



# A POSSIBLE PTEROSAUR WING PHALANX FROM THE KAIPAROWITS FORMATION (LATE CAMPANIAN) OF SOUTHERN UTAH, USA

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## ABSTRACT

An isolated bone from the late Campanian-aged Kaiparowits Formation of southern Utah is tentatively identified as the terminal wing phalanx (manual phalanx IV-4) from a pterosaur, representing the first report of this clade from the formation. The specimen is 60 mm long and hollow, with thin and delicate walls and expanded proximal and distal ends. This is consistent with anatomy reported for equivalent elements in pterodactyloid pterosaurs. Although the specimen cannot be more precisely identified, it is consistent with occurrences of pterosaurs in penecontemporaneous terrestrial depositional environments throughout western North America.

## Introduction

The Kaiparowits Formation of southern Utah, dated to the late Campanian (Roberts *et al.*, In Press, 2005), preserves a rich assemblage of archosaurs, including crocodyliforms (Irmis *et al.*, In Press), non-avian dinosaurs (Gates *et al.*, In Press; DeCourten & Russell, 1985; Zanno & Sampson, 2005; Gates & Sampson, 2007; Sampson *et al.*, 2010; Zanno *et al.*, 2011), and

birds (Farke & Patel, 2012). To date, no pterosaurs have been described from the Kaiparowits Formation, even though they are known from penecontemporaneous strata representing terrestrial environments throughout the Western Interior of North America (Currie & Russell, 1982; Currie & Padian, 1983; Padian, 1984; Currie & Jacobsen, 1995; McGowen *et al.*, 2002; Godfrey & Currie, 2005; Sullivan & Fowler, 2011). Here, we describe an isolated bone from

the Kaiparowits Formation, tentatively identified as a pterosaur wing phalanx. Although the material is scrappy, the rarity of pterosaurs in the Kaiparowits Formation encourages the description of even incomplete material.

### Institutional abbreviations

RAM, Raymond M. Alf Museum of Paleontology, Claremont, California, U.S.A.  
UNSM, University of Nebraska State Museum, Lincoln, U.S.A.

### Methods

The specimen RAM 15445 was serendipitously discovered at locality RAM V200810, while trenching around a skull roof of the hadrosaur *Gryposaurus* sp. (RAM 12065). Thus, one end of RAM 15445 was unfortunately destroyed before recovery. The bone and surrounding matrix were stabilized with polyvinyl acetate dissolved in acetone, and loose fragments were reattached using cyanoacrylate glue. Some of the matrix was removed mechanically with dental picks and similar tools, although most of the rock was left in place to support the delicate specimen.

Prior to its reattachment, a portion of the bone was digitally photographed with a scale bar. Measurements of the cross section were then obtained in ImageJ 1.46 (Rasband, 1997). Additional measurements of the specimen were taken directly from the specimen using digital calipers.

### Systematic Paleontology

Pterosauria Kaup, 1834

Pterosauria genus et species indet.

Referred specimen — RAM 15445, tentatively identified as manual phalanx IV-4.

Locality and horizon — RAM V200810, Grand Staircase-Escalante National Monument, Garfield County, Utah, U.S.A. The locality is within the Kaiparowits Formation, above a bentonite tentatively correlated with bentonite KBC-144, which was dated at  $75.51 \pm 0.15$  Ma (late Campanian; Roberts *et al.*, In Press; 2005). Thus, RAM V200810 is most likely within the uppermost part of the middle unit, or perhaps even the very base of the upper unit, of the Kai-

parowits Formation. Precise locality data are archived at the RAM and are available to qualified investigators upon request.

### Description

The single element preserved in RAM 15445 is hollow, with very thin and delicate walls. At a broken portion of the bone (figure 1A), the bone is oval in cross-section (4.7 mm by 2.7 mm in external dimensions) with a wall thickness ranging between 0.27 and 0.43 mm. The specimen is not crushed, but retains its original three-dimensional shape.

Including the impression that represents the missing end of the bone, RAM 15445 is 59.9 mm in length and 4.1 mm in maximum width at its midpoint. We tentatively identify one end (at the left side of figure 1A, B) as the proximal end, because it is expanded in what appears to be an articular surface. This end is slightly expanded relative to the shaft of the bone, measuring 7.2 mm in maximum width and 3.6 mm in minimum width.

The distal end is missing but preserved as an impression. This shows that the bone is slightly curved distally. Furthermore, a bilateral sulcus along the distal third of the shaft creates a slightly dumbbell-shaped cross section. As measured approximately 57 mm from the proximal end of the bone, the shaft is 2.2 mm in minimum width and 4.3 mm in maximum width.

### Discussion

#### *Identification and Comparison*

Specimen RAM 15445 is tentatively identified as manual phalanx IV-4 of a pterosaur, based on the bone's overall shape as well as the extreme thinness of its walls. Although avian and non-avian theropod limb bones are also hollow, they are generally thicker-walled than seen in RAM 15445. Furthermore, the lack of torsion along the shaft of RAM 15445, as well as the overall profile and cross sectional shape of the bone, are inconsistent with possibilities such as a theropod ulna, radius, or metacarpal. We thus consider an identification of pterosaur as the most parsimonious of possibilities.

