Zoosyst. Evol. 95 (2) 2019, 429–452 | DOI 10.3897/zse.95.35435

PENSOFT.

MUSEUM FÜR NATURKUNDE BERLIN

The paleoichthyofauna housed in the Colección Nacional de Paleontología of Universidad Nacional Autónoma de México

Kleyton Magno Cantalice[1], Alejandra Martínez-Melo[2,3], Violeta Amparo Romero-Mayén[2]

1 *Departamento de Paleontología, Instituto de Geología, Universidad Nacional Autónoma de México, Circuito de la Investigación S/N, Ciudad Universitaria, Coyoacán, Ciudad de México, 04510, México*

2 *Colección Nacional de Paleontología, Instituto de Geología, Universidad Nacional Autónoma de México, Circuito de la Investigación S/N, Ciudad Universitaria, Coyoacán, Ciudad de México, 04510, México*

3 *UMR 7207, Centre de recherche en Paléontologie - Paris. 8 rue Buffon, CP 38, 75005 Paris, France*

http://zoobank.org/514DEB4F-BD40-4ED1-898B-27A5F9013FB5

Corresponding author: *Kleyton Magno Cantalice* (kleytonbio@yahoo.com.br)

Academic editor: *Nicolas Hubert* ♦ **Received** 14 April 2019 ♦ **Accepted** 3 August 2019 ♦ **Published** 30 August 2019

Abstract

Fishes are a paraphyletic group composed by craniates except for the four-limbed clade Tetrapoda. This group was the only vertebrate representative until the Devonian but now comprises almost half of the vertebrate species, dominating nearly all aquatic environments. The fossil record is the key to understand the ancient paleobiodiversity and the patterns that lead the modern fish fauna, and paleontological collections play a fundamental role in providing accommodation, maintenance, and access to the specimens and their respective metadata. Here we present a systematic checklist of fossil fishes housed in the type collection of the Colección Nacional de Paleontología which is located at the Instituto de Geología of Universidad Nacional Autónoma de México. Currently housed in the type collection are 14 chondrichthyan specimens, belonging to two superorders, five orders, seven families, 10 genera, and five nominal species, and 361 osteichthyan specimens, belonging to eight orders, nine families, nine genera, and 26 nominal species. These fossils come from 32 localities and 15 geological units, which range temporally from the Jurassic to the Pleistocene. The paleoichthyofauna housed in the type collection of the Colección Nacional de Paleontología is remarkable for its singularity and reveals new insights about the origin and diversification of many groups of fishes. The recovery and curation of this fossil material indicates that knowledge of Mexican fossil fish diversity and its role in understanding lower vertebrate evolution are just emerging and reaffirms the importance of the biological and paleontological collections to the future biodiversity research.

Key Words

Collection, diversity, fishes, paleontology, taxonomy, Mexico

Introduction

Fishes are craniate animals that have gill arches and use fins for locomotion in aquatic environments (Berra 2007; Nelson et al. 2016; Clarke and Friedman 2018). Among vertebrates, fishes exhibit incomparable diversity in morphology, behavior, physiology, and distribution (Nelson et al. 2016). Currently, the extant fishes are classified in four distinct classes: Myxini (hagfishes), Petromyzontida (lampreys), Chondrichthyes (cartilaginous fishes, such as sharks and stingrays), and Osteichthyes. The last class is divided into ray-finned (Actinopterygii) and lobe-finned fishes, Dipnoi and Actinistia, respectively (Helfman et al. 1997). Nevertheless, if we consider the extinct ichthyofauna, the number of classes at least doubles (see Nelson et al. 2016).

In the current understanding of vertebrate systematics, fishes constitute a paraphyletic group (Gill and Mooi 2002; Berra 2007) because it excludes the four-limbed osteichthyan clade Tetrapoda, which shares a common ancestor with lobe-finned fishes (Zhu and Yu 2002). Nevertheless, with at least 32,000 species, fishes represent one-half of the world's living vertebrates and the study of fishes contributes to many subjects of scientific natural history knowledge, such as ontogeny, distribution, speciation, and diversification through space and time (Kornfield and Smith 2000; Peňáz 2001, Cavin et al. 2008; Nelson et al. 2016).

Fossils are physical evidence that helps in the recognition and interpretation of biological patterns and processes on Earth through time (Cavin et al. 2008). Nevertheless, by its composition, fossil material is so fragile that specific care is required for good long-term preservation, and museums and academic institutions are responsible for protecting and conserve this material (Allmon 1994, 2005; Llorente-Bousquets et al. 1994).

Paleontological collections not only have the responsibility of accommodating and storing the fossil record but also of providing the care and good conditions to use these materials for scientific research purposes and entertainment (Llorente-Bousquets et al. 1994; Cristín and Perrilliat 2011). Good practices in museum curation, such as the collection of specimens in appropriate spaces and conditions, the creation of systematic catalogues, and regulations for the proper use of fossils, are essential to generate and validate the information on which the advance of science is possible (Allmon 2005). Furthermore, paleontological collections have an important social and teaching role in spreading the scientific discoveries accessible to the public (Suarez and Tsutsui 2004).

The Colección Nacional de Paleontología of Universidad Nacional Autónoma de México (CNP-UNAM) is remarkable by its number of specimens collected in many regions of the country from various geological ages (e.g. Perrilliat 1993; Cristín and Perrilliat 2011; Perrilliat and Castañeda-Posadas 2013; Rojas-Zúñiga and Gio-Argáez 2016). Although the birth of CNP-UNAM was at the end of the 19th century, its formal consolidation inside the Institute of Geology occurred between 1978 and 1986. Only in 2004 did this collection become recognized as the National Collection of Paleontology and given the designation as the "Museum María del Carmen Perrilliat". All fossils housed at the CNP-UNAM have the acronym (IGM) and began to be incorporated in 1978. Previous fossil records are in other institutions or are lost.

Today, the CNP-UNAM has five sections: geographic reference, foreign materials, Recent materials, molds, and the collection of types (Perrilliat et al. 1986; Carreño and Montellano-Ballesteros 2005). The type collection includes: 1) specimens belonging to type series and 2) voucher specimens, which are recorded in this collection as hypotypes. This section comprises about 10,000 specimens of microfossils, plants, invertebrates, and vertebrates, ranging from the end Precambrian to the Quaternary period of the Cenozoic (e.g. Perrilliat 1993; Perrilliat and Castañeda-Posadas 2013).

After 25 years since the last report about the fossil vertebrates housed in the type collection of CNP-UNAM (Perrilliat 1993), fossil fish specimens have been incrementally added and many changes in fish taxonomy and classification have occurred. Therefore, following Article 72 of the International Code of Zoological Nomenclature, we present the systematic list of fishes currently housed in this collection and their respective localities. Furthermore, we provide information about the implications of these discoveries to understanding the taxonomy, biogeography, and early evolutionary history of some taxa and highlight the importance of biological collections to future research on paleodiversity in Mexico.

Methods

All fish fossils housed in the CNP-UNAM type collection were reviewed. Information on the taxonomy, age, and distribution are from both the collection database and the literature. For each species, we include the catalogue number (IGM), taxonomic classification, and respective distribution and age. Nomenclature on extinct Chondrichthyes follows Nelson et al. (2016) and Van de Laan (2018), while nomenclature on Recent Osteichthyes follows Betancur-R. et al. (2017) and Fricke et al. (2019). The nomenclature of extinct bony fishes follows Nelson et al. (2016), Van der Laan (2018), and original references. The maps were created with QGIS software version 2.18.19 (QGIS Development Team 2018) and the fossil fish localities were plotted using the software ArcView version 3.3 (Environmental Systems Research Institute, Inc., Redlands, California). Most of the taxonomic database used is available under open access at Unidad Informática para la Paleontología of UNAM (UNIPALEO; http://www.unipaleo.unam.mx).

Results

1. Systematic checklist list of CNP-UNAM fossil fishes

Subphylum Vertebrata Cuvier, 1812
Infraphylum Gnathostomata Zittel, 1879
Class Chondrichthyes Huxley, 1880
Subclass Elasmobranchii Bonaparte, 1838
Cohort Euselachii Hay, 1902
Order †Hybodontiformes Maisey, 1975
Superfamily †Hybodontoidea Owen, 1846
Family †Hybodontidae Agassiz, 1843
Genus †*Planohybodus* Rees & Underwood, 2008

†*Planohybodus* indet.

Referred specimen. IGM 9316, IGM 9317 (Alvarado-Ortega et al. 2014).

Locality and age. Llano Yosobé, Sabinal Formation, Tlaxiaco, Oaxaca; Jurassic (Kimmeridgian-Tithonian).

Subcohort Neoselachii Compagno, 1977
Superorder Galeomorphii Compagno, 1973
Order Carcharhiniformes Compagno, 1973

Carcharhiniformes indet.

Referred specimen. IGM 6990 (Ferrusquía-Villafranca et al. 1999).

Locality and age. Rancho el Jobo, San Juan Formation, Tuxtla Gutiérrez, Chiapas; Middle Eocene.

Family Carcharhinidae Jordan & Evermann, 1896
Genus *Galeocerdo* Müller & Henle, 1837

†*Galeocerdo rosaliensis* Applegate, 1978

Referred specimen. IGM 5854 (holotype).

Locality and age. Tirabuzón Formation, Santa Rosalía, Baja California Sur; Pliocene.

***Galeocerdo* indet.**

Referred specimen. IGM 6989 (Ferrusquía-Villafranca et al. 1999).

Locality and age. Rancho el Jobo, San Juan Formation, Tuxtla Gutiérrez, Chiapas; Middle Eocene.

Family Hemigaleidae Hasse, 1878
Genus *Hemipristis* Agassiz, 1843

***Hemipristis* indet.**

Referred specimen. IGM 6988 (Ferrusquía-Villafranca et al. 1999).

Locality and age. Rancho el Jobo, San Juan Formation, Tuxtla Gutiérrez, Chiapas; Middle Eocene.

Order Lamniformes Berg, 1958
Family Lamnidae Bonaparte, 1835
Genus *Carcharodon* Smith, 1938

†*Carcharodon auriculatus* Jordan, 1923

Referred specimen. IGM 6986 (Ferrusquía-Villafranca et al. 1999).

Locality and age. Rancho el Jobo, San Juan Formation, Tuxtla Gutiérrez, Chiapas; Middle Eocene.

Genus *Isurus* Rafinesque, 1810

†*Isurus* cf. *praecursor* Leriche, 1902

Referred specimen. IGM 6985 (Ferrusquía-Villafranca et al. 1999).

Locality and age. Rancho el Jobo, San Juan Formation, Tuxtla Gutiérrez, Chiapas; Middle Eocene.

Family Odontaspididae Müller & Henle, 1839
Genus *Carcharias* Rafinesque, 1810

***Carcharias* indet.**

Referred specimen. IGM 6983 (Ferrusquía-Villafranca et al. 1999).

Locality and age. Rancho el Jobo, San Juan Formation, Tuxtla Gutiérrez, Chiapas; Middle Eocene.

Genus *Odontaspis* Agassiz, 1838

***Odontaspis* indet.**

Referred specimen. IGM 6984 (Ferrusquía-Villafranca et al. 1999).

Locality and age. Rancho el Jobo, San Juan Formation, Tuxtla Gutiérrez, Chiapas; Middle Eocene.

Genus †*Striatolamia* Glikman, 1964

†*Striatolamia macrota* (Agassiz, 1843)

Referred specimen. IGM 6982 (Ferrusquía-Villafranca et al. 1999).

Locality and age. Rancho el Jobo, San Juan Formation, Tuxtla Gutiérrez, Chiapas; Middle Eocene.

Family †Otodontidae Glikman, 1964

†Otodontidae indet.

Referred specimen. IGM 6987 (Ferrusquía-Villafranca et al. 1999).

Locality and age. Rancho el Jobo, San Juan Formation, Tuxtla Gutiérrez, Chiapas; Middle Eocene.

Order Orectolobiformes Compagno, 1973
Suborder Orectoloboidei Regan, 1908
Family Ginglymostomatidae Gill, 1862
Genus *Nebrius* Rüppel, 1837

***Nebrius* indet.**

Referred specimen. IGM 6981 (Ferrusquía-Villafranca et al. 1999).

Locality and age. Rancho el Jobo, San Juan Formation, Tuxtla Gutiérrez, Chiapas; Middle Eocene.

Superorder Batoidea Compagno, 1973
Order Rhinopristiformes Last, Serét & Naylor, 2016
Family *incertae sedis*
Genus †*Tlalocbatos* Brito, Villalobos-Segura & Alvarado-Ortega, 2019

†*Tlalocbatos applegatei* Brito, Villalobos-Segura & Alvarado-Ortega, 2019

Referred specimens. IGM 5853 (holotype).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Megaclass Osteichthyes Huxley, 1880
Class Actinopterygii Woodward, 1891
Subclass Neopterygii Regan, 1923
Order *incertae sedis*
Family *incertae sedis*
Genus †*Cipactlichthys* Brito & Alvarado-Ortega, 2013

†*Cipactlichthys scutatus* Brito & Alvarado-Ortega, 2013

Referred specimens. IGM 6605 (holotype), IGM 6606 (paratype).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Order †Aspidorhynchiformes Bleeker, 1859
Family †Aspidorhynchidae Bleeker, 1859
Genus †*Vinctifer* Jordan, 1919

†*Vinctifer ferrusquiai* Cantalice, Alvarado-Ortega & Brito, 2018

Referred specimen. IGM 8873 (holotype).

Locality and age. Llano Yosobé, Sabinal Formation, Tlaxiaco, Oaxaca; Jurassic (Kimmeridgian-Tithonian).

Order †Pycnodontiformes Berg, 1937
Suborder †Pycnodontoidei Nursall, 1966
Family †Pycnodontidae Agassiz, 1833

†Pycnodontidae indet.

Referred specimen. IGM 3143 (Carranza-Castañeda and Applegate 1994).

Locality and age. Cerro los Mendoza, El Doctor Formation, Zimapán, Hidalgo; Cretaceous (Albian-Cenomanian).

Subfamily †Pycnodontinae (Agassiz, 1833)
Genus †*Pycnodus* Agassiz, 1833

†*Pycnodus* indet.

Referred specimen. IGM 4551 (Alvarado-Ortega et al. 2015).

Locality and age. Belisario Domínguez quarry, Tenejapa-Lacandón geological unity; Salto de Agua, Chiapas; Paleocene (Danian).

Genus †*Tepexichthys* Applegate, 1992

†*Tepexichthys aranguthyorum* Applegate, 1992

Referred specimens. IGM 3286 (holotype), IGM 3288-IGM 3289, IGM 3291-IGM 3300, IGM 3455, IGM 3513, IGM 3587, IGM 3689, IGM 3690, IGM 4052-IGM 4122 (paratypes).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Suborder †Gyrodontoidei Nursall, 1996
Family †Gyrodontidae Berg, 1940
Genus †*Gyrodus* Agassiz, 1833

†*Gyrodus* indet.

Referred specimens. IGM 9318, IGM 9319 (Alvarado-Ortega et al. 2014).

Locality and age. Llano Yosobé, Sabinal Formation, Tlaxiaco, Oaxaca; Jurassic (Kimmeridgian-Tithonian).

Infraclass Holostei Müller, 1845
Division Ginglymodi Cope, 1871
Order †Semionotiformes Arambourg & Bertini, 1958 (*sensu* López-Arbarello 2012)
Family †Semionotidae Woodward, 1890
Genus †*Tlayuamichin* López-Arbarello & Alvarado-Ortega, 2011

†*Tlayuamichin itztli* López-Arbarello & Alvarado-Ortega, 2011

Referred specimens. IGM 6716 (holotype), IGM 6717-IGM 6720 (paratypes).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Family †Macrosemiidae Wagner, 1860
Genus †*Notagogus* Agassiz, 1843

†*Notagogus novomundi* González-Rodríguez & Reynoso, 2004

Referred specimen. IGM 8172 (holotype), IGM 8173-IGM 8181 (paratypes).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Genus †*Macrosemiocotzus* González-Rodríguez, Applegate & Espinosa-Arrubarrena, 2004

†*Macrosemiocotzus americanus* González-Rodríguez, Applegate & Espinosa-Arrubarrena, 2004

Referred specimens. IGM 8163 (holotype), IGM 8164-IGM 8171 (paratypes).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Order Lepisosteiformes Hay, 1929

Lepisosteiformes indet.

Referred specimens. IGM 9321, IGM 9322 (Alvarado-Ortega et al. 2014).

Locality and age. Llano Yosobé, Sabinal Formation, Tlaxiaco, Oaxaca; Jurassic (Kimmeridgian-Tithonian).

Family Lepidotidae Owen, 1860
Genus *Scheenstia* López-Arbarello & Sferco, 2011

***Scheenstia* indet.**

Referred specimen. IGM 9320 (Alvarado-Ortega et al. 2014).

Locality and age. La Lobera, "Caliza con *Cidaris*", Tlaxiaco, Oaxaca; Jurassic (Oxfordian-Early Kimmeridgian).

