Fossil echinoderms of Mexico - An overview of the National Collection of Paleontology "Maria del Carmen Perrilliat", Institute of Geology, UNAM (Mexico)

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ABSTRACT

The National Paleontology Collection is the most important paleontological collection in Mexico due to the relevance of its specimens, curation, and service to the scientific community; and requires a taxonomic update. This work is based on the revision of the echinoderms deposited into the Collection of Types of the National Collection of Paleontology. We obtained the echinoderm database of the National Paleontology Collection, being collated with the specimens and their labels. All these specimens are included with their catalog number, taxonomy, localities, and geological age. The nomenclature and taxonomy of each species were revised based on the most recent references. The geological information (nomenclature, age, or unit) was derived from the original publications, updated, and complimented with more recently published data, in congruence with the Stratigraphic Lexicon of Mexico. The CNP houses a total of 385 records classified in 107 species: 19 Crinoidea, 1 Asteroidea, 1 Ophiuroidea, 84 Echinoidea, and 2 Holothuroidea; 27 changes in their taxonomy were done. The echinoderm records come from 69 localities, 52 assigned to 31 formations/units across the country, and 17 not assigned yet. The Cretaceous is the best represented period with 14 formations/units and 6 localities. San Juan Raya (Puebla) is the most diverse formation with 12 species of Echinoidea; The Tlayúa formation (Puebla), due to its excellent quality o preservation, is the only one with fossil ophiuroid and holothuroid species reported in Mexico. This paper is the beginning of a series of publications focused on the analysis of the systematics, paleodiversity, past ecosystem structures, and paleobiogeography of the Mexican fossil echinoderms and applying novel approaches.

Keywords: Echinodermata; Alpha Diversity; Taxonomy; Heritage; Cretaceous.

1. Introduction

The National Paleontology Collection (Colección Nacional de Paleontología, CNP) is the most important scientific collection of fossils in Mexico, due to its history, the relevance of the fossils and information it protects, as well as the services that it provides to the scientific, economic, and social development of this country (Perrilliat et al., 1986; Cristin and Perrilliat, 2011; Alvarado-Ortega, 2021).

The creation of a paleontological collection in Mexico did not originate in an explicit act; rather, this arises as a natural and necessary consequence to fulfill the tasks entrusted to the Geological Commission (the first Mexican institution dedicated to the recognition of geological resources in Mexico), explicit in a presidential decree dated in 1988 by President Porfirio Díaz. This fact allowed the beginning of the systematic study of fossil resources in Mexico, and the establishment of a national institution in charge of the protection, conservation, and administration of the fossils and their associated data. Between 1917 and 1929, this institution became part of the Departmento de Exploraciones y Estudios Geológicos of the Secretaria de Industria, Comercio y Trabajo, under the name of the Instituto de Geología, which in 1929 was incorporated into the National Autonomous University of Mexico (UNAM). Since that moment, this university became the depository of the most important paleontological collection in the country and the institution with the largest and most diverse group of paleontologists. Between 1978 and 1979, the Department of Paleontology of the Instituto de Geología (IGL-UNAM) issued the first regulation to incorporate, house, conserve and administer the fossils. The current and historical "national" relevance of the fossils deposited in the IGL-UNAM was recognized in 2004, by the rector Juan Ramón de la Fuente Ramírez, who named this as the Colección Nacional de Paleontología.

Currently, the CNP is located in the Institute of Geology, of the National Autonomous University of Mexico (UNAM), Mexico City, and consists of five sections: 1) The Type Collection (Colección de Tipos) that includes specimens belonging to specific type series as well as voucher specimens identified as hypotypes. 2) The Reference Geographical Collection (Colección Geográfica de Referencia) includes not studied or are not yet formally published specimens. 3) The Foreign Materials Collection (Colección de Materiales Extranjeros) contains fossils from other countries with comparative purposes. 4) The Recent Material Collection (Colección de Materiales Recientes) is a collection of the skeleton and hard parts of living species used for comparative purposes. 5) Molds Collection (Colección de Moldes) includes casts and molds made in plaster or resin of specimens that are part of the other CNP sections.

The National Paleontology Collection is currently the most representative of Mexico. Historically, this includes some of the first specimens from the country described as well as specimens of practically all its localities and geological sequences where echinoderms have been collected. Contrary, other young Paleontological Collections of Mexico include fossils of a regional and temporally limited domain; many of which are also already part of the National Collection of Paleontology. A direct comparison between the number and status of specimens deposited in the CNP, and other Paleontological Collections in Mexico is not possible at the moment, because the size and quality of the lasts have not been the subject of any accurate analysis, with restricted access, and nave no open-access databases.

The scientific study of the Mexican echinoderms only started in the 18th century, when Nyst and Galeotti (1839) reported the mollusks and echinoderms from San Juan Raya, Puebla. During the 1900s, numerous fossils of echinoderms, mainly crinoids, and echinoids, were reported and their taxonomical and field data were organized into different catalogs (Caso,1951; Maldonado-Koerdell, 1953; Buitrón-Sánchez, 1968; Buitrón-Sánchez, 1990a).

At the end of the 20th century, Buitrón-Sánchez and Solís-Marín (1993) published the last review of fossil and recent Mexican echinoderms revealing that the fossil record of this country includes 15 species of Crinoidea (10 Carboniferous, 1 Permian, 2 Jurassic, 2 Cretaceous), 1 species of Asteroidea (*Astropecten* sp. Cretaceous), 1 species of Ophiuroidea (?*Ophiura* sp. Cretaceous), 217 species of Echinoidea (2 Jurassic, 88 Cretaceous, 117 Tertiary, and 1 Quaternary), and 2 species of Holothuroidea (?*Holothuria* sp. and ?*Caudina* sp., both from the Cretaceous of Puebla). This report enlists the species and only gives the age and the states of Mexico where the specimens were found; no information about localities or catalog numbers is included.

Solís-Marín et al. (2013) revised the echinoderms of Mexico, including a mention of the fossil record. They mention a total of 248 species: 1 Eocrinoidea, 17 Crinoidea, 1 Asteroidea (*Pentasteria* sp.), 6 Ophiuroidea (*Ophiactis applegatei*; *Ophiura* sp.; aff. *Amphiura*, aff. *Ophiomusium*; aff. *Stegophiura*, and aff. *Ophiura*), 221 Echinoidea, and 2 Holothuroidea.

All the echinoderm fossil record from Mexico needs a revision and update. We can notice inconsistencies between those papers, and a lack of information in those revisions. The CNP is the largest, the best curated, and the only one open-access collection in the country; nevertheless, it constantly offers service to national and international researchers, giving access and preparing loans of the material, which inevitably results in not all the material being physically in the collection, and available for the users. Besides, during the history of the collection, not all the published catalog numbers were deposited; that is why the need to physically corroborate the databases with specimens and their labels.

This work is based on the revision of the described and referred echinoderms deposited into the Collection of Types of the National Collection of Paleontology. Data and images of the Mexican fossil echinoderm deposited in the CNP were accessed through the different bibliographic studies here referenced as well as the public information and images exposed in two different web pages. The first of these websites is https://datosabiertos.unam.mx/biodiversidad/ (Departamento de Paleontología, Instituto de Geología, 2020), supported by the Coordination of Digital University Collections (CCUD), whose main objective is to develop and implement technologies, methodologies, and legal regulations for university digital repositories that guarantee the online publication of digital university collections, and research data that are owned or are under the custody of the UNAM, promoting interoperability, open access and its preservation (Dirección General de Repositorios Universitarios, 2021). The second electronic site corresponds to Unidad Informatica para la Paleontología (UNIPALEO), in http://www.unipaleo.unam.mx/index.php. UNIPALEO is the Informatics Unit developed by the Institute of Geology (UNAM). This unit provides the information contained in the paleontological collections under the protection of the IGL; UNIPALEO aims to systematize and publish the information found in various paleontological collections of the Institute of Geology (Instituto de Geología, 2021).

2. Materials and methods

We obtained the echinoderm database of the National Paleontology Collection (CNP) from the published databases UNIPALEO y CCUD and the catalog of the type specimens of fossil invertebrates of the CNP (Perrilliat, 1981). This database was collated with the specimens housed in the CNP and their labels. All these specimens are included with their catalog number (IGM), taxonomy, localities (IGM-loc), and geological age.

The nomenclature and taxonomy of each species were revised based on most recent references: Moore and Jeffords (1968) for Crinoidea; Gale (2005) for Asteroidea; O'Hara et al. (2017) for Ophiuroidea; Miller et al. (2017) for Holothuroidea, Kroh and Smith (2010) for Echinoidea at order and family levels, for genera and species levels we based on Kroh and Mooi (2019). The publication by Moore and Jeffords (1968) is based on the parataxonomy of dissociated parts of crinoid columns, therefore all the species there described have to be considered as form-species.

The geological information (nomenclature, age, or unit) was derived from the original publications, updated, and complimented with more recently published data, in congruence with the Stratigraphic Lexicon of Mexico (Servicio Geológico Mexicano, 2020) was verified. The map was created with QGIS software version 3.12 (QGIS Development Team, 2018).

3. Results

The CNP houses a total of 385 records classified in 107 species (19 Crinoidea, 1 Asteroidea, 1 Ophiuroidea, 84 Echinoidea, and 2 Holothuroidea). Here we present the systematic paleontology of the records. † is for extinct taxa. Any incongruence with the CNP-UNAM online database found during the process was included as comments to the corresponding species. We also include the Geological context of Mexican echinoderms, giving the geological description for each of the 31 Formations and units here reported; this part is presented in alphabetic order. A table with all the records data organized by formation/unit is attached as supplementary material.

3.1. Systematic Paleontology

PHYLUM Echinodermata Bruguière, 1791

CLASS Crinoidea Miller, 1821

SUBCLASS Articulata Miller, 1821

ORDER Millericrinida† Sieverts-Doreck, 1952

FAMILY Millericrinidae† Jaekel, 1918

Genus *Angulocrinus*† d'Orbigny, 1840

Angulocrinus polyclonus† (Felix, 1891)

Vouchers. IGM 5214-IGM 5223 (Buitrón-Sánchez, 1990b).

Localities and age IGM-loc 1899; Tecomazuchil creek, Puebla; geological formation indeterminate; Oxfordian, Late Jurassic. IGM-loc 1671; Road Guadalupe Hidalgo-Tlaxiaco, Oaxaca; geological formation indeterminate; Oxfordian, Late Jurassic.

ORDER *Incertae sedis*

FAMILY Pentacauliscidae† Moore and Jeffords, 1968

Comments. The family is classified in the database within the informal group Pentameri.

Genus *Pentagonomischus*† Moore and Jeffords, 1968

Pentagonomischus plebeius† Moore and Jeffords, 1968

Voucher. IGM 4868 (Villanueva-Olea et al., 2016).

Locality and age. IGM-loc 4013; Sierra Las Mesteñas, Sonora; Caliza Naco Formation; Pennsylvanian, Carboniferous.

FAMILY Cyclomischidae† Moore and Jeffords, 1968

Comments. The family is classified in the database within the informal group Cyclici.

Genus *Axilinucrinus*† Villanueva-Olea and Sour-Tovar, 2011

Axilinucrinus angustus† Villanueva-Olea, Castillo-Espinoza, Sour-Tovar, Quiroz-Barroso and Buitrón-Sánchez, 2011

Voucher. IGM 4869 (Villanueva-Olea et al., 2016).

Locality and age. IGM-loc 4013; Sierra Las Mesteñas, Sonora; Caliza Naco formation; Pennsylvanian, Carboniferous.

Genus *Cylindrocauliscus*† Moore and Jeffords, 1968

Cylindrocauliscus fiski† Moore and Jeffords, 1968

Vouchers. IGM 2695 (Buitrón-Sánchez, 1977); IGM 4335 (Buitrón-Sánchez et al., 1987); IGM 4863 (Buitrón-Sánchez et al., 2017).

