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First fossil snake from McFaddin Beach, Texas, USA

Deanna Flores, Antonio Meza, Christopher J. Bell, Stacie Skwarcan, William Godwin, Jesse Fremont, and Patrick J. Lewis

ABSTRACT

McFaddin Beach is an archeological and paleontological locality extending approximately 32 km along the coast of Jefferson County, Texas, USA. Vertebrate fossils recovered from McFaddin Beach include *Mammuthus, Equus, Mammut,* and *Holmesina*, which indicates that at least some of the faunal material washed onto the beach is Pleistocene in age. A fossil snake was found on McFaddin Beach. It is a sample of partly cemented matrix containing more than 29 associated snake vertebrae, many in articulated sections. The fossil was CT-scanned and individual vertebrae were digitally segmented. Through this digital visualization, the vertebrae were identified to be from the precloacal trunk region. The snake was then qualitatively described and compared to the genera *Lampropeltis* (Kingsnakes), *Pantherophis* (Ratsnakes, Cornsnakes, and Foxsnakes), *Rhinocheilus* (Long-nosed snakes), and *Cemophora* (Scarlet snakes), which are all limited geographically to species currently present in southeastern North America. The fossil most resembled the genus *Lampropeltis*. The nearest fossils attributed to this genus are from Bee County, Texas, approximately 92 km from the modern Texas coast. This record expands prehistoric ranges of *Lampropeltis* to the continental shelf in times of low sea level.

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INTRODUCTION

During the examination of a private collection of McFaddin Beach (MB) material, a specimen was found consisting of partly cemented matrix that contains more than 29 associated snake vertebrae. McFaddin Beach extends approximately 32 km along the Gulf Coast of Jefferson County, Texas, USA (Figure 1). This beach is a secondary deposit for Paleoindian artifacts and fossils, most likely Pleistocene in age (Russell, 1975; Long, 1977; Turner and Tanner, 1994). The fauna described by this study and by Russell (1975) represent taxa that are characteristic of the Texas Coastal Plains as well as the greater Gulf Coast area. The identified megafauna can be divided into three groups, “extinct”, “extant”, and “local”, as described by Russell (1975). The extinct group includes taxa such as *Mammut, Equus,* and *Smilodon*, that were extinct by the end of the Pleistocene. The extant group includes extant taxa that no longer inhabit the Coastal Plains of Texas such as *Bison* and *Cynomys*. The local group includes taxa that are still found in the area at the present time such as *Didelphis, Procyon lotor, Odocoileus virginianus,* and *Canis latrans*. The source deposit (or deposits) for the artifacts and fossils is hypothesized to be somewhere on the continental shelf, as far as ~80 km out from the current shoreline near the ancient river valleys of what are today the Trinity, Sabine, Calcasieu, and Neches rivers (Russell, 1975; Long, 1977; Turner and Tanner, 1994). It is unknown if the fossils represent local populations that inhabited the area of the source location or if they represent vagrant groups that historically may have moved through the area.

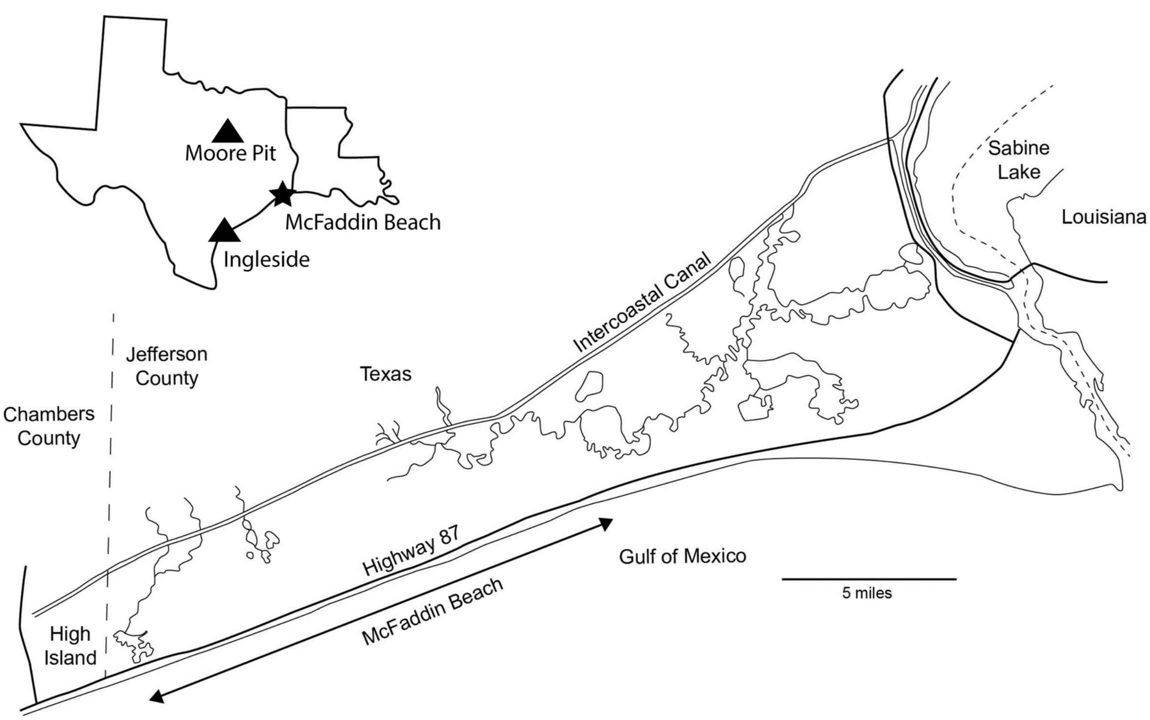

FIGURE 1. Location of McFaddin Beach (adapted from Stright et al., 1999).

