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# TAPHONOMY OF THE LATE TRIASSIC LAMY AMPHIBIAN QUARRY (GARITA CREEK FORMATION: CHINLE GROUP), CENTRAL NEW MEXICO

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**Abstract**—The Lamy amphibian quarry, located in central New Mexico in the Upper Triassic Garita Creek Formation of the Chinle Group, is a paucispecific assemblage dominated by the remains of large metoposaurid amphibians assigned to *Buettneria perfecta*. The quarry has long been considered to have been produced by drastic drought conditions. However, an examination of the original field data as well as specimens from the quarry reveal that the Lamy quarry is, in fact, a hydrodynamically sorted semi-attritional accumulation. Particularly relevant taphonomic features of the quarry are the fine-grained sediments that lack mudcracks and fine laminations that occur with the fossil material, as well as a strong preferred orientation to the material, hydrodyamic sorting and imbrication of fossils, lack of articulation, dominance of adult animals, lack of scavenging and no apparent weathering of the bone surfaces. It is probable that given the size distribution of the skulls, the Lamy amphibians died in a catastrophic mortality event elsewhere and were subsequently transported.

**Keywords:** taphonomy, Chinle Group, metoposaur, Late Triassic, *Buettneria*, paucispecific, attritional

## INTRODUCTION

The Lamy amphibian quarry, also known as the Gunter bonebed, is located just south of Lamy, New Mexico (Fig. 1A). The quarry was discovered in 1936, and the site was excavated in 1938 by a crew working for Harvard University (MCZ), and again in 1947 by a crew working for the National Museum of Natural History (Smithsonian). The bonebed is dominated by fossils of metoposaurid amphibians, identified as *Buettneria* by D.H. Dunkle in 1947 (Appendix 1), later re-assigned to *Metoposaurus fraasi* by Colbert and Imbrie (1956), but now assigned to *Buettneria perfecta* (Hunt, 1993; Long and Murry, 1995). The bonebed is paucispecific (e.g. Rinehart et al., 2001), not monospecific as is often implied in the literature (e.g., Romer, 1939; Colbert and Imbrie, 1956; Fiorillo et al., 2001). In addition to the *Buettneria* fossils, a few fossils of phytosaurs, a theropod, and an indeterminate reptile are the only macrovertebrate fossils (Hunt and Lucas, 1995). A microvertebrate assemblage consisting of redfieldiid fish scales, other fish skull elements, a possible archosauriform (prolacertiform?) centrum, the premaxilla of an extremely small labyrinthodont, and other fish, reptile, and amphibian teeth, is also known from the quarry (Rinehart et al., 2001)

Previous authors have attributed the deposit to a mass mortality event caused by severe drought conditions (Romer, 1939; Gregory, 1980). Indeed, Romer's (1939, p. 339) evocative image of "the last scene in the drama of drought – a shrinking residual pool" has been repeated by many subsequent workers. However, a review of the detailed field notes related to the Smithsonian excavation and an examination of several jackets of material from the quarry in the New Mexico Museum of Natural History (NMMNH) collection indicate that this assemblage was not caused by a drought, but is most likely a hydraulically sorted and transported semi-attritional assemblage. Here, we review the sedimentological and biological evidence for the taphonomic conditions that led to the formation of the Lamy amphibian quarry.

## STRATIGRAPHY AND AGE

The Lamy quarry is in the SW1/4 SW1/4 NE1/4 NE1/4 section 29, T12N, R11E, Santa Fe County, New Mexico. It is in the Garita Creek Formation of the Chinle Group (Hunt and Lucas, 1989; Lucas, 1991; Hunt and Lucas, 1995) (Fig. 1B). Near the quarry, the Garita Creek Formation is approximately 40 m thick, overlies interbedded sandstones and mudstones of the Santa Rosa Formation and underlies the crossbedded sandstones and conglomerates of the Trujillo Formation (Lucas, 1991). The Garita Creek Formation in east-central New Mexico yields tetrapods of Adamanian age (Lucas et al., 2001).

