

NEW SPECIMENS OF DILOPHOSAURUS WETHERILLI (DINOSAURIA:
THEROPODA) FROM THE EARLY JURASSIC KAYENTA FORMATION OF
NORTHERN ARIZONA

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Abstract: A review of the collections of the Museum of Northern Arizona has revealed a number of bones from the Kayenta Formation labeled as “large theropod.” A comparison of these bones to both published figures and to the holotype of *Dilophosaurus wetherilli*, housed at the University of California Museum of Paleontology, has revealed that the unidentified specimens at the Museum of Northern Arizona are almost certainly *Dilophosaurus wetherilli*. This new material is particularly interesting because it preserves parts of the pelvis not present in the holotype. The same locality preserves the first record of an infant *Dilophosaurus*.

Museum Abbreviations: Museum of Northern Arizona, MNA; University of California Museum of Paleontology, UCMP.

Previous Work: In 1942, the UCMP excavated the remains of an unknown medium-sized theropod from the Kayenta Formation, which was described by Welles (1954) as *Megalosaurus wetherilli*. This original description was based on UCMP specimens 37302 and 37303, but later, Welles renamed the animal, based on a new specimen, UCMP 77270, in which two parallel crests could be seen on the top of the skull, a feature not

present in the original material. Based on the new specimen, and a more extensive review of other *Megalosaurus* specimens, Welles proposed the name *Dilophosaurus wetherilli* (Welles, 1970). A few years later Welles (1984) published a full description of *D. wetherilli*, including a reconstruction of the skull and skeleton. Now it is apparent that there are two, possibly three, previously undiagnosed specimens of *Dilophosaurus wetherilli*. This material, and other material associated with it, was collected in 1978, in the Kayenta Formation from the area of Rock Head, in the Rock Head Quadrangle, northern Arizona. The location is designated as MNA location 219-0, and its precise position is on record at the Museum of Northern Arizona.

DESCRIPTION

Elements now referred to *D. wetherilli* as follows:

Cranial and Mandibular Skeleton

MNA P1.97, a complete tooth, without the root. The teeth of *Dilophosaurus* are quite distinctive, being laterally compressed, fairly long, but having a relatively small base. The teeth also expand basally. This tooth exhibits all of these characteristics. This specimen is approximately 5.1cm in length (Fig. 1.3).

MNA P1.111, fragments of a dentary. This specimen was difficult to identify, since it is in many small pieces. However, when viewed from the top, the shape of the alveoli become apparent. This shape is the same as the cross-section of the referred tooth, MNA P1.97. The fragments range from 2 to 5cm in length.

Forelimbs

MNA P1.116, left manus, digit 3, phalanx 1. This specimen compares favorably with the same element on UCMP 37302. This specimen measures approximately 4.8cm in length.

MNA P1.141, right manus, digit 3, phalanx 2. This element exhibits the same characteristics as UCMP 37302. This specimen is approximately 6cm in length.

MNA P1.3181, an infant specimen, composed of a distal humerus, a partial distal fibula and a tooth fragment. The humerus very closely resembles that of UCMP 37302, with the ectocondyle, ectepicondyle, entocondyle and entepicondyle all being present in the same arrangement as UCMP 37302, but much more pronounced, which is to be expected in a very young animal (Pers. Obs. 1998). The humerus is 5cm from the distal tip to the break. The fibula, while it does not preserve the end portion (as the bone is broken on both ends), does preserve the same general shape and curvature found in both MNA P1. 530 and MNA P1.539. The fibula is approximately 6cm in length, but is not complete. The tooth may or may not belong to this animal. It is too fragmented to make an identification (Fig. 1.1).

Vertebral Column

MNA P1.135, dorsal centrum and partial unfused neural spine. While this specimen is somewhat broken, it is possible to identify the shape of the vertebra. The shape is very similar to that of the dorsal vertebrae in UCMP 37302. This specimen is approximately 8.3cm in length.

MNA P1.176, a centrum. This is a much smaller dorsal vertebra than MNA P1.135, but it still preserves the diagnostic *Dilophosaurus* shape; narrow, with an arched dorsal surface and several pleurocoels. This specimen is approximately 3.1cm in length.