Superfamily Lepisosteoidea López-Arbarello, 2012
Family Lepisosteidae Agassiz, 1832

Lepisosteidae indet.

Referred specimens. IGM 7657-IGM 7662 (Rodríguez De la Rosa and Cevallos-Ferriz 1998).

Locality and age. El Pelillal, Cerro del Pueblo Formation, Coahuila; Cretaceous (Campanian).

Genus †*Nhanulepisosteus* Brito, Alvarado-Ortega & Meunier, 2017

†*Nhanulepisosteus mexicanus* Brito, Alvarado-Ortega & Meunier, 2017

Referred specimens. IGM 4898 (holotype), IGM 4899-IGM 4902 (paratypes).

Locality and age. Llano Yosobé, Sabinal Formation, Tlaxiaco, Oaxaca; Jurassic (Kimmeridgian-Tithonian).

Division Halecomorphi Cope, 1872
Order †Ionoscopiformes Grande & Bemis, 1998
Family †Ionoscopidae Lehman, 1966
Genus †*Quetzalichthys* Alvarado-Ortega & Espinosa-Arrubarrena, 2008

†*Quetzalichthys perrilliatae* Alvarado-Ortega & Espinosa-Arrubarrena, 2008

Referred specimen. IGM 8592 (holotype), IGM 8593-IGM 8596 (paratypes).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Family †Ophiopsidae Bartram, 1975
Genus †*Teoichthys* Applegate, 1988

†*Teoichthys kallistos* Applegate, 1988

Referred specimen. IGM 3460 (holotype), IGM 4126 (paratype).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

†*Teoichthys brevipina* Machado, Alvarado-Ortega, Machado & Brito, 2013

Referred specimens. IGM 6741 (holotype), IGM 6742 and IGM 6744 (paratypes), IGM 6604, IGM 6743, IGM 6745-IGM 6747 (Machado et al. 2013).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Order Amiiformes Hay, 1929
Family Amiidae Bonaparte, 1837
Subfamily †Vidalamiinae Grande & Bemis, 1998
Genus †*Pachyamia* Chalifa & Tchernov, 1982

†*Pachyamia mexicana* Grande & Bemis, 1998

Referred specimens. IGM 7379 (holotype), IGM 7380-IGM 7387 (paratypes).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Genus †*Melvius* Bryant, 1987

†*Melvius* indet.

Referred specimens. IGM 7663, IGM 7664 (Rodríguez De la Rosa and Cevallos-Ferriz 1998).

Locality and age. El Pelillal, Cerro del Pueblo Formation, Coahuila; Cretaceous (Campanian).

Infraclass Teleostei Müller, 1845
Order †Pholidophoriformes Wagner, 1860
Family †Pleuropholidae Saint-Seine, 1949
Genus †*Pleuropholis* Egerton, 1858

†*Pleuropholis cinerosorum* Alvarado-Ortega & Brito, 2016

Referred specimens. IGM 4733 (holotype), IGM 4734, IGM 4735, IGM 9323 (paratypes).

Locality and age. Llano Yosobé, Sabinal Formation, Tlaxiaco, Oaxaca; Jurassic (Kimmeridgian-Tithonian).

Order †Ichthyodectiformes Bardack & Sprinkle, 1969

†Ichthyodectiformes indet.

Referred specimen. IGM 9048 (Alvarado-Ortega et al. 2007).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Suborder †Ichthyodectoidei Maisey, 1991
Family †Ichthyodectidae Crook, 1892
Genus †*Unamichthys* Alvarado-Ortega, 2004

†*Unamichthys espinosai* Alvarado-Ortega, 2004

Referred specimens. IGM 8373 (holotype), IGM 8374-IGM 8376 (paratypes).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Megacohort Elopocephalai Arratia, 1999
Cohort Elopomorpha Greenwood, Rosen, Weitzman & Myers, 1966
Order Anguilliformes Goodrich, 1909

Anguilliformes indet.

Referred specimen. IGM 4547 (Alvarado-Ortega et al. 2015).

Locality and age. Belisario Domínguez quarry, Tenejapa-Lacandón geological unity, Salto de Agua, Chiapas; Paleocene (Danian).

Megacochort Osteoglossocephalai Betancur-R., Broughton, Wiley, Carpenter, López, Holcroft, Arcila, Sanciangco, Cureton, Zhang, Borden, Rowley, Reneau, Hough, Lu, Grande, Arratia & Ortí, 2013 (=Osteoglossocephala *sensu* Arratia 1999)
Supercorhort Osteoglossomorpha Greenwood, Rosen, Weitzman & Myers, 1966
Order Osteoglossiformes Berg, 1940
Suborder Osteoglossoidei Regan, 1909
Family Osteoglossidae Bonaparte, 1832
Subfamily Osteoglossinae Nelson, 1968
Genus †*Phaerodus* Leidy, 1873

†*Phaerodus* indet.

Referred specimen. IGM 4549 (Alvarado-Ortega et al. 2015).

Locality and age. División del Norte quarry, Tenejapa-Lacandón geological unity, Palenque, Chiapas; Paleocene (Danian).

Supercohort Clupeocephala Patterson & Rosen, 1977
Order †Crossognathiformes Taverne, 1989
Suborder †Pachyrhizodontoidei Forey, 1977

†Pachyrhizodontoidei indet.

Referred specimen. IGM 9049 (Alvarado-Ortega et al. 2007).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Family *incertae sedis*
Genus †*Michin* Alvarado-Ortega, Mayrinck & Brito, 2008

†*Michin csernai* Alvarado-Ortega, Mayrinck & Brito, 2008

Referred specimens. IGM 9028 (holotype), IGM 9029-IGM 9033 (paratypes).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Cohort Otomorpha Wiley & Johnson, 2010
Subcohort Clupei Wiley & Johnson, 2010
Order †Ellimmichthyiformes Grande, 1982
Family †Paraclupeidae Chang & Chou, 1974

†*Paraclupea seilacheri* Alvarado-Ortega & Melgarejo-Damián, 2017

Referred specimens. IGM 4717 (holotype), IGM 4718-IGM 4723 (paratypes).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Order Clupeiformes Rafinesque, 1810
Suborder Clupeoidei Rafinesque, 1810
Family *incertae sedis*

†*Ranulfoichthys dorsonudum* Alvarado-Ortega, 2014

Referred specimens. IGM 9034 (holotype), IGM 9467, IGM 9468 (paratypes); IGM 9035-IGM 9047 (Alvarado-Ortega, 2014).

Locality and age. Tlayúa quarry, Tlayúa Formation, Tepexi de Rodríguez, Puebla; Cretaceous (Albian).

Family Clupeidae Cuvier, 1817

Clupeidae indet.

Referred specimen. IGM 4548 (Alvarado-Ortega et al. 2015).

Locality and age. División del Norte quarry, Tenejapa-Lacandón geological unity, Palenque, Chiapas; Paleocene (Danian).

Subcohort Ostariophysi Lord, 1922
Section Otophysa (=Series Otophysi sensu Rosen & Greenwood, 1970)
Superorder Cypriniphysae Fink & Fink, 1981
Order Cypriniformes Rafinesque, 1810
Superfamily Cobitoidea Swainson, 1839
Family Catostomidae Agassiz, 1850
Subfamily Ictiobinae Smith, 1992
Genus *Ictiobus* Rafinesque, 1820

†*Ictiobus aguilerai* Alvarado-Ortega, Carranza-Castañeda & Álvarez-Reyes, 2006

Referred specimens. IGM 8444 (holotype), IGM 8445-IGM 8591 (paratypes).

Locality and age. La Cementera, La Viga, Tecalco, and El Hoyo, Tarango Formation, Tula de Allende, Hidalgo; Pliocene.

Order Siluriformes Rafinesque, 1810
Suborder Siluroidei Rafinesque, 1810
Superfamily Bagroidea Bleeker, 1858
Family Ariidae Bleeker, 1858

Ariidae indet.

Referred specimen. IGM 5318, IGM 5319 (Hernández-Junquera 1977).

Locality and age. Laguna de la Media Luna, Río Verde, San Luis Potosí; Pleistocene.

Cohort Euteleosteomorpha Greenwood, Rosen, Weitzman & Myers, 1966
Subcohort Neoteleostei Nelson, 1969
Infracohort Eurypterygia Rosen, 1973
Section Ctenosquamata Rosen, 1973
Subsection Acanthomorphata Rosen, 1973
Division Acanthopterygii Rosen & Patterson, 1969
Subdivision Percomorphaceae Betancur-R., Broughton, Wiley, Carpenter, López, Holcroft,

Arcila, Sanciangco, Cureton, Zhang, Borden, Rowley, Reneau, Hough, Lu, Grande, Arratia & Ortí, 2013 (=Percomorphacea sensu Wiley & Johnson, 2010)

Percomorphaceae indet.

Referred specimen. IGM 7968 (Cantalice and Alvarado-Ortega in press).

Locality and age. Ixtapa locality, Ixtapa Formation, Ixtapa, Chiapas; Miocene.

Genus †*Kelemejtubus* Cantalice & Alvarado-Ortega, 2017

†*Kelemejtubus castroi* Cantalice & Alvarado-Ortega, 2017

Referred specimens. IGM 4864 (holotype), IGM 4865-IGM 4867, IGM 4908, IGM 4909 (paratypes).

Locality and age. Belisario Domínguez and División del Norte quarries, Tenejapa-Lacandón geological unity, Salto de Agua and Palenque, Chiapas; Paleocene (Danian).

Series Syngnatharia Betancur-R., Wiley, Bailly, Miya, Lecointre et al., 2014
Order Syngnathiformes Berg, 1940
Suborder Syngnathoidei Regan, 1909
Superfamily Aulostomoidea Greenwood, Rosen, Weitzman & Myers, 1966
Family †Eekaulostomidae Cantalice & Alvarado-Ortega, 2016
Genus †*Eekaulostomus* Cantalice & Alvarado-Ortega, 2016

†*Eekaulostomus cuevasae* Cantalice & Alvarado-Ortega, 2016

Referred specimen. IGM 4716 (holotype).

Locality and age. Belisario Domínguez quarry, Tenejapa-Lacandón geological unity, Salto de Agua, Chiapas; Paleocene (Danian).

Series Carangaria Betancur-R., Broughton, Wiley, Carpenter, López, Holcroft, Arcila, Sanciangco, Cureton, Zhang, Borden, Rowley, Reneau, Hough, Lu, Grande, Arratia & Ortí, 2013(=Carangimorpha sensu Li et al. 2009)
Order Istiophoriformes Betancur-R., Broughton, Wiley, Carpenter, López, Holcroft, Arcila, Sanciangco, Cureton, Zhang, Borden, Rowley, Reneau, Hough, Lu, Grande, Arratia & Ortí, 2013
Family Istiophoridae Rafinesque, 1815

Istiophoridae indet.

Referred specimens. IGM 7885-IGM 7887, IGM 7890-IGM 7892, IGM 7894 (Fierstine et al. 2001).

Locality and age. La Angostura and Rancho Algodones, Trinidad Formation, Baja California Sur; Upper Miocene.

Genus *Makaira* Lacépède, 1802

***Makaira nigricans* Lacépède, 1802**

Referred specimens. IGM 7882-IGM 7884, IGM 7888, IGM 7889, IGM 7893 (Fierstine et al. 2001).

Locality and age. La Angostura, Los Dientes Grandes, Cañada de En medio, and Rancho Algodones, Trinidad Formation, Baja California Sur; Upper Miocene.

Series Ovalentaria Wainwright, Smith, Price, Tang, Sparks, Ferry, Kuhn, Eytan & Near, 2012
Superorder Atherinomorphae Betancur-R., Wiley, Arratia, Acero, Baily, Miya, Lecointre & Ortí, 2017 (=Atherinomorpha sensu Greenwood et al. 1996)
Order Cyprinodontiformes Berg, 1940

Cyprinodontiformes indet. (sensu Espinosa-Perez et al. 1991)

Referred specimen. IGM 7967 (Cantalice and Alvarado-Ortega in press)

Locality and age. Los Ahuehuetes, Pie de vaca Formation, Tepexi de Rodríguez, Puebla; Oligocene.

Suborder Cyprinodontoidei Dyer & Chernoff, 1996
Family Goodeidae Jordan & Gilbert, 1883
Genus †*Tapatia* Álvarez & Arriola-Longoria, 1972

†*Tapatia occidentalis* Álvarez & Arriola-Longoria, 1972

Referred specimen. IGM 7966 (Cantalice and Alvarado-Ortega in press).

Locality and age. Barranca de Santa Rosa, Amatitán, Jalisco; Pliocene.

Series Eupercaria Sanciangco, Carpenter & Betancur-R., 2016
Order Perciformes Rafinesque, 1810
Suborder Serranoidei Imamura & Yabe, 2002
Family Serranidae Swainson, 1839
Genus †*Paleoserranus* Cantalice, Alvarado-Ortega & Alaniz-Galvan, 2018

†*Paleoserranus lakamhae* Cantalice, Alvarado-Ortega & Alaniz-Galvan, 2018

Referred specimens. IGM 4550 (holotype), IGM 9469-IGM 9477 (paratypes).

Locality and age. Belisario Domínguez and División del Norte quarries, Tenejapa-Lacandón geological unity, Salto de Agua and Palenque, Chiapas; Paleocene (Danian).

2. CNP-UNAM fossil fish localities

The fossil fishes catalogued into the Type Collection of CNP-UNAM are from 32 paleontological localities belonging to four undefined geological units (Fig. 1; Suppl. material 1), seven marine formations, and five freshwater formations. The oldest strata found is from Oxfordian "Caliza con Cidaris" geological unit, Oaxaca, while the youngest fish fossil beds are from the Pleistocene of Laguna de Media Luna (San Luis Potosí), the Tarango Formation, near Tula (Hidalgo), and Pie de Vaca, near Tepexi de Rodríguez (Puebla) (Fig. 2). This range represents approximately the last 150 million years of Earth's history. Below are the main features of these Mexican lithostratigraphic units.

The Tirabuzón Formation

This geological unit was first known as the Gloria Formation and based on an outcrop exposed few kilometers away from Santa Rosalía town, Baja California Sur (Wilson 1948). Given that this last name was pre-occupied for a unit of Jurassic rocks from Coahuila (Imlay 1936), Applegate and Espinosa-Arrubarrena (1981) suggested the name of Cañada Gloria Formation for the rocks of Baja California Sur; however, the name of this geological unit changed to Tirabuzón Formation (Carreño 1981), based on Wilson (1948) and on nomenclatural incongruences present in the previous suggestions. The stratotype of the Tirabuzón Formation is inside the Bole Basin, at Santa Rosalía, Baja California Sur (Wilson 1948; Carreño 1981) and is a discontinuous basal conglomerate covered with potentially fossiliferous marine sandstone sediments that are overlaid with conglomerate strata containing a gradual lateral transition to littoral, deltaic, and nonmarine facies (Carreño 1981; Ortlieb and Colleta 1984; Carreño and Smith 2007). The abundant fossil content in this formation includes ichnofossils, foraminifers,

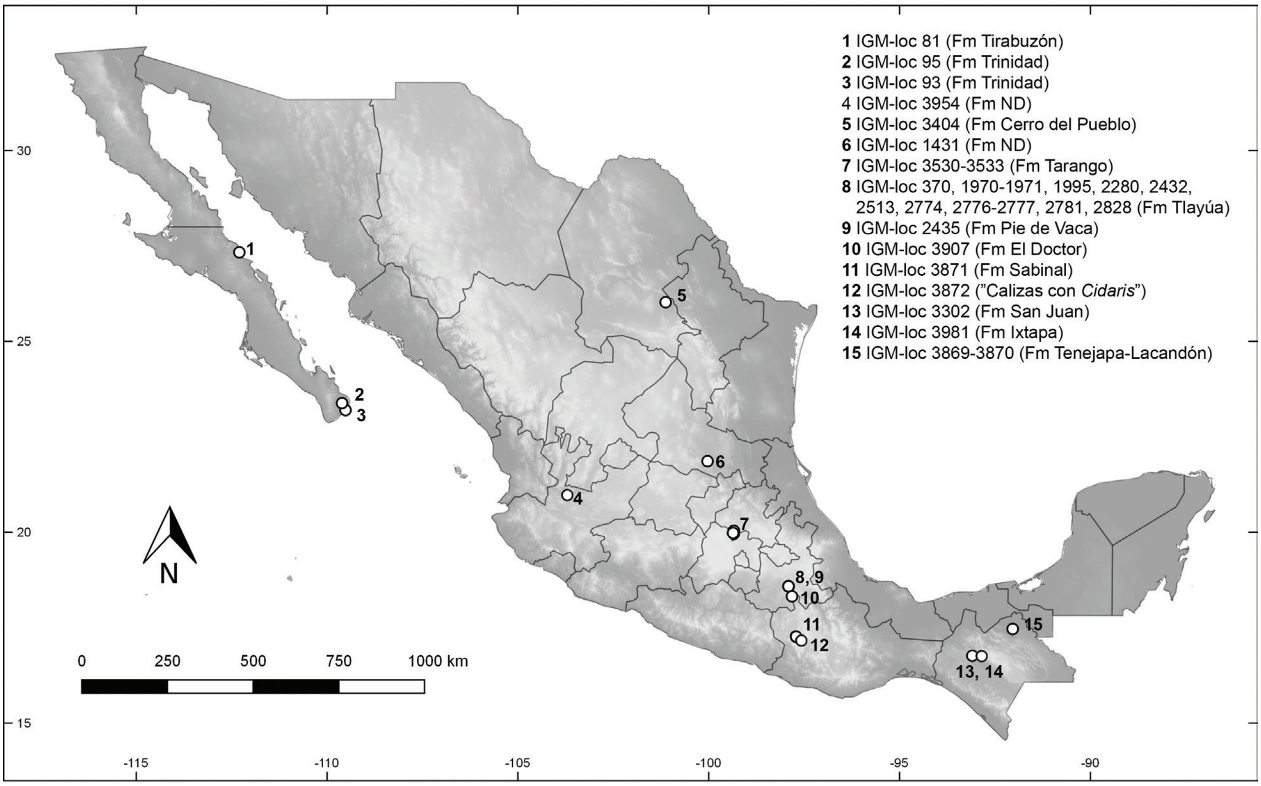

Figure 1. Map of Mexico, showing the localities currently catalogued at CNP-UNAM.