Localities and age. IGM-loc 3157; Aguacate river, between La Concordia and Chicomuselo, Chiapas; Santa Rosa lower Formation; Late Mississippian-Late Pennsylvanian, Carboniferous. IGM-loc 2514; Calnali, Hidalgo; Del Monte Formation; Pennsylvanian, Carboniferous. IGM-loc 4004; Pemuxco, Hidalgo; Tuzancoa Formation; Permian.

Genus *Baryschyr*† Moore and Jeffords 1968

Baryschyr anosus† Moore and Jeffords, 1968

Voucher. IGM 4336 (Buitrón-Sánchez et al., 1987); IGM 8987, IGM 9524 (Buitrón-Sánchez et al., 2017).

Localities and age. IGM-loc 2514; Calnali, Hidalgo; Dsel Monte Formation; Pennsylvanian, Carboniferous. IGM-loc 4004; Pemuxco, Hidalgo; Tuzancoa Formation; early Permian.

Genus *Cyclocaudex*† Moore and Jeffords, 1968

Cyclocaudex cf. costatus† Moore and Jeffords, 1968

Voucher. IGM 4337 (Buitrón-Sánchez et al., 1987).

Locality and age. IGM-loc 2514; Calnali, Hidalgo; Del Monte Formation; Pennsylvanian, Carboniferous.

Cyclocaudex insaturatus† Moore and Jeffords, 1968

Voucher. IGM 4338 (Buitrón-Sánchez et al., 1987).

Locality and age. IGM-loc 2514; Calnali, Hidalgo; Del Monte Formation; Pennsylvanian, Carboniferous.

Cyclocaudex jucundus† Moore and Jeffords, 1968

Vouchers. IGM 4339 (Buitrón-Sánchez et al., 1987); IGM 4870, IGM 4871 (Villanueva-Olea et al., 2016); IGM 8988 (Buitrón-Sánchez et al., 2017).

Localities and age. IGM-loc 2514; Calnali, Hidalgo; Del Monte Formation; Pennsylvanian, Carboniferous. IGM-loc 4013; Sierra Las Mesteñas, Sonora; Caliza Naco Formation; Pennsylvanian, Carboniferous. IGM-loc 4004; Pemuxco, Hidalgo; Tuzancoa Formation; Permian.

Comments. The specimens were referenced in the database as Cyclici indet.

Cyclocaudex plenus† Moore and Jeffords, 1968

Voucher. IGM 8989 (Buitrón-Sánchez et al., 2017).

Locality and age. IGM-loc 4004; Pemuxco, Hidalgo; Tuzancoa Formation; Permian.

Genus *Mooreanteris*† Miller, 1968b

Mooreanteris waylandensis† Miller, 1968b

Voucher. IGM 4340 (Buitrón-Sánchez et al., 1987).

Locality and age. IGM-loc 2514; Calnali, Hidalgo; Del Monte Formation; Pennsylvanian, Carboniferous.

FAMILY Floricyclidae† Moore and Jeffords, 1968

Comments. The family is classified in the database within the informal group Cyclici.

Genus *Floricyclus*† Moore and Jeffords, 1968

Floricyclus angustimargo† Moore and Jeffords, 1968

Voucher. IGM 4872 (Villanueva-Olea et al., 2016).

Locality and age. IGM-loc 4013; Sierra Las Mesteñas, Sonora; Caliza Naco Formation; Pennsylvanian, Carboniferous.

Floricyclus granulosus† Moore and Jeffords, 1968

Voucher. IGM 4873 (Villanueva-Olea et al., 2016).

Locality and age. IGM-loc 4013; Sierra Las Mesteñas, Sonora; Caliza Naco Formation; Pennsylvanian, Carboniferous.

Genus *Plummeranteris*† Moore and Jeffords, 1968

Plummeranteris sansaba† Moore and Jeffords, 1968

Voucher. IGM 4341 (Buitrón-Sánchez et al., 1987).

Locality and age. IGM-loc 2514; Calnali, Hidalgo; Del Monte Formation; Pennsylvanian, Carboniferous.

Genus *Lamprosterigma*† Moore and Jeffords, 1968

Lamprosterigma mirificum† Moore and Jeffords, 1968

Vouchers. IGM 2688-IGM 2694 (Buitrón-Sánchez, 1977).

Locality and age. IGM-loc 3157; Aguacate river, between La Concordia and Chicomuselo, Chiapas; Santa Rosa lower Formation; Late Mississippian-Late Pennsylvanian, Carboniferous.

FAMILY Leptocarphiidae† Moore and Jeffords, 1968

Comments. The family is classified in the database within the informal group Cyclici.

Genus *Cyclocrista*† Moore and Jeffords, 1968

Cyclocrista cheneyi† Moore and Jeffords, 1968

Referred specimen. IGM 4874 (Villanueva-Olea et al., 2016).

Locality and age. IGM-loc 4013; Sierra Las Mesteñas, Sonora; Caliza Naco Formation; Pennsylvanian, Carboniferous.

Genus *Preptoprennum*† Moore and Jeffords, 1968

Preptoprennum rugosum† Moore and Jeffords, 1968

Vouchers. IGM 4875 (Villanueva-Olea et al., 2016); IGM 5079 (González-Arreola et al., 1994).

Localities and age. IGM-loc 4013; Sierra Las Mesteñas, Sonora; Caliza Naco Formation; Pennsylvanian, Carboniferous. IGM-loc 2478; between Olinalá, Huamuxtitlán and Cualác, Guerrero; Los Arcos Formation; middle Permian.

Genus *Heterostelechus*† Moore and Jeffords, 1968

Heterostelechus keithi† Miller, 1968a

Voucher. IGM 4342 (Buitrón-Sánchez et al., 1987).

Locality and age. IGM-loc 2514; Calnali, Hidalgo; Del Monte Formation; Pennsylvanian, Carboniferous.

Comments. This specimen is included as a paratype in the collection database, but it is not reported in the original description of the species.

Genus *Cycloscapus*† Moore and Jeffords, 1968

Cycloscapus laevis† Moore and Jeffords, 1968

Vouchers. IGM 4876 (Villanueva-Olea et al., 2016); IGM 4910 (Buitrón-Sánchez et al., 2017).

Localities and age. IGM-loc 4013; Sierra Las Mesteñas, Sonora; Caliza Naco formation; Pennsylvanian, Carboniferous. IGM-loc 4004; Pemuxco, Hidalgo; Tuzancoa Formation; early Permian.

Genus Cyclocaudiculus† Moore and Jeffords, 1968

Cyclocaudiculus regularis† Moore and Jeffords, 1968

Voucher. IGM 4877 (Villanueva-Olea et al., 2016).

Locality and age. IGM-loc 4013; Sierra Las Mesteñas, Sonora; Caliza Naco Formation; Pennsylvanian, Carboniferous.

CLASS ASTEROIDEA DE BLAINVILLE, 1830

ORDER Paxillosida Perrier, 1884

FAMILY Porcellanasteridae Sladen, 1883

Genus *Paleoctenodiscus*† Blake, 1988

Comments. This is a monospecific genus.

Paleoctenodiscus campaniurnus† Blake, 1988

Type specimen. Holotype IGM 4290.

Locality and age. IGM-loc 3055; El Rosario, Baja California; geological formation indeterminate; Late Campanian, Late Cretaceous.

Comments. Type and only species of the genus, and the first fossil of the family. In the original paper it is spelled as both "*campaniurnis*" and "*campaniurnus*", but in the description, and Gale (2005) it is spelled as the latter. This species was originally assigned to Family Ctenodiscidae Sladen, 1889, but Gale (2005) reassigned the genus to the family Porcellanasteridae.

CLASS OPHIUROIDEA GRAY, 1840

ORDER Ophiurida Müller and Troschel, 1840

FAMILY Ophiactidae Matsumoto, 1915

Genus *Ophiactis* Lütken, 1856

Ophiactis applegatei† Martín-Medrano, Thuy, and García-Barrera, 2009

Type specimens. Holotype IGM 9298. Paratype IGM 9290.

Vouchers. IGM 9291-IGM 9297, IGM 9299-IGM 9301.

Localities and age. IGM-loc 370, 1995, 2432, 2513, 2772; Tepexi de Rodríguez, Puebla; Tlayúa Formation; Albian, Early Cretaceous.

Comments. The only other Paratype mentioned in the paper is the FCMP 602 (from the Museum of Paleontology, School of Sciences, UNAM). Note that in the database, all the referred specimens are incorrectly assigned as paratypes.

CLASS ECHINOIDEA LESKE, 1778

ORDER Cidaroida Claus, 1880

Cidaroida indet.

Vouchers. IGM 5915-IGM 5917 (Squires and Demetrion, 1992).

Localities and age. IGM-loc 1686; Mesa La Salina, San José de Gracia, Baja California Sur; Bateque Formation; Eocene, Paleogene. IGM-loc 1692; Mezquital river, San Isidro, Baja California Sur; Bateque Formation; Eocene, Paleogene.

FAMILY Psychocidaridae Ikeda, 1936

Genus *Caenocidaris*† Thiéry, 1928

Caenocidaris cf. cucumifera† (L. Agassiz, 1840a)

Vouchers. IGM 2459- IGM 2464 (Buitrón-Sánchez, 1974c).

Locality and age. IGM-loc 3152; Sierra de Las Águilas, Chihuahua; geological formation indeterminate; Late Jurassic.

FAMILY Cidaridae Gray, 1825

Genus *Cidaris* Leske, 1778

Cidaris muellerriedi Lambert, 1935

Vouchers. IGM 2188, IGM 2189 (Buitrón-Sánchez, 1970a).

Locality and age. IGM-loc 775; San Juan Raya, Tehuacán, Puebla; San Juan Raya Formation; Aptian, Early Cretaceous.

Cidaris submarginata Felix, 1891

Vouchers. IGM 1302, IGM 7369 (Alencáster and Buitrón-Sánchez, 1965). IGM 2281, IGM 2282 (Buitrón-Sánchez, 1970b).

Localities and age. IGM-loc 1310; Agua Escondida creek, Puebla; Caliza Chimeco Formation; Oxfordian, Late Jurassic. IGM-loc 1787; Guadalupe Hidalgo, Oaxaca; Calizas con *Cidaris* unit; Oxfordian, Late Jurassic.

Genus *Temnocidaris* Cotteau, 1863

Subgenus *Stereocidaris* Pomel, 1883

Comments. Included in the database as the genus *Stereocidaris*.

Temnocidaris (*Stereocidaris*) *fusiformis* (Cotteau, 1862)

Voucher. IGM 2632 (Buitrón-Sánchez, 1976).

Locality and age. IGM-loc 1558; La Cuachalalatera Canyon, Atenango del Río, Guerrero; Cuautla Formation; late Cenomanian-Turonian, Late Cretaceous.

ORDER Pedinoida Mortensen, 1939

FAMILY Pedinidae Pomel, 1883

Genus *Pedina*† L. Agassiz, 1838

Pedina (Pedina) sublaevis† L. Agassiz, 1840b

Voucher. IGM 2283 (Buitrón-Sánchez, 1970b).

Locality and age. IGM-loc 2680; Between Las Huertas and Fundición del Sol de Mayo Mine, Tlaxiaco, Oaxaca; Calizas con *Cidaris* unit; Oxfordian, Late Jurassic.

SUPERORDER Carinacea Kroh and Smith, 2010

Comments. Classified as Hemicidaroida before the establishment of the Carinacea Kroh and Smith, 2010.

FAMILY Hemicidaridae† Wright, 1857

Genus *Pseudocidaris*† Étallon, 1859

Pseudocidaris clunifera† (L. Agassiz, 1836)

Vouchers. IGM 2193-IGM 2208 (Buitrón-Sánchez, 1970a); IGM 2287-IGM 2289 (Buitrón-Sánchez, 1970b).

Localities and age. IGM-loc 775; San Juan Raya, Tehuacán, Puebla; San Juan Raya Formation; Aptian, Late Cretaceous. IGM-loc 3247; Tlaxiaco, Oaxaca; Capas Tlaxiaco unit; Late Jurassic.

Pseudocidaris lusitanica† De Loriol, 1890

Vouchers. IGM 2775-IGM 2778 (Buitrón-Sánchez, 1978).

