

# A TEMNOSPONDYL HANDPRINT FROM THE UPPER PALEOZOIC OF THE MATZITZI FORMATION, MEXICO

## UNA HUELLA DE TEMNOSPÓNDILO DEL PALEOZOICO SUPERIOR DE LA FORMACIÓN MATZITZI, MÉXICO

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**Resumen.**— Se reporta el molde natural de una huella de la mano izquierda de un temnospondilo indeterminado hallada en un afloramiento de la Formación Matzitzi (Pérmico superior) al noroeste del Estado de Oaxaca, México. Esta huella representa el primer registro de temnospondilos para el país y el registro más austral de este grupo en Norte América; además, este es el registro más antiguo conocido de un tetrápodo en México.

**Palabras clave.**— Amphibia, huella fósil, Pérmico, Temnospondyli, Tetrapoda.

**Abstract.**— We report a natural cast of the left manus of an indeterminate temnospondyl, found in an outcrop of the Matzitzi Formation (Upper Permian) in the northwestern region of the State of Oaxaca, Mexico. This ichnite is the first record of temnospondyls for the country, as well as the southernmost record of this group in North America; additionally, this is the oldest known record of a tetrapod in Mexico.

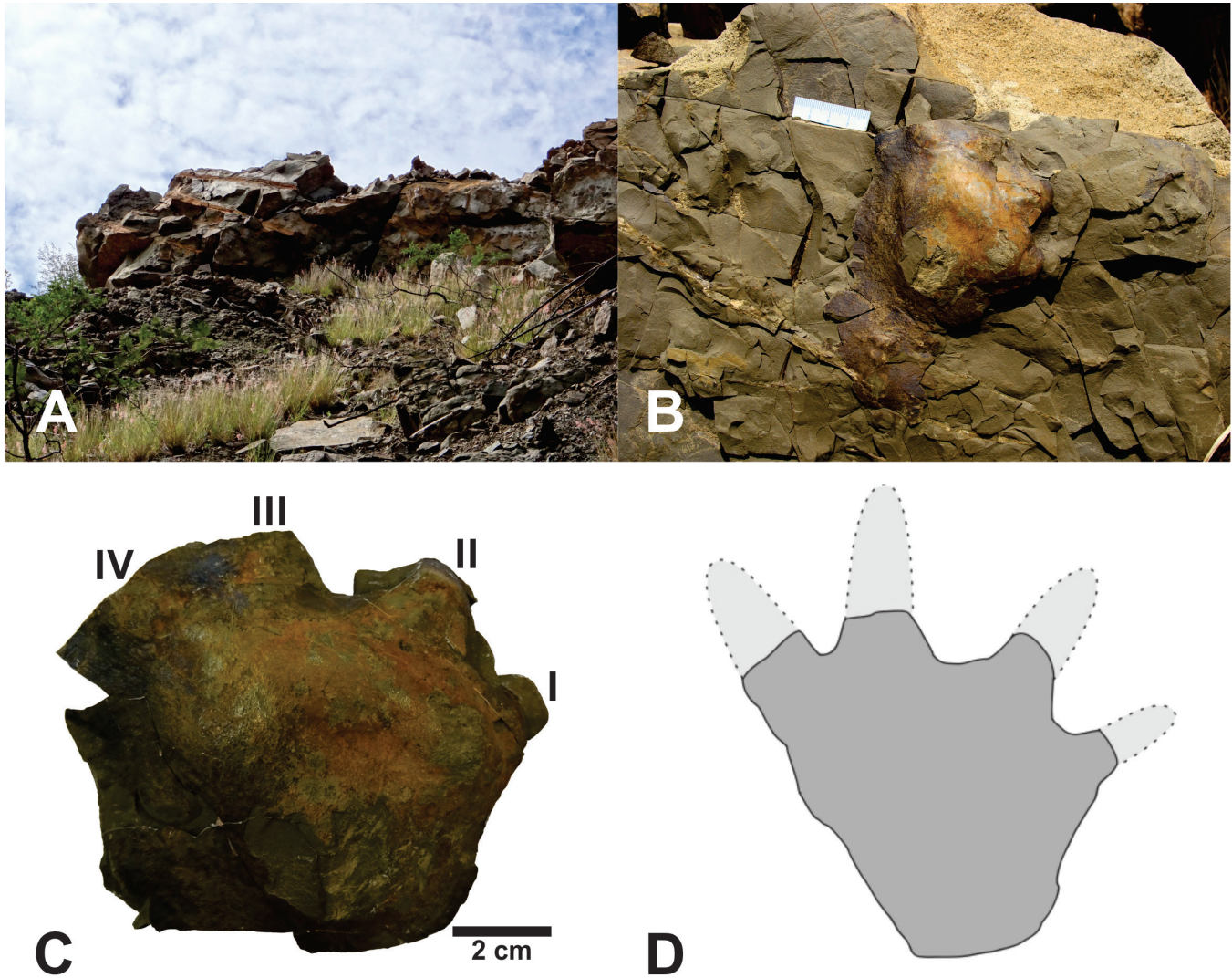
**Key words.**— Amphibia, fossil track, Permian, Temnospondyli, Tetrapoda.

