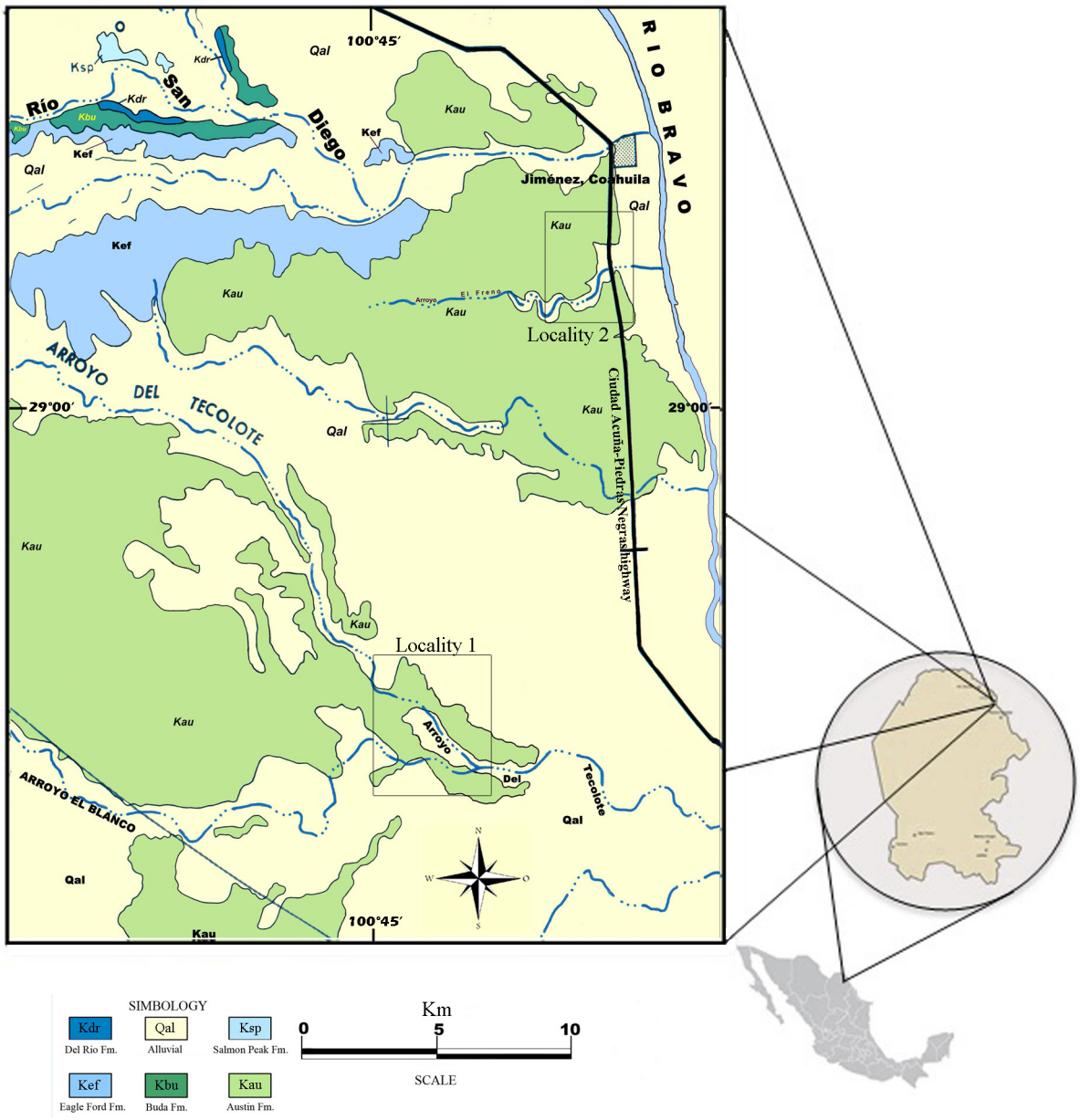

Figure 1 Localization map of the Austin Formation, the squares indicate the two sampling sites (Locality 1: Arroyo El Tecolote, Locality 2: Arroyo El Freno).

its study, documentation and housing as a part of the paleontological collection.

The specimens were mechanically and chemically prepared prior to its study. The mechanic preparation was conducted using a pneumatic engraving pen of variable speed in order to remove the covering rock. Afterwards, the chemical preparation consisted in placing the fossil material in a beaker and covers it with potassium hydroxide for at least 72 hours to dissolve the particles that remained after the mechanical preparation. Finally, the material was rinsed with tap water and let it dry. Once the paleontological material had been prepared, it was revised using a standard stereoscopic microscope LEICA-CME. The specimens were observed under different magnifications for its anatomical description and taxonomical determination according to the scientific literature criteria.

