

VERTEBRATE COPROLITES FROM THE LOWER PERMIAN (MIDDLE WOLFCAMPIAN) GALLINA WELL LOCALITY, JOYITA HILLS, SOCORRO COUNTY, NEW MEXICO

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Abstract—Vertebrate coprolites are the most common trace fossils found at the Lower Permian (middle Wolfcampian) Gallina Well locality in Socorro County, New Mexico (NMMNH locality 4668). Despite the relative abundance of coprolites at the locality, little attention has been paid to the coprolite ichno-assemblage. This ichno-assemblage includes the first occurrence of *Dakyonocopros arroyoensis* in New Mexico, the earliest appearance of *Alococopros triassicus*, and occurrences of *Heteropolacopros texaniensis* and amorphous coprolites. The age and faunal associations of *Alococopros triassicus* from the Gallina Well locality refute earlier assertions that longitudinally-striated coprolite forms were produced by stem archosauromorphs and are restricted to the Mesozoic and Cenozoic Eras.

INTRODUCTION

Vertebrate fossils have been collected at the Early Permian (lower Wolfcampian) Gallina Well locality since 1980, with an apparent bias toward vertebrate body fossils. Despite their abundance at the Gallina Well locality, vertebrate coprolites from this site are underrepresented in collections and unstudied in the literature. Here, we document the coprolite ichno-assemblage from the Gallina Well locality, which includes the first occurrence of *Dakyonocopros arroyoensis* Hunt et al., 2005 in New Mexico, the earliest occurrence of *Alococopros triassicus* Hunt et al., 2007, as well as records of *Heteropolacopros texaniensis* Hunt et al., 1998, and amorphous coprolites, likely produced by an amphibian or reptile due to the lack of a spiral structure characteristic of many fish coprolites.

In this article, CM = Carnegie Museum of Natural History, Pittsburgh, PA; and NMMNH = New Mexico Museum of Natural History and Science, Albuquerque, NM.

PROVENANCE

The Gallina Well locality (NMMNH locality 4668, CM locality 1057) is an Early Permian (middle Wolfcampian) vertebrate fossil site discovered by David S Berman in 1980 (Berman, 1993) that is approximately 20 km northeast of Socorro, New Mexico in the Joyita uplift. It is located stratigraphically low in the Early Permian Scholle Member of the Abo Formation (Fig. 1), is likely Coyotean in age and sits 46 m above the underlying Bursum Formation, which is early Wolfcampian in age (Spielmann et al., 2009). The fossiliferous bed is a reddish-brown, fluviially-deposited, calcrete-pebble conglomerate (Spielmann et al., 2009). Vertebrate body fossils from this locality include palaeoniscoid fish (Berman, 1993), temnospondyl amphibians *Zatrachys* sp. (Berman, 1993) and *Trimerorachis* sp. (Berman, 1993), a skull fragment of the lepospondyl *Diplocaulus* (Harris et al., 2005), a partial captorhinid skull and postcranial skeleton (Berman and Reisz, 1986), postcrania of the diadectomorph *Diadectes* sp. (Berman, 1993), and specimens of the sphenacodontid eupelycosaur *Sphenacodon* (Berman, 1993) and *Dimetrodon* (Cantrell et al., 2011).

SYSTEMATIC ICINOLOGY

There are three principle morphotypes of coprolites preserved in the Gallina Well ichnofauna that can be assigned to named ichnotaxa – *Dakyonocopros arroyoensis*, *Alococopros triassicus*, *Heteropolacopros texaniensis* as well as amorphous coprolites.

Dakyonocopros arroyoensis

Referred Specimen: NMMNH P-64621, complete coprolite (Fig. 2A-B).

