Paleontología Mexicana
Volumen 9, núm. 2, 2020, p. 145 – 150

Remains of a Diplodocid (Sauropoda: Flagellicaudata) from the Otlaltepec Formation Middle Jurassic (Bathonian-Callovian) from Puebla, Mexico

Rivera-Sylva, Héctor E.[a,*], Espinosa-Arrubarrena, Luis[b]

[a] Departamento de Paleontología, Museo del Desierto, Blvd. Carlos Abedrop Dávila 3745, 25022, Saltillo, Coahuila, Mexico.
[b] Departamento de Paleontología, Instituto de Geología, Universidad Nacional Autónoma de México, Circuito de la Investigación S/N, Ciudad Universitaria, Coyoacán, 04510, Mexico City, Mexico.

[*] hrivera@museodeldesierto.org

Abstract

Fieldwork in the late 1980s in the Otlaltepec Formation Middle Jurassic (Bathonian-Callovian) of southern Puebla resulted in the recovery of the first osteological record of a Flagellicaudata dinosaur from Mexico and the southern-most for North America. The material is represented by metatarsal fragments of the right pes, showing autapomorphies in metatarsal II for Flagellicaudata. The available material is incomplete and the sample remains small, but it suggests the possible presence of a new taxon. This specimen provides data on the distribution and diversity of sauropod dinosaurs of southern North America during the Middle Jurassic.

Key words: Jurassic, Sauropod, Flagellicaudata, Mexico.

Resumen

Trabajo de campo realizado a fines de la década de 1980 en la Formación Otlaltepec (Jurásico Medio; Bathoniano-Calloviano) del sur de Puebla dio como resultado la recuperación del primer registro osteológico de un dinosaurio Flagellicaudata de México y el más austral para América del Norte. El material está representado por fragmentos metatarsianos del pie derecho, mostrando autapomorfias en el metatarso II para Flagellicaudata. El material disponible está incompleto y la muestra sigue siendo pequeña, pero sugiere la posible presencia de un nuevo taxón. Este espécimen proporciona datos sobre la distribución y diversidad de los dinosaurios saurópodos del sur de América del Norte durante el Jurásico Medio.

Palabras clave: *Jurásico, Saurópodo, Flagellicaudata, México.*

1. Introduction

Sauropoda is phylogenetically defined as sauropodomorphs that are more closely related to *Saltasaurus* than to *Plateosaurus* (Wilson and Sereno, 1998). Sauropods are united by a set of derived postcranial features, including modifications in the vertebral column and hind limbs (Upchurch *et al.*, 2004).

Sauropods are among the best known dinosaurs which ranged in adult length from about 7 to 40 meters. Numerous specimens have been reported from the Late Triassic to Late Cretaceous of North and South America, Europe, Asia, Australia, and Africa. The highest diversity is known from the Upper Jurassic Morrison Formation of the western United States (Tschopp and Mateus, 2017). Among sauropods, Flagellicautada is the clade that is known best with two families, the Dicraeosauridae and the Diplodocidae. This group has a characteristic whip-like tail, bifid neural spines, palate-like chevrons, pencil-like teeth and the loss of the calcaneus, among other features (Harris and Dodson, 2004).

The fossil record of sauropods from Mexico are only known from footprints (Ferrusquía-Villafranca *et al.*, 1993, 1996, 2007; Jiménez-Hidalgo *et al.*, 2004; Rodríguez de la Rosa, 2007, Rodríguez de la Rosa *et al.*, 2012), and some opisthocoelicaudians osteological remains from Late Cretaceous deposits (Rivera-Sylva *et al.*, 2006; Rivera-Sylva and Carpenter, 2014), also there is mention of possible

Sauropodomorph material from the Early Jurassic La Boca Formation in Tamaulipas based only on the size of the bone fragments (Fastovsky *et al.*, 1995). Montellano-Ballesteros (2003) described some vertebrae from titanosaurid but later were ascribed to hadrosauria based on the morphology and geologic horizon where they were found (D'Emic *et al.*, 2010).

All the material here described was found by Shelton P. Applegate in 1987 near the town of San Felipe Otlaltepec, Puebla, about 150 km southeast of Mexico City (Fig. 1), and briefly mentioned in literature (Hernández and Espinosa-Arrubarrena, 1990; Rivera-Sylva and Carpenter, 2014). This material deserves a more accurate description as it is the first known remains of a Diplodocid from Mexico and the southernmost record for North America. Applegate gave us permission to work on this material shortly before he passed away.