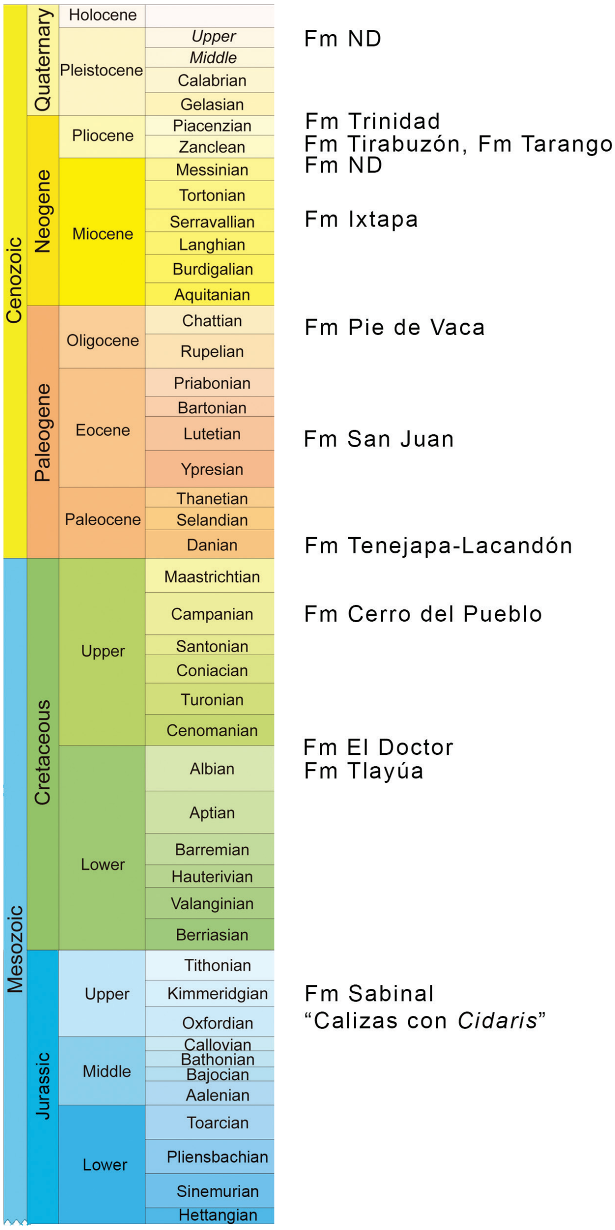

Figure 2. Partial chronostratigraphic chart correlating each formation catalogued in CNP-UNAM that contains fossil fishes and its respective geological age.

mollusks, echinoderms and cetaceans (Wilson 1948; Applegate 1978; Carreño 1981; Ortlieb and Colleta 1984; Quiroz-Barroso and Perrilliat 1989; Barnes 1998; Carreño and Smith 2007; Shroat-Lewis 2007). The age of the unit is Late Miocene-Early Pliocene based on planktonic foraminifers (Carreño 1981), nannofossils (Ortlieb and Colleta 1984), and the shark fauna (Applegate 1978).

The Trinidad Formation

Pantoja-Alor and Carrillo-Bravo (1966) first described this unit which is also located in Baja California Sur. Its stratotype is near the intersection of the Coyote and La Trinidad Streams, in the western margin of the Coyote Stream; however, these outcrops are from both San José del Cabo and Los Barriles Basins (Pantoja-Alor and Carrillo-Bravo 1966; Martínez-Gutiérrez and Sethi 1997; Schwennicke et al. 2017). The unit mainly has a fine-grained sandstone, siltstone, and mudstone but is also composed of gray-greenish, laminated, fine to medium marine sandstone, shale and siltstone, and some diatomite laminate toward the center of the San José del Cabo Basin (Martínez-Gutiérrez and Sethi 1997; Schwennicke et al. 2017). The age of the Trinidad formation range from the middle Miocene to upper Pliocene and its depositional environment has three distinct types of strata: 1) a basal nearshore-lagoon deposit; 2) a deep marine environment; 3) a high-energy, shallow marine waters, which they relate to inner shelf shoals and bars (Martínez-Gutiérrez and Sethi 1997; McCloy 1984; Carreño 1992; Fierstine et al. 2001; Schwennicke et al. 2017). The fossil record of the unit comprises nanoplanktons (Schwennicke et al. 2017), foraminifers and diatomite (McCloy 1984; Carreño 1992), mollusks (Martínez-Gutiérrez and Sethi 1997) fishes (Fierstine et al. 2001), and trace fossils (Schwennicke et al. 2017).

The Cerro del Pueblo Formation

Located in Coahuila state, this formation was described at the beginning 20th century (Imlay 1936); however, its formal description as Cerro del Pueblo Formation was later (Murray et al. 1962). Belonging to the Difunta Group (Eberth et al. 2004), its stratotype is northeast to Saltillo City, and its outcrops are in several localities in the Parras Basin (Murray et al. 1962). The lithology of the unit is mainly composed of mudstone and sandstone but also of lesser amounts of limonite, conglomerates, and limestone (McBride et al. 1974; Kirkland et al. 2000). The unit contains a vast fossil record, comprising plants (fruiting structures, palm fronds, conifer cones), rudists, bivalves, gastropods, cephalopods, elasmobranchs, bony fishes, dinosaurs, crocodiles, turtles (Kirkland et al. 2000), and insects (Cifuentes-Ruiz et al. 2006). There are seven distinct facies, and sediments were laid down in a low coastal plain and shallow marine conditions which were strongly influenced by frequent changes in the relative sea-level or coastal physical processes (Eberth et al. 2004). Hence, the paleoenvironment is a cyclic alternation of marine, estuarine, and freshwater environments (Cifuentes-Ruiz et al. 2006). The age of the formation ranges from uppermost late Campanian to Maastrichtian (Kirkland et al. 2000).

The Tarango Formation

This formation is in the Valley of Mexico (which includes the states of Ciudad de México, Estado de México, and Hidalgo) and was first proposed based on sediments exposed about 4 km southwest of Mixcoac, Mexico City (Bryan 1948; Ferrusquía-Villafranca et al. 2017). This geological unit is composed of sandstone and poorly cemented conglomerate, poorly cemented sandstone and interleaved clay, layers of clay, some layers of basalt interspersed with detrital units, lightly compacted conglomerate lenses, insulated limestone lenses, thin lenses of volcanic ash and tuff, and caliche nodules tuff, tuff-breccia, fluvial volcanic gravel, and thin pumice layers (Bryan 1948; Cervantes-Medel and Armienta 2004; Ferrusquía-Villafranca et al. 2017). The fossil record includes ostracods and diatoms (Ferrusquía-Villafranca et al. 2017), bony fishes (Alvarado-Ortega et al. 2006), and mammals of the genera *Equus* Linnaeus, 1758, *Cuvieronius* Osborn, 1923, *Mammuthus* Brookes, 1828, *Sylvilagus* Gray, 1867, *Canis* Linnaeus, 1758, and *Bison* Smith, 1827 (Castillo-Cerón et al. 1996). The depositional environment is a series of fluvial/lacustrine conditions with sandstone crossbedding which indicates deltaic conditions (Segerstrom 1962; Alvarado-Ortega et al. 2006; Ferrusquía-Villafranca et al. 2017). Based on the paleofauna, geochronology, and fault systems, the Tarango Formation is currently considered to present a Pliocene-Quaternary age (Castillo-Cerón et al. 1996; Suter et al. 2001).

The El Doctor Formation

The El Doctor Formation outcrops from the eastern portion of Queretaro state to the western edge of Hidalgo (Wilson et al. 1955). Its type locality is in the north flank, near El Doctor village in the Sierra Gorda, Queretaro, northeastern Peña de Bernal (Wilson et al. 1955; Segerstrom 1961; Aguirre-Díaz et al. 2013). This unit has a large limestone bank of varied textures with some chert lenses, dolomite interbeds, and shale partings (Segerstrom 1961). Based on lithology, there are four subunits: 1) La Negra, deposited in the deep of the neritic zone; 2) San Joaquín, with the same sediments of La Negra but deposited at a depth and under storm wave action; 3) Cerro Ladrón, a calcareous bank formed in shallow waters; and 4) Socavón, with clastic sediments deposited not far from the input origin (Wilson et al. 1955). The fossil record found in the El Doctor Formation includes rudists (Wilson et al. 1955), miliolids, corals, oysters, gastropods, ammonites, echinoids (Segerstrom 1962), planktic and benthic foraminifers, radiolarians (Bravo-Cuevas et al. 2009), crustaceans (Feldmann et al. 2007), and fishes (Carranza-Castañeda and Applegate 1994; Bravo-Cuevas et al. 2009). Its deposits originate on a platform shelf followed by a transitional marine system, including open sea to deep shelf margin, with alternation of neritic and open oceanic waters and, occasionally, influx of near-shore waters, probably during storms (Wilson et al. 1955; Carrillo-Martínez 1981; Bravo-Cuevas et al. 2009). The age of this formation is Albian-Cenomanian (Wilson et al. 1955; Bravo-Cuevas et al. 2009).

The Tlayúa Formation

The stratotype is a few kilometers north of Tepexi de Rodriguez town, Puebla state, eastern Mexico (Pantoja-Alor 1992). There is a subdivision of the Tlayúa Formation: 1) the Lower Member, formed by micritic limestones (mudstone to wackestone) with silica concretions and chert lenses; 2) the Middle Member, formed by red lithographic laminar limestone (mudstone) and chert lenses; and 3) the Upper Member, with layers of dolomite and dolomitic limestone (Pantoja-Alor 1992). The fossil record is preserved in the Middle Member and, by its abundance and exceptional quality of preservation, the Tlayúa Formation is currently considered the first fossil-*Lagerstätte* site found in Mexico (Alvarado-Ortega et al. 2007). The paleontological record are both marine and terrestrial fauna and flora, including rudists (Alencáster 1973), foraminifera, sponges, gorgonians, gastropods, ammonoids (Cantú-Chapa 1987), belemnoids (Seibertz and Buitrón 1987), bivalves, arthropods (Feldmann et al. 1998), asteroids (Buitrón-Sánchez et al. 2015), holothurians (Applegate et al. 1996), ophiuroids, fishes (Applegate 1987; Alvarado-Ortega 2004), lizards, crocodiles, turtles (Reynoso 1997, 2000), pterosaurs (Cabral-Perdomo and Applegate 1994), algae, and gymnosperms (Espinosa-Arrubarrena et al. 1996). The paleoenvironment is a double-enclosed shallow lagoon behind a barrier reef with stagnant, anaerobic, and hypersaline conditions and bounded by semi-arid land, on the other side, by a barrier bordering a deeper, well-oxygenated lagoon (Applegate 1987; Pantoja-Alor 1992; Espinosa-Arrubarrena and Applegate 1996). Nevertheless, some influences of an open sea have been proposed (Kashiyama et al. 2004). The age of Tlayúa quarry strata ranges between the Aptian and Albian stages in the Early Cretaceous between 125 and 100 Ma (Cantú-Chapa 1987; Seibertz and Buitrón 1987; Kashiyama et al. 2004).

The Pie de Vaca Formation

The outcrops of the Pie de Vaca Formation are in the southern portion of Puebla, a few kilometers northeast of Tepexi de Rodríguez town very close to the Tlayúa Formation (Pantoja-Alor 1992). The lithology of the formation consists of continental deposits of fluvial-lacustrine and alluvial environments formed by conglomerates, gravel, silt, clay, marl, limestone, travertine, and volcanic rocks (Pantoja-Alor 1992). These are followed by micritic sandstone with siliciclastic bands and intraclasts of flint, limestone, and volcanic rocks (Cabral-Perdomo et al. 2018). The fossil records of the unit are ichnites belonging to birds, camelids, felids, proboscideans, small artiodactyls (Cabral-Perdomo 1995, 2013), and bony fishes (González-Rodríguez et al. 2013; Guzmán 2015). Fungus, leaves, leaflets, wood, and fruits of angiosperms are also well conserved in this unit, as well as ostracods and stromatolites (Beraldi-Campesi et al. 2006). The paleoenvironmental condition is a tropical paleolake which evolved from a basin with alluvial conditions to shallow, alkaline, and evaporitic lacustrine circumstances, indicating the gradual desertification of the environment

(Beraldi-Campesi et al. 2006). Although the palynological record indicates an Eocene-Oligocene age for this formation (Martínez-Hernández and Ramírez-Arriaga 1999), the paleobotanical and ichnological record with associated mammals indicates with more robustness an Oligocene-Pleistocene age (Cabral-Perdomo 1995, 2013; Cabral-Perdomo et al. 2018; Ramírez and Cevallos-Ferriz 2002).

The Sabinal Formation

The Sabinal Formation is in northeastern Oaxaca, with its outcrops (Yosobé and La Lobera) in the southern portion of Tlaxiaco Basin (López-Ticha 1985; Meneses-Rocha et al. 1994; Alvarado-Ortega et al. 2014). The lithology of the formation consists of a sequence of mudstone and wackestone clay, marl, and dark gray to black bituminous shale strata with abundant calcareous concretions arranged in thin laminar layers and showing abundant light oil impregnations (Lopéz-Ticha 1985; Felix 1891; Meneses-Rocha et al. 1994; Alvarado-Ortega et al. 2014). The fossil contents of the unit are microfossils (ostracods), plants, invertebrates (mostly ammonites), marine reptiles, and bony fishes (Alvarado-Ortega et al. 2014; Barrientos-Lara et al. 2015). The paleoenvironment is as a transitional environment under the marine influence (Alvarado-Ortega et al. 2014). A Kimmeridgian-Tithonian age is attributed to the Sabinal Formation based on the ammonite assemblage (Alvarado-Ortega et al. 2014).

The "Caliza con Cidaris" geological unit

This Jurassic geological unit was informally named because it carries numerous remains of urchins belonging to the genus *Cidaris* Leske, 1778. Main outcrops of this unit are present between Tlaxiaco and Mixtepec in Oaxaca State (Buitrón 1970). This includes the outcrops in "La Titana" hills, near Tlaxiaco, firstly reported by Felix (1891) (also see Alvarado-Ortega et al. 2014). The numerous marine invertebrates recovered in the gray marls and limestones interbedded with shales present in this site suggest that its age could extend from the Late Callovian to the Early Kimmeridgian (Buitrón 1970). Besides the first fossil fishes from the Lobera site reported by Alvarado-Ortega et al. (2014), where "Caliza con *Cidaris*" sediments outcrops; the fossils already documented in this geological unit include three bivalves, echinoids, calcareous sponges, gastropods, annelids, crinoids, a brachiopod (Buitrón 1970; Felix 1891).

The San Juan Formation

Located to the northwest of Tuxtla Gutiérrez in Chiapas state (Licari 1960; Allison 1967; Ferrusquía-Villafranca 1996), the San Juan Formation have light-brown shales and yellowish-brown fine-grained calcarenite, composed of conglomerates, sandstone, siltstone, limestone, marl, and coquina (Ferrusquía-Villafranca 1996; Perrilliat et al. 2003). The fossil record in the unit contains foraminifers (Ferrusquía-Villafranca 1996; Perrilliat et al. 2003), calcareous algae, wood, bivalves, corals, annelids, gastropods, nautiloids, bivalves, echinoderms (Perrilliat et al. 2003), crustaceans, bony fishes (Vega et al. 2001), and sharks (Ferrusquía-Villafranca et al. 1999). The paleoenvironments are episodes of shallow, marine waters with high organic productivity and low terrigenous influence, combined with well-oxygenated shallow waters influenced by continental sedimentation and, probably, with marsh conditions from a deltaic lagoon system (Ferrusquía-Villafranca 1996; Perrilliat et al. 2003). Based on the foraminifer fossil record, the age assigned to the San Juan Formation is middle Eocene (Ferrusquía-Villafranca 1996; Perrilliat et al. 2003).

