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Late Cretaceous Mammal Horizons from the San Juan Basin, New Mexico

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ABSTRACT

Small mammals from Upper Cretaceous rocks exposed in Hunter Wash and higher in Ojo Alamo and Barrel Spring Arroyos, and near Burnham Trading Post in the San Juan Basin are described and compared to Late Cretaceous mammals from Wyoming, Montana, and Alberta. Superposed assemblages from the Hunter Wash-Ojo Alamo area cluster around two levels that are separated by about 200 m of strata and at least 1 million years of time. Small samples from the younger localities are comparable to Lance and Hell Creek mammals of the latest Cretaceous (late Maastrichtian). The older localities yield richer assemblages that display affinity with faunas from the Judith River, Old Man, and Milk River formations, generally thought to be Campanian in age. Present paleomagnetic reversal correlations suggest a middle to late Maastrichtian age for the entire terrestrial sequence in the San Juan Basin. This correlation agrees with the approximate ages of Lance and Hell Creek faunas, but is about 6 million years younger than ages presently estimated for known Judith River and Oldman assemblages.

Accepting the hypothesized paleomagnetic age for the San Juan Basin terrestrial rocks, this suggests that the Judithian land mammal "age" de-

fined by Lillegraven and McKenna (1986) persisted through most of the Maastrichtian and was replaced by Lancian-like assemblages after 68 million years ago. Further, the fact that the older Hunter Wash assemblage includes elements occurring in both the Milk River and the Judith River formations may suggest that differences between Milk River and Judith River are mainly ecological. Alternatively, Milk River and Judith River elements may have survived anomalously late in the San Juan Basin as a consequence of faunal provincialism. This view suggests that the San Juan Basin was part of a biogeographic province separate from northern faunas.

As a third alternative, if the paleomagnetic correlation for the San Juan Basin is rejected, the age of the Hunter Wash assemblage can be estimated on biochronological arguments as intermediate between the Milk River and Judith River faunas; i.e., near the Campanian/Maastrichtian boundary. Of course, further paleontological and chronological work throughout North America will help to clarify this situation by strengthening the biostratigraphic basis for the definition of mammalian biochrons.

INTRODUCTION

For some years, small mammals have been known to occur sparsely in Late Cretaceous rocks of the San Juan Basin, New Mexico. Screening efforts by Professor W. A. Clemens, now of the University of California, Berkeley, produced the first evidence of San Juan Mesozoic mammals. These fossils came from several localities in the terrestrial Fruitland Formation exposed in Hunter Wash, east of Bisti Trading Post (area A on fig. 1), stratigraphically below the Late Cretaceous Kirtland Formation, the overlying Ojo Alamo

Conglomerate, and the succeeding Paleocene Nacimiento Formation. Clemens' (1973) analysis showed this fauna to predate typical Lance Formation faunas of Wyoming, and suggested an "Edmontonian age" for the Fruitland mammals, while similarities to an assemblage from the Judith River Formation, Montana, were noted. Clemens (1973) added these Fruitland mammals to the "Hunter Wash Local Fauna" described earlier for reptiles (see Lehman, 1981).

Recently, Lehman (1984) reported three

LATE CRETACEOUS MAMMAL LOCALITIES, SAN JUAN BASIN, NEW MEXICO

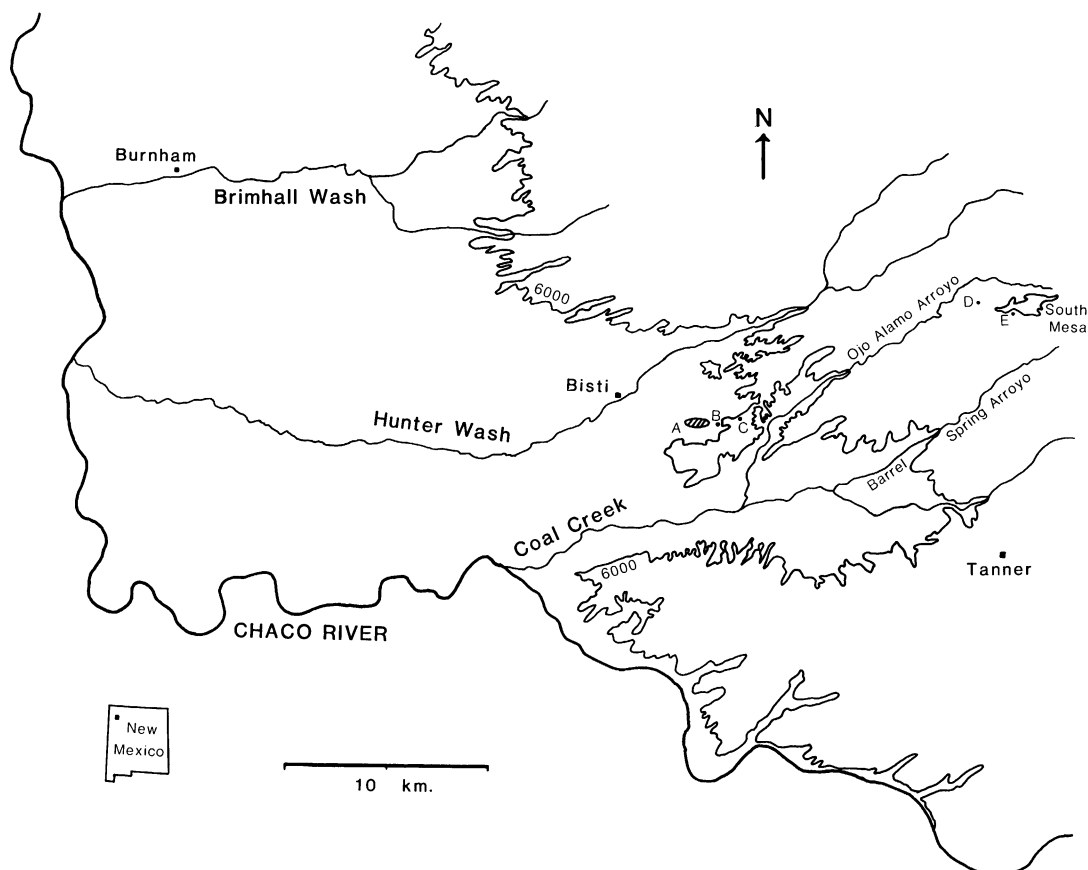


FIG. 1. Location map for Late Cretaceous mammal sites of the San Juan Basin, New Mexico, that are treated in this study. Superposed assemblages (fig. 2) are indicated by letters: A (shaded area), Lower Hunter Wash localities reported by Clemens (1973); B, Lindsay Microsite (75137) and Dead Feather (76168); C, Jacobs Bone Bed (7592); D, Jon Powell Microsite (8020); E, 7599. Burnham South is located about 3 km south of Burnham Trading Post, in exposures bordering Brimhall Wash. The 6000-ft contour line is plotted from the 7.5-minute Alamo Mesa East and Alamo Mesa West Quadrangles. South Mesa is indicated by plotting its 6400-ft contour line.

multituberculate teeth from claystones underlying the upper restricted Ojo Alamo Conglomerate (see fig. 2). One of these he attributed to *Essonodon browni*, a species restricted elsewhere to Lancian age (see Lillegraven and McKenna, 1986) faunas. Lehman (1984) considered that *Essonodon browni* and co-occurring dinosaurs, elements of the "Alamo Wash Local Fauna," suggest a Lancian correlation for the youngest Cretaceous deposits in the San Juan Basin.

Further small mammal remains, the sub-

ject of this study, were collected in the summers of 1975 to 1978 during the course of magnetostratigraphic-biostratigraphic fieldwork on Upper Cretaceous and Lower Cenozoic strata of the San Juan Basin, northwestern New Mexico. Results of that work were published in a series of papers, notably Butler et al. (1977), Lindsay et al. (1978), Lindsay et al. (1981), and Butler and Lindsay (1985). Butler et al. (1977) measured and sampled a continuous stratigraphic section through Upper Cretaceous rocks exposed in

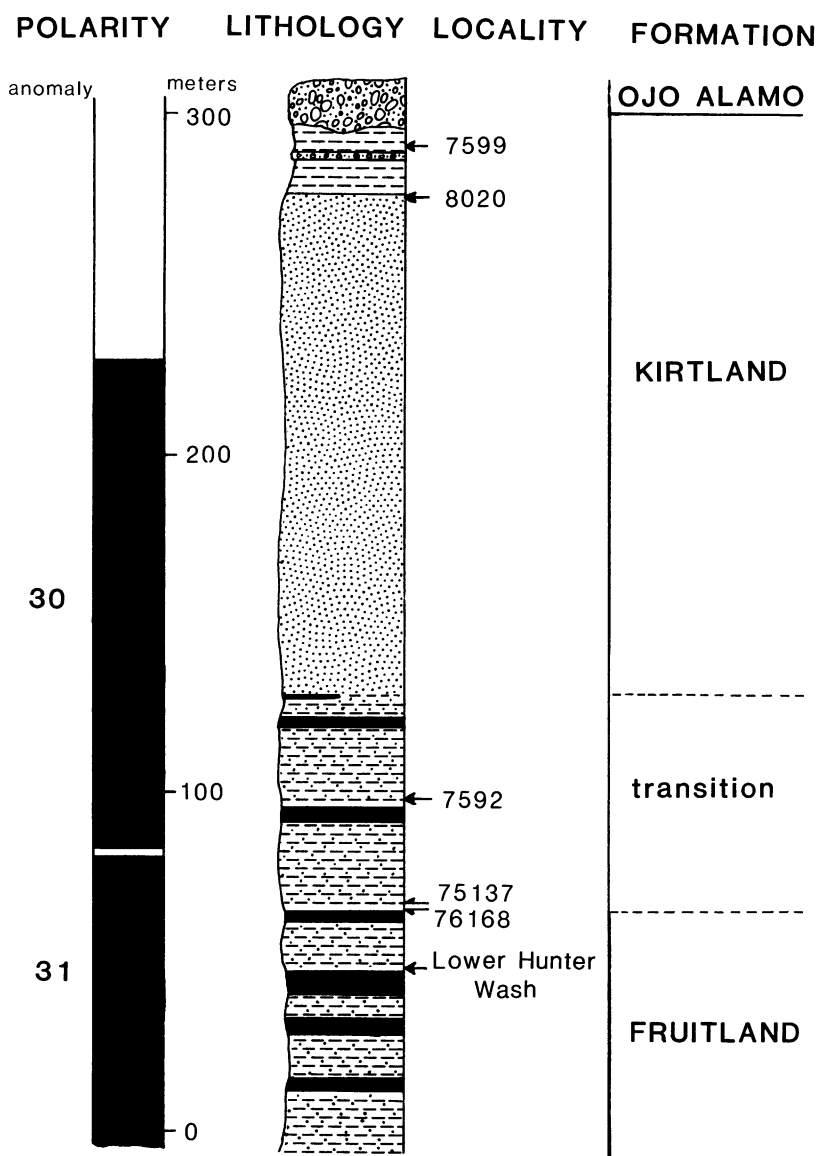


FIG. 2. Mammal sites superposed in the Late Cretaceous stratigraphic section of Butler et al. (1977). Magnetic polarity stratigraphy follows Butler et al. (1977) and Butler (1984). Lithology indicated as follows: coal (black shading), sandy siltstone (dashes with stippling), silty sandstone (stippling), claystone (dashes), conglomeratic sandstone (stippling with ovals). Arrows indicate fossil horizons for localities of figure 1; the Lower Hunter Wash arrow approximates the lowest of the horizons that produced the assemblage reported on by Clemens (1973). Burnham South correlates approximately with locality 7592. The Naashoibito Member of the Kirtland Formation is not indicated, but is usually considered to comprise the claystone at the level of locality 7599 and the thin underlying conglomeratic sandstone; for reasons discussed in the text, the Naashoibito should be redefined to include the claystone overlying locality 8020 also.

Hunter Wash and Ojo Alamo Arroyo to which microvertebrate localities in the area are easily correlated (figs. 1, 2) by tracing marker beds laterally. Paleomagnetic results argue for

a late Maastrichtian age for the entire Fruitland-Ojo Alamo section.

Other mammals described here came from Burnham South in Brimhall Wash, about 3

km south of Burnham Trading Post (fig. 1) and 20 km northwest of Bisti. A *Pentaceras* skull from this area was reported by Rowe et al. (1981; approximate latitude 36°20'25"N, longitude 108°27'W) and further locality data are on file at the Museum of Northern Arizona. These specimens were collected in May of 1978 in cooperation with Dr. Louis L. Jacobs and Mr. William R. Downs, both then of the Museum of Northern Arizona. A test sample of about 100 kg from *Unio* pockets about 3 m stratigraphically below and 30 m lateral to the Museum of Northern Arizona *Pentaceras* skull level proved highly productive. This locality is not tied to the Hunter Wash section, but the lithology is predominantly yellowish siltstones with abundant plant remains, typical of upper levels of the Fruitland Formation (labeled "transition" on fig. 2).

Productive localities have also been discovered in Fruitland exposures near Tanner Trading Post, about 10 km to the southeast of locality D (fig. 1), in the area known as the "fossil forest." Drs. J. Keith Rigby, Jr. and Donald Wolberg (in press) support a Judithian correlation for the assemblage from Quarry 1 of this area, which they consider to be stratigraphically correlative to the Hunter Wash fauna of Clemens (1973).

