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NEW RECORDS OF *KIMBETOHIA CAMPI* AND *XANCLOMYS MCGREWI* (MAMMALIA, MULTITUBERCULATA) FROM THE FORT UNION FORMATION OF THE GREAT DIVIDE BASIN, WYOMING

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ABSTRACT

The China Butte Member of the Fort Union Formation in the Great Divide Basin of Wyoming has yielded new records of the rare multituberculate taxa *Kimbetohia campi* and *Xanclomys mcgrewi*, with both occurrences based on single P4s. *Kimbetohia campi* from the Great Divide Basin is virtually identical to P4s from the type locality in the San Juan Basin of New Mexico and the paleogeographic range of *K. campi* is now extended into the northern Rocky Mountains. The stratigraphic range of *K. campi* in the San Juan Basin is restricted to Pu2 interval zone strata, which suggests that the Great Divide Basin occurrence is of similar age. The new record of *X. mcgrewi* is 55 km north of the type locality (Swain Quarry, Wyoming) and is its second known occurrence. Swain Quarry and the new site may be of similar age (To2 Interval Zone) based on their approximate stratigraphic positions. Additional description of premolars of *X. mcgrewi* from Swain Quarry accentuates their unusual morphology. The P4 has a well-developed labial cusp row whose posterior series of cusps are deflected lingually, a highly variable number of labial row cusps, a massive terminal lingual row cusp, and a cusp formula of 2–9:3–6. The p4 is uniquely triangular in lateral view and has a serration count of 7–12. Molars of *X. mcgrewi* in the Swain Quarry sample could not be identified.

INTRODUCTION

A thick series of sedimentary strata that spans the Cretaceous-Paleogene Boundary crops out in the Great Divide Basin of south central Wyoming (Hettinger et al., 2008) from which a large collection of early Paleogene mammal teeth was made by M. McKenna, J. Honey, and others. Description of these fossils will be an important addition to the Paleocene record of Mammalia from the northern Rocky Mountains (Eberle et al., 2013), with the first taxonomic report the description of a new arctocyonid, *Sigynorum magnadivisus*, from the China Butte Member of the Fort Union Formation (McComas and Eberle, 2015).

An initial survey of the large sample of multituberculate teeth from the China Butte Member within the Great Divide Basin (Figure 1) revealed a single P4 each of the rare taxa, *Kimbetohia campi* (UCM 105599) and *Xanclomys mcgrewi* (UCM 104547). *K. campi* was only confidently known from the Nacimiento Formation of New Mexico (Simpson, 1936; Sloan, 1981; Krause, 1982; Weil and Krause, 2008) and the North Horn Formation of Utah (Lofgren et al., 2012) and its occurrence in south central Wyoming is a significant geographic range extension (Figure 1). UCM 104547 represents the first record of *X. mcgrewi* from a site other than the type locality, Swain Quarry. The two P4s are described and their paleobiogeographic implications are discussed. Additions to the original description of the dentition of *X. mcgrewi* (Rigby, 1980) are also provided.

Upper teeth are represented by capital letters and lower teeth by lower case letters. Institutional abbreviations: AMNH, American Museum of Natural History, New York, New York; RAM, Raymond M. Alf Museum of Paleontology, Claremont, California; UCM, University of Colorado Museum of Natural History, Boulder, Colorado; UCMP, University of California Museum of Paleontology, Berkeley, California. Other abbreviations: NALMA, North American Land Mammal Age; Pu2, *Ectoconus*/*Taeniolabis taoensis* Interval Zone of the Puercan NALMA; To2, *Protoselene opisthacus*/*Mixodectes pungens* Interval Zone of the Torrejonian NALMA.

SYSTEMATIC PALEONTOLOGY

Order Multituberculata Cope, 1884
Family Ptilodontidae Simpson, 1928
Kimbetohia Simpson, 1936
Kimbetohia campi Simpson, 1936
(Figure 2; Table 1)

Holotype—UCMP 31305, skull fragment with right P1–4, P1 severely fragmented (Krause, 1982), from Betonnie-Tsosie Arroyo, Nacimiento Formation, San Juan Basin, New Mexico.

Referred Specimen—UCM 105599, left P4 from UCM locality 2011036, China Butte Member, Fort Union Formation, Great Divide Basin, Wyoming.