The Ixtapa Formation

Also located in Chiapas, the Ixtapa Formation is 28 km east from Tuxtla Gutiérrez City and its outcrops mainly at the east side of the Soyaló-Ixtapa highway (State Road 195) next to the bridge that crosses the Río Hondo 1 km north of Ixtapa Municipality (Langenheim and Frost 1963; Ferrusquía-Villafranca 1996). This unit has a sequence of pyroclastic materials interbedded with calcitic pebbly gravels and tuffs, which become more frequent towards the base of the unit forming part of interbedded layers of conglomerates, sandstones, and clays where crystalline and calcareous conglomerates are sporadically present (Langenheim and Frost 1963; Martínez-Hernández 1992). The fossil record in Ixtapa Formation is diverse and includes charophytes, foraminifers, mollusks (Daily and Durham 1966), palynomorph assemblages (e.g. dinoflagellates and mangrove pollen), proboscides, horses, rhinoceros (Langenheim and Frost 1963; Daily and Durham 1966), freshwater turtles (Ferrusquía-Villafranca 1996), and only one record of a bony fish (Cantalice and Alvarado-Ortega in press). The Ixtapa Formation was formed under a low-energy fluvial-lacustrine conditions over the Middle Miocene continental sandstones of the Coyolar Formation and is below the Pliocene-Pleistocene volcanic deposits of the Punta de Llano Formation (Ferrusquía-Villafranca 1996; Martínez-Amador et al. 2004; Hernández-Villalva et al. 2013). The paleoenvironment is a continental lacustrine or a brackish transitional environment near the coast (Daily and Durham 1966; Martínez-Hernández 1992). The age assigned to this Formation ranges from the Middle to Late Miocene (Ferrusquía-Villafranca 1996).

The Tenejapa-Lacandón geological unity

The Tenejapa-Lacadón geological unity was first mentioned by Islas-Tenorio et al. (2005). This layer represents the union of two contemporary and laterally continuous formations: Tenejapa, first described from outcrops of San Cristóbal de las Casas City (Quezada-Muñetón

1987), and Lacandón, primary known from Petén, Guatemala (Vinson 1962; Fourcade et al. 1999). Because it is not possible to determine the boundaries between the two Formations and the proper identity of each unit is poorly understood, here we interpret both formations as a single element, the Tenejapa-Lacandón geological unity (see Alvarado-Ortega et al. 2015). This layer outcrops in diverse portions of Chiapas state (Islas-Tenorio et al. 2004, 2005); however, the fossils housed in the CNP are from the División del Norte and Belisario Dominguez quarries. The first one is approximately 2 km southeast of the archeological site of Palenque City, while the last is 9.5 km from Palenque City. Both strata are limestone marls deposited in laminated and parallel strata, which show yellowish-creamy colors with some dark-grey silicified bands and nodules (Alvarado-Ortega et al. 2015; Cantalice et al. 2018a). The fossil specimens are many poor-preserved impressions of plant remains and a singular paleoicthyofauna (Alvarado-Ortega et al. 2015; Cantalice and Alvarado-Ortega 2016, 2017; Cantalice et al. 2018a). The number of well-preserved specimens (mostly on massive mortality) makes this geological unity a fossil-*Lagerstätte* site. The paleoenvironment of Tenejapa-Lacandón geological unity is a marine platform with influences of external conditions to the west, originating the Tenejapa Formation, and to the east, shallow waters influenced by primarily internal conditions composes the Lacandón Formation (Quezada-Muñetón 1987; Alvarado-Ortega et al. 2015). Studies based on stable strontium isotopes indicate a Paleocene (Danian) age for this geological unity (Alvarado-Ortega et al. 2015).

Discussion

Since the last systematic review of the vertebrates housed on the CNP-UNAM (Perrilliat 1993), the number of specimens of fossil fishes has increased from five to 375, and the number of valid species raised from two to 27, including 20 new to science. This means that the number of fossil fishes species housed in the collection is currently 11 times greater than previously, not considering, however, the fossils that were are not determinable to species, which represent almost one-half of the palaeoichthyological material currently housed in the type collection. These numbers show a great increment in the knowledge of Mexican fossil fishes over the last two decades.

Many of the species housed in CNP-UNAM are the oldest record of its respective group and the first report of the taxon in North America (Table 1). These represent not only an increase of the knowledge about the fish diversity but also constitute valuable tools to a new understanding of the historical biogeography of fishes. This is the case of †*Vinctifer ferrusquiai* (Fig. 3A), from Kimmeridgian-Tithonian marine deposits from Oaxaca, which is the oldest fossil record and the first report of a member of the genus †*Vinctifer* outside the Cretaceous Period (Cantalice et al. 2018b). Its age and distribution suggest that the family Aspidorhynchidae under went a

Table 1. Remarks of outstanding Mexican species housed at the CNP-UNAM. Abbreviation: A. America; L. last occurrence; N. North America; O. oldest occurrence. The asterisk means the oldest generic occurrence.

Taxon	Oldest or Last occurrence	First report	Apparent endemism
Class CHONDRICHTHYES			
Order †HYBODONTIFORMES			
Family †HYBODONTIDAE			
†*Planohybodus* indet.		N	
Order CARCHARHINIFORMES			
Family CARCHARHINIDAE			
†*Galeocerdo rosaliensis*			X
Order RHINOPRISTIFORMES			
Family *incertae sedis*			
†*Tlalocbatos applegatei*			X
Class ACTINOPTERYGII			
Order *incertae sedis*			
Family *incertae sedis*			
†*Cipactlichthys scutatus*			X
Order †ASPIDORHYNCHIFORMES			
Family †ASPIDORHYNCHIDAE			
†*Vinctifer ferrusquiai*	O*		X
Order †PYCNODONTIFORMES			
Family †PYCNODONTIDAE			
†*Pycnodus* sp.	O	A	
†*Tepexichthys aranguthyorum*			X
Division GINGLYMODI			
Order †SEMIONOTIFORMES			
Family †SEMIONOTIDAE			
†*Tlayuamichin itztli*			X
Family †MACROSEMIIDAE	L	A	
†*Notagogus novomundi*			X
†*Macrosemiocotzus americanus*			X
Order LEPISOSTEIFORMES			
Family LEPIDOTIDAE			
Scheenstia sp.		A	
Family LEPISOSTEIDAE	O	A	
†*Nhanulepisosteus mexicanus*			X
Division HALECOMORPHI			
Order †IONOSCOPIFORMES			
Family †IONOSCOPIDAE	L	A	
†*Quetzalichthys perrilliatae*			X
Family †OPHIOPSIDAE	L	A	
†*Teoichthys kallistos*			X
†*Teoichthys brevipina*			X
Order AMIIFORMES			
Family AMIIDAE	O	A	
†*Pachyamia mexicana*	O*		X
Order †PHOLIDOPHORIFORMES			
Family †PLEUROPHOLIDAE			
†*Pleuropholis cinerosorum*		A	X
Order †ICHTHYODECTIFORMES			
Family †Ichthyodectyidae			
†*Unamichthys espinosai*			X
Order OSTEOGLOSSIFORMES			
Family OSTEOGLOSSIDAE			
†*Phaerodus* indet.	O*		
Order †CROSSOGNATHIFORMES			
Family *incertae sedis*			
†*Michin csernai*			X
Order †ELLIMMICHTHYIFORMES			
Family †PARACLUPEIDAE			
†*Paraclupea seilacheri*		A	
Order CLUPEIFORMES			
Family *incertae sedis*			
†*Ranulfoichthys dorsonudum*			X
Order CYPRINIFORMES			
Family CATOSTOMIDAE	O		
†*Ictiobus aguilerai*			X
Division ACANTHOPTERYGII			
Order *incertae sedis*			
Family *incertae sedis*			
†*Kelemejtubus castroi*			X
Order SYNGNATHIFORMES	O		
Family †EEKAULOSTOMIDAE			
†*Eekaulostomus cuevasae*			X
Order CYPRINODONTIFORMES			
Family GOODEIDAE	O		
†*Tapatia occidentalis*			X
Order PERCIFORMES			
Family SERRANIDAE	O		
†*Paleoserranus lakamhae*			X

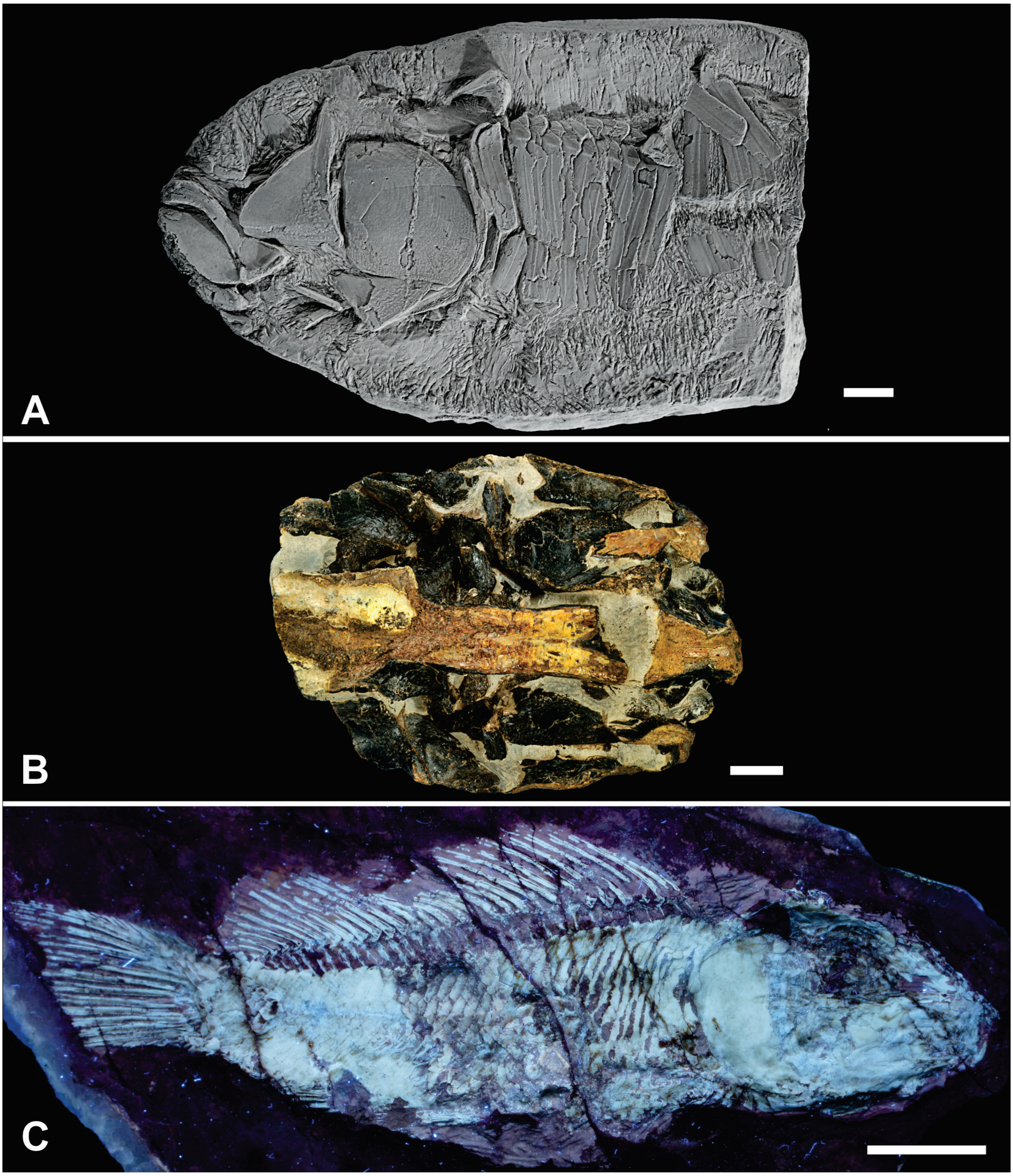

Figure 3. Some species housed in the CNP-UNAM type collection. **A.** †*Vinctifer ferrusquiai* Cantalice, Alvarado-Ortega & Brito, 2018; **B.** †*Nhanulepisosteus mexicanus* Brito, Alvarado-Ortega & Meunier, 2017; both being the most ancient species of their families to date; **C.** †*Macrosemiocotzus americanus* González-Rodríguez, Applegate & Espinosa-Arrubarrena, 2004, the first report of Macrosemiidae in North America. Scale bars: 10 mm.

rapid diversification and had a wide distribution during the Late Jurassic (Cantalice et al. 2018b). Another example is the earliest known lepisosteoid, †*Nhanulepisosteus mexicanus* (Fig. 3B), which raises the origin of modern gars to the Late Jurassic (Brito et al. 2017). Furthermore, the Paleocene fossil fishes from Chiapas (Fig. 4) push back the absolute age of origin of many acanthomorph groups (e.g. seabasses and flutemouth fishes) to the early Cenozoic, just after the K/Pg boundary (Late Paleocene, 63 Ma). These finds reveal that the Caribbean Region is an important place for the origin and diversification of some modern ray-finned fish lineages (Alvarado-Ortega et al. 2015; Cantalice and Alvarado-Ortega 2016, 2017; Cantalice et al. 2018a).

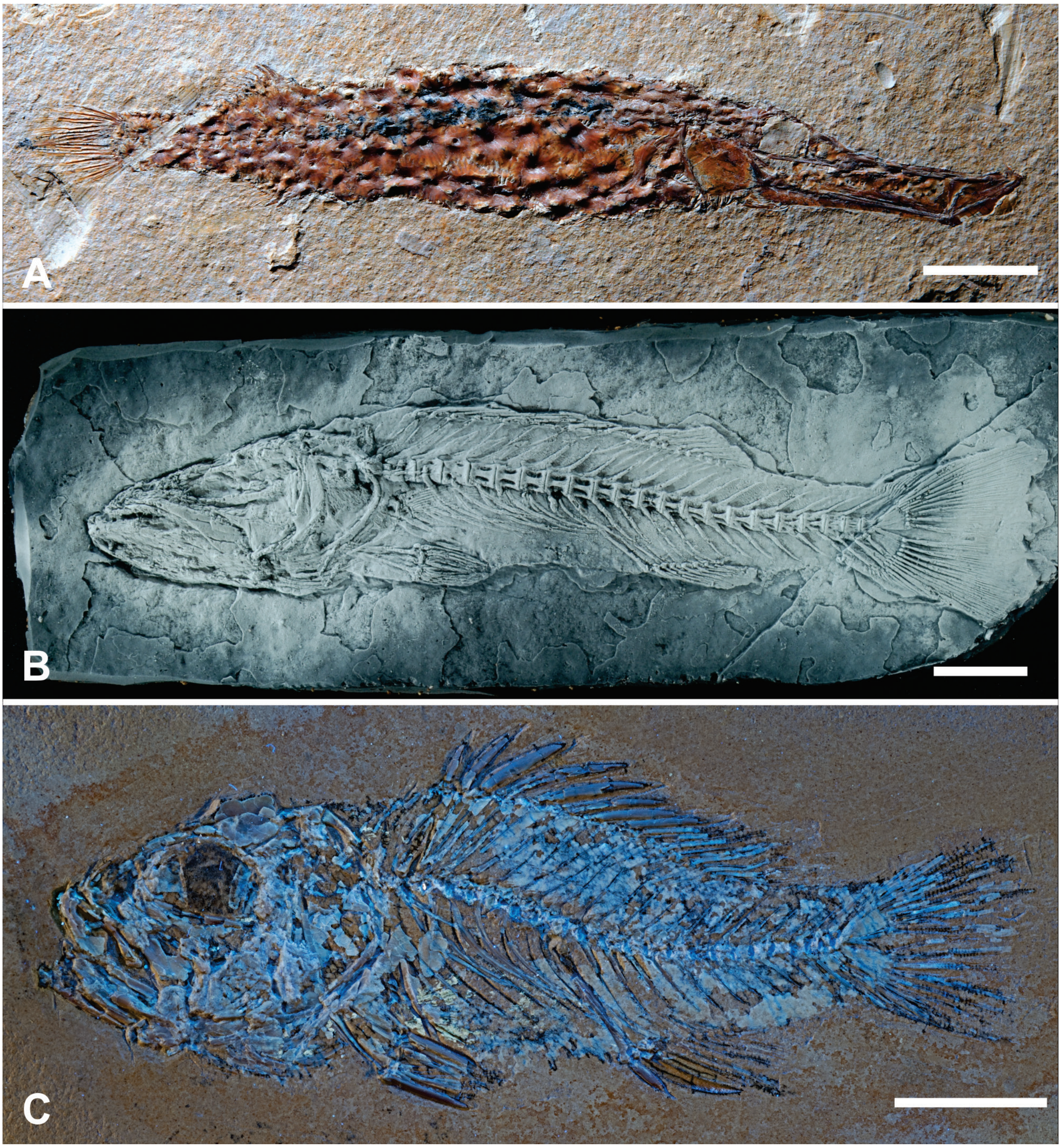

Figure 4. Paleocene fossil fishes found in marine outcrops of Chiapas housed in CNP-UNAM **A.** †*Eekaulostomus cuevasae* Cantalice & Alvarado-Ortega, 2016; **B.** †*Kelemejtubus castroi* Cantalice & Alvarado-Ortega, 2017; **C.** †*Paleoserranus lakamhae* Cantalice, Alvarado-Ortega & Alaniz-Galvan, 2018. Scale bars: 10 mm.

