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Theme Issue
An Ecosystem We Thought We Knew—
The Emerging Complexities of the Morrison Formation
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Cover

Small vertebrate fossils wrapped for transport, Cisco Mammal Quarry, Upper Jurassic Morrison Formation, Grand County, Utah.

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A Preliminary Report of the Fossil Mammals From a New Microvertebrate Locality in the Upper Jurassic Morrison Formation, Grand County, Utah

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ABSTRACT

The first Mesozoic mammals in North America were discovered in the Morrison Formation during the closing decades of the 19th century, as by-products of dinosaurs quarried by teams led by O.C. Marsh. These tiny fossils served as foundational specimens for our understanding of Mesozoic mammal evolution. There are now nearly 25 mammal-bearing localities known from the Morrison Formation, distributed across the Western Interior from the Black Hills to southern Colorado and west into Utah; the most historically important of these are in Wyoming (e.g., Como Quarry 9). Most Morrison mammals are known by jaws or jaw fragments, and several important Mesozoic groups (e.g., docodonts, dryolestoids, and to a large extent triconodonts and symmetrodonts) were established based on Morrison material, shaping the perception of mammalian diversity on a global scale. Despite heavy sampling of coeval sites elsewhere, the Morrison remains the most systematically diverse (at high taxonomic levels) assemblage of Jurassic mammals in the world.

Here, we describe two mammalian specimens and highlight other remains yet to be fully identified from a new microvertebrate locality in the Morrison Formation of eastern Grand County, Utah. The site is positioned low in the Brushy Basin Member and is similar in lithology and stratigraphic level to the famous small vertebrate localities of the Fruita Paleontological Area, located less than 50 km to the northeast. In addition to small archosaurs and squamates, limited excavation to date has yielded at least 20 mammalian specimens representing a minimum of six taxa, several of which are new and quite different from typical Morrison taxa. Preservation is generally excellent and includes partially articulated cranial and postcranial elements of small vertebrates. This new site has great potential to contribute new taxa and more complete morphological data than typical Morrison localities, underscoring the importance of continued field work in the Morrison.

INTRODUCTION

The Upper Jurassic Morrison Formation has yielded one of the most influential mammal assemblages worldwide. At least 40 taxa are currently described from 20+ localities (Foster, 2003; Kielan-Jaworowska and others, 2004), making it the most diverse Jurassic assemblage in the world and among the most diverse in the Mesozoic. Several factors were likely at play in generating this impressive record: (1) intense study of the Morrison Formation began in the 1870s (Marsh, 1878; Osborn, 1888; see summary in Simpson, 1929), and (2) the unit has

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a vast latitudinal range, with exposures across much of the Western Interior. This geographic expanse, coupled with as much as 7 Ma of depositional time (Trujillo and Kowallis, 2015), suggest that localities in the Morrison possibly represent a wide range of paleoenvironments of slightly different ages.

Typical Morrison mammal localities (e.g., Como Quarry 9 at Como Bluff, Wyoming) are characterized by variations of a standard assemblage of taxa, known mainly by jaws and jaw fragments: the mammaliaform *Docodon*, plagiaulacidan-grade multituberculate mammals, triconodontids, tinodontid "symmetrodonts," and various dryolestoids (see Kielan-Jaworowska and others, 2004). Mammal assemblages vary across the extent of the Morrison Formation; this has been studied in detail (Foster, 2001, 2003; Foster and others, 2006) using taphonomy and the distribution of *Docodon*, which is abundant in sites in the eastern half of the outcrop area but absent from sites to the west. These patterns have been explained in part by variations in paleoenvironment across Morrison localities (discussed in Foster 2001, 2003), and this is exemplified by the unique and well-preserved fauna from the Fruita Paleontological Area (FPA) (Callison, 1987; Kirkland, 2006). Occasional small skeletons have been found in articulation at sites in the FPA. Among mammals, the presence of the highly specialized *Fruitafossor* (Luo and Wible, 2005) suggests that uncaptured taxonomic diversity awaits future work in the FPA and more broadly in the Morrison.