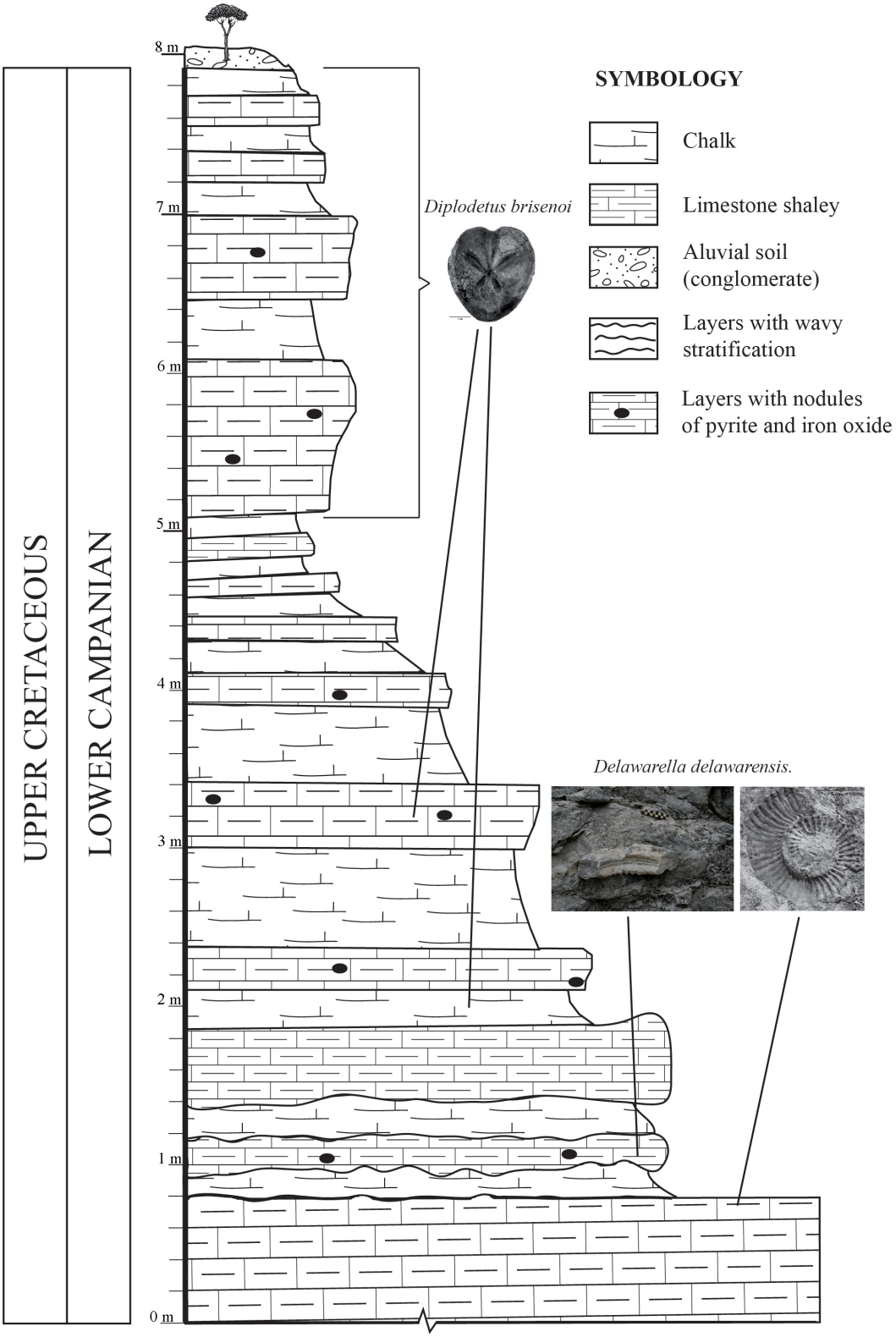

Figure 2 Stratigraphic profile and distribution of *Diplodetus brisenoi* nov. sp. at Arroyo El Freno, Jiménez, Coahuila.

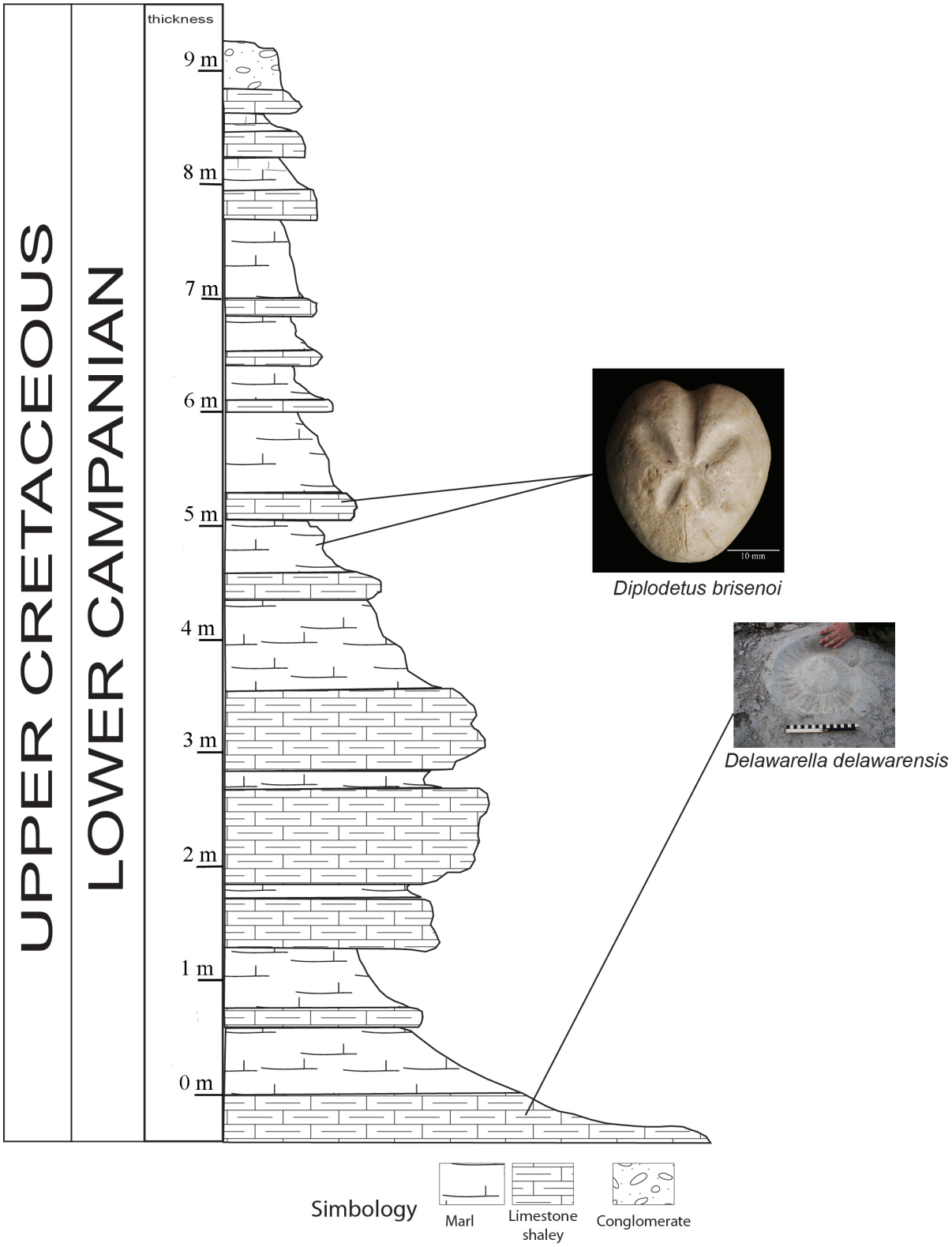

Figure 3 Stratigraphic profile of the Austin Formation at Arroyo El Tecolote, Jiménez, Coahuila, showing the vertical distribution of *Diplodetus brisenoi* nov. sp.

