TWO SPECIES OF GOMPHOTHERIIDS (MAMMALIA-PROBOSCIDEA) COLLECTED IN EARLY BLANCAN DEPOSITS OF CENTRAL MEXICO, *RHYNCHOTHERIUM FALCONERI* AND THE FIRST RECORD OF *RHYNCHOTHERIUM BROWNI* OUTSIDE OF SONORA: A COMPARISON

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Abstract—This work describes and compares the skull and lower jaw of two species of *Rhynchotherium* discovered in early Blancan deposits in central Mexico. This comparison establishes the differences between the species *Rhynchotherium falconeri* and *R. browni* and is the first record of *R. browni* outside of San José de Pimas, Sonora. The description of the skull and jaw of the same individual, referred to the gomphotheriid proboscidean *Rhynchotherium falconeri*, collected in deposits of early Blancan age (3.6 Ma), from the Rancho La Goleta locality, state of Michoacán, Mexico, corresponds to an adult individual that shows these diagnostic characters: deflection of the symphysis down and forward with an angle of 61°, the anterior edge of the ascending ramus at 90°, and the ventral inclination of the horizontal ramus at 25°, which gives it greater depth characteristics in the anterior region under the protolophid of m2. These are characters that support referral to *Rhynchotherium falconeri*, however, M3/m3 are simple tetraloph/tetralophid, with low cusps and simple trefoils, without accessory cusps or a heel. The anteroposterior length of M3 is among the smallest of *Rhynchotherium falconeri* known in faunas of North America. These measurements are within the range considered part of sexual dimorphism, so the specimen is assumed to correspond to a female. The skull is domed, the occipital almost straight in relation to the occlusal surface of the molars, the face is more elongate, and the premaxillae are narrow and open, so they are separated in the anterior medial part, the alveoli are complete with apparent divergent direction, and two long fragments of tusks are separated from the alveoli with small evidence of enamel.

In the San Miguel de Allende basin, in deposits of early Blancan age (3 Ma) in the Los Galvanes area, the first known record of *Rhynchotherium browni* was collected outside of San José de Pimas, Sonora. The jaw is larger, and the structures are more robust. The symphysis, although reconstructed, shows a probable inclination of ~77°, and the anterior edge of the ascending rami has an angle of 107°. The mandible presents the alveoli of m1's, and in front of them an extension of the lingual canal of approximately 70 mm. The horizontal ramus is longer and straighter, and shallower but wider transversely at the base of the ascending rami compared to *Rhynchotherium falconeri*. The M2 has three lophs, and the metaloph has a remarkable double trefoil. In m2 the tritolophid has a small cusp with signs of wear in the posterior medial part. The M3/m3 are tetraloph with simple trefoils and higher cusps, and have a heel represented by small cusps. The right i2 is complete, with no evidence of enamel.

Resumen—En este trabajo se describen y comparan el cráneo y mandíbula de dos especies del Gonfoterio *Rhynchotherium* descubiertas en depósitos del Blancano temprano de la región central de México. Su comparación establece las diferencias entre las especies de *Rhynchotherium falconeri* y *Rhynchotherium browni* y valida su separación en especies diferentes, es el primer registro *Rhynchotherium browni* que se conoce fuera de San José de Pimas, Sonora.

La descripción del cráneo y mandíbula del mismo individuo, referido a *Rhynchotherium falconeri,* colectado en depósitos del Blancano temprano (3.6 Ma), de la localidad Rancho La Goleta, estado de Michoacán, corresponde a un individuo adulto que muestra los caracteres diagnósticos: inclinación de la sínfisis hacia abajo y adelante en ángulo de 61°, el borde anterior de la rama ascendente en 90°, la notable inclinación del borde ventral de la rama horizontal en 25° que le dan de mayor profundidad en el protolofido de m2 y la región anterior en la sínfisis. M3/m3 con cuatro lofos, no se presentan evidencia de un talón. Los molares superiores e inferiores tienen coronas bajas con tréboles simples sin cúspides accesorias.

El largo anteroposterior de M3, está entre los más reducidos de *Rhynchotherium falconeri* de las faunas de Norte América. Estas medidas están dentro del rango considerado parte del dimorfismo sexual por lo que se supone el espécimen corresponde a una hembra. El cráneo está completo, el rostro es más alargado, los premaxilares son angostos y abiertos por lo que están separados en la parte media anterior, los I2 están completos con las puntas divergentes, con residuos de esmalte en el lado externo. En depósitos del Blancano temprano (3 Ma) del área de Los Galvanes, en San Miguel de Allende, se colectó el primer registro de *Rhynchotherium browni* conocido fuera de San José de Pimas, Sonora. Las estructuras de la mandíbula son más robustas, de mayor tamaño. La sínfisis, aunque reconstruida muestra una probable inclinación de ~77°, el borde anterior de la rama ascendente tiene un ángulo de 107°. Las dos ramas de la mandíbula presentan los alveolos de m1s y delante una extensión del canal lingual de aproximadamente 70 mm. La rama horizontal es más larga y recta, menos profunda pero más ancha en la base de las ramas ascendentes en comparación con *Rhynchotherium falconeri*. El M2 con tres lofos, el metalofo tiene un notable doble trébol. En m2 el tritolofido tiene una cúspide pequeña con señales de desgaste en la parte media posterior. M3 es tetralofo con tréboles simples, las cúspides

son altas y un talón representado por cúspides pequeñas, m3 tetralofo con tréboles linguales simples y cúspides pequeñas que evidencian un talón. El i2 derecho está completo, toda la superficie es lisa sin muestras de esmalte ni surcos.

INTRODUCTION

There is a wide representation of proboscideans in all the Hemphillian-Blancan deposits of the sedimentary basins located in the central region of Mexico. These have been collected during the project that began at the Instituto de Geología of the Universidad Nacional Autónoma de México (UNAM) and has continued for the last 25 years with the support of the Centro de Geociencias, UNAM. These records were collected in deposits of early-late Hemphillian to early and late Blancan age, and all the specimens are housed at the Instituto de Geología and Centro de Geociencias collections.

The gomphotheriids are an important part of these collections. The first records of *Gomphotherium hondurensis*, known outside the Tapasuma fauna, Gracias Formation in Honduras, have been described and published (Carranza-Castañeda, 2018). All these records have been collected in the Juchipila basin, Zacatecas state, Landa de Matamoros locality in the state of Queretaro and in the Tecolotlán basin, state of Jalisco. Their description has demonstrated their anatomical differences from *Rhynchotherium*, besides confirming that the origin of this genus was not in Central America; the origin may be in the late Hemphillian or early Blancan fauna from Mexico or the southern United States (Lucas and Morgan, 2008).

RHYNCHOTHERIUM IN MEXICAN FAUNAS

The first known evidence of *Rhynchotherium* comes from the state of Tlaxcala, where a jaw was collected, only a cast of which now exists (Fig. 1). Falconer (1868), proposed the genus name *Rhynchotherium* without assigning it to a species. Osborn (1918, 1921) referred the specimen to *Rhynchotherium tlascalae*. The location where it was collected is unknown, the age assigned to Pliocene and the provenance only refers to the state of Tlaxcala. At this point, it is appropriate to make a comment about where the mandible of *Rhynchotherium* described by Falconer (1868) could have been collected.

Dr. Sergio Ceballos, a paleobotanist from the Instituto de Geología, UNAM, led a project studying the lacustrine sediments that surround the town of Panotla, located in the southeastern part of the state of Tlaxcala. According to my information an upper molar of Equidae was collected there. I had the opportunity to examine and compare this fossil and it undoubtedly belongs to *Nannippus peninsulatus*, which is common in early Blancan localities in San Miguel de Allende basin. This molar is not in our collections, and that reason prevents me from illustrating it. Based on this find is it can be affirmed that early Blancan deposits are part of the stratigraphic sequence on Panotla.

In a new research project headed by Dr. Carlos Castañeda Posadas on the fossil woods from Panotla, a preliminary stratigraphic column was made from the La Mina locality of the lower part of the section where new species of trees were described. In the stratigraphy, three units with remains of plants and fish fossils, among other vestiges, were mentioned; the lower Unit a contains vertebrate remains, plants and invertebrates, in Unit c above were collected plants described as new tree species, and the three units were assigned to a Miocene age. Tentatively this is the most accurate information where the type specimen of *Rhynchotherium tlascalae* probably was collected (Castañeda-Posadas, 2004; Castañeda-Posadas, et al., 2009).

However, *Rhynchotherium* records have not been described in Miocene strata. According to Tobien (1973), Lucas and Morgan (2008), and Lucas (2010), the jaw of *Rhynchotherium tlascalae* corresponds to a *Gomphotherium*, among other features because the symphysis of *Rhynchotherium tlascalae* is deflected at an angle of less than 45 °, the same way as the records of *Gomphotherium* from Landa de Matamoros in Querétaro and Juchipila in Zacatecas that have been referred to the Miocene based on radiometric ages. (Carranza-Castañeda, 2018). Therefore, it is possible that the *Rhynchotherium* jaw described by Falconer (1868), could have been collected at stratigraphic levels equivalent to those described in the research on Panotla woods (Castañeda-Posadas 2009).

A second jaw was discovered by Barnum Brown (1911), at San Jose de Pimas, in the State of Sonora (Figure 1). Initially, Osborn (1921) considered the Sonora jaw as the neotype of *Rhynchotherium*, however, after comparing it with *Rhynchotherium tlascalae*, he reconsidered his opinion and assigned this specimen as a new species, *Rhynchotherium browni* (Osborn, 1936). The stratigraphic level and associated fauna and age of *Rhynchotherium browni* from San José de Pimas are unknown (Lucas et al., 1997).

Dalquest and Mooser (1980) mentioned from the Rancho El Ocote locality, state of Guanajuato (Catalogue number 11251), a right lower jaw referred to *Rhynchotherium* with the m1-m2 of a young animal as well as tusk fragments and isolated teeth. Another complete jaw referred to *Rhynchotherium falconeri* was described from the Las Tunas fauna in Baja California Sur (Miller, 1980). An additional complete jaw of a juvenile animal was collected in Baja California Sur; the symphysis has the same features, and the i2s have a narrow enamel band all along the tusks. This new find, based on the features of the jaw, has been referred to *Rhynchotherium falconeri*, and is described in this paper. Other records of *Rhynchotherium* have been mentioned from Rancho El Ocote fauna and other localities from central México (Carranza-Castañeda, 2006).

Other publications mention isolated teeth and tusks and jaw fragments referred to *Rhynchotherium*. However, most of these specimens were observed in museums in which the authors only mention specimens, but the information they provide is incomplete and deficient, with a lack of knowledge of the stratigraphy and stratigraphic level of each locality, in such a way that the mentioned specimens could also belong to *Stegomastodon* or *Cuvieronius* (Alberdi and Corona-M., 2005).

OBJECTIVE

The most accurate information known of *Rhynchotherium* is based on jaws and a few skull fragments. However, descriptions that include the skull and jaw of the same animal are very scarce. Due to this deficiency, different authors have reconsidered the validity of the described species (Miller, 1980, 1990; May 1981; Pasenko, 2007, 2012).

During the research projects carried out in early Blancan deposits of the central Mexico faunas, in the San Miguel de Allende basin, state of Guanajuato, a large fragment of skull and jaw were collected. The mandible presents different features: length and depth of horizontal rami, extension of the lingual canal, higher cusps in upper and lower molars with presence of a heel, and wider ventral part of the palate and other differences in the skull, features that do not appear in *Rhynchotherium falconeri* that allow detrmination of *Rhynchotherium browni* as a valid species.

In the state of Michoacán, in an early Blancan stratigraphic sequence of the Rancho la Goleta locality, a complete skull and jaw without deformation of the same animal were collected,