Description—UCM 105599 has a cusp formula of 1:4:7 and measures 4.55 mm in length and 2.65 mm in width. It has a blunt anterior margin that widens posteriorly and reaches its maximum width where a transverse line intersects labial row cusp one, middle row cusp two, and lingual row cusp three (Figure 2). Apices of cusps in both the labial and middle cusp rows exhibit little sign of wear. The lingual cusp row has seven cusps of similar size, of which the posterior three have slight wear on their apices. Lingual row cusps are taller than cusps in the middle and labial cusp rows.

Discussion—UCM 105599 is virtually identical in all respects to AMNH 59789 from the type locality of *Kimbetohia campi* in the San Juan Basin of New Mexico. Both UCM 105599 and AMNH 59789 have a cusp formula of 1:4:7 (Figure 2; Lofgren et al., 2012: fig. 1B) and are similar in size (Table 1). Also, both are widest in a transverse line that intersects labial row cusp one, middle row cusp two, and lingual row cusp three. There is little doubt that UCM 105599 represents *K. campi*.

Prior to description of UCM 105599, P4s of *K. campi* had only been described from New Mexico and Utah (Weil and Krause, 2008; Lofgren et al., 2012). The holotype of *K. campi* was described by Simpson (1936) based on a skull fragment (UCMP 31305) with a worn P4 collected in Betonnie-Tsosie Arroyo from the Nacimiento Formation in the San Juan Basin, New Mexico. Later, four additional P4s of *K. campi* (AMNH 58468, AMNH 58672, AMNH 58540, AMNH 59789) were reported from Betonnie-Tsosie Arroyo (Sloan, 1981). These P4s and a P4 (RAM 9027) of *K. campi* from the Gas Tank East site in the North Horn Formation of Utah were described by Lofgren et al. (2012). At that time, RAM 9027 was the only definitive occurrence of a P4 of *K. campi* from a site other than the type locality in New Mexico, which extended the known range of this rare taxon northwest by about 460 km (Figure 1).

UCM 105599 is from UCM locality V2011036, an anthill from the China Butte Member of the Fort Union Formation, about 9.4 m above the base of Daley Coal Zone (Hettinger et al., 2008). This site is within a 183 m thick section of the basal part of the China Butte Member that represents the Puercan NALMA (Eberle et al., 2013). *K. campi* is only known from Pu2 interval zone strata in the San Juan Basin (Williamson and Lucas, 1993). Although the Great Divide Basin occurrence is based on a single tooth, the rarity and restricted stratigraphic range of *K. campi* in the San Juan Basin suggests that Pu2 interval zone strata are also present in the Great Divide Basin of southern Wyoming. UCM 105599 also extends the paleogeographic record of *K. campi* into the northern Rocky Mountains, a significant range extension nearly 800 km north of the type locality (Figure 1).

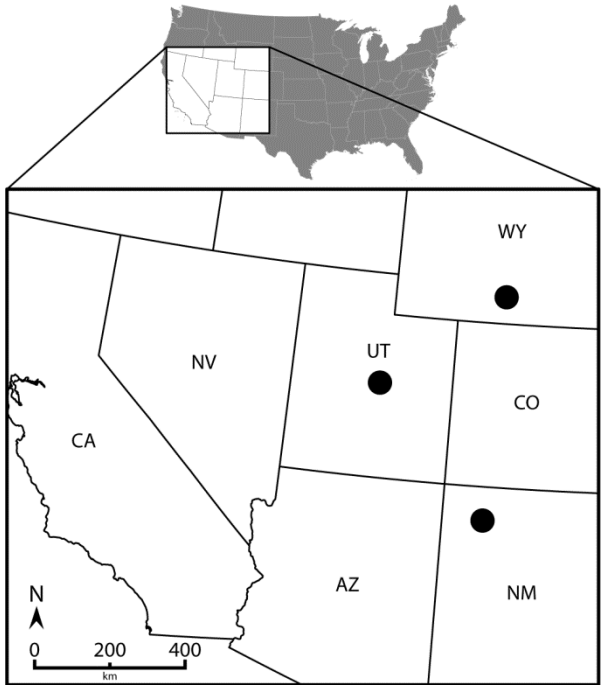

FIGURE 1. Map of states in the southwest United States, with dark circles denoting the location of the Great Divide Basin in Wyoming (WY), North Horn Formation in Utah (UT), and San Juan Basin in New Mexico (NM), locations with well documented records of *Kimbetohia campi*. *Xanclomys mcgrewi* is only known from the Great Divide Basin. CA: California; NV: Nevada; CO: Colorado; AZ Arizona.