When included in a phylogenetic context, some species housed in CNP-UNAM offer valuable details that help understanding the morphological and ecological changes that occurred in some groups of fishes through time. One example is the aulostomoid †*Eekaulostomus cuevasae* (Fig. 4A), which is considered the stem group of Recent flutemouth fishes and reveals that reduction of body scutes size and enlargement of the snout, trunk, and fin rays are evolutionary trends of aulostomoids (Cantalice and Alvarado-Ortega 2017). These morphological modifications are possibly related to improvements in predation in extant species (Cantalice and Alvarado-Ortega 2017). Moreover, including CNP-UNAM species in phylogenetic analyses also provide support to solve some incongruences on fish classification, such as †*Quetzalichthys* and †*Teoichthys* (Fig. 5), two genera collected in Tlayúa quarry (Puebla), which when included in the phylogeny of the order Ionoscopiformes proved the monophyly of the families Ophiopsidae and Ionoscopidae (Alvarado-Ortega and Espinosa-Arrubarrena 2008).

Mexico has been in the tropical region since the Jurassic, the period of the oldest fossil fish records report-

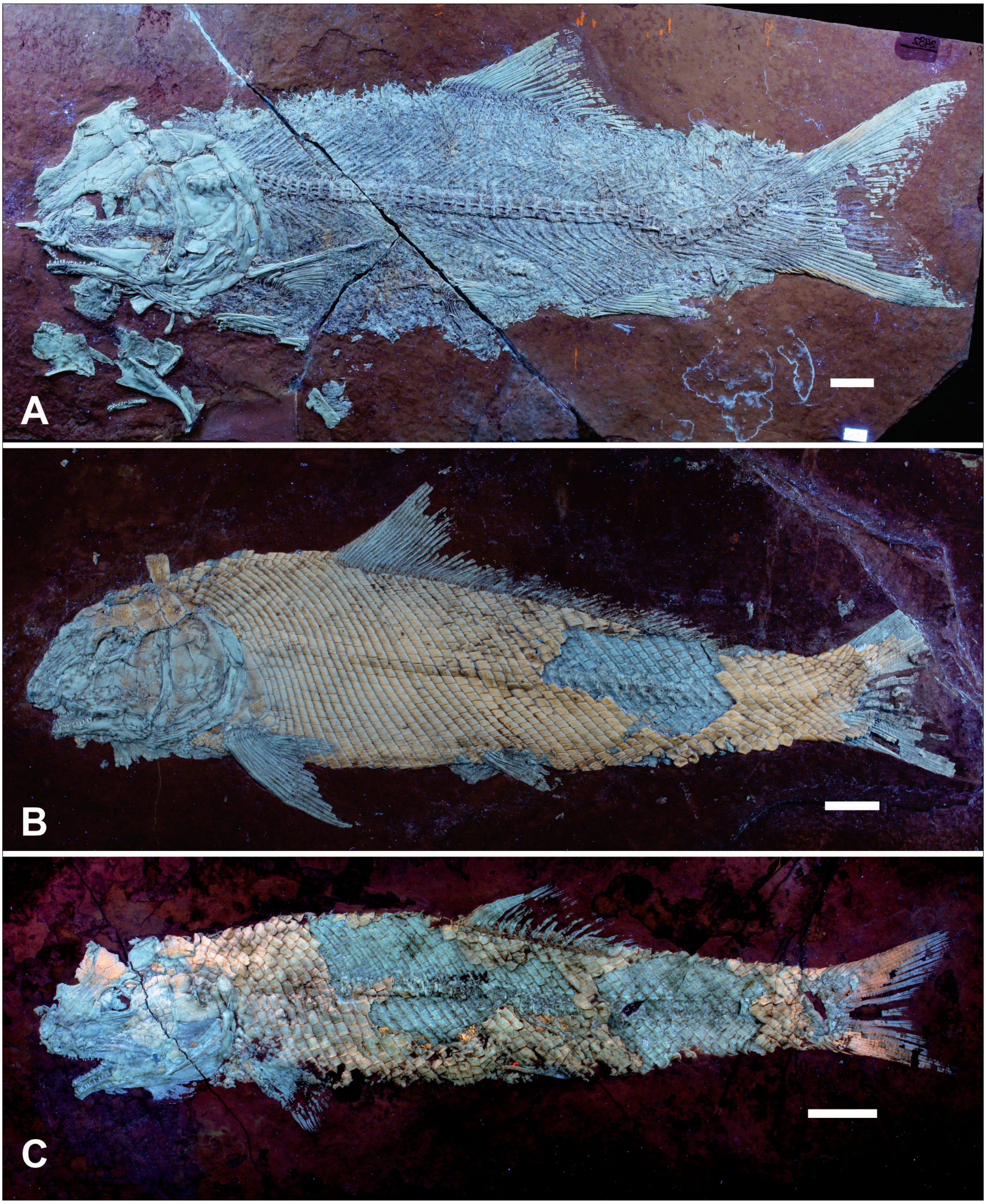

Figure 5. Cretaceous fossil fishes from Tlaúa quarry, Puebla, housed in CNP-UNAM **A.** †*Quetzalichthys perrilliatae* Alvarado-Ortega & Espinosa-Arrubarrena, 2008; **B.** †*Teoichthys kallistos* Applegate, 1988; **C.** †*Teoichthys brevipina* Machado, Alvarado-Ortega, Machado & Brito, 2013. Scale bar: 10 mm.

ed at CNP to date (Scotese 2014). The 150 million years since the Jurassic to present day could explain the diversification of several groups of fishes and the richness of possible Mexican endemic fauna (Table 1). Therefore, the continual collection and increases in knowledge of the paleoichthyofauna housed at CNP is fundamental to understand the patterns of fish diversity through the geological ages and highlights the Mexican fossil records as essential to understanding biogeographic patterns and current global fish diversity.

Conclusions

After 25 years since the last vertebrate catalogue (Perrilliat 1993), we present the first fossil fish catalogue of the species housed in the type collection of the Colección Nacional de Paleontología of Universidad Nacional Autónoma de México (CNP-UNAM). The increase of knowledge of fossil fish diversity, as its biological and biogeographical implications, are evidence that maintaining a proper collection of the Mexican fossil record is necessary for understanding the complex evolutionary history of fishes. The knowledge of the Mexican paleoichthyofauna is emerging. The formal description of many specimens housed in the geographic reference section is still necessary and increasing with periodic fieldwork. Palaeoichthyology is a promising research area in Mexican paleontology.

Acknowledgements

Our sincere thanks to J. Alvarado-Ortega, the curator of CNP-UNAM. We give thanks to all researchers and members of the Instituto de Geología that helped add to the number of specimens in the CNP-UNAM type collection over time. We also thank D. Ruiz-Ramoni for the help with preparing the map, L.P. Crivano Machado, G.R. de Paula Machado, and J. Miguel Contreras for the photographs, R. Forsyth, L. Cavin, M.R. de Britto, M.E. Bichuette, N. Yonow, and P. Pankov for the review of the manuscript, and to R.O. Roney for his English revision of the manuscript. This research is supported by DGA-PA-PAPIIT project IN209017, UNAM. K.M. Cantalice was supported by the DGAPA postdoctoral fellowship; A. Martínez-Melo was supported by the EPE-CONACYT postdoctoral fellowship.

References

Agassiz L (1832) Untersuchungen über die fossilen Fische aus der Lias-Formation. Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefaktenkunde 3: 139–149.

Agassiz JLR (1833–1843) Recherches sur les poisons fossils, tome II, contenat l'histoire de l'ordre des ganoïdes. Neuchâtel, Swiss, 336 pp. https://doi.org/10.5962/bhl.title.4275

Agassiz JLR (1833–1843) Recherches sur les poisons fossils, tome iii, contenant l'histoire de l'ordre des placoïdes. Neuchâtel, Swiss, 390 pp. https://doi.org/10.5962/bhl.title.4275

Agassiz L (1850) Lake Superior: Its physical character, vegetation, and animals, compared with those of other and similar regions. Gould, Kendall and Lincoln, Boston, 428 pp. https://doi.org/10.5962/bhl.title.1827

Aguirre-Díaz, GJ, Aguillón-Robles A, Tristán-González M, Labarthe-Hernández G, López-Martínez M, Bellón H, Nieto-Obregón J (2013) Geological setting of the Peña de Bernal Natural Monument, Querétaro, México: an endogenous volcanic dome. Geosphere 9(3): 557–571. https://doi.org/10.1130/GES00843.1

Alencáster G (1973) Una nueva especie de *Toucasia* en el Cretácico medio de los estados de Oaxaca y Puebla. Paleontología Mexicana 36: 4–20. http://www.ojs-igl.unam.mx/index.php/Paleontologia/article/view/57/37

Allison RC (1967) The Cenozoic stratigraphy of Chiapas, Mexico, with discussions of the classification of the Turritellidae and selected Mexican representatives. PhD thesis, University of California, Berkley, California.

Allmon WD (1994) The value of natural history collections. Curator 37(2): 83–89. https://doi.org/10.1111/j.2151-6952.1994.tb01011.x

Allmon WD (2005) The importance of museum collections in paleobiology. Paleobiology 31(1): 1–5. https://doi.org/10.1666/0094-8373(2005)031<0001:TIOMCI>2.0.CO;2

Alvarado-Ortega J (2004) Description and relationships of a new ichthyodectiform fish from the Tlayúa Formation (Early Cretaceous: Albian), Puebla, Mexico. Journal of Vertebrate Paleontology 24(4): 802–813. https://doi.org/10.1671/0272-4634(2004)024[0802:DAROAN]2.0.CO;2

Alvarado-Ortega J (2014) Ancient herring from the Tlayúa Quarry (Cretaceous, Albian) near Tepexi de Rodríguez, Puebla State, central Mexico, closing the gap in the early diversification of Clupeomorpha. Cretaceous Research 50: 171–186. https://doi.org/10.1016/j.cretres.2014.02.022

Alvarado-Ortega J, Brito PM (2016) A Jurassic pleuropholid fish (Teleostei, Pleuropholidae) in the Tethys Sea domain of North America. Journal of Vertebrate Paleontology 36(5): e1201767. https://doi.org/10.1080/02724634.2016.1201767

Alvarado-Ortega J, Espinosa-Arrubarrena L (2008) A new genus of ionoscopiform fish (Halecomorphi) from the Lower Cretaceous (Albian) lithographic limestones of the Tlayúa quarry, Puebla, México. Journal of Paleontology 82(1): 163–175. https://doi.org/10.1666/04-152.1

Alvarado-Ortega J, Melgarejo-Damián MP (2017) *Paraclupea seilacheri* sp. nov., a double armored herring (Clupeomorpha, Ellimmichthyiformes) from the Albian limestones of Tlayúa quarry, Puebla, Mexico. Revista Mexicana de Ciencias Geológicas 34(3): 234–249. https://doi.org/10.22201/cgeo.20072902e.2017.3.528

Alvarado-Ortega J, Carranza-Castaneda O, Alvarez-Reyes G (2006) A new fossil species of *Ictiobus* (Teleostei: Catostomidae) from Pliocene lacustrine sediments near Tula de Allende, Hidalgo, Mexico. Journal of Paleontology 80(5): 993–1008. https://doi.org/10.1666/0022-3360(2006)80[993:ANFSOI]2.0.CO;2

Alvarado-Ortega J, De Mayrinck D, Brito PM (2008) A basal pachyrhizodontid fish (Actinopterygii, Teleostei) from the Lower Cretaceous of the Tlayúa quarry, central Mexico. Comptes Rendus Palevol 7(5): 269–275. https://doi.org/10.1016/j.crpv.2008.03.006

Alvarado-Ortega J, Barrientos-Lara JI, Espinosa-Arrubarrena L, Melgarejo-Damián MP (2014) Late Jurassic marine vertebrates from Tlaxiaco, Oaxaca state, southern Mexico. Palaeontologia Electronica 17(1): 24A, 1–25. https://doi.org/10.26879/454

Alvarado-Ortega J, Espinosa-Arrubarrena L, Blanco A, Vega FJ, Benammi M, Briggs DE (2007) Exceptional preservation of soft tissues in Cretaceous fishes from the Tlayúa Quarry, central Mexico. Palaios 22(6): 682–685. https://doi.org/10.2110/palo.2006.p06-059r

Alvarado-Ortega J, Cuevas-García M, Melgarejo-Damián MP, Cantalice KM, Alaniz-Galvan A, Solano-Templos G, Than-Marchese BA (2015) Paleocene fishes from Palenque, Chiapas, southeastern Mexico. Palaeontologia Electronica 18(2): 39A, 1–22. https://doi.org/10.26879/536

Álvarez J, Arriola-Longoria J (1972) Primer goodeido fósil procedente del Plioceno jalisciense (Pisces: Teleostomi). Boletín de la Sociedad de Ciencias Naturales de Jalisco 6: 6–15.

Applegate SP (1978) Phyletic studies; part I; tiger shark. Universidad Nacional Autónoma de México, Instituto de Geología, Revista 2(1): 55–64. https://dialnet.unirioja.es/descarga/articulo/281998.pdf

Applegate SP (1987) A preliminary study of the Tlayúa Quarry near Tepexi de Rodríguez, Puebla. Revista de la Sociedad Mexicana de Paleontología 1: 40–54.

Applegate SP (1988) A new genus and species of a holostean belonging to the family Ophiopsidae, *Teoichthys kallistos*, from the Cretaceous, near Tepexi de Rodríguez, Puebla. Revista Mexicana de Ciencias Geológicas 7(2): 200–205. https://dialnet.unirioja.es/descarga/articulo/2231766.pdf

Applegate SP (1992) A new genus and species of pycnodont from the Cretaceous (Albian) of central Mexico, Tepexi de Rodríguez, Puebla. Revista Mexicana de Ciencias Geológicas 10(2): 164–178. https://dialnet.unirioja.es/descarga/articulo/281893.pdf

Applegate SP, Buitrón-Sánchez BE, Solís-Marin FA (1996) Seven new taxa of holothurians (Holothuroidea: Echinodermata) from the Lower Cretaceous (Albian) Tlayúa quarries, near Tepexi de Rodriguez, Puebla, Mexico. The Paleontological Society Special Publication 8: 1–10. https://doi.org/10.1017/S2475262200000125

Applegate SP, Espinosa-Arrubarrena L (1981) The geology and selachian paleontology of Loma del Tirabuzón (Corkscrew Hill) Santa Rosalía, B.C.S. In: Ortlieb L, Roldán J (Eds) Geology of northwestern Mexico and Arizona. Hermosillo, México. Universidad Nacional Autónoma de México, Estación Regional del Noroeste, Hermosillo: 257–263.

Arambourg C, Bertini L (1958) Super-ordre des holostéens et des Halecostomi (Holostei et Halecostomi). In: Grassé PP (Ed.) Traité de Zoologie: Anatomie, systématique, biologie, 13. Masson et Cie, Paris, 2173–2203.

Arratia G (1999) The monophyly of Teleostei and stem-group teleosts. Consensus and disagreements. In: Arratia G, Schultze HP (Eds) Mesozoic fishes 2–systematics and fossil record. Verlag Dr. F. Pfeil, München, 265–334. http://www.pfeil-verlag.de/wp-content/uploads/2015/05/2_48d15.pdf

Bardack D, Sprinkle G (1969) Morphology and relationships of saurocephalid fishes. Fieldiana, Geology 16: 297–340. https://doi.org/10.5962/bhl.title.5210

Barnes LG (1998) The sequence of fossil marine mammal assemblages in México Instituto de Investigaciones en Ciencias de la Tierra, Universidad Autonoma del Estado de Hildalgo, Publicación Especial 1: 26–79.

Barrientos-Lara JI, Fernández MS, Alvarado-Ortega J (2015) Kimmeridgian pliosaurids (Sauropterygia, Plesiosauria) from Tlaxiaco, Oaxaca, southern Mexico. Revista Mexicana de Ciencias Geológicas 32(2): 293–304. http://hdl.handle.net/11336/9068

Bartram AWH (1975) The holostean fish genus *Ophiopsis* Agassiz. Zoological Journal of the Linnean Society 56(3): 183–205. https://doi.org/10.1111/j.1096-3642.1975.tb00263.x

Beraldi-Campesi HB, Cevallos-Ferriz SRS, Centeno-García E, Arenas-Abad C, Fernández LP (2006) Sedimentology and paleontology of an Eocene-Oligocene alluvial-lacustrine arid system, southern Mexico. Sedimentary Geology 191(3–4): 227–254. https://doi.org/10.1016/j.sedgeo.2006.03.018

Berg LS (1937) A classification of fish-like vertebrates. Bulletin de l'Académie des Sciences de l'URSS 4: 1277–1280.