STRATIGRAPHY

Figure 2 shows the local stratigraphy of late Cretaceous terrestrial sediments exposed in Hunter Wash and Ojo Alamo/Barrel Spring Arroyos. Coal layers toward the base of the long sequence of drab sandstones and siltstones represent coastal swamp deposits in a delta plain environment (Lucas and Mateer, 1983; Manfrino, 1984). The predominantly gray to yellow siltstone and coal-bearing strata referred to the Fruitland Formation grade upward into the buff siltstones and sandstones without coal of the Kirtland Formation. Dinosaurs occur throughout the sequence, but are more common in the lower Fruitland levels. For mapping purposes, a high continuous coal, such as that underlying UALP locality 76168 (fig. 2), may be chosen as the arbitrary top of the Fruitland Formation (see Fassett and Hinds, 1971). However, no consensus has been established on this issue and

the lithology between the formations is designated as transitional on figure 2.

A sharper contact is that between light-colored silty sands and overlying dark claystones at the top of the Kirtland Formation (the 270-m level on fig. 2). Higher within these claystones is a thin sand that is locally conglomeratic. Dinosaur remains are abundant throughout the claystone, above and below this sand unit. Capping the sequence is a thick, fossil wood-bearing conglomerate with an unconformable base that locally cuts deep into the underlying sediments. The convoluted history of stratigraphic nomenclature for these beds was reviewed by Fassett (1973). The nomenclature remains unstable.

Following Baltz et al. (1966), I restrict the name "Ojo Alamo Formation" to designate the thick conglomerate capping the section at South Mesa (fig. 2). Elsewhere in the San Juan Basin, strata considered the Ojo Alamo Formation include several channel sands with intervening beds of silty sand. Perhaps this is one reason why some earlier authors had included the lower, thin sandy conglomerate and *overlying* claystone near South Mesa in the Ojo Alamo Formation (see fig. 2 and Fassett, 1973). Baltz et al. (1966) call these lower units the Naashoibito Member of the Kirtland Formation. These authors argue convincingly that the upper boundary of the Naashoibito Member, and therefore the division between the Ojo Alamo and Kirtland formations, should be the unconformity separating markedly different lithologies at the 295-m level in figure 2. Below, I argue for revision of the lower boundary of the Naashoibito Member.

The distinctive lithology of the Naashoibito Member is the colorful claystone, mainly light gray to purple with maroon bands and rich in dinosaur fossils. This contrasts with the less fossiliferous, drab yellow and beige silts and sands of lower Kirtland beds. In the Ojo Alamo Arroyo section, the thick Kirtland silty sands are overlain by 12 m of claystone, followed by a thin conglomeratic sand, less than 2 m thick over most of its range, and then more claystone, 10 to 15 m in thickness (varying according to erosion at the base of the Ojo Alamo Conglomerate).

Both claystone units should be included in the Naashoibito Member on the grounds of

lithological homogeneity, including abundance of fossils (a lithic criterion accepted by the North American Commission on Stratigraphic Nomenclature, 1983, p. 858). These claystones probably represent overbank floodplain deposits and the thin, sandy "lower conglomerate" within them would be an element of that river system. Further, the "lower conglomerate" pinches out to the north. I would extend the lower boundary of the Naashoibito Member downward from this "lower conglomerate" to the sharp contact between dark clays and light silty sands within the Kirtland Formation. This revision has the added advantage of making the Naashoibito Member coincident with Brown's (1910) "Ojo Alamo" dinosaur assemblage.

I consider the Naashoibito Member to be an overbank facies of the Kirtland sands and silts. Its outcrops are best developed within only several kilometers of South Mesa. Southeast of Split Lip Flats the facies is absent, but it is present in lesser thickness and without the lower conglomerate further to the southeast at Tsosie Arroyo. In the southwest quarter of section 16 and the southeast quarter of section 17, township 24 north, range 11 west near South Mesa, the lower claystones interfinger laterally into typical drab Kirtland lithology. This lateral gradation conflicts with Lehman's (1981) hypothesis that the Naashoibito could be an erosional remnant of the McDermott Formation of Colorado. Rather, the development of the Naashoibito facies may indicate a local shift in the regimen of deposition toward finer-grained overbank deposits with possible development of paleosols (the maroon bands), that perhaps heralds the environment of deposition dominant for the Paleocene Nacimiento Formation.

HUNTER WASH-ALAMO WASH LOCALITIES AND LOCAL FAUNAS

Cretaceous mammal localities occurring along the measured section of figure 2 cluster in two areas at two general stratigraphic levels. The lower assemblages occur high in the Fruitland Formation exposed along Hunter Wash. Several new fossil localities discussed here occur within 25 m above the Lower Hunter Wash assemblage reported by Clem-

ens (1973, the Hunter Wash Local Fauna) and yield comparable mammals (see fig. 1 and table 3, this paper). Microvertebrates occur in lignitic clay pebble conglomerates at the bases of channel sandstones. A few specimens described below come from UALP localities 75137 (Lindsay Microsite) and 76168 (Dead Feather) but by far the bulk of the sample derives from the higher UALP locality 7592 (Jacobs Bone Bed).

The second cluster of localities is nearly 200 m above Jacobs Bone Bed in the top of the Kirtland Formation, primarily in the Naashoibito Member. UALP 8020 (Jon Powell Microsite) occurs in a beige silt and clay pebble conglomerate 3 m below the dark blue-gray to light gray lower claystone. Two to three meters above the lower conglomeratic bed, microvertebrates occur in a light gray silty claystone. The several sites at this level on the southern slope of South Mesa are designated collectively UALP 7599. Lehman (1984) reported a tooth of *Essonodon browni* from UNM locality BUNM-77-675, probably from a level somewhat above that of UALP 7599 (Lehman, personal commun.).

Mammal localities not in this section are Quarry 1 of the Fossil Forest, correlated to the Lower Hunter Wash horizon by Rigby and Wolberg (in press), and Burnham South, which may be comparable in age to Jacobs Bone Bed on the basis of lithology and fauna (table 3).

Two "local faunas" have been designated. Clemens (1973) used his assemblage (here termed Lower Hunter Wash) as the basis for the mammalian component of the Hunter Wash Local Fauna and mammals from those rocks constitute the only assemblage that should be referred to this local fauna. Younger fossils in the same section (e.g., Jacobs Bone Bed) and assemblages from laterally distant localities (Fossil Forest and Burnham South) could represent the same paleocommunity as the Hunter Wash Local Fauna, but this can not be demonstrated until all available collections are studied. The other designated local fauna is that of the Naashoibito Member, the Alamo Wash Local Fauna (Clemens, 1973; Lehman, 1981). The small samples of mammals from UALP localities 8020 and 7599 and from BUNM-77-675 are

assigned to this local fauna and encompass the same stratigraphic interval as do the dinosaurs in the fauna.

ACKNOWLEDGMENTS

A crucial part of this study was comparison of samples with those made by Dr. W. A. Clemens from lower localities in Hunter Wash, and I thank him for this courtesy and for his critiques. I am also indebted to Drs. J. A. Lillegraven and M. C. McKenna for permission to examine their "Mesaverde" collections. Dr. R. F. Butler provided access to unpublished data and perspective in evaluating chronologies. I deeply appreciate the work and companionship in the field of the following: Drs. L. L. Jacobs and E. H. Lindsay, Messrs. W. R. Downs, R. A. Haskin, R. D. McCord, L. H. Taylor, and Y. Tomida, and Ms. B. R. Standhardt. I thank all of the above as well as D. Archibald, R. Cifelli, K. M. Flanagan, E. Gaffney, C. Holton, T. Lehman, J. Maisey, M. Norell, M. J. Novacek, R. H. Tedford, J. Wahlert, and A. Wyss for their insights and for reading the manuscript. The skillful and patient work of Lauren Duffy and Joan Whelan with the photomicrographs was indispensable. Dr. R. Cifelli and Mr. M. Morales of the Museum of Northern Arizona provided important information on Burnham specimens. Mr. Will Downs kindly processed some of the samples with heavy liquids at Northern Arizona University. Fieldwork was supported by NSF grants to Lindsay and Butler of the University of Arizona and a 1978 Colorado Plateau research grant to me from the Museum of Northern Arizona. Laboratory and travel expenses were funded through the AMNH Carter Fellowship.

ABBREVIATIONS

INSTITUTIONAL

AMNH, American Museum of Natural History, New York, NY 10024
MNA, Museum of Northern Arizona, Flagstaff, AZ 86001
PMAA, Provincial Museum and Archives of Alberta
SJB, San Juan Basin
UA, University of Alberta, Edmonton, Alberta T6G, 2E9

UALP, University of Arizona Laboratory of Paleontology, Tucson, AZ 85721

UNM, University of New Mexico, Albuquerque, NM 87131

V, MNA specimen number prefix

MEASUREMENTS

H, height in millimeters (mm)

L, length in mm

Ma, Megaannum, 10⁶ years ago

W, width in mm

METHODS

Several multituberculates from UALP localities 7592, 75137, and 76168 (see figs. 1, 2) were discovered as surface finds during the course of fieldwork in 1975 and 1976. Following these finds, about two tons of matrix from locality 7592 and about one ton representing several sites in the Naashoibito Member of the Kirtland Formation were collected. In 1978 nearly 100 kg of matrix were taken as a test sample from the *Unio* beds at Burnham South. These samples were washed through screens and produced the bulk of the specimens described here.

After drying, blocks of sediment were soaked in tandem screen boxes and occasionally agitated in water. Fruitland and lower Kirtland matrix was uncooperative because blocks tended to form clayballs that would disintegrate only after long soaking. However, after one washing there was little residual matrix to sort. Neither kerosene nor industrial detergents were helpful on these lithologies, but the Naashoibito claystone disaggregated readily after treatment with kerosene. Dried matrix was soaked for 10 minutes in kerosene and then placed immediately in a screen box in a tub of water.

Concentrate was sorted under magnification and some was processed by using heavy liquids. Specimens were numbered and mounted individually on pins. A Nikon EPOI "Shopscope" with a biaxial moveable stage was used to measure specimens. Measurements were recorded from an IKL "Microcode" digital readout micrometer and rounded to 0.01 mm. Multituberculate premolar dimensions follow Novacek and Clemens (1977). Other tooth measurements follow Clemens (1963, 1966). See Archibald (1982) for recent systematic review.



FIG. 3. Scanning electron photomicrographs of small multituberculates. Indeterminate multituberculate of "plagiaulacoid" grade; A, V 4609, right lower premolar in anterior and external views, and C, V 4608, left antermost lower premolar in external view. *Mesodma formosa* P⁴ (B), UALP 15642 in internal and occlusal views. D, *Paracimexomys judithae* left M₁, UALP 15636 in occlusal view. E, *Paracimexomys* n. sp. right M₂, UALP 15637 in occlusal view. F, *Mesodma* cf. *M. senecta* M₁, UALP 15603 in occlusal view. G-K (one bar scale), *Mesodma* cf. *M. senecta* in occlusal view; M₂, V 2453 and UALP 15602; M₂, V 2448, 3162, and 2454. L-N (one bar scale), *Mesodma* n. sp. or *Cimexomys* cf. *C. antiquus* in occlusal view; M₂ UALP 15616, M₁ UALP 15617, and M₂ UALP 15620. O-S, *Mesodma* cf. *M. senecta* upper premolars in occlusal view; in succession, V 2426 and UALP specimens 15609, 15610, 15614, and 15615. All bar scales equal 0.5 mm.

SYSTEMATICS

ORDER MULTITUBERCULATA COPE, 1884

FAMILY, GENUS, AND SPECIES
INDETERMINATE

REFERRED MATERIAL: V4608 and 4609; left and right lower anterior premolars, respectively (figs. 3, 4).

LOCALITY: Burnham South.

DESCRIPTION: Two trenchant lower premolars can be compared to known plagiaulacoid premolars, but no close identification is possible at present due to the poor representation of this taxon and the lack of knowledge of multituberculate anterior premolars in general. The bladelike crowns and lateral ridges of each are canted, directed posterodorsally, and the single root in each juts anteriorly along the same inclined axis, in the opposite direction. V 4608 (0.92 mm long and 0.54 wide) is smaller and less complex than V 4609 (L, W = 1.33, 0.76) and both are simple, single-rooted teeth. Therefore, V 4608 could represent the antermost lower premolar of its owner, while V 4609 would occupy the immediately succeeding locus. Thus V 4608 and 4609 compare favorably with the plagiaulacoid teeth designated by Hahn (1978) as P_1 and P_2 , respectively.

P_1 is narrower anteriorly than posteriorly and bears a posterolingual heel that would underlap the anterior face of P_2 . Posterolabially, the base of the crown is inflated and supports a damaged cuspule near the base of the second labial ridge. P_1 bears two serrations, the second being stronger, and each is confluent with rounded labial and lingual ridges, the strongest being the second labial ridge. P_2 has three serrations, each with rounded, poorly developed labial and lingual ridges. Lingually P_2 is flat, but it swells labially between the first and second serrations, where a single cuspule is well developed low on the side of P_2 . Serrations show apical wear increasing posteriorly.

DISCUSSION: The presence of trenchant lower anterior premolars suggests that multituberculates of "plagiaulacoid grade" persisted into the Late Cretaceous of the San

Juan Basin. Plagiaulacoids, as the ancestors of all later multituberculates, constitute a paraphyletic group and retention of lower premolars is a primitive trait that does not exclude the taxon represented by V 4608 and 4609 from known clades of advanced multituberculates. Hence, designation of these teeth as "Plagiaulacoidea" would call attention to the presence of a primitive trait in some San Juan Basin multituberculate, but would be misleading in that close relationship to Jurassic-Early Cretaceous plagiaulacoids is not established.

The anterior lower premolar of plagiaulacoids is normally simple and single rooted (see Simpson, 1928) hence, V 4608 and 4609 are designated P_1 and P_2 . However, V 4608 has two serrations, unlike the usually smooth anterior premolar of known plagiaulacoids. Also plagiaulacoid premolars behind P_1 figured by Hahn (1978) have at least two roots, unlike V 4609. V 4608 and 4609 could be designated P_2 and P_3 , suggesting a root structure atypical for plagiaulacoids but a crown and root structure perhaps to be expected in multituberculate lineages that lost premolars. If the premolar row were in the process of reduction, the single rooted V 4609 could be a homologue of the ptilodontoid peglike P_3 .