3. Systematical paleontology

Order Spatangoida CLAUS, 1876
Suborder Micrasterina Fischer, 1966
Family Brissidae Gray, 1855
Genus *Diplodetus* Schlüter, 1900
Diplodetus brisenoi nov. sp.
(Figures 4 and 6)

Diagnosis. Test with the following characteristics: Length between 35.5 to 36.4 mm. Width between 32 to 32.4 mm, apical height 20.1 to 21.1 mm, oval, cordiform, the lateral profile is higher in the posterior part of the apical system than in the anterior part. The last one is considerably more convex in contrast with the strongly truncated at the posterior part. Paired ambulacra petaloids, with pores in the fissure, the paired petals pores present equally size and form to the posterior ambulacra, which are short and sunken in a deep furrow. The odd ambulacra present oval pores separated by a pair of granules. The area of the test is rounded in its anterior part and truncated in the posterior part, with a elongated periproct supramarginal ended in tip in both edges, with a compact semi-ethmolytic apical system.

Holotype: FCBUANL_2458; Complete specimen with external visible characteristics.

Paratypes: FCBUANL_2454 and FCBUANL_2523; both specimens are complete with visible external characteristics.

***Locus typicus*:** Arroyo El Freno and Arroyo El Tecolote, municipality of Jiménez, Coahuila, Northeastern Mexico.

Stratigraphic position: Austin Formation, Lower Campanian (Upper Cretaceous).

***Derivatio nominis*:** Species name in honor to Professor Carlos Humberto Briseño de la Fuente for his important contribution to the invertebrate zoology in the Mexican state of Nuevo León and in the Northeastern of Mexico.

General Description. The echinoid specimens assigned to *Diplodetus brisenoi* from the Austin Formation at Jiménez, Coahuila display a cordiform morphology with maximum length that varies from 35.5 mm to 36.4 mm, width of 32.0 mm to 32.4 mm and a height between 20.1 mm and 21.1 mm. Oval test with a cordiform outline, the anterolateral margins are rounded and the posterolaterals are almost straight, the width of the anterior third becomes narrower. The lateral profile is higher in the posterior part of the apical system than in the anterior part and it is considerably truncated at the back, the inferior surface is slightly convex.

The apical system becomes slightly eccentric towards the posterior part, with four genital gonoporesequally spaced, with a compact semi-ethmolytic apical system, with the posterior genital plates in contact with its posterior part of the madrepore plate, posterior ocellar plates in contact. Odd ambulacra (anterior) completely sunken; the pores of the petaliferus are short and in chevron pattern (inverted V), each pair of pores is separated by a tiny tubercle (Figure 6). Paired petals are moderately sunken, the anterior pair is longer than the posterior pair, the first extends up to 2/3 of margin and shows a divergent angle between 135 and 150 degrees, the posteriors are close to each other and depicting a divergent angle of 124 to 126 degrees (Figure 4D), the posterior petals pair extends up to the half of margin, pair-pore of the petals zone with a pair of transversally elongated pores and separated by four tubercles, pair-pore of the petals zone as wider as the interpores. The peristome is small, subpentagonal and is located to ¼ of the anterior margin. The periproct is elongated, pointed in both endings and is in a supramarginal position, outstanding the truncated part of the test. It presents a peripetal fasciola.

Dimenssions in milimeters

Specimen	Length	Width	Height
FCBUANL_2454	35.7	32	21.1
FCBUANL_2458	35.5	32.4	20.1
FCBUANL_2523	36.4	32.2	20.2