As a result of a 2015 survey of Jurassic units in southern and eastern Utah, a joint field party from the University of Louisville and the Oklahoma Museum of Natural History (OMNH) discovered a new microvertebrate locality in the Morrison Formation of eastern Grand County, which we named the Cisco Mammal Quarry (CMQ) after the nearby ghost town of Cisco, Utah (figure 1; exact coordinates are on file at the OMNH and are available to qualified investigators upon request). Limited excavation to date has yielded a large diversity of small taxa, including squamates, archosaurs, and mammals (table 1). Several specimens are relatively complete and well preserved, and preliminary study suggests that some represent previously unknown mammal taxa. The sample from CMQ also includes the second occurrence of *Fruitafossor*, otherwise known only from the FPA, highlighting unrecognized diversity and rich potential of continued exploration in the Morrison Formation. Our ongoing work at the CMQ is certain to increase the already high mammalian diversity, provide evidence on intraformational geographical and temporal faunal variation, and produce further refinement of our understanding of the Morrison Jurassic ecosystem, the standard against which any other Jurassic fauna is to be compared.

INSTITUTIONAL ABBREVIATIONS

DINO = Dinosaur National Monument, Jensen, Utah; OMNH = Oklahoma Museum of Natural History, Norman, Oklahoma YPM = Yale Peabody Museum, New Haven, Connecticut.

GEOLOGIC SETTING

Rock units in the CMQ (OMNH locality V1728) area range from the Middle Jurassic Entrada Sandstone, forming the cliffs above the river, to the Upper Creta-

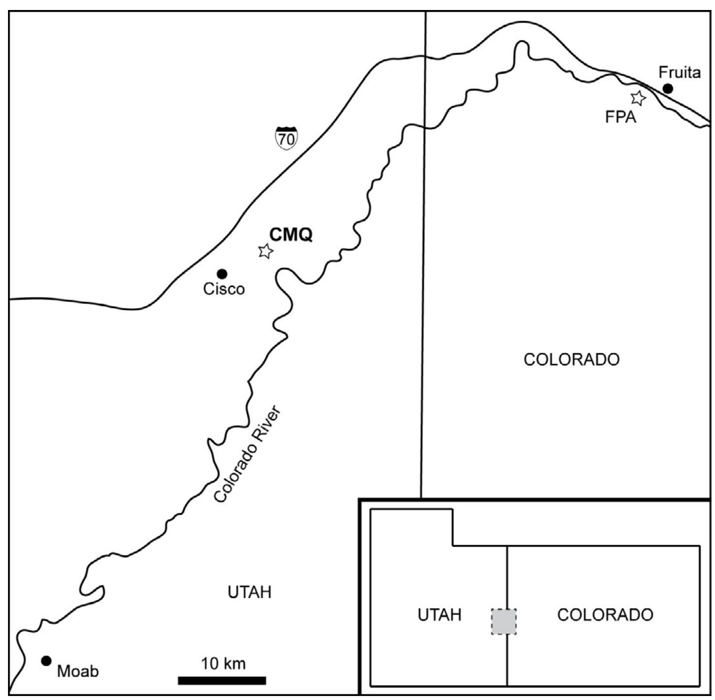

Figure 1. Location of new mammal-bearing small vertebrate locality, the Cisco Mammal Quarry (CMQ, OMNH V1728), in Grand County, Utah. Enlarged area is indicated by gray portion of inset map. CMQ and FPA (Fruita Paleontological Area) are indicated by open stars.

Table 1. Preliminary taxonomic list from the Cisco Mammal Quarry (OMNH locality V1728, Upper Jurassic Morrison Formation), a new mammal-bearing small vertebrate locality in Grand County, Utah.

- Osteichthyes
  - Osteichthyes indet.

- Squamata
  - Serpentes
    - Parviraptoridae
      - Parviraptoridae indet.
    - Serpentes indet.
  - Squamata indet.

- Archosauria
  - Dinosauria
    - Heterodontosauridae
      - ?*Fruitadens* sp.
  - Archosauria indet.