A persistent challenge in the fossil record of snakes is that the majority of fossils attributable to snakes are isolated vertebrae, or short series of articulated (or associated) vertebral elements (e.g., Auffenberg, 1963; Rodriguez-Robles and De Jesus-Escobar, 1999; Holman, 2000; Caldwell et al., 2015; Caldwell, 2020; Head et al., 2022). A problem in the interpretation of those fossils is the degree to which isolated vertebrae, or short series of vertebrae, can reliably be diagnosed to finer levels in a taxonomic hierarchy (Head et al., 2022; Smith and Georgalis, 2022). Many herpetofaunal species lineages have poor documentation of evolutionary morphology due to many Quaternary palaeontologists using a traditional comparative approach instead of an apomorphy based approach to identifications (Holman, 1999; Bell et al., 2010). Recent work has shown that the apomorphy based approach to identification results in higher level taxonomic resolution instead of species level resolution (Bell et al., 2004). Much of the traditional approach does have a tendency to ignore some level of variation (sexual dimorphism, ontogeny, etc.) which can result in some members being mistaken for a different species (Bell et al., 2010). Both approaches also suffer from previously published characteristics that were restricted to a specific geographic context instead of a wider phylogenetic context (Bell et al., 2010). Utilization of geographic data can help refine taxonomic resolution, such as North American natricine snakes are able to be distinguished from North American elapids but not all natricine snakes can be separated from all elapid snakes (Bell et al., 2004). Here, we qualitatively describe the MB fossil through CT scanning and digital visualization methods. We use some apomorphies (e.g., presence or absence of hypapophyses or of distinct subcentral ridges) along with geographic data to narrow down higher-level taxonomy of the specimen. To further narrow the specimen down to a genus level identification, we utilize the traditional approach to compare the specimen to known genera for phenetic similarity.

MATERIAL AND METHODS

The MB specimen (SHSU-1-311) was donated to the Sam Houston State Natural History Collections by Jesse Fremont, curator of the Orangefield Cormier Museum. The specimen currently is on loan to be displayed at the Orangefield Cormier Museum in Orangefield, Texas.

Some vertebral sections are visible on the surface of the MB specimen SHSU-1-311, but much of the material is obscured by matrix. To view the specimen in greater detail, it was CT-scanned at the University of Texas at Austin High-Resolution X-ray Computed Tomography Facility (UT-CT) using the NSI scanner. The machine at UT-CT had Hamamatsu X-ray focus high power source operating at 160 kV and 0.2mA with an aluminum filter and a Perkin Elmer detector. The CT scan was continuous with two frames averaged, zero skipped frames, 3000 projections, four gain calibrations, 5 mm calibration phantom, data range of -20 to 360 adjusted grayscale values, and beam-hardening correction of 0.25. Post-reconstruction ring correction applied by Dr. Jessie Maisano used parameters oversample of two, radial bin width of 21, sectors of 32, minimum arc length of two, angular bin width of nine, and an angular screening factor of four. Voxel size is 32.9 μm, based on distance of source to object 240.838 mm and distance of source to detector 1465.675 mm. The total number of slices is 1958. The CT scans and a surface scan are catalogued and digitally stored with the natural history collections at Sam Houston State University. The scan was imported in Avizo (version 9.7), and three articulated sections of vertebral column were recognized, including a total of 29 individual vertebrae that could be digitally isolated. Additional vertebrae present in the specimen could not be isolated due to their similarity in density with the surrounding matrix.

To identify the specimen down to the genus level, the vertebral morphology was compared to that of specimens from the genera *Lampropeltis* (51 specimens consisting of *L. getula, L. triangulum, L. calligaster,* and *L. mexicana), Pantherophis* (26 specimens consisting of *P. obsoletus, P. vulpinus,* and *P. guttatus*), *Rhinocheilus* (27 specimens consisting of *R. lecontei*), and *Cemophora* (10 specimens consisting of *C. coccinea*) at Sam Houston State University and the Vertebrate Paleontology Lab at The University of Texas at Austin. Comparative specimens were limited geographically to southeastern North America. Specimen availability also limited the geographic range of comparative specimens. Descriptions and images from the literature were also used to assist in identification on the basis of vertebral morphology, commonly used with other extinct snake specimens (Auffenberg, 1963; Holman, 1995, 2000; Krysko, 2001; McCartney et al., 2014; Szyndlar and Georgios, 2023). Other taxa (e.g., natricine snakes or tribe Sonorini) were excluded based on size, general dimensions of the vertebrae (e.g., short stubby neural spine, concave neural arches), and presence of a hypophysis.

Abbreviations

SHSU-Sam Houston State University, Natural History Collections

MB-McFaddin Beach, Texas

TxVP-Vertebrate Paleontology Lab, University of Texas at Austin

SYSTEMATIC PALEONTOLOGY

Class REPTILIA Laurenti, 1768
Order SQUAMATA Oppel, 1811
Family COLUBRIDAE Oppel, 1811
Genus *LAMPROPELTIS* Fitzinger, 1843
Lampropeltis sp. Fitzinger, 1843
(Figures 2, 3)

SHSU-1-311. A conglomeration of matrix with articulated segments of precloacal trunk vertebrae and ribs imbedded.