MNA P1.177, a large centrum and partial neural spine. This dorsal vertebra is highly diagnostic, showing the laterally compressed centrum characteristic of *Dilophosaurus*, along with the sweeping neural spine that has a platform on the anterior portion, which then rises to form the spine. This specimen also possesses clearly defined pleurocoels on the centrum. This specimen is approximately 8.5cm in length.

MNA P1.138, a vertebra centrum. This specimen preserves a nearly complete caudal centrum, and also provides a glimpse at the age of the animal. The suture for the attachment of the neural spine is present on the left side of the vertebra, and the basalmost portion of the neural spine is preserved on the right side. However, the spine is clearly not fused, since the suture line is still quite obvious, which would indicate that this animal was not fully grown. Coupled with the relatively smaller size of this centrum, this animal was most likely a juvenile. This specimen is approximately 4.5cm in length (Fig. 1.2).

MNA P1.247, a partial rib head that measures 6.5cm in width. MNA P1.142, a partial rib. Both conform well to what is known of the ribs in *D. wetherilli*

Pelvic Girdle and Hindlimb

MNA P1.109, a juvenile femur. This specimen is quite similar to the preserved femur of UCMP 37302, but only measures 28.1 centimeters in length, as opposed to 54cm for UCMP 37302 (Welles, 1954). The entocondyle, ectocondyle and ectocondylar tuber are all present on the distal end of MNA P1.109, and all look like the corresponding parts of UCMP 37302. The greater trochanter and fourth trochanter are not present because the bone is broken in these areas (Fig. 1.5).

MNA P1.102, juvenile distal left fibula. This specimen has the same shape as the fibula illustrated by Welles (1984), and also conforms to the other two distal fibulae referred herein. This is much smaller than what is seen in the other two referred fibulae, however, it is the size that one would expect from an animal that had a femur the size of MNA P1.109 (Gay, in prep). This specimen is approximately 11cm in length.

MNA P1.160, the proximal end of the right femur; MNA P1.161, the distal end of MNA P1.160. These two specimens, MNA P1.160 and 161 are quite diagnostic of *Dilophosaurus*. As with MNA P1.109, the ectocondyle, entocondyle and ectocondylar tuber are all present, and conform to the arrangement in UCMP 37302. In MNA P1.160, the anterior trochanter is present. However, the greater trochanter is broken off. In MNA P1.161, most of the shaft is broken away, so the presence of the fourth trochanter cannot be determined. The total reconstructed length of this femur is approximately 56cm.

MNA P1.154, proximal end of the right pubis. The iliac facet and the ischial facet are both clear, and conform to what is seen in UCMP 37302. This specimen is approximately 5.7cm in width. This is much smaller than the other two preserved pubes, however, this is the size of pubis one would expect from an animal that had a femur the size of MNA P1.109.

MNA P1.248, complete left pubis. This specimen is more broken up on the surface, but most of the pubis is preserved. As with MNA P1.154, this specimen preserves the iliac and ischial facets. This specimen measures approximately 57cm in length, and 13.2cm in width at the proximal end. MNA P1.530, distal left fibula. This appears to conform to the fibula of *Dilophosaurus*. This specimen, while broken, measures approximately 20.2cm in length (Fig. 1.4).

MNA P1.539, a distal right fibula. This conforms to the fibula of *Dilophosaurus*. It is almost a mirror image of MNA P1.530. This specimen measures approximately 20.3cm.

MNA P1.101, partial proximal left pubis. While broken, there is still enough to identify it as *Dilophosaurus* based on general morphology. The iliac facet is present, but the portion of the bone that would bear the ischial facet is broken away. This specimen measures approximately 12.4cm in width.

MNA P1.122, an ischium fragment. This fragment is broken on both ends, and weathered on one end, making diagnosis somewhat difficult. However, it would appear that this is a fragment of the pelvis, and is too wide and flat to be a portion of the pubis. Therefore, it is most likely a fragment of the ischium. The length of this specimen is approximately 9.3cm.

MNA P1.131, pedal digit 3, phalanx 1. This specimen appears to conform quite well with the same element of UCMP 37302. The length of this specimen is approximately 12cm.