Locality and age. IGM-loc 3130; Loc. A731, Constitución section, NW Oaxaca; San Ricardo Formation; Kimmeridgian, Late Jurassic.

Pseudocidaris thurmanni† (L. Agassiz, 1840a)

Vouchers. IGM 2779-IGM 2780 (Buitrón-Sánchez, 1978).

Locality and age. IGM-loc 3129; Loc. A661, Pueblo Viejo river section, W Chiapas; San Ricardo Formation; Kimmeridgian, Late Jurassic.

Pseudocidaris sp.†

Vouchers. IGM 2234-IGM 2239 (Buitrón-Sánchez, 1970a).

Localities and age. IGM-loc 901; Santa Ana Teloxtoc, Puebla; Zapotitlán Formation; Barremian, Early Cretaceous.

Pseudocidaris cf. quenstedti† (Mérian in Désor, 1855)

Voucher. IGM 2290 (Buitrón-Sánchez, 1978).

Locality and age. IGM-loc 2997; Pacheco ranch, Tlaxiaco, Oaxaca; Calizas con *Cidaris* unit; Oxfordian, Late Jurassic.

FAMILY Pseudodiadematidae† Pomel, 1883

Genus *Acrocidaris*† L. Agassiz, 1840b

Acrocidaris nobilis† L. Agassiz, 1840b

Voucher. IGM 2291 (Buitrón-Sánchez, 1970b).

Locality and age. IGM-loc 2997; Pacheco ranch, Tlaxiaco, Oaxaca; Calizas con *Cidaris* unit; Oxfordian, Late Jurassic.

Genus *Pseudodiadema*† Désor, 1855

Pseudodiadema aguilerai† (Maldonado-Koerdell, 1953)

Vouchers. IGM 2209, IGM 2210 (Buitrón-Sánchez, 1970a).

Locality and age. IGM-loc 775; San Juan Raya, Tehuacán, Puebla; San Juan Raya Formation; Aptian, Early Cretaceous.

Genus *Pedinopsis*† Cotteau, 1863

Pedinopsis meridanensis† Cotteau, 1863

Voucher. IGM 2633 (Buitrón-Sánchez, 1976).

Locality and age. IGM-loc 1558; Cuachalalatera Canyon, Atenango del Río, Guerrero; Cuautla Formation; Late Cenomanian-Early Turonian, Late Cretaceous.

Comments. Smith (in Smith and Kroh, 2011) mention that *Pedinopsis* is a stem group of Echinacea Claus, 1876. Here we keep it in the family Pseudodiadematidae.

ORDER Phymosomatoida Mortensen, 1904

FAMILY Emiratiidae† Ali, 1990

Genus *Loriolia*† Neumayr, 1881

Loriolia ornata† (Goldfuss, 1826)

Vouchers. IGM 2242-IGM 2244 (Buitrón-Sánchez, 1971).

Locality and age. IGM-loc 423; Sierra San Ignacio, 4.3 km SW of El Milagro ranch, Chihuahua; Benigno Formation; Albian, Early Cretaceous.

Comments. Initially, *Loriolia* was listed in the database as Hemicidaridae.

Loriolia rotulare† (L. Agassiz, 1840b)

Voucher. IGM 2211 (Buitrón-Sánchez, 1970a).

Locality and age. IGM-loc 775; San Juan Raya, Tehuacán, Puebla; San Juan Raya Formation; Aptian, Early Cretaceous.

Comments. Smith and Rader (2009) include this species in the genus *Polydiadema* Lambert, 1888.

Genus *Tetragramma*† L. Agassiz, 1838

Tetragramma gloriae† Buitrón-Sánchez, 1973b

Type specimens. Syntypes IGM 2455, IGM 2456.

Locality and age. IGM-loc 3232; Huetamo, Michoacán; San Lucas Formation; Hauterivian-Aptian, Early Cretaceous.

Comments. The specimen IGM 2456 is lost.

Tetragramma malbosii† (L. Agassiz, 1847) in L. Agassiz and Désor

Vouchers. IGM 2245, IGM 2246 (Buitrón-Sánchez, 1971).

Locality and age. IGM-loc 75; Cerro Las Conchas, Arivechi, Sonora; geological formation indeterminate; Aptian, Early Cretaceous.

Tetragramma picteti† (Désor, 1856)

Vouchers. IGM 2212-IGM 2216 (Buitrón-Sánchez, 1970a).

Locality and age. IGM-loc 775; San Juan Raya, Tehuacán, Puebla; San Juan Raya Formation; Aptian, Early Cretaceous.

Tetragramma streeruwitzi† (Cragin, 1893)

Vouchers. IGM 2247, IGM 2248 (Buitrón-Sánchez, 1971).

Locality and age. IGM-loc 387; Cerro de Muleros, Chihuahua; geological formation indeterminate; late Albian, Early Cretaceous.

Tetragramma cf. variolare† (Brongniart, 1822)

Voucher. IGM 2217 (Buitrón-Sánchez, 1970a).

Locality and age. IGM-loc 775; San Juan Raya, Tehuacán, Puebla; San Juan Raya Formation; Aptian, Early Cretaceous.

FAMILY Phymosomatidae† Pomel, 1883

Genus *Phymosoma*† Haime, in D'Archiac and Haime, 1853

Phymosoma mexicanum† Böse, 1910

Type specimens. Syntypes IGM 2249, IGM 2250 (Buitrón-Sánchez, 1971).

Voucher. IGM 2218 (Buitrón-Sánchez, 1970a).

Localities and age. IGM-loc 387; Cerro de Muleros, Chihuahua; geological formation indeterminate; Late Albian, Early Cretaceous. IGM-loc 775; San Juan Raya, Tehuacán, Puebla; San Juan Raya Formation; Aptian, Early Cretaceous.

ORDER Salenioida Delage and Herouard, 1903

FAMILY Saleniidae L. Agassiz, 1838

Genus *Heterosalenia*† Cotteau, 1861

Heterosalenia tlaxiacensis† Buitrón-Sánchez, 1970b

Type specimen. Syntype IGM 2284.

Locality and age. IGM-loc 2680; Between Las Huertas and Fundición del Sol de Mayo mine, Tlaxiaco, Oaxaca; Calizas con *Cidaris* unit; Oxfordian, Late Jurassic.

Genus *Salenia* Gray, 1835

Salenia mexicana† Schlüter, 1887

Vouchers. IGM 2190-IGM 2192 (Buitrón-Sánchez, 1970a); IGM 2240, IGM 2241 (Buitrón-Sánchez, 1971); and IGM 2285, IGM 2286 (Buitrón-Sánchez, 1970b).

Localities and age. IGM-loc 775; San Juan Raya, Tehuacán, Puebla; San Juan Raya Formation; Aptian, Early Cretaceous. IGM-loc 388; La Encantada, W Placer de Guadalupe, Chihuahua; geological formation indeterminate; Albian, Early Cretaceous. IGM-loc 2997; Pacheco ranch, Tlaxiaco, Oaxaca; Capas Tlaxiaco unit; Late Jurassic.

Comments. The specimen IGM 2286 (Buitrón-Sánchez, 1970b) is lost.

Salenia texana† Credner, 1875

Voucher. IGM 2457 (Buitrón-Sánchez, 1973a).

Locality and age. IGM-loc 3195; Between Jala and el Túnel, Colima; Potomac Division unit; Albian, Early Cretaceous.

ORDER Stomopneustoida Kroh and Smith, 2010

FAMILY Stomechinidae† Pomel, 1883

Comments: Previously classified as Phymosomatoida, until the description of Stomopneustoida Kroh and Smith, 2010

Genus *Stomechinus*† Désor, 1856

Stomechinus semiplacenta† (L. Agassiz, 1847), in Agassiz and Desor.

Vouchers. IGM 2292-IGM 2294 (Buitrón-Sánchez, 1970b).

Locality and age. IGM-loc 2997; Pacheco ranch, Tlaxiaco, Oaxaca; Calizas con *Cidaris* unit; Oxfordian, Late Jurassic.

FAMILY Stomopneustidae Mortensen, 1903

Genus *Stomopneustes* (L. Agassiz, 1841)

Stomopneustes pristinus Jackson, 1937

Vouchers. IGM 11213-IGM 11228 (Martínez-Melo, 2019b).

Locality and age. IGM-loc 3880; Chacamax river, Palenque, Chiapas; Tulijá Formation; Miocene, Neogene.

ORDER Arbacioida Gregory, 1900

FAMILY Acropeltidae Lambert and Thiery, 1914

Genus *Goniopygus*† L. Agassiz, 1838

Goniopygus (*Goniopygus*) *zitteli*† W.B. Clark, 1891

Vouchers. IGM 2219-IGM 2224 (Buitrón-Sánchez, 1970a).

Locality and age. IGM-loc 901; Santa Ana Teloxtoc, Puebla; Zapotitlán Formation; Barremian, Early Cretaceous.

FAMILY Arbaciidae Gray, 1855

Genus *Codiopsis*† L. Agassiz, in Agassiz and Désor, 1846

Codiopsis lorini† Cotteau, 1851

Voucher. IGM 2295 (Buitrón-Sánchez, 1970a).

Locality and age. IGM-loc 3247; Tlaxiaco, Oaxaca; Capas Tlaxiaco unit; Late Jurassic.

FAMILY INCERTAE SEDIS

Genus *Magnosia*† Michelin, 1853

Comments. Smith and Kroh (2011) place them as a stem group in order Arbacioida, with no assignment to a family.

Magnosia (*Magnosia*) *lens*† Désor, 1858

Voucher. IGM 2225 (Buitrón-Sánchez, 1970a).

Locality and age. IGM-loc 936; Salina, Paraje La Chica, Zapotitlán, Puebla; Zapotitlán Formation; Barremian, Early Cretaceous.

ORDER Holectypoida Duncan, 1889

FAMILY Holectypidae† Lambert, 1900

Genus *Coenholectypus*† Pomel, 1883

Coenholectypus planatus† (Römer, 1849)

Voucher. IGM 2251 (Buitrón-Sánchez, 1971).

Locality and age. IGM-loc 387; Cerro de Muleros, Chihuahua; geological formation indeterminate; late Albian, Early Cretaceous.

Coenholectypus transpecosensis† (Cragin, 1893)

Vouchers. IGM 2226 (Buitrón-Sánchez, 1970a); IGM 2252, IGM 2253 (Buitrón-Sánchez, 1971).

Localities and age. IGM-loc 775; San Juan Raya, Tehuacán, Puebla; San Juan Raya Formation; Aptian, Early Cretaceous. IGM-loc 3194; Sierra de Tlahualilo, Coahuila; Aurora Formation; late Albian, Early Cretaceous. IGM-loc 387; Cerro de Muleros, Chihuahua; geological formation indeterminate; late Albian, Early Cretaceous.

Genus *Discoides*† Parkinson, 1811

Discoides cordobai† Buitrón-Sánchez, 1971

Type specimens. Holotype IGM 2257. Paratypes IGM 2254-IGM 2256, IGM 2258.

Locality and age. IGM-loc 3133; Sierra de La Ranchera, Chihuahua; Lágrima Formation; middle Albian, Early Cretaceous.

ORDER Echinoneoida H. L. Clark, 1925

FAMILY Conulidae† Lambert, 1911

Genus *Conulus*† Leske, 1778

Conulus chiapasensis† Lambert, 1936

Vouchers. IGM 2541-IGM 2543 (Buitrón-Sánchez, 1974a).

Locality and age. IGM-loc 1996; Ocozocoautla, Chiapas; Ocozocoautla Formation; Late Cretaceous.

Conulus cookei† Buitrón-Sánchez, 1974a

Type specimens. Holotype IGM 2544. Paratype IGM 2545.

Locality and age. IGM-loc 1996; Ocozocoautla, Chiapas; Ocozocoautla Formation; Late Cretaceous.

Conulus lamberti† Buitrón-Sánchez, 1974a

Type specimen. Holotype 2546.

Locality and age. IGM-loc 1996; Ocozocoautla, Chiapas; Ocozocoautla Formation; Late Cretaceous.