2. Geology

During the Jurassic, large portions of the Western Interior of North America were inundated by a shallow epicontinental seaway bonded on the west by a subduction generated volcanic arc that extended northward from Mexico along the western margin of the United States into southwestern Canada (Kvale *et al.*, 2001). As global eustatic sea levels fluctuated in response to tectonic controls, this shallow seaway spread southward from the Arctic to inundate the Western Interior in a series of at least four major pulses, consisting of transgressions in the Early Jurassic (Pliensbachian-Toarcian), twice in the Middle Jurassic (Bajocian-Callovian), and again during the Late Jurassic in early Oxfordian (Pipiringos and O'Sullivan, 1978).

The Otlaltepec Formation is composed of rhythmically alternating conglomerate to fine grained sandstone deposits, which are locally overlain by fine-grained sandstone beds with ripple cross lamination and drapes of horizontally laminated siltstone and mudstone (Martini *et al.*, 2016; Martini *et al.*, 2017). Based on this assemblage of lithofacies, the Otlaltepec Formation has been interpreted as an overbank environment within a floodplain with anastomosed rivers that was intermittently flooded during high-water stages and with subaerial exposition during low-water periods, favoring pedogenesis and the development of paleosols (Martini *et al.*, 2016).

The age of the Otlaltepec Formation has long been debated as between Middle Jurassic and Early Cretaceous (Ortega-Guerrero, 1989; Morán-Zenteno *et al.*, 1993). More recent work has reported a U-Pb zircon geochronologic age for the Otlaltepec Formation between 163.5 ± 1 and 167.5 ± 4 Ma (Martini *et al.*, 2016). Sedimentary rocks of the Otlaltepec Formation contain abundant fossil of gymnosperms (*e.g. Otozamites*, *Williamsonia*, *Brachyphyllum*, *Pelourdea*, *Neoggeratiopsis*, *Mexiglossa*, and *Cycadolepis*), and trunk molds (Velasco-de León *et al.*, 2013). The palynological assemblages also indicates a dominance of gymnosperms (*Inaperturopollenites*, *Spheripollenites*, and *Araucariacites*), and small proportion of pteridophytes (*Cicatricosisporites*, *Cyathidites*, *Deltoidospora*, *Klukisporites*, *Leptolepidites*, *Manumia* and *Nodosisporites*), as well as spores of freshwater zygnematacean green algae (*Ovoidites* and *Chomotriletes*) (Gerwert-Navarro *et al.*, 2018).