Also from the same locality as the above referred specimens are several vertebrae, long bone fragments and some crushed skull elements, most likely referable to *Dilophosaurus*, several scutes from the dinosaur *Scelidosaurus* (Padian, 1989), some small reptile bones, a single bivalve, a gastropod (*Eucyclomorpalus* [Knight et al., 1960]), some unidentified plant material, and a proximal femur from an unknown dinosaur. This femur differs significantly from both *D. wetherilli* and *Syntarsus kayentakatae*. It is too large for, and shaped differently than *Scutellosaurus*. It is possible that it is referable to the undescribed heterodontosaurid mentioned by Attridge et al.

(1985), though no figure or description is given. However, the description of a femur head from a heterodontosaur by Weishampel and Witmer (1990) notes that the greater trochanter is not well separated from the head, and the lesser trochanter is not well separated from the greater trochanter. This is quite different than what is seen in this specimen (MNA P1.115), where the greater and lesser trochanters stand out some distance from each other and from the head of the femur. Therefore, this femur will remain undiagnosed for the time being.

DISCUSSIONS AND IMPLICATIONS

While most of the material from this site is damaged, there is enough material present to positively identify at least three individuals, based on the presence of three proximal pubes, two femora of differing size, and MNA P1.3181 (the infant). Welles (1984) uses the presence of several individuals preserved together to state that *Dilophosaurus* probably traveled in small groups. While this may be likely, based on footprint data from the underlying Moenave Formation (Welles, 1980), there is no direct evidence to support this position. In fact, the depositional environments of the Kayenta Formation (Luttrell, 1987) would seem to indicate that since streams were not always flowing, flash floods would pick up scattered and isolated material from different individuals and deposit them together in the same area.

In these specimens, several elements are preserved that are not present in either UCMP 37302 or UCMP 77270. These include the partial ribs, which are unremarkable, save their presence. More interesting, however, is MNA P1.248, a complete left pubis. While *D. wetherilli* (Welles, 1984; Rowe and Gauthier, 1990) is illustrated with a small expansion at the tip of the pubis, this specimen shows that the pubis lacks the expansion

illustrated by previous authors. It should also be noted that what is labeled as the pubis in UCMP37302 is illustrated as the ischium in Welles (1984) and Rowe and Gauthier (1990), and conversely for what is labeled as the ischium in UCMP 37302. It is likely that these labels have been accidentally switched between then and the present.

Perhaps the most interesting material present from MNA Location 219-0 is MNA P1.3181. This is the first record of an infant *Dilophosaurus*, and is also one of the earliest known infant dinosaurs in North America, preceded only by specimens of *Coelophysis bauri*. While quite small, the fibula fragment is easily identified as *Dilophosaurus*, based on the curvature of the bone, which is identical to the curve and structure of MNA P1.530 and MNA P1.539. Although this is a small amount of material, the humerus and fibula are diagnostic. This is not a specimen of *Syntarsus kayentakatae*. The shape of the humerus is quite different from that illustrated by Rowe and Gauthier (1990). Instead, it seems to conform more to the illustration of the humerus of *Dilophosaurus* (Welles, 1984; Rowe and Gauthier, 1990). As mentioned before, the fibula conforms perfectly to that of the newly referred *Dilophosaurus* material.

The presence of an infant is important for several reasons. First, this can begin to give an understanding of the growth rates of early theropods. While Colbert (1989) mentions that there is an almost complete growth series present in *Coelophysis* no study of bone histology has been done on this animal, as has been done for *Maiasaura* (Horner et al., 2000). A comparison between the growth rate of *Coelophysis* and that of *Dilophosaurus* could begin to give insights into the growth rates of early theropods, something about which very little is known.

Finally, if for no other reason, the presence of an infant *Dilophosaurus* is important because it is the first one known. While neither the MNA nor the UCMP *Dilophosaurus* specimens are mature individuals (as evidenced by a lack of fusion in the pelvis and vertebral elements), this specimen is certainly the youngest example of this genus known so far.

The environment of deposition at the site was most likely a stream bed, based on the fact that most of the specimens show some evidence of transport, and with the exception of the bivalve and the gastropod, none of the animals are complete. This likely indicates transport over some distance, although if the bones had been laying on the surface for a while before transport, this may not be the case. Luttrell (1987) states that the Kayenta is mainly fluvial, with some aeolian deposits occurring in the sandy facies of the Kayenta, in southern Utah, eastern Colorado and northern Arizona. The position of Rock Point, as indicated by Luttrell, lies at the edge of a dune environment, on an ephemeral stream with transverse bars. This would seem to indicate that the animals died and most likely weathered on the surface before being transported to one of the bars along the stream, possibly by a flood event. This would account for the variety of animals represented by small fragments, and many of the bones being broken.