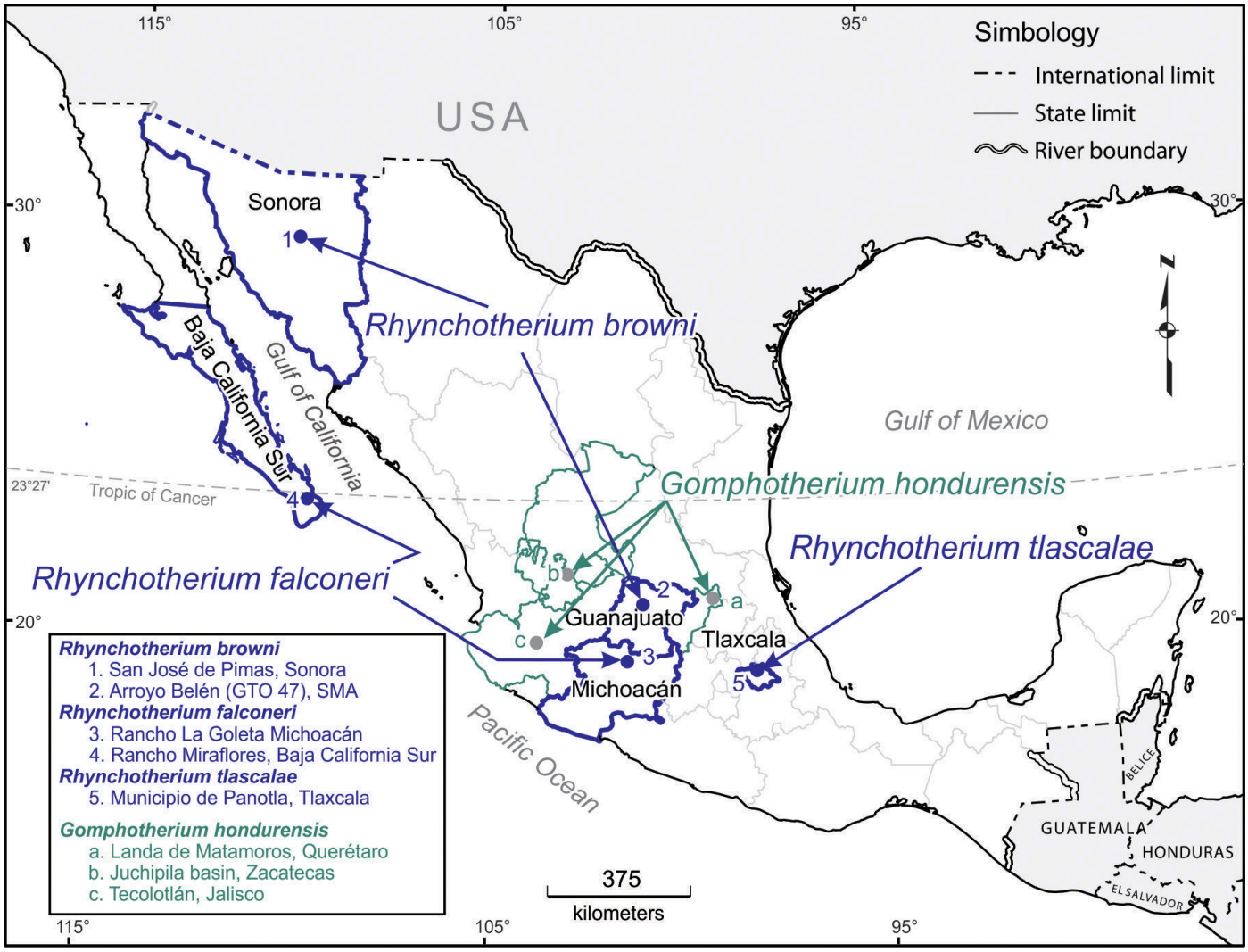

FIGURE 1. Map of Mexico, showing the states where *Rhynchotherium* was collected: Tlaxcala, "*Rhynchotherium" tlascalae*; San Miguel de Allende basin Guanajuato; San Jose de Pimas, Sonora *Rhynchotherium browni*; Rancho La Goleta, Michoacán; Baja California Sur, Las Tunas Local Fauna, area of Miraflores, *Rhynchotherium falconeri*.

which, because of the characteristics of the mandibular symphysis, has been referred to *Rhynchotherium falconeri* (Carranza-Castañeda, 1976).

The description of these specimens collected in central Mexico allows comparison of the features in jaws and skulls to establish the differences and similarities of each one of these records, and to determine the validity of the two species, based on diagnostic characters. This is the objective of the present work.

MATERIALS AND METHODS

The specimens described in this work were collected on outcrop and at a stratigraphic level by the traditional methods used in paleontology. The preparation was carried out at the Instituto de Geología and the Centro de Geociencias of UNAM, and the fossils are housed in the collections of both institutions.

Comparisons were made with specimens from the Los Angeles County Museum of Natural History (LACMNH) and the collection of the Texas Memorial Museum Vertebrate Collections at the University of Texas at Austin, New Mexico Museum of Natural History collections and illustrations in the consulted publications.

The skull and jaw measurements mentioned in the text are the maximum width and length and were taken according to figures 11.1 and 11.2 of Tassy (1996) and are in millimeters. The molar measurements are always the maximum anteroposterior length and the transverse width of the first or second lophs/lophids, and the index is the ratio of these measurements. The dimensions of each specimen are shown in tables and figures that will be mentioned in the text.

Volcanic ash of the GTO 47 locality was dated using $^{40}Ar/^{39}Ar$ (Kowallis et al., 2017). New analysis of the volcanic ash was by ^{238}U / ^{206}Pb, LAICPMS at the Laboratorio de Estudios Isotópicos del Centro de Geociencias, UNAM. The analysis of the volcanic ash from Rancho La Goleta was done in The Center of Human Origins (Carranza-Castañeda, 1991).

ABBREVIATIONS

Ap, Anteroposterior; Tr, Transverse; My, Million years; ~, Approximately; mm, millimeters; cm, centimeters; m, meters; R, Right; L, Left; AZMNH, Arizona Museum of Natural History Mesa; CGEO, Centro de Geociencias; IGM Instituto de Geología; LACMNH, Los Angeles County Museum of Natural History; LAICPMS, Ablación Láser con Espectrómetría de Masas por Plasma Inductivamente Acoplado; LVMNH, Las Vegas Museum of Natural History; NALMA, North America Land-Mammal "Ages"; NMMNH, New Mexico Museum of Natural History; MPGJ, Museo de Paleontología, Geociencias

Juriquilla; TxVP, Vertebrate Paleontology Collections, Jackson Museum of Earth History, University of Texas at Austin; UALP, University of Arizona Laboratory of Paleontology Tucson; UCMP, University of California Museum of Paleontology; UNAM, Universidad Nacional Autónoma de México, BCSM, Baja California Sur Miraflores; GTO, Guanajuato state; Mich., Michoacán state; SMA, San Miguel de Allende.

BIOSTRATIGRAPHIC SEQUENCE OF SAN MIGUEL DE ALLENDE BASIN

In San Miguel de Allende Basin, an important diversity of mammals with ages ranging from late Hemphillian (4.89 ± 0.16 My) to early Blancan (4.74 ± 0.14 My, NALMA) has been collected. The proboscideans have an important stratigraphic representation. In the late-latest Hemphillian-early Blancan, isolated teeth and jaws of *Stegomastodon* were collected in the Blanco layer (Hh4) of the Rancho El Ocote stratigraphic sequence. Besides, in early Blancan deposits of the Los Galvanes area, a significant find was made. A skull and jaw of *Rhynchotherium browni*, which is the only record known outside of San José de Pimas, Sonora, was collected. This important discovery will be described in the next paragraphs.

Los Galvanes Area

In the Los Galvanes area, early Blancan deposits of GTO 47 Arroyo Belén locality are in a tributary of the mainstream called Arroyo El Tanque. Here, an unusual find of a skull and jaw that correspond to the same animal were collected and referred to *Rhynchotherium browni*. The analysis of $^{238}U/^{206}Pb$ method gave an age of 2.96 ± 0.17 (in the text the age is referred to as 3.0 Ma). Describing this find is part of the objective of this paper.

The base of the stratigraphic sequence is the late Hemphillian locality Rinconada GTO 43, of remarkable importance due to its diversity of mammals of this age (Carranza-Castañeda, 1992, 2006, 2018; Carranza-Castañeda et al., 2013). The sequence is overlain by a 1–1.50 m thick caliche layer that represents the unconformity at the Hemphillian-Blancan boundary.

Above the discordance, early Blancan deposits contain abundant fauna of this age, and the greatest diversity of South American immigrants collected in GTO 4 Arroyo El Tanque and its tributaries, reveal the first step of the GABI with a more dynamic exchange of South American immigrants represented by the first records of *Paramylodon garbanii*, *Glyptotherium texanum* and *Neochoerus cordobae*, associated with North American mammals: *Nannippus peninsulatus*, *Equus simplicidens*, *Borophagus diversidens*, *Felis* sp. *Hypolagus mexicanus*, *Paranotolagus complicatus*, *Capromeryx tautonensis*, *Hexobelomeryx fricki*, and *Platygonus* sp. (Montellano-Ballesteros and Carranza-Castañeda, 1981, 1986; Miller and Carranza-Castañeda, 1984; Jiménez-Hidalgo et al., 2004, Gillette et al., 2016; Carranza-Castañeda, 2016).

GTO 47 Arroyo Belén

The stratigraphy of the locality GTO 47 Arroyo Belén is as follows: at the base of the sequence the bed is a gray clay with abundant carbonate concretions where the skull and jaw of *Rhynchotherium* were collected. The thickness at this site is 3 m, however, in other places the thickness is greater. This layer is covered by well sorted sand with no evidence of cross bedding with a thickness of 1.50 m. The sand layer is covered by different strata of ashy clay about 2 m thick, where the volcanic ash was collected. The analysis by $^{207}Pb/^{235}U$ gave a result of 2.96 ± 0.17 My early Blancan age (3.0 My).

The whole thickness of the stratigraphic sequence is 35 m, and the volcanic ash collected at the top gave an age of 2.6 My; these layers are covered by a caliche stratum up to 1 m-thick. All of the sequence is covered by a dark brown and reddish clay with different concentrations of sand; these layers contain the most advanced equid material. The isolated teeth and phalanx have been assigned to *Equus,* and the age has been referred to the Pleistocene.

RANCHO LA GOLETA LACUSTRINE SEQUENCE

The fluvio-lacustrine deposits of the Charo sequence are part of the east-west oriented basin that overlie the Miocene volcanic rocks of the Mil Cumbres complex. The La Goleta locality is included in the fluviolacustrine deposits of the sequence (3.6 My). The study area is located about 8 km east of Morelia city, capital of the state of Michoacán, in early Blancan deposits. Geology and stratigraphy of the entire basin have been studied in detail by Israde-Alcantara et al. (2008).

The skull and jaw were collected in an area where corn and other cereals are grown, so the stratigraphy is the result of personal observation of surrounding sites where fluviolacustrine deposits are best exposed. The base of the stratigraphic sequence of Rancho La Goleta is a series of clay strata with different amounts of fine sand, sand and ash lenses with gravel and sand paleochannels. The sample of volcanic ash was collected from this layer. This sequence is covered by very fine sediments of white color that have an approximate thickness of up two meters at its largest exposure, west of the town of Charo; local people call this sediment "Tizati" (diatomite). Layers are composed of clay, sand and gravels in different proportions, and it is at this level in a layer of medium-fine sand where the skull and jaw of *Rhynchotherium falconeri* were collected. In addition to the *Rhynchotherium* material, rodents (*Prosigmodon chihuahuensis*) lagomorphs (*Hypolagus* sp.) and molars of *Equus simplicidens* were collected in the same stratigraphic sequence.

SYSTEMATIC PALEONTOLOGY

MAMMALIA, Linnaeus, 1758
PROBOSCIDEA, Illigeri, 1811
GOMPHOTHERIIDAE, Hay, 1922
RHYNCHOTHERIUM Falconer, 1868
Rhynchotherium browni Osborn, 1936

Referred material. IGM 4862 (Fig. 2 and Table 1). The skull is poorly preserved, especially the basicranium and occipital area. The ventral part of the palate is almost complete, the right maxillary bears M2-M3 and the complete alveolus of I2, the second loph on M2 with a double trefoil; the left maxillary has M3 and two complete lophs of M2 and part of the alveolus. The basicranium is destroyed, the choanae are almost complete, the occipital region, condyles and foramen magnum are badly damaged, the frontals, parietals and part of the skull vault are crushed and incomplete, and the same occurs with part of the rostrum.

The mandible is nearly complete with two rami; the left side is well preserved, the ascending ramus ends in the condyle, the angle between the occlusal line and the anterior edge of the ascendant ramus is 107°, the coronoid process is partially missing, and the horizontal rami are stout. Left dentary with complete m3, and two lophid m2, and a complete alveolus of m1; the right sides of m3 and m2 are complete as well as the complete right i2 without evidence of enamel; the entire alveolus of m1 has some remains of enamel in situ. The lower mandibular symphysis is incomplete, and part of the posterior lingual channel is preserved.

Locality. GTO 47 Arroyo Belén, San Miguel Allende basin, Guanajuato state.

Age. Early Blancan.

Distribution. *Rhynchotherium browni* has been reported from the Pliocene of San José de Pimas, Sonora state, and this report in GTO 47 Arroyo Belen, early Blancan of San Miguel Allende basin, Guanajuato state.