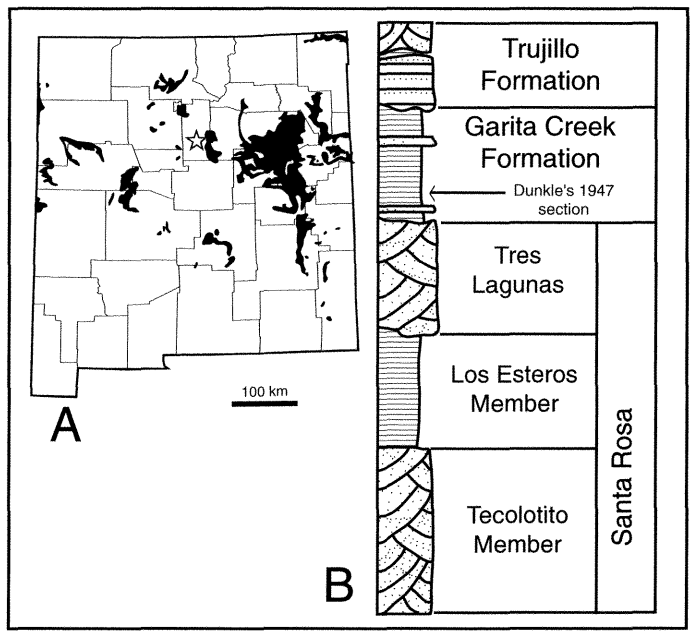


FIGURE 1. Index map (A) and generalized stratigraphic section (B) showing the Lamy amphibian quarry. Star denotes the Lamy amphibian quarry relative to Triassic outcrops in New Mexico.

## TAPHONOMIC ANALYSIS

### Sedimentological Data

The Lamy bonebed is at the base of a green and red mottled claystone, according to Dunkle's field notes from the Smithsonian excavations of 1947 (Fig. 2). The color mottling is most likely a