In addition to the well documented Puercan records, two Cretaceous occurrences of *K. campi* were reported from western North America, but both were tentative (Clemens, 1973a; 1973b). Two p4s from the Lance Formation of Wyoming initially assigned to ?*Mesodma* sp. (Clemens, 1964), were referred to *K. campi* (Clemens, 1973a), but are now included in the hypodigm of *Clemensodon megaloba* (Krause, 1992). Also, a preliminary report of mammals from the Hunter Wash local fauna of the Fruitland Formation of New Mexico included cf. *K. campi* (Clemens, 1973b). This tentative record has not been substantiated, but it was noted by Clemens et al. (1979), Flynn (1986: table 3), and Lillegraven and McKenna (1986: table 10), the latter with the "cf." removed. A second and smaller species of *Kimbetohia* may be present in Montana and Colorado. Middleton and Dewar (2004) described *Kimbetohia? mziae* from the Denver Formation of Colorado, but the referral to *Kimbetohia* was tentative

because a P4 was not recovered. *K.*? *mziae* also occurs in the Tullock Formation of Montana (Weil, 2009) and may be the same unnamed species of *Kimbetohia* from the Tullock Formation tentatively reported by Van Valen and Sloan (1965: table 1) and Sloan (1981).

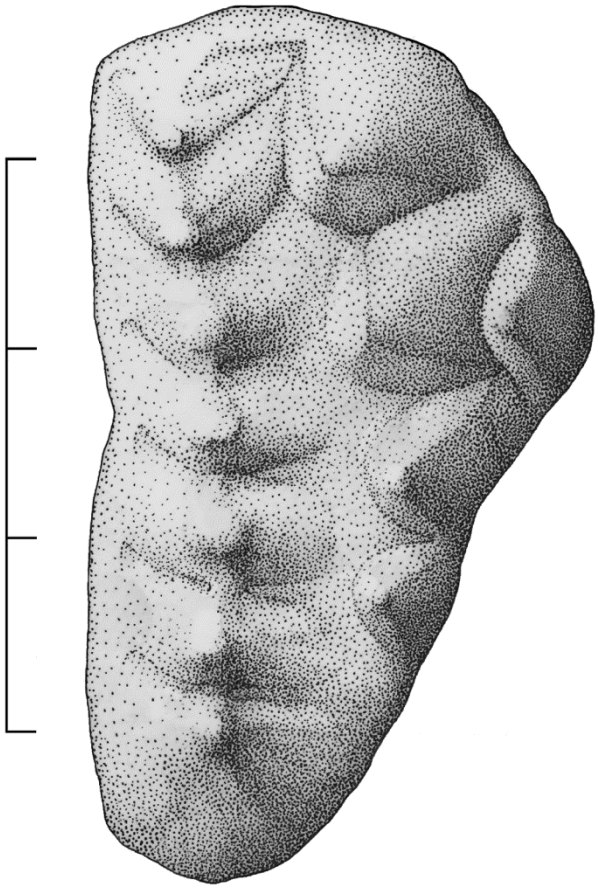

FIGURE 2. Occlusal view of UCM 105599, left P4 of *Kimbetohia campi* from UCM locality 2011036, Fort Union Formation, Wyoming. Scale bar in mm.

Kimbetohia campi is a rare component of early Paleocene multituberculate faunas of North America, but the recent reports from Utah and Wyoming suggest a more extensive Puercan distribution for the species than the one documented here. The recovery of a P4 of *K.? mziae* could confirm its taxonomic assignment and would then confidently extend the paleogeographic distribution of the genus into Montana and Colorado.

Family Neoplagiaulacidae Ameghino, 1890
Xanclomys Rigby, 1980
Xanclomys mcgrewi Rigby, 1980
(Figures 3, 4, 5)

Holotype—AMNH 87859, dentary fragment with p3–4 from Swain Quarry, China Butte Member, Fort Union Formation, Wyoming.