Description. To preserve the specimen as well as possible, it was necessary to put a cover of fiberglass throughout the skull dorsal region, to observe the outline and shape of the cranial

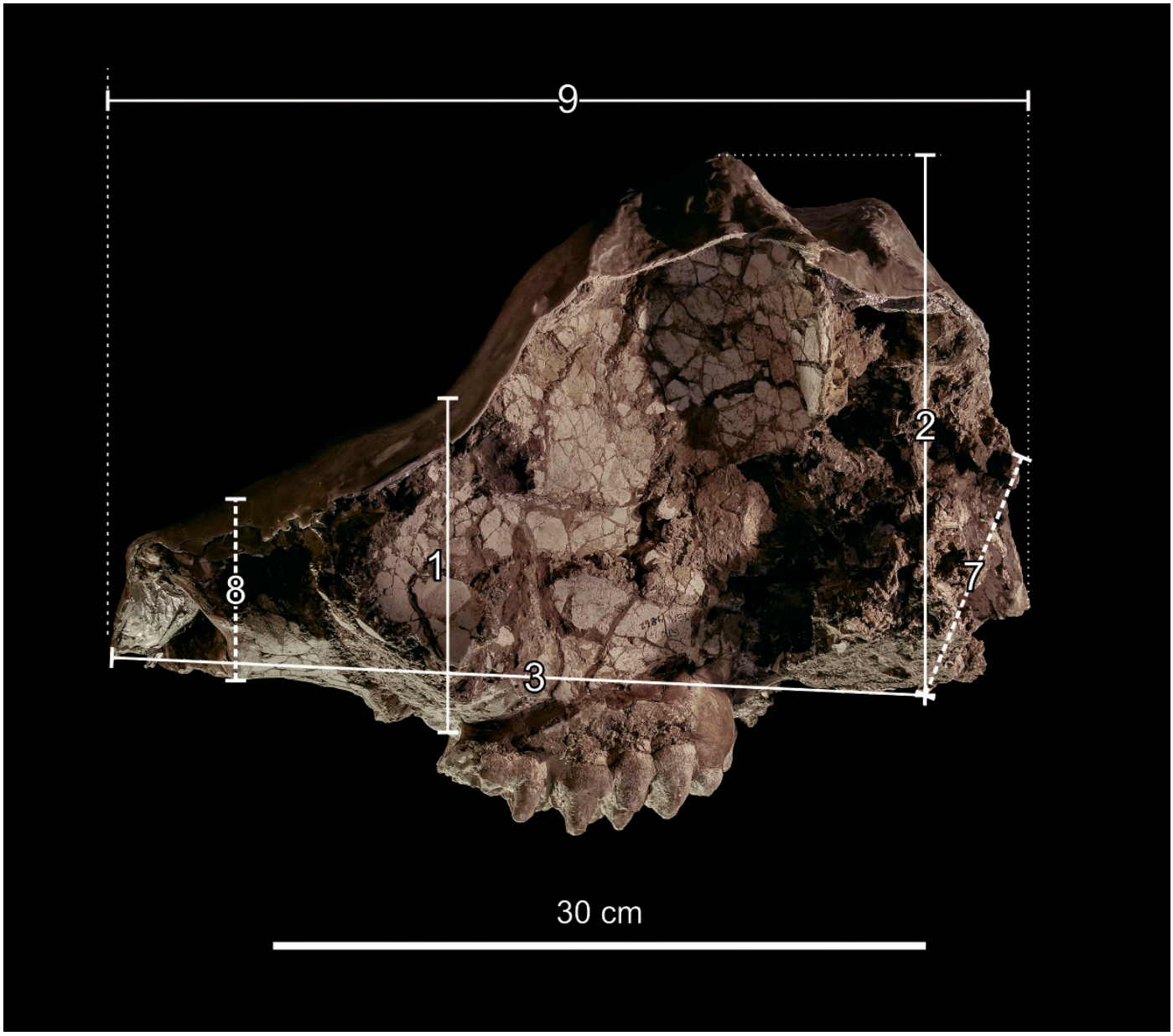

FIGURE 2. Lateral view of the *Rhynchotherium browni* cranium, IGM 4862, GTO 47, Arroyo Belén, SMA Basin, Early Blancan.

vault, and take the measurements as accurately as possible, considering the anatomical position. The left side is better preserved, although only the profile of the skull can be seen, which is short and inclined to the infraorbital foramina, the premaxillae are less inclined, the occipital condyles are slightly above the line of the maxillaries, the facial area is high and the occipital region is apparently straight. The measurements of the lateral region are illustrated in Figure 2, and the measurements are in Table 1.

Upper dentition. (Fig. 3a-b and Table 2). A shared character in all upper and lower molars is the thickness of the enamel of between 5–6 mm. In the ventral region of the skull, the premaxillaries are flattened, the left premaxillary is complete with a tubular shape, and the I2 socket is rounded with a diameter of ~105 mm. The premaxillaries are joined in their middle part throughout the palate to the anterior end without any opening. The right maxillary displays M2s and M3s that are well preserved, and there is no evidence of M1. The M2 is trilophodont, and the protoloph is partially worn, and the dentine is exposed. An unusual feature is found in the metaloph in that the lingual cusp maintains its characteristic form of trefoil, but the posttrite is elongate and has two smaller cusps on each side that show moderate wear and acquire the shape of a trefoil; the two trefoils are joined in the middle part of the loph, which implies that the metaloph is formed by two trefoils joined in the middle part by the enamel. This cusp arrangement is seen only in this specimen. The tritoloph is simple with a pretrite trefoil, and the posttrite has two small cusps. A cingulum is absent (Fig. 3b).

The M3's are completely erupted, with four well-developed lophs that have no evidence of wear as the dentine is not exposed on any cusp. The protoloph has an almost imperceptible cingulum on the anterior part that ends in the posterior part of the tetraloph. The protoloph on the lingual side has a well-defined trefoil, and the posttrite is formed by two cusps; the lingual cusp on the metaloph of left M3 is high and blunt, surrounded by two smaller cusps that form the trefoil, an additional small cusp that is in the middle posterior joint of the enamel of the posttrite, closing the valley and forming a trefoil. On the tritoloph, the lingual cusp is formed by three well-developed cusps, and the lateral cusp overlaps the central cusp, without forming a well-

TABLE 1. IGM 4862, *Rhynchotherium browni*, right lateral view of the skull (Plastic cover on top). The number in the first column corresponds with the ID of the lines shown in Figure 2.

	Description	Measurement (mm)
1	Facial height taken at the anterior grinding tooth.	~285
2	Cranial height taken from top of the cranium to the pterygoid process.	~456
3	Facial length taken from the tip of the rostrum to the pterygoid process.	~660
4	Height of the orbit temporal fossa taken from squamosal to the anterior border of the orbit.	
5	Height of the orbit.	~96
6	Height of the maxilla ventral to the process zygomaticus.	
7	Length of basicranium from the condyles to the pterygoid process.	~280
8	Height of the premaxilla.	~128
9	Maximal length taken from the tip of the rostrum to the occipital area.	~730

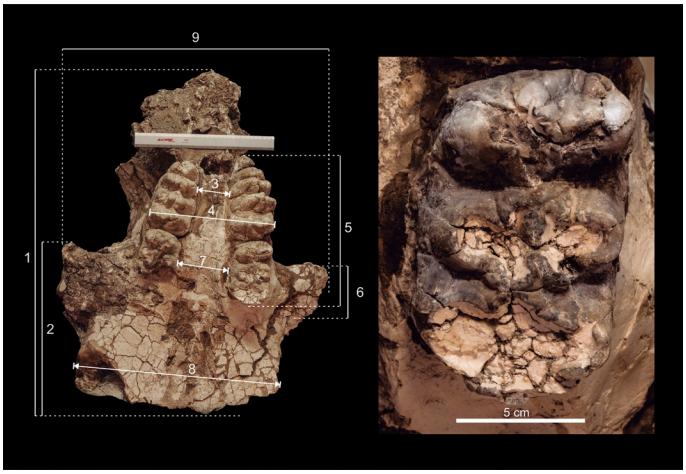

FIGURE 3. **A,** Occlusal view and **B,** M2 double trefoil of the *Rhynchotherium browni* Cranium IGM 4862, GTO 47, Arroyo Belén locality, SMA Basin, Early Blancan.

defined trefoil. On the right tooth, the lingual cusp is a columnar trefoil, and the posttrites on both sides have two aligned cusps without evidence of wear. The tetraloph with a lingual trefoil is better defined on the left side, and the posttrite has two small cusps aligned along its transverse axis; posteriorly, there is no evidence of a heel. The maxillae are slightly closer at the back, and the tritolophs of the M3s are closer in comparison with the metalophs of M2, which are almost 70 per cent as far apart. Figure 3 shows an occlusal view.

Description of the jaw. (Fig. 4, and Table 3). The jaw is nearly complete with two rami and the right i2. The coronoid process is partly missing in both ascending rami, and the horizontal rami are robust, although the right one is slightly crushed dorsoventrally between m3-m2. The distal portion of the symphysis is missing, the posterior part of the lingual groove

TABLE 2. IGM 4862 *Rhynchotherium browni,* measurements of the ventral part of the skull. The number in the first column corresponds with the ID of the lines shown in Figure 3.

	Description	Measurement (mm)
1	Maximal length taken from the condyles~ to anterior par of alveolus I2~.	782
2	Maximal anterior length taken at the zygomatic arches to alveoli I2.	327
3	Internal maximal width of the palate between third loph of M3.	110
4	Maximum width of the palate across the labial side of first lophid M3.	257
5	Length from the anterior grinding tooth m2 to the choanae.	290
6	thickness of the zygomatic process of the maxilla.	95
7	Internal width of the palate taken at second loph of M2.	118
8	Maximal width of the palate across the alveoli I2.	451
9	Maximal cranial width taken at the zygomatic arch.	592

TABLE 3. IGM 4862 *Rhynchotherium browni*, measurements of the left lateral side of jaw. The number in the first column corresponds with the ID of the lines shown in Figure 4.

	Description	Measurement (mm)
	Angle of deflection of the symphysis.	77°
	Angle of the anterior border of ascendant ramus respect to of local line.	107°
1	Maximum length from the condyle to anterior border of the symphysis.	
2	Maximum length from the condyle to the lingual cannel.	730
3	Maximum length horizontal ramus from the angle to lingual channel.	530
4	Height of the condyle from the occlusal line	289
5	Height of the coronoid process.	-
6	Maximum ventral depth of the horizontal ramus under first lophid of m2.	145
7	Maximum depth horizontal ramus posterior the third lophiid of m2.	130
8	Maximum depth horizontal ramus below the third lophid of m3.	132
9	Maximum wide of anterior part of the symphysis.	-
10	Length of the internal lingual groove.	-
11	Width of the ascendant ramus in the occlusal line.	228
12	Jaw depth below anterior alveolus m1.	153

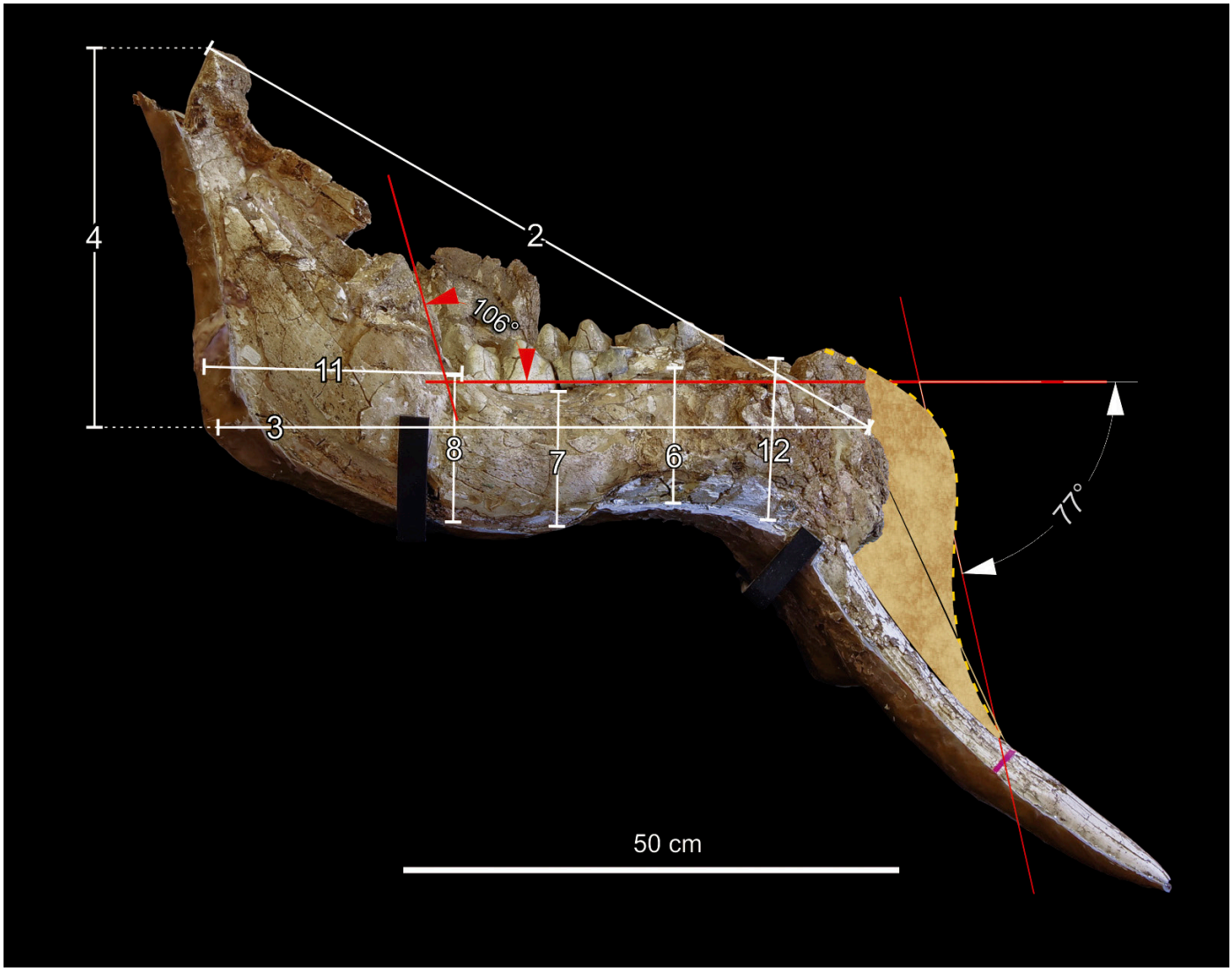

FIGURE 4. Lateral view of the Jaw from *Rhynchotherium browni*, IGM 4862; the symphysis is partially reconstructed at the front.

above i2 is 73 mm wide, and the distance from the first lophid of m2 to the lingual channel including the alveoli of m1 is 145 mm. It is remarkable that in front of the first lophid of m1, the lingual canal continues for 7 cm before beginning its downward deflection.

The continuity of the lingual canal is straight and ends in a curvature of almost 90°, suggesting that the symphysis was shorter and its deflection greater than other records described in Mexico and the USA. The left ramus has no deformation or crushing, the ascending branch is broken at the masseteric foramen, and the anterior border of the ascending ramus forms an angle of 107 ° with the occlusal line (Fig. 4).