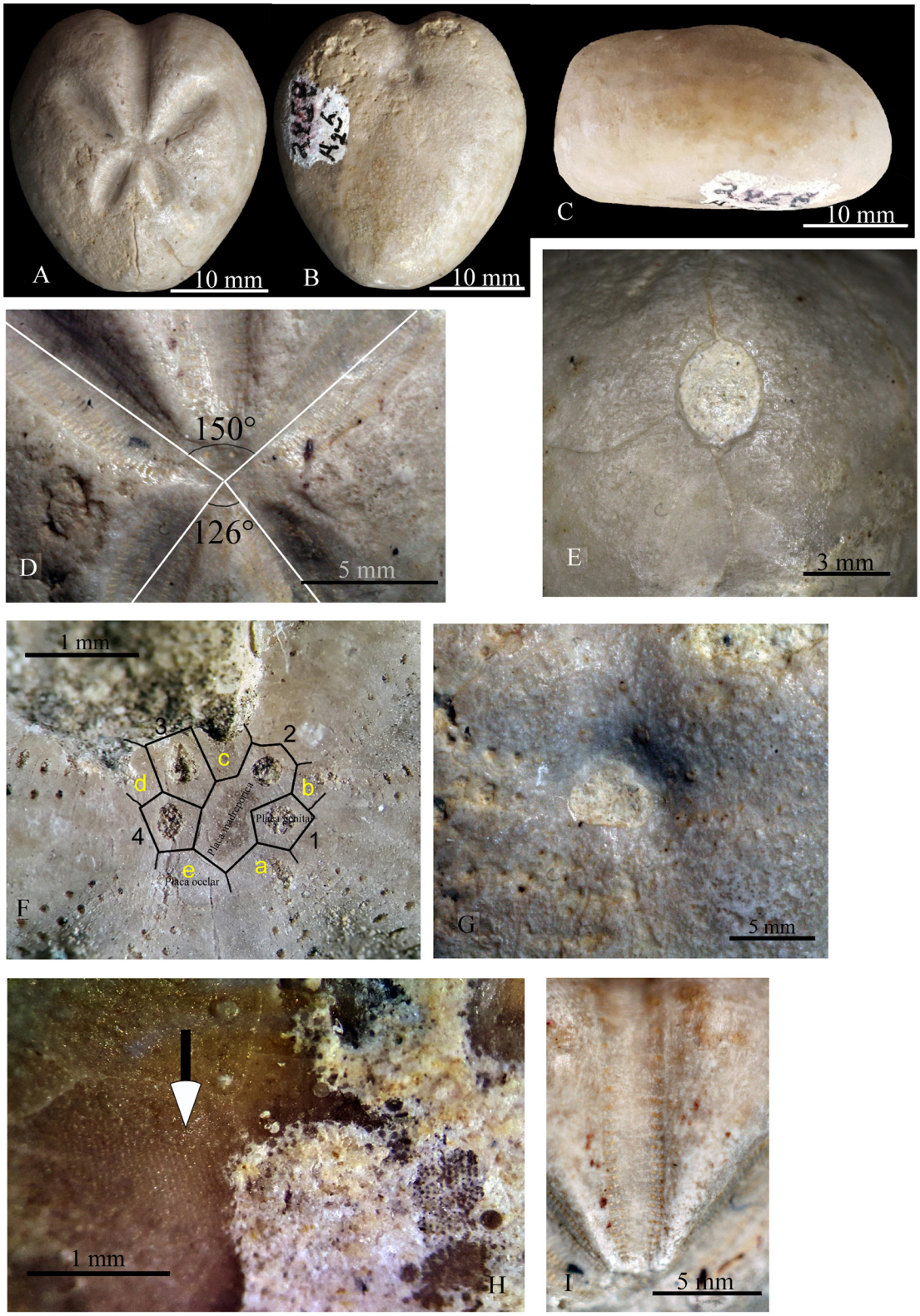

Figure 4 A: *Diplodetus brisenoi* nov. sp. Holotype FCBUANL_2458 apical, B: ventral view, C: lateral view, D: close-up of the apical system, E: view of the periproctal area, F: close-up of the apical system showing the arrangement of the genitals and ocellar plates (semi-ethmolyitic type), G: close-up of the peristoma, H: A fragment of the peripetal fasciole in *D. brisenoi*, showed by the arrow, I: Close-up of the unpaired ambulacrum showing the poriferous zones.

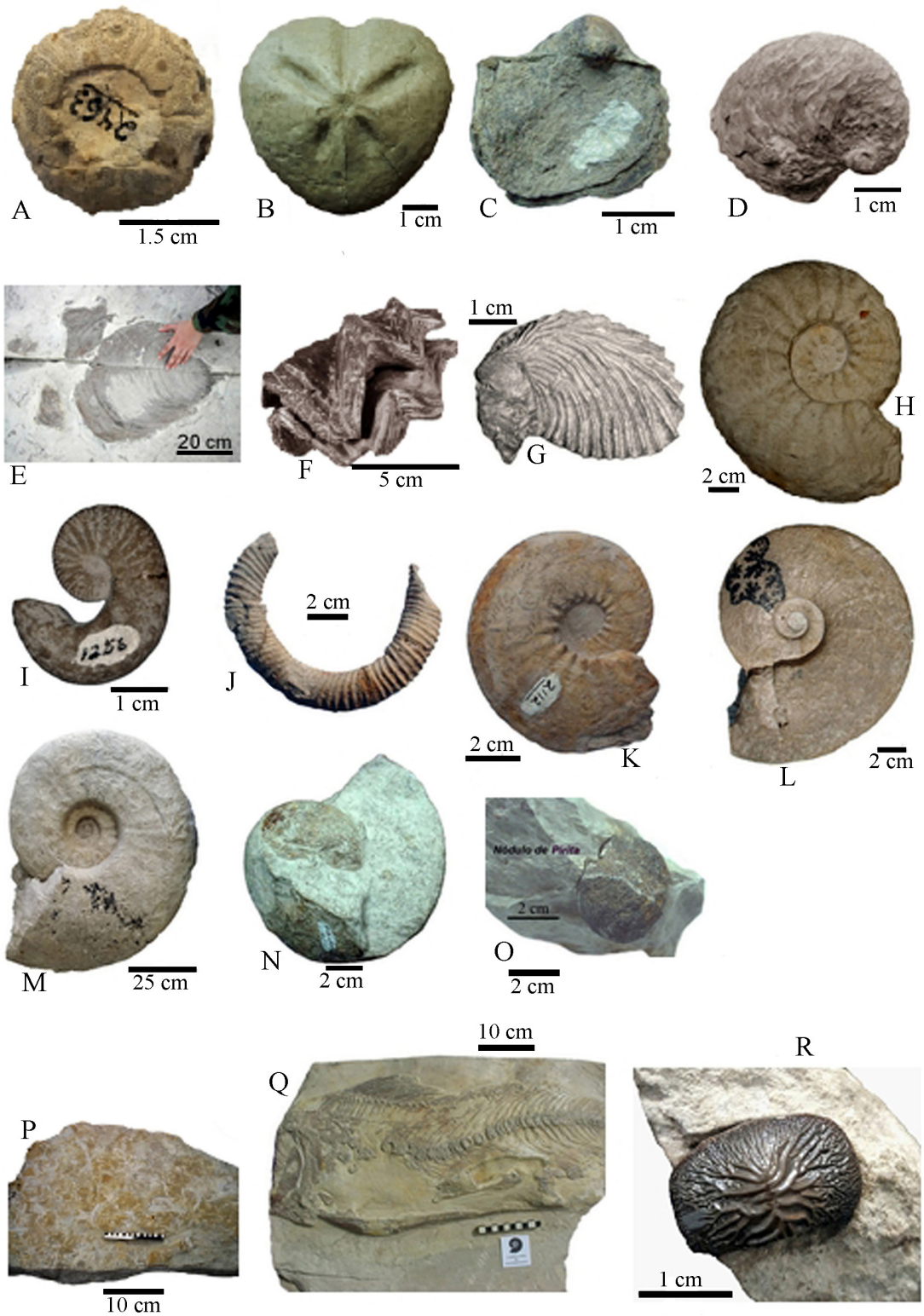

Figure 5 Associated fauna to *Diplodetus brisenoi* nov. sp. from Austin Formation in the study area. A: *Cidaris texanus* Clark, B: *Micraster uddeni* Cooke, C: *Pycnodonte aucella* Roemer, D: *Exogyra ponderosa* Roemer, E: *Inoceramus undulatoplicatus* Roemer, F: *Lopha macoyi*, G: *Lopha travisana* Stephenson, H: *Pseudoschloenbachia mexicana* (Renz, 1936), I: *Scaphites hippocrepis* (DeKay, 1828), J: *Gliptoxoceras* sp., K: *Menabites* (*Delawarella*) *janneti* (Young, 1963), L, M: *Parapuzosia bosei*, N: *Eutrephoceras* sp., O: Pyrite nodule, P: *Ichnofossils* (*Thalassinoides*), Q: Teleostean fish *Goulmimichthys* sp., R: *Ptychodus* sp.