The abrasion on serrations (but none exists on the labial cusp) of V 4609 is possible evidence of apical wear, although the serrations may have been damaged before fossilization or during screening. Apical wear on lower premolars is shared with paulchoffatiids (Clemens and Kielan-Jaworowska, 1979).

If two small plagiaulacoid premolars have been recovered, some other larger elements of the dentition of this species should also be represented in the San Juan Basin sample. These premolars may correspond to molars of one of several small multituberculates described below and *Paracimexomys* is a possible candidate. Archibald (1982) associated the Plagiaulacidae as the sister group to *Paracimexomys* plus other advanced multituberculates. *Paracimexomys* has relatively small P_4 , short M_1^1 , and waisted M_2^2 as in plagiaulacids (primitive characters that are modified in other multituberculates). Perhaps *Paracimexomys* also retained anterior lower premolars.

SUBORDER AND FAMILY INCERTAE SEDIS

Paracimexomys Archibald, 1982*Paracimexomys judithae* (Sahni, 1972)

REFERRED MATERIAL: UALP 15636, left M_1 and V 2450, right M_1 (fig. 3).

LOCALITIES: Jacobs Bone Bed and Burnham South, respectively.

DESCRIPTION: Both lower first molars (L, W = 1.80, 1.20; 1.68, 1.21) are slightly waisted labially, posterior to their transverse midlines. The unfluted cusps are low, rounded pyramids in the labial row, higher and subcrescentic in the lingual row. The cusp formula is 4:3 in each. The anterolabial cusp is the lowest and reduced earliest by wear; the two anterolingual cusps are closely approximated and joined at their bases for more than half their height. Discussion of these teeth is deferred to the following section.

Paracimexomys new species

REFERRED MATERIAL: UALP 15637, right M^2 (fig. 3).

LOCALITY: Jacobs Bone Bed.

DESCRIPTION: M^2 (L, W = 1.36, 1.07) has a cusp formula of 3:3:1. Cusps are subcrescentic with shallow fluting. The medial cusp row resembles that of *P. priscus* (described by Archibald, 1982) and the anterior cusp is readily discernible, but is confluent with the concave anterior wall of M^2 . Internal cusps are distinct, unlike those of *P. priscus*. They are equally spaced and of equal height, but increase in size posteriorly. M^2 is slightly waisted between the second and third internal cusp. The single anteroexternal cusp lies on a low ridge that joins the anterior medial cusp and the external arm of the crescentic posterior medial cusp. As in *P. priscus*, internal and medial cusp rows diverge posteriorly.

DISCUSSION: The two lower first molars described above appear to be referable to *Paracimexomys judithae* (Sahni, 1972). *Paracimexomys* was erected by Archibald (1982), who recognized that its species persisted through the Late Cretaceous as contemporaries of species of *Cimexomys*. *Paracimexomys* is characterized by its short M_1^1 with low cusp formulas, waisted molars, and divergence of major cusp rows in M^1 and M^2

(the first trait is probably primitive for both genera). Archibald (1982) designated *P. priscus* as the type species of *Paracimexomys* and perceptively favored placing *P. judithae* in that genus. He noted that the M_1 referred by Sahni (1972) to the latter species differed morphologically and was misidentified. The San Juan lower first molars, however, resemble those of *P. priscus* and are of appropriate smaller size to pertain to *P. judithae*. Archibald (1982, his Table 17) indicates that the average M^1 of *P. priscus* (L = 2.41) is somewhat longer than M_1 (2.23); AMNH 77110, M^1 of *P. judithae* (L = 1.8) is somewhat longer than the average of UALP 15636 and V 2450 (1.74). The latter specimens cannot be separated from *P. judithae* at present. On the other hand, UALP 15637 differs from M^2 of *P. priscus* and is too small to pertain to *P. judithae*, if relative dimensions for *P. priscus* are characteristic for the genus (see measurements in Lillegraven, 1969). Probably this tooth indicates the presence of a new small species of *Paracimexomys* at Jacobs Bone Bed.

SUBORDER PTILODONTOIDEA
(GREGORY AND SIMPSON, 1926)FAMILY NEOPLAGIAULACIDAE
AMEGHINO, 1890*Mesodma* Jepsen, 1940*Mesodma formosa* (Marsh, 1889)

REFERRED MATERIAL: UALP specimens 15641 (left posterior half of P_4), 15642 (left P^4), 15643 (posterior half of right M^1), 15644 (posterior fragment of right M_1) (figs. 3, 5).

LOCALITIES: Specimens 15641 and 15644 from locality 7599; the others from locality 8020; Naashoibito Member of the Kirtland Formation.

DESCRIPTION: The broken P_4 is heavily worn and its length (2.2 mm) represents about two-thirds of the specimen. The height of 1.44 mm is probably a minimal estimate. There are two damaged posterior cuspules and four serrations anterior to these preserved on the specimen. The posterolabial cup is a worn shallow depression. P^4 is damaged but complete (L, W = 2.53, 1.15). The two anteroexternal cusps lie below and opposite the second and third medial cusps. The seven medial

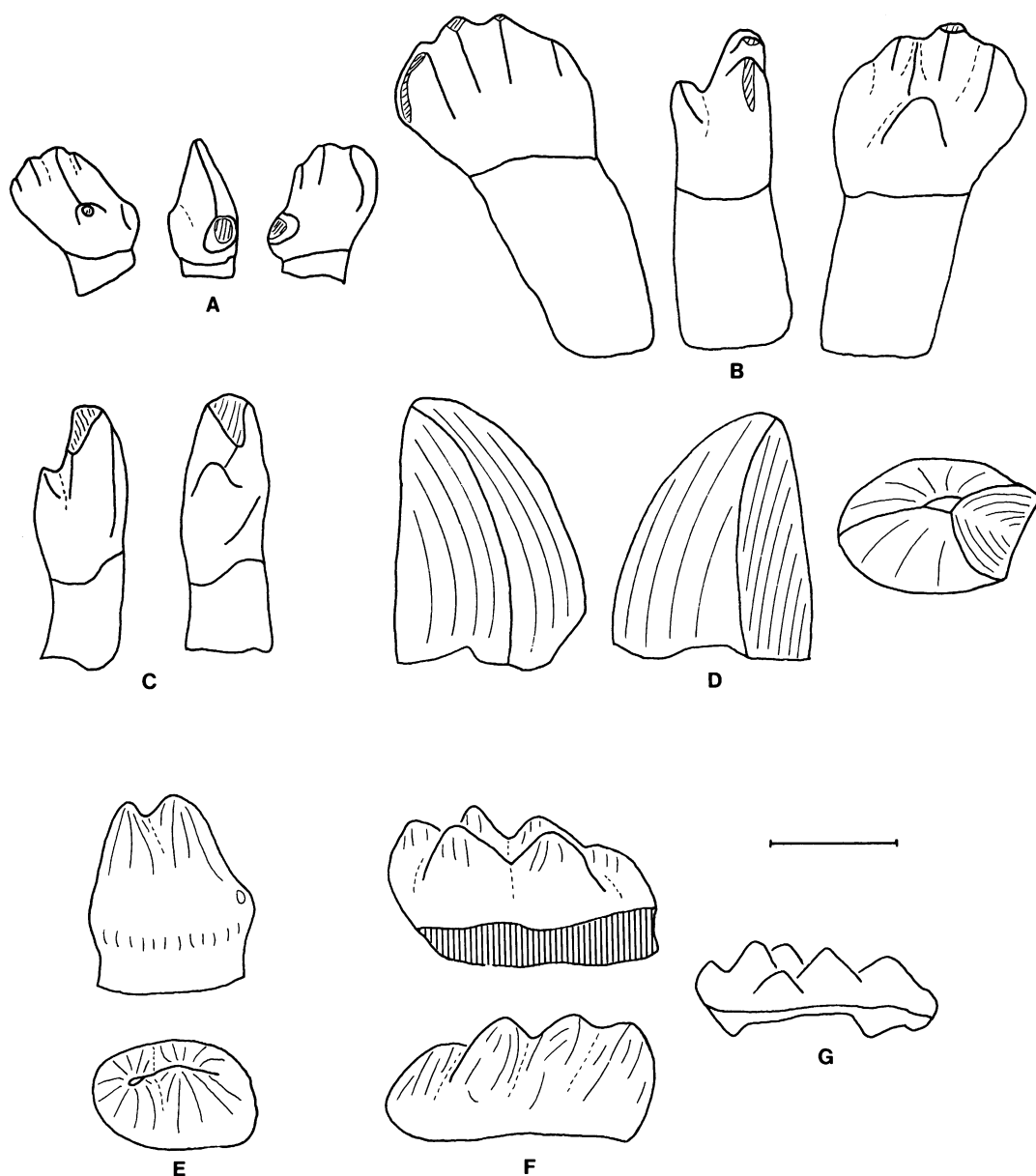


FIG. 4. Line drawings of several multituberculates from Burnham South. **A, B**, V 4608 and 4609, anterior lower premolars of "plagiaulacoid" grade, each in three views. **C**, V 4611, *Mesodma* sp. upper incisor in external and posterior views. **D**, V 4610, ptilodontoid lower incisor fragment in ventral, internal, and apical views. **E**, V 2456, multituberculate morphotype C in internal (?) and apical views. **F**, V 2429, high crowned deciduous premolar in two views, the base of which is corroded on one side. **G**, V 4603, *Mesodma* deciduous (?) premolar in side view for comparison with F. Scale for all specimens equals 1 mm.

cusps are of uniform height and are spaced evenly. Apical crown height increases posteriorly, but apparently in reduced increments from cusps 5 to 7 which are unfortu-

nately damaged. M^1 ($W = 1.62$) has subcrescentic cusps with shallow fluting on the external and medial rows. The complete internal row commences anteriorly opposite

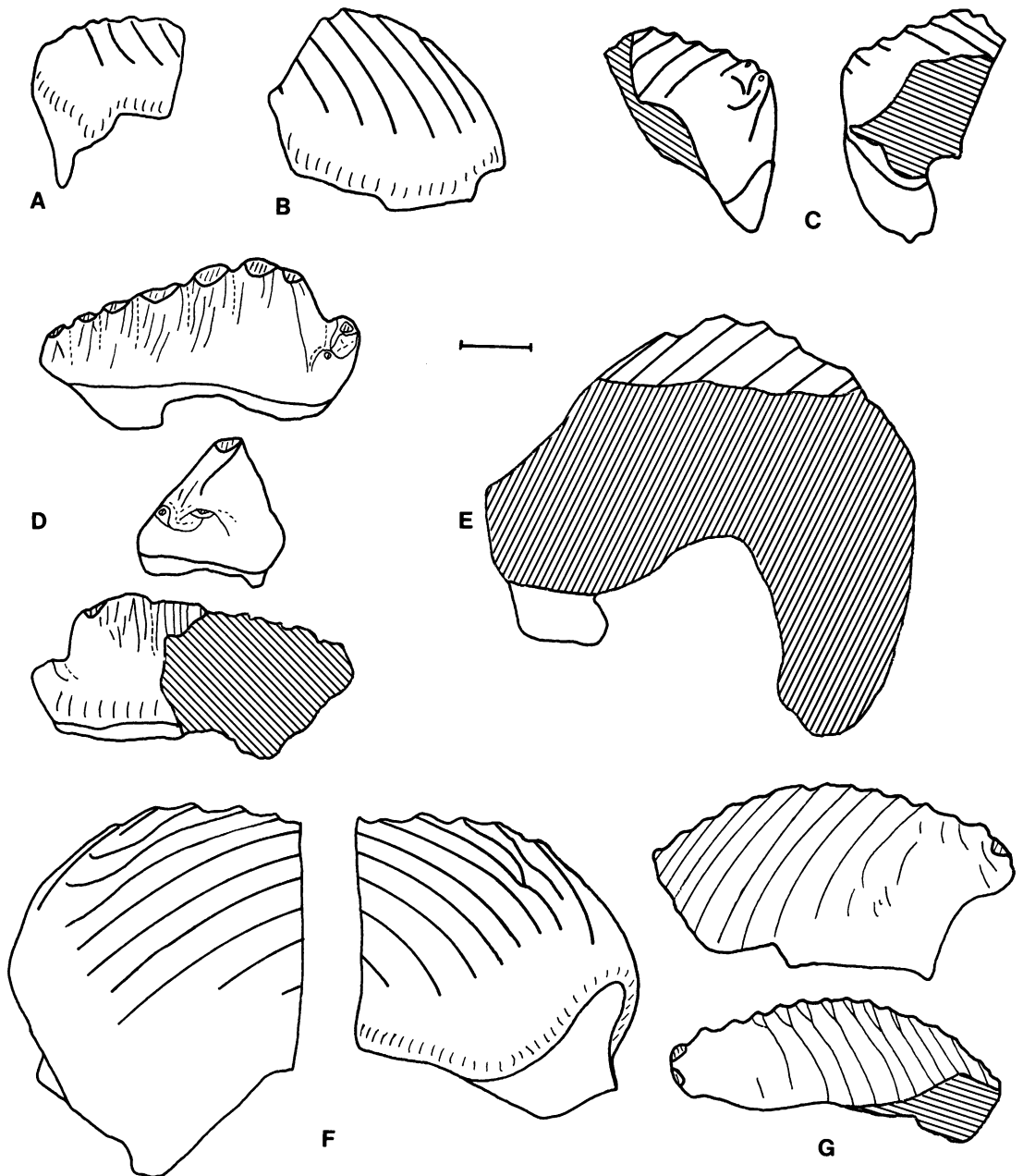


FIG. 5. Line drawings of multituberculate premolars. A, *Mesodma formosa*, UALP 15641. B, C, *Mesodma* cf. *M. senecta*, UALP 15601 and V 4600. D-F, *Cimolodon electus*; V 4607 in three views, UALP 15628, and UALP 15627 in two views. G, Eucosmodontid, UALP 15633 in two views. Scale for all specimens equals 1 mm.

the valley between the fifth and sixth medial cusps (counted from the posterior end of M^1). There are five internal cusps, the antermost preceded by a minute cusp. These cusps

increase in size posteriorly, except the last one, which is low and incorporated into a wall that leads to the last medial cusp.