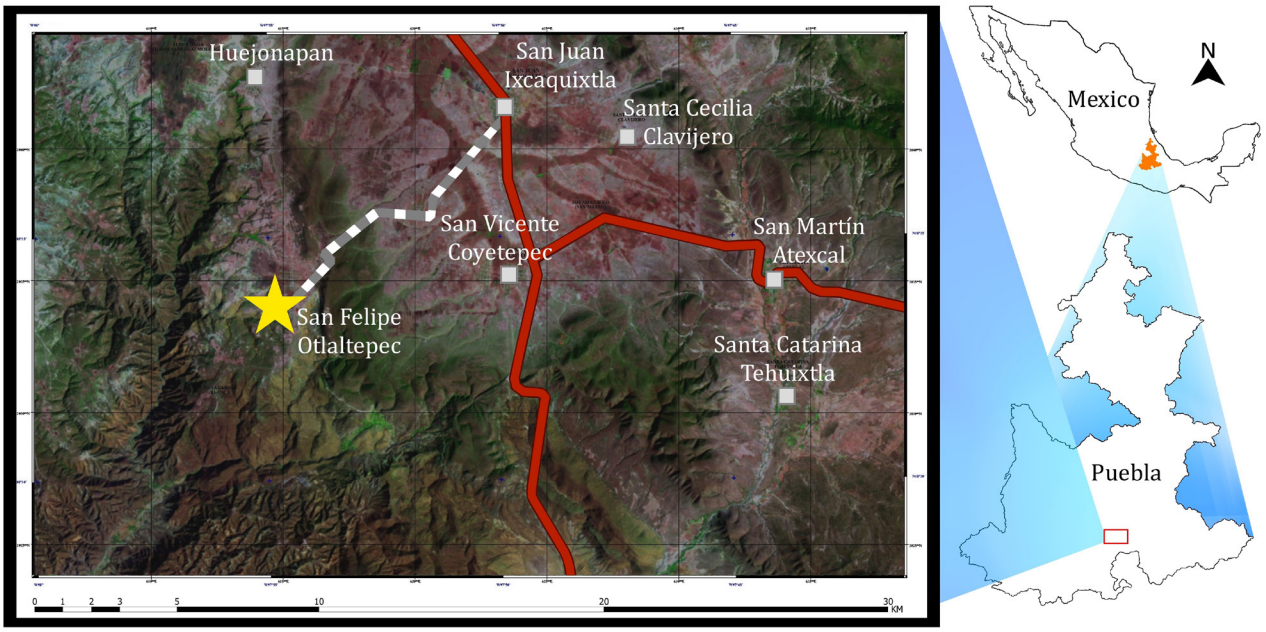

Figure 1. Locality map of the fossil site (yellow star).

The flora indicates the dominances of a sub-warm, sub-humid climate. The integration of sandstone petrologic and paleontologic data suggest that deposition of Jurassic clastic successions in the Oltaltepec Basin was accompanied by major changes in climatic conditions, as an evolution from dry or seasonal to humid conditions is supported by sandstone whole-rock composition and fossil flora (Martini *et al.*, 2017).

3. Material and Methods

The 81 fossil fragments were collected at "Boca del Agua Chica" during extensive surface survey by Shelton P. Applegate, of all those fragments only three could be identify satisfactory. All fossils are stored in the Museo de Paleontología del Instituto de Geología de la Universidad Nacional Autónoma de México. Locality information is on file at that institution. The specimens were photographed using a Canon EOS Rebel XS with a Canon EF 35-80 mm 1:4-5.6 III lens.

Institutional Abbreviations: **IGM-** Museo de Paleontología, Instituto de Geología, UNAM, Mexico City, Mexico.

4. Systematic paleontology

Sauropoda Marsh, 1878
Diplodocoidea Marsh, 1884
Flagellicaudata Harris and Dodson, 2004

Flagellicaudata indet.

Referred specimens: IGM 11514, proximal end of right metatarsal II (Fig. 2 a–d), distal end of right metatarsal II (Fig. 2 e–f), and the proximal end of right metatarsal III (Fig. 2 g–h).

Horizon and Locality: Otlaltepec Formation, from the lower layers of the gorge in the locality known as "Boca del Agua Chica", 1 km southwest of the town of San Felipe Otlaltepec.

Age: Middle Jurassic (Bathonian-Callovian).

Description:

Metatarsal: The proximal end of the metatarsal II has a trapezoidal articular surface and shortens to the shaft. The distal end of metatarsal II has a convex articular surface, with rugose ridges on the dorsolateral margin and rectangular outline with rounded corners, with an undivided articular surface, with concave lateral margin in proximal view. In the lateral condyle can be seen the laterodistal process. It broadens distally, slightly concave transversely.