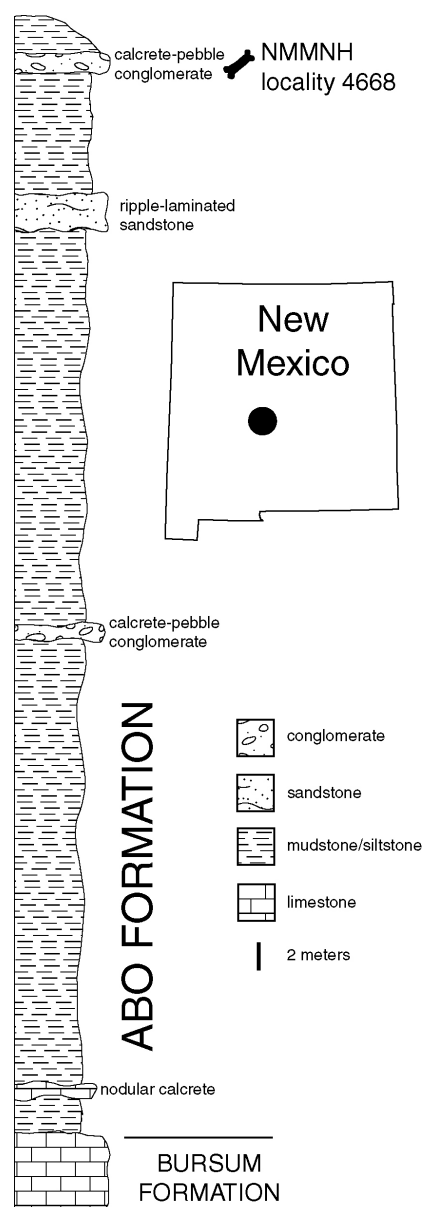


FIGURE 1. Stratigraphic section showing the location of the Gallina Well locality (NMMNH locality 4668) in the Scholle Member of the Abo Formation, Socorro County, New Mexico.