Berg LS (1940) Classification of fishes both Recent and fossil. Travaux de l'Institut Zoologique de l'Académie des Sciences de l'URSS 5(2): 1277–1280. http://krishikosh.egranth.ac.in/bitstream/1/15662/1/77269.pdf

Berg LS (1958) System der rezenten und fossilen Fischartigen und Fische. Deutscher Verlag Wissenschaft, Berlin, 310 pp.

Berra T (2007). Freshwater fish distribution, second edition. The University of Chicago Press, Chicago and London, 606 pp.

Betancur-R R, Wiley EO, Bailly N, Miya M, Lecointre G, Ortí G (2014) Phylogenetic classification of bony fishes – version 3. http://www.deepfin.org/Classification_v3.htm

Betancur-R R, Wiley EO, Arratia G, Acero A, Bailly N, Miya M, Lecointre G, Ortí G (2017) Phylogenetic classification of bony fishes. BMC Evolutionary Biology 17: 162. http://doi.org/10.1186/s12862-017-0958-3

Betancur-R R, Broughton RE, Wiley EO, Carpenter K, López JA, Li C, Holcroft NI, Arcila D, Sanciangco M, Cureton II JC, Zhang F, Buser T, Campbell MA, Ballesteros JA, Roa-Varon A, Willis S, Borden WC, Rowley T, Reneau PC, Hough DJ, Lu G, Grande T, Arratia G, Ortí G (2013) The tree of life and a new classification of bony fishes. PLOS Currents Tree of Life: 1–49. https://doi.org/10.1371/currents.tol.53ba26640df0ccaee75bb165c8c26288

Bleeker P (1858) Zevende bijdrage tot de kennis der visch fauna van Sumatra. Visschen van Palembang. Acta Societatis Regiae Scientiarum Indo-Neêrlandicae 5: 1–12. https://doi.org/10.5962/bhl.title.144153

Bleeker P (1859) Tiental vischsoorten van de Kokos-eilanden, verzameld door Dr. A. J. Anderson. Natuurkundig Tijdschrift voor Nederlandsch Indië 20: 142–143. https://biodiversitylibrary.org/page/13420753

Bleeker P (1862) Atlas ichthyologique des Indes Orientales Néêrlandaises, publiésous les auspices du Gouvernement colonial nérlandais, tome I. Scaro'des et Labro'des. F. Muller, Amsterdam, 48 pp.

Bonaparte CL (1831) Saggio di una distribuzione metodica degli animali vertebrati. Rome, 144 pp. https://doi.org/10.5962/bhl.title.48624

Bonaparte CL (1832) Iconografia della fauna Italica: per le quattro classi degli animali vertebrati, Tome III, pesci, fasciolo 1, puntata 1–6. Dalla Tipografia Salviucci, Rome. https://doi.org/10.5962/bhl.title.70395

Bonaparte CL (1835) Iconografia della fauna Italica: per le quattro classi degli animali vertebrati, tome III, pesci, fasciolo 12–14, puntata 59–79. Dalla Tipografia Salviucci, Rome. https://doi.org/10.5962/bhl.title.70395

Bonaparte CL (1838) Iconografia della fauna Italica: per le quattro classi degli animali vertebrati, tome III, pesci, fasciolo 22–23, puntata 104, 110–120. Dalla Tipografia Salviucci, Rome. https://doi.org/10.5962/bhl.title.70395

Bravo-Cuevas VM, González-Rodríguez KA, Esquivel-Macías C, Fielitz C (2009) Advances on stratigraphy and paleontology of the Muhi Quarry from the Mid-Cretaceous (Albian-Cenomanian) of Hidalgo, central Mexico. Boletín de la Sociedad Geológica Mexicana 61(2): 155–165. https://doi.org/10.18268/BSGM2009v61n2a2

Brito PM, Alvarado-Ortega J (2013) *Cipactlichthys scutatus*, gen. nov., sp. nov. a new halecomorph (Neopterygii, Holostei) from the Lower Cretaceous Tlayúa Formation of Mexico. PLoS ONE 8 (9): e73551. https://doi.org/10.1371/journal.pone.0073551

Brito PM, Alvarado-Ortega J, Meunier FJ (2017) Earliest known lepisosteoid extends the range of anatomically modern gars to the Late Jurassic. Scientific Reports 7(1): 17830 pp. https://doi.org/10.1038/s41598-017-17984-w

Brito PM, Villalobos-Segura E, Alvarado-Ortega J (2019) A new early cretaceous guitarfish (Chondrichthyes, Batoidea) from the Tlayúa Formation, Puebla, Mexico. Journal of South American Earth Sciences 90: 155–161. https://doi.org/10.1016/j.jsames.2018.12.005

Brookes J (1828) A catalogue of the Anatomical & Zoological Museum of Joshua Brookes, Esq., F.R.S. F.L.S. &c. Richard Taylor, London, 124 pp. https://archive.org/details/b22475886/page/n0

Bryan K (1948) Los suelos complejos y fósiles de la altiplanicie de México, en relación a los cambios climáticos. Boletín de la Sociedad Mexicana 13: 1–20. https://doi.org/10.18268/BSGM1948v13n1a1

Bryant LJ (1987) A new genus and species of Amiidae (Holostei; Osteichthyes) from the Late Cretaceous of North America, with comments on the phylogeny of the Amiidae. Journal of Vertebrate Paleontology 7(4): 349–361. https://doi.org/10.1080/02724634.1988.10011669

Buitrón BE (1970) Equinoideos del jurásico superior y del Cretácico inferior de Tlaxiaco, Oaxaca. In: Segura LR, Rodríguez-Torres R (Eds) Excursión México-Oaxaca, Libro-Guía. Sociedad Geológica Mexicana, México, 153–163.

Buitrón-Sánchez BE, Durán-González A, Martín-Cao-Romero C, Solís-Marín FA, Laguarda-Figueras A. (2015) Lower Cretaceous (Albian) Asteroidea (Echinodermata) from Tepexi de Rodríguez, Puebla, Mexico. Revista de Biología Tropical 63(2): 7–15. https://doi.org/10.15517/rbt.v63i2.23124

Cabral-Perdomo MA (1995) Los Icnofósiles de Vertebrados Terrestres del Terciario Tardío del área de Tepexi de Rodríguez, Estado de Puebla. Bachelor thesis, Universidad Nacional Autónoma de México, Ciudad de México, México.

Cabral-Perdomo MA (2013) Icnofósiles de vertebrados terrestres del Cenozoico Tardío en el área de “Pie de Vaca”, Tepexi de Rodríguez, Estado de Puebla. Paleontología Mexicana 3: 51–58. http://www.ojs-igl.unam.mx/index.php/Paleontologia/article/download/176/111

Cabral-Perdomo MA, Applegate SP (1994) Pterosaurs from the Tlayúa Quarries near Tepexi de Rodríguez, central México and its palaeoecological significance. Journal of Vertebrate Paleontology 14(3): 19A.

Cabral-Perdomo MA, Bravo-Cuevas VM, Pérez-Pérez A, García-Cabrera N (2018) Descripción de las huellas de camélidos y félidos de la localidad Pie de Vaca, Cenozoico Tardío de Puebla, centro de México y algunas consideraciones paleobiológicas. Boletín de la Sociedad Geológica Mexicana 70(2): 397–416. https://doi.org/10.18268/BSGM2018v70n2a9

Cantalice KM, Alvarado-Ortega J (2016) *Eekaulostomus cuevasae* gen. and sp. nov., an ancient armored trumpetfish (Aulostomoidea) from Danian (Paleocene) marine deposits of Belisario Domínguez, Chiapas, southeastern Mexico. Palaeontologia Electronica 18(3): 1–24. https://doi.org/10.26879/682

Cantalice KM, Alvarado-Ortega J (2017) *Kelemejtubus castroi*, gen. et sp. nov., an ancient percomorph (Teleostei, Actinopterygii) from the Paleocene marine deposits near Palenque, Chiapas, southeastern Mexico. Journal of Vertebrate Paleontology 37(6): e1383265. https://doi.org/10.1080/02724634.2017.1383265

Cantalice KM, Alvarado-Ortega J, Alaniz-Galvan A (2018a) *Paleoserranus lakamhae* gen. et sp. nov., a Paleocene seabass (Perciformes: Serranidae) from Palenque, Chiapas, southeastern Mexico. Journal of South American Earth Sciences 83: 137–146. https://doi.org/10.1016/j.jsames.2018.01.010

Cantalice KM, Alvarado-Ortega J, Brito P (2018b) On the occurrence of *Vinctifer ferrusquiai* sp. nov. (Actinopterygii, Aspidorhynchiformes) in the Kimmeridgian (Late Jurassic) deposits near Tlaxiaco, Oaxaca, southern Mexico. Revista Mexicana de Ciencias Geológicas 35(2): 179–187. https://doi.org/10.22201/cgeo.20072902e.2018.2.713

Cantalice KM, Alvarado-Ortega J (in press) The first record of a freshwater percomorph fish on the Miocene of Ixtapa, Chiapas, southeastern Mexico. Boletín de la Sociedad Geológica Mexicana.

Cantú-Chapa A (1987) Las Amonitas del Albiano Superior de Tepexi de Rodríguez, Puebla. Revista de la Sociedad Mexicana de Paleontología 1(1): 159–160.

Carranza-Castañeda O, Applegate SP (1994) Primer registro de peces picnodóntidos en el Estado de Hidalgo. Revista de Investigación de la Universidad Autónoma Del Estado de Hidalgo 1(1): 56.

Carreño AL (1981) Ostrácodos y Foraminíferos planctónicos de la Loma del Tirabuzón, Santa Rosalía, Baja California Sur e implicaciones bioestratigráficas y paleoecológicas. Revista del Instituto de Geología 5(1): 55–64. https://dialnet.unirioja.es/descarga/articulo/2231640.pdf

Carreño AL (1992) Neogene microfossils from the Santiago Diatomite, Baja California Sur, Mexico. Paleontología Mexicana 59(1): 1–37. http://ojs-igl.unam.mx/index.php/Paleontologia/article/viewFile/186/117

Carreño AL, Montellano-Ballesteros M (2005) La paleontología mexicana. Boletín de la Sociedad Geológica Mexicana 57(2): 137–147. https://doi.org/10.18268/BSGM2005v57n2a2

Carreño AL, Smith JT (2007) Stratigraphy and correlation for the ancient Gulf of California and Baja California Peninsula, Mexico. Bulletins of American Paleontology 371: 1–146.

Carrillo-Martínez M (1981) Contribución al estudio geológico del macizo calcáreo El Doctor, Querétaro. Revista del Instituto de Geología 5(1): 25–29. https://dialnet.unirioja.es/descarga/articulo/2231633.pdf

Castillo-Cerón J, Cabral-Perdomo MA, Carranza-Castañeda O (1996) Vertebrados fósiles del estado de Hidalgo. Universidad Autónoma del Estado de Hidalgo, Hidalgo, 127 pp.

Cavin L, Longbottom A, Richter M (2008) Fishes and the break-up of Pangaea. Special Publication 295. The Geological Society, London, 372 pp. https://doi.org/10.1144/SP295.2

Cervantes-Medel A, Armienta MA (2004) Influence of fault in gonground water quality in Valle del Mezquital, Mexico. Geofísica Internacional 43(3): 477–493. http://www.geofisica.unam.mx/iframes/editorial/publicaciones/investigacion/geofisica_internacional/anteriores/2004/03/Cervantes.pdf

Chalifa Y, Tchernov E (1982) *Pachyamia latimaxillaris*, new genus and species (Actinopterygii: Amiidae), from the Cenomanian of Jerusalem. Journal of Vertebrate Paleontology 2(3): 269–285. https://doi.org/10.1080/02724634.1982.10011935

Chang M, Chou C (1974) [Late Mesozoic fossil fishes from Province Chekiang]. Vertebrata PalAsiatica 12(3): 183–186. [In Chinese] http://www.ivpp.cas.cn/cbw/gjzdwxb/xbwzxz/200905/W020090813377540535384.pdf

Cifuentes-Ruiz P, VrŠanský P, Vega FJ, Cevallos-Ferriz SRS, González-Soriano E, Delgado de Jesús CR (2006) Terrestrial arthropods from the Cerro del Pueblo Formation (Campanian, Late Cretaceous), Difunta group, northeastern Mexico. Geologica Carpathica 57: 347–354. http://www.geologicacarpathica.com/browse-journal/volumes/57-5/article-367/#

Clarke J, Friedman M (2018) Body-shape diversity in Triassic-Early Cretaceous neopterygian fishes: Sustained holostean disparity and predominantly gradual increases in teleost phenotypic variety. Paleobiology 44(3): 402–433. https://doi.org/10.1017/pab.2018.8

Compagno LJV (1973) Interrelationships of living elasmobranchs. In: Greenwood P, Miles R, Patterson C (Eds) Interrelationships of fishes. Academic Press, New York, 15–61.

Compagno LJV (1977) Phyletic relationships of living sharks and rays. American Zoologist 17: 303–322. https://doi.org/10.1093/icb/17.2.303

Cope ED (1871) Contribution to the ichthyology of the Lesser Antilles. Transactions of the American Philosophical Society 14(3): 445–483. https://doi.org/10.2307/1005256

Cope ED (1872) Observations on the systematics of the fishes. The American Naturalist 5(8): 579–593. https://doi.org/10.1086/270831

Cristín A, Perrilliat MC (2011) Las colecciones científicas y la protección del patrimonio paleontológico. Boletín de la Sociedad Geológica Mexicana 63(3): 421–427. https://doi.org/10.18268/BSGM2011v63n3a4

Crook AR (1892) Uber einige fossile Knochen fischeaus dermittleren Kreide von Kansas. Palaeontographica 39: 107–124.

Cuvier G (1812) Sur un nouveau rapprochement à établir entre les classes qui composent le règne animal. Annales du Muséum d´Histoire Naturelle 19: 73–84.

Cuvier G (1816) Le Règne animal distribué d'après son organisation, pour servir de base à l'histoire naturelle des animaux et d'introduction à l'anatomie comparée, tome 2, contenant les reptiles, les poissons, les mollusques et les annelides. Deterville, Paris, 532 pp. https://doi.org/10.5962/bhl.title.41460

Daily FK, Durham W (1966) Miocene charophytes from Ixtapa, Chiapas, Mexico. Journal of Paleontology 40(5): 1191–1199. https://www.jstor.org/stable/1301993?seq=1#metadata_info_tab_contents

Dyer BS, Chernoff B (1996) Phylogenetic relationships among atheriniform fishes (Teleostei: Atherinomorpha). Zoological Journal of the Linnean Society 117(1): 1–69. https://doi.org/10.1006/zjls.1996.9999

Eberth DA, Delgado de Jesús CR, Lerbekmo JF, Brinkman DB, Rodríguez-De la Rosa RA, Sampson SD (2004) Cerro del Pueblo Fm (Difunta group, Upper Cretaceous), Parras Basin, southern Coahuila, Mexico: reference sections, age and correlation. Revista Mexicana de Ciencias Geológicas 21(3): 335–352. http://www.redalyc.org/service/redalyc/downloadPdf/572/57221303/1

Egerton PMG (1858) British fossils. Plate VII. *Pleuropholis*. Memoirs of the Geological Survey of the United Kingdom, Figures and Descriptions Illustrative of British Organic Remains Decade IX: 1–7.

Espinosa-Arrubarrena L, Applegate SP (1996) A possible model for the paleoecology of the vertebrate bearing beds in the Tlayúa quarries, near Tepexi de Rodríguez, Puebla, México. In: Arratia G, Viohl G (Eds) Mesozoic fishes-systematics and paleoecology. Verlag Dr. F. Pfeil, München, 539–550.

Espinosa-Arrubarrena L, Applegate SP, González-Rodríguez K (1996) The first Mexican record of a coelacanth (Osteichthyes: Sarcopterygii) from the Tlayúa Quarry near Tepexi de Rodriguez, Puebla, with a discussion on the importance of this fossil. Sixth North American Paleontological Convention. Washington (EUA), June 1996. Abstracts of papers: Special Publications (Paleontological Society) 8: 116. https://doi.org/10.1017/S2475262200001180

Feldmann RM, Vega FJ, Applegate SP, Bishop GA (1998) Early Cretaceous arthropods from the Tlayúa Formation at Tepexi de Rodríguez, Puebla, Mexico. Journal of Paleontology 72(1): 79–90. https://doi.org/10.1017/S0022336000024033

Feldmann RM, Vega FJ, Martínez-López L, González-Rodríguez KA, González-León O, Fernández-Barajas MR (2007) Crustacea from the Muhi Quarry (Albian-Cenomanian) and a review of aptian Mecochiridae (Astacidea) from Mexico. Annals of Carnegie Museum 76(3): 145–156. https://doi.org/10.2992/0097-4463(2007)76[145:CFTMQA]2.0.CO;2

Felix J (1891) Versteinerungenaus der mexicanischen Jura- und Kreide-Formation. Palaeontographica 37: 140–194.