- Mammaliaformes
    - Morganucodonta
      - Morganucodonta indet.
  - Mammalia
    - Order and Family incertae sedis
      - *Fruitafossor windscheffeli*
    - Multituberculata
      - "Plagiaulacida"
        - *Glirodon grandis*
      - Multituberculata indet.
    - Eutriconodonta
      - Eutriconodonta indet.
    - Trechnotheria
      - Dryolestidae
        - *Dryolestes priscus*
      - Paurodontidae
        - Paurodontidae indet.
      - Trechnotheria indet.

ceous Mancos Shale, exposed on the flats along Interstate 70. Exposures of the Morrison Formation in the immediate vicinity of the locality are discontinuous, tilted, and terraced to some degree as the landscape descends to the Colorado River; consequently, specific beds can be difficult to follow laterally and precise placement of the locality in the section is uncertain. To the southwest of the locality, the colorfully-banded smectitic mudstones typical of the Brushy Basin Member rise to a steep cliff capped by the lower Yellow Cat Member of the Lower Cretaceous Cedar Mountain Formation (Kirkland and others, 2017). Large sandstone channels become much more common in outcrops down section to the east and northeast, as is typical of the Salt Wash Member (Turner and Peterson, 2004). Consequently, coarse stratigraphic placement of the CMQ is likely low in the Brushy Basin Member. The sequence of pale-colored mudstone and fine-grained sandstone beds that is exposed at the locality is laterally equivalent to the interval at the FPA, which contains the productive microvertebrate localities (S. Maidment, Imperial College, London, personal communication, 2016). These sites have also been placed low in the Brushy Basin Member (Kirkland, 2006).

The locality is at the top of a rounded, pale-gray knob in the center of a somewhat isolated series of outcrops, the surface of which has weathered to the popcorn texture and convex slopes characteristic of smectitic clays. The hill preserves an irregular sequence of mudstone and thinner sandstone beds, mostly of uniform pale color. The sandstone beds are more resistant to weathering and appear rounded in profile when exposed. Detailed study of the sedimentology at and around the CMQ has yet to be completed, but the beds seem to lack sedimentary structures and are strongly indurated. The mudstone beds are smectitic and calcareous, containing a substantial proportion of fine- to very fine grained sand. Small flecks of biotite are present, and barite nodules are common with some as large as 10 cm. Bone has been found at low density throughout much of the worked section, and does not appear to be concentrated at a particular horizon or horizons.

It is tempting to draw some comparisons with the well-studied sections at the FPA, which is located less than 50 km to the northeast, just across the Colorado border. In the thorough lithofacies analysis by Kirkland (2006), the general characteristics of the drab floodplain facies, which yielded the Main Callison Quarry and several other sites, seem most congruent with features of the CMQ. Mudstone beds are dominant over sandstone beds, and primary sedimentary structures are lacking. Barite nodules are present, and the beds are calcareous.

In a few aspects, the CMQ also resembles alkaline pond facies of Kirkland (2006), which yielded the important Tom's Place microvertebrate site, where the presence of biotite and the relative abundance of barite nodules are similar, but Kirkland (2006) described the mudstones of this facies as laminated and non-calcareous. Only one thin, ill-defined laminated mudstone lens has been found at the CMQ so far; it is calcareous but differs from the typical mudstone at the site in being distinctively darker in color, waxier, and less smectitic, and is far less sandier. This lens yielded a mammalian maxilla, but the lens pinches out quickly where the main quarry face is exposed.

METHODS

The initial discovery at the site was a portion of a small limb element weathering from just below the top of the knob. Other small bones were discovered as surface float 2 or 3 m below a different face of the knob. Surface exploration of the knob yielded an additional small limb element in situ 2 m below the first, suggesting a potentially thick productive zone. Work at the CMQ in 2016 used mainly hand tools; picks, chisels, and sledge hammers. Rock near the surface is fractured to some degree, but is very hard and does not break easily or predictably. A generator-powered jackhammer was used in the 2017 field season to more efficiently fracture the quarry surface. The general approach has been to opportunistically explore various faces of the top of the knob, quarrying out blocks ~0.5 m in diameter, and carefully reducing them with small hand sledges. Bone is not concentrated at horizons or along any discernible planes, occurring seemingly at random and in three dimensions. Therefore, each broken surface must be carefully examined for tiny fossils, often with a hand lens, as specimens are typically discovered when sectioned. Fortunately, most bone is jet back and stands out in strong contrast to the pale-colored rock (though bone ranges in color to pale brown). Specimens needing stronger magnification or preparation were wrapped for transport back to the OMNH. Two mammalian specimens were discovered in situ; these were given small plaster caps for protection, and a gas-powered rock saw was used to cut them free in small blocks of rock. However, the nature of the smectitic clays at the site was not appreciated at the time, and the water from the uncured plaster caused the rock to swell and disturb the specimens. Care must be taken to keep specimens and their surrounding rock dry, and liberal application of glue is possibly preferable for stability in the field, even if it must be removed from the specimen later during preparation.