The horizontal ramus is strong. The greatest depth under the first lophid of m1 is 153 mm, under the first lophid of m2 it is 145 mm, below the third lophid of m2 it is 130 mm and below the third lophid of m3 it is 132 mm. The maximum transverse width of the horizontal ramus across the roots of the ascending ramus of m3 is 148 mm. Two foramina are distinguished on the lingual side; the upper one is 82 mm in front the anterior lophid of m2 and below the alveolus of m1, and the other foramen is in the half of the symphysis fragment 132 mm from the anterior end.

Lower dentition. (Fig. 5, and Table 4). The alveoli of m1 are present in the two rami, the m1 is extremely worn with three lophids, and the Ap length is ~90 mm. The right m2 is well preserved, the labial enamel of the protolophid is partly missing in a concave structure, and dentine covers all of the surface. The metalophid and the tritolophid in the lingual cusp have slight evidence of wear, and in the posterior half of the tritolophid an additional small cusp with evidence of wear is located. The maximum Ap length is 130 mm, the width across the second lophid of the right m2 is 80 mm with an index of 6, and the depth of the horizontal rami below the m2 is 130 mm.

The first three lophids of the m3 are fully formed, and on the labial side the trefoils are simple without accessory cusps and with open valleys. The tetralophid is unerupted, however, the labial hemilophid has a well-defined trefoil structure. The X Ray taken of the jaw shows the small heel defined by two small conids at the back of the tetralophid. The Ap length is 193 mm, and the protolophid is 84 mm wide with an index of 4.3. The cingulum is weak and located only on the anterior part of the protolophid; the height of the posttrite is 70 mm, and in the metalophid is 68 mm; the trilophid and tetralophid are unerupted and in the alveolus.

The right side of the jaw retains the only tusk that is complete and well preserved. It has no enamel or evidence that it had during life. The posterior part has a uniform, smooth surface throughout its length. Along the last 18 cm from the tip, regular wear is evident, and the tusk is almost smooth. The length is 450 mm measured from the alveolus in the inner part of the

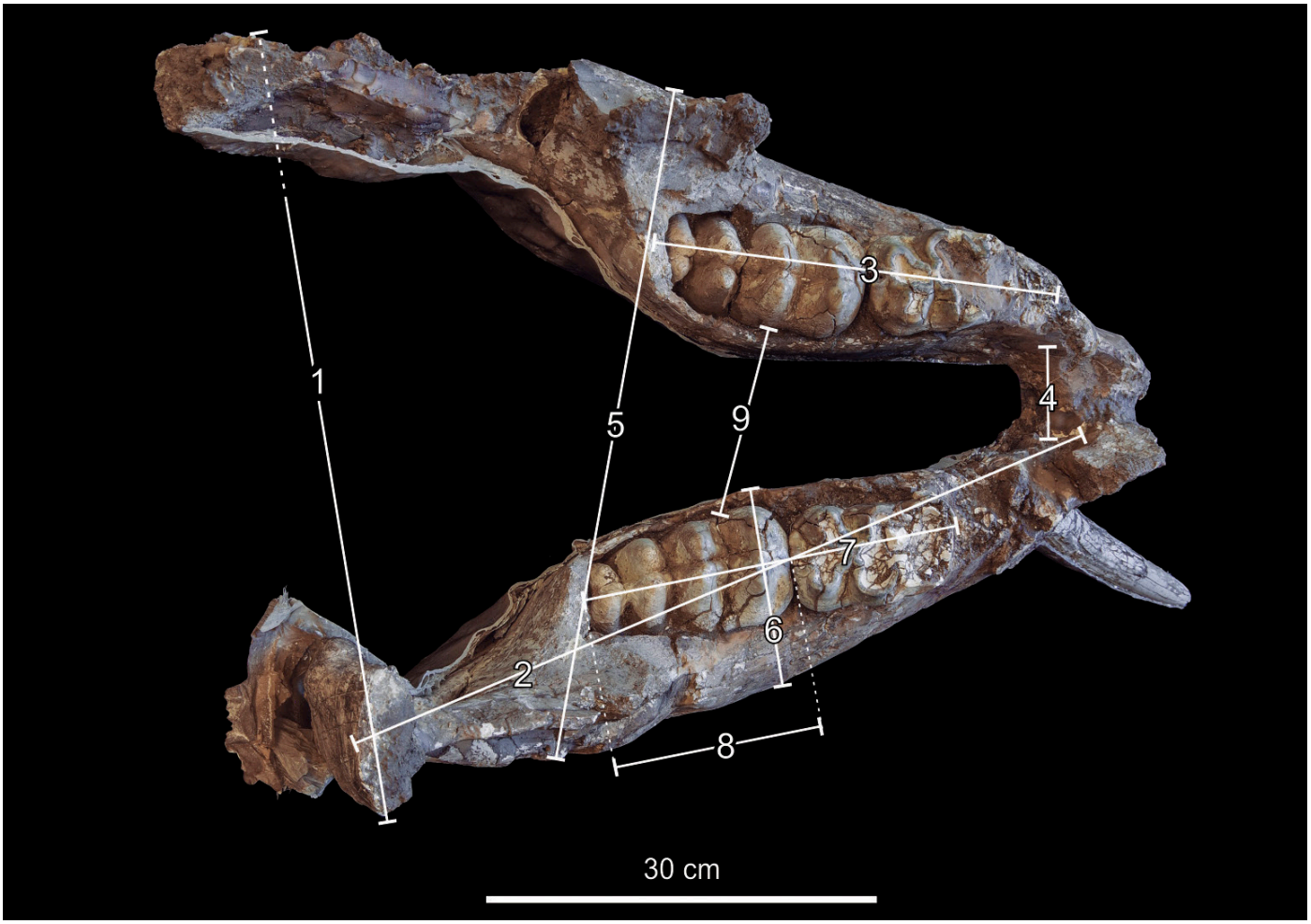

FIGURE 5. Occlusal view of the *Rhynchotherium browni* jaw, IGM 4862. (The lines are the projection where the measurements were taken).

incomplete symphysis to the tip. It has an ovoid cross-sectional shape, and on the last 18 cm the inner side is flatter, and the anterior end acquires a triangular shape due to natural wear and ends at a flattened tip, shaped like a chisel. From the outer side of its base, the sockets display signs of their divergence of 15 cm from the midline in an adult form, which implies that the separation of the tips would be 30 cm when the adult age was reached (Fig. 5, Table 4).

In gomphotheriids, where the posterior root of i2 ends is considered an important character. In *Gomphotherium hondurensis*, i2 ends before anterior edge of the symphysis (Carranza-Castañeda, 2018). This characteristic has also been mentioned in *Rhynchotherium falconeri,* where the end of the i2 is posterior to the lingual groove (Pasenko, 2007, 2012). Due to the importance of the position of the i2 roots in *Rhynchotherium*, an X-Ray was taken of the jaws of the specimen collected in GTO 47 Arroyo Belen and revealed that the i2 ends posterior to the symphysis border, almost under the first lophid of m1, as mentioned in the description of *Rhynchotherium falconeri* from Arizona (Pasenko, 2007, 2012). This characteristic should be considered important in the diagnosis of *Rhynchotherium* (Fig. 6).

RHYNCHOTHERIUM Falconer, 1868
Rhynchotherium falconeri Osborn, 1923

Referred material. IGM 11432, skull and jaw of the same animal, collected at the same stratigraphic level, locality Rancho La Goleta, state of Michoacán, early Blancan age. MPGJ 3532, jaw of a young individual, BCSM 43. MPGJ 5231 complete I2.

TABLE 4. IGM 4862 *Rhynchotherium browni,* ventral view of the jaw. The number in the first column corresponds with the ID of the lines shown in Figure 5.

	Description	**Measurement** (mm)
1	Distance between the condyles.	472
2	Maximal length from the anterior border of lingual channel to the condyle.	722
3	Maximal length from the posterior border of alveolus de m3 to anterior border of m1.	370
4	Posterior width of the lingual channel.	68
5	Maximum width of the jaw across at the roots of ascendant rami.	435
6	Maximum transverse width of the horizontal ramus in first lophid m3.	136
7	Maximum lenght m2-m3.	319
8	Maximum length m3.	195
9	Maximum lingual width between the second lophid m3.	145
10	Maximum width horizontal ramus in the rooth of ascendant ramus.	148

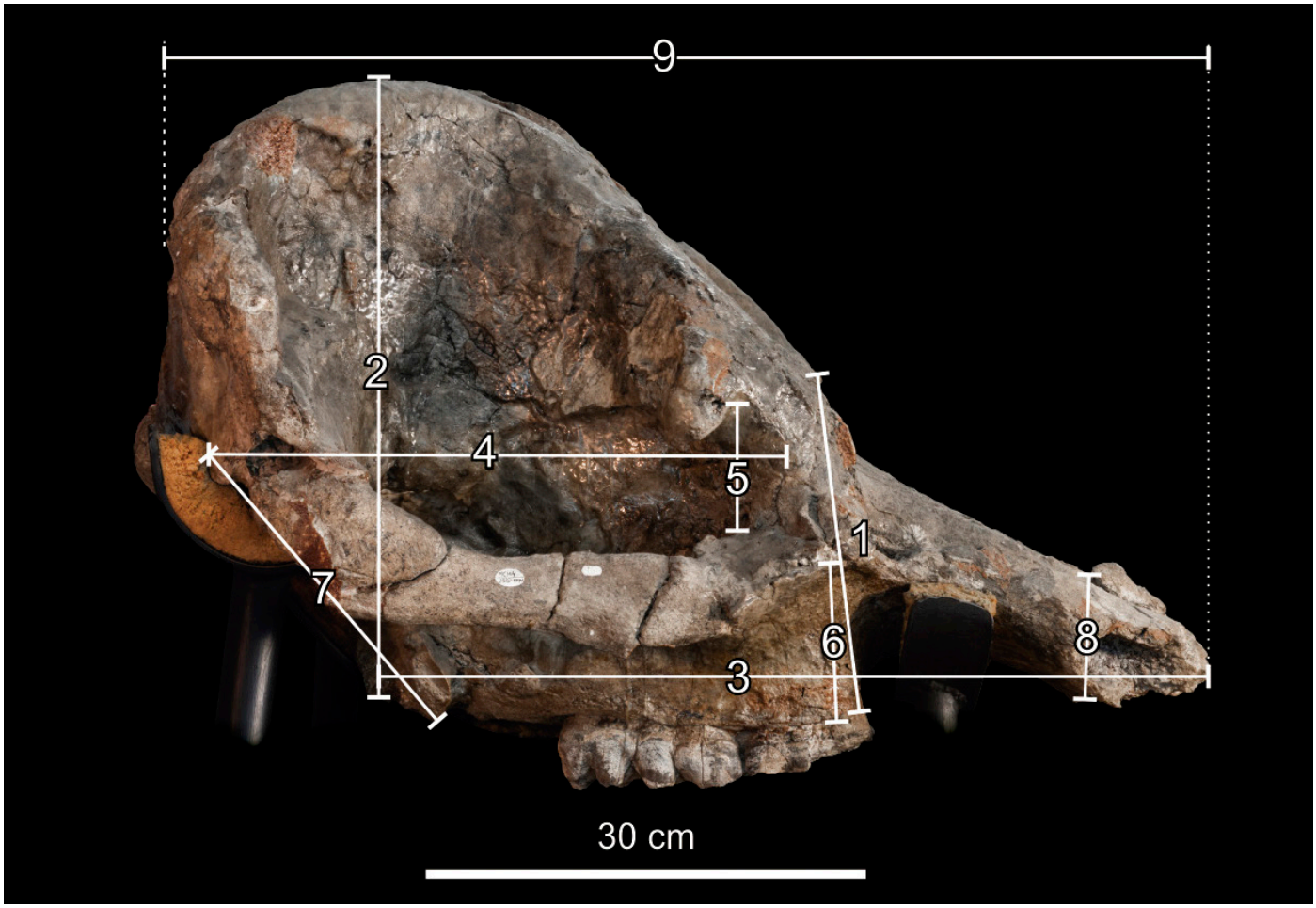

FIGURE 7. Lateral view of *Rhynchotherium falconeri,* IGM 11432.

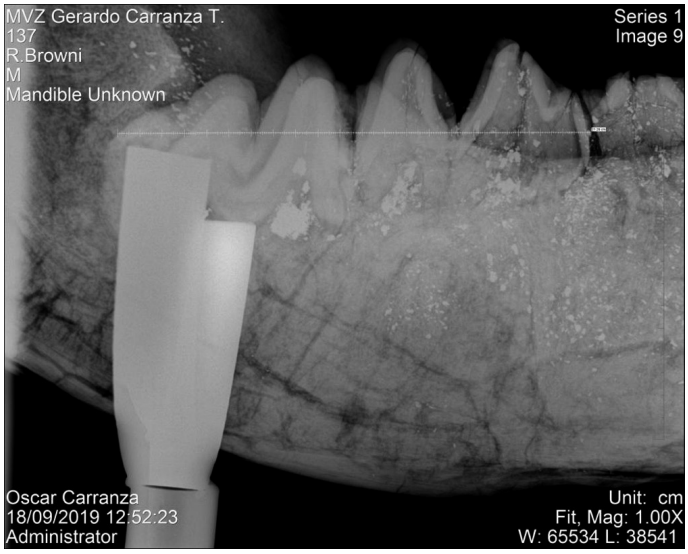

FIGURE 6. Xray radiography of the M3 from *Rhynchotherium browni*, IGM 4862.

TABLE 5. IGM 11432 *Rhynchotherium falconeri,* lateral view of the skull. The number in the first column corresponds with the ID of the lines shown in Figure 7.