Conulus raulini† (D'Orbigny, 1853)

Vouchers. IGM 2547-IGM 2549 (Buitrón-Sánchez, 1974a).

Locality and age. IGM-loc 1996; Ocozocoautla, Chiapas; Ocozocoautla Formation; Late Cretaceous.

Conulus cf. stephensoni† Cooke, 1953

Voucher. IGM 2550 (Buitrón-Sánchez, 1974a).

Locality and age. IGM-loc 1996; Ocozocoautla, Chiapas; Ocozocoautla Formation; Late Cretaceous.

Genus *Globator*† L. Agassiz, 1840a

Globator cf. orbignyana† (L. Agassiz, 1840a)

Voucher. IGM 2551 (Buitrón-Sánchez, 1974a).

Locality and age. IGM-loc 1996; Ocozocoautla, Chiapas; Ocozocoautla Formation; Late Cretaceous.

Globator parryi† (Hall, 1857) in Conrad

Vouchers. IGM 2259, IGM 2260 (Buitrón-Sánchez, 1971).

Locality and age. IGM-loc 387; Cerro de Muleros, Chihuahua; geological formation indeterminate; late Albian, Early Cretaceous.

ORDER Cassiduloida L. Agassiz and Désor, 1847

FAMILY Cassidulidae L. Agassiz and Désor, 1847

Genus *Cassidulus* Lamarck, 1801

Cassidulus ellipticus† Kew, 1920

Vouchers. IGM 6384-IGM 6386 (Squires and Demetrion, 1995).

Locality and age. IGM-loc 1698; Mesa La Ladera, San José de Gracia, Baja California Sur; Bateque Formation; early Eocene, Paleogene.

ORDER Echinolampadoida Kroh and Smith, 2010

FAMILY Echinolampadidae Gray, 1851

Genus *Calilampas*† Squires and Demetrion, 1995

Calilampas californiensis† Squires and Demetrion, 1995

Type specimens. Holotype IGM 6387. Paratypes IGM 6388-IGM 6391.

Localities and age. IGM-loc 1697; La Tortuga river, San José de Gracia, Baja California Sur; Bateque Formation; early Eocene (Paleogene). IGM-loc 1695; Mesa La Salina, San José de Gracia, Baja California Sur; Bateque Formation; early Eocene, Paleogene. IGM-loc 1699; Mesa La Ladera, San José de Gracia, Baja California Sur; Bateque Formation; early Eocene, Paleogene.

Genus *Echinolampas* Gray, 1825

Echinolampas aldrichi† Twitchell, 1915 in Clark and Twitchell

Vouchers. IGM 2555 (Buitrón-Sánchez, 1974b); IGM 11229-IGM 11233 (Martínez-Melo, 2019b); IGM 4123 (Buitrón-Sánchez et al., 2019).

Locality and age. IGM-loc 3206; Simojovel, Chiapas; geological formation indeterminate; Oligocene, Paleogene. IGM-loc 3879; Don Eber site, Palenque, Chiapas; Tulijá Formation; Miocene, Neogene. IGM-loc 3880; Chacamax river, Chiapas; Tulijá Formation; Miocene, Neogene. IGM-loc 4039; between Hacienda de San Marcos and Mesón, Veracruz; Coatzintla Formation; Oligocene, Paleogene.

Comments. Specimen IGM 2555 is lost. Initially identified as Cassiduloida indet., the classification of the specimens has been updated in Martínez-Melo (2019b) and Buitrón-Sánchez et al. (2019).

Echinolampas veracruzensis† Buitrón-Sánchez, Solís-Marín, Conejeros and Caballero, 2019

Type specimen. Holotype IGM 4124.

Locality and age. IGM-loc 4039; between Hacienda de San Marcos and Mesón, Veracruz; Coatzintla Formation; Oligoceno, Paleogene.

Echinolampas sp.

Vouchers. IGM 5918, IGM 5919 (Squires and Demetrion, 1992).

Localities and age. IGM-loc 1693 and IGM-loc 1694; San Juan de Abajo river, San José de Gracia, Baja California Sur; Bateque Formation; Eocene, Paleogene.

ORDER Clypeasteroida L. Agassiz, 1835

FAMILY Faujasiidae† Lambert, 1905

Genus *Hardouinia*† Haime in D’Archiac and Haime, 1853

Hardouinia aequorea† (Morton, 1834)

Voucher. IGM 6259 (Martínez-Melo, 2019a).

Locality and age. IGM-loc 956; Cárdenas, San Luis Potosí; Cárdenas Formation; Campanian–Maastrichtian, Cretaceous.

FAMILY Oligopygidae† Duncan, 1889

Comments. Previously classified in Holectypoida but here updated as Clypeasteoida.

Genus *Haimea*† Michelin, 1851

Haimea bajasurensis† Squires and Demetrion, 1994

Type specimens. Holotype IGM 5934. Paratypes IGM 5935-IGM 5937.

Locality and age. IGM-loc 3054; 1.25 km E from Transpeninsular highway, Baja California Sur; Tepetate Formation; early Miocene, Neogene.

Genus *Oligopygus*† De Loriol, 1887

Oligopygus rotundus† Cooke, 1942

Voucher. IGM 2905 (Buitrón-Sánchez and Silva, 1979).

Locality and age. IGM-loc 3028; 1km E Tantoyuca, Veracruz; Tantoyuca Formation; late Eocene, Paleogene.

Oligopygus wetherbyi† De Loriol, 1887

Voucher. IGM 2552 (Buitrón-Sánchez, 1974b).

Locality and age. IGM-loc 3095; Amatán, Chiapas; geological formation indeterminate; Oligocene, Paleogene.

FAMILY Clypeasteridae L. Agassiz, 1835

Genus *Clypeaster* Lamarck, 1801

Clypeaster chiapasensis† Müllerried, 1951

Type specimen. Neotype IGM 11234 (Martínez-Melo, 2019b).

Vouchers. IGM 11235-IGM 11256 (Martínez-Melo, 2019b).

Locality and age. IGM-loc 3636; El Gato, Palenque, Chiapas; Tulijá Formation; Miocene, Neogene.

Clypeaster pileus† Israelsky, 1924

Voucher. IGM 2553 (Buitrón-Sánchez, 1974b).

Locality and age. IGM-loc 3206; Simojovel, Chiapas; geological formation indeterminate; Oligocene, Paleogene.

Clypeaster rogersi† (Morton, 1834)

Voucher. IGM 2554 (Buitrón-Sánchez, 1974b).

Locality and age. IGM-loc 3207; Teapa, Chiapas; geological formation indeterminate; Oligocene, Paleogene.

FAMILY Echinarachniidae Lambert in Lambert and Thiéry, 1914

Genus *Astrodapsis*† Conrad, 1856

Astrodapsis bajasurensis† Squires and Demetrion, 1993

Type specimens. Holotype IGM 5926. Paratypes IGM 5927-IGM 5933.

Locality and age. IGM-loc 1700; mouth of Mezquital river, Baja California Sur; Isidro Fomation; middle Miocene, Neogene.

Genus *Vaquerosella*† Durham, 1955

Vaquerosella perrillatae† Martínez-Melo and Alvarado-Ortega, 2020

Type specimens. Holotype IGM 11463. Paratypes IGM 11464-IGM 11470.

Vouchers. IGM 11471-IGM 11483.

Locality and age. IGM-loc 248; San Ignacio River, Baja California Sur; San Ignacio Formation; Miocene, Neogene. IGM-loc 265; Nacho River, Baja California Sur; San Ignacio Formation; Miocene, Neogene.

Comments. This is the first species of the genus reported out of California, USA, and the most plesiomorphic form (Martínez-Melo and Alvarado-Ortega, 2020).

FAMILY Mellitidae Stefanini, 1912

Genus *Encope* L. Agassiz, 1840a

Encope grandis inezana† Durham, 1950

Type specimens. Paratypes IGM 2825-IGM 2827.

Locality and age. IGM-loc 3156; Loc. A-3584, Santa Inés Bay, Baja California Sur; geological formation indeterminate; Pleistocene, Quaternary.

Encope loretoensis† Durham, 1950

Type specimens. Paratypes IGM 8150, IGM 8151.

Locality and age. IGM-loc 108; Algodones ranch, Baja California Sur; geological formation indeterminate; late Pliocene, Neogene.

Encope michoacanensis† Durham, 1994

Type specimens. Holotype IGM 7057. Paratypes 7058-IGM 7061.

Locality and age. IGM-loc 906; La Mira, Michoacán; geological formation indeterminate; early Miocene, Neogene.

Encope micropora L. Agassiz, 1841

Voucher. IGM 7062 (Durham, 1994).

Locality and age. IGM-loc 3211; Santa Cruz, Oaxaca; geological formation indeterminate; Pliocene, Neogene to Pleistocene, Quaternary.

Comments. In the database is found as *Encope perspective* L. Agassiz, 1841.

Encope shepherdi† Durham, 1950

Vouchers. Paratypes IGM 2822-IGM 2824.

Locality and age. IGM-loc 3155; Loc. A-3517, Marquer Bay, El Carmen island, Baja California Sur; Marquer Formation; late Pliocene, Neogene.

Encope tatetlaensis† Böse, 1906

Type specimens. Syntypes IGM 147, IGM 148, IGM 7154.

Locality and age. IGM-loc 2178; Santa María Tatetla, Veracruz; geological formation indeterminate; Pliocene, Neogene.

ORDER Spatangoida L. Agassiz, 1840a

FAMILY Toxasteridae† Lambert, 1920

Genus *Heteraster*† d'Orbigny, 1855

Heteraster aguilerai† Buitrón-Sánchez, 1970a

Type specimen. Holotype IGM 2227.

Locality and age. IGM-loc 932; Barranca Salitrillo, Tehuacán, Puebla; San Juan Raya Formation; Aptian, Early Cretaceous.

Heteraster alencasterae† Buitrón-Sánchez, 1970a

Type specimens. Holotype IGM 2228. Paratype IGM 2229.

Locality and age. IGM-loc 932; Barranca Salitrillo, Tehuacán, Puebla; San Juan Raya Formation; Aptian, Early Cretaceous.

Heteraster bravoensis† (Böse, 1910)

Type specimens. Syntypes of *Enallaster bravoensis* IGM 404, IGM 405, IGM 7223, IGM 2274-IGM 2278 (Buitrón-Sánchez, 1971).

Locality and age. IGM-loc 392; Loc. 8, Chihuahua; geological formation indeterminate; late Albian, Cretaceous. IGM-loc 387; Cerro de Muleros, Chihuahua; geological formation indeterminate; late Albian, Cretaceous.

Comments. The initial description considered more than 60 specimens. The specimen IGM 404, and probably several others are lost. Note that Buitrón-Sánchez (1971) cited the species as *Whashitaster bravoensis*.

Heteraster mexicanus† (Cotteau, 1890)

Voucher. IGM 2458 (Buitrón-Sánchez, 1973a).

Locality and age. IGM-loc 3196; Loma Noral, Rosario, Colima; Potomac Division unit; Albian, Early Cretaceous.

Heteraster cf. mexicanus† (Cotteau, 1890)

Voucher. IGM 402 (Böse, 1910).

Locality and age. IGM-loc 388; La Encantada close to Placer de Guadalupe, Chihuahua; geological formation indeterminate; Albian, Cretaceous.

Comments. Included as Vraconian, which is a subdivision of the Albian age, used mostly in western Europe.

Heteraster cf. obliquatus† (W.B. Clark, 1893)

Voucher. IGM 403 (Böse, 1910).

Locality and age. IGM-loc 388; La Encantada close to Placer de Guadalupe, Chihuahua; geological formation indeterminate; Albian, Early Cretaceous.

Comments. Included as Vraconian, which is a subdivision of the Albian age, used mostly in western Europe.

Genus *Macraster*† Römer, 1888

Macraster aguilerae† (Böse, 1910)

Type specimen. Syntype IGM 2261 (Buitrón-Sánchez, 1971).

Locality and age. IGM-loc 387; Cerro de Muleros, Chihuahua; geological formation indeterminate; Albian, Early Cretaceous.