Description and Diagnosis

The specimen identification was narrowed down to belonging to the family Colubridae due to the lack of hypapophyses on the trunk vertebrae, distinct subcentral ridges/grooves, and prominent

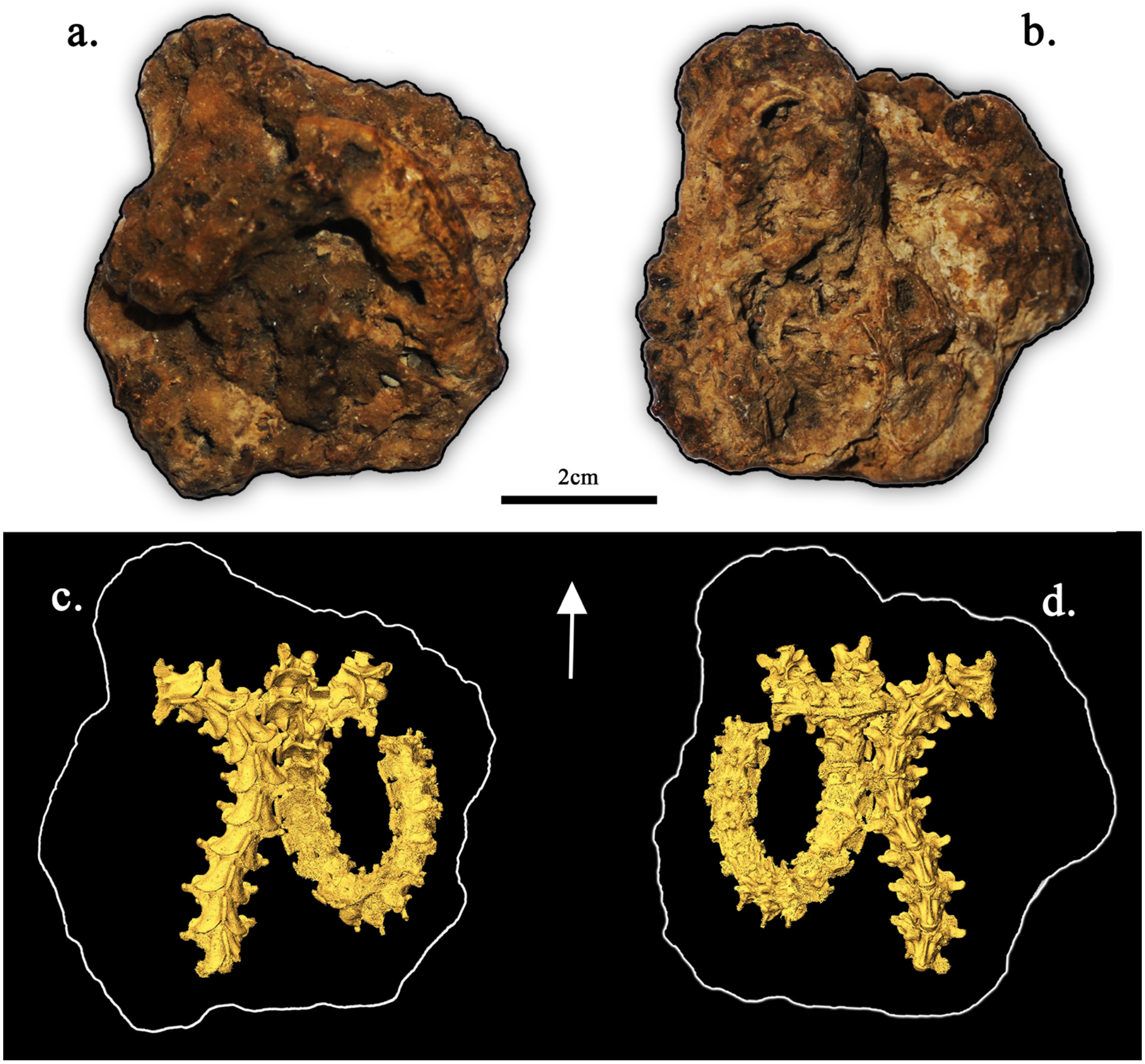

FIGURE 2. The specimen of *Lampropeltis* (SHSU-1-311) from McFaddin Beach. Dorsal (a) and ventral (b) view of specimen within the matrix. CT scan of articulated sections of precloacal trunk vertebrae (below). Dorsal (c) and ventral (d) view of specimen in situ with outline of matrix. Arrow indicates anterior for dorsal views (a and c). Not all vertebral elements could be segmented and visualized because the density of bone and crystalline matrix was too similar. Scale bar equals 2 cm.

