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Patricia A. Holroyd and J. Howard Hutchison (2016). Fauna and setting of the *Adelolophus hutchisoni* type locality in the Upper Cretaceous (Campanian) Wahweap Formation of Utah

Cover photo: Dentary fragment of the bowfin fish cf. *Melivius chauliodous* in ventral and dorsal view.

Citation: Holroyd, P. A. and Hutchison, J. H. 2016. Fauna and setting of the *Adelolophus hutchisoni* type locality of the Upper Cretaceous (Campanian) Wahweap Formation of Utah. *PaleoBios*, 33. ucmp_paleobios_31196

Fauna and setting of the *Adelolophus hutchisoni* type locality in the Upper Cretaceous (Campanian) Wahweap Formation of Utah

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We report new data on the type locality of the hadrosaurid ornithischian *Adelolophus hutchisoni* Gates et al., 2014 from the Campanian-aged Wahweap Formation of southern Utah, and the remainder of the vertebrate assemblage from the site. The type locality (UCMP V98173) is a previously-reported U.S. Geological Survey locality (USGS D815) and is stratigraphically low in the upper member of the Wahweap Formation. Additional taxa from the same site include acipenseriforms (sturgeon), amiiforms (bowfin), and lepisosteiforms (gar fish), baenid and trionychid turtles, and both theropod and ornithischian dinosaurs.

Keywords: Acipenseriformes, Amiiformes, Lepisosteiformes, Testudines, Theropoda, Ornithischia

INTRODUCTION

Gates et al. (2014) recently named the new lambeosaurine hadrosaurid *Adelolophus hutchisoni* based on a maxilla, University of California Museum of Paleontology (UCMP) 152028. Specimens of *Adelolophus* Gates et al., 2014 from the Wahweap Formation are the oldest definitive lambeosaurine skeletal material reported to date (Gates et al. 2014). Regarding the type locality, in the caption of their stratigraphic figure 9.1 they state, “The locality of UCMP 152028 is unknown, but based on an examination of the host matrix it is likely to have originated from the Upper Member.” Sampson et al. (2013, fig. 28.3) also showed the likely stratigraphic position of *Adelolophus* (as “new lambeosaurine”) as high in the upper member of the Wahweap Formation, just below the capping sandstone. Given the importance of establishing the first appearance of this taxon, it is critically important to document its stratigraphic position and context.

Examination of records on file and online at UCMP and related literature indicate that the type locality is both known and previously published, and we herein clarify the type locality in accordance with recommendation 76A.2 of the International Code on Zoological Nomenclature. We also report additional taxa and specimens from the same site.

UCMP 152028 is accessioned into the UCMP collections under the locality number V98173, which is recorded on the holotype maxilla above the specimen number and separated

from it by a line, as is the typical convention for physically labeling UCMP specimens. UCMP locality V98173 is named “USGS D815,” reflecting its concordance with that locality. USGS D815 refers to a U.S. Geological Survey collection number (Denver catalogue) and is a locality near Death Ridge in Kane County, Utah, published by Zeller (1973, plate 1). Zeller (1973: Table 1) (Fig. 1) also reported the presence of both a tyrannosaurid saurischian and an ornithopodus

TABLE 1.—FOSSIL COLLECTIONS FROM THE DEATH RIDGE QUADRANGLE

[Mollusca identification and zone assignment by W. A. Cobban, U.S. Geological Survey; vertebrate identification by G. E. Lewis, U.S. Geological Survey. Locations of fossil collections are shown on the geologic map, and stratigraphic positions are given in the generalized columnar section of rocks]

USGS locality No. or field No.	Collectors	Fossils
D6061	Fred Peterson	<i>Plesielliptio</i> sp. <i>Tulolomops laevibasalis</i> Yen <i>Goniobasis? subtrtuosa</i> (Meek and Hayden) <i>Campeloma</i> sp.
D815	H. D. Zeller and F. J. Alvey.	Fragmentary dinosaur bones. “Genera and species are indeterminate, but a tyrannosaurid theropodous saurischian (large bipedal carnivorous dinosaur) and an ornithischian, probably ornithopodous (bipedal herbivore) seem to be represented” (G. E. Lewis, written commun., Nov. 25, 1966).