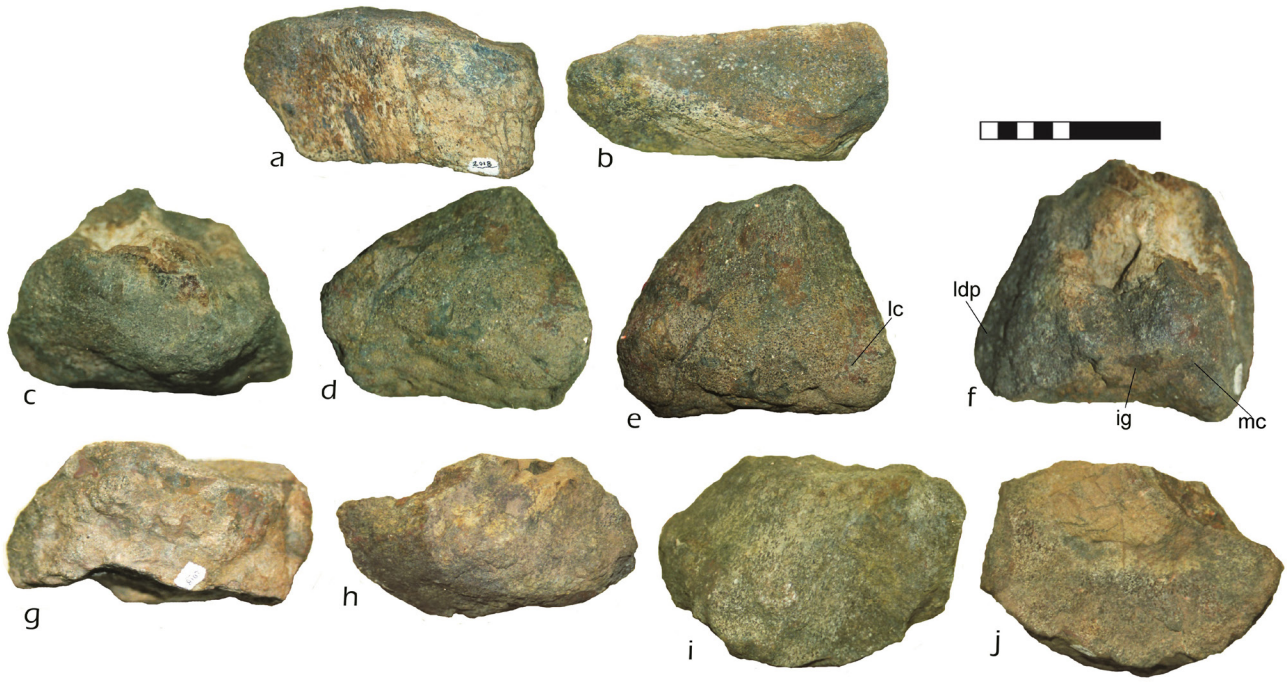

Figure 2. IGM 11514, Proximal end of metatarsal II in: a) medial, and b) caudal view. Distal end of metatarsal II in: c) cranial, d) caudal, e) dorsal, and f) ventral view. Proximal end of metatarsal III in: g) cranial, h) caudal, i) lateral, and j) medial view. Abbreviations: ig, intercondylar groove; lc, lateral condyle; ldp, laterodistal process; mc, medial condyle. Scale bar = 10 cm.

The proximal end of metatarsal III is rugose, pitted, and have a slightly concave proximal articular surface with a subrectangular outline, with a boot-shape outline sagittally. For measurements see Table 1.

Comments: The diagnostic aspects of the sauropod include autapomorphic characters of the pes on a high taxonomic level in all known North American sauropods (Wilhite, 2005; Bonnan, 2005; Páramo *et al.*, 2020). The articular surface of the metatarsal II is convex as seen in other sauropods (Gilmore, 1936; Ostrom and McIntosh, 1966; Bonnan, 2005; D´Emic *et al.*, 2011; Maltese *et al.*, 2018), with distinct rugose ridges as those described for the distal articular surfaces of metatarsal II as well as for the laterodistal process as seen in other Flagellicaudatans (Ostrom and McIntosh, 1966; McIntosh *et al.*, 1992; Harris, 2007; Remes, 2009; Whitlock, 2011; Tschopp *et al.*, 2015). The presence in metatarsal II of rugosities on dorsolateral margin near the distal end, the intermediate robustness, and the concave lateral margin in proximal view are autapomorphic characters for Flagellicaudata according to Tschopp *et al.* (2015). The metatarsal III, although broken sagittally, can be seen a boot-shape characteristic of the metatarsals III in other sauropods (Gilmore, 1936; Ostrom and McIntosh, 1966; D´Emic *et al.*, 2011; Maltese *et al.*, 2018) (Fig. 3).

Table 1. Measurements (mm) of the Flagellicaudata metatarsals (IGM 11514).