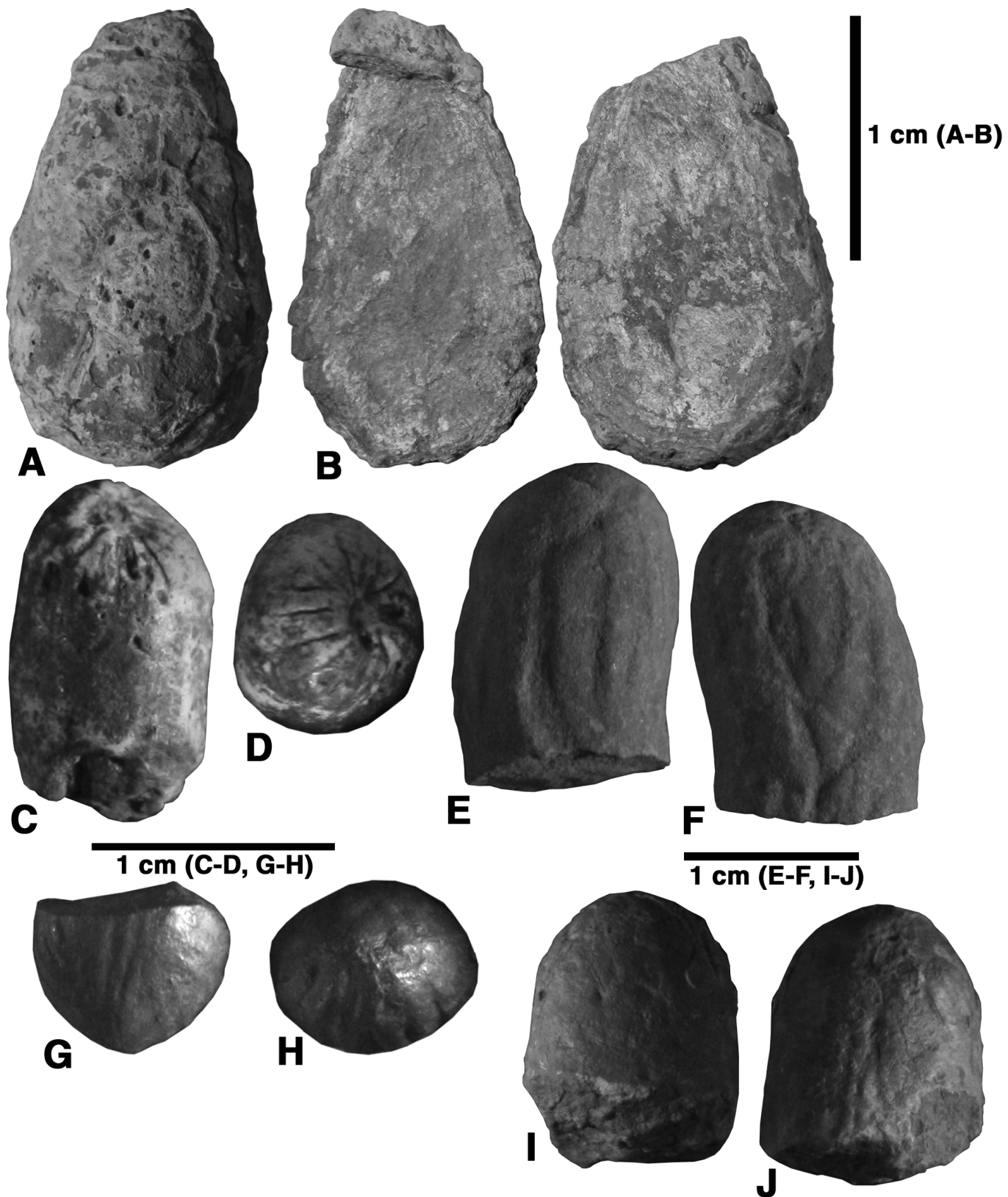


FIGURE 2. **A-B**, *Dakyronocopros arroyoensis* specimen from the Gallina Well locality, NMMNH P-64621, in **A**, lateral and **B**, two longitudinal section views. **C-J**, *Alococopros triassicus* specimens from the Gallina Well locality, **C-D**, NMMNH P-64627, in **C**, lateral and **D**, apical views; **E-F**, NMMNH P-64628, in lateral views; **G-H**, NMMNH P-62986, in **G**, lateral and **H**, apical views; **I-J**, NMMNH P-64630, in lateral views.

Description: NMMNH P-64621 is 41 mm long, with a maximum width of 22 mm and a minimum width of 7 mm. The specimen is tear-drop shaped and flattened from the side, with no evidence of spiraling or inclusions and, thus, clearly pertains to *Dakyrnocopros arroyoensis* (Hunt and Lucas, 2005). The coprolite is cleaved along its length, providing a natural longitudinal section.

Discussion: The age of the locality (early Wolfcampian) is within the temporal range of *D. arroyoensis* described by Hunt and Lucas (2005) (early Wolfcampian-middle Leonardian). This is the first occurrence of *Dakyrnocopros arroyoensis* outside of Texas, which extends the geographic range of *D. arroyoensis* westward from Texas into New Mexico. While it is the largest specimen we describe from the Gallina Well locality, it is considerably smaller than the holotype from Texas, which is 104 mm long. *D. arroyoensis* was likely produced by an aquatic or terrestrial tetrapod (Hunt and Lucas, 2005).

Alococopros triassicus

Referred Specimens: NMMNH P-64627, P-64628, P-62986, and P-64630, all incomplete coprolites (Fig. 2C-J).

Description: All referred specimens share characteristics common to *Alococopros triassicus*, specifically arcuate shape in lateral view and sub-rounded in cross section with regularly-spaced, thin, longitudinal grooves. The largest specimen of *A. triassicus*, NMMNH P-64628, has a length of 13 mm and a maximum diameter of 8 mm. The smallest specimen complete enough to measure, NMMNH P-64627, has a maximum diameter of 4 mm and a partial length of 10 mm. None of the specimens exhibit any inclusions.

Discussion: The only prior records of *A. triassicus* are from the Early through Late Triassic of Australia, India, and North America (Hunt et al., 2007). The specimens from the Gallina Well Locality greatly extend the chronological distribution of *A. triassicus* and also cast doubt upon previously made arguments concerning its producer. As outlined in Hunt et al.'s (2007) review of Triassic vertebrate coprolites, Northwood (2005) made the case for stem archosauromorphs as possible producers of *A. triassicus* (and longitudinally striated forms in general) because: (1) they both were thought to have first appeared in the Early Triassic; (2) extant reptile feces have longitudinal rugae; and (3) *A. triassicus* resembles the feces of extant crocodiles (Young, 1964). However, because examples of *A. triassicus* from the Gallina Well locality are considerably older than any known archosauromorphs, we conclude that stem archosauromorphs are not solely the producers of these coprolites. Faunal associations point toward an amphibian or more basal reptilian producer. This assessment is reinforced by the fact that some extant amphibians and reptiles have longitudinal intestinal rugae (Hunt et al., 2005). Further, Hunt and Lucas (2010) called into question the validity of longitudinal striations as diagnostic features of crocodile feces.

Heteropolacopros texaniensis

Referred Specimens: NMMNH P-64622, P-64623, P-64624, and P-64786, all complete coprolites (Fig. 3A-D).