DISCUSSION: The Alamo Wash *Mesodma*

agrees closely, in side by side comparison, with *M. formosa* from the Lance Formation. P_4 morphology is unlike P_4 of *M. senecta* or *M. primaevus*, which have fewer cusps with shallow fluting. Allocation to *M. formosa* depends on size, and this identification is a statement of probability, pending acquisition of larger samples. Alamo Wash premolar dimensions fall within the small end of the range reported for *M. formosa* by Novacek and Clemens (1977). M^1 dimensions fall at the large extreme of the range for samples of *M. formosa*. An additional Alamo Wash specimen, UALP 15644, is a very worn M^1 fragment ($W = 0.88$), that is small for this species.

Mesodma formosa is also reported from the Puercan Mammilon Hill at Tsosie by Sloan (1981). This provides an interesting documentation of a species surviving across the Cretaceous-Tertiary boundary in the San Juan Basin. A similar situation occurs in Saskatchewan where *Mesodma thompsoni* occurs in both Cretaceous and Paleocene horizons of the Ravenscrag Formation (Johnston and Fox, 1984).

The presence of *Mesodma formosa* is indicated by premolars in the Alamo Wash sample, but dimensions of molars suggest that other species of this genus may have existed with it, as in other latest Cretaceous localities. An additional fragment of a large M^2 (UALP 15645 from loc. 7599) is too large for any known species of *Mesodma*. This tooth may belong to a species of *Cimolodon* or *Cimolomys*.

Mesodma cf. *M. senecta* Fox, 1971b

REFERRED MATERIAL: P_4 fragments UALP 15601 and V 4600; M^1 fragment, V 4601; M^2 , UALP 15602 and V 2453, 4602; M^1 , UALP 15603 and 15604; M^2 , UALP 15605–15608 and V 2448, 2454, 3162; anterior upper premolars UALP 15609–15615 and V 2422, 2424, 2426, 2432, 4603. Dimensions are listed in table 1; see figures 3–6.

LOCALITIES: UALP specimens from Jacobs Bone Bed, others from Burnham South.

DESCRIPTION: P_4 is represented by UALP 15601, an anterolingual fragment with eight internal ridges, and by V 4600, a posterior portion. The anteromost ridge on UALP 15601 coincides with the anterior margin of

P_4 and is poorly defined. The second, third, and fourth ridges are well developed and increase progressively in length. The posterior P_4 fragment preserves six serrations, the last being a cuspule situated close to the penultimate cusp. Internal ridges are absent from the last three serrations; an external ridge is present on the third-last.

The M^1 fragment includes four pyramidal, subcrescentic medial cusps and three external cusps, all of which are fluted. The internal row includes three small, closely spaced cusps, followed by a large cusp and then a smaller, poorly differentiated cusp in the wall joining the internal and medial rows. The three M^2 agree in cusp formula (1:3:4). The single crescentic external cusp lies on a cingulum that bears variable cuspules. The cingulum extends to the posterior wall of the second medial cusp or the anterolabial arm of the third medial cusp. Medial cusps are crescentic and fluted and the first forms part of the anterior wall of M^2 . The four internal cusps are uniform in size; one of three M^2 has a small cuspule poorly developed on the anterior margin of the first.

Both M^1 have four internal cusps, but the larger UALP 15603 has seven external cusps, one more than UALP 15604. In the external row, cusps are conical anteriorly, becoming subcrescentic posteriorly. The posterior external cusp is weakly divided (15604) or completely divided (15603). The higher, longitudinally elongated internal cusps increase in size posteriorly, and are fluted on their external sides. The first two are closer together than the others. M^2 cusp formula is difficult to determine due to wear, but appears to be 4 or 5:2. Specimens that could be interpreted to have five external cusps show variable separation of the fourth and fifth. Both rows are fluted on their medial sides. External cusps increase in height posteriorly; major internal cusps decrease in height posteriorly.

Anterior upper premolars are assigned to this species on the basis of size. They present an array of morphologies. Three (table 1) have three cusps as in P^2 of *Mesodma* sp. (Clemens, 1963), except that the base of V 2432 is expanded anterointernally. Two have four cusps, as in P^3 of *Mesodma* sp. (Clemens, 1963). Five presumably deciduous teeth (cf. DP^2 of *M. formosa* in Lillegraven, 1969) show

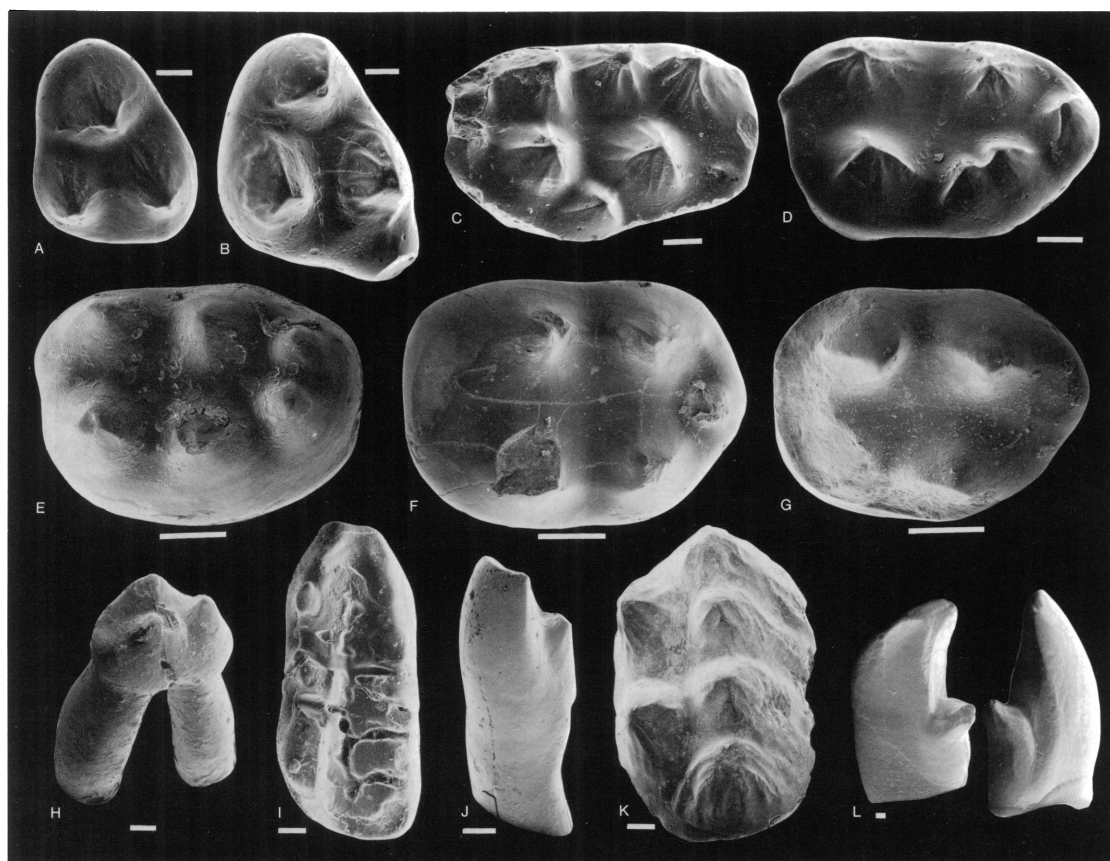


FIG. 6. Scanning electron photomicrographs of *Mesodma* cf. *M. senecta* (A-D), *Mesodma* n. sp. or *Cimexomys* cf. *C. antiquus* (E-I), *Mesodma* sp. (J, K), and cf. *Cimolodon* sp. (L, two views). A, B, Upper premolars of the anteromost and following loci, V 2424 and 2432; C and D, deciduous (?) upper premolars V 4603 and 2422; E-G, upper premolars V 4606, 2442, 4605 of the same (?) locus, showing variant forms; H, anteromost premolar V 3164; I, M₁ V 4604; J, upper incisor V 4611; K, deciduous upper premolar V 2429; L, upper incisor UALP 15632. Bar scales all equal 0.2 mm.

five cusps, five plus a cuspsule, or six cusps. The basic pattern is four cusps arranged in a rectangle plus an anterior median cusp. The median cusp may be twinned. Other cuspsules vary in occurrence. Two additional teeth (?DP³) are multicusped with high diversity in cusp arrangement.

DISCUSSION: Without complete fourth premolars, assignment of this sample to *Mesodma senecta*, a taxon from the Milk River Formation, Alberta, is tentative. UALP 15601 has long anterior lingual ridges as in *M. senecta* and size appears comparable. *M. primaevus* differs from both samples (and from later *Mesodma*) in lacking long lingual ridges

on the first three serrations. The lower internal border of UALP 15601 is not as straight as that of UA 5378, holotype of *M. senecta*. Fox (1971b) referred only premolars to *M. senecta*. Molars of the Hunter Wash sample are of appropriate size to belong to *M. senecta* and are smaller than those of *M. primaevus*. Presence of six or seven external cusps on M₁ and four or five external cusps on M₂ is unusually great for latest Cretaceous *Mesodma*. In summary, the Hunter Wash *Mesodma* resembles *M. senecta*, but is unlike *M. primaevus*. Closer evaluation of affinities with the known species of *Mesodma* must await larger collections.

TABLE 1
Tooth Dimensions for *Mesodma* cf. *M. senecta*

Element		L	W
P ₄	UALP 15601	3.18+	
P ₄	V 4600	2.6++	
M ¹	V 4601	1.9++	1.66
M ²	UALP 15602	1.89	1.67
M ²	V 2453	1.91	1.85
M ²	V 4602	1.66++	1.64+
M ₁	UALP 15603	2.73	1.26
M ₁	UALP 15604	2.40	1.24
M ₂	UALP 15605	1.68	1.45
M ₂	UALP 15606	1.73+	1.30+
M ₂	UALP 15607	1.73	1.55
M ₂	UALP 15608	1.73+	1.35+
M ₂	V 2448	1.84	1.42
M ₂	V 2454	1.68	1.57
M ₂	V 3162	1.63	1.54
P ^x (3 cusps)			
	UALP 15609	1.16	1.34
	V 2424	0.99	1.26
	V 2432	1.29	1.46
P ^x (4 cusps)			
	UALP 15610	1.26	1.25
	V 2426	1.55	1.27
P ^x (5 cusps)			
	UALP 15611	1.54	1.04
	UALP 15612	1.56	1.01
	UALP 15613	1.48	0.94
P ^x (6 cusps)			
	UALP 15614	1.56	0.99
P ^x (multicusped)			
	UALP 15615	1.60	1.04
	V 4603	1.84+	1.19

Mesodma new species or *Cimexomys*
cf. *C. antiquus* Fox, 1971b

REFERRED MATERIAL: M², UALP 15616 and V 2445; M₁, UALP 15617 and 15618 and V 4604; M₂, UALP 15619–15621; anterior upper premolars, UALP 15622–15624 and V 2442, 4605, 4606, 3164; table 2, figures 3, 4, 6.

LOCALITIES: UALP specimens from Jacobs Bone Bed, others from Burnham South.

DESCRIPTION: M² cusp formula, 1:3:3, is certain for only one tooth. The anterior medial cusp lies on the anterior wall of M². The anterior internal cusp is elongated longitudinally.

TABLE 2
Tooth Dimensions for ?*Mesodma* n. sp. or *Cimexomys* cf. *C. antiquus*

Element		L	W
M ²	UALP 15616	1.34	1.29
M ²	V 2445	1.58	1.41
M ₁	UALP 15617	2.18	1.14
M ₁	UALP 15618	2.16	1.15
M ₁	V 4604	2.21	1.04
M ₂	UALP 15619	1.20	0.93
M ₂	UALP 15620	1.10	1.05
M ₂	UALP 15621	1.27	0.94
P ^x (3 cusps)			
	UALP 15624	0.81	1.08
	V 3164	0.83	1.16
P ^x (4 cusps)			
	V 4605	0.86	0.69
P ^x (5 cusps)			
	UALP 15622	1.25	0.88
	UALP 15623	1.15	0.86
	V 2442	1.03	0.75
P ^x (6 cusps)			
	V 4606	1.00	0.76

dinally. M₁ has six or seven external and four internal cusps. UALP 15617 has a small seventh cusp apparently added anteriorly. The three M₂ agree in cusp formula, 4:2. The posterior two external cusps are incompletely divided. Cusps are crescentic and the broad medial valley contains crenulations.

Premolars assigned to this taxon are smaller than those assigned to *Mesodma* cf. *M. senecta*, in agreement with relative molar sizes. Variations in morphology are comparable to those seen in the cf. *M. senecta* sample. V 3164, a small three-cusped premolar, may correspond to P¹ and has two longitudinally placed roots. The three-cusped UALP 15624, ?P², has two roots placed transversely, the larger being internal, and an anterointernal basal expansion. V 4605 has four cusps, as in P³ of other species of *Mesodma*. The remaining premolars have five or six cusps, as in the deciduous teeth of cf. *M. senecta*.