Referred Specimen—UCM 104547, left P4 from UCM locality 2011038, China Butte Member, Fort Union Formation, Wyoming.

Description of UCM 104547 and Swain Quarry Specimens—The dentition of *Xanclomys mcgrewi* was described by Rigby (1980), but it was brief and the unique P4 was not well illustrated. To improve knowledge of this rare taxon, further description of the dentition of *X. mcgrewi* is provided based on AMNH and UCM specimens from the type locality.

The holotype of *X. mcgrewi* (AMNH 87859) is a dentary fragment with a worn and damaged p4 (crown chipped). One of three designated paratypes is AMNH 87860, a dentary fragment with p3, heavily worn p4, and m1 alveoli, a specimen erroneously illustrated as the holotype (Rigby, 1980: pl. 1, figs. 4–6). Both the holotype and this paratype have a damaged or worn p4, so illustration of a well preserved p4 (AMNH 87857i) was provided by Rigby (1980: pl. 1, figs. 10–11; specimen mislabeled as AMNH 87587i).

In labial or lingual view, the p4 of *X. mcgrewi* is triangular in outline and has an elongate anterior slope inclination of about 35 degrees and a steeper posterior slope inclination of approximately 60 degrees (Figure 3A–B). The labial side of AMNH 87857i is distinguished from the lingual side by its slightly expanded exodaenodont lobe and small posterior shelf. Well-defined ridges are evident in labial and lingual view that roughly parallel the inclination of the anterior slope, except where they steepen on the lower half of the posterior slope. Ridges are absent on the crest of the anterior slope except on or adjacent to the apex, where faint ridges and one to three tiny serrations can be present. The posterior slope of the p4 of *X. mcgrewi* has robust serration development as tall individual serrations occur where ridges intersect the posterior tooth margin, except near the apex on the posterior slope where serrations are small or absent, likely owing to wear. Thus, with even minor apical wear, determining the number of serrations becomes difficult. For example, AMNH 87857i has minor apical wear and it is difficult to determine if it had three anterior and eight posterior serrations or two anterior and nine posterior serrations (Figure 3A–B). The highest serration count observed in any unworn Swain Quarry p4 was three anterior and nine posterior serrations (AMNH 87857d).

AMNH 101082i (Figure 3C) illustrates the progression of wear on the p4 of *X. mcgrewi* as about 20% of the crown has been removed, with wear equally distributed on the anterior and posterior slopes. Also, labial and lingual ridges in AMNH 101082i are much less distinct compared to slightly worn p4s such as