	Description	**Measurement** (mm)
1	Facial height taken at the anterior grinding tooth.	319
2	Cranial height taken from top of the cranium to the pterigoid process.	494
3	Facial length taken from the tip of the rostrum to the pterigoid process.	690
4	Length from condyles to the anterior border of the orbit.	338
5	Height of the orbit.	90
6	Height of the maxilla ventral to the process zygomaticus.	134
7	Lenght of basicranium from the condyles to the pterigoid process.	286
8	Height of the premaxilla.	~85
9	Maximal length taken from the tip of the rostrum to the occipital area.	840

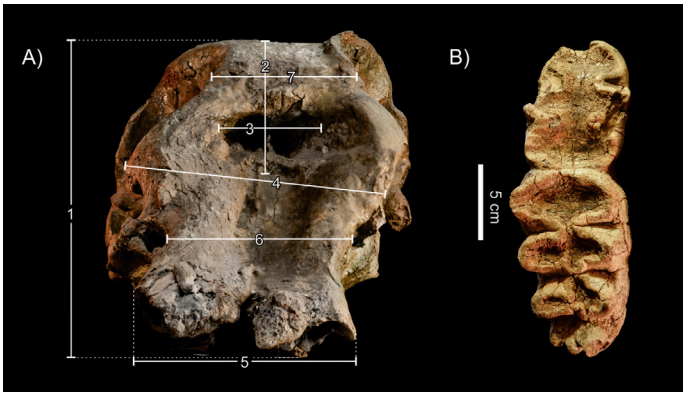

FIGURE 8. **A,** Anterodorsal view and **B,** molar M2-M3 of *Rhynchotherium falconeri*, IGM 11432.

TABLE 6. IGM 11432 *Rhynchotherium falconeri*, antero-dorsal view of the skull. The number in the first column corresponds with the ID of the lines shown in Figure 8A.

	Description	**Measurement** (mm)
1	Maximal length taken from the occipital border to the alveolus of I2.	840
2	Length of the cerebral part.	230
3	Width of the nasal bones upon the nasal fossa.	210
4	Maximal supra orbital width.	395
5	Anterior rostral width.	324
6	Posterior rostral width taken between the infraorbital foramina.	305
7	Minimum cerebral width between the temporal lines.	237
Posterior part of the skull		
8	Sagittal height of the occipital.	388
9	Maximum width of the occipital.	548

MPGJ 5231 BCSM 40, fragment of I2.

Age. Early Blancan, 3.6 My.

Description. In specimen IGM 11432 (Fig. 7, Table 5), the skull is complete, only the left zygomatic arch is missing. The I2s are not in the alveoli; two fragments were collected, the longest is 45 cm, very eroded without evidence of enamel. The jaw is complete without deformation, and the complete symphysis is deflected downward at an angle of 61°. The horizontal rami are deep and stout. The i2 tusks are included in the alveoli, and the enamel is moderately preserved on the labial side. The teeth are very worn, signifying that the specimen corresponds to an old individual. M2s/m2s with three loph/lophids and M3s/m3s with fourth loph/lophs with simple trefoil's and posttrite without accessory cusps.

In antero-dorsal view, the skull has a slight distortion to the left side, but this feature does not affect the structures except for a slight fold in the left parietal. The lateral profile is low, the occipital region is almost straight and slightly sloped to the anterior, the occipital is faintly concave and the entire skull has a moderate dome shape. The nasal bone is faintly shifted to the left. The tusks are out of the alveoli, and only two extremely eroded fragments were recovered. The largest fragment has small traces of enamel no larger than five cm long and just one-

TABLE 7. IGM 11432 *Rhynchotherium falconeri,* jaw lateral right side. The number in the first column corresponds with the ID of the lines shown in Figure 9.

	Description	**Measurement** (mm)
	Angle of deflection of the symphysis.	61°
	Angle of the anterior border of ascendant ramus respect to occlusal line.	90°
1	Maximum length from the condyle to anterior border of the symphysis.	840
2	Maximum length from the condyle to the lingual cannel.	590
3	Maximum length horizontal ramus from the angle to lingual channel.	-
4	Height of the condyle from the occlusal line.	264
5	Height of the coronoid process.	187
6	Maximum ventral depth of the horizontal ramus under first lophid of m2.	212
7	Maximum depth horizontal ramus posterior the third lophiid of m2.	198
8	Maximum depth horizontal ramus below the third lophid of m3.	158
9	Maximum wide of anterior part of the symphysis.	124
10	Length of the internal lingual groove.	255
11	Width of the ascendant ramus in the occlusal line.	223

centimeter wide without evidence of twisting.

The upper part of the skull is shaped like a moderately high dome, the nasal and frontal bones form a relatively flat surface that is inclined at 40° with respect to the occlusal line, and the rostrum is large. The level of the condyles is almost the same as the upper part of the orbit, and the occipital is almost straight.

The premaxillae are joined by a deep concave depression where the tubular-rounded alveoli are located. In their anterior part, the premaxillae are separated by an aperture of approximately 10 cm, and at the end of the left alveolus in the inner part there is a rough prominence for possible muscle insertion. The alveoli of the tusks have a rounded shape, and, based on their position in the premaxillae, it is assumed that they were divergent from the alveoli. The width of the premaxilla is 375 mm, narrower than the 428 mm of *Rhynchotherium browni* (Fig. 8a, Table 6).

In the back of the skull, the exoccipital is flat to slightly concave, and only the condyles protrude faintly. The width is 548 mm, and the upper part is 388 mm high and almost straight. The upper part of the occiput is faintly directed forward, and the lambdoid crest is lower.

Upper dentition. The maxillae are almost parallel. Each maxilla bears two teeth, M2 and M3, and both are aligned on an anteroposterior axis. The M2 is trilophid and very worn. The dentine covers all the occlusal surface, but it is more exposed on the protoloph and decreases towards the tritoloph. This wear corresponds to that of an old individual. On the protoloph the enamel is well preserved lingually. The M3 is tetralophid, and the trefoils are well-defined on the lingual side of the second and third lophs, but they do not have accessories cones in the posttrites. The fourth loph is formed by an oval cusp on the

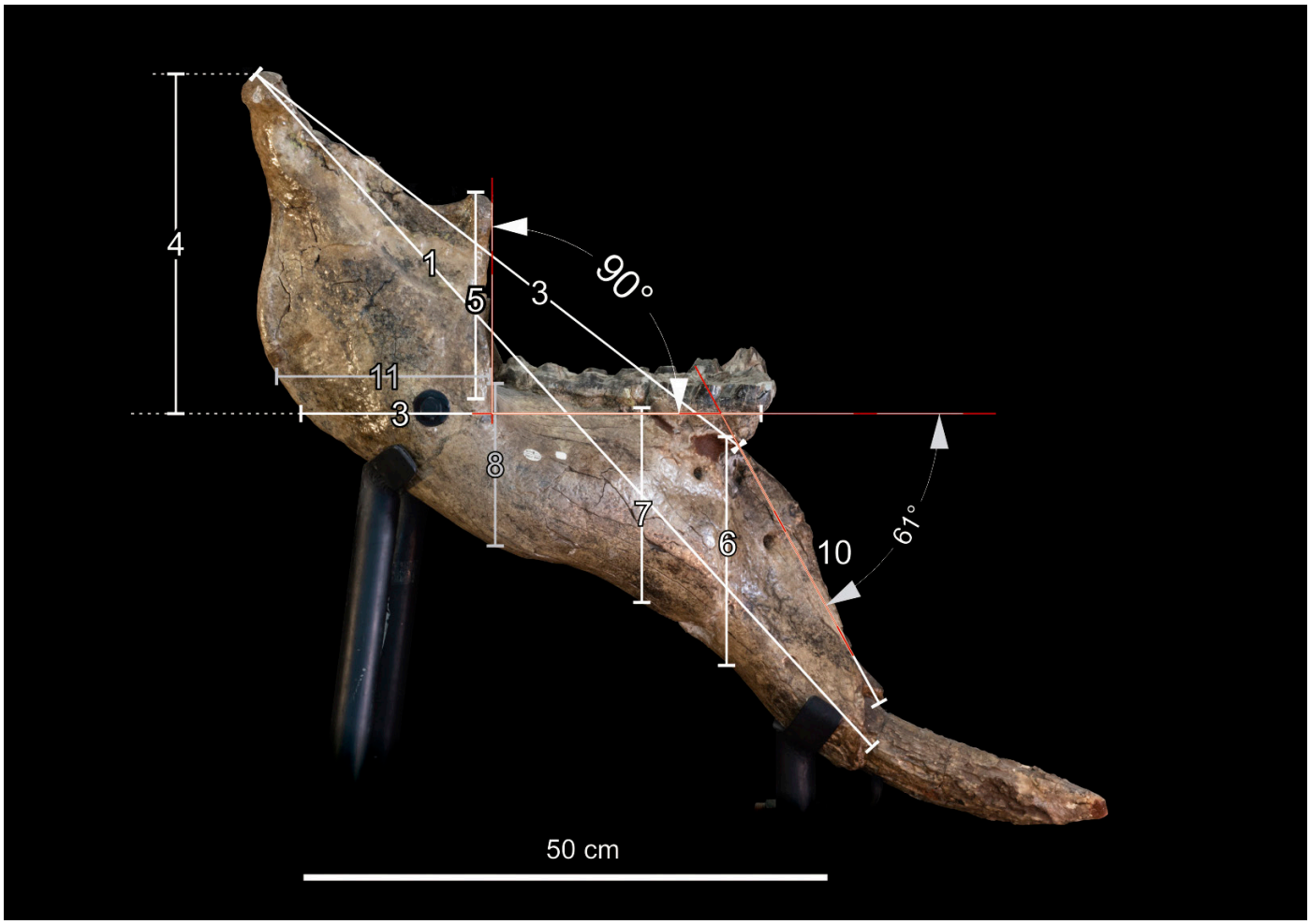

FIGURE 9. Lateral view of the jaw from *Rhynchotherium falconeri*, IGM 11432, the measurements are shown in Table 7.

TABLE 8. IGM 11432, *Rhynchotherium falconeri,* measurements and anteroposterior view of the jaw. The number in the first column corresponds with the ID of the lines shown in Figure 10.

	Description	**Measurement** (mm)
1	Maximal distance between the condyles.	485
2	width of the jaw from the root of the horizontal ramus.	387
3	Width of the symphysis below the anterior lophid of m2.	65
4	Uppermost posterior internal width of the lingual channel.	49
5	Maximum anterior part of the lingual channel.	50
6	Maximal width of the anterior part of the symphysis.	132
7	Width of horizontal ramus taken at the root of ascending ramus.	145
8	Length of the lingual channel.	256

lingual side, and the posttrite is formed by two small cusps. There are no posterior cusps to form a heel (Fig. 8b)

The jaw. (Figure 9; Table 7) IGM 11432 Rancho la Goleta is the best-preserved specimen that displays the characteristics that have been described for *Rhynchotherium* (Osborn, 1936; Miller, 1990; Pasenko, 2007; Lucas and Morgan, 2008).

The mandible is complete without distortions modifying its features, and with two rami that hold the complete tusks. The condyles are complete and separated by 485 mm; the anterior edge of the ascending rami forms an angle of 90° in relation to the occlusal line, and ends at the coronoid process, which is lower than the condyle; the posterior border has a prominent mandibular angle and ends in the massive and blunt condyle.

The root of the ascending ramus has a 145-mm width. The horizontal ramus is deep and stout, and a special feature is the ventral edge with an inclination of 25° in relation to the occlusal line. This characteristic causes the depth of the horizontal ramus to change at different points. The deepest part is 212 mm below the protolophid of m2. Between the third lophid of m2 and the anterior part of the m3 its depth is 178 mm, and at the third lophid of m3 the depth is only 158 mm. Three mental foramina are present in the dentary; the upper is located under the middle of m2, another in the middle of the beak and the lowest in the end of the symphysis.

The most important character of the jaw that differentiates *Rhynchotherium* from other gomphotheriids is the symphysis, which is stout and directed forward and downward. In the specimen from La Goleta (IGM 11432) the symphysis is deflected at an angle of 61°, immediately at the base of the protolophid of

m2. The lingual groove is found all along the symphysis, and it is slightly narrower and deeper (65 mm) posteriorly and wider and shallow at the anterior end. The length of the lingual channel is 256 mm. The anterior part of the beak is oval-rounded, and the alveoli are in the base of the lingual groove (Fig. 10 Table 8).

The alveoli of the tusks begin almost together in the anterior part of the symphysis, but the tips rapidly start to diverge, and the maximum is 15 cm from the midline. The shape of the tusks is oval, the anteroposterior axis in the right tusk is 63 mm, the Tr is 50 mm and the length of the entire tusk is 243 mm. The enamel is represented by small, narrow fragments along the tusk, and the main part of the enamel was lost during fossilization. The fluting channels are about 8 mm wide and cover all the surface, and each tusk has a flat, chisel-like end.

The ascending ramus is complete, and the anterior edge is straight at 90° from the occlusal surface and ends in the thin coronoid process that is lower than the condyle. The angular edge of the horizontal rami of the jaw is very pronounced and ends above the occlusal line.

Lower dentition. (Fig. 11, Table 9) The m2 has three lophids with strong evidence of wear. The dentin covers the internal surface of each lophid. The enamel limits the outline of the lophids, and only in the protolophid is there a well-defined trefoil; another important feature is the lower height of the cusps. The m3 is tetralophid, and the lophids of m2 also have great wear, with the dentine exposed, and the low height of the cusps is remarkable. The tetralophid is reduced, with the labial cusp elongated and the posttrite with two small conids. There is no evidence of accessory cusps between the lophids, and there are only small conids at the back of the tetralophid without forming a heel.