Macraster cf. texanus† Römer, 1888

Voucher. IGM 407 (Böse, 1910).

Locality and age. IGM-loc 3117; Cerro de Muleros, between Bisbee and Southern Pacific trains, close to Río Bravo, Chihuahua; geological formation indeterminate; Albian, Early Cretaceous.

Comments. Included as Vraconian, which is a subdivision of the Albian age, used mostly in western Europe.

Macraster dartoni† (Cooke, 1955)

Vouchers. IGM 2262, IGM 2263 (Buitrón-Sánchez, 1971).

Locality and age. IGM-loc 3133; Sierra de La Ranchera, Chihuahua; Lágrima Formation; middle Albian, Early Cretaceous.

Macraster cf. dartoni† (Cooke, 1955)

Voucher. IGM 5236 (Buitrón-Sánchez, 1990a).

Locality and age. IGM-loc 2588; Sierra El Chanate, Sonora; Morita Formation; Aptian, Early Cretaceous.

Comment. The species is excluded from the genus *Macraster* by Kamyabi-Shadan et al. (2014).

Macraster cf. nodopyga† Lambert, 1920

Voucher. IGM 2264 (Buitrón-Sánchez, 1971).

Locality and age. IGM-loc 429; Sierra Banco de Lucero, Chihuahua; Lucero Formation; late Albian, Early Cretaceous.

Genus *Washitaster*† Lambert, 1927

Washitaster longisulcus† (Adkins and Winton, 1920)

Voucher. IGM 2279 (Buitrón-Sánchez, 1971).

Locality and age. IGM-loc 387; Cerro de Muleros, Chihuahua; geological formation indeterminate; late Albian, Early Cretaceous.

FAMILY Hemiasteridae H.L. Clark, 1917

Hemiasteridae indet.

Vouchers. IGM 11397-IGM 11400 (Alvarado-Ortega et al, 2020).

Locality and age. IGM-loc 3995; Tzimol, Chiapas, Mexico; Angostura Formation; Campanian, Late Cretaceous.

Genus *Hemiaster*† Désor, in Agassiz and Désor, 1847

Hemiaster calvini† W.B. Clark, 1893

Vouchers. IGM 2267-IGM 2270 (Buitrón-Sánchez, 1971).

Locality and age. IGM-loc 3194; Sierra de Tlahualilo, Coahuila; Aurora Formation; late Albian, Early Cretaceous.

Hemiaster cf. jacksoni† Maury, 1936

Voucher. IGM 2634 (Buitrón-Sánchez, 1976).

Locality and age. IGM-loc 1558; Barranca de La Cuachalalatera, Atenango del Río, Guerrero; Cuautla Formation; late Cenomanian-Turonian, Late Cretaceous.

Hemiaster sp.

Vouchers. IGM 2265, IGM 2266 (Buitrón-Sánchez, 1971).

Locality and age. IGM-loc 423; Sierra San Ignacio, 4.3 km SW of El Milagro ranch, Chihuahua; Benigno Formation; Albian, Early Cretaceous.

Hemiaster whitei† (W.B. Clark, 1891)

Vouchers. IGM 2230-IGM 2233 (Buitrón-Sánchez, 1970a); IGM 2271-IGM 2273 (Buitrón-Sánchez, 1971, Martínez-Melo et al. 2017).

Localities and age. IGM-loc 932; Barranca Salitrillo, Tehuacán, Puebla; San Juan Raya Formation; Aptian, Early Cretaceous. IGM-loc 432; Sierra de Juárez, Chihuahua; Benigno Formation; Albian, Early Cretaceous.

FAMILY Micrasteridae Lambert, 1920

Genus *Micraster*† L. Agassiz, 1835

Micraster (*Gibbaster*) *sonorensis*† Buitrón-Sánchez, 1971

Type specimen. Holotype IGM 2280.

Locality and age. IGM-loc 75; Cerro Las Conchas, Arivechi, Sonora; geological formation indeterminate; Aptian, Early Cretaceous.

FAMILY Schizasteridae Lambert, 1905

Genus *Linthia*† Désor, 1853

Linthia variabilis† Slocom, 1909

Voucher. IGM 5879 (Michaud, 1984).

Locality and age. IGM-loc 1996; Ocozocoautla, Chiapas; Ocozocoautla Formation; Maastrichtian, Late Cretaceous.

Genus *Schizaster*† L. Agassiz, 1836

Schizaster dumblei Israelsky, 1924

Vouchers. IGM 11308-IGM 11310 (Martínez-Melo, 2019b)

Localities and age. IGM-loc 3636; El Gato, Palenque, Chiapas; Tulijá Formation; Miocene, Neogene. IGM-loc 3880; Chacamax river, Palenque, Chiapas; Tulijá Formation; Miocene, Neogene.

Schizaster (*Paraster*) *aff. lecontei*† Merriam, 1899

Type specimen. Syntype IGM 5921 (Squires and Demetrion, 1992).

Voucher. IGM 5920 (Squires and Demetrion, 1992).

Localities and age. IGM-loc 1693; San Juan de Abajo creek, San José de Gracia, Baja California Sur; Bateque Formation; early Eocene, Paleogene. IGM-loc 1686; Mesa La Salina, San José de Gracia, Baja California Sur; Bateque Formation; early Eocene, Paleogene.

FAMILY Prenasteridae Lambert, 1905

Genus *Agassizia* Valenciennes, 1846

Agassizia regia† Israelsky, 1924

Vouchers. IGM 11257-IGM 11307 (Martínez-Melo, 2019b).

Locality. IGM-loc 3636; El Gato site, Palenque, Chiapas; Tulijá Formation; Miocene, Neogene.

Comment: The specimen of *Agassizia regia* was published with the collection number IGM-11527 by Martínez-Melo (2019b); this is a typographic mistake, and the collection number must be corrected to IGM 11257.

FAMILY Maretiidae Lambert, 1905

Genus *Eupatagus* L. Agassiz, in Agassiz and Désor, 1847

Eupatagus batequensis† Squires and Demetrion, 1992

Type specimens. Holotype IGM 5922. Paratype IGM 5923.

Locality and age. IGM-loc 1693; San Juan de Abajo creek, San José de Gracia, Baja California Sur; Bateque Formation; early Eocene, Paleogene.

Eupatagus (*Eupatagus*) *mooreanus*† Pilsbry, 1914

Voucher. IGM 2906 (Buitrón-Sánchez and Silva, 1979).

Locality and age. IGM-loc 3028; 1 km E Tantoyuca, Veracruz; Tantoyuca Formation; late Eocene, Paleogene.

CLASS HOLOTHUROIDEA DE BLAINVILLE, 1834

ORDER Dendrochirotida Grube, 1840

FAMILY Cucumariidae Ludwig, 1894

Genus *Paleopentacta*† Applegate, Buitrón-Sánchez, Solís-Marín, and Laguarda-Figueras, 2009

Paleopentacta alencasterae† Applegate, Buitrón-Sánchez, Solís-Marín, and Laguarda-Figueras, 2009

Type specimen. Holotype IGM 6853.

Locality and age. IGM-loc 2513; Tepexi de Rodríguez, Puebla; Tlayúa Formation; middle-late Albian, Early Cretaceous.

Comments. The species is spelled either *Paleopentacta alencasterae* or *Paleopentacta alencasterai* in the original publication. In the CNP database, the species is wrongly recorded as "*Paleopenctata*" but correctly spelled as "*alencasterae*".

FAMILY Psolidae Burmeister, 1837

Genus *Parapsolus*† Applegate, Buitrón-Sánchez, Solís-Marín and Laguarda-Figueras, 2009

Parapsolus tlayuensis† Applegate, Buitrón-Sánchez, Solís-Marín, and Laguarda-Figueras, 2009

Type specimen. Holotype IGM 6850.

Locality and age. IGM-loc 370; Tepexi de Rodríguez, Puebla; Tlayúa Formation; middle Albian, Early Cretaceous.

Comments. The original description assigned the genus *Parapsolus* to the family Psolidae Perrier, 1902. However, the family Psolidae was named by Burmeister, 1837. Erroneously this species was also referred to as *Parapsolus thayuensis* in the original publication. *Parapsolus tlayuensis* is retained in the CNP database.

3.2 Geological context of Mexican echinoderms

Echinoid fossils housed in the Type Collection of CNP are from 13 of the 31 Mexican states. They are from 48 localities that represent 35 distinct lithostratigraphic units or formations. These geological units are:

Angostura Formation. This Campanian-Maastricthian formation includes marls, limestones, and sandstones interbedded, were deposited in shallow marine waters with low energy, and now are exposed in Chiapas and Tabasco (Sánchez-Montes de Oca, 1969; Quezada-Muñetón, 1987).

Aurora Formation. Also referred as the Aurora Group or Aurora Shale, this unit is a sequence of Albian-Cenomanian homogeneous limestone with flint nodules, dolomite banks, and calcareous breccia, deposited in shallow shelf, lagoonal and reef conditions, and exposed in the different northern regions of Mexico, in Chihuahua, Coahuila de Zaragoza, Durango (Burrows, 1910; Tardy, 1972; González et al., 2007; Ramírez-Gutiérrez, 2011; Buitrón-Sánchez, 1971).

Bateque Formation. This Eocene sequence consists of very fine-grained sandstone interbedded with fossiliferous lenses, deposited into a delta with shallow and warm-water conditions, and exposed the region between Laguna San Ignacio to San Juanico, northern Baja California Sur (Squiries and Demetrion, 1992).

Benigno Formation. The Albian strata of this unit are exposed in the Sierra de Fresnos, northern Chihuahua, and consist of medium to thick and massive fossiliferous limestones that were deposited in a shallow open marine platform (Nichols, 1958; Haenggi, 1966; Monreal and Longoria, 1999; López-Doncel et al., 2005).

Caliza Chimeco Formation. This Oxfordian fossiliferous formation is exposed near Petlalcingo, southern Puebla, and is composed of sandy and clayey limestones and calcarenites that were deposited on a coastal environment with high energy and fluvial inputs (Pérez-Ibargüengoitia et al., 1965; Alencáster and Buitrón-Sánchez, 1965; Caballero-Miranda, et al., 1989; Grimaldo, 2010).

Caliza Naco Formation. Also considered as a Group, this Carboniferous-Permian geological unit consists of shallow platform marine deposits that are exposed in Arizona as well as Chihuahua and Sonora (Blodgett et al., 2002).

Calizas con *Cidaris* unit. This informally named Oxfordian-Kimmeridgian geological unit is exposed between Puebla and Oaxaca, is a sequence of marls, limestones, and calcareous coquinas interbedded that were deposited under a shallow marine condition of low energy (Erben, 1956; Carrasco-Ramírez, 1981; Alvarado-Ortega et al., 2014).

Capas Tlaxiaco unit. The late Jurassic marine fauna of the Capas Tlaxiaco unit exposed near Tlaxiaco, Oaxaca were reported by Buitrón-Sánchez (1970b), with an age potentially ranging from the Portlandian (Tithonian, Late Jurassic) to the Neocomian (Berriasian to Hauterivian, Early Cretaceous). This is a sequence of yellowish sandstones and marly shales deposited in nearshore shallow marine conditions.

Cárdenas Formation. This is a Maastrichtian sequence consists of shales, calcareous shales, and sandstones, calcarenites, limestones, and sandy shale and limonite interbedded: was deposited in a marine deep platform of high energy, and is exposed in the Sierra Madre

Oriental, in Tamaulipas, Nuevo León, and San Luis Potosí (Myers, 1968; Carrillo-Bravo, 1971).

Coatzintla Formation. This is a late Oligocene-early Miocene marine sequence and is well exposed around the border between Veracruz and Tamaulipas, consists of clays and sandstones with reef limestone lenses interbedded, and was deposited into the Tampico Misantla Basin into a continental platform with localized slope conditions (Salas, 1949a; Barker and Blow, 1976; Buitrón-Sánchez et al., 2019).

Cuautla Formation. This late-Cenomanian-late Turonian of thick to massive gray limestones deposited in transitional shallow and deep open marine conditions, in territories that now are part of Morelos, Estado de México, and Hidalgo (Fries, 1960; Aguilera-Franco, 2003).