The specimens described in this paper, as well as others currently under study, were mechanically prepared under magnification using carbide needles and, occasionally, a pneumatic micro-jack. While the rock at the CMQ is very hard and difficult to fracture, it responds very favorably to traditional preparation techniques. Partial embedding of the specimens in carbowax mounted in a plaster holder was used to facilitate preparation and provide support; Butvar® B76 in different concentrations was used as the main adhesive and consolidant, which occasionally was mixed with sediment to provide a semi-permanent support to fragile portions of the specimens. Here, we follow the general practice of abbreviating molars with the letter "M;" teeth belonging to the upper dentition are indicated with an uppercase letter. Right and left are abbreviated "R" and "L", respectively.

SYSTEMATIC PALEONTOLOGY

Mammalia Linnaeus, 1758
Multituberculata Cope, 1884
"Plagiaulacida" Ameghino, 1889
Family *incertae sedis*
Glirodon Engelmann and Callison, 1999
Glirodon grandis Engelmann and Callison, 1999
Figures 2A and 2B

Holotype: DINO 10822, a partial skull.
Type locality: Dinosaur National Monument, Uintah County, Utah.
Referred material: OMNH 78595, an isolated LM1.
Locality: OMNH V1728 (Cisco Mammal Quarry), Morrison Formation (Kimmeridgian-Tithonian), Grand County, Utah.

Description

OMNH 78595 is a rectangular tooth with two rows of cusps, lacking ornamentation. Though the lingual cusp row is heavily worn, it is clear that the buccal cusps would have been noticeably taller on an unworn tooth. The three cusps in the buccal row are evenly spaced, pyramidal, and subequal in size, with some wear on their lingual faces. Steep, vertical valleys separate the cusps from one another. There is a weak, short cingulum limited to the space immediately mesial to the first buccal cusp, connected by a straight, weak crest to the apex of the cusp. There are four cusps in the lingual row, all with rounded bases. There is breakage through the second cusp of the row, but it appears that the mesial two cusps are relatively smaller and are positioned closer to one another, with the remaining cusps larger than the first two (but roughly equal in size to one another). The central valley is broadest mesially and narrows distally, as the lingual cusp row transcribes an arc directed towards the distal midline of the tooth. The central valley is walled mesially by a low crest, but is open distally. The lingual cusps are flattened by wear, which is present buccal, apically, and lingually. The buccal shift of the distal cusps of this row creates a faint bulge at the distolingual corner of the crown, but there is no evidence of a lingual cingulum or additional row of cusps.

Remarks

OMNH 78595 agrees with described morphology of *Glirodon grandis* (Engelmann and Callison, 1999). The specimen differs from the similar plagiaulacidan *Ctenacodon laticeps* (Marsh, 1881), the only other Morrison multituberculate in which the M1 has been described, based on several features. *Ctenacodon* has a small anterior cuspule in addition to the three main cusps in the buccal row (Simpson, 1929); there are only three buccal cusps in OMNH 78595. Additionally, in *Ctenacodon* the cusps of the lingual row are mostly subequal with one another and are better aligned buccolingually with the buccal cusps than in OMNH 78595. The holotype of *C. laticeps*, YPM 11761, bears a faint cingulum basal and adjacent to the valley separating lingual cusps 3 and 4, suggesting the possibility of incipient cusp development; given that variability cannot be assessed, the significance of this difference with respect to M1 of *Glirodon* cannot be established.