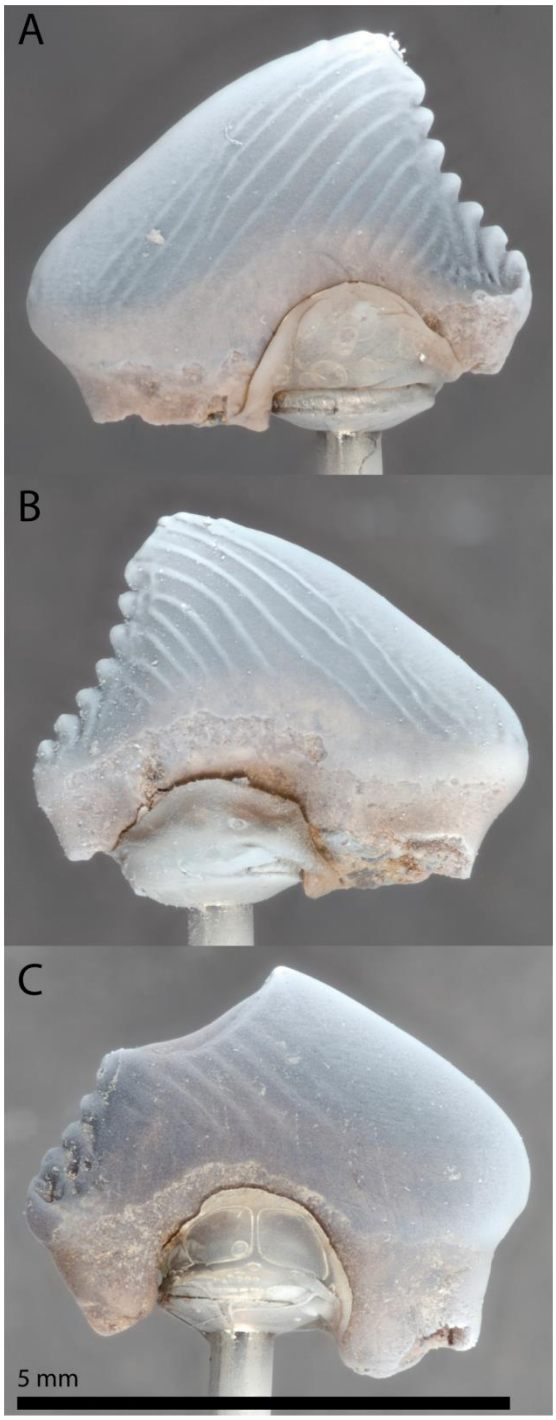

FIGURE 3. Two p4s of *Xanclomys mcgrewi* from Swain Quarry, Fort Union Formation, Wyoming. **A**, Labial view of AMNH 87857i, left p4; **B**, Lingual view of AMNH 87857i; **C**, Labial view of AMNH 101082i, worn right p4. Scale bar applies to all three specimens.

AMNH 87857i (Figure 3A–C). After heavy wear, only the basal part of the p4 is still intact (Rigby, 1980: pl. 1, figs. 4–5). The proportion of unbroken *X. mcgrewi* p4s from Swain Quarry with moderate or heavy wear is about 50%, an unusually high percentage compared to most large samples of multituberculate p4s (pers. obs. D. L. Lofgren). The p4 serration count observed in the Swain Quarry sample was 0–3 on the anterior slope, and 7–9 on the posterior slope.

The more than 70 P4s of *X. mcgrewi* from Swain Quarry exhibit significant variation in cusp morphology and cusp formula. In occlusal view, the unique P4 of *X. mcgrewi* has two well-developed, moderately arcuate, and lingually concave cusp rows, separated by a well-developed middle valley that widens posteriorly, and then narrows at the posterior tooth margin, because the labial cusp row deflects lingually (Figure 4A–B). The labial cusp row is about 60% of the length of the lingual cusp row. The lingual cusp row often has a lingually deflected lobe on its posterior terminus, a feature, that when present, increases the width of the tooth.

The number of labial row cusps and their morphology is highly variable in *X. mcgrewi* and are best described in two segments, an anterior series that forms the labial tooth margin and a posterior series that deflects lingually at the posterior terminus of the anterior series. The anterior series is comprised of two to six cusps that increase in height and size posteriorly with the last cusp usually the largest and tallest of the row. Initial cusp wear on the labial cusp row is centered on this large cusp. Usually the cusps in the anterior series of the labial cusp row are closely appressed but segregated by steep narrow valleys (Figure 5). Less often, the anterior part of the labial cusp row is ridge-like and valleys between individual cusps may not extend to the labial margin of the tooth (Figure 4A). A few specimens have an anterior labial cusp row that is composed mainly of one massive, elongate cusp (Figure 4B). When the anterior part of the labial cusp row is ridge-like, usually one or two small cusps are present posterior to the largest and tallest cusp of the row (Figure 4A–B).

Posterior to the anterior series of cusps of the labial row cusp, a posterior series of cusps deflects lingually and additional small cusps are almost always present on the tooth's posterior margin. These smaller cusps are a posterolingual extension of the labial cusp row and vary from one to three in number when present. Of the 70 P4s where these posterior labial row cusps could be counted, three lacked cusps, 31 had one cusp, 29 had two, and seven had three. If three cusps are present, they are usually orientated obliquely, about 45 degrees relative to the orientation of the anterior series of labial row cusps (Figure 4A). The most labial cusp of this posterior series is usually the largest,

whereas the most lingual cusp is positioned adjacent to or low on the labial slope of the terminal lingual row cusp. Thus, the cusp formula of the entire labial cusp row is highly variable, as two to nine can be present. For example, UCM 31284 has nine labial row cusps, six anterior and three posterior (Figure 4A), AMNH 101017h has four, three anterior and one posterior (Figure 4B), and UCM 104547 has four, four anterior and none posterior (Figure 5: tiny cuspule located anterior to labial row cusp one not counted in cusp formula). Only two specimens (AMNH 101019a, AMNH 101018n) had two labial row cusps.