Ferrusquía-Villafranca I (1996) Contribución al conocimiento geológico de Chiapas-El área de Ixtapa-Soyaló. Boletín del Instituto de Geología 109: 1–130.

Ferrusquía-Villafranca I, Applegate SP, Espinosa-Arrubarrena L (1999) First Paleogene selachifauna of the Middle American-Caribbean-Antillean region, La Mesa de Copoya, west-central Chiapas: systematics and paleontological significance. Revista Mexicana de Ciencias Geológicas 16(2): 155–174. https://dialnet.unirioja.es/descarga/articulo/281130.pdf

Ferrusquía-Villafranca I, Lundelius El, Ruíz-González JE (2017) Pleistocene radiometric geochronology and vertebrate paleontology in Mexico: overview and critical appraisal. Natural History Museum of Los Angeles County Contributions to Science 525: 1–23. https://nhm.org/site/sites/default/files/pdf/contrib_science/lacc-525.1.-Ferrusqui-Villafranca-et-al.pdf

Fierstine HL, Applegate SP, González-Barba G, Schwennicke T, Espinosa-Arrubarrena L (2001) A fossil blue marlin (*Makaira nigricans* Lacepede) from the middle facies of the Trinidad Formation (upper Miocene to upper Pliocene), San José del Cabo Basin, Baja California Sur, Mexico. Bulletin of the Southern California Academy of Sciences 100(2): 59–73. https://pdfs.semanticscholar.org/8b1e/70dddd550a844be374f9d63c65a78f2e1cfb.pdf

Fink SV, Fink, WL (1981) Interrelationships of the ostariophysan fishes (Teleostei). Zoological Journal of the Linnean Society 72(4): 297–353. https://doi.org/10.1111/j.1096-3642.1981.tb01575.x

Forey PL (1977) The Osteology of *Notelops*, Woodward, *Rhacopelis* Agassiz and *Pachyrhizodus* Dixon (Pisces: Teleostei). Bulletin of the British Museum (Natural History) 28(2): 197–201.

Fourcade E, Piccioni L, Escribá J, Rosselo E (1999) Cretaceous stratigraphy and paleoenvironments of the Southern Petén Basin, Guatemala. Cretaceous Research 20(6): 793–811. https://doi.org/10.1006/cres.1999.0184

Fricke R, Eschmeyer WN, Van der Laan R (2019) Eschmeyer's catalog of fishes: genera, species, references. http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp [Electronic version accessed 12 mar 2019]

Gill AC, Mooi RD (2002) Phylogeny and systematics of fishes. In: Hart PJB, Reynolds JD (Eds) Handbook of fish biology and fisheries, volume 1: fish biology. Blackwell Publishing, Oxford, 15–42. https://doi.org/10.1002/9780470693803.ch2

Gill T (1862) Analytical synopsis of the order of Squali; and revision of the nomenclature of the genera. Annals of the New York Academy of Sciences 7(1): 367–408. https://doi.org/10.1111/j.1749-6632.1862.tb00166.x

Glikman LS (1964) Sharks of the Paleogene and their stratigraphic significance. NaukaPress, Moscow, 229 pp.

González-Rodríguez K, Reynoso VH (2004) A new *Notagogus* (Macrosemiidae, Halecostomi) species from the Albian Tlayúa Quarry, Central Mexico. In: Arratia G, Tintori A (Eds) Mesozoic fishes 3–systematics, paleoenvironments and biodiversity. Verlag Dr. Friedrich Pfeil, München, Germany, 265–278. https://www.pfeil-verlag.de/wp-content/uploads/2015/05/3_53d15.pdf

González-Rodríguez K, Applegate SP, Espinosa-Arrubarrena L (2004) A New World Macrosemiidae (Neopterygii: Halecostomi) genus in the Albian of Tepexi de Rodríguez, Puebla, Central Mexico. Journal of Vertebrate Paleontology 24(2): 281–289. https://doi.org/10.1671/1862

González-Rodríguez K, Espinosa-Arrubarrena L, González-Barba G (2013) An overview of the Mexican fossil fish record. In: Arratia G, Schultze HP, Wilson MVH (Eds) Mesozoic fishes 5–global diversity and evolution. Verlag Dr. Friedrich Pfeil, München, Germany, 9–34. http://www.pfeil-verlag.de/wp-content/uploads/2015/05/4_59d01.pdf

Goodrich ES (1909) A treatise on zoology. Part IX, Vertebrata Craniata (first fascicle: cyclostomes and fishes). Adam & Charles Black, London, 518 pp. https://doi.org/10.5962/bhl.title.13773

Grande L (1982) A revision of the fossil genus †*Diplomystus*, with comments on the interrelationships of clupeomorphs fishes. American Museum Novitates 2728: 1–34. http://hdl.handle.net/2246/5342

Grande L, Bemis WE (1998) A comprehensive phylogenetic study of amiid fishes (Amiidae) based on comparative skeletal anatomy. An empirical search for interconnected patterns of natural history. Journal of Vertebrate Paleontology 18(S1): 1–696. https://doi.org/10.1080/02724634.1998.10011114

Gray JE (1867) Notes on the skull of hares (Leporidae) and picas (Lagomyidae) in the British Museum. Annals and Magazine of Natural History 20(3): 219–225. https://doi.org/10.1080/00222936708694118

Greenwood PH, Rosen DE, Weitzman SH, Myers GS (1966) Phyletic studies of teleostean fishes, with a provisional classification of living forms. Bulletin of the American Museum of Natural History 131(4): 339–456. http://hdl.handle.net/2246/1678

Guzmán AF (2015) El registro fósil de los peces mexicanos de agua dulce. Revista Mexicana de Biodiversidad 86(3): 661–673. https://doi.org/10.1016/j.rmb.2015.05.003

Hasse JCF (1878) Das natürliche System des Elasmobranchier auf Grundlage des Baues und der Entwickelung des Wirbelsäule. Zoologischer Anzeiger 1(7–8): 144–148, 167–172. https://biodiversitylibrary.org/page/30123346

Hay OP (1902) Bibliography and catalogue of the fossil vertebrata of North America. Government Printing Office, Washington, 868 pp. https://doi.org/10.5962/bhl.title.20094

Hay OP (1929) Second bibliography and catalogue of the fossil Vertebrata of North America. Carnegie Institute of Washington, Washington, 2003 pp. https://archive.org/details/secondbibliograp008803mbp/page/n7

Helfman GS, Collette BB, Facey DE (1997) The diversity of fishes. Blackwell Science, Massachusetts, 528 pp.

Hernández-Junquera A (1977) Fauna local Laguna de la Media Luna, Pleistoceno Tardío, Municipio de Río Verde, San Luis Potosí, México. Bachelor thesis, Universidad Nacional Autónoma de México, Mexico City, Mexico.

Hernández-Villalva DV, Calvillo-Canadell L, Cevallos-Ferriz SR (2013) Inferencia del paleoclima de la Formación miocénica en Ixtapa Chiapas, utilizando la fisionomía foliar de los fósiles. Paleontología Mexicana 63, 2(1): 48–65. http://www.ojs-igl.unam.mx/index.php/Paleontologia/article/view/157/99

Huxley TH (1880) On the application of the laws of evolution to the arrangement of the Vertebrata and more particularly of the Mammalia. Proceedings of the Zoological Society of London 1880: 649–662.

Imamura H, Yabe M (2002) Demise of the Scorpaeniformes (Actinopterygii: Percomorpha): an alternative phylogenetic hypothesis. Bulletin of Fisheries Sciences, Hokkaido University 53(3): 107–128. https://eprints.lib.hokudai.ac.jp/dspace/bitstream/2115/21975/1/53%283%29_P107-128.pdf

Imlay RW (1936) Evolution of the Coahuila Peninsula, Mexico: part IV, geology of the western part of the Sierra de Parras. Geological Society of America Bulletin 47: 1091–1152. https://doi.org/10.1130/GSAB-47-1039

Islas-Tenorio JJ, Ramírez-García MG, Moreno-Ruiz JP, Gómez Ávilez J (2004) Carta Geológica-Minera, Villahermosa, E15-8, Escala 1:250,000, Estados de Tabasco, Chiapas y Oaxaca. Informe 272004ISTJ0001. Consejo de Recursos Minerales, 77 pp. https://mapserver.sgm.gob.mx/InformesTecnicos/CartografiaWeb/T272004ISTJ0001_01.PDF

Islas-Tenorio JJ, Sáenz-Pita MR, Cureño-Suriano R (2005) Carta Geológico-Minera Tenosique E15-9, escala 1:250,000, Estados de Chiapas, Tabasco y Campeche. Informe 072005ISTJ0001. Consejo de Recursos Minerales, 58 pp. https://mapserver.sgm.gob.mx/InformesTecnicos/CartografiaWeb/T072005ISTJ0001_01.PDF

Jordan DS (1919) New genera of fossil fishes from Brazil. Proceedings of the Academy of Natural Sciences, Philadelphia 71(3): 208–210. https://www.jstor.org/stable/pdf/4063814.pdf

Jordan DS (1923) A classification of fishes including families and genera as far as known. Stanford University Publications, University Series, Biological Sciences 3(2): 77–243.

Jordan DS, Gilbert CH (1883) Notes on a collection of fishes from Charleston, South Carolina, with descriptions of three new species. Proceedings of the United States National Museum 5(328): 580–620. https://doi.org/10.5479/si.00963801.5-328.580

Jordan DS, Evermann BW (1896) A check-list of the fishes and fish-like vertebrates of North and Middle America. United States Commission of Fish and Fisheries, Report of the Commissioner 21(5): 207–584.

Kashiyama Y, Fastovsky DE, Rutherford S, King J, Montellano-Ballesteros M (2004) Genesis of a locality of exceptional fossil preservation: paleoenvironments of Tepexi de Rodríguez (mid-Cretaceous, Puebla, Mexico). Cretaceous Research 25: 153–177. https://doi.org/10.1016/j.cretres.2003.11.002

Kirkland J, Hernández-Rivera R, Aguillón-Martínez C, Delgado de Jesús C, Gómez-Núñez R, Vallejo I (2000) The Late Cretaceous Difunta group of the Parras Basin, Coahuila, Mexico, and its vertebrate fauna. Guide book of the field trips, Society of Vertebrate Paleontology, Mexico 131–172.

Kornfield I, Smith PF (2000) African cichlid fishes: model systems for evolutionary biology. Annual Review of Ecology and Systematics 31(1): 163–196. https://doi.org/10.1146/annurev.ecolsys.31.1.163

Lacépède BGE (1802) Histoire naturelle des poissons, tome quatrième. Plassan, Paris, 728 pp. https://doi.org/10.5962/bhl.title.6882

Langenheim RL, Frost SH (1963) Upper Tertiary continental sediments at Ixtapa, Chiapas, Mexico—preliminary notice. Geological Society of America, Special Paper 76: 209–210.

Lehman JP (1966) Actinopterygii. In: Piveteau J (Ed.) Traité de paléontologie, 4 (3): actinoptérygiens, dipneustes, crossoptérygiens. Paris Masson et cie, Paris, 242 pp.

Leidy J (1873) Notice of remains of fishes in the Bridger Tertiary Formation of Wyoming. Proceedings of the Academy of Natural Sciences of Philadelphia 25: 97–99.

Leriche M (1902) Les poissons paléocènes de la Belgique. Mémoires du Musée Royal d'Histoire Naturelle de Belgique 2(5): 1–48. http://

biblio.naturalsciences.be/rbins-publications/memoires/bibliographic_references/tome-2/0265c4f-art1.pdf

Leske NG (1778) Additamenta ad Iacobi Theodori Klein naturalem dispositionem echinodermatum et lucubratiunculam de aculeis echinorum marinorum. Lipsiae, Ex Officina Gleditschiana, 278 pp. https://doi.org/10.5962/bhl.title.11571

Li B, Dettaï A, Cruaud C, Couloux A, Desoutter-Meniger M, Lecointre G (2009) RNF213, a new nuclear marker for acanthomorph phylogeny. Molecular Phylogenetics and Evolution 50(2): 345–363. https://doi.org/10.1016/j.ympev.2008.11.013

Licari GR (1960) Geology and amber deposits of the Simojovel area, Chiapas, Mexico. Master thesis, University of California-Berkeley, Berkeley.

Linnaeus C (1758) Systema Naturae: systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Holmiae, Sweden, 824 pp. https://doi.org/10.5962/bhl.title.542

Llorente-Bousquets J, Luna-Vega I, Mainero JS, Tapia LB (1994) Biodiversidad, su inventario y conservación: teoría y práctica en la taxonomía alfa contemporánea. In: Llorente-Bousquets J, Luna-Vega I (Eds) Taxonomía biológica. Ediciones Científicas Universitarias, Mexico City, 507–522.

López-Arbarello A, Alvarado-Ortega J (2011) New semionotiform (Neopterygii) from the Tlayúa Quarry (Early Cretaceous, Albian), Mexico. Zootaxa 2749(1): 1–24. https://doi.org/10.11646/zootaxa.2749.1.1

López-Arbarello A (2012) Phylogenetic interrelationships of ginglymodian fishes (Actinopterygii: Neopterygii). PLoS ONE 7(7): e39370. https://doi.org/10.1371/journal.pone.0039370

López-Arbarello A, Sferco E (2011) New semionotiform (Actinopterygii: Neopterygii) from the Late Jurassic of southern Germany. Journal of Systematic Palaeontology 9(2): 197–215. https://doi.org/10.1080/14772019.2010.493751

López-Ticha D (1985) Revisión de la estratigrafía y potencial petrolero de la Cuenca de Tlaxiaco, México. Boletín de la Asociación Mexicana de Geólogos Petroleros 37(1): 49–92.

Lord CE (1922) A list of the fishes of Tasmania. Papers & Proceedings of the Royal Society of Tasmania: 60–73. https://doi.org/10.5962/bhl.part.7021

Machado GP, Alvarado-Ortega J, Machado LP, Brito PM (2013) *Teoichthys brevipina*, sp. nov., a new ophiopsid fish (Halecomorphi, Ionoscopiformes) from the Lower Cretaceous Tlayúa Formation, Central Mexico. Journal of Vertebrate Paleontology 33(2): 482–487. https://doi.org/10.1080/02724634.2013.729962

Maisey JG (1975) The interrelationships of phalacanthous selachians. Neues Jahrbuchfür Geologie und Paläontologie 9: 563–567.

Martínez-Amador H, Rosendo-Brito B, Fitz-Bravo C, Tinajera-Fuentes E, Beltrán-Castillo HD (2004) Carta Geológico-Minera Tuxtla Gutiérrez E15-11, escala 1:250,000. Estados de Chiapas y Oaxaca. Informe 072004MAAH0001. Consejo de Recursos Minerales, 106 pp. https://mapserver.sgm.gob.mx/InformesTecnicos/CartografiaWeb/T072004MAAH0001_01.pdf

Martínez-Gutiérrez G, Sethi PS (1997) Miocene-Pleistocene sediments within the San José del Cabo Basin, Baja California Sur, Mexico. In: Johnson ME, Ledesma-Vázquez J (Eds) Pliocene carbonates and related facies flanking the Gulf of California, Baja California, Mexico. Geological Society of America Special Paper 318: 141–166. https://doi.org/10.1130/0-8137-2318-3.141

Martínez-Hernández E (1992) Caracterización ambiental del Terciário de la región de Ixtapa, estado de Chiapas-un enfoque palinoestratigráfico. Revista del Instituto de Geología 10(1): 54–64.

Martínez-Hernández E, Ramírez-Arriaga E (1999) Palinoestratigrafía de la región de Tepexi de Rodríguez, Puebla, México – implicaciones cronoestratigráficas. Revista Mexicana de Ciencias Geológicas 16: 187–207. https://www.uv.mx/personal/tcarmona/files/2010/08/Martinez-y-Ramirez-1999.pdf

McBride EF, Weidie AE, Wolleben JA, Laudon RC (1974) Stratigraphy and structures of the Parras and La Popa basins, northeastern Mexico. Geological Society of America Bulletin 85: 1603–1622. https://doi.org/10.1130/0016-7606(1974)85<1603:SASOTP>2.0.CO;2

McCloy C (1984) Stratigraphy and depositional history of the San José del Cabo Trough, Baja California Sur, Mexico. In: Frizzell VA Jr (Ed.) Geology of the Baja California peninsula. Pacific Section of the Society of Economic Paleontologists and Mineralogists, Los Angeles, 267–273.

Meneses-Rocha JJ, Monroy-Audelo MA, Gómez-Chavarría JC (1994) Bosquejo paleogeográfico y tectónico del sur de México durante el Mesozoico, México. Boletín de la Asociación Mexicana de Geólogos Petroleros 44(2): 18–45.