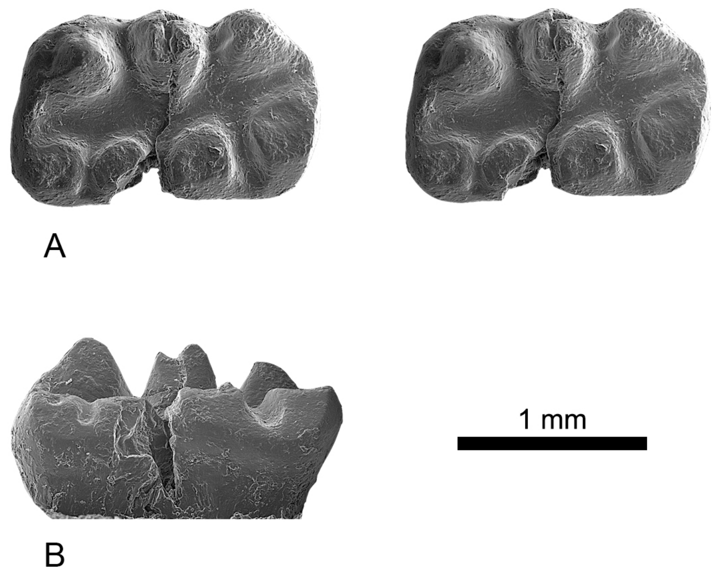

Figure 2. OMNH 78595, isolated LM1 of *Glirodon grandis* in occlusal (A) stereopair and (B) lingual views, from the Cisco Mammal Quarry (OMNH locality V1728, Upper Jurassic Morrison Formation, Grand County, Utah).

Dryolestoidea Butler, 1939
Dryolestidae Marsh, 1879
Dryolestes Marsh, 1878
Dryolestes priscus Marsh, 1878
Figure 3A and 3B

Holotype: YPM 11820, a right dentary fragment.
Type locality: Como Quarry 9, Morrison Formation (Kimmeridgian-Tithonian), Albany County, Wyoming.
Referred material: OMNH 78594, an isolated LM4.
Locality: OMNH V1728 (Cisco Mammal Quarry), Morrison Formation (Kimmeridgian-Tithonian), Grand County, Utah.

Description

OMNH 78594 is an isolated upper molar with three roots, the lingual of which is much larger than either buccal root. The crown is mesiodistally compressed (trigon angle of 45°) but bears a shallow ectoflexus and

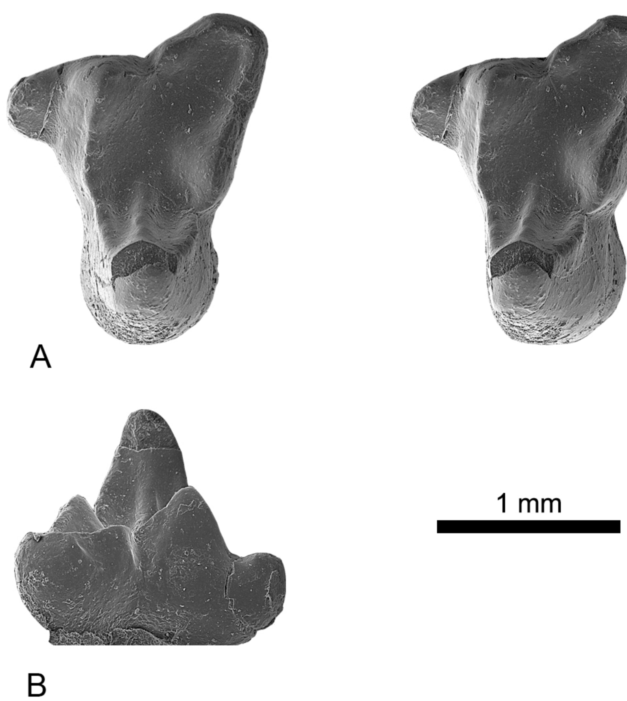

Figure 3. OMNH 78594, isolated LM4 of *Dryolestes priscus* in occlusal (A) stereopair and (B) buccal views, from the Cisco Mammal Quarry (OMNH locality V1728, Upper Jurassic Morrison Formation, Grand County, Utah).