In overall morphology, RAM 15445 is most similar to phalanges IV-4 illustrated for several pterodactyloids, including the tapejarid *Sinopterus dongi* and the ornithocheirid *Anhanguera*

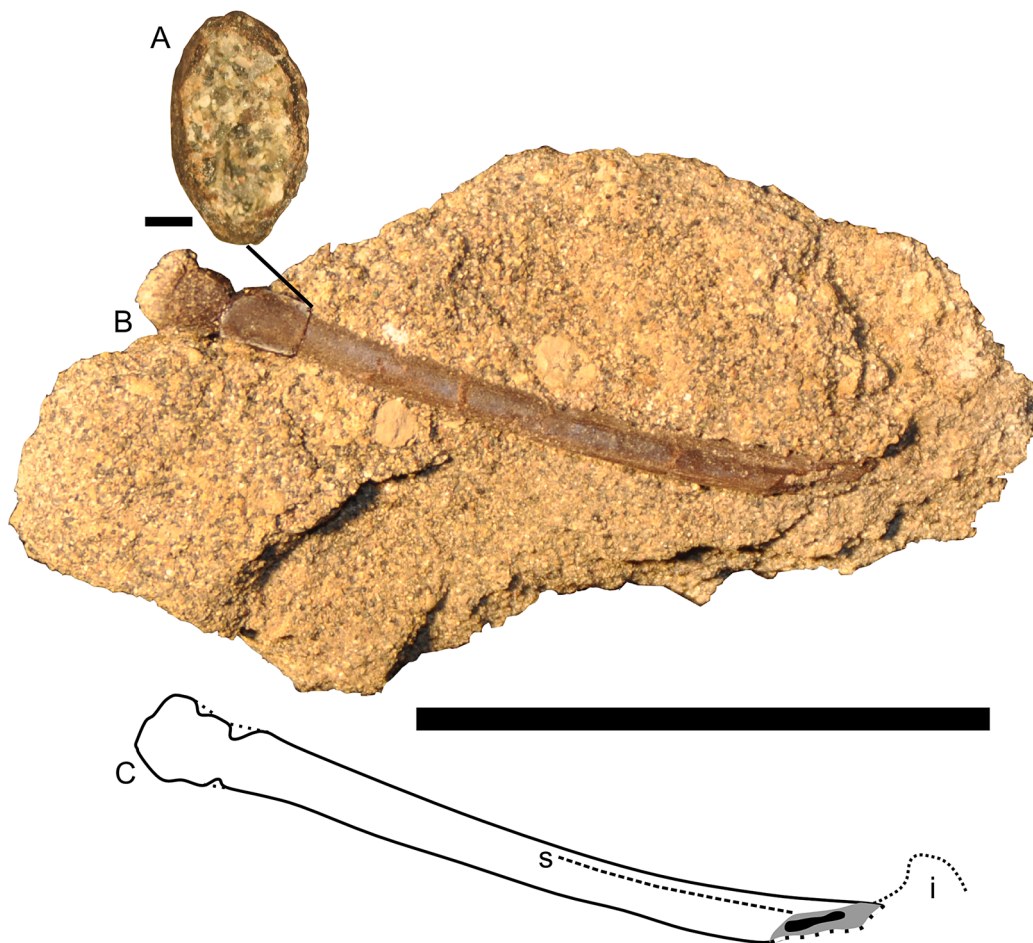


Figure 1. Possible manual phalanx from a pterosaur, RAM 15445. A) Cross section of bone at point indicated by line to B; B) Photograph of bone; C) interpretive line drawing of bone. Abbreviations: i, impression; s, sulcus. Upper scale bar, for A, equals 1 mm. Lower scale bar, for B and C, equals 5 cm. Figure by the authors.

*spielbergi* (Veldmeijer, 2003; Wang & Zhou, 2003). As in the interpreted anatomy of RAM 15445, both *S. dongi* and *A. spielbergi* show a slight distal curve and expanded proximal and distal ends in their equivalent phalanges

Some other pterosaurs also exhibit a manual phalanx IV-4 with distal curvature, although they thin distally rather than expand, in contrast with RAM 15445. These include *Arthur-dactylus conandoylei* (Frey & Martill, 1994), *Anhanguera ligabuei* (Dalla Vecchia, 1993) and *Hauxia pterus corollatus* (Lü *et al.*, 2006). A specimen of *Nyctosaurus gracilis* (UNSM 93000), also has a curved distal phalanx that tapers to a point, as well as some *Pteranodon* spp. with the appropriate anatomy preserved (Eaton, 1910). Unfortunately, comparable material for North American pterosaurs from terrestrial environments is not known. In general, it seems likely that phalangeal anatomy similar to that of RAM

15445 is probably quite widespread and not of major taxonomic significance.

#### *Pterosaurs from Campanian Terrestrial Assemblages of North America*

Many of the pterosaur bones described from Late Campanian terrestrial sites in North American sites are not identifiable to species, and none are elements directly comparable to RAM 15445. From the Dinosaur Park Formation, azhdarchid fossils include parts of several individuals of various sizes (Currie & Russell, 1982; Currie & Padian, 1983; Godfrey & Currie, 2005), most of them relatively large (estimated wingspans between 2.5 and 13 m; Godfrey & Currie, 2005). The Two Medicine Formation has also yielded azhdarchids, including *Montanazhdarcho minor* (Padian, 1984; Padian *et al.*, 1995; McGowen *et al.*, 2002), and material from the Kirtland Formation of New Mexico and the Di-

nosaur Park Formation of Alberta was referred to a possible azhdarchid, *Navajodactylus boerei* (Sullivan & Fowler, 2011).

Despite the paucity of material, all of these specimens indicate the distribution of pterosaurs throughout terrestrial environments of western North America during the late Campanian. The newly described specimen, RAM 15445, is not particularly remarkable within this context, nor does it offer much in the way of anatomical information. Nonetheless, this specimen is important in establishing the presence of pterosaurs within the Kaiparowits Formation of southern Utah. Additional work is needed to discover, collect, and interpret more complete specimens that will better establish the identity of Kaiparowits pterosaurs.

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