Del Monte Formation. This Carboniferous-Pennsylvanian unit is a sequence of carbonated sand and siltstones deposited in a shallow platform with high energy, and exposed in the Huizachal-Peregrina region, Tamaulipas (Carrillo-Bravo, 1961; Malpica and De La Torre, 1980).

Isidro Formation. The Miocene strata of this unit consist of green, white, and yellow stratified sandstone interbedded with gypsum and greenish shales, which were deposited in coastal and neritic conditions, and are exposed near the Los Cabos, southern Baja California Sur (Darton, 1921; Heim, 1922; McLean et al., 1987).

Lágrima Formation. This Albian sequence of thick-bedded marls, limestones, and sandstones exposed northeastern Chihuahua, was deposited in well-oxygenated waters of a shallow marine platform (Haengii, 1966; Ortuño-Arzate, 1985; Monreal and Longoria, 1999).

Los Arcos Formation. This unit also named the Olinalá Formation is a Permian sequence exposed near Olinalá town, Guerrero, which consists of basal conglomerates and siltstones plus carbonate sandstones that were deposited into deltaic environment enclosed in a large Bay (Corona-Esquivel, 1981; Flores de Dios and Buitrón-Sánchez, 1982; Vachard et al., 1993)

Lucero Formation. This Albian marine unit described by Rodríguez-Torres and Guerrero-García (1969) is exposed in northern Chihuahua, is a sequence of limestones interbedded with calcareous shales deposited into a shallow marine shelf to the continental slope (Rodríguez-Torres and Guerrero-García, 1969; Santiago-Bautista et al., 2019).

Marquer Formation. This is a Pliocene sequence of calcareous conglomerates with volcanic pebbles, calcareous sandstones, marls, coquina, algal limestone, and coral-reef materials, which were deposited in shallow marine conditions, and exposed near the La Salada ranch, Baja California Sur (Anderson, 1950; Durham, 1950; Kirkland et al., 1966; Simian and Johnson, 1997; Carreño and Smith, 2007; López-Pérez, 2008).

Morita Formation. This Aptian marine sedimentological unit exposed in Sierra El Chanate Hills, northern Sonora, is a sequence of siltstones and calcareous sandstones deposited into a deltaic plain with sporadic sea raids (Jacques-Ayala et al., 1990; Ramírez-López and Jaimes-Deloya, 2016; González-León and Jacques-Ayala, 1988; García-Barragán and Jacques-Ayala, 2011). Madhavaraju and González–León (2012) mention that this could be part of a major marine transgression during Aptian–Albian.

Ocozocoautla Formation. This unit exposed in central Chiapas is composed of quarzitic gravel within a red clayed matrix; calcareous sandstone; sandy shales interbedded with calcareous sandstones and sandy limestones; fine-grained sandstone interbedded with shales and calcareous sandstones (Sapper, 1894; Sánchez-Montes de Oca, 1969). This carries abundant early Maastrichtian fossils of different inner and outer shelf environments, including shallow marine coastal and restricted lagoonal conditions (Buitrón-Sánchez, 1974a; García-Barrera, et al., 1998; González-Barba et al., 2001; Vega-Vera et al., 2001; Filkorn et al., 2005; Omaña, 2006; Than-Marchese et al., 2011).

Potomac Division unit. Angermann (1907) suggests that a marine stratum exposed near the Colima-Manzanillo railroad track, in Colima, there are similar to the Cretaceous Potomac Formation in the eastern coastal plain, USA. These mid-Albian Mexican strata are bituminous and well-stratified calcareous and clayey layers that were deposited in shallow-water conditions (Corona-Esquivel, 1993; Eguiluz-de Antuñano et al., 2019).

San Ignacio Formation. Miocene marine sequence of whitish volcanoclastic sandstones interlayered with conglomeritic sandstones, marls, coquinas, and lutites that was named by Mina-Uhink (1956, 1957); this geological unit shows porphyry intrusions and is discordantly covered by continental strata composed of late Miocene-early Pliocene andesitic breccias, rhyolites, fluvial gravels, and sandstones, polymictic conglomerates, and even basalt flows belonging to the Comondú Group (Carreño and Smith, 2007).

San Juan Raya Formation. This rich fossil Aptian sequence of green to gray shales with layers of purple shales and calcareous shales that are intercalated with sandstones and calcareous sandstones deposited around the San Juan Raya town, southern Puebla (Aguilera, 1906; Burckhardt, 1930; Alencáster, 1956; Calderón-García, 1956; Reyeros-Navarro, 1963; Buitrón-Sánchez, 1970a; Barceló-Duarte, 1978, Buitrón-Sánchez and Barceló-Duarte, 1980). The fossil and lithology data suggest that this unit was deposited under shallow marine waters, in the shelf zone, and under oxygenated and with little or no disturbance (Salas, 1949b; Alencáster, 1956; Escalante-Ruiz and Quiroz-Barroso, 2006).

San Lucas Formation. This unit exposed in Michoacán and Guerrero was deposited under pelagic conditions and is a sequence of shales, siltstones sandstones with lenses of limestone and rudists, fine-grained conglomerates, and few horizons of volcanic pyroclastic materials and lava flows (Pantoja-Alor, 1959; Pantoja-Alor, 1990b). The fossils assemblage as far recovered indicates that this is a Late Valanginian to Late Aptian deposit (Buitrón-Sánchez, 1973b; Gómez-Luna et al., 1993; Alencáster and Pantoja-Alor, 1996; Guerrero-Suástegui, 1997; Pantoja-Alor et al., 2004; Omaña et al., 2005).

San Ricardo Formation. This Callovian-Aptian? unit is present between Chiapas and Oaxaca, Chiapas, as a sequence of green to gray shales, siltstones, gypsum beds, limestones, marls, and medium- to coarse-grained sandstones deposited in shallow, coastal and continental shelf environments (Richards, 1963; Silva-Pineda, 1977; Buitrón-Sánchez, 1978; Michaud, 1988; Mandujano-Velásquez and Vázquez-Meneses, 1996).

Santa Rosa Formation. This Carboniferous-Mississippian unit is a sequence of carbonated sandstones and siltstones interbedded deposited in shallow marine waters and exposed around the border of Chiapas and Guatemala (Dollfus and Montserrat, 1868; Hernández-García, 1973).

Tantoyuca Formation. The Tantoyuca Formation is a Mid to Late Eocene sequence of sandstones, conglomerate with coarse to fine sediment, sandy shale lenses, and scarce flints that were deposited close shoreline under uniform and moderate depth conditions into the Tampico-Misantla Basin, northwestern Veracruz (Dumble, 1923; VerWiebe, 1924; Buitrón-Sánchez and Silva, 1979; Nava-Pérez and Alegría-Luna, 2001).

Tepetate Formation. These strata exposed near the Tepetate ranch, west-central Baja California Sur, is a sequence of green sandstones interbedded with well-stratified grayish sandstones and a gray to purple shales (Darton, 1921; Heim, 1922) that also was named as the Monterey and the Rosario formations (Heim, 1922; McWilliams et al., 1951). Its Early Eocene micro and nano fossils suggest that this is a deep marine deposit (Miranda-Martínez and Carreño, 2008; García-Cordero and Carreño, 2009).

Tlayúa Formation. The Albian deposits of this formation exploited near Tepexi de Rodríguez, southern Puebla, consists of laminated and parallel limestones interbedded with thin and red clay strata that were deposited into a shallow lagoon with cyclic connection to the open sea (Cantú-Chapa, 1987; Pantoja-Alor, 1990a; Espinosa-Arrubarena and Applegate, 1996).

Tulijá Formation. The Miocene unit is exposed in low land in the eastern region of Chiapas; this consists of dark blue and brownish grey clays, sandstones, and limestones interbedded with coquinas that were deposited near shore or lagoonal environments under high energy and shallow marine conditions (Quezada-Muñeton, 1987).

Tuzancoa Formation. Deposits of this Permian geological unit are exposed near Calnalí town, Hidalgo, and show volcanic beds as well as turbiditic, carbonated detritic, and conglomerates that were deposited into a deep marine basin (Ochoa-Camarrillo, 1996; Rosales-Lagarde et al., 2005).

Zapotitlán Formation. The Barremian sequence of this unit exposed near Hill Zapotitlán, southern Puebla, consists of sandstones interbedded with shales, calcareous shales and marls (Aguilera, 1906; Buitrón-Sánchez, 1970a; Buitrón-Sánchez and Barceló-Duarte, 1980; Hernández-Estévez, 1980; Feldmann et al., 1995). Fossil and lithological data shows that this is a marine low-depth littoral sequence (Müllerried, 1933; Alencáster, 1965; Barceló-Duarte, 1978; Mendoza-Rosales, 2010; Vega-Vera et al., 2019).

4. Discussion

4.1 Summary of the current Echinoderm collection housed at CNP-UNAM

The present review of the CNP-UNAM reveals that this has 107 echinoderm species, which represent five classes, and ages ranging between the Carboniferous and the Pleistocene. These include 19 crinoids (17 Carboniferous, 1 Permian, 1 Jurassic), 1 asteroid (Cretaceous), 1 ophiuroid (Cretaceous), 85 echinoids (11 Jurassic, 48 Cretaceous, 14 Paleogene, 13 Neogene, and 1 Pleistocene), and 2 holothuroids (Cretaceous) (Figure 1). This number could be significantly higher; however, at the dawn of the 19th century (Figure 2), when the first research projects aimed at the formal study of the fossil and extant echinoderms began, the scientific institutions in Mexico were still incipient, and the efforts to establish a scientific paleontological collection were unsuccessful. Therefore, many of the first fossil echinoderms studied were deposited outside of the country or were lost. Indisputably, the greatest contribution to the knowledge of the Mexican fossil echinoderms is found in the efforts of Dr. Blanca Estela Buitrón Sánchez who, between 1965 and 1990, worked intensively in this phylum, mainly in echinoids and crinoids. Unfortunately, this first impulse lost intensity, resulting in the reduction of the number of studies performed, and in the reduction of the number of specimens incorporated into the CNP-UNAM per year.

Since 1995 to date, only eight new echinoderms have entered the CNP-UNAM (Figure 1). These records are very important because they include complete and well-preserved specimens of three species representing the first occurrence of two echinoderm classes, one ophiuroid and two holothuroid species, which are part of the Albian assemblage of the Tlayúa Lagerstätte. Today, additional research on holothurian and ophiuroid microfossils is required to recognize more broadly and completely the diversity that these organisms had over time within the Mexican territory.

A peculiarity of the Mexican fossil crinoids, observed in the 43 specimens cataloged and deposited in the CNP-UNAM, is its low diversity and bad preservation. Hardly, these are fragmented, incomplete, and disintegrated specimens or icnofossils. This fact has only allowed their identification following the parataxonomic criteria established by Moore and Jeffords (1968), as part of 19 form-taxa, 17 of them from the Carboniferous. This is an apparent bias that reflects the scarce Paleozoic marine deposits present in Mexico as well as the abundance of post-Paleozoic shallow marine fossiliferous sites scattered throughout the country.

The paleontological studies on Mexican echinoderms already published are entirely focused on their taxonomy, with little or no attention to other important paleontological aspects, such as their taphonomic and paleoenvironmental implication, or their use as defining elements into phylogenetic and biogeographical studies. Except for Martínez-Melo and Alvarado-Ortega (2020), these studies did not determine the phylogenetic meaning of such fossils nor addressed the paleoenvironmental or palaeoecological implications of these organisms.