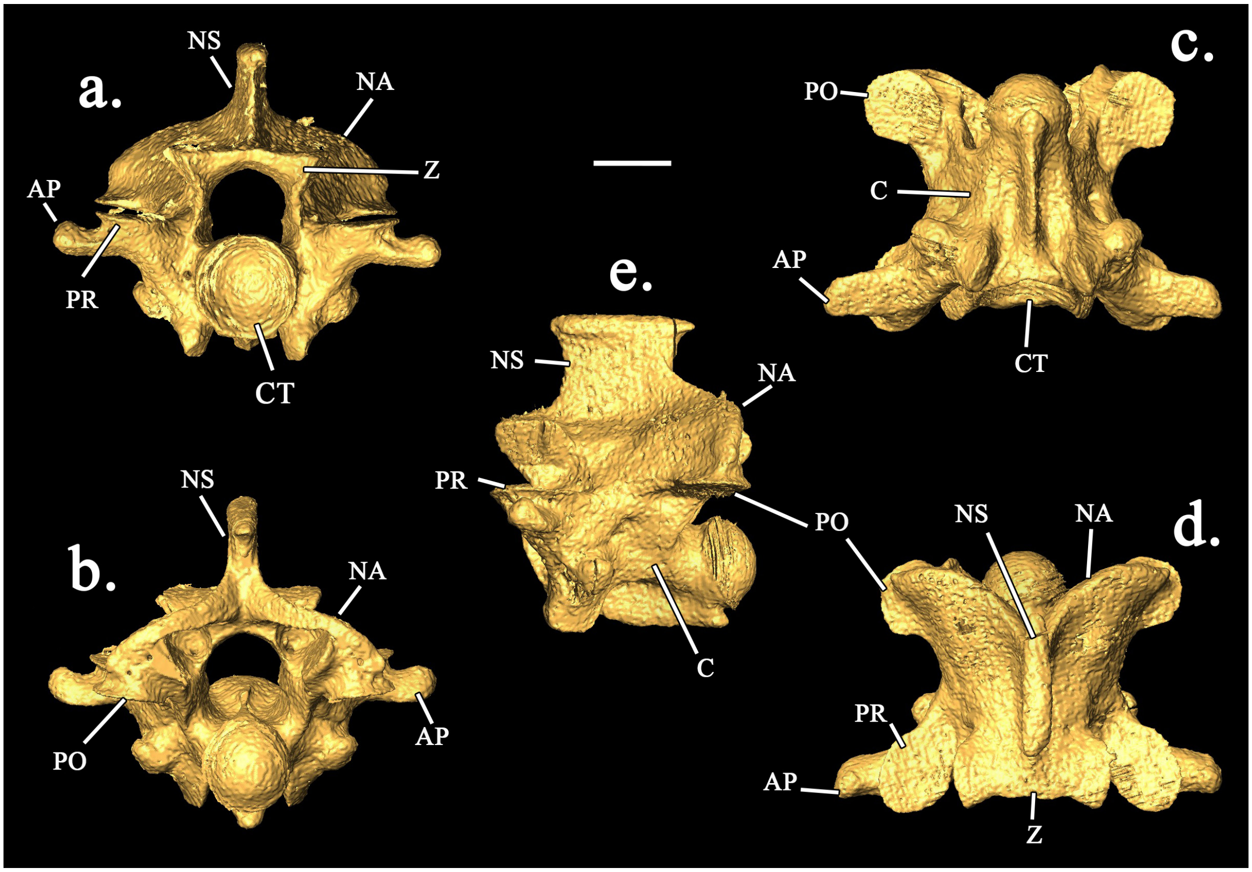

FIGURE 3. CT scan of an individually segmented precloacal trunk vertebra from SHSU-1-311 in (a) cranial, (b) caudal, (c) ventral, (d) dorsal, and (e) left lateral views. Abbreviations: Accessory process (AP), Centrum (C), Cotyle (CT), Neural arch (NA), Neural spine (NS), Postzygapophysis (PO), Prezygapophysis (PR), Zygosphene (Z). Scale bar equals 2 mm.

well-projected prezygapophyseal accessory processes (Holman, 2000). From the family, possible identifications were narrowed down based on size and similarity. Because the vertebrae have distinct synapophyses (rib attachment points) and various unsegmented ribs are preserved within the material encasing the specimen, the vertebrae are interpreted to be from the precloacal trunk region of the vertebral column. The vertebrae have an average centrum length of 5.62 mm and an average neural arch width of 5.01 mm. The ratios of neural spine length to neural spine height, and cotyle width to cotyle height of SHSU-1-311 are 1.39 and 0.99, respectively. Neural spine heights are greater than lengths, and they also have a posterior overhang. The neural arches are moderately vaulted with convex laminae. The prezygapophyseal accessory processes exhibit lengths less than the greatest lengths of the prezygapophyseal processes and are thick with rounded/blunted ends. The zygapophyses are pronounced laterally, and the zygosphene lacks an anteriorly flattened roof. The subcentral ridges are strongly developed. These characters are all consistent with referral to the specimen of *Lampropeltis* (Figures 3, 4).

Comparisons

Members of *Pantherophis* have characteristics similar to *Lampropeltis*, but *Pantherophis* has less depressed neural arches, higher and thinner neural spines, and longer, less rounded accessory processes than seen in SHSU-1-311 (Auffenberg, 1963; Parmley, 1986a; Holman, 1995, 2000). Specimens of *Pantherophis* (Figure 5) have a similar general shape to SHSU-1-311, especially with the neural spine and zygapophyses. The vertebrae differ in the lack of lateral distinctions of the zygosphene, in wider neural arches, and in how the accessory processes do not have as much of an upward curve seen in cranial and caudal views (Figure 5).

The neural spine length is greater than the height in *Rhinocheilus* compared to that of SHSU-1-311 (Figures 3, 6). Both specimens have a poste-