Figure 1. Faunal list from generalized columnar section. Coal Investigations Map C-58 (Sheet 2 of 2). Online at <http://pubs.usgs.gov/coal/058/plate-2.pdf>

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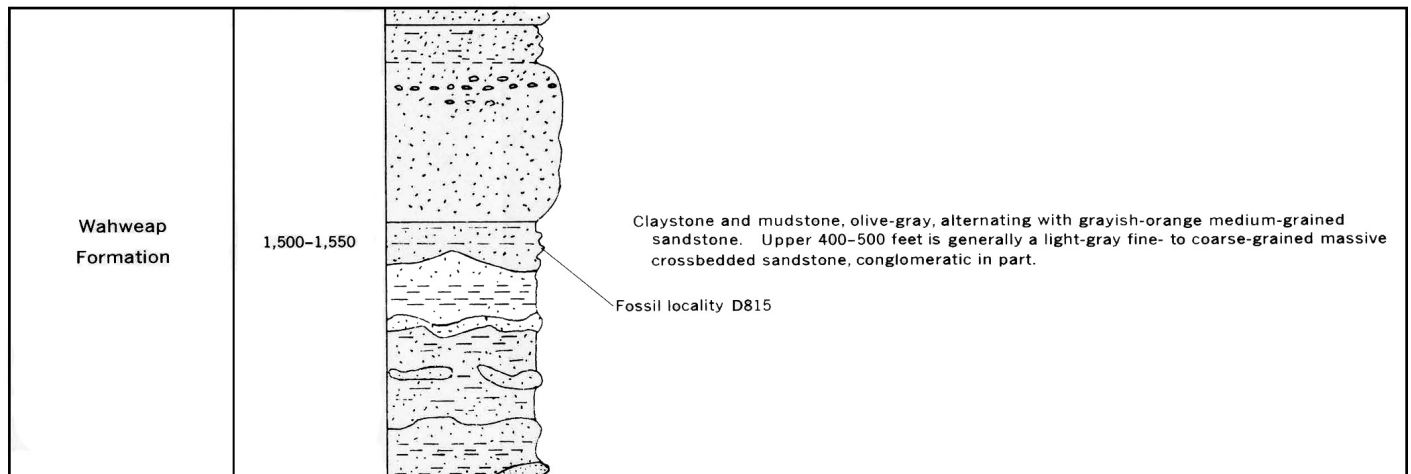


Figure 2. Stratigraphic placement of USGS D815=UCMP V93128 from Zeller (1973, plate 1) Online at: <http://pubs.usgs.gov/coal/058/plate-1.pdf>

ornithischian from the site based on identifications made by G. Edward Lewis of the U.S. Geological Survey in Denver from fragmentary bones collected by H. D. Zeller and F. J. Alvey. Stratigraphically, USGS D815 is depicted as being approximately at the middle of a 1500-1550 feet [approximately 450-470 meter thick] formation (Zeller 1973: plate 2); the generalized columnar section is shown here in Figure 2. An unpublished report on file at the USGS in Denver (Zeller 1969) and reproduced in part here as indicates that Zeller placed the locality at 700 feet [approximately 213 meters] above the base of the formation, approximately in the middle of the section. In the slightly thinner, 380 meter-thick composite section measured by Jinnah et al. (2009), the upper member is from approximately 170 to 290 meters above the base of the formation. Therefore by either meters above the base of the section or approximate position within the overall thickness of the formation, Zeller's measurements place USGS D815 within the upper member. In contrast to the comparatively higher position suggested by Sampson et al. (2013), we hypothesize the locality is lower within the upper member and may partially fill a gap between the assemblages of the middle member and those known from high in the upper member. Lithologically, although all specimens at UCMP V98173 were found as float, they clearly derive from a well-cemented sandstone, which adheres to most specimens. Such well-cemented sandstone units are a characteristic of the upper member compared to underlying units (Eaton 1991).

The second author used the locality data provided in Zeller (1973) to relocate this locality and make a new collection. A number of specimens were collected as float and included not only the type maxilla of *A. hutchisoni*, but also a diversity

of other vertebrates. The mesosuchian crocodylians were reported by Irmis et al. (2013), and here we briefly report other parts of the assemblage, including fish, turtles, and other dinosaur bones.

SYSTEMATIC PALEONTOLOGY

ACIPENSERIFORMES BERG, 1940 (*SENSU GRANDE ET AL., 2002*)
Fig. 3B

Referred Specimen—UCMP 235236, fragment of a pectoral fin spine.

Remarks—The presence of a sturgeon fish is recorded by UCMP 235236, a fragment from near the base of a pectoral fin spine. It is composed of fused lepidotrichia, which is a synapomorphy of Acipenseriformes (Grande et al. 2002, Hilton et al. 2011).