	Length	Width	Height
MT II prox	180	80	97
MT II dist	118	165	134
MT III prox	175	100	134

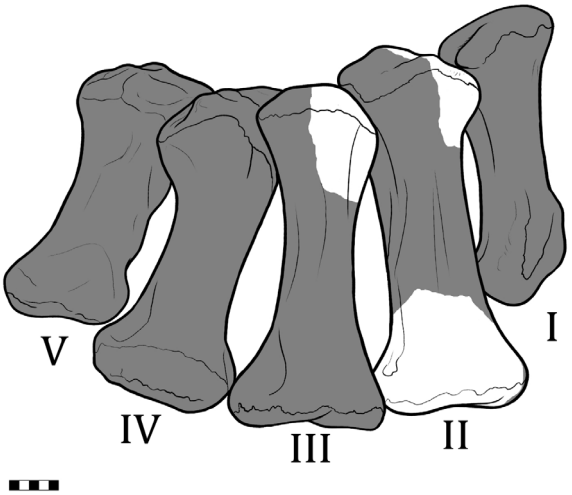

Figure 3. IGM 11514, Flagellicaudata indet.: reconstruction of right pes in cranial aspect. Scale bar = 5 cm (After Ostrom and McIntosh, 1966).

5. Discussion

The Middle Jurassic dinosaur record is considered sparse worldwide with relatively little known about dinosaurs from this period (Lockley and Hunt, 1995; Kvale *et al.*, 2001). The United States Middle Jurassic has produced few bones and tracks of dinosaurs and by comparision the geographically closest region to Mexico during the Middle Jurassic. However that the major branches of dinosaurs were established worldwide during this time and Neornithischia, the Thyreophora, the Heterodontosauridae, the Sauropodomorpha and the Neotheropoda. Only theropods and sauropods had been reported from the western United States (Lockley *et al.*, 2007; Kvale *et al.*, 2001; Adams *et al.*, 2014) and theropod, sauropod, ornithopod, and nodosaurid tracks from Mexico (Ferrusquía-Villafranca *et al.*, 2007; Rodríguez-de la Rosa *et al.*, 2018).

These material from the Otlaltepec Formation, demonstrate conclusively that Flagellicaudatans occupied this region of North America throughout the Bathonian-Callovian. Though incomplete, the material from the Otlaltepec Formation of Puebla is the first unequivocal material of this clade. Unfortunately, the preserved bones can only be identified at a high taxonomic level, and they can be determined as coming from a single individual because they were found in the field very close to each other, and all come from an individual with the same size range.

The presence of a diplodocid in the Middle Jurassic of Mexico is indicative of a rapid evolutionary radiation and dispersal of the group after the separation of the continents of the Southern and Northern hemispheres during the Middle Jurassic (Rauth *et al.*, 2005), suggesting the possible presence of a new taxon.

6. Conclusion

This study illustrates for the first time definitive postcranial diplodocid material from the Otlaltepec Formation. Taphonomic and facies factors may influence the currently known fossil record of sauropods in Mexico (Rivera-Sylva and Carpenter, 2014). Regardless, this new record of Diplodocoids from Puebla are a very important addition to the Middle Jurassic sauropod record, and also of interest in light of purported differences between the Middle Jurassic faunas of the northern and southern hemispheres (Rauth *et al.*, 2005).

Although the available material is currently limited, continuing field efforts in the Mixteca Region of Puebla will surely result in more complete, diagnostic sauropod materials that will be invaluable in making definitive taxonomic assignments, as well as biogeographic comparisons between taxa inhabiting northern and southern regions of Laurasia in the late Middle Jurassic.

The paucity of Middle Jurassic dinosaur faunas worldwide makes the sauropod material being uncovered

in Mexico of great importance to our understanding of the development of the Sauropoda. As these specimens as the osteological southern-most record of Sauropoda for North America. The material already discovered on Puebla provides tantalizing glimpses of the potential of future collecting and study in the Mixteca Region of Mexico, and added much data for interpreting the biogeography, diversity, and evolutionary patterns of the group.

The diplodocid remains from Puebla reveals a faunal exchange in southern North America during the Middle Jurassic. Additional work, particularly the description and interpretation of new or poorly known taxa, will undoubtedly, clarify both the detail and broader aspects of the sauropod radiation during the Middle Jurassic which was more important than previously thought, promoted by the feeding mechanisms which allowed niche partitioning, and therefore their diversification (Upchurch and Barret, 2005; Barret and Upchurch, 2005).

Acknowledgments

We would like to dedicate this paper to Shelton P. Applegate, who died unexpectedly on the 20th of August 2005. "Shelly" was an outstanding vertebrate paleontologist, and whose effort is the basis of this paper.