a comparatively wide metastylar lobe, suggesting that the tooth is from the middle of the molar series (likely M4, see remarks below). The paracone is tall and erect, with sharp pre- and postparacristae. The base of the crown is somewhat constricted buccal to the paracone, making the crown slightly waisted in occlusal view. A weak median ridge (Martin, 1999) descends buccally from the apex of the paracone (which is damaged), but fades into the trigon basin without contacting any other structures. No median or central cusp is present. The metacone is distinct and broad but much lower than the paracone; the cusp bulges slightly beyond the distal edge of the crown, though this would likely be flattened by wear (the crown bears very little wear). A deep notch separates the metacone from the paracone, but the crest distal to the metacone is uninterrupted and courses around the distobuccal edge of the crown to join the ectocingulum. The stylocone is roughly half the height of the paracone and is positioned somewhat mesially relative to typical *Dryolestes* upper molars. The stylocone anchors the buccal end of the preparacrista, which curves slightly distally to climb to the apex of the cusp but is otherwise straight. A weak distobuccally-directed crest joins the apex of the stylocone with the ectocingulum, but the internal face of the cusp is smooth and weakly convex. The parastyle is positioned low on the crown and directly mesial to the stylocone. Though slightly displaced by breakage, the parastyle has a broad, oblique lingual face; no crest connects the parastyle with the stylocone. The metastyle is a low cusp positioned just distal to the deepest point of the ectoflexus. The ectoflexus, which is continuous but for a notch between stylocone to metastyle, bears a sharp ectocingulum which joins the postmetacrista to rim the metastylar lobe of the crown.

Remarks

OMNH 78594 compares very favorably with the M4 of AMNH 101130, a specimen originally referred to *Herpetairus humilis* (Prothero, 1981, figure 3D). Martin (1999) revised many dryolestid taxa and synonymized *Herpetairus* with *Dryolestes*; we follow his taxonomy here and assign this specimen to *D. priscus*. OMNH 78594 differs from AMNH 101130 only in lacking the weak, internally directed crest on the stylocone, and in a more mesial position of the metastylar cusp, closer to the ectoflexus.

DISCUSSION

Although exploration of the CMQ is certainly still in early phases, the number and quality of specimens recovered, and the diversity of taxa they record, thus far suggest that this locality has tremendous potential to improve our understanding of Jurassic terrestrial vertebrate evolution. Among high-level taxa, mammals seem to be surprisingly abundant (though fossils in general are sparse at the site). The sample thus far includes approximately 25 specimens, ranging from isolated teeth or postcranial elements to partial skulls and skeletons (examples illustrated in figure 4). These specimens are awaiting final preparation and study, but preliminary results indicate that several of the mammalian taxa in our small sample are new, suggesting that the CMQ fauna may be quite different from traditional Morrison faunas and even from the geographically proximate FPA. However, the presence of *Glirodon* and *Fruitafossor* suggests at least some degree of regional homogeneity, as both taxa are present at the FPA and the former also in Rainbow Park at Dinosaur National Monument (Engelmann and Callison, 1999). The CMQ specimens of the burrowing mammal *Fruitafossor* include a well-preserved skull and partial skeleton, still undergoing preparation, as well as other isolated material (in addition to the tentatively referred braincase in figure 4). *Dryolestes* is a rather common faunal element in sites around Como Bluff in southeastern Wyoming (Kielan-Jaworowska and others, 2004), with a much broader distribution extending to the Guimarota coal mine in Portugal (Martin, 1999). However, the specimen described here represents the first reported occurrence of this taxon in the western portion of the Morrison Formation. Foster and others (2006) proposed east-west paleoenvironmental partitioning of Morrison mammal localities based on facies analysis and the distribution of the possibly burrowing mammaliaform *Docodon*; a similar trend has been found for semiaquatic turtles and crocodyliforms (Foster and McMullen, 2017). The occurrence of *Dryolestes* at Como Bluff in the east and the CMQ in the west suggests at least some mammal taxa were broadly distributed during the depositional interval of the Morrison Formation, while others were local, reflecting heterogeneous depositional environments or small temporal differences between localities.