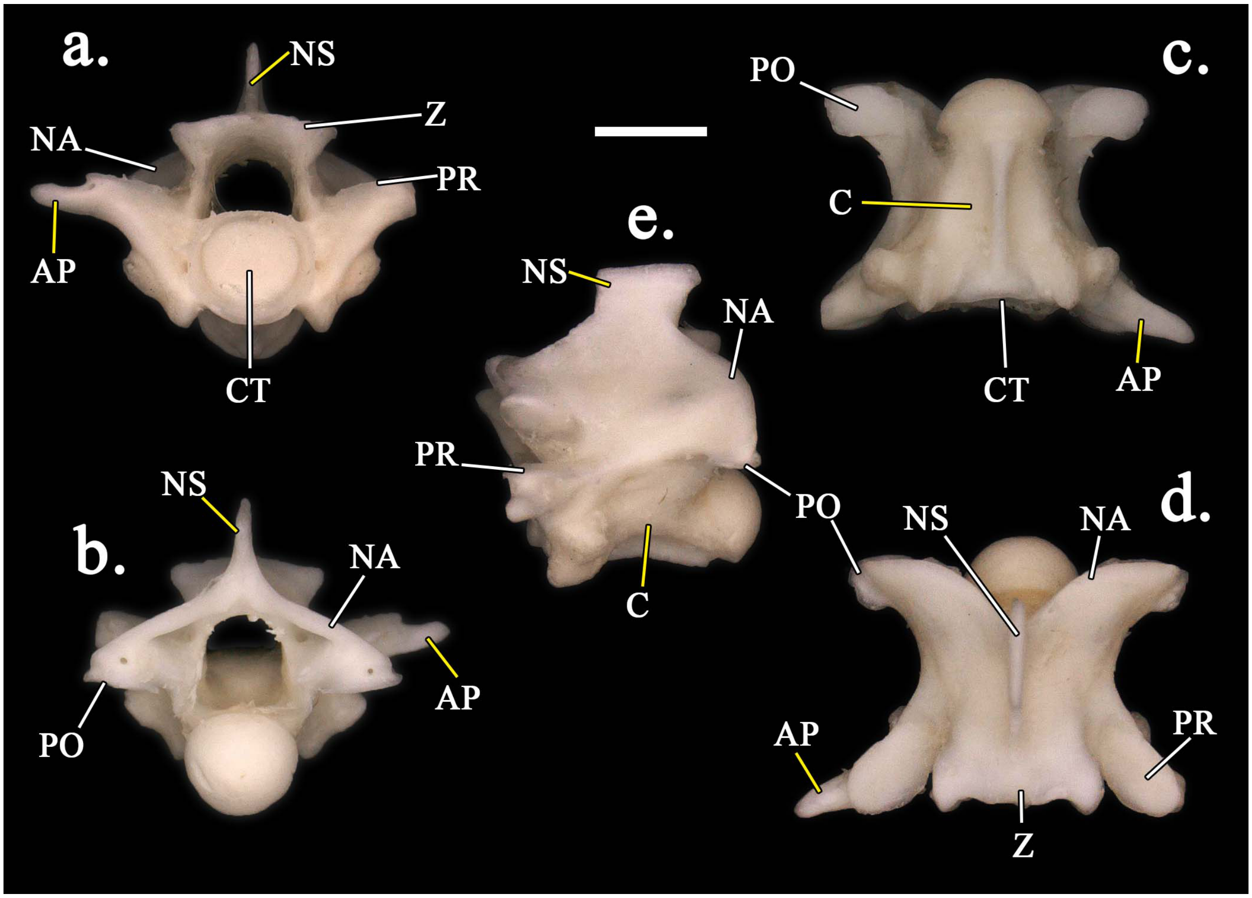

FIGURE 4. A modern trunk vertebra of *Lampropeltis calligaster* (SHSVM 0044-03) in (a) cranial, (b) caudal, (c) ventral, (d) dorsal, and (e) left lateral views. Abbreviations: Accessory process (AP), Centrum (C), Cotyle (CT), Neural arch (NA), Neural spine (NS), Postzygapophysis (PO), Prezygapophysis (PR), Zygosphene (Z). Diagnostic features represented by yellow lines. Scale bar equals 2 mm.

rior overhang. The neural spine has a less rounded ventral portion anteriorly and a more rounded ventral portion posteriorly in comparison to SHSU-1-311. The neural arches appear to be more rounded and wider in the *Rhinocheilus* specimen (Figure 6). The prezygapophysis and postzygapophysis are similar in shape to SHSU-1-311. The accessory process is rounded but extends more laterally. The zygosphene is similar in shape with a more rounded medial portion.

Specimens of *Cemophora* have a greater neural spine length than height, with a slight posterior overhang (Figure 7). The neural arches are not as depressed as those of SHSU-1-311. The prezygapophysis and postzygapophysis are both similar in shape to SHSU-1-311. The accessory process is not rounded (Figure 7). The zygosphene is similar in the lateral distinctions but is not as flat medially as seen in SHSU-1-311 (Figures 3, 7). This specimen has a projection on the portion below the neural spine in lateral view, not seen in SHSU-1-311.

TAPHONOMY

A detailed taphonomic study of the specimen has not been completed. This fossilized aggregation of snake vertebrae is well preserved and is currently the only articulated specimen from MB. The current hypothesis is that cement deposited around the bones during fossilization yielded tightly articulated vertebrae and created a protective layer against wave action for the specimen as a whole (Figure 2). An articulated, multi-element skeleton suggests that the specimen may have been rapidly buried, was in a burrow, was fossorial, was trapped in a rapid influx of sediment, or a combination of these possibilities (Lopes et al., 2008). Small crystalline structures are found scattered around the surface of the fossil.

DISCUSSION

The specimen, SHSU-1-311, is the only snake fossil known from MB and is one of the smallest-