We would like to thank Maria del Carmen Perilliat and Jesus Alvarado for getting access to the Museo de Paleontología del Instituto de Geología de la UNAM. Kenneth Carpenter is thank for review an early version of the paper. Natalia Amezcua-Torres (SGM) for provided geologic information, and special thanks to Rubén Guzmán-Gutiérrez for providing hard to find bibliography. Thanks to Daniel Barrera-Guevara for producing the reconstruction and the map. Also we would like to thank two unknown reviewers that contribute to the improvement of this paper. HRS want to thank in a very special manner to Lourdes Sylva, Lucia Alfaro and Angela Rivera for their support while producing this paper.

References

Adams, T.L., Breithaupt, B.H., Matthews, N.A., 2014, Paleoecology and Paleoenvironment of Middle Jurassic dinosaurs (Yellow brick road dinosaur tracksite, Bighorn Basin, Northern Wyoming): in Lockley, M.G., Lucas, S.G. (eds.), Fossil footprints of western North America, NMMNHS Bulletin, 62, 225–233.

Barret, P.M., Upchurch, P., 2005, Phylogenetic and taxic perspectives on sauropod diversity, in Curry Rogers, C., Wilson, J. (eds.) The sauropods: Evolution and Paleobiology, California University Press, Berkeley, 104–124.

Bonnan, M., 2005, Pes anatomy in sauropod dinosaurs: implications for functional morphology, evolution, and phylogeny, *in* Tidwell, V., Carpenter, K. (eds.), Thunder-Lizards, Indiana University Press, Bloomington, 346–380.

D'Emic, M., Wilson, J., Thompson, R., 2010, The end of the sauropod dinosaur hiatus in North America: Palaeogeography, Palaeoclimatology, Palaeoecology, 297, 486–490.

D'Emic, M., Wilson, J. Williamson, T., 2011, A Sauropod Dinosaur Pes from the Latest Cretaceous of North America and the Validity of *Alamosaurus sanjuanensis* (Sauropoda, Titanosauria): Journal of Vertebrate Paleontology, 31, 1072–1079.

Fastovsky, D.E., Clark, J.M., Strater, N.H., Montellano, M., Hernandez, R., Hopson, J.A., 1995, Depositional environments of a Middle Jurassic Terrestrial Vertebrate Assemblage, Huizachal Canyon, Mexico: Journal of Vertebrate Paleontology, 15(3), 561–575.

Ferrusquía-Villafranca, I., Tilton, T.L., Lang, H.R., Pittman, J.G., Lockley, M.G., 1993, Dinosauricnitas tardicretácicas en Puebla suroccidental y su significación geológico-paleontológica, Memorias del IV Congreso Nacional de Paleontología, Sociedad Mexicana de Paleontología, 33–34.

Ferrusquía-Villafranca, I., Jiménez-Hidalgo, E., Bravo-Cuevas, V.M., 1996, Footprints of small sauropods from the Middle Jurassic of Oaxaca, southeastern Mexico, in Morales, M. (ed.), The Continental Jurassic, Museum of Northern Arizona Bulletin, 60, 119–126.

Ferrusquía-Villafranca, I., Bravo-Cuevas, V.M., Jiménez-Hidalgo, E., 2007, The Xochixtlapilco dinosaur ichnofauna, Middle Jurassic of Oaxaca, Southeastern Mexico description and paleontologic significance: Natural History Museum of Los Angeles County, Contributions in Science, 515, 1–40.

Gerwert-Navarro, M., Villanueva-Amadoz, U., Michelangelo, M., 2018, Paleonenvironmental reconstruction of the Middle Jurassic Otlaltepec Formation of Oaxaca, Mexico, in: Book of Abstracts 1st Palaeontological Virtual Congress, 163 p.

Gilmore, C.W., 1936, Osteology of *Apatosaurus*, with special reference to specimens in the Carnegie Museum: Memoirs of the Carnegie Museum, 11(4), 175–301.

Harris, J.D., 2007, The appendicular skeleton of *Suuwassea emilieae* (Sauropoda: Flagellicaudata) from the Upper Jurassic Morrison Formation of Montana (USA): GeoBios, 40, 501–522.

Harris, J.D., Dodson, D., 2004, A new diplodocoid sauropod dinosaur from the Upper Jurassic Morrison Formation of Montana, USA: Acta Palaeontologica Polonica, 49(2), 197–210.