AMIIFORMES HAY, 1929
AMIIDAE BONAPARTE, 1838
MELVIUS BRYANT, 1988

Melvius cf. *M. chauliodous* (HALL AND WOLBERG, 1989)
Fig. 4

Referred Specimens—UCMP 235226, 235227 (Fig. 4A), and 235228 (Fig. 4E), vertebral centra; UCMP 235229, occipital condyle and basioccipital (Fig. 4D); UCMP 235230, dentary fragment (Fig. 4B); UCMP 235231, parietal fragment; UCMP 235232, cleithrum fragment; UCMP 235233, ceratohyal (Fig. 4C).

Remarks—The occurrence of a bowfin fish (?*Melvius*) in

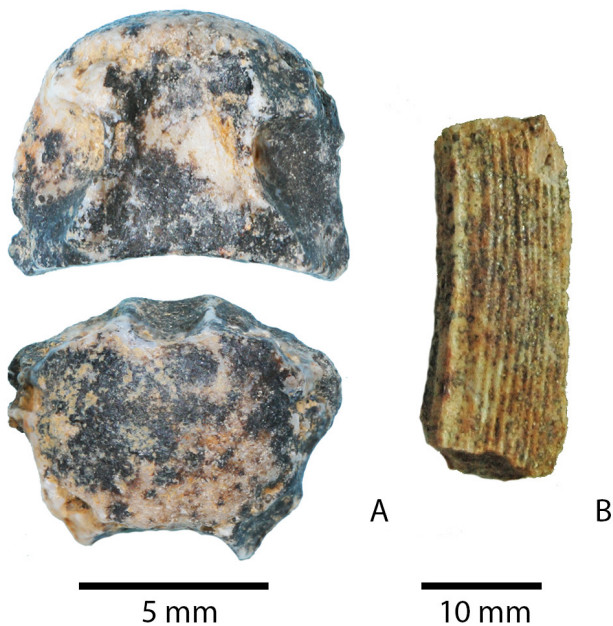


Figure 3. Lepisosteidae (gar fish). **A.** UCMP 235235, vertebral centrum. Acipenseriformes. **B.** UCMP 53908 from locality V5618, Lance Formation, Wyoming. **C.** UCMP 235236, fragment of pectoral fin spine.

the Wahweap Formation was noted by Brinkman et al. (2013, table 10.3), but no specimens were singled out in the taxonomic discussion of that paper. Only two species of the large bowfin *Melvius* are currently known: *M. thomasi* Bryant, 1988 from the Maastrichtian of the Rocky Mountain region (Bryant 1988, Grande and Bemis 1998); and *M. chauliodous* from the Campanian of New Mexico (Hall and Wolberg 1989; Sullivan et al. 2011). These specimens are ascribed to *Melvius* based on the ventrolaterally concavities in the vertebral centra and dorsoventrally compression of the basioccipital, which are apomorphies for the genus (Grande and Bemis 2010). In size and morphology the Wahweap *Melvius* are most similar to those described and illustrated by Sullivan et al. (2011) as *M. chauliodous* and to the vertebral centrum attributed questionably to *Melvius* by Brinkman et al. (2013) from the stratigraphically lower John Henry Member of the Straight Cliffs Formation. Notable among the referred specimens is the isolated ceratohyal, UCMP 235233. This element was not previously known for *Melvius*. It resembles that of the early Cretaceous *Calamopleurus cylindricus* Agassiz, 1841 as figured by Grande and Bemis (1998: figs. 306-307 and 312-313), although it is shorter than in that taxon. We assign it to *Melvius* based on its large size.

These specimens cannot be assigned to species. Currently

the only element known to distinguish the species of *Melvius* from one another is the ornamentation pattern of the postinfraorbital (Grande and Bemis 1998).

LEPISOSTEIFORMES HAY, 1929

LEPISOSTEIDAE CUVIER, 1825

Fig. 3A

Referred Specimens—UCMP 235234, scale fragment; UCMP 235235, vertebra (Fig. 3A).

Remarks—The recovery of a single small partial gar scale with a layer of ganoine and one vertebra record the presence of the gar family. The morphology of both is similar to that of lepisosteids as commonly found throughout the Cretaceous and Paleogene of the Western Interior.

TESTUDINES BATSCH, 1788

BAENIDAE COPE, 1882

ARVINOCHELYS LIVELY, 2015A

Arvinochelys sp.

Fig. 5D

Referred Specimen—UCMP 235584, anterior plastron fragment.

Remarks—UCMP 235584 is a fused partial anterior lobe of the plastron of a large baenid lacking extragulars (also called intergulars by some authors). It differs from *Neurankylus* Lambe, 1902 and several other baenids in the absence of extragulars and from co-occurring *Denazinemys* Lucas and Sullivan, 2006 in having the midline length of the gulars shorter than the humerals. In both of these features, the specimen closely resembles *Arvinochelys goldeni* Lively, 2015a, from the overlying Kaiparowits Formation. This specimen is the first referred to the genus from outside the type formation and extends the stratigraphic range of the taxon.