DISCUSSION: This material indicates presence of an additional small multituberculate in the upper levels of the Fruitland Formation, but is insufficient to differentiate between *Mesodma* and *Cimexomys*. Size and

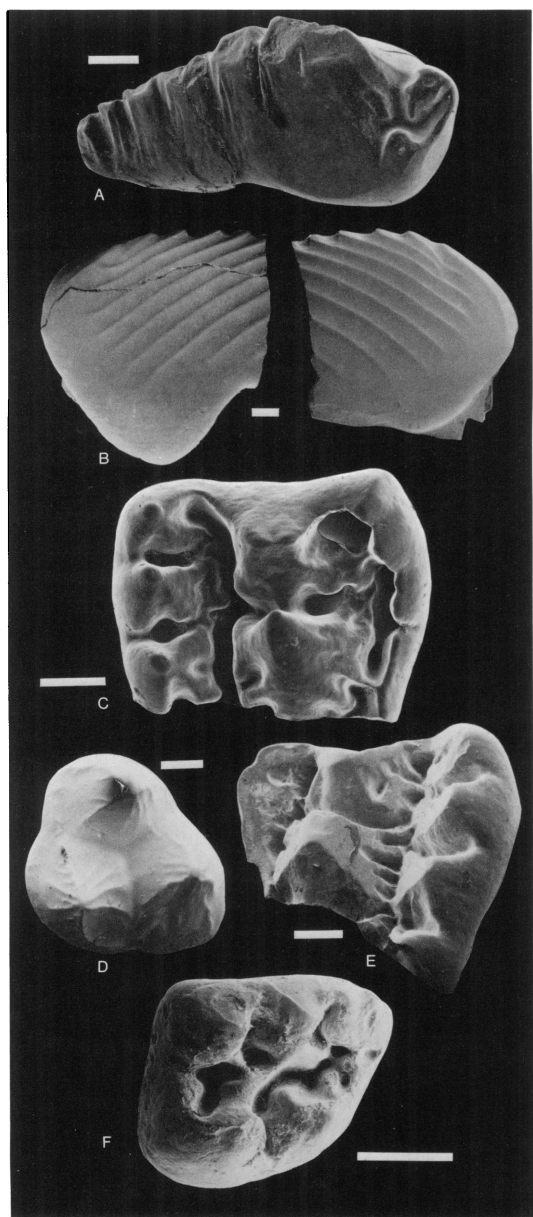


FIG. 7. Scanning electron photomicrographs of *Cimolodon electus* (A, B), *Meniscoessus intermedius* (C-E), and cf. *Essonodon* n. sp. (F). A, P₄ V 4607; B, P₄ UALP 15627 in two views; C, E, V 2457 and 2451, two M₂ (oblique view of V 2451); D, anterior upper premolar V 3161; F, M₂ V 2455. All bar scales equal 0.5 mm.

morphology of the specimens are consistent with those of *C. antiquus* (Fox, 1971b).

cf. *Mesodma* sp.

One small upper incisor, V 4611 from Burnham South, may pertain to a species of *Mesodma*. The major cusp bears a strong posterior internal ridge, giving the oblique wear facet a triangular shape (figs. 4, 6). The low, smaller posterior cusp is slightly worn. Cross-sectional dimensions of greatest length and width are 0.7 and 0.6 mm. The smooth enamel is continuous around the crown and beyond the posterior cusp.

FAMILY CIMOLODONTIDAE MARSH, 1889

Cimolodon Marsh, 1889

Cimolodon electus Fox, 1971b

REFERRED MATERIAL: UALP 15627 and 15628, left anterior portion and damaged right P₄; V 4607, left P₄; UALP 15625 and 15626, damaged deciduous premolars (figs. 5, 7).

LOCALITIES: Specimens 15625-15627 from Jacobs Bone Bed, 15628 from Lindsay Microsite, and 4607 from Burnham South.

DESCRIPTION: UALP 15628, a corroded, broken P₄ is 6.1 mm long and about 3 mm high and serrations cannot be counted. It is strongly arched as in other *Cimolodon*. UALP 15627 (W = 2.95, H = 3.4) is the fresh anterior two-thirds of a left P₄ and preserves six serrations, followed by at least five external ridges. The external ridge of the second serration descends below the level of the first serration, perhaps farther than in UA 5310, holotype of *C. electus*. The following external ridges increase progressively in length to a maximum at the ridge of the ninth serration. The ventral ends of the ridges of the third and fourth serrations bend anteriorly. Internally, the ridge of the second serration is deflected posteriorly and continues to well below the first serration. At the level of this indentation, the following ridge bends posteriorly and terminates at the succeeding ridge. The latter ridge from the fourth serration is in turn indented where the preceding ridge intersects it.

P₄ (L, W, H = 4.4, 1.79, 2.2) is damaged and lacks its anteroexternal corner. It bears seven medial cusps, which increase uniformly in height posteriorly except that the sixth and seventh closely situated cusps are of about the same level. All medial cusps are worn,

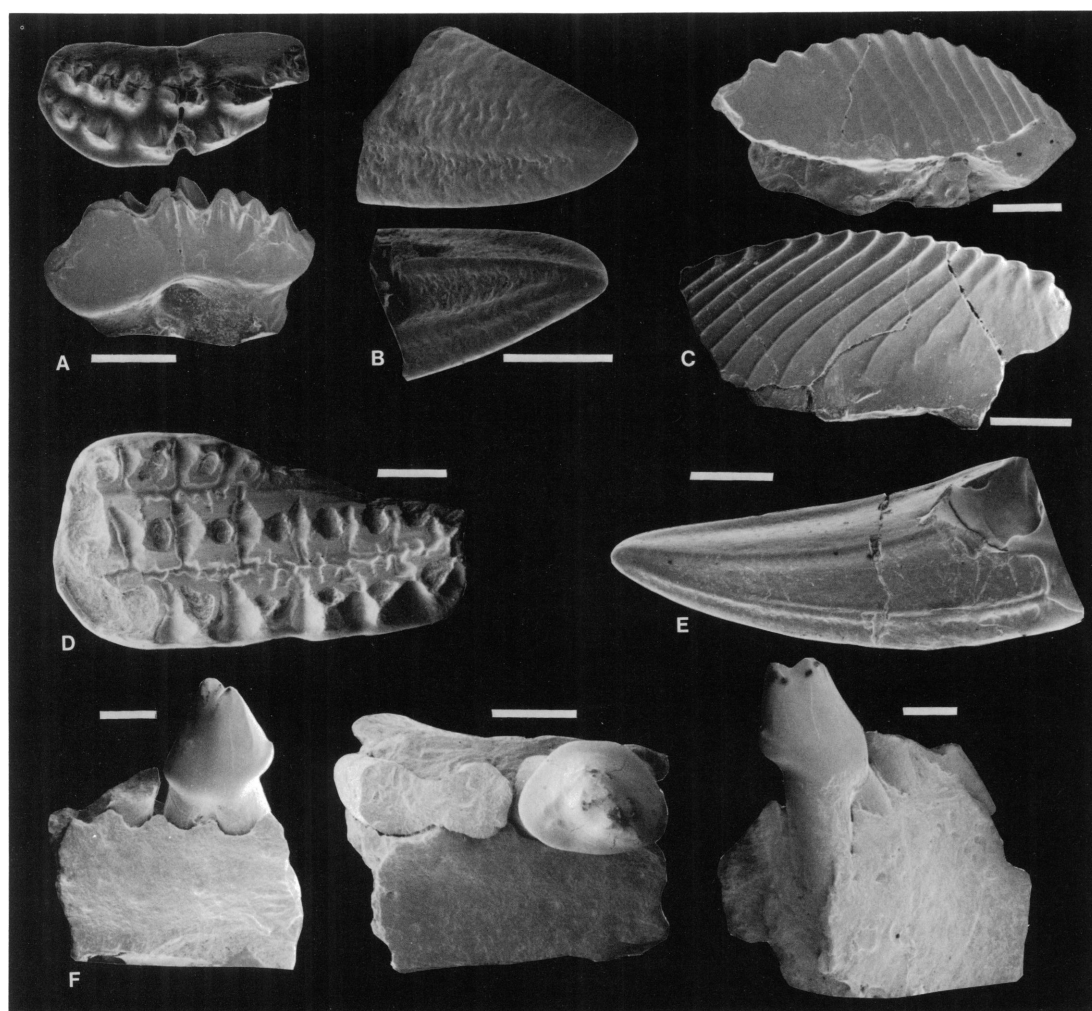


FIG. 8. Scanning electron photomicrographs of various multituberculates. A, *Cimolodon* n. sp. P⁴, two views of UALP 15629; B, cf. *Meniscoessus* sp., tip of lower incisor UALP 15640; C, eucosmodontid P₄ UALP 15633 at two magnifications; D, *Meniscoessus intermedius* M¹ UALP 15639; E, internal view of eucosmodontid lower incisor V 2433, showing rolled enamel borders at top and near bottom of image; F, three views of UALP 15634, multituberculate morphotype C. All scales equal 1 mm.

yielding an approximate height measured with respect to the posterointernal base of the crown and the highest cusp. All medial cusps bear strong striations and the ultimate cusp is situated near the end of P⁴, yielding a steep posterior wall. There are two basal posterior cusps linked by a posterior ridge, one behind the seventh medial cusp and a smaller, lower cusp at the posterointernal corner of P⁴.

Two anterior upper premolars are attributed to this taxon. Both have four major cusps arranged in a rectangle. UALP 15626 has at

least one extra smaller cusp at its presumably posterior end as in DP² of *C. nitidus* (Szalay, 1965). UALP 15625 bears a small cusp in the middle of one side and may also be deciduous. Further discussion is deferred to the next section.

Cimolodon new species, near *C. nitidus*

REFERRED MATERIAL: UALP 15629 and 15630, two damaged right P⁴; 15631, anterior left P⁴ fragment (fig. 8).

LOCALITY: Jacobs Bone Bed.

DESCRIPTION: Of the three upper fourth premolars, only UALP 15629 (L, W, H = 3.07, 1.81, 1.2) includes the posterior extremity. There are five major medial cusps, the first three closely approximated, and each bears vertical striations. Cusps are short, but increase in size posteriorly. The fourth and fifth cusp are of about equal height (1.2 mm). There are four major cusps in the external row, the third being the largest. In addition, a minute, anteroexternal cuspule occurs in all three P⁴. The external row is nearly as long as the medial row and both are gently convex labially. The posterior wall of the fifth medial cusp is steep (not quite as steep as in V 4607) and this cusp is near the posterior end of the tooth. There is a minute, basal, posterointernal cuspule and perhaps another on the damaged ridge descending from the fifth medial cusp.

DISCUSSION: There are two species of *Cimolodon* in the Hunter Wash and Burnham South assemblages. Specimens attributed here to *Cimolodon electus* Fox, 1971b, differ from the original hypodigm in minor details that are not considered systematically significant, given the small samples. The anteromost internal ridges of P₄ differ somewhat from those of Fox's (1971b) material. Crown height of P⁴ and length of the crown posterior to its ultimate medial cusp are somewhat greater in UA 5323 than in V 4607. Sizes of the San Juan Basin and Alberta specimens are closely comparable. All specimens of *C. electus* are larger than most specimens of *C. nitidus*. UALP 15627 is proportionately wider than P₄ of *C. nitidus*.

Cimolodon n. sp. is represented only by upper premolars, and may belong to the same species as P₄ AMNH 77267, *Cimolodon* sp. from Judith River (see Sahni, 1972). Sizes of P⁴ of *Cimolodon* n. sp. lie well below the lower end of the size range for *C. nitidus*. In addition, P⁴ crown height of *Cimolodon* n. sp. is disproportionately lower and medial cusps are positioned farther apart, with intervening valleys between cusps 4, 5, and 6. In other traits *Cimolodon* n. sp. resembles *C. nitidus* closely, notably: (1) medial and external cusp rows are curved, (2) the external row is nearly as long as the medial, (3) the posterior wall of the ultimate medial cusp is

steep, and (4) position of posterobasal cusps and ridges leading to the ultimate medial cusp is similar. Differences noted above could be considered primitive with respect to *C. nitidus* except that *Cimolodon* n. sp. is advanced over *C. nitidus* in its diminutive posterobasal cusps. Among known species of the genus, *Cimolodon* n. sp. can be considered the sister to *C. nitidus*.

Whereas *Cimolodon nitidus* and *Cimolodon* n. sp. are clearly closely related, *C. electus* stands apart, particularly with respect to P⁴. The external row of P⁴ is short and the medial row is straight, characters reminiscent of species referred to *Cimolomys*. However, the high number of medial cusps in P⁴ of *C. electus* (seven), the steep posterior wall of its ultimate cusp, and the shortness of the crown posterior to that cusp all point toward affinity with *C. nitidus*. For the moment, *C. electus* can be retained in *Cimolodon*, but there is need for reassessment of the limits of this genus and of the interrelationships of *Cimolomys*, *Cimolodon*, and *Paracimexomys*.

cf. *Cimolodon* sp.

One upper incisor, UALP 15632 from Lindsay Microsite, may be attributable to a species of *Cimolodon*. Its cross section (L, W = 2.6, 1.6) is triangular as is the oblique wear facet on the major cusp. A posterointernal ridge leads to the smaller posterior cusp, which shows slight wear. At the posteroexternal corner of the triangle the enamel is folded into two longitudinal ridges. The enamel is rugose and continuous around the incisor, but is retracted anterointernally to the level of the posterior cusp (see fig. 6).