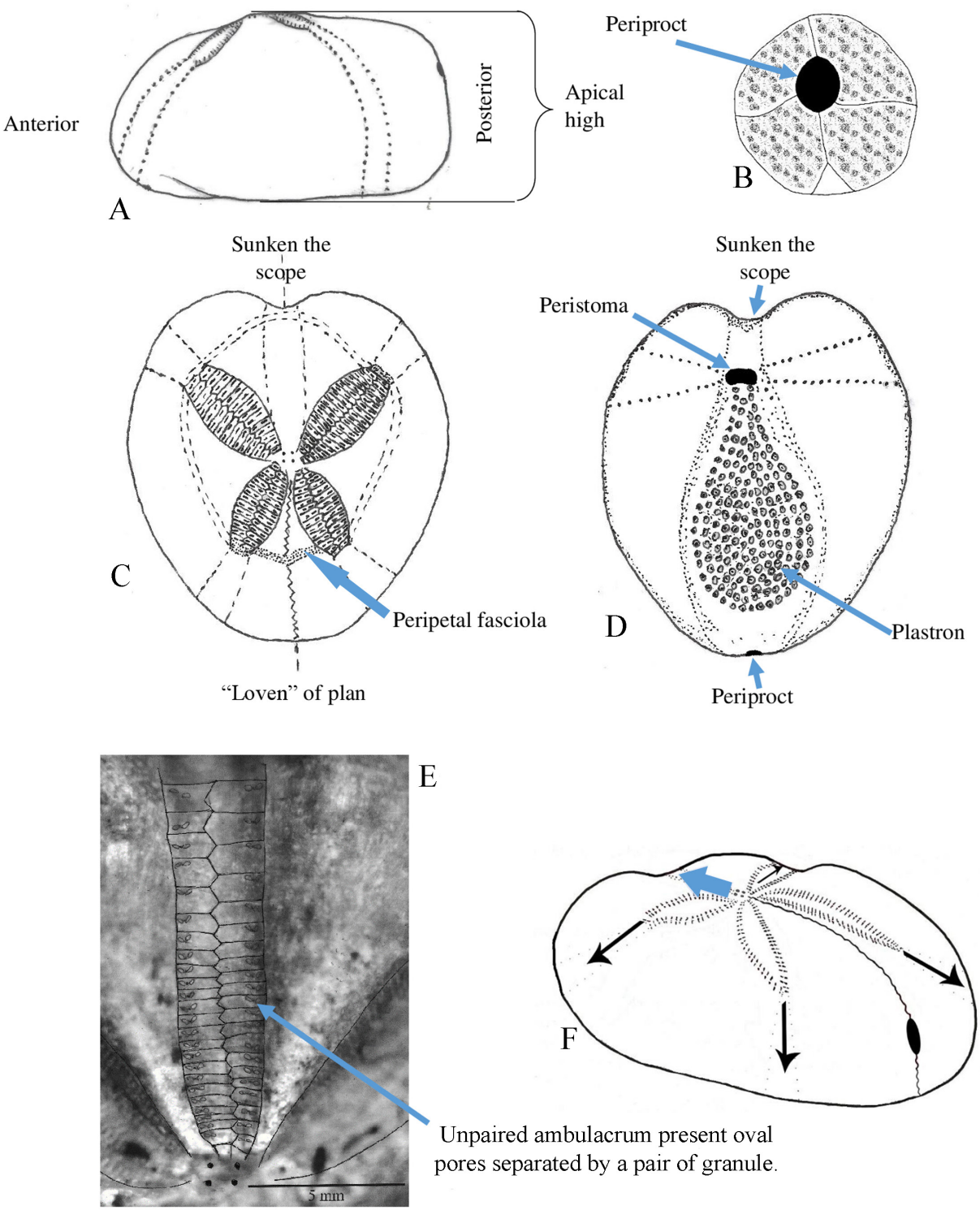

Figure 6 Morphological characteristics *Diplodentus brisenoi* nov. sp. A: Line drawing showing the total height of the specimens of *Diplodetus brisenoi* nov. sp., B: Line drawing of the periprocal area showing the plates surrounding the periproct, C: Line drawing of the apical section showing the cordiforme morphology of *Diplodetus brisenoi* nov. sp. as well as the fragments of the peripetal faciole, D: Line drawing of the ventral section showing, the oval shape of the peristoma which is observed with a slightly extended edge and a groove that are forming the unpaired ambulacrum, E: Close-up of the unpaired ambulacra showing the ambulacral plates and pores in chevron, F:Line drawing diagram of *Diplodetus brisenoi* showing the direction of the movement (arrows) generated by the ambulacral tube feet in the process of cleaning and feeding the echinoid when it was completely or partially buried into the soft sediment.

4. Discussion

The specimens reported in this work showing a combination of morphological characters that can easily differentiate from other species of the genus *Diplodetus*, and are therefore the support to consider *Diplodetus brisenoi* as a new species of echinoid (Table 1): medium size test, length between 35.5 mm to 36.4 mm. Width between 32.0 mm and 32.4 mm. Apical height from 20.1 mm to 21.1 mm, oval, cordiform. Paired petaloids ambulacra, sunken in a deep furrow. Paired petals moderately sunken, the anterior pair is longer than the posterior, the first extends up to 2/3 of the margin and portrays a divergent angle between 135 and 140 degrees, the posteriors are very close together, presents a divergent angle of 124 to 126 degrees (Figures 4D and 4H), peripetal fasciola present.

In *D. brevistella* (Schlüter, 1899) the test is not as wide as long, shallow notch of the odd ambulacra is almost absent at area level, with a sub anal and peripetal fasciola. In *D. americanus* (Stephenson, 1941), the size of the test is considered as medium, reaching 57.0 mm of length, the unpaired petals are at superficial level, the paired petals show a divergent angle of 120 degrees in the anterior part and 55° in the posterior part. In *D. bucardium* (Goldfuss, 1829) the test has a length of 55.0 mm and it is higher in the posterior part, with a cordiform outline. In *D. duponti* (Lambert, 1911), the size of the test reaches a minimum length of 60.0 mm, the anterior margin is cut and shortened, the paired ambulacra present a divergent angle of 105°, 1.5 times more than the posterior. Taking in consideration *D. coloniae* (Cotteau, 1877), the outline of the test is more oval with the anterior scot light, the paired petals present a divergent angle of 140-150°.

Distribution of genus *Diplodetus*: *Diplodetus* has been widely reported in different localities of Europe, and in a more restricted distribution area in Africa and America (Fischer, 1966). This genus is reported during the Upper Campanian and Lower Mastrichtian in Belgium (Jagt, 2000) and for the Campanian in Spain (Rehfeld and Ernest, 1998). In the American continent, *Diplodetus* is also known for the Campanian of Texas.