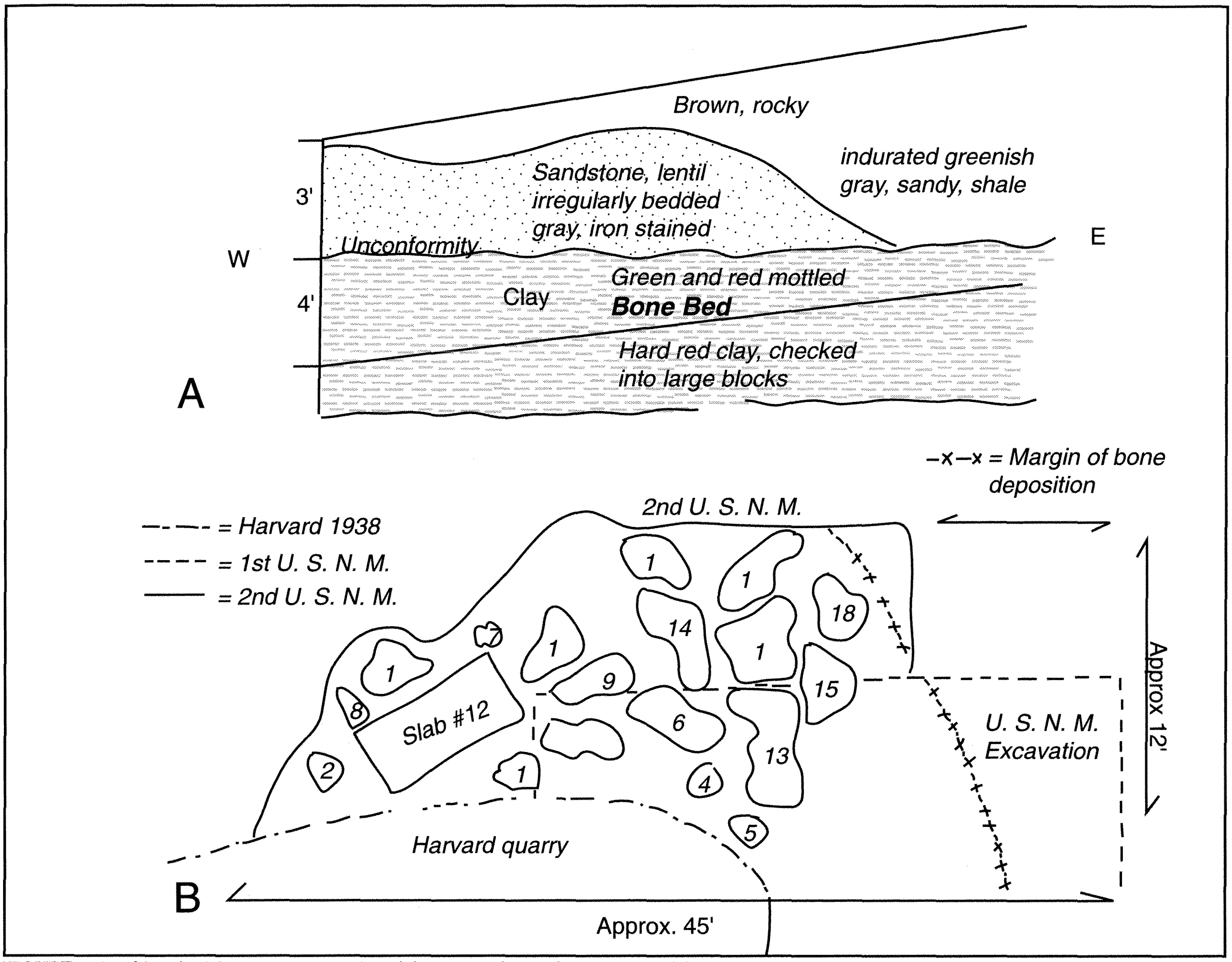


FIGURE 2. Dunkle's (1947) microstratigraphy of the quarry (A) and quarry map (B).

pedogenic alteration of the sediments after deposition. Examination of two unprepared jackets did not reveal any coarser material, such as sand or mud pebbles that might indicate deposition in a channel. Thus, we interpret these claystone deposits as distal floodplain where deposition (if any) of coarser material occurred during extreme flood events. Similar mudstones in Chinle strata are routinely identified as floodplain overbank deposits (e.g., Blakey and Gubitosa 1984; Kraus and Middleton, 1987; Newell, 1993; Therrien and Fastovsky, 2000). There are no apparent mudcracks, which would be expected if the site were a body of water that was drying up under drought conditions. Furthermore, the claystones are not laminated nor does their geometry suggest deposition by ponded water.

The bones themselves occur as a jumble of selected skeletal elements in a single layer (Fig. 3). An arbitrary "north" was drawn on photographs of both excavated slabs illustrated by Colbert and Imbrie (1956, pl. 28) (with "north" towards the top of the page) and orientations of as many elements as were visible were measured. There is a strong preferred orientation to the material in the Harvard block, and a weaker orientation to the material in the Smithsonian block (Fig. 4). There is also a moderate degree of imbrication (overlap of bones) visible in the Harvard block, especially of the flat skeletal elements (e.g., skulls, girdle elements). However, the deposit consists almost entirely of skulls, mandibles, girdle elements and vertebrae, with only a few limb bone fragments. This unique assemblage of skeletal elements and preferred orientation of elements indicates substantial hydrodynamic sorting.

The skulls and mandibles fall into Voorhies' Group III (Voorhies, 1969), whereas the vertebral and girdle elements fall into Group I. The Group I elements have a high surface area to volume ratio (SA:V), whereas the Group III elements have a low SA:V. A high SA:V indicates that the element may be moved by a low velocity current, whereas low SA:V objects require a stronger current in order to be transported.

The presence of the two hydrodynamic end members in the Lamy amphibian quarry can be explained in two ways. First, the assemblage could represent a mixture of elements deposited by two different flow regimes at two different times. The second possibility is that the metoposaurid skull, being very broad and flat, may be treated as similar to other wide, flat bones such as scapulae and interclavicles. In this case, the behavior of the skulls is more similar to that of the bones in Group I. Thus, the entire bonebed could have been created by a low velocity current.

The microvertebrates identified by Rinehart et al. (2001) were recovered during mechanical preparation of an interclavicle from the main bonebed collected by MCZ. These fossils were probably entrained in very thin (< 10 mm thick) sandy stringers.

FIGURE 3. Slab of material removed from the Lamy amphibian quarry by the Harvard field crew in 1938. Fossils include skulls, mandibles and assorted postcranial elements of the metoposaurid temnospondyl *Buettneria*.