UALP 15632 is considerably larger than AMNH 77265, an upper incisor attributed by Sahni (1972) to *Meniscoessus major*. Neither incisor has multiple cusps as in that of *M. robustus* (Clemens, 1963; Archibald, 1982), which averages 5 to 6 mm in antero-posterior cross section. The simpler morphology and much smaller size of UALP 15632 and AMNH 77265 argue against referral of either to *Meniscoessus*, although the upper incisors of early species of this genus are unknown. Based on relative sizes and species abundances in their respective faunas, I tentatively suggest that UALP 15632

may pertain to *Cimolodon*, while AMNH 77265 could be assigned to *Cimolomys clarki*.

SUBORDER TAENIOLABIDOIDEA
(GRANGER AND SIMPSON, 1929)

FAMILY CIMOLOMYIDAE (MARSH, 1889)

Meniscoessus Cope, 1882

Meniscoessus intermedius Fox, 1976

REFERRED SPECIMENS: UALP 15639 left M¹; UALP 15638, V 2451 and V 2457, two left and one right M², respectively; V 2447 left M₁ fragment; V 3161 right ?P² (figs. 7, 8).

LOCALITIES: UALP 15639 from locality 76168, UALP 15638 from locality 7592, others from Burnham South.

DESCRIPTION: M¹ (L, W = 5.85, 2.97) has a moderately long internal row that is well developed for half the length of M¹ and continues anteriorly as a worn cingulum for another quarter the length of the tooth. There are six pyramidal external cusps, the first being smallest, the last being fused by wear to a crest joining the last medial cusp. This fused area is large, but I interpret it to represent a single cusp, because its anterior border does not pass the midline of the penultimate medial cusp. Of the eight medial cusps, the first two are nearly fused by wear. They increase in size to the fourth cusp and the fourth through eighth are subcrescentic. The internal row apparently bears only four major pyramidal cusps; the first is clearly the smallest, the third the largest. Cusp walls are deeply fluted.

M² is generally triangular in outline, its anteroexternal angle being more acute than its anterointernal corner. The external cusp row is short and narrow; the medial and internal rows are directed posteroexternally with respect to the midline of the tooth. The single unworn M² shows two small external cusps followed by a cingulum bearing cuspules and joining the anteroexternal arm of the third medial cusp. There are three medial subcrescentic cusps. The anterior wall of M² inflects posteriorly and forms the anterior face of the first medial cusp. There are five pyramidal internal cusps, the last being the smallest. UALP 15638 (L, W = 3.26, 2.9 approximately) has more deeply fluted cusps than V 2451 (3.2+, 3.1) or V 2457 (2.2++,

2.56). All are considered referable to *Meniscoessus*, although fluting also occurs in *Cimolomys* and *Cimolodon*.

M₁ is represented by a posterior fragment, whose posteroexternal corner includes two closely appressed cusps that lie behind the anterior border of the last internal cusp. The three-cusped anterior upper premolar (2.53, 2.43) slopes less steeply posteriorly than anteriorly and is considered P² because the anterointernal cusp lies about opposite the laterally compressed external cusp unlike P¹ in other *Meniscoessus* (see Archibald, 1982, his fig. 26).

DISCUSSION: *Meniscoessus* is considered a taeniolabidoid, following Fosse et al. (1985). These authors note that the genus has large enamel prisms as do other taeniolabidoids, which they consider to be a derived condition. Based on size, the San Juan Basin sample of *Meniscoessus* agrees closely with the holotype (M₁₋₂) of *M. intermedius* (see Fox, 1976). UALP 15639 is near the size of PMAA P72.14.1 (L, W = 5.7, 3.2), an M¹ referred to *M. intermedius* by Fox (1976). Both are similar in length and shape of the internal row of cusps. The two teeth differ in cusp count (6:8:4 for UALP 15639; 8:9:5 for PMAA P72.14.1; Fox, 1976, p. 1217) but perhaps not significantly so, as authors may interpret cusp formulas differently. Examining Fox's (1976) figure 3, I count only seven external cusps and note that where PMAA P72.14.1 has a small anterior cusp on the internal row, UALP 15639 has a narrow cingulum obliterated by wear. Both M¹ are smaller than those of *M. major* (average length and width are about 80% of average length and width derived from Fox's, 1980 data for *M. major*). As Fox (1976) noted, most *M. major* M¹ have more cusps than most *M. intermedius* M¹, apparently even more than suggested by PMAA P72.14.1.

The San Juan Basin sample of *Meniscoessus* is important because it includes three upper second molars, an element unknown in the hypodigm of *M. intermedius*. All three have a fully developed, pyramidal first medial cusp at the anterior wall of M², whereas this cusp is compressed or even platelike in most species of *Cimolodon* or *Cimolomys*. Average M² length and width are 70 to 75 percent of those of *M. major* (measurements

of Fox, 1980). The external row is narrower, with smaller and fewer cusps than in *M. major*. At the same time, the internal and medial rows are oblique with respect to the long axis of M^2 , and are directed posteroexternally; they are longitudinal in *M. major*. *M. conquistus*, represented by AMNH 3011 (M_2 ; L, W = 6.5, 5.9 approximately), is large and differs from both *M. intermedius* and *M. major* in having a longer external row, more crescentic cusps, and a plate anterior to three medial cusps. *M. conquistus*, *M. robustus*, and *M. borealis* are all similarly derived in having crescentic cusps and in other aspects of their morphology, except that they appear to show progressive increase in size (see Archibald, 1982). Whether they can be considered separate species or whether *M. conquistus* and *M. borealis* represent clinal variants of *M. robustus* may be answerable in the future, but for the following discussion, the three morphotypes are considered to represent one *M. robustus* species group.

Fox (1976) considers *M. intermedius* to be a good candidate for ancestry to the larger *M. major*, and that *M. intermedius* could be derivable from the older (Aquilan) *M. ferox*, in part by increase in the number of cusps on M^1 . However, Fox (1980, his table 2) feels that *M. major* could not be ancestral to *M. robustus* unless there were a secondary decrease in number of cusps on M^1 and reversal in other traits. Rather, he suggests that *M. robustus* probably evolved from something like *M. ferox* via an unknown path. If *M. intermedius* and *M. major* share a similar cusp formula, that would remove both species from the ancestry of *M. robustus*.

The San Juan Basin material sheds new light on this interpretation. If both PMAA 72.14.1 and UALP 15639 are referable to *M. intermedius*, then M^1 is seen to have a broader range of observed cusp formula than previously expected, 6-7 or 8:8-9:4-5; M^2 yields 2:3:5, although the external cusp count is arbitrary. Hence cusp formulas for M^1 and M^2 of *M. intermedius* average below those of *M. major*, more in line with those of *M. robustus*. As Fox (1980) demonstrated, *M. major* does not seem to present a good ancestor for *M. robustus* (by virtue of its autapomorphously high cusp formula), but known morphology does not bar *M. intermedius* from

the ancestry of either species. *M. major* and the derived *M. robustus* could have evolved in splitting fashion from a morphotype like that seen in the *M. intermedius* sample.

Figure 9 summarizes the apparent relationships and stratigraphic occurrences of known species of *Meniscoessus*. Characters uniting *M. ferox* with the other species are few, owing to its poor representation. Like *M. ferox* (see traits on fig. 9), some *Cimolodon* P^4 have four medial cusps and both this genus and *Cimolomys* include large species with fluted cusps. The systematic position of *M. ferox* and the interrelationships of all three genera remain to be clarified.

M. intermedius is primitive with respect to *M. major* in lower average cusp formula, and to the *M. robustus* species group in lacking crescentic cusps. *M. intermedius* is smaller than either as well. The cladogram shows these relationships and does not rule out the possibility that *M. intermedius*, so far as known, could represent the direct common ancestor to all later *Meniscoessus*.

cf. *Meniscoessus* sp.

REFERRED MATERIAL: UALP 15640, right lower incisor fragment from locality 7599, Naashoibito Member, Kirtland Formation (fig. 8).

DESCRIPTION: The presence of a cimolomyid, perhaps close to *Meniscoessus robustus*, is indicated in the Alamo Wash Local Fauna by the tip of a lower incisor. The labial surface of the fragment bears one low, rounded longitudinal ridge bordered by a shallow groove on either side. The lingual side has two sharper, higher ridges. Rugose enamel covers the entire fragment. These traits are shared by *M. robustus*, but the 2.4 mm length of incisor does not include the dorsal beading of *M. robustus* described by Clemens (1963).

cf. *Essonodon* new species

REFERRED MATERIAL: V 2455, right M_2 from Burnham South.

DESCRIPTION: The presence of a new species allied to *Essonodon browni* is indicated in the Fruitland Formation by a single M_2 (L, W = 1.32, 1.09). The cusp formula (3:2) and crescentic cusp shape (fig. 7) agree with *Essonodon browni*. Cusp apices are directed poste-

FORMATION

Lance, Hell Creek, St. Mary River

Judith River, Oldman

Lowermost Oldman, Fruitland,
Mesaverde

Milk River

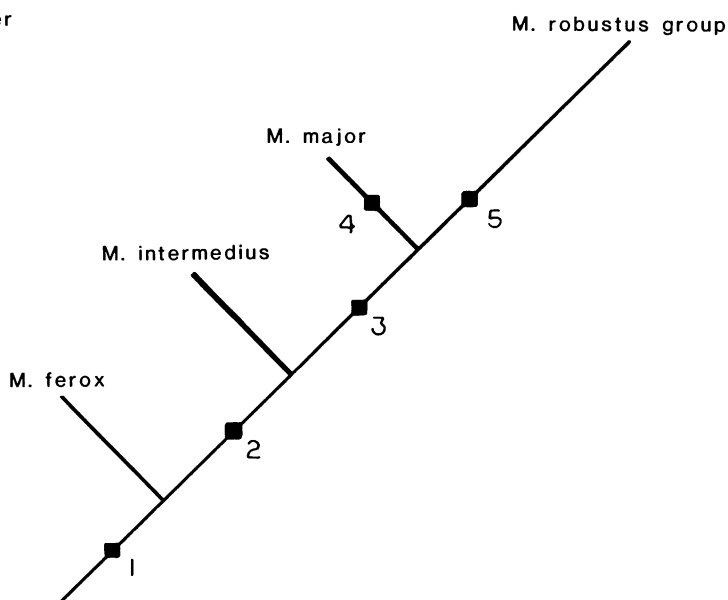


FIG. 9. Diagram showing stratigraphic distribution of species of *Meniscoessus* and derived character states indicating phylogenetic relationship. There is no vertical scale, but note the strong correlation with decreasing age of the sequence of formations from bottom to top. Characters are based in part on Clemens (1963) and Fox (1980). (1) Premolars reduced relative to molars; P^4 with four or five medial cusps bearing strong fluting; large size. (2) Subcrescentic molar cusps; M^1 cusp formula, 6–7 or 8:8–9:4–5; M^2 cusp formula, 2:3:ca. 5. (3) Larger size; M^1 much longer than P^4 ; P^4 width about half of length; M^2 cusp rows parallel. (4) Cusp formulas increase to 9:8–9:6 for M^1 and 3:3:4 for M^2 . (5) Cusps fully crescentic; greater size; P^4 further reduced relative to M^1 and its width is greater than one-half its length.

riorly and toward the midline of M_2 . There is also a sinuous ridge in the medial valley, intersecting external and internal cusps, similar to that of *E. browni*. Aside from being much smaller, the San Juan Basin species may be generically distinct from *E. browni* on the basis of its length/width ratio, 1.21. This ratio averages well below 1.0 in *E. browni* (Archibald, 1982).

CF. FAMILY EUCOSMODONTIDAE
(JEPSEN, 1940)

New Genus and Species

REFERRED MATERIAL: V 2433, lower right incisor from Burnham South; UALP 15633, a fragment of a left P_4 from locality 7592 (fig. 8).

DESCRIPTION: The presence of a eucosmodontid in the Fruitland Formation is suggested by a 7 mm length of a lower incisor

with restricted enamel. The greatest cross-sectional dimensions are 2.5×1.9 mm; the incisor is triangular in cross section, with acute dorsal and ventral angles, and an obtuse internal angle. The rugose enamel covers the rounded external side of the incisor and wraps around the acute dorsal and ventral angles. The enamel extends further around the ventral angle than the dorsal angle, but is otherwise absent from the internal side. Toward the tip, the tooth curves both dorsally and internally.

The premolar pertains to a large, apparently new genus of multituberculate. Originally over 5 mm long, it possesses at least 15 serrations including at least three posterior cuspules (the last is broken). Lateral ridges are closely spaced and curve gently. The ridge of the fourth last serration is short and discontinuous (see fig. 8). Instead of a ridge, discontinuous sinuous lines occur below the third

last serration. The crown does not appear to be as high as in known *Cimolodon*, and there are too many serrations for any known cimolomyid. This premolar is consistent in size with the eucosmodontid incisor described above, but it is unique among described eucosmodontids in close spacing and morphology of ridges. Some *Eucosmodon*, although larger, have as many ridges as UALP 15633; however, this unworn specimen does not show the characteristic heavy posterior wear of *Eucosmodon*.

MULTITUBERCULATA INDETERMINATE

MORPHOTYPE A: V 2429, Burnham South, resembles strongly in cuspiration AMNH 77255 from Judith River, which Sahni (1972) described as a posterior deciduous premolar. However, V 2429 (L, W = 1.82, 1.42) is much smaller and is not waisted as is AMNH 77255. Both teeth have two conical cusps in one row and four more in the other (fig. 6). V 2429 is higher crowned (about 1 mm from base to cusp tip; see fig. 4) than other small anterior premolars from the San Juan Basin. This tooth could be a DP⁴ from an animal the size of *Mesodma*.

MORPHOTYPE B: V 4610 is a ptilodontoid lower right incisor fragment from Burnham South. The incisor is blunt-tipped and rounded externally. Internally the incisor is scoop-like in its dorsal half and bears a single strong ridge (fig. 4). Rugose enamel covers the entire 2.1 mm fragment.