Description: Referred specimens possess microspiral heteropolar morphology (*sensu* Neumayer, 1904; see also Hunt et al., 1994, p. 299, fig. 9.1) with 3-4 whorls forming less than 50% of the length and the tighter coiled end having a wider diameter than the rest of the coprolite, which are features characteristic of *Heteropolacopros texaniensis* (Hunt et al., 2005). The largest complete specimen of *H. texaniensis*, NMMNH P-64624, has a length of 20.1 mm, a maximum width of 8 mm and a maximum thickness of 5 mm. The smallest complete specimen, NMMNH P-64786, has a length of 11.7 mm, a width of 5 mm and a maximum thickness of 1.6 mm. Many of the specimens have whorls that make up less than 30% of the total length. All are tapered on both ends, with the whorled end being more rounded and having a larger diameter. None of the specimens exhibit any inclusions.

Discussion: This ichnospecies is the most common found at the Gallina Well locality. The locality serves as an excellent example of the *Heteropolacopros* ichnofacies described by Hunt et al. (2007) in having microspiral heteropolar coprolites occurring in fluvial redbeds. The spiral morphology of *H. texaniensis* suggests a primitive fish, possibly a chondrichthyan or dipnoan as the producer (Hunt et al., 2005).

Amorphous coprolites

Referred Specimens: NMMNH P-64632, P-64633, P-64634, P-64635, all complete coprolites (Fig. 3E-H).

Description: These four coprolites lack any obvious internal structure or spiraling. The largest amorphous specimen, NMMNH P-64635, has a length of 26.5 mm and a maximum diameter of 12 mm. The smallest specimen, NMMNH P-64633, has a length of 19 mm and a maximum diameter of 9.5 mm. Most are tapered at both ends and slightly arcuate in shape. There are no identifiable inclusions in any of the specimens.

Discussion: The amorphous coprolites from the Gallina Well locality tend to be slightly larger than examples of *Heteropolacopros* and *Alococopros*, but still smaller than the single specimen of *Dakyrnocopros*. Due to the lack of internal structure and the relatively large size of the amorphous coprolites from the Gallina Well locality it is likely that they were produced by a tetrapod (Hunt et al., 2005).

DISCUSSION

The Lower Permian (middle Wolfcampian: Coyotean) Gallina Well locality in south-central New Mexico contains three distinct coprolite morphotypes: *Heteropolacopros texaniensis*, *Dakyrnocopros arroyoensis* and *Alococopros triassicus*, as well as amorphous coprolites. Faunal associations and morphological features of these coprolites suggest underived fish and various tetrapods as producers. A comparable coprolite ichno-assemblage from north-central New Mexico was documented by Hunt et al. (2005) from three Early Permian (middle Wolfcampian: Coyotean) localities in the Arroyo Del Agua area of the Chama Basin: the VanderHoof quarry, Welles quarry and Quarry Butte locality. All three localities were likely deposited by a single large lake (Langston, 1953) or ephemeral crevasse channels within a locally anastomosed river system (Eberth and Berman, 1983, 1993; Berman et al. 1988; Eberth and Miall, 1991) and contain examples of *Heteropolacopros texaniensis*, *Hyronocopros amphipola* as well as larger amorphous coprolites. The Arroyo Del Agua ichno-assemblage is similar to that from Gallina Well and was likely produced by underived fish and tetrapods (Hunt et al., 2005).

The presence of *Dakyrnocopros arroyoensis* at the Gallina Well locality extends the geographic range of the ichnogenus from the Early Permian (middle Wolfcampian to middle Leonardian) strata of Texas into the Early Permian (middle Wolfcampian) strata of New Mexico. *Dakyrnocopros arroyoensis* occurs in conjunction with *Heteropolacopros texaniensis* in the Texan Early Permian strata as it does at the Gallina Well locality in south-central New Mexico.

Perhaps the most interesting morphotype in the Lower Permian Gallina Well locality ichno-assemblage is *Alococopros triassicus*. These coprolites mark the earliest occurrence of the ichnogenus (known previously from the Early Triassic) and refute previous assertions that longitudinally-striated coprolite forms were produced by stem archosauromorphs. It is likely that *Alococopros triassicus* specimens from the Gallina Well locality were instead produced by an amphibian or more basal reptile.