## Biological Data

None of the material recovered from the Lamy amphibian quarry is articulated or associated to any significant degree. Unfortunately, much of the material from the bonebed is covered with a thick concretionary material that obscures the bone surface. However, examination of the few limb bones and girdle elements that had been prepared at NMMNH shows bone surfaces that are in good condition, with no apparent scavenger marks. Illustrated specimens (Colbert and Imbrie, 1956; Hunt, 1993) also show no evidence of scavenging. The bone ends are beginning to splinter and reveal inner bone tissue, which may be interpreted as a sign of moderate weathering (Behrensmeyer's [1978] stage 1-2).

The few limb bones that are present are all broken perpendicular to the long axis of the bone, indicating that the bones were fossilized prior to fracturing. Fresh bone will usually fracture in a spiral around the long axis (Shipman, 1981; Fiorillo et al., 2000). For the girdle material that could be examined, the bone surface is cracked and highly fragmented, though the skeletal elements are still more or less complete. Some specimens have a mosaic-like appearance, with fragments of the bone surface floating in a darker, fine-grained matrix. This particular form of preservation may be due to expansion of the inner bone material by replacement during fossilization, causing the outer bone surface to fragment open (Holz and Barbarena, 1994).

In the two large blocks collected for Harvard and the Smithsonian, there are 18 skulls, which may be used to estimate the minimum number of individuals (MNI) and evaluate population dynamics. The skulls range in length from 314 mm to 543 mm, with an average length of 439 mm. These skulls appear to represent mostly adult individuals, with no juvenile cranial material immediately apparent (Fig. 5). An age profile that is dominated by adult animals is typically indicative of a catastrophic mortality event, because adults in their prime are usually the healthiest members of a population. An attritional assemblage would, on the other hand, contain more juvenile and old members of a population, because these individuals are most susceptible to disease and predation (e.g., Voorhies, 1969; Wilson, 1988; Holz and Barberena, 1994).

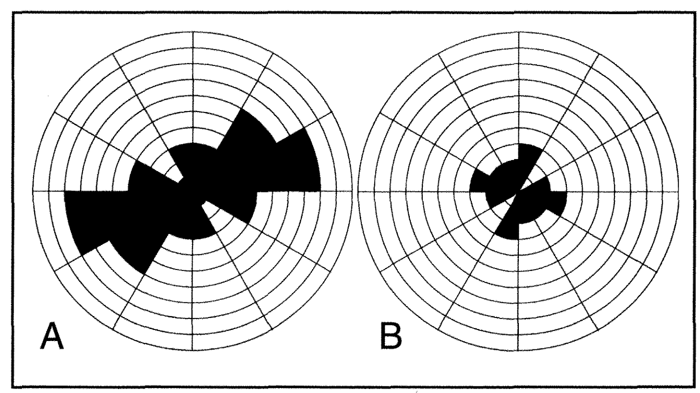


FIGURE 4. Rose diagrams for **A**, the Harvard slab and **B**, the Smithsonian slab. Measurements were taken on the skulls, mandibles and a few of the small long bones.

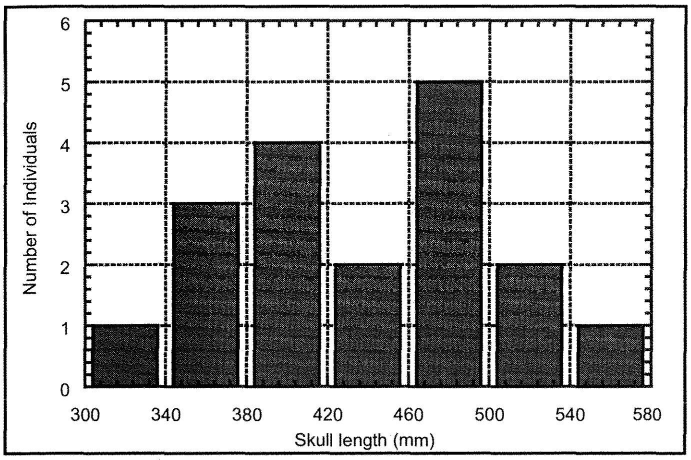


FIGURE 5. Histogram of the skull lengths of the Lamy amphibians, from data in Colbert and Imbrie (1956).