4.2 Updates of the CNP-UNAM database

The present review of those 107 echinoderm species recorded into the CNP-UNAM allowed to update the taxonomical status of 23 taxa, which are cataloged into this collected with invalid names (Table 1). Additionally, during this exercise, missing catalogued specimen that actually were recorderd; these are IGM-2456 *Tetragramma gloriae* Buitrón-Sánchez (Buitrón-Sánchez, 1973b), IGM-2555 *Echinolampas aldrichi* Twitchell (Buitrón-Sánchez, 1974b), and IGM-2286 *Salenia mexicana* (Buitrón-Sánchez, 1970). Several specimens received IGM catalog numbers before publication, but have not yet been deposited in the CNP-UNAM: IGM-4873 *Floricyclus granulosus* Moore and Jeffords; IGM-4875 *Preptopremnum rugosum* Moore and Jeffords; IGM-4876 *Cycloscapus laevis* Moore and Jeffords and IGM-4877 *Cyclocaudiculus regularis* Moore and Jeffords, all published in Villanueva-Olea et al. (2016).

Buitrón-Sánchez et al. (2015) reported seven asteroids from the Tlayúa lagerstätte (Puebla), which unfortunately were not properly deposited into the CNP-UNAM and were published with incorrect IGM-numbers previously assigned to ammonoids: *Astropecten* sp. (IGM-3742 to IGM-3744), *Plutonaster* sp. (IGM-3745), *Tamaria* sp. (IGM-3746), *Ophidiaster* sp. (IGM-3747), and *Echinaster* sp. (IGM-3748). Besides, the specimens IGM-3743 and IGM-3746 are the part and counterpart of the same specimen.

Finally, we noted that the holothuroids species described by Applegate et al. (2009) have inconsistent spellings throughout their description. The nomenclatural acts of these species correspond to *Paleopentacta alencasterae* and *Parapsolus tlayuensis*; however, in other parts of the paper, the specific epithets of these species are erroneously typed as *alencasterai*, and *thayuensis* respectively. Our species list highlights the correct spellings (Figure 3).

4.3 Geological summary

The Mexican fossil echinoderms here reported have been recovered from 31 geological units or formations with ages ranging from the Carboniferous to Neogene. These records include 3 Carboniferous, 2 Permian, 4 Jurassic, 13 Cretaceous, 4 Paleogene, and 5 Neogene. In the present manuscript, it is remarkable the presence of unavailable geological data (ND) of different localities with specimens included in this work. These localities include 2 Jurassic, 5 Cretaceous, 1 Paleogene, 3 Neogene, and 1 Quaternary (Figure 4); ND data are derived from inaccurate or unfinished geological studies that have already been published. Although the CNP-UNAM is tasked with updating this information, the geological belonging of these localities has not been determined yet. In the future, these sites should be visited again to supplement their geological information.

The Capas Tlaxiaco unit covers a range from the Portlandian (Tithonian, Late Jurassic) to the Neocomian (Berriasian to Hauterivian, Early Cretaceous). The localities with catalog numbers IGM-loc 2997 and IGM-loc 3247 have been assigned to the Early Cretaceous, "Capas Tlaxiaco" unit; nevertheless, the original description of the specimens (Buitrón-Sánchez, 1970b) refers to a region as "to the west of Tlaxiaco town (Oaxaca)", where only Jurassic outcrops are to be found. These inconsistencies can be solved only by having the precise coordinates of the collection site. (*Salenia mexicana*, *Codiopsis lorini*, and *Pseudocidaris clunifera*)

The Potomac Division unit (Colima) has been described as a shallow water paleoenvironment (Corona-Esquivel, 1993), where two species of echinoderms were reported, *Salenia texana* and *Heteraster mexicanus*. In the surrounding area (Sierra de los Libros, Colima), the Madrid Formation has been described as a succession of carbonates formed by facies of a relatively deep environment that includes the deposit of turbidites made up of benthic microfossils and allochemical material transported to the basin Eguiluz-de Antuñano et al. (2019). Genus *Heteraster* has been reported in environments up to 100 m in depth (Forner and Castany, 2010); while the living reports of genus *Salenia* can reach 2,000 m in depth (Pawson and Pawson, 2013). With further information, we would propose to assign the Potomac Division records to the Madrid Formation.

The San Juan Raya Formation carries the most diverse assemblage of echinoids in México, in which 12 species have been identified. In this report, we assigned the San Juan

Raya Formation records to the Aptian (Cretaceous). Analysis based on calcareous nannoplankton analysis carried out at the Barranca Agua de Burro and Barranca El Gavilán sections of the San Juan Raya Formation, indicate a late Valanginian? – early Hauterivian age (González-León et. al., 2015). A recent analysis based on coral diversity Löser (2021) reports that at least some parts of the San Juan Raya Formation are older and may have an Upper Valanginian to Lower Hauterivian age, even though a Barremian age and even Aptian also cannot be excluded.

The Tlayúa Formation (Puebla), due to its excellent quality of preservation, is the only one with fossil ophiuroid and holothuroid species reported in Mexico. This formation also has been reported for the class Asteroidea (Buitrón-Sánchez et al., 2015), but those specimens are not properly deposited in the CNP-UNAM yet. Crinoids have been described in Tlayúa, but the formal description of the echinoids from this formation is in progress.

The CNP-UNAM does not have fossil echinoderms from the North-eastern, Center, or Center-Pacific Mexican regions, nor Yucatán Peninsula (Figure 5). The collects have been focused on outcrops more attractive for science, but also easier to be reached. It is necessary to conduct more fieldwork along with the whole country, to recognize new localities with fossil records of echinoderm species.

5. Conclusions

The CNP houses a total of 385 records classified in 107 species: 19 Crinoidea, 1 Asteroidea (*Paleoctenodiscus campaniurnus*), 1 Ophiuroidea (*Ophiactis applegatei*), 84 Echinoidea, and 2 Holothuroidea (*Paleopentacta alencasterae* and *Parapsolus tlayuensis*); 27 changes in their taxonomy were done (Table 1).

The echinoderm records come from 69 localities, 52 assigned to 31 formations/units across the country, and 17 not assigned yet (IGM-loc 75, 108, 387, 388, 392, 906, 1671, 1899, 2178, 3055, 3095, 3117, 3152, 3156, 3206, 3207, and 3211). The Cretaceous is the best represented period with 14 formations/units and 6 localities not yet assigned.

San Juan Raya (Puebla) is the most diverse formation with 12 species of Echinoidea: *Cidaris muellerriedi*, *Coenholectypus transpecosensis, Hemiaster whitei*, *Heteraster aguilerai*, *Heteraster alencasterae*, *Heteraster alencasterae*, *Loriolia rotulare*, *Phymosoma mexicanum*, *Pseudocidaris clunifera*, *Pseudodiadema aguilerai*, *Salenia mexicana*, *Tetragramma cf. variolare*, and *Tetragramma picteti*.

The Tlayúa formation (Puebla), due to its excellent quality o preservation, is the only one with fossil ophiuroid and holothuroid species reported in Mexico. This formation also has reports for the class Asteroidea (Buitrón-Sánchez et al., 2015), but those specimens are not properly deposited in the CNP.

The Colección Nacional de Paleontología (CNP) collections of Mexican fossil echinoderms are the most important in Mexico/the world; whit these updates, it can now be reliably used to inform future collecting and investigations. This paper is the beginning of a series of publications focused on the analysis of the systematics, paleodiversity, past ecosystem structures and paleobiogeography of the Mexican fossil echinoderms and applying novel approaches.

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Declaration of interest

None

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FIGURES AND TABLE CAPTIONS

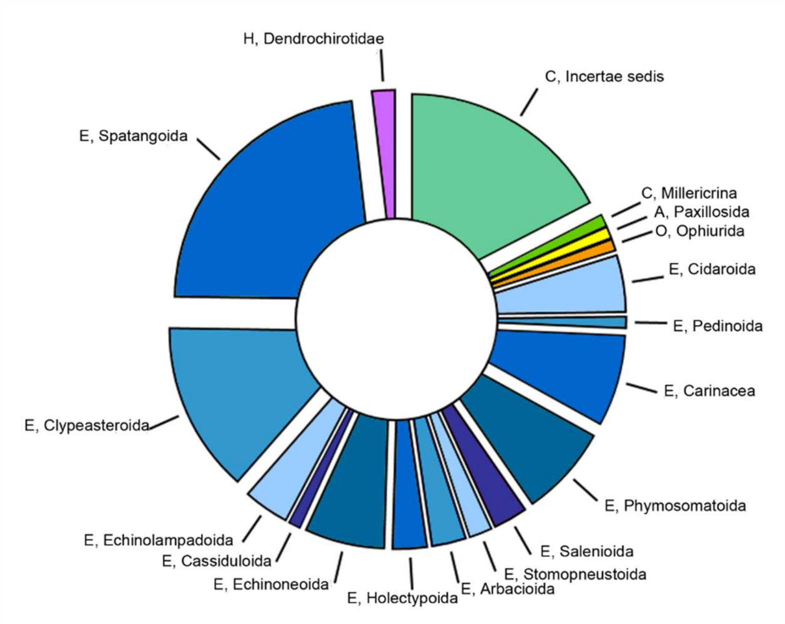

Figure 1. Taxonomic diversity. Diversity of the echinoderm groups represented in the 109 species in the CNP-UNAM. The pie-chart illustrates the percentage of species per echinoderm orders. H, Holothuroidea (pink); C, Crinoidea (green); A, Asteroidea (yellow); O, Ophiuroidea (orange); E, Echinoidea (blue).

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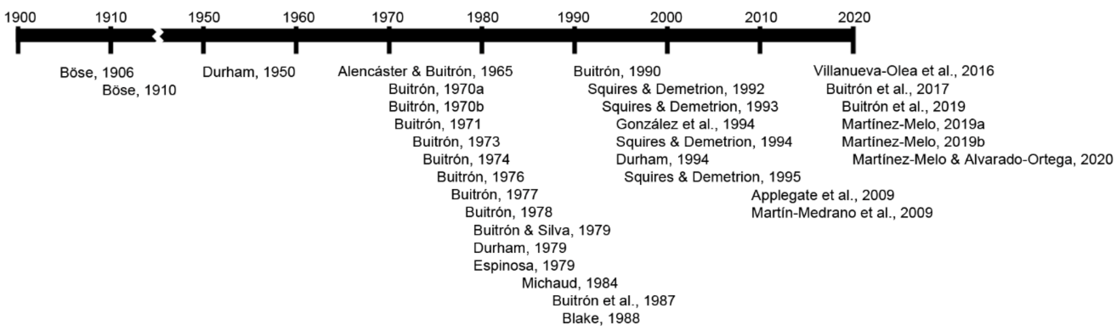

Figure 2. Chronology of the publications that described echinoderm specimens currently housed into the CNP-UNAM.