DENAZINEMYS LUCAS AND SULLIVAN, 2006

Denazinemys nodosa (GILMORE, 1916)

Fig. 5A

Referred Specimen—UCMP 252017, first costal (Fig. 5A); UCMP 235242, unassociated miscellaneous fragments.

Remarks—These elements can be assigned to the monotypic genus *Denazinemys* based on the distinctive shell sculpturing in which nodules are developed irregularly over the carapace. They differ from those typically attributed to *Scabremys* Sullivan, Jasinski, and Lucas, 2013, which are more linear in organization (see also discussion in Lively 2015b).

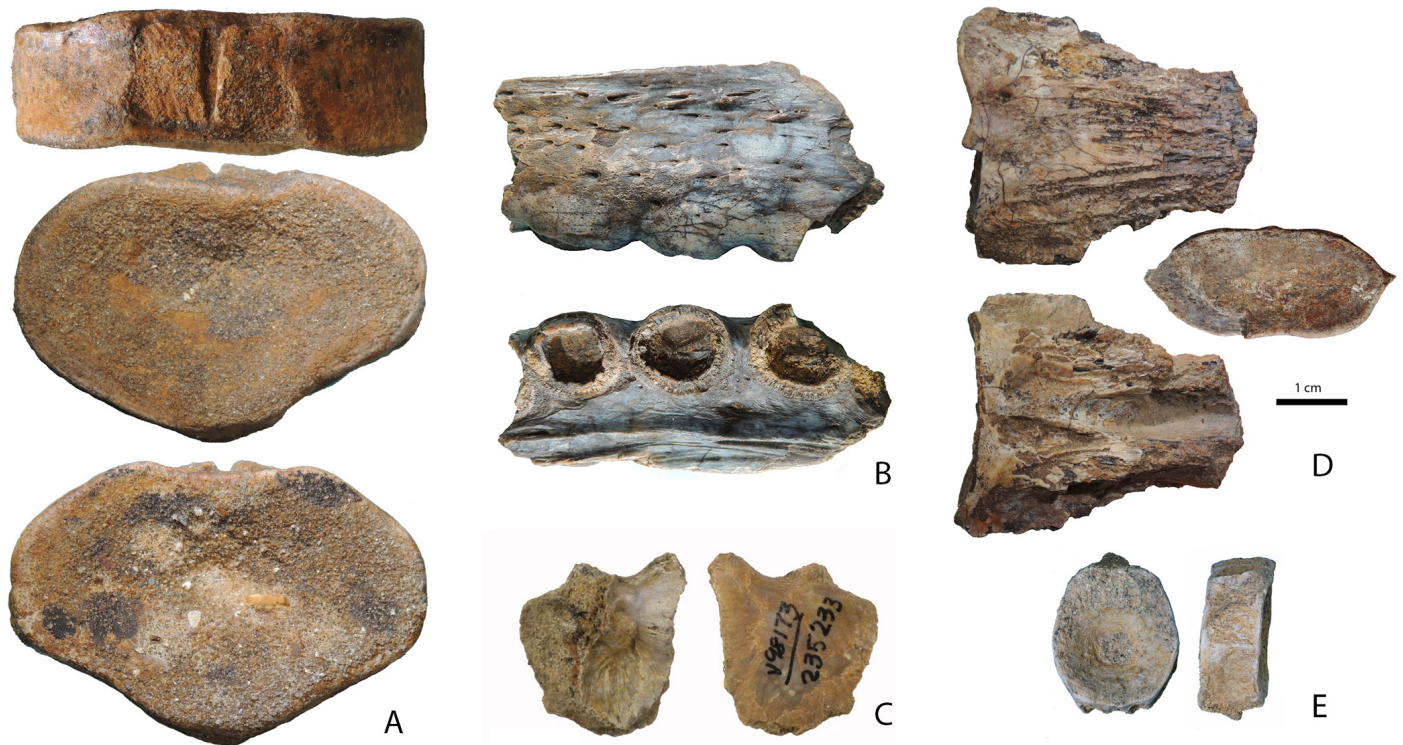


Figure 4. *Melvius* cf. *M. chauliodous* **A.** UCMP 235227 (from top to bottom) in dorsal, anterior, and posterior views. **B.** UCMP 235230, dentary fragment in ventral and dorsal view. **C.** UCMP 235233, ceratohyal in dorsal and ventral view. **D.** UCMP 235229, occipital condyle and basioccipital in ventral, posterior, and dorsal views. **E.** UCMP 235228, vertebral centrum in anterior and lateral views.