MORPHOTYPE C: Three anterior upper premolars from high in the Fruitland Formation are grouped here despite their considerable range in size, because they have a novel, common morphology (fig. 8). They are high peaked, bicuspid teeth that are expanded anteriorly at the base so that the back of the fundamentally conical tooth is steeper than the front. UALP 15634 (L, W = 1.77, 1.78) is preserved in a maxilla fragment from Lindsay Microsite. It bears two roots and is preceded by the two roots of an anteroposteriorly elongated premolar. Because the foremost root is directed anteriorly, I interpret its position as P¹ and consider the preserved premolar to be P². The shallowly striated cusps are aligned anteroexternally-posterointernally. The base of the enamel reaches farther

dorsally on its external side than its internal side. There is a minute, posterior basal cuspule.

UALP 15635 from Jacobs Bone Bed is smaller (1.41, 1.13) and relatively narrower. It resembles UALP 15634 in other characters, but lacks a posterior cuspule. V 2456 from Burnham South (fig. 4) is smaller still (1.18, 1.00) and lacks a cuspule.

METATHERIA

FAMILY DIDELPHIDAE

Alphadon Simpson, 1927

Alphadon marshi Simpson, 1927

REFERRED MATERIAL: UALP 13633 and 13634, right M³ and left M² (fig. 10).

LOCALITIES: UALP 8020 and 7599, respectively, Naashoibito Member, Kirtland Formation.

DESCRIPTION: M² (L, W = 2.26, 2.52) and M³ (2.21, 2.83) have strong conules, metacones about equal in size to paracones, and prominent stylar cusps A, B, C, and D. A is well developed on a cingulum bearing an anterolabial flange in M² (M³ is damaged here). B is the largest style. C is central and opposite an ectoflexus that is prominent at least in M². D is larger than C. These traits compare well with *A. marshi* from the Lance Formation (Clemens, 1966). That cusp D is larger than C distinguishes these specimens from those assigned to *A. russelli*, the only other known species of *Alphadon* of comparable size (see Fox, 1979). Also, *A. russelli* has molars that are narrower anteroposteriorly. UALP 13634 is distinctive in its expanded stylar cusp A region and in having a low, minute cuspule labial to and between cusps B and C. As represented at present, the Alamo Wash species is indistinguishable from *A. marshi*.

Alphadon cf. *A. wilsoni* Lillegraven, 1969

REFERRED MATERIAL: UALP 15712, right M¹ or M² labial fragment; UALP 15650, left M² or M³; V 2443, left ?M³; UALP 15711, right M⁴; V 2428, left M⁴; UALP 15649, left M₂; UALP 15647, right M₃; UALP 15646, trigonid of W = 1.31 (fig. 10).

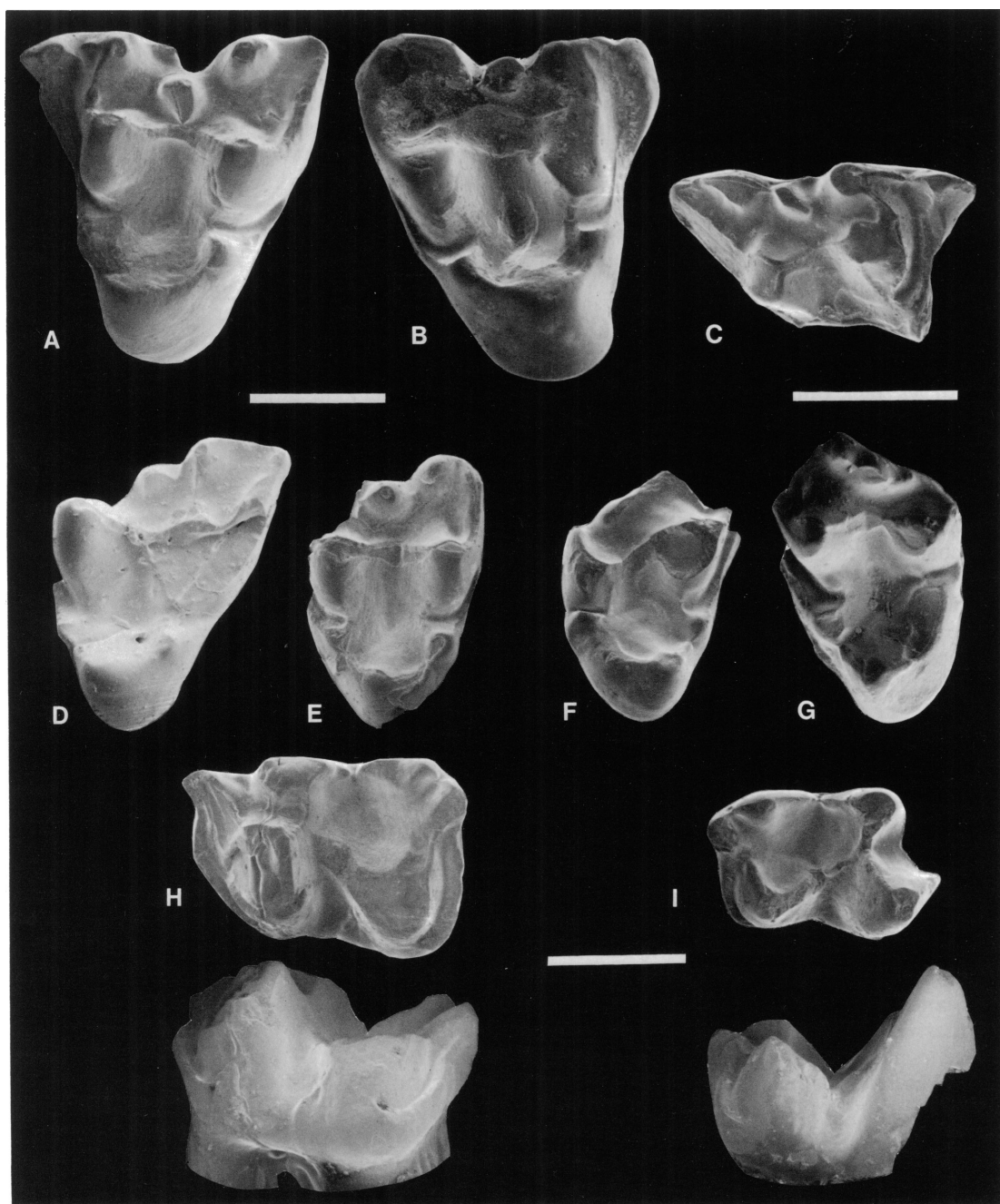


FIG. 10. Scanning electron photomicrographs of *Alphasodon marshi* (A, B) and *Alphasodon* cf. *A. wilsoni* (C-I). A, B, UALP 13634 and 13633, left M² and right M³; C-E, upper molar fragments UALP 15712, V 2443, and UALP 15650; F, G, M⁴ UALP 15711 and V 2428 at different magnifications; H, I, lower molars UALP 15649 and 15647. Each of the three bar scales equals one millimeter: one scale for A, B, D-F; one for C and G; one for H and I.

LOCALITIES: UALP specimens from Jacobs Bone Bed, others from Burnham South.

DESCRIPTION: The styler shelf of UALP 15712 (L = 1.78) is transversely narrow and

indented by a shallow ectoflexus. Cusp B is the largest; D is considerably lower, but is the second largest cusp. A is next in size and situated on a triangular anterolabial shelf. C is smallest and closer to D than B in position. B is close to the paracone. The paracone is worn to a lower level than the metacone, but may have been about the same size. The broken V 2443 ($W = 2.02$) has a deeper ectoflexus with a central cusp C that is about half the size of cusp D. UALP 15650 ($L, W = 1.43+, 1.89+$) has a central stylar cusp C at a moderately deep ectoflexus. C is larger than D on this tooth.

Both M^4 lack only their anterolabial tips; they have distinct conules and deep trigon basins. The paracone is larger and taller than the metacone in each, but more markedly so in UALP 15711, which has a broader trigon basin. The stylar shelf is narrow and simple, but cusp development varies between the teeth. V 2428 ($L, W = 1.2+, 1.8+$) possesses a large stylar cusp that is central with respect to the paracone and metacone. On the ridge anterior and posterior to this style are smaller cuspules. UALP 15711 ($L, W = 1.3+, 1.9+$) has a weaker stylar ridge and lacks these cuspules.

The worn M_2 ($L = 2.15$; trigonid $W = 1.23$; talonid $W = 1.34$) has strong anterior and posterior cingulids that nearly reach the labial side of the protoconid and hypoconid, respectively. The paraconid diverges from the metaconid and reaches nearly as far lingually. The hypoconulid is strongly compressed lingually and posteriorly recumbent. The damaged M_3 is smaller ($L = 1.7+$; $W = 1.22, 1.08$) and perhaps more gracile, but similar in other respects.

DISCUSSION: Upper molars described here are somewhat smaller than averages cited by Lillegraven (1969) for *Alphadon wilsoni*, but lower molars agree in size. The sample is grouped together on the basis of similar small size, and tentatively is considered homogeneous. However, the two M^4 differ in details and among other upper molars, UALP 15650 has a large stylar cusp C, while V 2443 has a small C cusp. The observed difference in relative size of cusp C in UALP 15650 and V 2443 would correspond to that seen in M^2 and M^3 of *A. wilsoni* (Lillegraven, 1969). Although this sample is compared with caution

to *A. wilsoni*, the species clearly belongs to the *A. wilsoni*-*A. marshi* clade. Lillegraven and McKenna (1986) assign to this clade a new species from the "Mesaverde" of Wyoming that is larger than the San Juan Basin species, but agrees with it in other morphology.

The San Juan Basin sample differs from *A. creber* in possessing stylar cusp C (absent in *A. creber*, Fox, 1971a). AMNH 77367, M_2 or M_3 and holotype of *A. halleyi*, is relatively narrower and has a longer talonid than lower molars in the San Juan Basin sample. AMNH 77370, an upper molar referred to *A. halleyi* by Sahni (1972, p. 381), has stylar cusp D larger than C as in UALP 15650. Larger samples of *A. halleyi* from the "Mesaverde" Formation of Wyoming provide better knowledge of this species (Lillegraven and McKenna, 1986) and suggest that this species could be represented in the San Juan Basin.

Alphadon sp. A

REFERRED MATERIAL: V 2431, left M_2 or M_3 from Burnham South (fig. 11).

DESCRIPTION: This lower tooth ($L = 2.5+$) lacks its paraconid, but anterior and posterior widths are about equal (1.65). Aside from its larger size with respect to the cf. *A. wilsoni* sample, V 2431 is distinguished by its hypoconulid, which is large, not recumbent, and relatively more central in position.

Alphadon sp. B

REFERRED MATERIAL: V 2427, upper molar fragment from Burnham South, and UALP 15648, left trigonid from Jacobs Bone Bed (fig. 11).

DESCRIPTION: V 2427 possesses a large D cusp and a smaller C cusp. C is posterior to the deepest part of the ectoflexus. UALP 15648 ($W = 1.86$) is an isosceles triangle with a large, divergent paraconid. Although broken, the paraconid appears to have been at least as large as the metaconid. These specimens are considered together on the basis of large size.

UALP 15648 would suggest the presence of *Eodelphis* in the San Juan Basin, if its paraconid were larger than its metaconid. However, V 2427 has a large D cusp unlike *Eodelphis*. *A. rhaister* is larger than either

specimen and V 2427, with its approximated cusps C and D, is unlike *A. rhaister*, in which C is close to B. These specimens seem closer to *A. marshi*, but are larger than known samples of that species.

EUTHERIA

LEPTICTIDA INCERTAE SEDIS

Gypsonictops Simpson, 1927

Gypsonictops new species

REFERRED SPECIMENS: V 3163, left M_3 from Burnham South, and UALP 15713, upper molar fragment from UALP 7592 (fig. 11).

DESCRIPTION: V 3163 ($L = 2.53$) has a high but deeply notched trigonid ($W = 1.75$), with the protoconid somewhat larger than the metaconid. The paraconid is much smaller than either and, although close to the metaconid, is distinct and only slightly labial with respect to the metaconid. Its tip is planed off by wear. There is a strong, short anterior cingulum. The talonid is relatively wide (1.44), but elongated and basined with a high hypoconulid as would be expected in M_3 . The talonid slopes ventrally to the anterior and has a distinct, cusped entoconid. The hypoconid and hypoconulid are larger and elongated along the talonid margin. The central hypoconulid constitutes the highest part of the talonid. A small valley between entoconid and hypoconulid drains posterolingually. The cristid obliqua is low and intersects the trigonid labial to the midline of M_3 . A second oblique talonid ridge runs from the notch between the entoconid and hypoconulid to the trigonid, lingual to the midline. M_3 bears two roots, the posterior one being transversely compressed and directed posteriorly.