## DISCUSSION

While the age profile and the apparent lack of scavenging at the Lamy amphibian quarry seem to indicate a catastrophic event with quick deposition, the lack of skeletal articulation, coupled with the hydrodynamic sorting of the assemblage, rule out a catastrophic event with immediate, *in situ* deposition of the bones. It is more likely that the Lamy bonebed accumulated in a topographic low in the floodplain over a relatively short time span. There is, of course, the possibility that there was a mass mortality event elsewhere, and the decayed remains were then moved by a flow of water into their present location. Due to the relatively unweathered nature of the bones and the lack of scavenging, we propose that the amphibian corpses were buried shortly after death, then re-exposed. The partially decayed corpses were then subjected to further disarticulation and weathering prior to fluvial transport to their final resting place.

There is no clear evidence, however, to support the drought-induced mortality event that has been proposed by other authors; indeed, there is incontrovertible evidence against it. There is no sedimentological evidence of drought, such as mudcracks, nor is there any biological evidence. In other bonebeds that have been related to drought, bones are found trampled down into the underlying sediment, and often, the bones are spirally fractured, indicating breakage while the bone was still fresh (Shipman, 1981; Fiorillo et al., 2000). The lack of juvenile remains, coupled with the lack of articulation and sorting of skeletal elements as well the lack of evidence for trampling also cannot be satisfactorily explained by a drought. Hunt and Lucas (1989, 1995) also argued against a drought-induced death event producing the Lamy bonebed, though they presented no explicit evidence other than to note the disarticulation and alignment of elements.

## CONCLUSION

The Lamy amphibian quarry is most likely a semi-attritional deposit. It is probable that given the size distribution of the skulls, the Lamy amphibians died in a catastrophic mortality event elsewhere and were subsequently transported. The lack of articulation and the lack of scavenging, when taken together, preclude the *in situ* death of the amphibians. However, the lack of scavenging provides evidence of a rapid burial of the corpses, which was probably followed by a reworking of the corpses back onto the surface, allowing for weathering and final disarticulation. If the hydrodynamic sorting, alignment and imbrication of the material are also taken into account, it becomes apparent that the fossils were probably entrained in a flow of water and deposited in a topographic low on the floodplain. The sedimentological and biological evidence together do not support the drought hypothesis that has long been advocated to explain this bonebed. Instead, the data indicate a semi-attritional taphonomic mode for this fossil assemblage: a catastrophic mortality event, followed by rapid burial of the corpses, re-exposure of the skeletons and finally, fluvial transport of the material into a topographic low.

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## APPENDIX 1—DESCRIPTION OF JACKETED USNM MATERIAL (DUNKLE, 1947)

Jacket numbers as in Figure 2B.

1: *Buettneria*. Skull, right side up, lacking right orbit and part of snout; vertebrae, plates, etc. June 3, 1947.

2: *Buettneria*. Complete skull, upside down. Vertebrae and various large bones on the bottom of the block, June 4, 1947.

3: *Buettneria*. 2 complete skulls, one right side up and other upside down. June 4, 1947.

4: *Buettneria*. One skull, right side up. Badly checked. June 4, 1947.

5: *Buettneria*. Skull, upside down. Poor. June 4, 1947.

6: *Buettneria*. 3 skulls, two right side up and the other upside down. June 5, 1947.

7: Undetermined plate. June 5, 1947.

8: Undetermined bone or plate one end of which is still imbedded in, on the NW corner of the slab (D-47-12). June 5, 1947.

9: *Buettneria*. 2 complete skulls, one right side up and the other upside down. Very good. June 5, 1947.

10: *Buettneria*. One complete skull, right side up; plus clavicles and various other bones. June 6, 1947.

11: *Buettneria*. 2 skulls one of which is upside down; plus various other plates. Very good. June 6, 1947.

12: *Buettneria*. Exhibition slab, 4 _' x 9 _', containing 7 complete skulls, 2 incomplete skulls as well as numerous vertebrae and various other elements. June 21, 1947.

13: *Buettneria*. 2 skulls, one of which is upside down; plus numerous other bones. Moderately good. June 14, 1947.

14: *Buettneria*. One skull, upside down; plus an interclavicle. Very large and good. June 14, 1947.