NEURANKYLUS LAMBE, 1902

Neurankylus sp.

Fig. 5C

Referred Specimen—UCMP 235240, portion of a first costal.

Remarks—UCMP 235240 preserves a portion of the left first costal and adjacent peripherals region. Its free margin, although abraded, appears to have been strongly acute. The ventral exposure of the marginals expands rapidly posteriorly, and there is a distinct medial sulcus. The axillary buttress is relatively weak, arched strongly laterally and the tract of costal rib one is low and rounded. The external surface sculpture is very weak and consists of very small (< 1mm), shallow and irregular pits. All of these features most closely resemble those of *Neurankylus*, but determining what species is present in the Wahweap Formation is complicated by the taxonomy of the *Neurankylus* of the Kaiparowits Formation. Two *Neurankylus* morphotypes are recognized in the Kaiparowits Formation. Hutchison et al. (2013) referred to them as morphotypes A and B, and Lively (2015b) named the two morphotypes *N. hutchisoni* Lively, 2015b and *N. utahensis* Lively, 2015b. The two differ primarily in size, and

the anatomical regions preserving discrete characters used to differentiate the two species are not present here.

BAENIDAE, INDETERMINATE

Referred Specimens—UCMP 235237, miscellaneous fragments; UCMP 235238, 235239, plastron fragments; UCMP 235241, miscellaneous fragments

Remarks—Shell fragments of a large, unornamented baenid turtle with acute unserrated peripherals and curved rather than pillar-like plastral buttresses are among the most common fossils from this site. Morphologically these are most similar to those of *Neurankylus*, a common turtle in the overlying Kaiparowits Formation (Hutchison et al. 2013, Lively 2015b), and these are the most common non-dinosaurian fossils in the assemblage.

NANHSIUNGCHELYIDAE YEH, 1966

BASILEMYS HAY, 1902

Fig. 5B

Referred Specimen—UCMP 235256, shell fragment.

Remarks—This specimen is referred to the genus based on the distinctive shell sculpture characteristic of