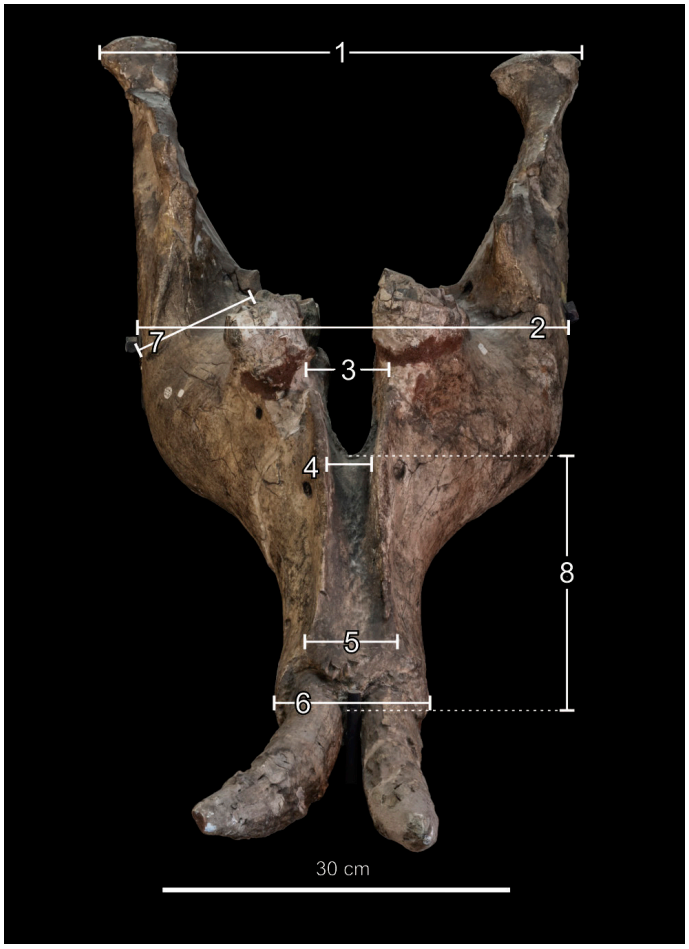

FIGURE 10. Anteroposterior view of the jaw from *Rhynchotherium falconeri*, IGM 11432, measurements are shown in Table 8.

TABLE 9. IGM 11432 *Rhynchotherium falconeri*, measurements of the lower jaw. The number in the first column corresponds with the ID of the lines shown in Figure 11.

	Description	**Measurement** (mm)
1	Distance between condyles.	485
2	Maximal length from the anterior border of lingual channel to the condyle.	620
3	Maximal length from the posterior border of alveolus of m3 to anterior border of m1/m2.	269
4	Posterior width of the lingual channel.	55
5	Maximum width of the jaw across at the roots of ascendant rami.	385
6	Maximum transverse width of the horizontal ramus in first lophid m3.	112
7	Maximum length m2-m3.	272
8	Maximum length m3.	154
9	Maximum lingual width between right the second lophid m3.	62
10	Maximum width horizontal ramus in the heel of m3.	145

It is notable that the upper and lower molars of *Rhynchotherium falconeri* have very much lower cusps. It is certainly an old individual, but the preservation of enamel on M3/ m3, is complete even with strong wear, which suggests that the cusps of the lophs/lophids were not so high during the animal's life.

BAJA CALIFORNIA SUR

In the Las Tunas Local Fauna, Baja California Sur, the first record of *Rhynchotherium falconeri* from Mexico was described. The most relevant element is a jaw with m2-m3 of an old individual. The horizontal rami, part of the ascending ramus, the part of the symphysis and partial tusk with enamel fragments are associated material of *Rhynchotherium* (Miller, 1980). Although in a new study area in Miraflores, in deposits of early Blancan age, there is evidence of proboscideans, the most important is the locality BCSM 41 Rhynchos, where the most significant material has been collected and referred to *Rhynchotherium falconeri.*

The stratigraphy of the Rhynchos locality is very general. The fossils have been collected in a "channel" located at the top of The Refugio Formation of marine origin, with abundant material of bivalves, abundant gastropods and remains of marine mammals. The layer where the fossil was collected is a clay layer approximately 3 m thick, and some small faults are exposed at the locality

Referred material. The most important fossil collected at the locality is the specimen MPGJ 3532, a jaw from a young individual (Fig. 12). The symphysis is deflected 60° and presents two depressions that are interpreted as alveoli for dp4. The horizontal ramus is stout with a 72-mm depth under the metalophid of m2. The anterior border of the ascending ramus is 90° with respect to the occlusal line and ends in the flat coronoid process, which is 72 mm high. The width of the ascending ramus in the root is 134 mm, and the posterior border ends in the condyle that is 148 mm high.

The dm1 is complete and trilophid, with three well-defined trefoils on the labial side, has clear wear, Ap length of 69 mm and

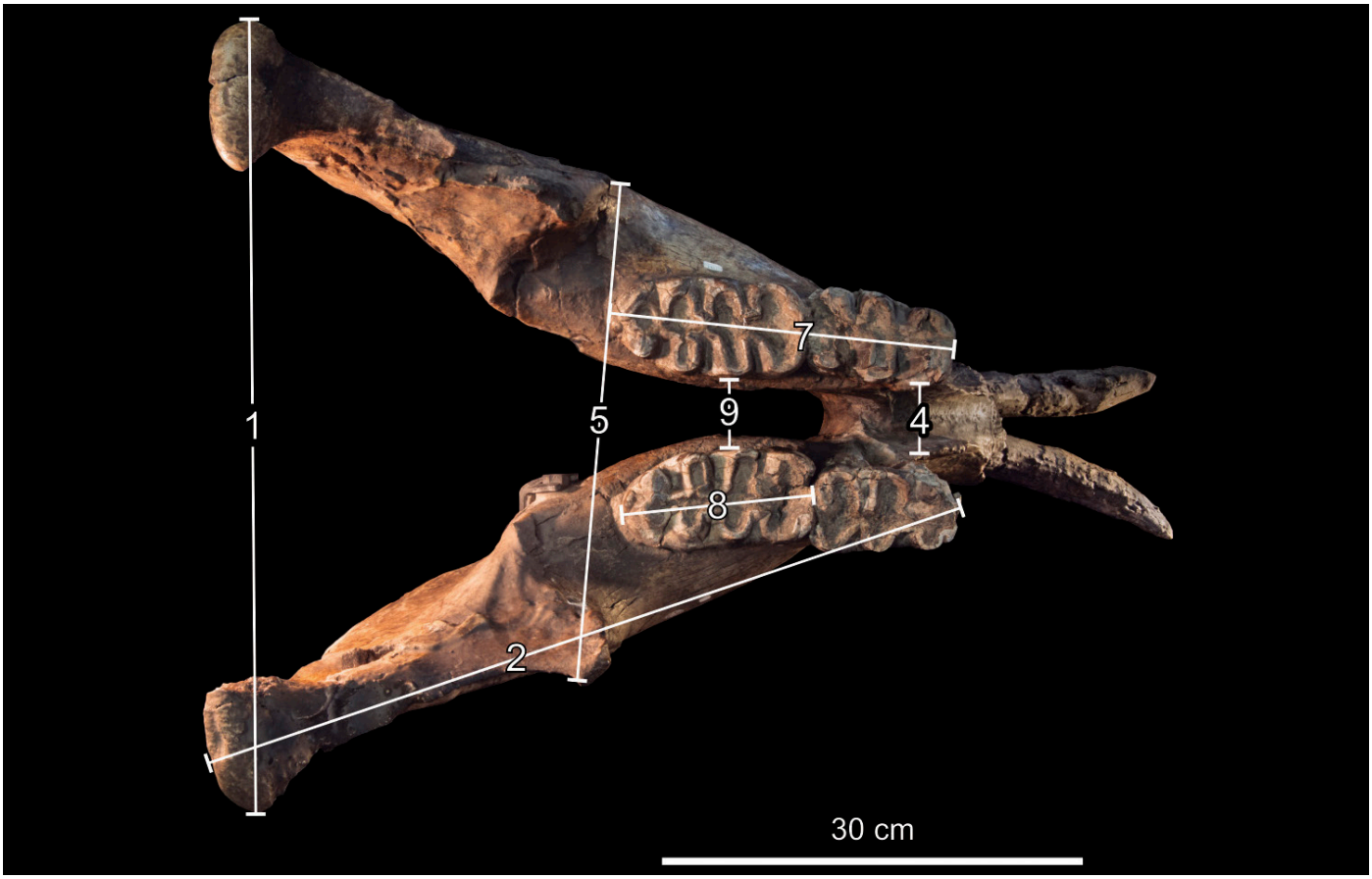

FIGURE 11. Occlusal view of the jaw from *Rhynchotherium falconeri*, IGM 11432, measurements are shown in Table 9.

Tr of 49 mm of the metaloph. The m2 is trilophid, with simple trefoils without accessory cusps. The depth of the horizontal rami below m2 is 72 mm. The m3 is unerupted, developing in the base of the ascending ramus, and the X Ray shows four lophids and a small cusp at the posterior end (Fig. 12)

The i2s are complete, with an oval shape, and they are 194 mm long with Ap of 28 mm and Tr of 24 mm. The enamel band is 18 mm wide and is inserted within the symphysis; during fossilization, small parts of the enamel along the tusk have been lost, and a deep groove appears in their place.

The specimen MPGJ 5231 is a complete and slightly curved upper tusk. The length from the root to the anterior end is 128 cm, it has an oval shape with a 98-mm width across its major axis and a 79-mm transverse width, with an outward curvature, and all of the surface is smooth without grooves. The enamel band is 60 mm wide and is twisted in a clockwise direction. The specimen MPGJ 5232 is a tusk fragment with an oval shape and part of the root. The length is 82 cm, with an enamel band of 63 mm width, without groove or channels.

DISCUSSION

The taxonomic history of *Rhynchotherium* has been widely discussed by different authors (Frick, 1933; Miller, 1980, 1990; Webb and Perrigo, 1984; Lambert, 1996; Pasenko, 2007, 2012; Lucas and Morgan, 2008), and it is not within the scope of this document to revise taxonomy. Appropriate comparison will be made with specimens from Blancan-Irvingtonian faunas: UALP 23404, University of Arizona, Laboratory of Paleontology; LVMNH 871 from Greenlee County, Arizona and housed in Las Vegas Museum Natural History; AZMNH 3708 Arizona Museum of Natural History, Mesa; UF/FGS 5450 from Bone Valley Florida and *Rhynchotherium edensis* from the Warren Local Fauna.

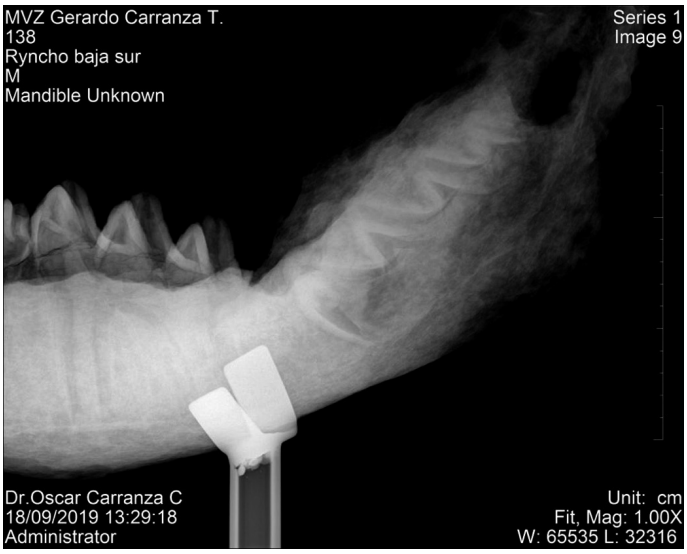

FIGURE 12. Xray radiograph of *Rhynchotherium falconeri*, MPGJ 3532, BCS M 41 Rhynchos locality, note the unerupted M3 in the ascendant ramus.

TABLE 10. Comparison of upper and lower molar measurements of *Rhynchotherium* from central Mexico. Abbreviations: met- metalophid; proto- protolophid.

	Rhynchotherium browni					***Rhynchotherium falconeri***				
	M2		M3		INDEX	M2		M3		INDEX
Upper molars										
Maximum Ap length	Right	134	Left	170	5.1	Right	107	Right	143	5.8
Maximum Tr width	Met	82	Proto	89		Met	82	Met	84	
Lower molars										
Maximum Tr length	Right	130	Right	~193	4.3	Left	121	Left	156	5.3
Maximum Tr width	Met	77	Met	84		Met	77	Met	84	
Tusk right		430					230			
Ap/Tr		53/55					52/49			
Protolophid height				68					35	
Metalophid height				73					34	

The comparison between the two *Rhynchotherium* specimens collected in early Blancan deposits located between parallels 19°–21° N, in central Mexico preserve the characters that have been considered diagnostic of *Rhynchotherium*. However, some differences between the two Mexican specimens are remarkable, including the variation in size of different structures, specifically the depth of the horizontal rami (Figure 9). The separation of the mandibular rami is evident by the lingual distance between the third lophids of m3, which is reasonably objective because the jaws are normally united by the symphysis (Fig. 5). These observations reveal that in *Rhynchotherium* features have a wide range of variability, and this raises new questions about the consistency and taxonomic value of some of them.