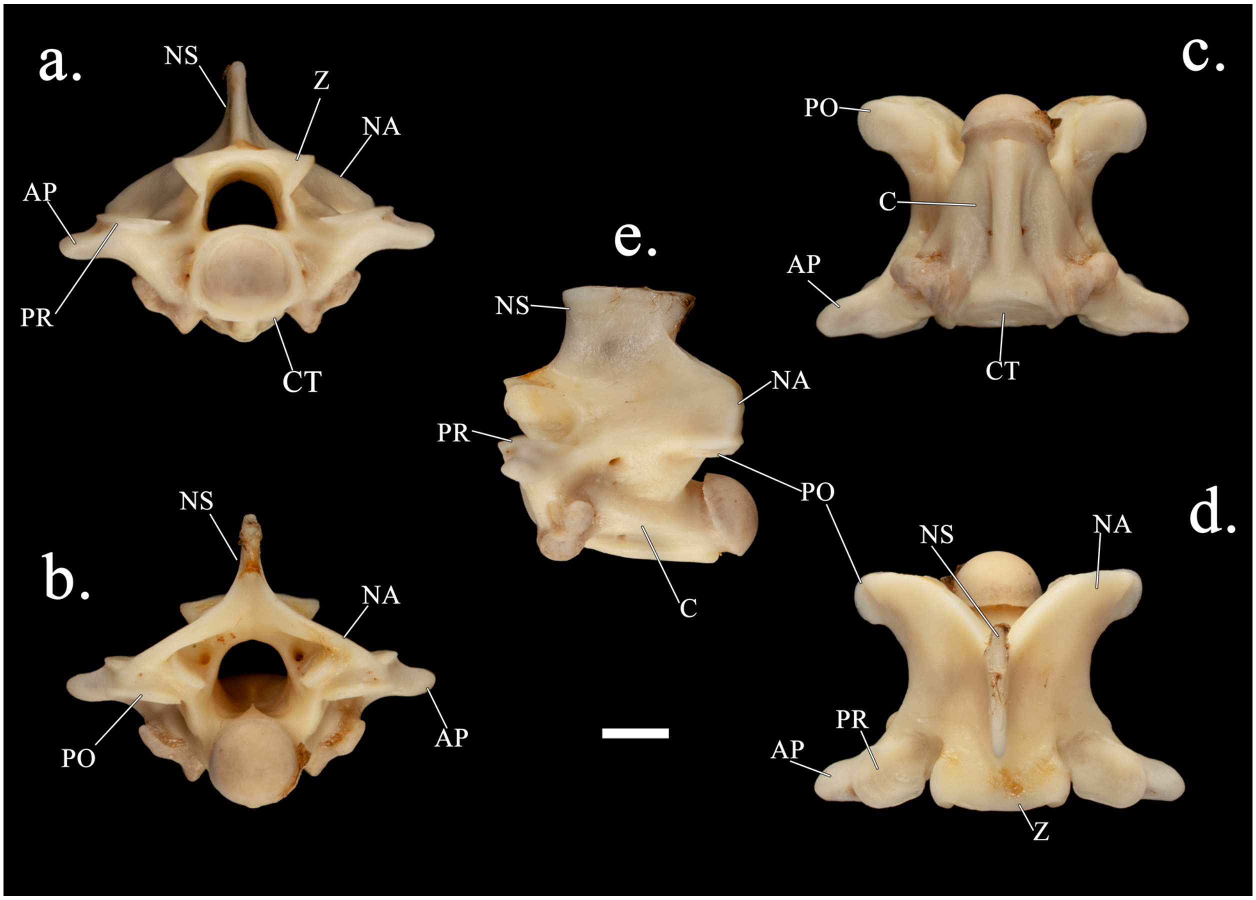

FIGURE 5. A modern trunk vertebra of *Pantherophis* sp. (TxVP M-5984) in (a) cranial, (b) caudal, (c) ventral, (d) dorsal, and (e) left lateral views. Abbreviations: Accessory process (AP), Centrum (C), Cotyle (CT), Neural arch (NA), Neural spine (NS), Postzygapophysis (PO), Prezygapophysis (PR), Zygosphene (Z). Scale bar equals 2 mm.

bodied, most well-preserved fossils collected from the locality. The fossil was difficult to identify using externally visible morphology as much of it was obscured (Figure 2A-B). The use of CT was vital to adequately identify the specimen. The use of X-ray computed tomography and digital segmentation software allows for the study of and visualization of microfossils in three dimensions for specimens that are not easily extracted using traditional preparation methods. The use of CT scanning is mainstream due to its practicality (Bell and Mead, 2014; Gignac et al., 2016; Georgalis and Scheyer, 2022). For the study of microvertebrates, the use of CT has allowed many researchers to ask and explore new and exciting questions. The implementation of CT provides an avenue to access new fossil snakes and gather quantitative data, in the form of geometric morphometrics, to help diagnose and identify specimens.

Fossils assigned to *Lampropeltis* first appeared during the Miocene (Rodriguez-Robles and De Jesus-Escobar, 1999; Armstrong et al., 2001; Krysko, 2001; Bryson, et al., 2007; Pyron and Burbrink, 2009; Krysko et al., 2017) and are reported from sites throughout the United States and Mexico (Holman, 2000). In Texas, fossils assigned to *Lampropeltis* were found in locations dated throughout the Pleistocene (Holman, 1964; Parmley, 1986b; Holman and Winkler, 1987; Parmley, 1988a, 1988b, 1990; Holman, 2000) and were previously assigned to the species *Lampropeltis triangulum, Lampropeltis calligaster, Lampropeltis mexicana,* and *Lampropeltis getula*. Several species, including *Lampropeltis alterna, L. annulata, L. triangulum, L. calligaster,* and *L. getula*, are also found in the modern fauna of Texas, but only three species *(Lampropeltis triangulum, Lampropeltis calligaster,* and *Lampropeltis getula)* have modern ranges which include the coast (Werler and Dixon, 2010; Dixon et al., 2020). Fossil material of *Lampropeltis* has not been reported from any coastal localities in Texas. At least 13 localities in Texas