CONCLUSION

With more material now referred to *Dilophosaurus wetherilli*, our understanding of this enigmatic theropod increases. With a partial growth series, and the addition of an infant *Dilophosaurus*, an understanding of the growth in early theropods, can be developed. The complete pubis referred to *D. wetherilli* does not preserve a reconstructed pubic boot, contra Welles (1984) and Rowe and Gauthier (1990). It should also be noted that this

specimen, coming from Rock Head, is almost 120 miles away from the original type locality outside of Tuba City (Welles, 1970). Further work is also being done on the material referred in this paper, so more information will soon be available on much of this material.

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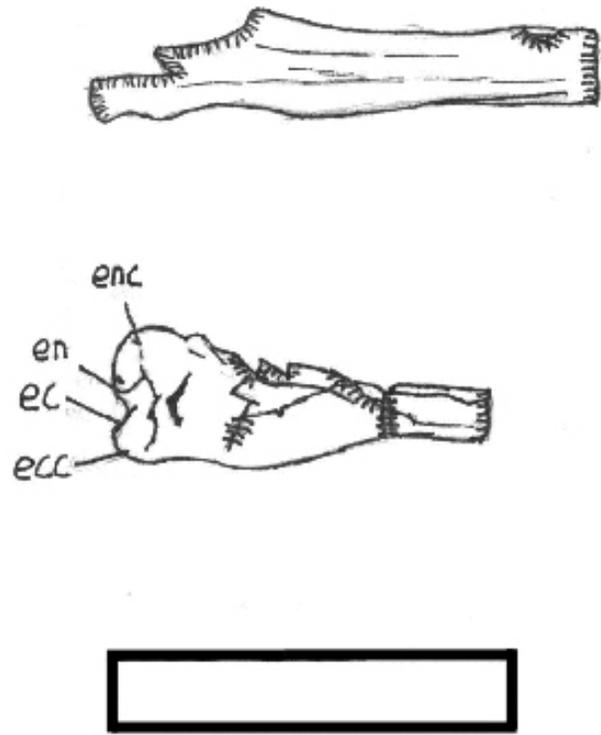


Figure 1.1: MNA P1.3181. Line drawing of fibula and humerus. Fibula in medial view, humerus in anterior view. enc, entepicondyle;. en, entocondyle; ec, ectocondyle; ecc, ectepicondyle. Scale bar = 5cm.

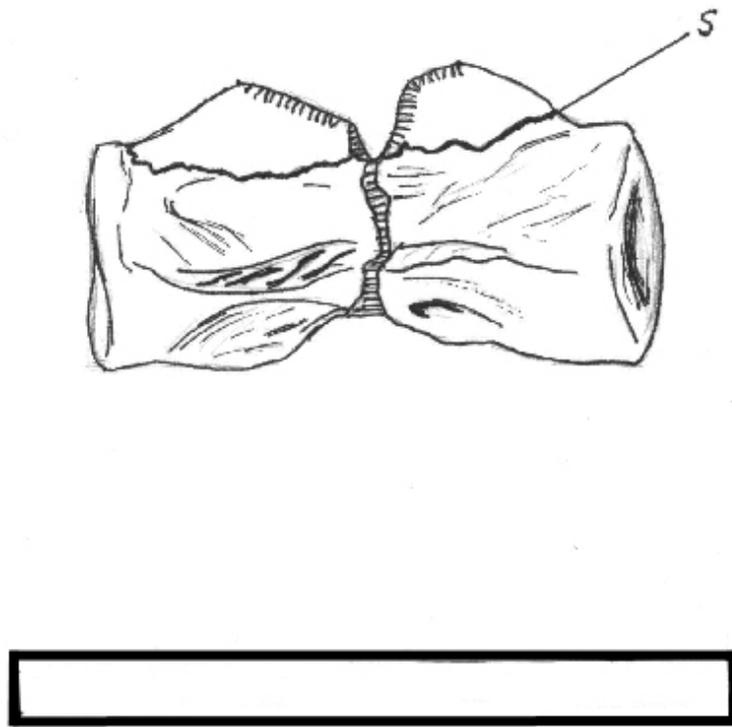


Figure 1.2: MNA P1.138. Juvenile caudal centrum showing un-fused neural spine and suture. Oblique view. S, suture. Scale bar = 5cm.