For over a hundred years the Matzitzi Formation has been fundamental for the study of the Paleozoic of Mexico. The first description of the Matzitzi Formation comes from the work of the geologist José G. Aguilera who described, in the contribution “Bosquejo geológico de México”, a new geological formation for the southeast region of Puebla State, close to the Tehuacán Valley. Aguilera (1896) named the new geological formation as “Matzitzi” and suggested a possible Early Jurassic age. He also pointed out that the formation extended throughout several towns such as San Francisco Xochiltepec, Los Reyes Metzontla, Caltepec, San Luis Atolotitlán and Coatepec. Several years later, Wieland (1914) recognized that the Matzitzi Formation was very rich in fossil plants; however, it was many decades until Silva-Pineda (1970) began a detailed study of the paleofloristic diversity of the zone.

In her work, Silva-Pineda (1970) discarded the Early Jurassic age proposed by Aguilera (1896), and mentioned that the age of the Matzitzi Formation was likely Pennsylvanian (Upper Carboniferous), based on the fossil plants that she recognized.

On the other hand, many new studies on the geology, stratigraphy and the paleofloristic diversity of the Matzitzi Formation have been carried out recently, considerably improving our knowledge about this important geological unit (e.g. Centeno-García et al., 2009; Flores-Barragan, 2019; Velasco-de León et al., 2020; Villanueva-Amadoz et al., 2020; Flores-Barragan & Velasco-de León, 2021; Bedoya et al., 2021; Flores-Barragan et al., 2021; Martini et al., 2021).

Regarding the paleodiversity of the Matzitzi Formation, new studies have extensively documented its fossil flora, providing several records that include the orders Equisetales, Gigantopteridales, Glossopteridales, Lepidodendrales, Marattiales, Osmundales, Peltaspermales and Voltziales. They suggest an Upper Permian age and a sub-humid environment for this formation (Velasco-de León et al., 2020; Flores-Barragan & Velasco-de León, 2021; Flores-Barragan et al., 2021). Although the plant diversity of the Matzitzi Formation is vast, no remains of vertebrate or invertebrate fauna have been found



**Figura 1.** A) Corte de carretera cerca del kilómetro 89 de la carretera Cuacnopalan-Oaxaca en el municipio de Tepelmeme Villa de Morelos, Oaxaca, en donde se encontró la huella; B) Matriz de roca con el molde natural como fue hallado a un costado del camino; C) Molde de la huella (CFZMt-312) como se encuentra preservado en la Colección de Paleontología de la Facultad de Estudios Superiores Zaragoza; D) Reconstrucción de la vista de la palma de la mano izquierda del temnospondilo indeterminado de la Formación Matzitzi; el área gris representa al espécimen CFZMt-312, mientras que las líneas punteadas son una interpretación de los dedos faltantes.

**Figure 1.** A) Cut slope near the kilometer 89 of the Cuacnopalan-Oaxaca highway in the Municipality of Tepelmeme Villa de Morelos, Oaxaca, where the handprint was found; B) Rock matrix with the natural cast as it was found aside the road; C) Handprint cast (CFZMt-312) as it is preserved at the Colección de Paleontología of the Facultad de Estudios Superiores Zaragoza; D) Reconstruction of the palmar view of the left manus of the indeterminate temnospondyl from the Matzitzi Formation; the grey area represents the specimen CFZMt-312, while the dotted lines are an interpretation of the missing fingers.

until now. Here, we report a fossil ichnite of an early tetrapod which represents the first record of an animal for the Matzitzi Formation.

On May 6th, 2013, during a fieldtrip to Santiago Yosondúa, we stopped along the road between the limits of Puebla and Oaxaca states near kilometer 89 of the Cuacnopalan-Oaxaca highway

in the Municipality of Tepelmeme Villa de Morelos, Oaxaca (18.1142498° N, 97.3397921° W; WGS84; 1,615 m.a.s.l.). Here we found a large fragment of rock matrix that broke off and fell from the upper part of the cut slope (Fig. 1A). The rock matrix included what apparently was the natural cast of a footprint of an unidentified tetrapod (Fig. 1B). The cast was collected by carefully removing it from the rock matrix, and then it was



**Figura 2.** Reconstrucción paleoambiental de la Formación Matzitzi. La diversidad vegetal de la zona estaba principalmente compuesta por licófitas arborescentes (Lepidodendrales), colas de caballo (Equisetales), helechos (Marattiales) y otros órdenes de plantas que sugieren un ambiente sub-húmedo, mientras que la única fauna conocida fueron temnospondilos de tamaño mediano o relativamente grande. Ilustración por Diana S. Guzmán-Madrid.