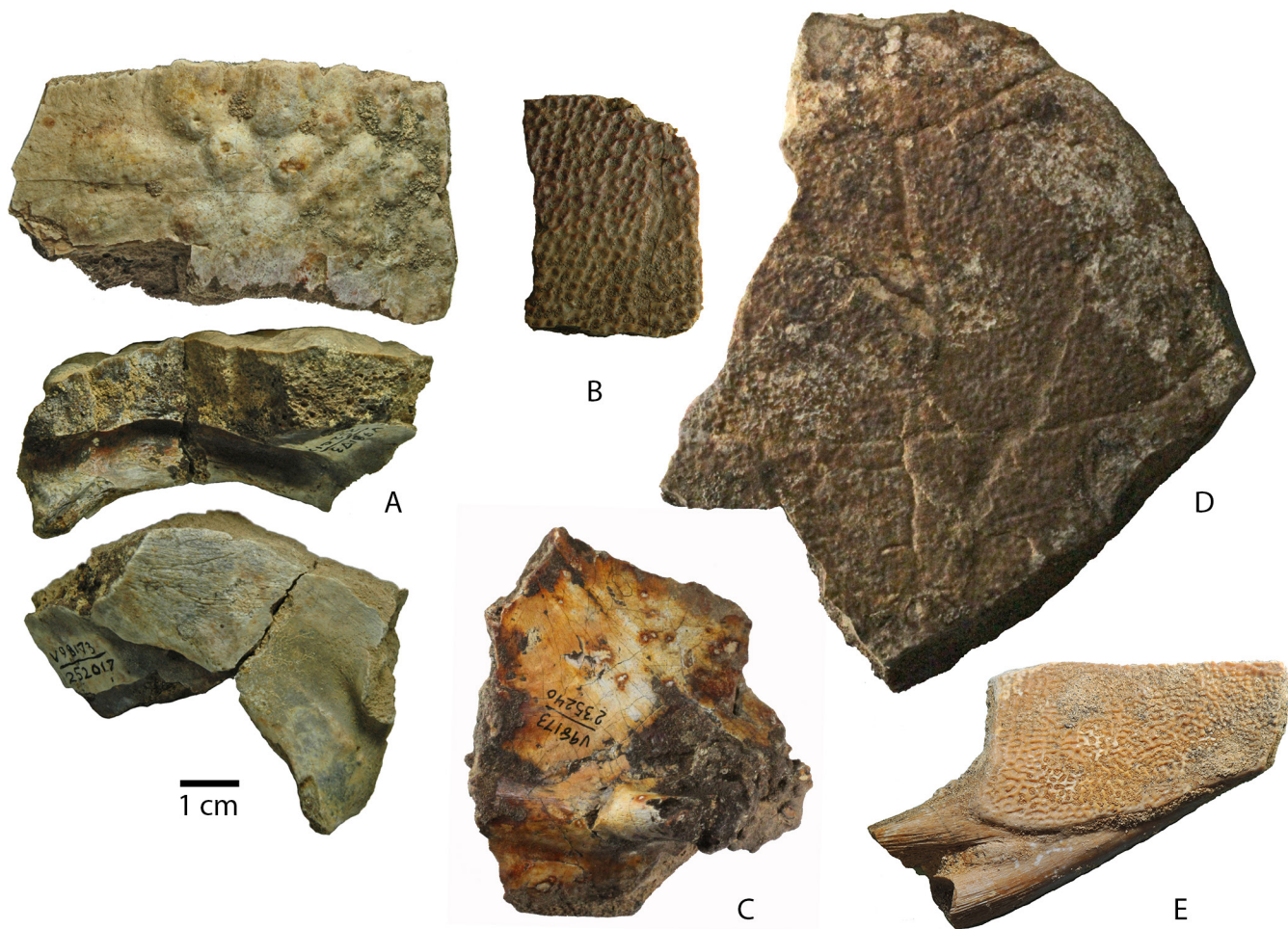


Figure 5. A. *Denazinemys nodosa*, UCMP 252017, first costal in dorsal, posterior, and ventral views. B. *Basilemys*, costal fragment. C. *Neurankylus* sp., UCMP 235240, first costal in ventral view (anterior to top). D. *Arvinochelys* sp., UCMP 235584, anterior plastron fragment in ventral view. E. Trionychidae indeterminate, UCMP 235243, left hypoplastron.

Nanhsiungchelyidae, which is comprised of rows of triangular or pyramidal tubercles separated by pits (Brinkman and Nicholls 1993).

TRIONYCHIDAE GRAY, 1825

Fig. 5E

Referred Specimens—UCMP 235243, hypoplastron (Fig. 5E); UCMP 235244, miscellaneous shell fragments.

Remarks—UCMP 235243 is a hypoplastron of a small trionychid, the only complete element recovered. This element is most similar to those ascribed to *Aspideretoides* Gardner et al. 1995, but given the similarity among trionychids and the unstable taxonomy of this group, we conservatively only assign it to Trionychidae. Most of the specimens documenting the presence of trionychid turtles are carapace and plastron fragments showing the characteristic pitted shell sculpture but lack other clearly diagnostic characters. Those specimens

are batch-cataloged under the number UCMP 235244.

DINOSAURIA (OWEN, 1842)
ORNITHISCHIA SEELEY, 1888
HADROSAURIDAE COPE, 1870

Figs. 6, 7A

Referred specimens—UCMP 235252, limb bone fragment; UCMP 235253, vertebra (Fig. 7A); UCMP 252000 (Fig. 6D-F), 252001 (6A-C), 235254-235255, jaw fragments.

Remarks—Many of the bones from this assemblage likely belong to hadrosaurines, which are the most abundant ornithopods in the formation (Gates et al. 2013). Multiple ontogenetic stages appear to be present (e.g., in dentary fragments UCMP 252000 and 252001) and some very large individuals are known (e.g., UCMP 235253). However, given that no postcrania are yet known for *Adelolophus* and multiple taxa may be present, we refrain from attributing any to