FIGURE 4. Occlusal views of P4s of *Xanclomys mcgrewi* from Swain Quarry, Fort Union Formation, Wyoming. **A**, UCM 31284, left P4 (cusp formula 9:3); **B**, AMNH 101017h, left P4 with broken posterior labial row cusp (cusp formula 4:5). Scale bar applies to both specimens.

In comparison to the labial cusp row, variation in cusp morphology and cusp formula of the lingual cusp row is minimal. The lingual cusp row has 3–6 cusps, which increase in height and size posteriorly, with a massive terminal cusp occupying over half the area of the lingual cusp row (Figures 4A, 5). Two to three small cuspules can be present on the apex of this massive cusp in unworn specimens (Figure 4B), but with slight wear, they will merge to form a single wear facet. Apices of the cusps of the lingual cusp row are anteroposteriorly aligned and elongated so that they would form one posteriorly rising and continuous ridge if they were not separated by deep, narrow valleys. The terminal lingual row cusp is strongly anteroposteriorly elongated, with steep labial and lingual slopes, and is much taller than any other lingual row cusp. Initial wear on the P4 is centered on this massive cusp. On many specimens, a ridge is developed on the posterior slope of the terminal lingual row cusp that curves lingually as it descends to meet the posterior tooth margin. The cusp formula of the P4 of *X. mcgrewi* is 2–9:3–6.

Discussion—The new record of *Xanclomys mcgrewi* (UCM 104547) is a slightly worn P4 with two well developed cusp rows separated by a medial valley that widens posteriorly with the labial cusp row about 60% of the length of the lingual cusp row, features that clearly align it with P4s of *X. mcgrewi*. Ranges in lengths and widths of P4s of *X. mcgrewi* from Swain Quarry are 2.60–3.75 mm and 2.20–3.00 mm respectively (Rigby, 1980: table 5). The length of UCM 104547 is 3.44 mm, and is similar to P4s of *X. mcgrewi*. Also, width of UCM 104547 is 2.07 mm or about 0.1 mm less than the narrowest P4 of *X. mcgrewi*, a minor disparity. UCM 104547 has a cusp formula of 4:3 and the development of its labial row cusps is unusual as the lingual extension of the labial cusp row is very short and not cuspidate. Only three P4s from Swain Quarry (AMNH 87888f, AMNH 87888q, AMNH 101017m) lacked a cuspidate lingual extension of the labial cusp row, but the rarity of this condition is not considered significant considering the great amount of variation observed in the labial cusp row of P4s of *X. mcgrewi*.

UCM 104547 is only the second known occurrence of *X. mcgrewi*. It is from UCM locality 2011038, an anthill in the upper part of the China Butte Member of the Fort Union Formation that is only 55 km north of Swain Quarry, a minor geographic range extension of the species within the Great Divide Basin of Wyoming. Both UCM locality 2011038 and Swain Quarry, the type locality of *X. mcgrewi*, are above the Muddy Creek Coal Bed and below the Fillmore Ranch Coal Zone (Hettinger et al., 2008). Swain Quarry was tentatively correlated to the To2 Interval Zone of the Torrejonian NALMA (Lofgren et al., 2004). Strata that yielded UCM locality 2011038 may be of similar age based on approximate stratigraphic position, but this cannot be confirmed because the stratigraphic relationship between the sites is not well established.