Müller J (1845) Über den Bau und die Grenzen der Ganoiden und über das natürlichen System der Fische. Physikalisch-Mathematische Abhandlungen der königlichen Akademie der Wissenschaftenzu Berlin 1844: 117–216.

Müller J, Henle FGJ (1837) Über die Gattungen der Haifische und Rochennacheiner. mit Hrn. Henle unternommenen gemeinschaftlichen Arbeit über die Naturgeschichte der Knorpelfische. Berichtüber die zur Bekanntmachung geeignetenVerhandlungen der Königlichen Preussischen Akademie der Wissenschaftenzu Berlin 1837: 111–118.

Müller J, Henle FGJ (1839) Systematische Beschreibung der Plagiostomen. Verlag von Veit und Company, Berlin, 200 pp. https://doi.org/10.5962/bhl.title.6906

Murray GE, Weidie Jr. AE, Boyd DR, Forde RH, Lewis Jr. PD (1962) Formational divisions of the difunta group, Parras basin, Coahuila and Nuevo León, México. The American Association of Petroleum Geologists Bulletin 46(3): 374–383. https://doi.org/10.1306/BC743829-16BE-11D7-8645000102C1865D

Nelson GJ (1968) Gill arches of teleostean fishes of the division Osteoglossomorpha. Zoological Journal of the Linnean Society 47(312): 261–277. https://doi.org/10.1111/j.1096-3642.1968.tb00511.x

Nelson GJ (1969) Infraorbital bones and their bearing on the phylogeny and geography of osteoglossomorph fishes. American Museum Novitates 2394: 1–37. http://hdl.handle.net/2246/2604

Nelson JS, Grande TC, Wilson MV (2016) Fishes of the world. John Wiley & Sons, New Jersey, 715 pp. https://doi.org/10.1002/9781119174844

Nursall JR (1996) The phylogeny of the pycnodont fishes. In: Arratia G, Viohl G (Eds) Mesozoic fishes-systematics and paleoecology. Verlag Dr. F. Pfeil, München, 125–152.

Ortlieb L, Colleta B (1984) Síntesis cronoestratigráfica sobre el Neógeno y el Cuaternario marino de la Cuenca de Santa Rosalía, Baja California Sur, México. In: Malpica-Cruz V, Celis-Gutiérrez S, Guerrero-García J, Ortlieb L (Eds) Neotectonics and sea level variations in the Gulf of California area, a Symposium. Universidad Nacional Autónoma de México, Hermosillo, 241–268. http://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_5/b_fdi_12-13/15453.pdf

Osborn HF (1923) New subfamily, generic, and specific stages in the evolution of the Proboscidea. American Museum Novitates 99: 1–4. http://hdl.handle.net/2246/3264

Owen R (1846) Lectures on the comparative anatomy and physiology of the vertebrate animals delivered at the Royal College of Surgeons of England 1844 and 1846. Part I. Fishes. Longman, Brown, Green and Longmans, London, 308 pp. https://doi.org/10.5962/bhl.title.13539

Owen R (1860) Palaeontology, or, a systematic summary of extinct animals and their geological relations. A. and C. Black, Edinburgh, 494 pp. https://doi.org/10.5962/bhl.title.153670

Pantoja-Alor J (1992) Geología y Paleoambiente de la Cantera Tlayúa, Tepexi de Rodríguez, estado de Puebla. Revista del Instituto de Geología 9(2): 156–169. http://satori.geociencias.unam.mx/9-2/(4)Pantoja.pdf

Pantoja-Alor J, Carrillo-Bravo J (1966) Bosquejo geológico de la región de Santiago-San José del Cabo, Baja California. Boletín de la Asociación Mexicana de Geólogos Petroleros 18(1–2): 1–12.

Patterson C, Rosen, DE (1977) Review of ichthyodectiform and other Mesozoic teleost fishes, and the theory and practice of classifying fossils. Bulletin of the American Museum of Natural History 158(2): 81–172. http://hdl.handle.net/2246/1224

Peňáz M (2001) A general framework of fish ontogeny: a review of the ongoing debate. Folia Zoologica 50(4): 241–256.

Perrilliat MC (1993) Catálogo de ejemplares tipo de vertebrados fósiles en la Colección Paleontológica del Instituto de Geología, UNAM, México. Paleontología Mexicana 61: 1–52. http://www.ojs-igl.unam.mx/index.php/Paleontologia/article/view/88/57

Perrilliat MC, Applegate SP, Espinosa-Arrubarrena L (1986) Organización y funcionamiento de las colecciones paleontológicas del Museo de Geología del Instituto de Geología de la UNAM. Revista Mexicana de Ciencias Geológicas 6(2): 272. https://dialnet.unirioja.es/descarga/articulo/2231724.pdf

Perrilliat MC, Avendaño J, Vega FJ (2003) Middle Eocene cypraeoideans from the San Juan Formation, Chiapas, southern Mexico. Revista Mexicana de Ciencias Geológicas 20(1): 41–51. http://www.redalyc.org/html/572/57220104/

Perrilliat MC, Castañeda-Posadas C (2013) Catálogo de plantas fósiles en la Colección Nacional de Paleontología del Instituto de Geología, UNAM, México. Boletín del Instituto de Geología 119: 1–109. http://www.geologia.unam.mx:8080/igl/publs/boletin/bol119.pdf

Quezada-Muñetón JM (1987) El Cretácico Medio-Superior, y el límite Cretácico Superior-Terciario inferior en la Sierra de Chiapas. Boletín de la Asociación Mexicana de Geólogos Petroleros 39(1): 1–98.

Quiroz-Barroso S, Perrilliat MC (1989) Pectínidos del Plioceno del área de Santa Rosalía, Baja California Sur. Paleontología Mexicana 53: 1–79. http://www.ojs-igl.unam.mx/index.php/Paleontologia/article/view/80/51

Rafinesque CS (1810) Caratteri di alcuni nuovi generi e nuove specie di animali e piante della Sicilia, con varie osservazioni sopra i medesim. Sanfilippo, Palermo, 105 pp. https://doi.org/10.5962/bhl.title.104418

Rafinesque CS (1815) Analyse de la nature, ou tableau de l'univers et des corps organisés. L'Imprimerie de Jean Barravecchia, Palermo, 224 pp. https://doi.org/10.5962/bhl.title.106607

Rafinesque CS (1820) Ichthyologia Ohiensis: or, natural history of the fishes inhabiting the river Ohio and its tributary streams, preceded by a physical description of the Ohio and its branches. Lexicon, Kentucky, 90 pp. https://doi.org/10.5962/bhl.title.6892

Ramírez JL, Cevallos-Ferriz SRS (2002) A diverse assemblage of Anacardiaceae from Oligocene sediments, Tepexi de Rodríguez, Puebla, Mexico. American Journal of Botany 89(3): 535–545. https://doi.org/10.3732/ajb.89.3.535

Rees J, Underwood CJ (2008) Hybodont sharks of the English Bathonian and Callovian (Middle Jurassic). Palaeontology 51(1): 117–147. http://doi.org/10.1111/j.1475-4983.2007.00737.x

Regan CT (1908) A revision of the sharks of the family Orectolobidae. Proceedings of the Zoological Society 1908: 347–364. https://biodiversitylibrary.org/page/31209892

Regan CT (1909) The classification of teleostean fishes. Proceedings of the Zoological Society 47(8): 75–86. https://doi.org/10.1080/00222931108693067

Regan CT (1923) The skeleton of *Lepidosteus*, with remarks on the origin and evolution of the lower neopterygian fishes. Journal of Zoology 93(2): 445–461. https://doi.org/10.1111/j.1096-3642.1923.tb02191.x

Reynoso VH (1997) A "beaded" sphenodontian (Diapsida: Lepidodauria) from the Early Cretaceous of central Mexico. Journal of Vertebrate Paleontology 17(1): 52–59. https://doi.org/10.1080/02724634.1997.10010953

Reynoso VH (2000) An unusual aquatic sphenodontian (Reptilia: Diapsida) from the Tlayúa Formation (Albian), central Mexico. Journal of Paleontology 74(1): 133–148. https://doi.org/10.1666/0022-3360(2000)074<0133:AUASRD>2.0.CO;2

Rodríguez-De la Rosa RA, Cevallos-Ferriz SR (1998) Vertebrates of the El Pelillal locality (Campanian, Cerro del Pueblo Formation), southeastern Coahuila, Mexico. Journal of Vertebrate Paleontology 18(4): 751–764. https://doi.org/10.1080/02724634.1998.10011104

Rojas-Zúñiga A, Gio-Argáez FR (2016) Museos Comunitarios de México y la Paleontología. Estudio de caso: formación San Juan Raya, Puebla, México. Boletín de la Real Sociedad Española de Historia Natural. Sección aula, museos y colecciones 3: 21–32.

Rosen DE (1973) Interrelationships of higher euteleostean fishes. In: Greenwood PH, Miles RS, Patterson C (Eds) Interrelationships of fishes. Academic Press, London, 397–513.

Rosen DE, Patterson C (1969) The structure and relationships of the paracanthopterygian fishes. Bulletin of the American Museum of Natural History 141(3): 357–474. http://hdl.handle.net/2246/1996

Rosen DE, Greenwood PH (1970) Origin of the Weberian apparatus and the relationships of the ostariophysan and gonorynchiform fishes. American Museum Novitates 2428: 1–26. http://hdl.handle.net/2246/2638

Rüppell WPES (1837) Neue Wirbelthiere zu der Fauna von Abyssinien gehörig. Fische des Rothen Meeres. Siegmund Schmerber, Frankfurt am Main, 148 pp. https://doi.org/10.5962/bhl.title.53778

Saint-Seine P (1949) Les Poissons des calcaires lithographiques de Cerin (Ain). Société Anonyme de l'Impresion A. Rey, Lyon, 357 pp.

Sanciangco MD, Carpenter KE, Betancur-R. R (2016) Phylogenetic placement of enigmatic percomorph families (Teleostei: Percomorphaceae). Molecular Phylogenetics and Evolution 94(part B): 565–576. https://doi.org/10.1016/j.ympev.2015.10.006

Schwennicke T, Santisteban-Mendívil DM, Pérez-Venzor JA, Cortés-Martínez MY, Plata-Hernández E (2017) Evolución estratigráfica de la cuenca Los Barriles, Baja California Sur, México. Revista Mexicana de Ciencias Geológicas 34(3): 212–233. https://doi.org/10.22201/cgeo.20072902e.2017.3.476

Scotese CR (2014) Atlas of Jurassic paleogeographic maps, PALEOMAP atlas for ArcGIS. Volume 4. The Jurassic and Triassic, Maps 32–42, Mollweide Projection, PALEOMAP Project, Evanston, IL.

Segerstrom K (1961) Geologic investigation in Mexico: Geology of the Bernal-Jalpan area Estado de Querétaro, Mexico. United States Government Printing Office, Washington, 85 pp. https://pubs.usgs.gov/bul/1104b/report.pdf

Segerstrom K (1962) Geologic investigation in Mexico: Geology of south-central Hidalgo and northeastern México, Mexico. United States Government Printing Office, Washington, 162 pp. https://pubs.usgs.gov/bul/1104c/report.pdf

Seibertz E, Buitrón BE (1987) Paleontología y estratigrafía de los *Neohibolites* del Albiano de Tepexi de Rodríguez, Estado de Puebla (Cretácico Medio; México). Revista de la Sociedad Mexicana de Paleontología 1(1): 285–299.

Shroat-Lewis RA (2007) Taphonomy of a Pliocene ophiuroid mass mortality Lagerstätte in the Tirabuzón Formation, Baja California Sur. Master thesis, University of North Carolina, North Carolina. https://libres.uncg.edu/ir/uncw/f/shroat-lewisr2007-1.pdf

Smith A (1838) On the necessity for a revision of the groups included in the Linnean genus *Squalus*. Proceedings of the Zoological Society of London 5(57): 85–86.

Smith GR (1992) Phylogeny and biogeography of the Catostomidae, freshwater fishes of North America and Asia. In: Mayden RL (Ed.) Systematics and Historical Ecology of North American Freshwater Fishes. Stanford University Press, California, 778–826.

Suarez AV, Tsutsui ND (2004) The value of museum collections for research and society. BioScience 54(1): 66–74. https://doi.org/10.1641/0006-3568(2004)054[0066:TVOMCF]2.0.CO;2

Suter M, López-Martínez M, Quintero-Legorreta O (2001) Quaternary intra-arc extensión in the central Trans-Mexican volcanic belt. Geological Society of America Bulletin 113(6): 693–703. https://doi.org/10.1130/0016-7606(2001)113<0693:QIAEIT>2.0.CO;2

Swainson W (1839) The natural history of fishes, amphibians, and reptiles, or monocardian animals, volume 2. Longman, Orme, Brown, Green, Longmans, and Taylor, London, 368 pp. https://doi.org/10.5962/bhl.title.62140

Taverne L (1989) Crossognathus Pictet, 1858 du Crétacé inférieur de l'Europe et systématique, paléozoogéographie et biologie des Crossognathiformes nov. ord. (Téléostéens) du Crétacé et du Tertiaire. Palaeontographica Abteilung A, 79–105.

Thiollière V (1858) Note sur les poisons fossiles du Bugey, et sur l'application de la méthode de Cuvier à leur classement. Bulletin de la Société Géologique de France 2(15): 782–793.

Vega FJ, Cosma T, Coutiño MA, Feldmann RM, Nyborg TG, Schweitzer CE, Waugh DA (2001) New Middle Eocene decapods (Crustacea) from Chiapas, Mexico. Journal of Paleontology 75(5): 929–946. https://doi.org/10.1017/S002233600003986X

Van der Laan R (2018) Family-group names of fossil fishes. European Journal of Taxonomy 466: 1–167. https://doi.org/10.5852/ejt.2018.466

Vinson GL (1962) Upper Cretaceous and tertiary stratigraphy of Guatemala. AAPG Bulletin 46(4): 425–456. https://doi.org/10.1306/BC743835-16BE-11D7-8645000102C1865D

Wagner JA (1860) Vergleichung der weltlichen Fauna des lithographischen Schiefer von Kermit den gleichnamigen Ablagerungenimfränkischen Jura. Gelehrten Anzeiger der königlichbayerischen Akademie der Wissenschaften 48(51): 390–412.

Wainwright PC, Smith WL, Price SA, Tang KL, Sparks JS, Ferry LA, Kuhn LK, Eytan RI, Near TJ (2012) The evolution of pharyngognathy: a phylogenetic and functional appraisal of the pharyngeal jaw key innovation in labroid fishes and beyond. Systematic Biology 61(6): 1001–1027. https://doi.org/10.1093/sysbio/sys060

Wiley EO, Johnson GD (2010) A teleost classification based on monophyletic groups. In: Nelson JS, Schultze HP, Wilson MVH (Eds) Origin and phylogenetic interrelationships of teleosts. Verlag Dr. Friedrich Pfeil, München, 123–182. https://repository.si.edu/handle/10088/9786

Wilson BW, Hernández JP, Meave E (1955) Un banco calizo del Cretácico en la parte oriental del estado de Querétaro, México. Boletín de la Sociedad Geológica Mexicana 18(1): 1–10. https://doi.org/10.18268/BSGM1955v18n1a1

Wilson IE (1948) Buried topography, initial structures and sedimentation in Santa Rosalía Area, Baja California, Mexico. American Association of Petroleum Geologists 32(9): 1762–1807. https://doi.org/10.1306/3D933C20-16B1-11D7-8645000102C1865D

Woodward AS (1890) The fossil fishes of the Hawkesbury series at Gosford, New South Wales. Annals and Magazine of Natural History 35(6): 423–424. https://doi.org/10.1080/00222939008694061

Woodward AS (1891) Catalogue of fossil fishes in the British Museum (Natural History), part II, containing the Elasmobranchi (Acanthodi), Holocephali, Ichthyodorulites, Ostracodermi, Dipnioi, and Teleostomi (Crossopterygii and Chondrostean Actinopterygii). Order of the Trustees, London, 567 pp. https://doi.org/10.5962/bhl.title.61854

Zhu M, Yu X (2002) A primitive fish close to the common ancestor of tetrapods and lungfish. Nature 418: 767–770. https://doi.org/10.1038/nature00871

Zittel KA (1879) Studien uber fossile Spongien, III. Monactinellidae, Tetractinellidae und Calcispongiae. Abhandlungen der Königlich Bayerischen Akademie der Wissenschaften. Mathematisch-naturwissen-schaftliche Klasse 13(2): 91–138.

Supplementary material 1

Supplementary Information

Authors: Kleyton Magno Cantalice, Alejandra Martínez-Melo, Violeta Amparo Romero-Mayén

Data type: locality data

Explanation note: Table with essential information about the distinct geological localities containing fishes catalogued in the CNP-UNAM.

Link: https://doi.org/10.3897/zse.95.35435.suppl1