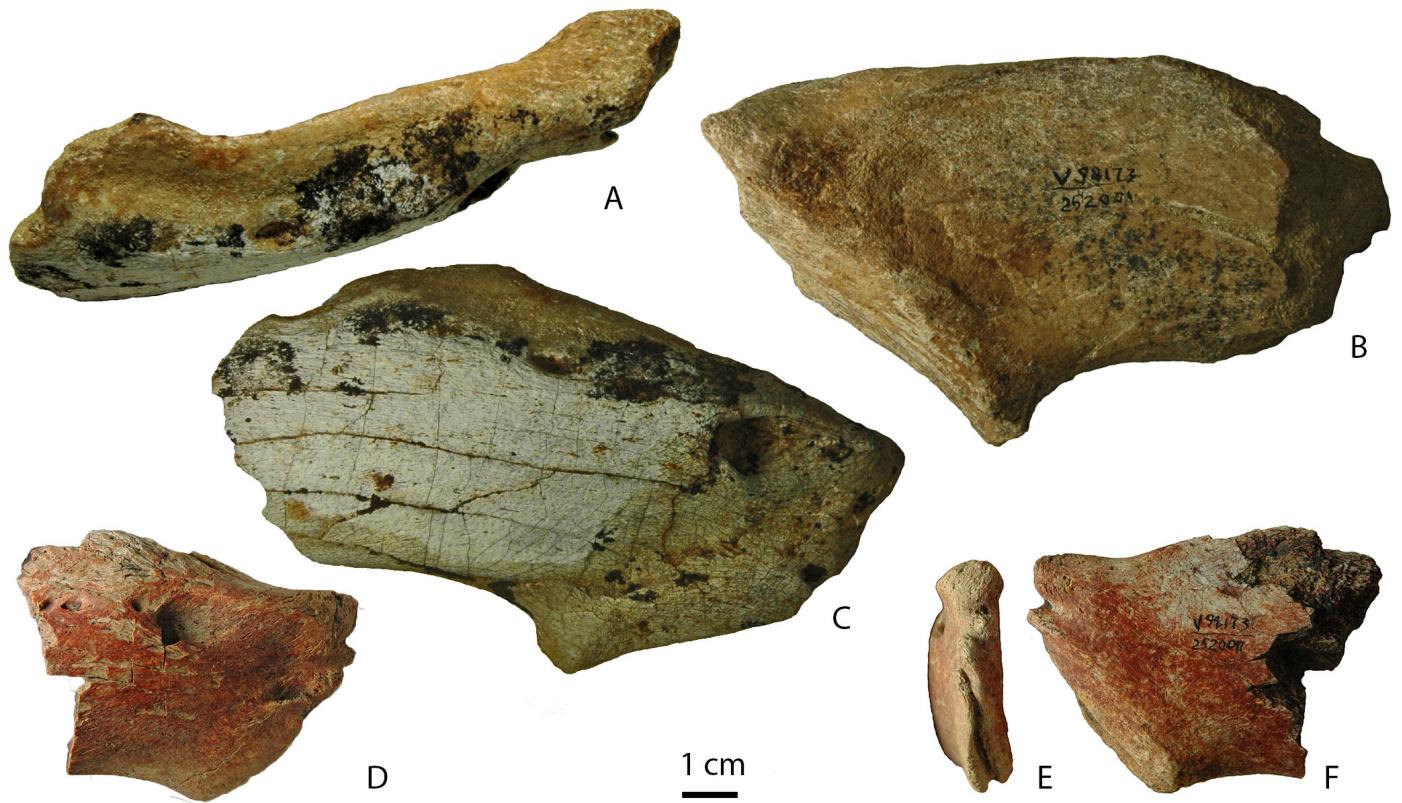


Figure 6. Hadrosauridae indet. **A-C.** UCMP 252001, anterior dentary in dorsal (A), medial (B), and lateral (C) views. **D-F.** UCMP 252000, anterior dentary of juvenile in lateral (D), anterior (E), and medial (F) views.