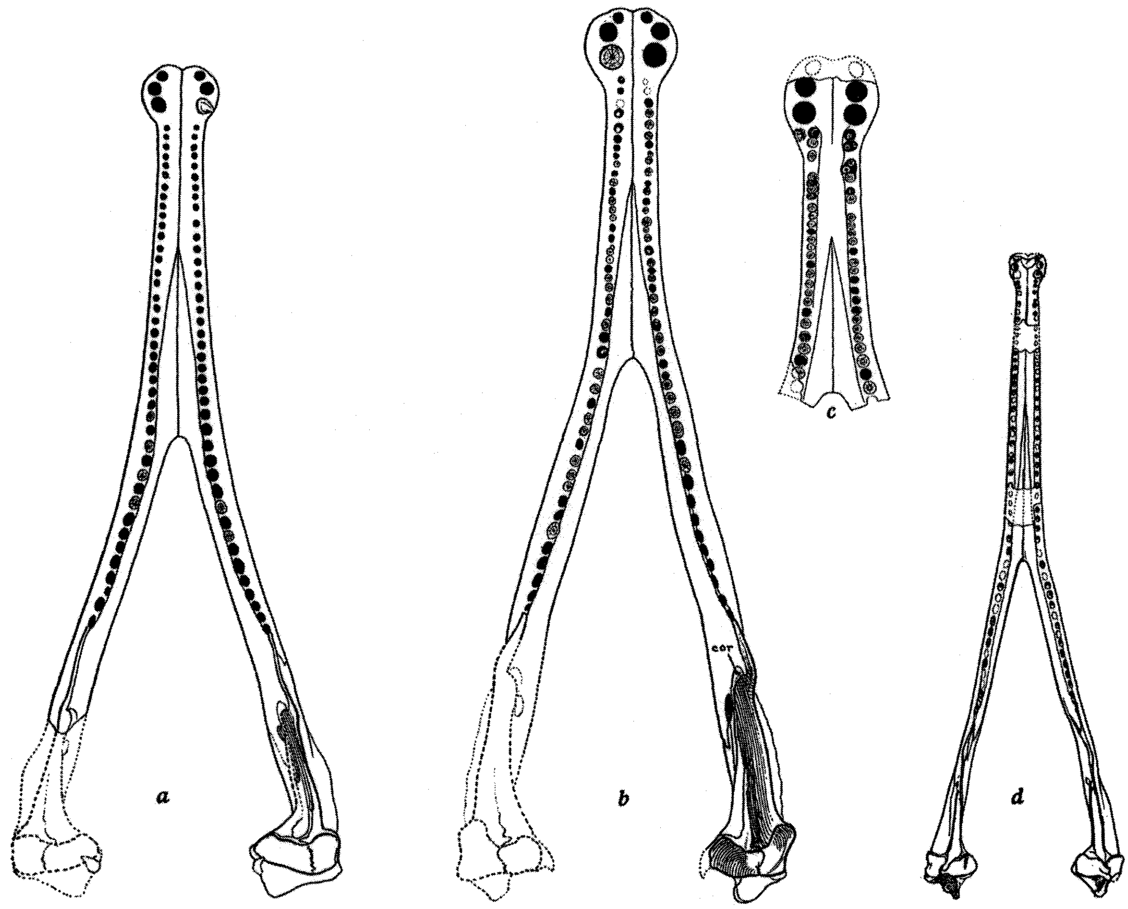
15: *Buettneria*. One skull, right side up and various plates. Poor. June 16, 1947.

16: *Buettneria*. 2 skulls, right side up with various other bones. Good. June 17, 1947.

17: *Buettneria*. 2 skulls, right side up with various additional bones. One skull large and good. June 17, 1947.

18: *Buettneria*. One skull, two interclavicles, plus various bones. Fair. June 17, 1947.

19: *Buettneria*. One skull, right side up, lacking anterior snout extremity, associated with a variety of bones. Fair. June 17, 1947.




Lower jaws of four species of *Machaeroprosopus*, x1/9. a. *M. adamanensis* (type) b. *M. lithodendrorum* (type). c. *M. lithodendrorum* from specimen in geological collection of Northwestern University; collected eight miles south of Adamana, Arizona. d. *M. tenuis* (type) (from Camp, 1930, fig. 12, p. 45).