Aside from Cretaceous rocks, the record of the genus is less common. It has been described in Paleocene rocks of Madagascar, Ukraine and Western Europe (Cotteau, 1877). The presence of *D. brisenoi* in northeastern Mexico, represent the only known record for the genus in Mexico (Silva-Martínez *et al.*, 2014) and the second one in America, and it is also the most austral record for this continent (Figure 7).

Paleoecology and paleobiology of the genus *Diplodetus*: In the Northeastern of Mexico, the Austin Formation has been widely described by different authors at different localities (Shumard, 1860; Reeside, 1927; Adkins, 1930; Young, 1963; Carrasco, 1963, 1969; Taff, 1892; Santamaría-Zabala, 1991; Sohl *et al.*, 1991; Eguiluz de Antuñano, 2001; Escalante *et al.*, 2002; Romo-Ramírez *et al.*, 2002; Santiago *et al.*, 2003; Stinnesbeck *et al.*, 2005; Myers, 2010; Silva-Martínez *et al.*, 2014). It was deposited under conditions of an inner/medium continental shelf environment. The stratigraphic age for this unit was ranked from Coniacian to Lower Campanian (Silva-Martínez *et al.*, 2014).

The Early Campanian was a time of transgressions that influenced the Northeastern of Mexico, it carried a major influx of terrigenous sediment into the Gulf of Sabinas (Sohl *et al.*, 1991). This increment in the terrigenous input favored the formation of a soft-to hardseafloor, which make easier the establishment of benthonic biota (*e.g.* echinoderms).

In the study area, the presence of several groups of endobenthonic organisms such as serpulids and other unidentified burrowers, for ammonites, the kind of preservation displays internal moulds that, in addition to the presence of *Diplodetus brisenoi*, may evidence the presence of a soft seafloor. The genus *Diplodetus*, like other genera of the family Brissidae is characterized as detritivorous organisms that exhibit an endobenthonic behavior. This ecological adaptation was linked with the modification of the position of the peristoma and the periproct from the original Bauplan or "Loven plane" (Moore

Table 1. Comparison chart of the different species of *Diplodetus*.

SPECIES	*Diplodetus brevistella* (Schlüter, 1899)	*Diplodetus americanus* (Stephenson, 1941).	*Diplodetus bucardium* (Goldfuss, 1829).	*Diplodetus duponti* (Lambert, 1911).	*Diplodetus coloniae* (Cotteau, 1877).	*Diplodetus brisenoi* nov sp.
TEST SHAPE	Sub-cordiforme, wider than long.	Cordiforme.	Subcordiforme.	Subcordiforme.	Oval outline.	Strongly cordiforme.
SIZE	Medium size test. Length between 50 to 53 mm.	Cordiforme medium sized. A minimum length of 57 mm.	Test slightly longer than wider (until ca. 55 mm of length).	The test is not as wide as long (more than 60 mm), with the frontal notch, but not too deep and the posterior part is truncated.	Test as long as wide. Length up to 57 mm.	Medium size test, Length: between 35.5 to 36.4 mm. Wide at the area level, between 32 and 32.4 mm. Apical height of 20.1 to 21.1, and oval.
AMBULACRAL SYSTEM	Adapically in a furrow Ambulacra.	Ambulacra matched deeply sunk into a groove. Petals almost the same lenght.	Ambulacra almost the same size and in a deep furrow.	Paired ambulacra, in a moderate furrow, less depth than in *D. bucardium* and *D. parvistella.*	Ambulacra in a shallow groove or absent.	Petaloid-paired ambulacra with pores in the fissure, the paired petals have the same size and shape to the posterior ambulacra, which are short and sunken in a deep furrow.
UNPAIRED AMBULACRES	The anterior notch is shallow or absent.	Posterior petal inclined; anterior ambulacra practically at surface level of the test.	Frontal groove slightly marked. Truncated vertically on the back.	Groove in the shallow anterior margin.	The anterior ambulacra is cut out slightly on the margin. Vertically truncated posterior part.	The odd petal presents oval pores separated by a pair of granules.
PAIRED AMBULACRA	Paired petaloids ambulacra with elongated pores.	Paired ambulacra deeply sunken, divergent anterior pair at 120°, and 1.5 more times than the posterior pair (divergent at 55°).	Petaloid Ambulacra almost same size and in a deep furrow, the anterior pair presents a divergent angle of 100°, 1.4 – 1.5 times more than the posterior pair, with elongated pores.	Anterior petals divergent in 105°, 1.5 times greather than the posteriors, with elongated rounded pores.	Paired petals slightly different in length. Petals pairs with a divergent angle of 140 – 150 degrees.	Paired petals moderately depressed, the anterior pair is longer than the posterior pair. The first extends two-thirds of the way to the margin and presents a divergent angle between 135 and 140 degrees, the posterior ones are close together and present a divergent angle of 124 to 126 degrees.
APICAL SYSTEM	Etmophract type apical system with four gonopores.	Apical system at the top of the test.	Not described by the author.	Not described by the author.	Ethmofract with four gonopores.	Semiethmolytic type apical system with four gonopores.
FASCIOLA	Subanal fasciola present; peripetal fasciola present, although generally represented only by a diffuse or partial band of granulations.	Subanal fasciola, and posterior peripetal well developed.	Subanal fasciola well developed, Peripetal fasciola is observed bording the posterior petals.	Subanal fasciola well developed, wide; irregular peripetal fasciola bording the posterior petals.	Subanal fasciola present.	Peripetal fasciola present.

et al., 1966). Such characteristics are also well exposed in specimens of *D. brisenoi*, which confirms its detritivorous and endobenthonic behavior for this species. Also other endobenthonic organisms (*e.g.* serpulids) are able to bury themselves into the sediment (Figure 6F).