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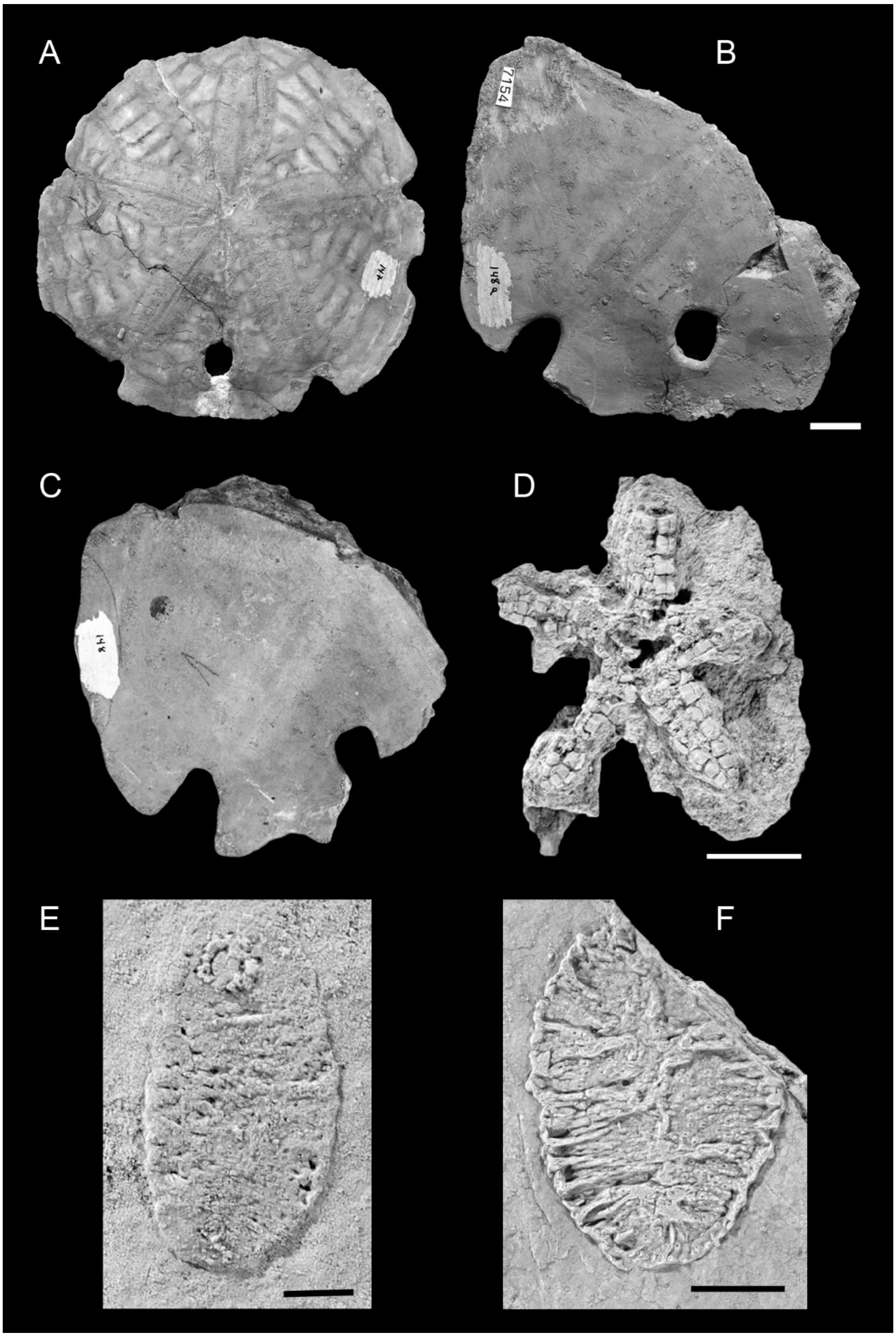

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Figure 3. Relevant specimens. The first echinoderms housed in the CNP; A, *Encope tatetlaensis*† Böse, 1906 IGM 147; B, *E. tatetlaensis*† IGM 7154; and, C, *E. tatetlaensis*†

IGM 148 (Pliocene, Santa María Tatetla, Veracruz). The single fossil asteroid housed in the CNP; D, *Paleoctenodiscus campaniurnus*† Blake, 1988 Holotype IGM 4290 (Late Campanian, Baja California). The only two species of fossil holothuroids collected in Mexico; E, *Parapsolus tlayuensis*† Applegate, Buitrón-Sánchez, Solís-Marín, and Laguarda-Figueras, 2009 Holotype IGM 6850 (Albian, Tlayúa Formation, Puebla); F, *Paleopentacta alencasterae*† Applegate, Buitrón-Sánchez, Solís-Marín, and Laguarda-Figueras, 2009 Holotype IGM 6853 (Albian, Tlayúa Formation, Puebla).

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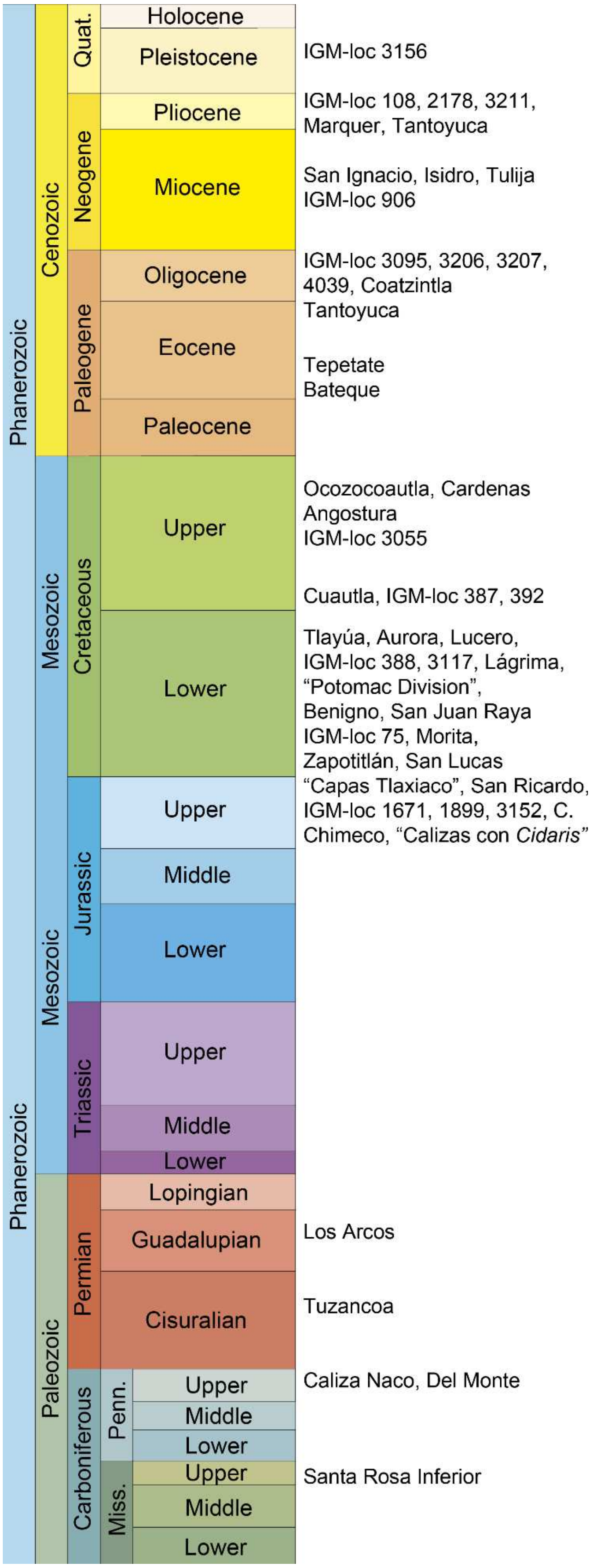

Phanerozoic
Cenozoic
Quat.
Holocene
Pleistocene
IGM-loc 3156
Neogene
Pliocene
IGM-loc 108, 2178, 3211, Marquer, Tantoyuca
Miocene
San Ignacio, Isidro, Tulija IGM-loc 906
Paleogene
Oligocene
IGM-loc 3095, 3206, 3207, 4039, Coatzintla Tantoyuca
Eocene
Tepetate Bateque
Paleocene
Mesozoic
Cretaceous
Upper
Ocozocoautla, Cardenas Angostura IGM-loc 3055
Cuautla, IGM-loc 387, 392
Lower
Tlayúa, Aurora, Lucero, IGM-loc 388, 3117, Lágrima, "Potomac Division", Benigno, San Juan Raya IGM-loc 75, Morita, Zapotitlán, San Lucas
Jurassic
Upper
"Capas Tlaxiaco", San Ricardo, IGM-loc 1671, 1899, 3152, C. Chimeco, "Calizas con *Cidaris*"
Middle
Lower
Triassic
Upper
Middle
Lower
Paleozoic
Permian
Lopingian
Guadalupian
Los Arcos
Cisuralian
Tuzancoa
Carboniferous
Penn.
Upper
Caliza Naco, Del Monte
Middle
Lower
Miss.
Upper
Santa Rosa Inferior
Middle
Lower

Figure 4. Stratigraphy distribution. Stratigraphic distribution of the formations, geological units, and localities with fossil echinoderm records. Localities with IGM-loc have not been assigned yet to a formation or unit.

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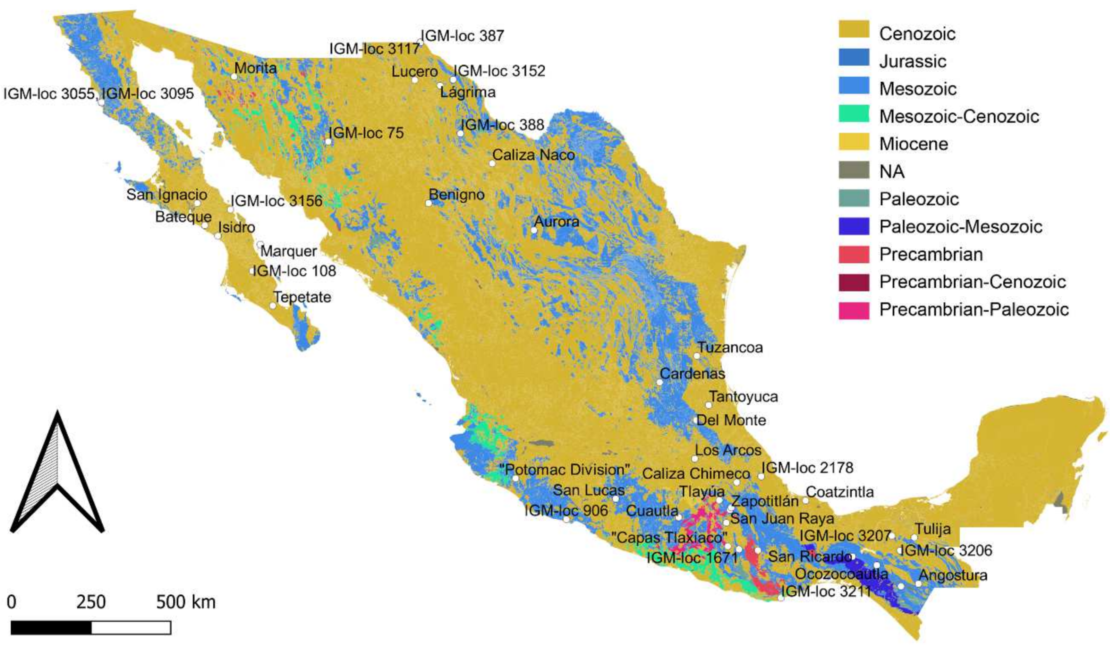

Figure 5. Geologic map. Map of the fossiliferous localities in Mexico with echinoderm reports. (Based on Servicio Geológico Mexicano, 2017).

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Table 1. Taxonomic corrections. Checklist of the taxonomic changes to the database.

TAXON	IN DATABASE	CORRECT
	CLASS CRINOIDEA	
Cyclomischidae	Cyclici	*Incertae sedis*
Floricyclidae	Cyclici	*Incertae sedis*
Leptocarphiidae	Cyclici	*Incertae sedis*
	CLASS ASTEROIDEA	
Paleoctenodiscus	Ctenodiscidae	Porcellanasteridae
	CLASS ECHINOIDEA	
Acrocidaris	Hemicidaroida	Pedinoida
Calilampas	Cassiduloida: Pliolampadidae	Echinolampadoida: Echinolampadidae
Carinacea	Hemicidaroida	Superorder Carinacea
Conulus	Holectypoida	Echinoneoida
Discoides	Discoididae	Holectypidae
Encope micropora	*Encope perspective*	

Eupatagus	Brissidae	Maretiidae
Globator	Holectypoida	Echinoneoida
Goniopygus	Arbaciidae	Acropeltidae
Haimea	Clypeasteroida: Echinarachniidae	Oligopygidae
Hemiaster	Toxasteridae	Hemiasteridae
Heterosalenia	Acrosaleniidae	Saleniidae
Loriolia	Pseudodiadematidae	Emiratiidae
Magnosia	Arbaciidae	Incertae sedis
Oligopygidae	Holectypoida	Clypeasteroida
Pedinopsis	Hemicidaroida	Pedinoida
Pseudodiadema	Hemicidaroida	Pedinoida
Stomechinidae	Phymosomatoida	Stomopneustoida
Stomechinidae	Phymosomatoida	Stomopneustoida
Temnocidaris (*Stereocidaris*)	*Stereocidaris*	
Tetragramma	Pseudodiadematidae	Emiratiidae
Washitaster bravoensis	*Enallaster bravoensis*	
CLASS HOLOTHUROIDEA		
Paleopentacta alencasterae	*Paleopenctata alencasterae*	