**Figure 2.** Paleoenvironmental reconstruction of the Matzitzi Formation. The plant diversity of the zone was mainly composed by arborescent lycophytes (Lepidodendrales), horsetails (Equisetales), ferns (Marattiales) and other plant orders that suggest a sub-humid environment, while the only known fauna were middle-sized or relatively large temnospondyls. Artwork by Diana S. Guzmán-Madrid.

wrapped in foam rubber and transported to the Colección de Paleontología of the Facultad de Estudios Superiores Zaragoza in Mexico City, where it is housed under the catalog number CFZMt-312. The specimen is a natural cast of lutite of fine-grained sandstone. The ichnite is very broad distally with a marked decrease in width proximally, the measurements as preserved are 84.3 mm of length and 99.8 mm of width (Fig. 1C). The ichnite is the natural cast of an impression of the left manus of a middle-sized or relatively large tetrapod. The handprint cast is very well-preserved, which suggests that the animal was a plantigrade that deeply embedded its forelimb. The handprint

cast allows us to observe some notable features of the hand such as the palmar pads and the palmar transverse creases (Fig. 1C). Four digits are distinguishable, all of them broken at the level of the middle part of the proximal phalanges; all the digits show a remarkable gap among them indicating that the animal walked with wide-spread fingers (Fig. 1D).

The Temnospondyli was a diverse group of small to very large early tetrapods that successfully flourished from the Carboniferous to the Early Cretaceous (Carroll, 1988, 2009; Benton, 2014). Through time, temnospondyls developed a very

high morphological disparity, and between the late Paleozoic and the early Mesozoic, they were widely widespread due to their morphological adaptations to life in terrestrial and aquatic environments (Fortuny et al., 2011, 2016). Most temnospondyls had a robust body with a broad rounded or triangular skull adapted to feed on a wide variety of prey (Fortuny et al., 2011). Another notable morphological characteristic of temnospondyls is that most known species had five digits in the pes and four digits in the manus (Dikes, 2015; Mujal & Schoch, 2020), with very rare exceptions of pentadactyly in both limbs only seen in a few derived taxa such as *Metoposaurus krasiejowensis* (Konietzko-Meier et al., 2020).

Considering that recent research demonstrates that tetradactyly was a trait persistently present in the manus of most temnospondyls (Konietzko-Meier et al., 2020), we confidently refer the specimen CFZMt-312 to this group of early tetrapods (Fig. 1C, D). Recent research proposes that some temnospondyls might have impressed their manus much deeper than their pes, depending on the location of their centre of mass of their body (Mujal et al., 2023), which may explain why the handprint from the Matzitzi Formation is preserved in detail.

The presence of temnospondyls in the Upper Paleozoic of the Matzitzi Formation is significant because this record provides key information about the fauna and paleoenvironment of the zone (Fig. 2). Recently, Flores-Barragan and Velasco-de León (2021) suggested that the floristic elements of the Matzitzi Formation indicate that the depositional environment was sub-humid, however, the occurrence of temnospondyls suggests that the paleoenvironment was also warm (Fig. 2), considering that recent research demonstrates that temnospondyls had a strong preference for perennial water sources and warm climates (Liu et al., 2021). Osteological and ichnological remains of temnospondyls are well known for several localities of the Upper Carboniferous, Lower Permian and Late Triassic of Canada and the United States of America (Holmes et al., 1998; Bolt & Chatterjee, 2000; Lucas et al., 2011; Milner & Schoch, 2013; Lucas, 2019); nevertheless, this is the first time that evidence of this group is found in Mexico. Therefore, this represents the southernmost record of temnospondyls in North America, given that all previous southern records are from the south of New Mexico and Texas in the United States (Lucas et al., 2011; Milner & Schoch, 2013).

In relation to the Mexican fossil record, vertebrate fossils from the Paleozoic are quite scarce, and so far, the oldest known vertebrate remains are chondrichthyan teeth from the Late Devonian of Cerro Las Pintas in Sonora (Martínez-Pérez

et al., 2020), and teeth and dermal denticles from the Upper Pennsylvanian and Lower Permian of San Salvador Patlanoaya in Puebla (Sour-Tovar et al., 2000; Derycke-Khatir et al., 2005; González-Rodríguez et al., 2013). Consequently, the handprint from the Matzitzi Formation represents the third oldest record of a vertebrate in Mexico. In addition, this is the earliest record of a tetrapod for Mexico, considering that the subsequent record are ichthyosaur vertebrae from the Late Triassic of Sonora (Lucas & González-León, 1995), while the oldest terrestrial vertebrates before this record were remains of crocodylomorphs, dinosaurs, sphenodontians and mammaliaforms from the Early Jurassic of La Boca Formation in the State of Tamaulipas (Clark et al., 1994). Finally, we expect to carry out new fieldwork at the Matzitzi Formation to search for more vertebrate remains that would help us to understand the paleoecology of this important fossil site of the Paleozoic of Mexico.

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