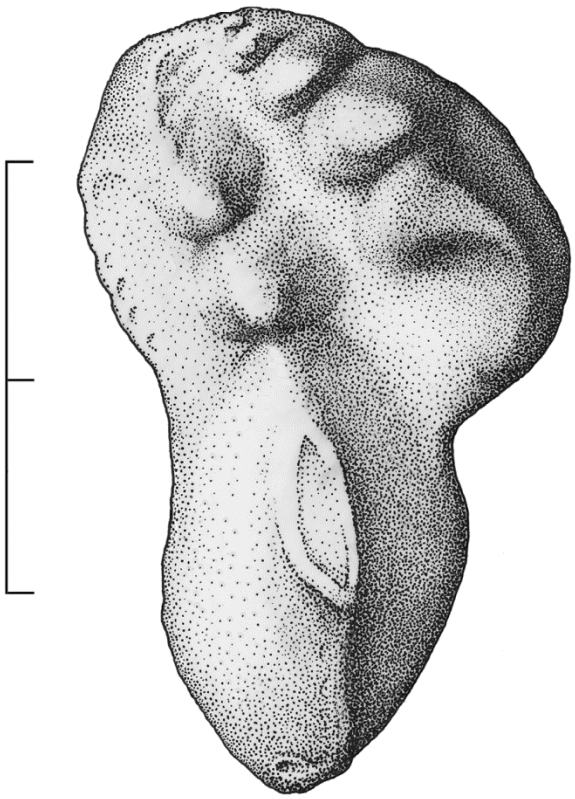

FIGURE 5. Occlusal view of UCM 105547, left P4 (cusp formula 4:3) of *Xanclomys mcgrewi* from UCM locality 2011038, Fort Union Formation, Wyoming. Scale bar in mm.

Swain Quarry has yielded about 28,000 mammal specimens (Rigby, 1980). The sample of the P4 and p4 of *X. mcgrewi* both exceed 60 specimens, large numbers that indicate other parts of the dentition were sampled. A tentative attempt was made to identify the m1s and M1s, as Rigby (1980: 36) questionably referred three specimens of each to *X. mcgrewi* with the admission that these "molars are probably confused with elements referable to *Neoplagiaulax*." These specimens have been renumbered with former numbers in parentheses; m1s, AMNH 140203 (AMNH 101027g), AMNH 140205 (AMNH 101028e), and AMNH 140216 (AMNH 101030j), M1s, AMNH 140218 (AMNH 101049f), AMNH 140219 (AMNH 101056c), and AMNH 140198 (AMNH 101058k). These six m1s and M1s were compared directly to m1s and M1s of *Neoplagiaulax hunteri* from Swain Quarry (now referred to *Neoplagiaulax nelsoni*; Sloan, 1987) and there was no consistent difference between the samples in cusp formula, size, or cusp morphology. Thus, molars of *Xanclomys mcgrewi* in the Swain Quarry sample remain unidentified.

The P4 and p4 of *Xanclomys* are unique. The genus was originally referred to Neoplagiaulacidae (Rigby, 1980; Sloan, 1987). McKenna and Bell (1997) placed *Xanclomys* in Neoplagiaulacinae (new rank) within Ptilodontidae, but Weil and Krause (2008) re-erected Neoplagiaulacidae and included *Xanclomys*, noting that its fourth premolars are unique and that the Neoplagiaulacidae needed revision. More complete material of *Xanclomys* would greatly aid in this endeavor.

SUMMARY

The China Butte Member of the Fort Union Formation within the Great Divide Basin has yielded a P4 of *Kimbetohia campi* (UCM 105599) and a P4 of *Xanclomys mcgrewi* (UCM 104547). UCM 105599 is virtually identical to AMNH 59789 from the type locality of *K. campi* in the San Juan Basin of New Mexico. Although the Great Divide Basin occurrence is based on a single tooth, restriction of *K. campi* to the Pu2 interval zone in the San Juan Basin suggests that the Great Divide Basin occurrence is of similar age. UCM 105599 extends the paleogeographic record of *K. campi* into the northern Rocky Mountains, a range extension nearly 800 km north of the type locality in New Mexico.

The newly discovered P4 of *Xanclomys mcgrewi* from the Great Divide Basin has a cusp formula of 4:3 with two well-developed cusp rows. The labial cusp row is about 60% of the length of the lingual cusp row, and a massive terminal cusp dominates the latter, general features that align it with P4s from Swain Quarry, the type locality. This is the second known occurrence of *X. mcgrewi* and strata that yielded the specimen are 55 km north of Swain Quarry and may be similar in age to the type locality (To2 Interval Zone).

The dentition of *Xanclomys mcgrewi* from Swain Quarry was reanalyzed and the cusp formula of the P4 is revised to 2–9:3–6. Also, the morphology of labial row cusps is highly variable and a uniquely developed posterior series of one to three small cusps that deflects lingually is present in most P4s. The p4 has robust posterior slope serrations, a unique triangular outline in lateral view, and a serration count of 7–12. Molars of *X. mcgrewi* in the Swain Quarry sample were not identified.

ACKNOWLEDGMENTS

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