The occurrence of sedimentary pyrite in some strata of the Austin Formation in the study area (personal observation) suggests that during the deposition of the Austin Formation, there was a deficit in oxygen concentration, it makes possible the preservation of organic matter in the centimeters just below the sediment-water interface, in contrast to the water column, where the well oxygenated conditions promote the presence of epibenthonic fauna (Gryphaea, Exogyra, *Lopha*) and nektonic organisms such as fishes and ammonites. It seems that organic matter served as a food source to endobenthonic organisms. The specimens of *D. brisenoi* were able to process rich organic matter particles that serve as nutrients. The sediment was removed and captured through the

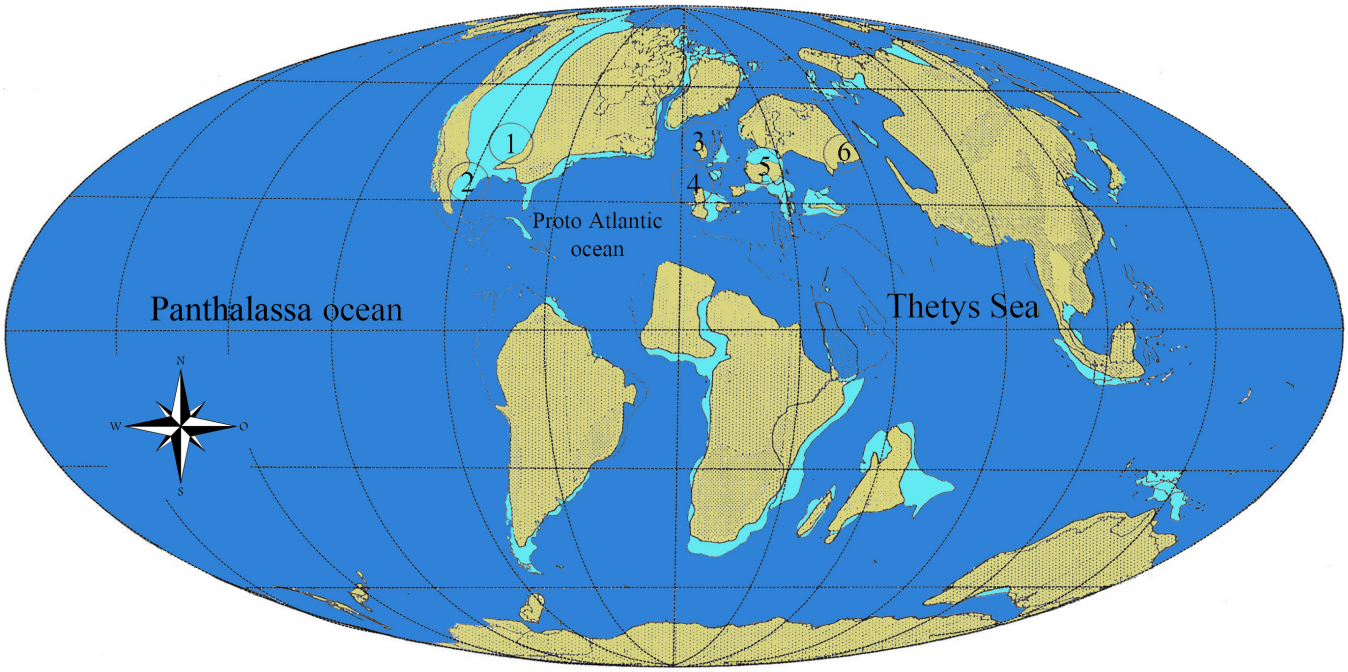

Figure 7 Paleogeographic map showing the distribution of the genus *Diplodetus* spp. during Early Campanian (Late Cretaceous). 1: *D. americanus*, Texas, USA, 2: *D. brisenoi* nov. sp., Jiménez, Coahuila, Mexico, 3: *D. parvistella*, *D. americanus*, *D. bucardium*. Netherlands, 4: *Diplodetus parvistella*, *D. bucardium*, Belgium, 5: *Diplodetus brevistella*, Germany, 6: *Diplodetus coloniae*, Ukrania. Paleogeographic map modificated from Smith *et al.* (1994).

ambulacral feet, and moved through the fasciole to the peristome.

It seems that a continental shelf scenario, with a soft seafloor and the organic matter in the sediment made easier the presence of detritivorous organisms in the study area, such as several genera of echinoids, the specimens of *D. brisenoi*, serpulid worms and other burrowers.

5. Conclusion

The description of three echinoids specimens of the genus *Diplodetus* reported by Silva-Martínez *et al.* (2014) from the Lower Campanian Austin Formation (Upper Cretaceous), shows significative morphological differences with *D. brevistella*, *D. americanus*, *D. bucardium*, *D. duponti* and *D. coloniae* therefore *Diplodetus brisenoi* nov. sp., must be considered as a new echinoid species from the Austin Formation (Lower Campanian), from the Mexican state of Coahuila, northeastern Mexico.

Continental shelf environments, the presence of soft seafloor, and organic matter in the sediment, which represent a food source for endobenthonic organisms, are the main features that define a scenario that contribute to the developement of detritivore organism, such as *D. brisenoi* in the Austin Formation of northeastern Mexico.

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7. References

Adkins, W.S., 1930, Texas Comanchean Echinoids of the genus *Micraster*: University of Texas, Bulletin, 3001, 101–120.

Boule, M., 1899, Note sur de nouveaux fossiles secondaires de Madagascar: Bulletin du Muséum d'Histoire: Naturelle, 5, 130–134.

Carrasco, B.V., 1963, Estratigrafía de la parte Superior del Grupo Austin en Jiménez Coahuila (México): Revista del Instituto Mexicano del Petróleo, 1(2), 18–25.

Carrasco, B.V., 1969, Amonitas del Campaniano Inferior del Norte de Coahuila: Sociedad Geológica Mexicana, 30(2), 144–151.

Cotteau, G., 1877, Description des Echinides, *in* Locard, A. (ed.), Description des Faunes des terrains Tertiaires moyens de la Corse: Annales de la Société d'Agriculture, Histoire Naturelle et Ars Utiles de Lyon, Paris & Genève, 227–335

Cotteau, G., 1908, Paléontologie de Madagascar; 6. Les échinides: Annales de Paléontologie 3,145–188.

DeKay, J.E., 1828, Report on several fossil multilocular shells from the state of Delaware: With observations on a second specimen of the new fossil genus *Eurypterus*: Annales of the Lyceum of Natural History, 2, 273–279.

Eguiluz de Antuñano, A.S., 2001, Geologic Evolution and Gas Resources of the Sabinas Basin in North-eastern Mexico, *in* Bartolini, C., Bluffer, R.T., Cantu-Chapa, A. (eds.), The western Gulf of Mexico Basin Tectonics, Sedimentary Basins, and petroleum systems: AAPG Memoir, 75, 241–270.