DISCUSSION: V 3163 appears to be assignable to a new species of *Gypsonictops* under study by Rigby and Wolberg (in press) from the Fossil Forest assemblage, San Juan Basin

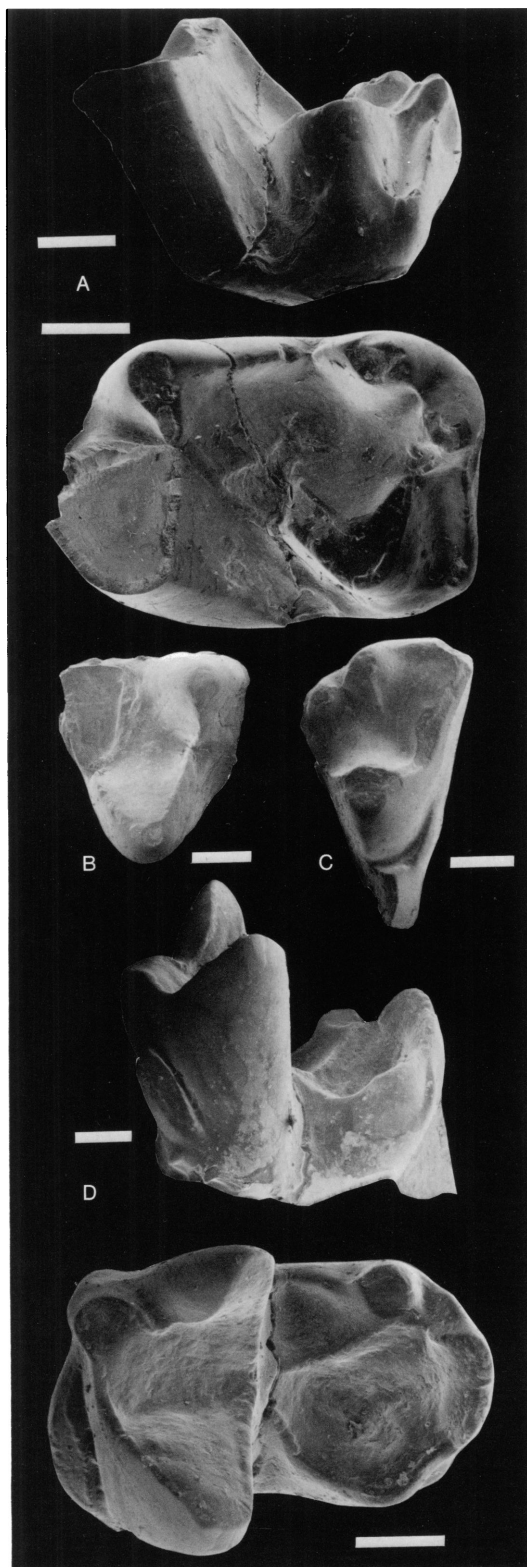


FIG. 11. Scanning electron photomicrographs of *Alphadon* sp. A (A), *Alphadon* sp. B (B, C), and *Gypsonictops* n. sp. (D). A, Lower molar V 2431 at two magnifications; B, trigonid UALP 15648, and C, upper molar fragment V 2427; D, M_3 V 3163 at two magnifications. All bar scales equal 0.5 mm.

TABLE 3
San Juan Basin Cretaceous Mammal Assemblages

(1) Lower Hunter Wash horizons (source: Clemens [1973] and UALP localities 75137 and 76168); (2) Jacobs Bone Bed (UALP 7592, 25 m above 75137); (3) Burnham South, high in Fruitland Formation; (4) UALP 7599 and 8020; BUNM-77-675 (Lehman, 1984).

Taxon	LHW ¹	7592 ²	BS ³	Alamo Wash ⁴
"Plagiaulacoid"			x	
<i>Paracimexomys judithae</i>	x	x	x	
<i>Paracimexomys</i> n. sp.		x		
<i>Mesodma formosa</i>				x
cf. <i>M. senecta</i>	?	x	x	
<i>M.</i> n. sp. or cf. <i>C. antiquus</i>		x	x	
cf. <i>Kimbetohia campi</i>	x			
<i>Cimolodon electus</i>	x	x	x	
<i>Cimolodon</i> n. sp.	x	x		
<i>Meniscoessus intermedius</i>	x	x	x	
cf. <i>Meniscoessus</i> sp.				x
cf. <i>Essonodon</i> n. sp.	?		x	
<i>Essonodon browni</i>				x
Eucosmodontid	x	?	x	
<i>Alphadon marshi</i>				x
cf. <i>A. marshi</i>	x			
cf. <i>A. wilsoni</i>		x	x	
<i>Alphadon</i> sp. A			x	
<i>Alphadon</i> sp. B		x	x	
<i>Alphadon</i> ? n. sp.	x			
cf. <i>Pediomys cooki</i>	x			
<i>Gypsonictops</i> n. sp.	x	x	x	
cf. <i>Cimolestes</i> sp.	x	x		

(see Introduction). Compared to *G. hypocynus*, the paraconid of V 3163 is less reduced and the trigonid wall is more deeply notched posteriorly. Also, the entoconid and hypoconulid are larger in V 3163. This new species is also known from lower horizons of the Fruitland Formation in Hunter Wash (Clemens, personal commun.). The upper molar fragment UALP 15713 can be assigned provisionally to this species, representing a high stratigraphic occurrence.

ORDER, FAMILY, AND GENUS INDETERMINATE

UALP 15714, the labial half of an upper molar from Jacobs Bone Bed (locality 7592), is cited here simply to record an additional

eutherian from a high level in Hunter Wash. Its narrow labial shelf and sharp paracone and metacone are similar to those of species of *Cimolestes*. Cf. *Cimolestes* sp. was recorded from lower levels by Clemens (1973).

SAN JUAN BASIN ASSEMBLAGES

Table 3 summarizes taxonomic distribution by locality in the order of observed stratigraphic horizon (inferred from Burnham South). The Lower Hunter Wash assemblage, based mainly on Clemens (1973) and additions from two UALP localities, will be revised following the research of Rigby and Wolberg (in press). The questionable occurrence of cf. *Essonodon* sp. is noted from Armstrong-Ziegler (1978); she also lists cf. *Peraedectes* sp. The "large" *Mesodma* of Clemens (1973) is probably the same as the sample here referred to cf. *M. senecta*. This fauna has been called the Hunter Wash Local Fauna by Clemens (1973).

The Jacobs Bone Bed assemblage occurs 25 m above the Lower Hunter Wash localities and the mammals from both are similar (see table 3). This assemblage is essentially the same as that from the Burnham area. Sediments at Jacobs Bone Bed and Burnham South show strong lithological similarity and can be considered characteristic of the high Fruitland beds that are transitional with the Kirtland Formation. Multituberculates from these localities are similar to those from low in Hunter Wash and the Theria from all three areas, although poorly represented, may prove to be identical. Further study of these assemblages will provide a basis for evaluating whether they represent the same paleocommunity.

The Alamo Wash Local Fauna is distinct faunally and stratigraphically, lying nearly 200 m above UALP 7592 (Jacobs Bone Bed). Mammals from these high Kirtland strata appear to represent the Lancian age, based on co-occurrence of *Essonodon browni* (see Lehman, 1984), *Alphadon marshi*, and *Mesodma formosa*. Although the diversity of the fauna is certainly undersampled because less than one ton of matrix was washed, several fragmentary teeth suggest that at least one more species of *Mesodma* and two larger multituberculates were present. The Alamo Wash

assemblage as presently represented resembles assemblages collected from the Lance Formation of Wyoming (Clemens, 1963, 1966), the Scollard Formation of Alberta (Lillegraven, 1969), and the Hell Creek Formation of Montana (Archibald, 1982). It thus suggests that the latest Cretaceous Lancian land mammal "age" (Lillegraven and McKenna, 1986) can be identified in New Mexico, in agreement with analyses of dinosaur faunas by Sloan (1970) and Lehman (1981). Temporal affinities of the older Hunter Wash localities are more complex and deserve further discussion.

AFFINITIES OF THE HUNTER WASH MAMMALS AND TEMPORAL CORRELATION

Russell (1975) outlines a seriation of Late Cretaceous mammalian assemblages, based on inferred correlations to marine biochronology and on presumed ancestral-descendant relationships among mammals. The oldest known Campanian fauna is that from the upper part of the Milk River Formation, Alberta. It is considered older than the few fossils found elsewhere in the lower part of the Oldman Formation, Alberta. Stratigraphically above the latter (see Fox, 1976, p. 1217) in the upper part of the Oldman Formation is a well represented fauna that Fox (1980) considers a Judith River, Montana, faunal equivalent (near the Campanian/Maastrichtian boundary; see Lillegraven and McKenna, 1986). The mammalian localities of the "Mesaverde" Formation, Wyoming, may be similar in age (Lillegraven and McKenna, 1986). The poorly represented fauna from the younger St. Mary River Formation of Alberta, includes only three multituberculates that can be identified to species (Sloan and Russell, 1974) and perhaps all three occur in Lancian assemblages. As mentioned above, large Lancian assemblages are known from Wyoming, Montana, and Alberta.

The Lower Hunter Wash, Jacobs Bone Bed, and Burnham South assemblages include species represented at several pre-Lancian localities in North America. Affinity with mammals from the Campanian Milk River Formation, Alberta, lies in the presence of *Cimolodon electus*, cf. *Mesodma senecta*, and

the possible *Cimexomys antiquus* in Hunter Wash. *Meniscoessus intermedius* occurs in the younger lowermost part of the Oldman Formation, Alberta, and the "Mesaverde" Formation, Wyoming (Lillegraven and McKenna, 1986), as well as in the San Juan Basin. *Paracimexomys judithae* and perhaps one or more marsupial species are shared by the New Mexico and the Judith River, Montana, assemblages. Certain other Hunter Wash elements suggest Lancian comparison, although none represent Lancian species: *Gypsonictops* n. sp., *Cimolodon* n. sp., cf. *Kimbetohia campi*, cf. *Alphadon marshi*, cf. *A. wilsoni*, and cf. *Pedionomys cooki*. Because faunal correlation must be based on species level identifications, the Hunter Wash assemblage seems most comparable to mammals from several pre-Lancian sites, but by how much the Hunter Wash Local Fauna predates the Lancian "age" is not clear.

Russell (1975) names chronostratigraphic "stages" for the rocks containing (or equivalent to) classic Late Cretaceous mammalian assemblages. The Milk River mammals of the Aquilan "stage" are shown to be older than the mammals of the Judithian "stage"; however, only one Aquilan assemblage is described (Fox, 1971a, 1971b). Faunal differences with Judithian assemblages could reflect ecology as well as time. Calling upon the meager phylogenetic evidence that does exist, Lillegraven and McKenna (1986) establish as biochronological units the Aquilan and Judithian land mammal "ages."

On faunal grounds alone, the Hunter Wash Local Fauna hypothetically might be considered intermediate in age between Milk River and Judith River assemblages, or equivalent to the early part of the Judithian land mammal "age," based on presence of *Meniscoessus intermedius*, which is also known from the lower part of the Oldman Formation. Following the arguments of Lillegraven and McKenna (1986), this would yield an age for the Hunter Wash Local Fauna near the Campanian/Maastrichtian boundary, about 74 Ma, according to the time scale of Lowrie and Alvarez (1981).

The San Juan Basin sequence demonstrates superposition of different faunas. Figure 2 shows the stratigraphic occurrence of the Hunter Wash and Alamo Wash assem-

blages with the paleomagnetic reversal sequence of Butler et al. (1977) as revised by Butler (1984) and Butler and Lindsay (1985). These data show that the Hunter Wash Local Fauna occurs in normal magnetozones interpreted as the upper part of anomaly 31 and the lower part of anomaly 30, which is equivalent to the late Maastrichtian (about 68 Ma; Lowrie and Alvarez, 1981). This fauna would predate by at least one million years the Lancian Alamo Wash Local Fauna, which occurs in the reversed interval above anomaly 30. Existence of the magnetozones should not be dismissed arbitrarily. However, by postulating varying rates of deposition and a major hiatus at the base of the Ojo Alamo Conglomerate, Lucas and Schoch (1982) propose correlation of the normal magnetozones with anomaly 33, yielding a late Campanian age. Correlation of the normal magnetozones to anomalies 30 and 31 is supported by a radiometric date and other arguments in Lindsay et al. (1983).

The most parsimonious correlation of the normal magnetozones, without the prejudice of biochronological assumptions, is with anomalies 30 and 31. This is consistent with a Lancian "age" for the Alamo Wash Local Fauna of the upper part of the Kirtland Formation. However, the Hunter Wash Local Fauna would occur in rocks of about 68 Ma, about 6 million years younger than similar Judithian "age" faunas. The identification of the magnetozones as anomalies 30 and 31 would be modified, and the apparent difficulty in correlating the mammals would disappear if there existed a major unconformity of several million years hiatus *within* the Kirtland Formation. This is not apparent in the field and to my knowledge has never been suggested by other workers.

Accepting the paleomagnetic correlation for the moment, it appears that the Judithian land mammal "age" as recognized in the San Juan Basin persisted to about 68 Ma. This leaves less than 2 million years duration for the Lancian "age" (including Edmontonian time). This chronology suggests that the Judithian paleofauna was stable for several million years and was replaced by a Lancian paleofauna of short duration, which was in turn replaced by Puercan mammals. Another conclusion would follow if the Lancian "age"

mammals were shown to have appeared elsewhere much earlier than 68 Ma. Perhaps the San Juan and El Gallo (Baja California) faunas belong to a biogeographically distinct southwestern faunal province as has been suggested by Clemens (1973) and Clemens et al. (1979). Biochrons established for the northern Wyoming-Montana-Alberta faunas may not be applicable in the San Juan Basin, although the younger Alamo Wash Local Fauna seems comparable to "Lancian" faunas of the north. Instead, Aquilan and Judithian elements may have persisted later in New Mexico than in the northern region. This provinciality has been postulated for dinosaur faunas by Sloan (1970).

If the paleomagnetic correlation is rejected, then biochronological arguments can be used to support an early Judithian (Campanian/Maastrichtian boundary) age for the Hunter Wash local fauna. This yields an age several million years older than the Lancian Alamo Wash local fauna. Miscalibration of the magnetozones could result from very slow sedimentation and occurrences of short lacunae, such that the reversed polarities between anomalies 30 and 33 are represented by little sediment.

Selection among the above alternatives may become clear as a result of ongoing research by Rigby and Wolberg and by others (in press; see references therein). Imperative also is extensive screening of Naashoibito sediment, which would establish unequivocally the existence or absence of a Lancian assemblage in the San Juan Basin.

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