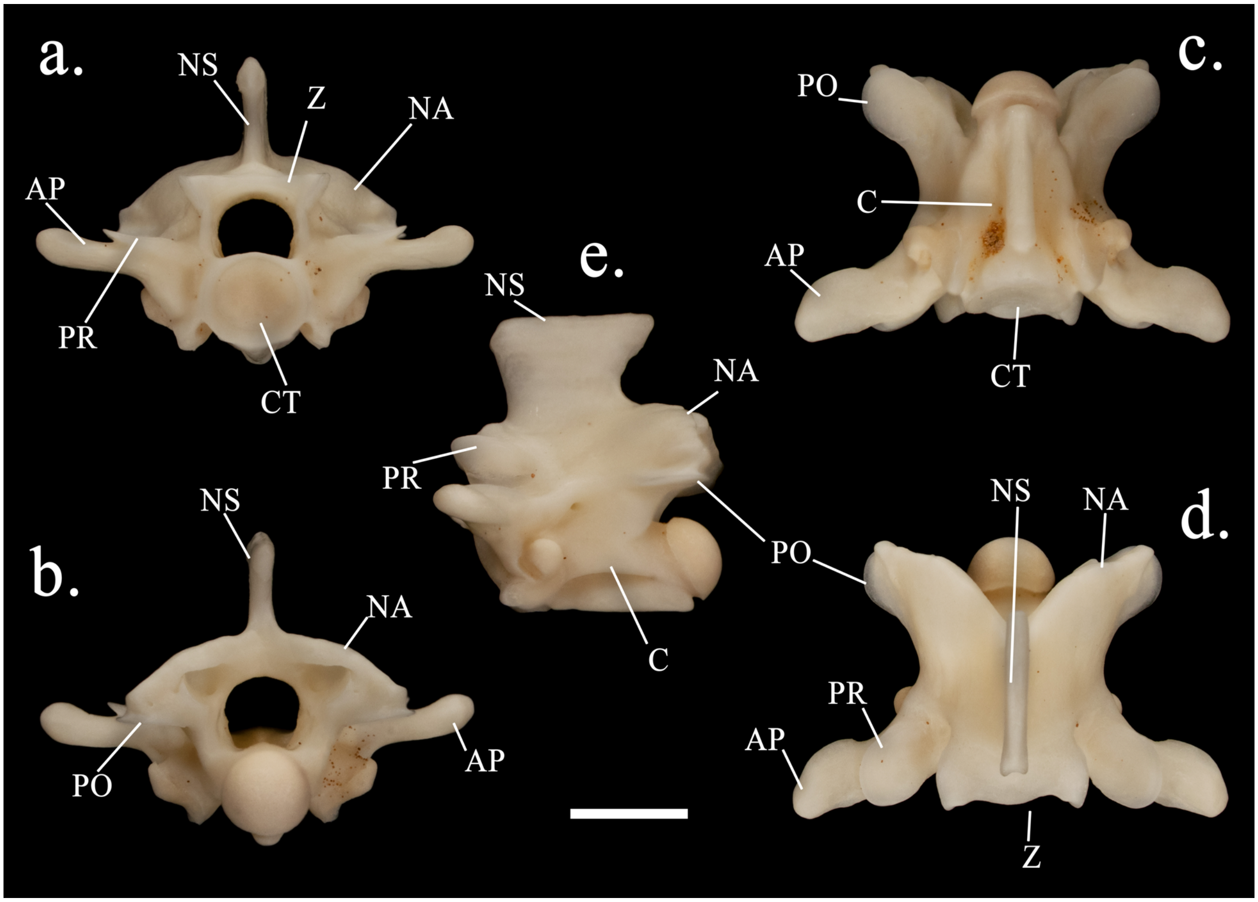

FIGURE 6. A modern trunk vertebra of *Rhinocheilus* sp. (TxVP M-9755) in (a) cranial, (b) caudal, (c) ventral, (d) dorsal, and (e) left lateral views. Abbreviations: Accessory process (AP), Centrum (C), Cotyle (CT), Neural arch (NA), Neural spine (NS), Postzygapophysis (PO), Prezygapophysis (PR), Zygosphene (Z). Scale bar equals 2 mm.

were previously reported to include fossils of *Lampropeltis*; the closest locality to McFaddin Beach is Berclair Terrace Site 1 in Bee County, Texas, which is approximately 96 km from the coast (Conkin and Conkin, 1962).

The current range of *Lampropeltis* does include the Texas Coast, but no fossil specimens of *Lampropeltis* are known from the modern coast. Although the original site of deposition of the fossil is unknown, it may have been close to the shoreline at that time; during the Pleistocene (the hypothesized age of the specimen based on associated fauna) the coast was as much as 129 km south of its modern position (Anderson, 2007). This fossil material supports the presence of *Lampropeltis* on the coast in the Pleistocene regardless of how far the unknown source location is from the modern shoreline.

Although few fossils from McFaddin Beach have been formally published, this site and the fossils found there provide valuable insight into the Gulf Coast region during the Pleistocene. Faunal similarities with deposits in Florida suggest a potential faunal region specific to the Gulf Coast. Fossil deposits are uncommon on continental shelves, and only a few are known from North America (e.g., Whitmore et al., 1967; Hoyle et al., 2004), the North Sea (Erdbrink and Van Bree, 1995; Van Kolfschoten and Laban, 1995; Van Essen and Mol, 1996; Mol et al., 2006), Argentina (Tonni and Cione, 1999; Cione et al., 2005), Uruguay (Rinderknecht, 2006), and Brazil (Lopes et al., 2008; Lopes and Buchmann, 2011). McFaddin Beach was for many decades a popular site for private collectors, and many of the known fossils and artifacts are not curated in public institutions. There are three main institutionalized collections from McFaddin Beach: the natural history collections at Sam Houston State University (Huntsville, Texas), the Texas Vertebrate Paleontology Laboratory (Austin, Texas), and the Museum of the Gulf Coast (Port Arthur, Texas). The collections manager and students at Sam Houston State University (SHSU) continue to work with local private collectors that