The *Rhynchotherium* specimens were referred to two different species because there are differences between them that justify this assignment. Among these dissimilarities, and as is shown in Figure 4, it is remarkable that the mandible of *Rhynchotherium browni*, in front of the protolophid of m1, has a straight extension of the lingual canal of about 7 cm that ends in a smooth curvature where the symphysis is broken. This feature has only been described in jaw W.T. 1113 from the latest Hemphillian of Christian Ranch fauna, where the lingual channel is 75 mm in front of the anterior border of m2 (Savage, 1955). This character has not been mentioned in *Rhynchotherium falconeri* from Arizona, nor in the Rancho La Goleta jaw, in which the symphysis is deflected 61° immediately below the protolophid of m2, as seen in the juvenile jaw MPGJ 3532 that retains the possible alveoli of dp4 (Fig. 9).

Another difference in *Rhynchotherium falconeri* (IGM 11432) is the jaw, which is smaller, however, the most relevant difference is in the ventral border of the horizontal rami that have a significant inclination of 25 degrees in relation to the occlusal line. This feature implies that the horizontal rami are deeper, thicker and acquired a "triangular" shape of the symphysis, having its maximum depth under the metalophid of m2, 212 mm, and is reduced progressively toward the fourth lophid of m3, 158 mm; however, the ramus is deeper than in *Rhynchotherium browni*. Pasenko (2007) listed the depth of the ramus below m2 in *Rhynchotherium falconeri* from faunas of North America, and in IGM 11432 the depth under m2 is deeper, 198 mm, close in depth to UALP 23404 with 194 mm and LVMNH 871 with 190 mm. Other records of the depth are less, including cf. *Rhynchotherium edensis* described from deposits of late Hemphillian age, with 167 mm. In contrast, in *Rhynchotherium browni* from San Miguel de Allende the depth under the first lophid of m2 is 145 mm, which represent a considerable difference from IGM 11432, *Rhynchotherium falconeri* from Mexico, and records from North America

The cusps of M2 in *Rhynchotherium browni* are higher, but the most notable difference is found in the complete right M2 where the lingual cusp of the metaloph is a well-defined trefoil, but the posttrite prolongs the middle part of the hemiloph and has two lateral cusps. The wear of the molar shows two trefoils joined in the middle part by the enamel of each one of these trefoils (Figure 3b). This feature is an important difference, because in *Rhynchotherium falconeri* from México, the cusps are simple trefoils, and the posttrites do not have accessory cusps. Compared with records from North American faunas some similarities are observed; in specimen LVMNH 871 the posttrite has an incipient trefoil in m2; it is important to point out that the geological age is referred to late or latest Blancan (Miller, 1980). However, UALP 23404 of late Blancan age from 111 Ranch, presents a double trefoil pattern in m3. The geological age of *Rhynchotherium browni* is 3.0 My, and the age could be the basis of the difference.

One more difference between the Mexican species is found in the size of the m3. The size of the IGM 11432 specimen from Rancho La Goleta is smaller, with an Ap of 156 mm and a Tr of 84 mm. The study about sexual dimorphism in *Rhynchotherium* (Pasenko, 2012) suggests the possibility that m3 with lengths between 153-176 mm could correspond to females. Taking into consideration this possibility, the difference in size of m3 is a character of sexual dimorphism, then perhaps the explanation of the smaller size of IGM 11432 is that the specimen represents a female.

The M3s/m3s of IGM 11432 from La Goleta, besides the short length of m3, have cusps that are lower (Figs. 8b, 9). The size and height of the cusps could be related to the strong natural wear, where the enamel maintains the contour of the lophids. In IGM 11432 from La Goleta the height of the protolophid is barely 35 mm, and the metalophid is 34 mm on the lingual side. It is remarkable the difference in height between the two specimens, which indicates the *Rhynchotherium* from La Goleta is an adult animal. Note the size of the cusps of IGM 11432, *Rhynchotherium browni* from SMA, in which the protolophid is 68 mm and the metalophid is 73 mm, nearly 50% larger.

In comparison with the records from American faunas, the heights of the cusps are in the range of average; in UALP 23404 the metalophid is 48.3 mm, and the tritolophid is 52.5 mm (Pasenko, 2007). The difference in height with the specimen IGM 11432 from La Goleta is remarkable. The wear of the cusps possibly is part of the explanation of the height of the cusps, but the preservation of enamel in the outline of m3 suggests that perhaps the molars of *Rhynchotherium falconeri* from La Goleta were more brachydont with lower crowned than in *R. browni*.

More additional differences of IGM 11432 are in m3, which has only three well-defined lophids with trefoils in the labial hemilophid; the fourth lophid is narrow, represented by a reduced oval labial cusp and two small cusps that form the posttrite, and does not have any other accessory cusps posteriorly forming a heel (Fig. 8b). In IGM 4862 from SMA the m3 is partially unerupted and the three first lophids have trefoils in the labial hemiloph, the fourth is partially in the alveolus, but the X Ray photograph shows a small conulid on the back of the tetralophid that suggests an incipient heel. This represents another important variation among the *Rhynchotherium* species from central Mexico.

In m3, differences are observed in number of lophids and presence or absence of a heel when compared with described specimens of North America faunas: UALP 23404, the m3s have four lophids and a pentalophid with small conids (Pasenko, 2007); LVMNH 871, with fourth lophids, an incipient pentalophid with two conids, and a well-developed cingulum (Miller, 1990); UF/FGS 5450, the m3s with four lophids, an incipient pentalophid with two-three cusps, besides presenting a double trefoil on m3 (Olsen, 1957); and in AZMNH p3708, m3s with four complete lophids and a pentalophid with two primary cusps and two smaller conids (Pasenko, 2012).

Based on this analysis, it is important to point out that IGM 11432, *Rhynchotherium falconeri* from La Goleta, has the only m3 with a reduced cusp in the tetralophid and no heel. This suggests teeth are more brachydont and less complicated than others described in the North American faunas (Figs. 8b and 11).

The comparison between the skulls of central Mexico is very restricted because of the poor preservation of *Rhynchotherium browni.* The skull seems to have a straight occipital region inclined slightly towards the anterior, and the upper part of the skull is dome-shaped. The rostrum is short, and the nasal and frontal portions are inclined at an apparent angle of 45 °. In the ventral region, the premaxillae are slightly flattened to tubular, are wider and joined all along the diameter of the alveolus of I2, which is larger than in *Rhynchotherium falconeri* (Figs. 2 and 3).

Compared to the skull of *Rhynchotherium falconeri*, the nasal and frontal bones form a relatively inclined surface, which implies an elongate shape of the rostrum with a dome-shaped skull that has a defined inclination of approximately 40°. In addition, the premaxillae are long and flat, but narrow and open at least 15 cm in the anterior part. The diameter of the alveoli is smaller and apparently directed downwards (Fig. 8a-b).

The previous comments allow us to assume that the IGM 11432 *Rhynchotherium falconeri* presents characters that are noteworthy and different from the records described in the faunas of North America. These differences indicate that the Goleta specimen could represent a less advanced form than *Rhynchotherium browni* collected in early Blancan deposits of the SMA. Despite this comparison, the characters of this specimen show significant differences from similar records from North American faunas, collected in late Blancan deposits. Furthermore, when comparing the late Hemphillian record of *Rhynchotherium* cf. *R. edensis* from the Warren Local Fauna the m3s have only four lophids and it has been mentioned that there is an incipient lophid that has a large cusp and two conulids that can be a fifth hemilophid. Also, UF/FGS 5450 the type of *Rhynchotherium simpsoni* from the late Hemphillian Bone Valley Formation has a m3 with four lophids and an incipient pentalophid composed of two-three cusps, a feature that is not present in *Rhynchotherium falconeri* from La Goleta, which was collected from early Blancan age deposits.

The specific characters described by Osborn (1936) for *Rhynchotherium browni* include lower tusks with wide enamel bands and a rudimentary basal cone on m2. The specimen of *Rhynchotherium browni* (IGM 4862) has an additional small cusp posteriorly on the m2, with evidence of wear. The right tusk does not have enamel or evidence of having had it, and it is complete and smooth throughout its length due to normal use. The root of i2 is deep in the symphysis below the protolophid of m1 (Figure 6).

In *Rhynchotherium falconeri,* i2 has a large horizontal band partially cracked along the tusk and within the symphysis. Two upper tusks fragments were collected at La Goleta, associated with the skull and jaw, but are very poorly preserved, only one small piece of enamel is present so it is impossible to find any sign of torsion; although it is evident its diameter is smaller compared with the I2 of *Rhynchotherium browni.*

The jaw of the young individual from early Blancan deposits, BCSM 41 Rhynchos, has an enamel band that goes into the symphysis. AZMNH P3708, from the late Blancan 111 Ranch, according to the diagnosis, may not have enamel on i2, and the Blancan skull and jaws from LVMNH 871 from southeastern Arizona, has no enamel on i2 or traces of having had it.

On UF/FGS 5450 *Rhynchotherium simpsoni* of late Hemphillian age from the Bone Valley Formation the enamel is "absent," and in its place are grooves. If we compare the features of *Rhynchotherium falconeri* material, two tusk fragments MPGJ 5231 and MPGJ 5232 from adult individuals, from Baja California Sur, along the tusk the surface is smooth without grooves, the enamel band in each one has a spiral shape, however, some layers are lost and the tusk acquired a texture different with small groove-like striations. In the juvenile jaw MPGJ 3532 collected in the same locality, the tusks have the enamel band on the external side, and where the enamel is incomplete, there are always deep grooves.

In *Rhynchotherium falconeri* MPGJ 11432 from La Goleta, the upper tusks are highly eroded with multiple deep grooves, the outer layers including the enamel band were stripped away, and the only observable enamel fragment is found in a smooth portion of the tusk. Also, part of the tusk is eroded, the enamel band is wide but broken partially, and in these sites shallow grooves are present. In the same way in the juvenile MPGJ BCS jaw of *Rhynchotherium falconeri* the enamel band in i2 is found on the outer side, however, at the sites where it has been broken, the dentine has different texture, only when a few layers are broken away the grooves are deep. According to these comments, the texture in *Rhynchotherium browni* is complete in the i2, however the enamel is absent and the external surface is smooth all the way without groves. According to these comments, the texture in *Rhynchotherium simpsoni* tusks suggests that during the life time, the tusks could have had enamel that was lost during the fossilization when the upper layer was stripped away (Webb and Tessman, 1968; Olsen, 1957, Lucas and Morgan, 2008).

In *Rhynchotherium* cf. *R. edensis* from the late Hemphillian, Warren Local Fauna, the enamel is present on i2. Therefore, it is observed that the presence of enamel in the lower tusks is highly variable and its importance should be considered in the diagnosis of *Rhynchotherium.* In some records it is not mentioned or it does not appear as in *Rhynchotherium browni* described in this work that has no evidence of having had the enamel.

CONCLUSIONS

The (IGM 11432) *Rhynchotherium falconeri* record described in this work was collected in deposits of early Blancan

age (3.6 My by method $^{40}K/^{40}Ar$), of central México, and it is composed of a skull and jaw from the same animal, collected from the Rancho La Goleta locality, state of Michoacán. This specimen is referred to this species based on the deflection of the symphysis at an angle of 61°, and the anterior edge of the ascending rami at an angle of 90°. The ventral edge of the horizontal ramus inclined at 25° determines the remarkable depth of the jaw below m2 of 198 mm; M2/m2 are trilophid with simple trefoils and low cusps, and the dentine widely exposed by wear. The M3/m3 have four lophs/lophids and simple trefoils, without evidence of accessory cusps that can form a fifth loph/lophid. These molars are more brachydont than those described for other records from Mexico and the USA. The skull is known for the first time, and is moderately high dome-shaped, has an occipital region that is wide, flat and slightly tilted to the front, with a relatively long rostrum and narrow premaxillae that open forward, and the alveoli are approximately 8 cm in diameter. The length of M3/m3 are among the smallest known, and this size is within the limits that have been considered a character of sexual dimorphism that corresponds to females (Pasenko, 2012), in which case this specimen should be considered female.

The characters mentioned above differ from the features that have been observed in the second specimen referred to *Rhynchotherium browni*, IGM 4862, collected in early Blancan deposits (3.0 My method ^{238}U /^{206}Pb) at the Locality GTO 47 Arroyo Belén, in the San Miguel de Allende basin. Consisting of a skull and jaw of the same animal, the main differences are the elongated jaw with small continuity of the lingual canal in front of the m1. The symphysis is deflected ~77° (this angle was measured to the limit of symphysis reconstruction), the anterior border of the ascending rami is 107°, the strong and almost straight horizontal ramus has a maximum depth under the m1 of 153 mm, and the right lower tusk lacks enamel. As for the dentition, the m1 alveoli are in the rami, with three lophids; the trilophid m2 has simple trefoils and small cusps with evidence of wear posterior to the tritolophid; and the horizontal rami are 130 mm deep below m2, and below m3 it is almost equal, only 132 mm. Another relevant distinction is the M2 right molar with two complete trefoils in the metaloph, a M3 tetraloph with evidence of a heel, higher cusps with no evidence of wear, and a greater length of m3/M3. No cingulum is present, the jaw is larger than in *Rhynchotherium falconeri* and the lower tusk lacks enamel. This is the first record of *Rhynchotherium browni* known outside the location of San Jose de Pimas, state of Sonora, its age is determined to early Blancan (3.0 My), and its geographical distribution is extended from Sonora to central Mexico.