Hernández, R., Espinosa-Arrubarrena, L., 1990, Dinosaurs localities from Mexico: Journal of Vertebrate Paleontology, 9 (Supplement 3), 27A.

Jiménez-Hidalgo, E., Hernández, R., Ortega-Palacios, L., 2004, New Late Cretaceous vertebrate tracks from the Sabinas basin, northeastern Coahuila, northeastern Mexico, Journal of Vertebrate Paleontology, 24 (supplement 3), 76A.

Kvale, E.P., Johnson, G.D., Mickelson, D.L., Keller, K., Furer, L.C., Archer, A.W., 2001, Middle Jurassic (Bajocian and Bathonian) Dinosaurs Megatracksites, Bighorn Basin, Wyoming, U.S.A.: Palaios, 16(3), 233–254.

Lockley, M.G., Hunt, A.P., 1995, Dinosaurs tracks and other fossil footprints of the western United States: Columbia University Press, New York, 338 pp.

Lockley, M.G., Mitchell, L., Odier, G.P., 2007, Small theropod track assemblages from Middle Jurassic eolianites of eastern Utah: paleontological insights from dune ichnofacies in a transgressive sequence: Ichnos, 14, 131–142.

Maltese, A., Tschopp, E., Holwerda, F., Burnham, D., 2018, The real Bigfoot: a pes from Wyoming, USA is the largest sauropod pes ever reported and the northern-most occurrence of brachiosaurids in the Upper Jurassic Morrison Formation: PeerJ 6:e5250. https://doi.org/10.7717/peerj.5250.

Marsh, O.C., 1878, Principal characters of American Jurassic dinosaurs. Part I: American Journal of Science, Series 3, 16, 411–416.

Marsh, O.C., 1884, Principal characters of American Jurassic dinosaurs. Part VII, On the Diplodocidae, a new family of the Sauropoda: American Journal of Science, Series 3, 27, 161–167.

Martini, M., Ramírez-Calderon, M., Solari, L., Villanueva-Amadoz, U., Zepeda-Martínez, M., Ortega-Gutiérrez, F., Elías-Herrera, M., 2016, Provenance analysis of Jurassic sandstones from the Otlaltepec Basin, souther Mexico: Implications for the reconstruction of Pangea break-up: Geosphere, 12(6), 1842–1864.

Martini, M., Velasco-de León, P., Zepeda-Martínez, M., Lozano-Carmona, D.E., Ramírez-Calderon, M., 2017, Field guide to the Jurassic

Otlaltepec and Tezoatlán Basins, southern Mexico: sedimentological and paleontological records of Puebla and Oaxaca: Boletín de la Sociedad Geológica Mexicana, 69(3), 691–709.

McIntosh, J.S., Walter, P.C. Jr., Russell, D.A., 1992, A new diplodocid sauropod (Dinosauria) from Wyoming, U.S.A.: Journal of Vertebrate Paleontology, 12(2), 158–167.

Montellano-Ballesteros, M., 2003, A titanosaurid sauropod from the Upper Cretaceous of Chihuahua, Mexico: Revista Mexicana de Ciencias Geológicas, 20, 160–164.

Morán-Zenteno, D.J., Caballero-Miranda, C.I., Silva-Romo, G., Ortega-Guerrero, B., González-Torres, E., 1993, Jurassic-Cretaceous paleogeographic evolution of the northern Mixteca terrane, southern Mexico: Geofísica Internacional, 32(3), 453–470.

Ortega-Guerrero, B., 1989, Paleomagnetismo y geología de las unidades clásticas mesozoicas del área Totoltepec-Ixcaquixtla, Estados de Puebla y Oaxaca (Ms. thesis), Universidad Nacional Autónoma de México, 155 pp.

Ostrom, J.H., McIntosh, J.S., 1966, Marsh's Dinosaurs: The Collections of Como Bluff, Yale University Press, New Haven, 388 pp.

Páramo, A., Mocho, P., Ortega, F., 2020, Three-dimensional analysis of the titanosaurian limb skeleton: implications for systematic analysis: Journal of Iberian Geology. https://doi.org/10.1007/s41513-020-00139-8

Pipiringos, G.N., O´Sullivan, R.B., 1978, Principal unconformities in Triassic and Jurassic rocks, Western Interior United States-a preliminary survey: U.S. Geological Survey Professional Paper, 1035-A, 29 pp.