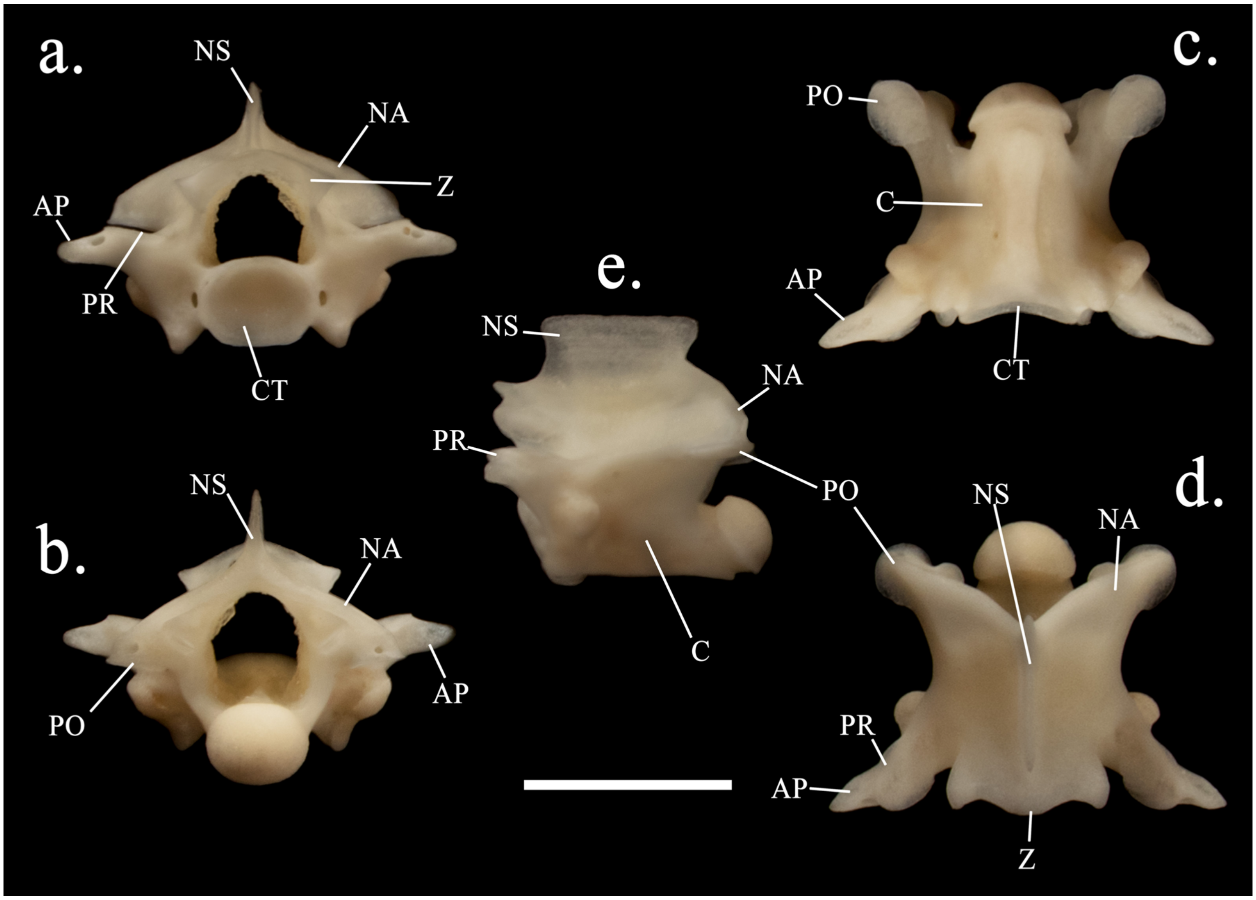

FIGURE 7. A modern trunk vertebra of *Cemophora* sp. (TxVP M-9139) in (a) cranial, (b) caudal, (c) ventral, (d) dorsal, and (e) left lateral views. Abbreviations: Accessory process (AP), Centrum (C), Cotyle (CT), Neural arch (NA), Neural spine (NS), Postzygapophysis (PO), Prezygapophysis (PR), Zygosphene (Z). Scale bar equals 2 mm.

collected, or still collect, materials from McFaddin Beach, and have entered into collaborations that result in transfer of private collections to the museum. As the McFaddin Beach faunal material is studied, it will provide an excellent opportunity to evaluate how taphonomic processes of shelf deposits differ from inland deposits that preserve vertebrate fossils.

CONCLUSIONS

The vertebrae are, to our knowledge, the first articulated fossils found from MB. Articulated specimens, especially of this size, are highly unusual at MB because the beach recovery site is a secondary deposit where elements are redeposited by waves from unknown primary offshore deposits. The discovery of the *Lampropeltis* specimen provides a rare glimpse into the make-up of the small vertebrate community of MB as much of the site's fossil record is biased toward larger-bodied animals.

The Jesse Fremont collection includes other fossils that yield insight into the McFaddin Beach fauna. Collections staff at the natural history collections at SHSU have been successful in working with private collectors to archive four other formerly private collections into formal collections held in the public trust (e.g., Bell et al., 2020; Flores, 2022). Those collectors have provided valuable fossils and shared knowledge about the history of deposits, collections, and research on fossil material from McFaddin Beach that greatly enhances not only the understanding of the fossils themselves, but also their historical context and scientific relevance.

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