Escalante, M.J.C., Rocha, R.M., Chiapa, G.R.R., Bastida, J.R., 2002, Carta Geológico-Minera Ciudad Acuña, H14-7, Escala 1:250000: Estado de Coahuila, Informe técnico.

Fischer, A.G., 1966, Spatangoids, *in* Moore, R.C. (ed.), Treatise on Invertebrate Paleontology, Part U, Echinodermata 3, 2. – Geol. Soc. Am., Boulder/Univ. Kansas Press, Lawrence: U543–U628.

Goldfuss, A., 1829, Petrefacten Deutschlands und der angranzenden Lander: Düsseldorf.

Gray, J.E., 1855, An arrangement of the families of Echinida, with descriptions of some new genera and species: Proceedings of the Zoological Society London, 23, 35–39.

Jagt, J.W.M., 2000, Late Cretaceous-Early Paleogene echinoderms and the K/T boundary in the southeast Netherlands and northeast Belgium. Part 4. Echinoids, Scripta: Geologica, 121, 181–375.

Lambert, J., 1911, Description des Échinides crétacés de la Belgique principalement de ceux conservés au Musée royal de Bruxelles. II. Échinides de l'étage Sénonien: Mémoires du Musée Royal d'Histoire Naturelle de Belgique, 4: 1–81, pls 1–3.

Moore, R.C., 1966, Treatise on Invertebrate Paleontology: Geological Society of America and University of Kansas Press, Volume L, 429–434.

Morton, S.G., 1841, Descriptions of two new species of fossils from the Lower Cretaceous strata of New Jersey: Proceedings of the Academy of Natural Sciences of Philadelphia, 1, 131–132.

Myers, T.S., 2010, Earliest occurrence of the Pteranodontidae (Archosauria: Pterosauria) in North America; New material from the Austin Group in Texas: Journal of Paleontology, 84(6), 1071–1081.

Newman, M.C., Ownby, D.R., Mezin, L.C.A., Powell, D.C., Christensen, T.R.L., Lerberg, S.B., and Anderson, B.-A., 2000, Applying species-sensitivity distributions in ecological risk assessment: assumptions of distribution type and sufficient number of species: Environmental Toxicology and Chemistry 19, 508–515.

Reeside, B.J., 1927, The Cephalopods of the Eagle Sandstone and Related Formations in the Western Interior of the United States: United States Government Printed office, Professional Paper 151, 23 p.

Rehfeld, U., Ernst, G., 1998, Hydrozoan build-ups of *Millepora irregularis* sp. nov. and fungiid coral meadows of Cunnolites Alloiteau (Anthozoa)-palaeoecological and palaeoceanographical implications for the Upper Cretaceous of north Cantabria (northern Spain), Facies 39, 125–138.

Renz, O., 1936, Stratigraphie und mikropaläontologische Untersuchung der Scaglia (Obere Kreide-Tertiär) im zentralen Apennin: Ecoglae geologicae Helvetiae, 29, 1–149.

Romo-Ramírez, J.R., Herrera-Monreal, J.C., Rodríguez-Rodríguez, J.S., 2002, Carta Geológico-Minera San Miguel H13-12, escala 1:250000: Pachuca, Hidalgo, México, Consejo de Recursos Minerales, informe, 64 p.

Santamaría-Zabala, R., 1991, Ammonoideos del Cretácico Superior de la Plataforma Nord-Castellana y parte de la Cuenca Navarro-Cántabra. Paleontología y Bioestratigrafía: Universidad Autónoma de Barcelona, Barcelona, Tesis Doctoral, 375 p.

Santiago, C.B., Herrera-M.J.C., Ontiveros, E.E., Martínez, R.L., 2003, Carta Geológico-Minera Piedras Negras, H14-10, Escala 1:250000: Estado de Coahuila y Chihuahua, Informe técnico.

Schlüter, C., 1899, Ueber einige von Goldfuss beschriebene Spatangiden. II: Stück. Zeitschrift der deutschen geologischen Gesellshaft, 51, 104-124, pls. 9-10.

Schlüter, C., 1900, Ueber einige Kreide-Echiniden. Zeitschrift der deutschen geologischen Gesellschaft, 52, 360-379, pls. 15-18.

Shumard, B.F., 1860, Descriptions of new Cretaceous fossils from Texas: Transactions of the Academy of Science of the Saint Louis, 1, 590-610.

Silva-Martínez, L.E., Blanco-Piñón, A.,de León-González, J.A., 2014, Equinoideos del Cretácico Tardío del Norte de Coahuila, México: Boletín de la Sociedad Geológica Mexicana, 66 (2), 377-395.

Smith, A. G., Smith, D.G., Funell, B.M., 1994, Atlas of Mesozoic and Cenozoic Coastlines: Cambridge University Press, Cambridge, 99 p.

Sohl, N.F., Martinez, E., Salmeron-Urena, P., Soto-Jaramillo, F., 1991, Upper Cretaceous, *in* Salvador, A. (ed.), The Gulf of Mexico basin: Geological Society of America, The Geology of North America, J, 205–244.

Stephenson, L.W., 1941, The larger invertebrate fossils of the Navarro Group of Texas (exclusive of corals and crustaceans and exclusive of the fauna of the Escondido Formation). — Texas Univ. Bull., 4101: 1-641, pls. 1-95.

Stinnesbeck, W., Ifrim, C., Schmidt, H., Rindfleisch, A., Buchy, M-C., Frey, E., González-González, A., Vega, F.J., Cavin, L., Keller, G., Smith, K.T., 2005, A new lithographic limestone deposit in the Upper Cretaceous Austin Group at El Rosario, County of Múzquiz, Coahuila, northeastern Mexico: Revista Mexicana de Ciencias Geológicas, 22(3), 401-418.

Taff, B.J., 1892, Reports on the Cretaceous area north of the Colorado River: Annual Report of the Geological survey of Texas, 3, 267-379.

Vega, F.J., Garassino, A., Zapata-Jaime, R., 2013, *Enoploclytia tepeyacensis* n. sp. (Crustacea, Decapoda, Erymidae) from the Cretaceous (Campanian) of Coahauila, NE Mexico: Boletín de la Sociedad Geológica Mexicana, 65(2), 207-211.

Young, K., 1963, Upper Cretaceous Ammonites from the Gulf Coast of the United States, University of Texas Publication, 6304, 48-123.