Rauhut O.W.M., Remes K., Fechner R., Cladera G., Puerta P., 2005, Discovery of a short-necked sauropod dinosaur from the Late Jurassic period of Patagonia: Nature, 435(7042), 670–672.

Remes, K., 2009, Taxonomy of Late Jurassic diplodocid sauropods from Tendaguru (Tanzania): Fossil Record, 12(1), 23–46.

Rivera-Sylva, H.E., Guzmán-Gutiérrez, J.R., Palomino-Sánchez, F.R., 2006, Preliminary report on a vertebrate fossil assemblage from the Late Cretaceous of Chihuahua, Mexico: Hantkeniana, 5, 66–68.

Rivera Sylva, H.E., Carpenter, K., 2014, Saurischian dinosaurs from Mexico, in Rivera Sylva, H.E., Carpenter, K., Frey, E., (eds), Dinosaurs and other reptiles from the Mesozoic from Mexico, Indiana University Press, Bloomington, 156–180.

Rodríguez de la Rosa, R.A., 2007, Hadrosaurian footprints from the late Cretaceous Cerro del Pueblo Formation of Coahuila, Mexico, in Díaz-Martínez, E., Rábano, I. (eds.), Fourth European Meeting on the Palaeontology and Stratigraphy of Latin America. Cuadernos del Museo Geominero B, 339–343.

Rodríguez de la Rosa, R.A., Bravo-Cuevas, V.M., Carrillo-Montiel, E., Ortíz-Ubilla, A., 2012, Lower Cretaceous dinosaur tracks from Puebla, Mexico: Journal of Vertebrate Paleontology, 23 (supplement 3), 90A.

Rodríguez-de la Rosa, R.A., Velasco-de León, P., Arellano-Gil, J., Lozano-Carmona, D.E., 2018, Middle Jurassic ankylosaur tracks from Mexico: Boletín de la Sociedad Geológica Mexicana, 70(2), 379–395.

Tschopp, E., Mateus, O., Benson, R.B.J., 2015, A specimen-level phylogenetic analysis and taxonomic revision of Diplodocidae (Dinosauria: Sauropoda): PeerJ, 3:e857. https://doi.org/10.7717/peerj.857.

Tschopp, E., Mateus, O., 2017, Osteology of *Galeamopus pabsti* sp. nov. (Sauropoda: Diplodocidae), with implications for neurocentral closure timing, and the cervico-dorsal transition in diplodocids: PeerJ 5: e3179. https://doi.org/10.7717/peerj.3179.

Upchurch, P., Barrett, P.M., Dodson, P., 2004, Sauropoda, in Weishampel, D.B., Dodson, P., Osmólska, H. (eds.), The Dinosauria, 2nd Edition, University of California Press, Berkeley, 259–322.

Upchurch and Barret, 2005, Sauropodomorph diversity through time: Macroevolutionary and paleoecological implications, in Curry Rogers, C., Wilson, J. (eds.) The sauropods: Evolution and Paleobiology, California University Press, Berkeley, 125–156.

Velasco-de León, M.P., Ortíz-Martínez, E., Silva-Pineda, A., Lozano-Carmona, D.E., 2013, Distribución y ambiente de las gimnospermas fósiles del terreno Mixteco: Paleontología Mexicana, 63, 122–143.

Whiltlock, J.A., 2011, A phylogenetic analysis of Diplodocoidea (Saurischia: Sauropoda): Zoological Journal of the Linnean Society, 161(4), 872–915.

Wilhite, D.R., 2005, Variation in the appendicular skeleton of North American sauropod dinosaurs: Taxonomic implications, in Tidwell, V., Carpenter, K. (eds.), Thunder-Lizards, Indiana University Press, Bloomington, 268–301.

Wilson, J.A., Sereno, P.C., 1998, Early evolution and higher-level phylogeny of sauropod dinosaurs: Society of Vertebrate Paleontology Memoir, 5, 1–68.

Manuscript received: June 25, 2020.
Corrected manuscript received: November 17, 2020.
Manuscript accepted: November 25, 2020.