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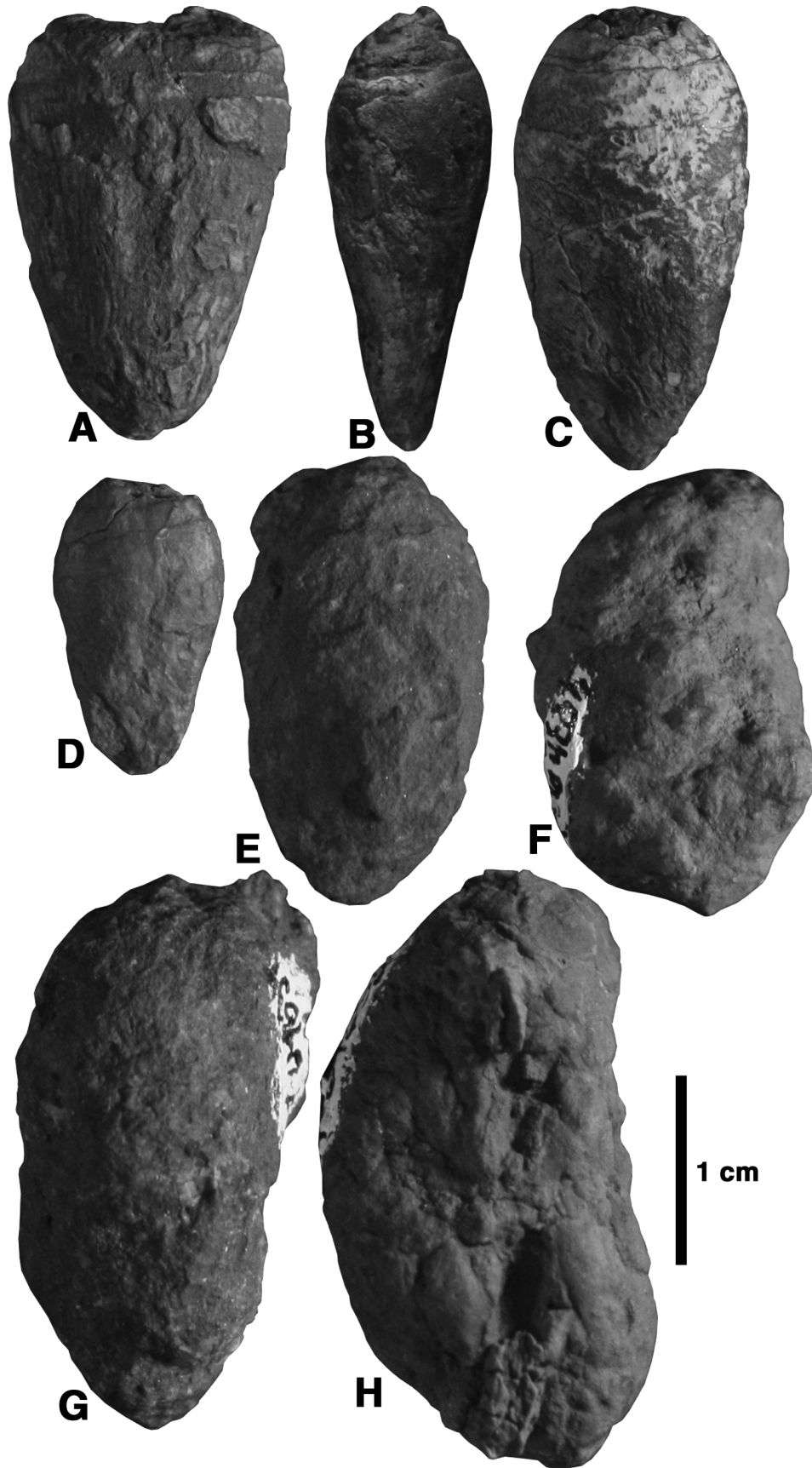


FIGURE 3. **A-D**, *Heteropolacopros texaniensis* specimens from the Gallina Well locality, **A**, NMMNH P-64622, in lateral view; **B**, NMMNH P-64623, in lateral view; **C**, NMMNH P-64624, in lateral view; **D**, NMMNH P-64786, in lateral view. **E-H**, Amorphous coprolites from the Gallina Well locality, **E**, NMMNH P-64632, in lateral view; **F**, NMMNH P-64633, in lateral view; **G**, NMMNH P-64634, in lateral view; **H**, NMMNH P-64635, in lateral view.

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A prominent coprolite from the Late Triassic Kap Steward Formation, east Greenland. Photo by Nicole Klein.