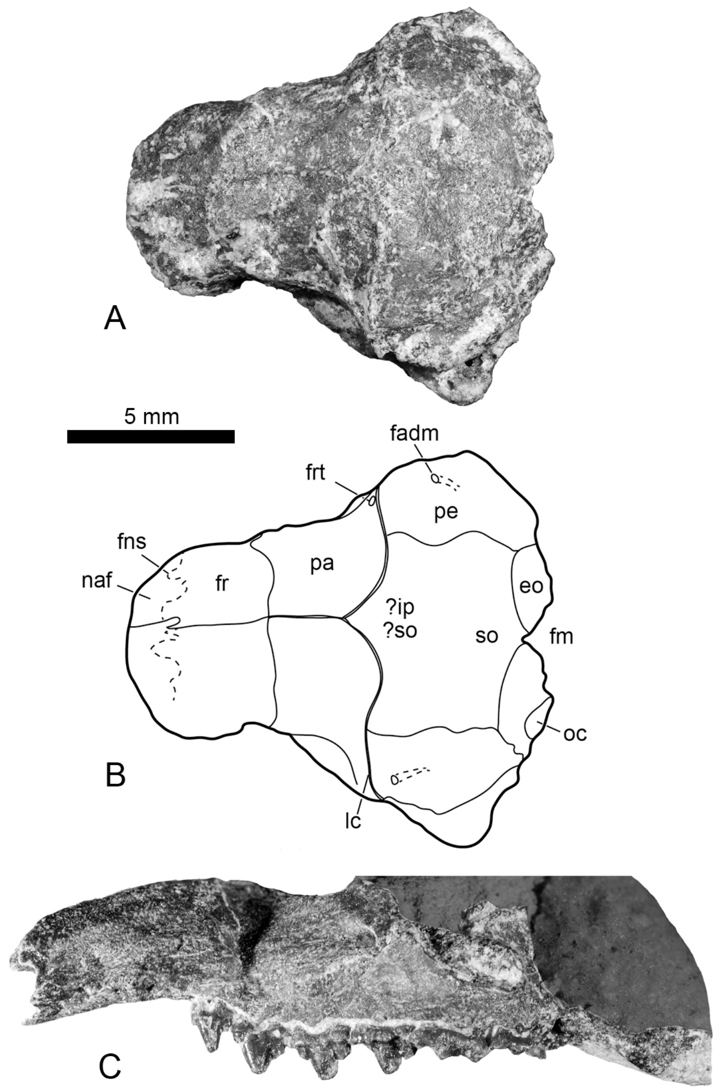

Figure 4. Examples of high-quality preservation of small mammalian fossils from the Cisco Mammal Quarry (OMNH locality V1728, Upper Jurassic Morrison Formation, Grand County, Utah). (A, B) OMNH 78599, undescribed partial skull of ?*Fruitafossor*, preserving braincase and mesocranium in dorsal view, with interpretive illustration. (C) OMNH 69352, undescribed morganucodontan left maxilla in lateral view (matrix on posterior portion digitally darkened). Abbreviations: eo = exoccipital; fadm = foramen for arteria diploëtica magna; fm = foramen magnum; fns = frontonasal suture; fr = frontal; frt = foramen for ramus temporalis; lc = lambdoidal crest; naf = facet for nasal (missing); oc = occipital condyle; pa = parietal; pe = petrosal; ?so = supraoccipital; ?ip = interparietal. Scale bar applies to both specimens.

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REFERENCES

Ameghino, F., 1889, Contribución al conocimiento de los mamíferos fósiles de la República Argentina: Actas de la Academía Nacional de Ciencias de Córdoba, v. 6, p. 1–1027.

Butler, P.M., 1939, The teeth of the Jurassic mammals: Proceedings of the Zoological Society of London, v. 109, p. 329–356.

Callison, G., 1987, Fruita—a place for wee fossils, *in* Averett, W.R., editor, Paleontology and geology of the Dinosaur Triangle: Grand Junction, Colorado, Museum of Western Colorado Guidebook, p. 91–96.