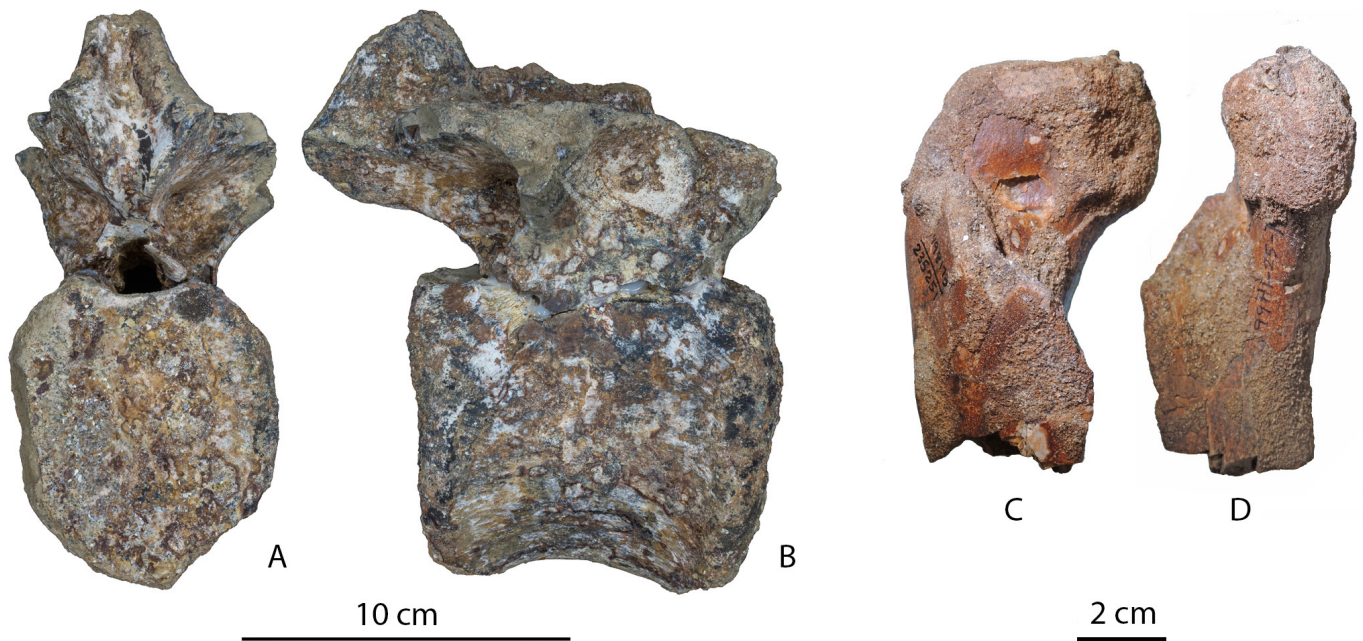


Figure 7. Hadrosauridae. **A.** UCMP 235253, thoracic vertebra. Theropoda. **B.** UCMP 235251, proximal femur.

a lower taxonomic level. Many additional partial postcrania were also recovered and are retained at UCMP.

SAURISCHIA SEELEY, 1888
TYRANNOSAURIDAE OSBORN, 1906

Referred specimen—UCMP 235245, partial tooth

Remarks—Zanno et al. (2013) noted that the tyrannosaurid of the Wahweap represents a new genus and species. UCMP 235245 is the base of a large (approximately 20 mm anteroposterior length), mediolaterally compressed tooth which is sufficient to indicate a tyrannosaurid, but it is otherwise non-diagnostic.

THEROPODA MARSH, 1881
Fig. 7B

Referred specimens—UCMP 235246, distal phalanx; UCMP 235247, 235251 (Fig. 7B), proximal femora; UCMP 235248, metatarsal III; UCMP 235249-50, distal femur

Remarks—Zanno et al. (2013) noted that the tyrannosaurid of the Wahweap represents a new genus and species, and *Lythronax argestes* Loewen, Irmis, Sertich, Currie, and Sampson 2013 was described from the lower part of the middle member and diagnosed based on cranial characters. UCMP 235245 is the base of a large (approximately 20 mm anteroposterior length), mediolaterally compressed tooth which is sufficient to indicate a tyrannosaurid, but it is otherwise non-diagnostic.

DISCUSSION

UCMP locality V98173 (=USGS D815), the type locality of *Adelolophus hutchisoni*, can be placed with greater stratigraphic confidence within the Wahweap Formation, slightly more than 200 meters above the base of the formation. It likely lies within the lower part of the upper member of the formation and potentially fills a gap in the record of vertebrates through this part of the local and regional Cretaceous stratigraphy. The assemblage from the site is similar in taxonomic composition to other Wahweap Formation locality-level assemblages (DeBlieux et al. 2013) in having an abundance of baenids, both *Melivius* and lepisosteiform fishes, and a mix of saurischian and ornithischian dinosaurs. It differs in having mesosuchian crocodylians that are otherwise poorly known from the Wahweap (Irmis et al. 2013), in being the sole site at which the lambeosaurine hadrosaur *A. hutchisoni* is known, and in lacking the turtles *Compsemys* Leidy, 1856, *Adocus* Cope, 1868, and *Naomichelys* Hay, 1908 otherwise reported from the Wahweap Formation (Sampson

et al. 2013: Table 28.2).

ACKNOWLEDGMENTS

We thank J. Munthe and B. Ramsey for collecting with the second author in 1999. We thank K.C. McKinney of the US Geological Survey in Denver for verifying that the specimens from USGS D815 continue to be retained as part of the USGS collections and providing information on Zeller's original recovery of specimens at this site. UCMP specimens from this site were collected under a Bureau of Land Management permit to J. H. Hutchison, and we thank the staff of Grand Staircase-Escalante National Monument for their support of fieldwork. Figure 7b was photographed by Dave Strauss and is released under a CC-BY 3.0 license. Dave Strauss is also thanked for his advice on photography of other specimens illustrated here. Josh Lively and two anonymous reviewers provided constructive feedback on the manuscript.

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