The only confirmed Mexican records of *Rhynchotherium* are those described from the Las Tunas Local Fauna (Miller, 1980), in addition the reports described in this work, all assigned an early Blancan age. Another record of gomphotheriids has been mentioned previously in Hemphillian deposits of Rancho El Ocote, San Miguel Allende basin. The most indicative record collected in Rancho El Ocote and assigned to *Rhynchotherium* (Dalquest and Mooser, 1980) was a right juvenile jaw fragment. According to the authors, this jaw was collected at the locality, but it does not mention the site or stratigraphic level, nor does it mention diagnostic features of *Rhynchotherium* such as the deflection downward of the symphysis. The authors recognize that the anterior part of the symphysis with the alveolus for the tusk is missing. However, in reviewing this specimen, it is obvious that the horizontal ramus is straight, elongated, and, in front of m1 there is no evidence of alveoli for possible deciduous premolars, and the presence of alveoli for i2 and deflection of the symphysis are questionable.

Based on preservation of the jaw it becomes clear that it was collected in the upper part of the stratigraphic sequence in the Blanco layer (not to be confused with the Blanco LF in Texas of late Blancan age), which has been assigned a latest Hemphillian (Hh4) age (Carranza-Castañeda, 1989; Carranza-Castañeda et al*.,* 2013). It is a layer of clay-sandy sediment with compact volcanic ash. All fossil materials that have been collected at this level have the same kind of fossilization, unlike the basal Rhino layer, which has a high clay content. All the fossil material has multiple fractures and angled edges caused by contraction as the clayey sediment dries.

In addition, recently a complete *Stegomastodon* jaw was recovered in this Blanco layer, and several isolated teeth have been collected. The comparison with the jaw described by Dalquest and Mooser (1980) is remarkable in that both have similarities, including an extended part of the groove channel, symphysis without evidence of i2 alveolus, nearly straight horizontal ramus with slight convex curvature under the first lophid of m2, and the mental foramen placed 106 mm in front of the m1. These features suggest that probably the Dalquest and Mooser (1980) jaw was collected in the Blanco layer of latest Hemphillian age (Carranza-Castañeda, 2013).

From the previous comments, it is significant that the jaw described by Dalquest and Mooser (1980) does not have characters considered diagnostic of *Rhynchotherium* (Miller, 1990; Pasenko, 2007, 2012; Lucas and Morgan, 2008). However, it shares some similarities with the *Stegomastodon* jaw from the Blanco layer housed in the Centro de Geociencias. Based on these comparisons, the jaw described by Dalquest and Mooser (1980) could be reassigned to *Stegomastodon*. This find also allows us to state that in the stratigraphic sequence of Rancho El Ocote there are not confirmed records of *Rhynchotherium* remains.

In the Tecolotlán basin, state of Jalisco, two tusks were collected at the same locality where the *Gomphotherium hondurensis* jaw was recovered and have an age of late Hemphillian (4.89 My). The tusks have a broad band of enamel, ~6 cm wide, and evident spiral-shaped around the entire tusk. This characteristic differentiates it from the *Gomphotherium hondurensis* tusks collected in the early-late Hemphillian age Juchipila basin localities, where the enamel in the tusk is a wide and straight band along the entire tusk. This record suggests the first evidence of *Rhynchotherium* in the late Hemphillian faunas in México and confirms that its origin was not in Central American faunas. (Lucas and Morgan, 2008; Carranza-Castañeda, 2018).

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REFERENCES

Alberdi, M.T. and Corona-M., 2005, Revisión de los gonfoterios en el Cenozoico tardío de México: Revista Mexicana de Ciencias Geológicas, v. 22, p. 246-260.

Carranza-Castañeda, O., 1976, *Rhynchotherium falconeri* del Rancho la Goleta, III Congreso Latinoamericano de Geología, Universidad Nacional Autónoma de México, Instituto de Geología, v. 3, p. 28.

Carranza-Castañeda, O., 1989, Rinocerontes de la fauna del Rancho El Ocote, Mioceno tardío (Henfiliano tardío) de Guanajuato, México: Universidad Nacional Autónoma de México, Instituto de Geología, Revista, v. 8(1), p. 88-99.

Carranza-Castañeda, O., 1991, Faunas de Vertebrados fósiles del Terciario tardío del Centro de México, *in* III Congreso Nacional de Paleontología: Sociedad Mexicana de Paleontología, Memorias, p. 20-26.

Carranza-Castañeda, O., 1992, Una Nueva Localidad del Henfiliano Tardío de la Mesa Central: Universidad Nacional Autónoma de México, Instituto de Geología, Revista, v. 10(2), p. 151-159.

Carranza-Castañeda, O., 2006, Late Tertiary fossil localities in central México between 19°-23°N, *in* Carranza-Castañeda O., Lindsay, E.H. (eds.), Advances in late Tertiary vertebrate paleontology in Mexico and the Great American Biotic Interchange: Universidad Nacional Autónoma de México, Instituto de Geología and Centro de Geociencias, Publicación Especial, v. 4, p. 45-60.

Carranza-Castañeda, O., Aranda-Gómez, J.J., Wang, X. and Iriondo, A., 2013, The early–late Hemphillian (Hh2) faunal assemblage from Juchipila Basin, State of Zacatecas, Mexico, and its biochronological correlation with other Hemphillian faunas in Central Mexico: Natural History Museum of Los Angeles County, Contributions in Science, v. 521, p. 13-49.

Carranza-Castañeda, O., 2016, Roedores caviomorfos (Rodentia Hydrochoeridae) del Blancano temprano tardío–Irvingtoniano de los estados de Guanajuato, Jalisco y Sonora, México: relación con Phugatherium dichroplax: Revista Mexicana de Ciencias Geológicas, v. 33, p. 297-315.

Carranza-Castañeda, O., 2018, Early and late Hemphillian records of *Gomphotherium hondurensis* (Mammalia Proboscidea) from central México: New Mexico Museum of Natural History and Science, Bulletin 79, p. 83-98.

Castañeda-Posadas, C., 2004, Identificación de maderas Terciarias de Panotla, Tlaxcala, México y sus implicaciones paleontológicas: Mexico, Facultad de Ciencias, Universidad Nacional Autónoma de México, Bachelor tesis, 67 p.

Castañeda-Posadas, C., Calvillo-Canadell, L. and Cevallos-Ferriz, S., 2009, Woods from Miocene sediments in Panotla, Tlaxcala, Mexico: Review of Palaeobotany and Palynology, v. 156, p. 494-506.

Dalquest, W.W. and Mooser, O.B., 1980, Late Hemphilian mammals of the Ocote local fauna, Guanajuato, Mexico: Texas Memorial Museum, Pearce Sellards Series, no. 32, 1-25.

Falconer, H., 1868, Palaeontological memoirs of the late Hugh Falconer with a biographical sketch of the author: London, Volume 2, 675 pp.

Frick, C., 1933, New remains of trilophodont-tetralophodont mastodons: Bulletin of the American Museum of Natural History, v. 59, p. 505-652.

Gillette, D.D., Carranza-Castañeda, O., White, R.S., Jr., Morgan, G.S., Thrasher, L.C., McCord, R. and McCullough, G., 2016, Ontogeny and sexual dimorphism of *Glyptotherium texanum* (Xenarthra—Cingulata) from the Pliocene and Pleistocene (Blancan–Irvingtonian NALMA) of Arizona, New Mexico and Mexico: Journal of Mammal Evolution, v. 23, p. 133-154.

Hay, O.P., 1922, Further observations on some extinct elephants: Proceedings of the Biological Society of Washington, v. 35, p. 97-101.

Illiger, C., 1811, Prodromus systematis mammalium et avium additis terminis zoographicis utriusque classis: Berlin, Sumptibus C. Salfeld, 330 p.

Israde-Alcántara I., Robles-Camacho J. and Domínguez J.M., 2008, Arcillas del tipo beidellita–nontronita en sedimentos neógenos de la cuenca lacustre Cuitzeo–Charo, Michoacán, México: Contexto geológico e implicaciones paleoambientales. Boletín de la Sociedad Geológica Mexicana, v. 60, p. 159-171. http://dx.doi.org/10.18268/BSGM2008v60n2a2.

Jimenez-Hidalgo, E., Carranza-Castañeda, O. and Montellano Ballesteros, M., 2004, A Pliocene record of Capromeryx (Mammalia: Antilocapridae) in Mexico: Journal of Paleontology, v. 78, p. 1179-1186.

Kowallis, B.J., Christiansen, E.H., Carranza-Castañeda, O., Miller, W.E., Ross, K.T. and Tingey, D.G., 2017, The Geology of the Tecolotlan Graben, Jalisco, Mexico: Geological Society of America Digital Map and Chart, 22, 37 p. doi:10.1130/2017.DMCH022.TXT

Lambert, W.D., 1996, The biogeography of the gomphotheriid proboscideans of North America, *in* Shoshani, J., and Tassy, P., eds., The Proboscidea: Evolution and palaeoecology of elephants and their relatives: Oxford, Oxford University Press, 143-148.

Lucas, S., 2010, *Rhynchotherium* Falconer, 1868 (Mammalia; Proboscidea): proposed conservation of usage by designation of *Rhynchotherium falconeri*, 1923, as the type species: Bulletin of Zoological Nomenclature, v. 67(2), Case 3515.

Lucas, S.G. and Morgan, G.S., 2008, Taxonomy of *Rhynchotherium* (Mamammalia, Proboscidea) from the Miocene-Pliocene of North America: New Mexico Museum of Natural History and Science, Bulletin 44, p. 71-87.

Lucas, S.G., Morgan, G.S. and González-León, C.M., 1997, *Rhynchotherium* (Mammalia, Proboscidea) de San José de Pimas, Sonora: Geología del Noroeste, v. 2, p. 7-8.

May, S.R., 1981, Geology and mammalian paleontology of the Horned Toad Hills, Mojave Desert, California: Riverside: University of California, M.S. Thesis, 250 p

May, S.R. Woodburne, M.O., Lindsay, E.H., Albright, L.B., Sarna-Wojcicki, A., Wan, E., and Wahl, D.B., 2011, Geology and mammalian paleontology of the Horned Toad Hills, Mojave Desert, California, USA: Palaeontologia Electronica, v. 14(3), 1-63.

McDonald, H.G. and Carranza-Castañeda, O., 2017, Increased xenarthran diversity of the Great American Biotic Interchange: a new genus and species of ground sloth (Mammalia, Xenarthra, Megalonychidae) from the Hemphillian (late Miocene) of Jalisco, Mexico: Journal of Paleontology, v. 114, 0022-3360/15/0088-0906, doi: 10.1017/jpa.2017.45.

Miller, W.E., 1980, The late Pliocene Las Tunas local fauna from southernmost Baja California, Mexico: Journal of Paleontology, v. 54, p. 762-805.

Miller, W.E., 1990, A *Rhynchotherium* skull and mandible from southeastern Arizona: BYU Geology Studies, v. 36, p. 57-67.

Miller, W.E. and Carranza-Castañeda, O., 1984, Late Cenozoic mammals from central Mexico: Journal of Vertebrate Paleontology, v. 4, p. 216-236.

Montellano-Ballesteros M. and Carranza-Castañeda, O., 1981, Edentados Pliocénicos de la Región Central de México, *in* Anais Do II Congreso Latino-Americano de Paleontología, 2: Porto Allegre, Brazil, p. 683-691.

Montellano-Ballesteros, M. and Carranza-Castañeda, O., 1986,

Descripción de un milodóntido del Blancano temprano de La Mesa Central de México: Universidad Nacional Autónoma de México, Instituto de Geología, Revista, v. 6(2), p. 193-203.

Olsen, S., 1957, A new beak-jawed mastodont from Florida: Journal of the Palaeontological Society of India, v. 2, p. 131-135.

Osborn, H.F., 1918, A long-jawed mastodon skeleton from South Dakota and phylogeny of the Proboscidea: Geological Society of America Bulletin, v. 29, p. 133-136.

Osborn, H.F., 1921, The evolution, phylogeny, and classification of the Proboscidea: American Museum Novitates, no. 1, p. 1-15.

Osborn, H.F., 1923, New subfamily, generic and specific stages in the evolution of the Proboscidea: American Museum Novitates, no. 99, p. 1-4.

Osborn, H.F., 1936, Proboscidea Volume I Moeritheroidea Deinotheroidea Mastodontoidea: New York, The American Museum Press, 802 p.

Pasenko, M.R., 2007, *Rhynchotherium falconeri* (Proboscidea, Gomphotheriidae) from 111 Ranch, southeastern Arizona with a discussion of the genus: Journal of Vertebrate Paleontology, v. 27, p. 195-203.

Pasenko, M.R., 2012, New remains of *Rhynchotherium falconeri* (Mammalia, Proboscidea) from the earliest Pleistocene 111 Ranch, Arizona, U.S.A. with a discussion on sexual dimorphism and paleoenvironment of Rhynchotheres: Palaeodiversity, v. 5, p. 89-97.

Savage, D.E., 1955, A survey of various Late Cenozoic vertebrate faunas of the Panhandle of Texas. Part II. Proboscidea: University of California Publications in Geological Sciences, v. 31, p. 51-72.

Tassy, P., 1996, Growth and sexual dimorphism among Miocene elephantoids: the example of *Gomphotherium angustidens*, *in* Shoshani, J. and Tassy, P., eds., The Proboscidea: evolution and palaeoecology of elephants and their relatives: New York, Oxford University Press, p. 92-100.

Tobien, H., 1973, On the evolution of Mastodonts (Proboscidea, Mammalia). Part 1: The bunodont trilophodont Groups: Notizblatt des Hessischen Landesamtes für Bodenforschung, v. 101, p. 202-276.

Webb, S.D. and Perrigo, S.C., 1984, Late Cenozoic vertebrates from Honduras and El Salvador: Journal of Vertebrate Paleontology, v. 4, p. 237-254.

Webb, S.D. and Tessman, N., 1968, A Pliocene vertebrate fauna from low elevation in Manatee County, Florida: American Journal of Science, v. 266, p. 777-811.