Cope, E.D., 1884, The Tertiary Marsupialia: American Naturalist, v. 18, p. 686–697.

Engelmann, G.F., and Callison, G., 1999, *Glirodon grandis*, a new multituberculate mammal from the Upper Jurassic Morrison Formation, *in* Gillette, D.D., editor, Vertebrate paleontology in Utah: Utah Geological Survey Miscellaneous Publication 99-1, p. 161–177.

Foster, J.R., 2001, Taphonomy and paleoecology of a microvertebrate assemblage from the Morrison Formation (Upper Jurassic) of the Black Hills, Crook County, Wyoming: Brigham Young University Geology Studies, v. 46, p. 13–33.

Foster, J.R., 2003, Paleoecological analysis of the vertebrate fauna of the Morrison Formation (Upper Jurassic), Rocky Mountain region, U.S.A.: New Mexico Museum of Natural History and Science Bulletin, v. 23, p. 1–95.

Foster, J.R., and McMullen, S.K., 2017, Paleobiogeographic distribution of Testudinata and neosuchian Crocodyliformes in the Morrison Formation (Upper Jurassic) of North America—evidence of habitat zonation?: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 468, p. 208–215.

Foster, J.R., Trujillo, K.C., Madsen, S.K., and Martin, J.E., 2006, The Late Jurassic mammal *Docodon*, from the Morrison Formation of the Black Hills, Wyoming—implications for abundance and biogeography of the genus: New Mexcio Museum of Natural History and Science Bulletin, v. 36, p. 165–169.

Kielan-Jaworowska, Z., Cifelli, R.L., and Luo, Z-X., 2004, Mammals from the age of dinosaurs—origins, evolution, and structure: New York, Columbia University Press, 630 p.

Kirkland, J.I., 2006, Fruita Palaeontological Area (Upper Jurassic, Morrison Formation), western Colorado—an example of terrestrial taphofacies analysis: New Mexico Museum of Natural History and Science Bulletin, v. 36, p. 67–95.

Kirkland, J.I., Suarez, M., Suarez, C., and Hunt-Foster, R., 2017, The Lower Cretaceous in east-central Utah—the Cedar Mountain Formation and its bounding strata: Geology of the Intermountain West, v. 3, p. 101–228.

Linnaeus, C., 1758, Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Vol. 1—Regnum animale. Editio decima, reformata: Stockholm, Laurentii Salvii, 824 p.

Luo, Z.X., and Wible, J.R., 2005, A Late Jurassic digging mammal and early mammalian diversification: Science, v. 308, p. 103–107.

Marsh, O.C., 1878, Fossil mammal from the Jurassic of the Rocky Mountains: American Journal of Science, v. 15, p. 459.

Marsh, O.C., 1879, Notice of new Jurassic mammals: American Journal of Science, v. 20, p. 396–398.

Marsh, O.C., 1881, Notice of new Jurassic mammals: American Journal of Science, v. 21, p. 511–513.

Martin, T., 1999, Dryolestidae (Dryolestoidea, Mammalia) aus dem Oberen Jura von Portugal: Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft, v. 550, p. 1–119.

Osborn, H.F., 1888, On the structure and classification of the Mesozoic Mammalia: Journal of the Academy of Natural Sciences Philadelphia, v. 9, p. 186–265.

Prothero, D.R., 1981, New Jurassic mammals from Como Bluff, Wyoming, and the interrelationships of non-tribosphenic Theria: Bulletin of the American Museum of Natural History, v. 167, p. 277–326.

Simpson, G.G., 1929, American Mesozoic Mammalia: Memoirs of the Peabody Museum, v. 3, p. 1–235.

Trujillo, K.C., and Kowallis, B., 2015, Recalibrated $^{40}Ar/^{39}Ar$ ages for the Upper Jurassic Morrison Formation, Western Interior, U.S.A: Geology of the Intermountain West, v. 2, p. 1–8.

Turner, C.E., and Peterson, F., 2004, Reconstruction of the Upper Jurassic Morrison Formation extinct ecosystem—a synthesis: Sedimentary Geology, v. 167, p. 309–355.