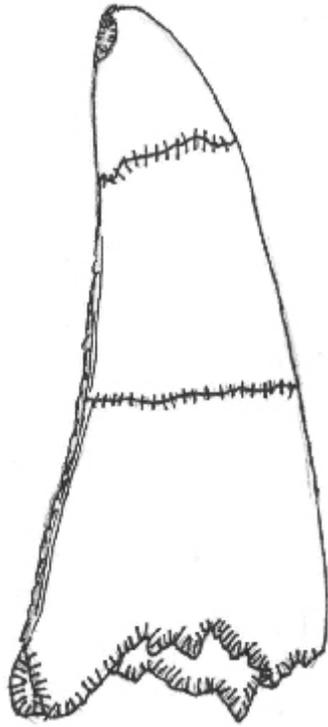


Figure 1.3: MNA P1.97. Tooth. Scale bar = 5cm.

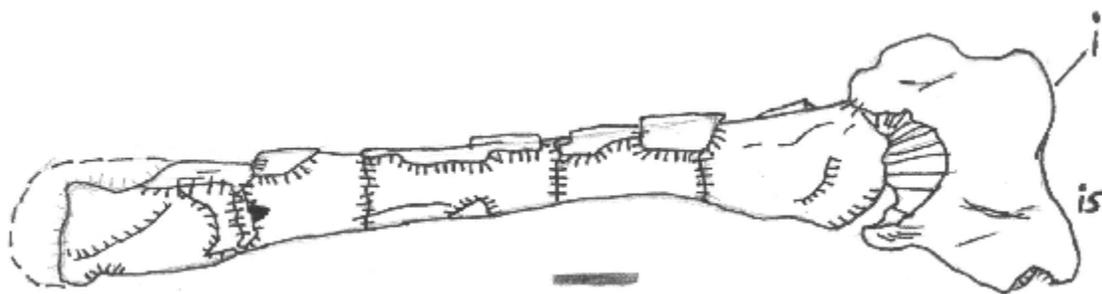


Figure 1.4: MNA P1.258, left pubis in left lateral view. i, iliac facet; is, ischial facet.

Scale bar = 5cm.

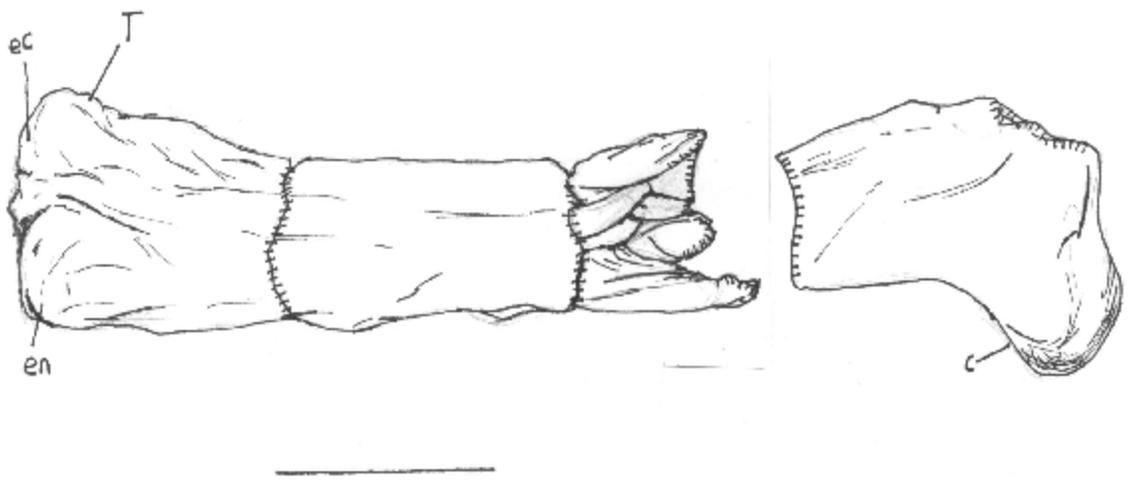


Figure 1.5: MNA P1. 109. Juvenile left femur in posterior view. c, caput; ec, ectocondyle; en, entocondyle; T, ectocondylar tuber. Scale bar = 5cm.

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